KEMENTERIAN PENGAJIAN TINGGI

ROBOT DESIGN HANDBOOK

ROBOCON MALAYSIA 2022

LAGORI : TUJU TIN

"Merempuh Cabaran Membina Impian"

KOMPLEKS SUKAN AZMAN HASHIM
UNIVERSITI SAINS MALAYSIA
PULAU PINANG

2 HINGGA 5 JUN 2022

DENGAN KERJASAMA

USM UNIVERSITI SAINS MALAYSIA

APEX™

JPT | JABATAN PENDIDIKAN TINGGI

rtm

The book **ROBOT DESIGN HANDBOOK** is published by the Universiti Sains Malaysia (USM) Technical Committee of ROBOCON Malaysia 2022.

Technical Committee of ROBOCON Malaysia 2022,
Universiti Sains Malaysia (USM),
Seberang Perai Selatan,
Nibong Tebal 14300,
Pulau Pinang,
MALAYSIA

First published in 2022

National library of Malaysia

Cataloguing-in-Publication Data

ISBN 978-967-26736-0-6

9 789672 673606

ROBOT DESIGN HANDBOOK

Robot Design Handbook

EDITORS: Teh Jiashen, Muhammad Najwan Hamidi, Ooi Chia Ai, Mohamed Salem Mohamed Othman

TABLE OF CONTENTS

EDITOR NOTE

This handbook compiles all the technical design reports from the participating teams of the ROBOCON Malaysia 2022. Each chapter of this book describes the design of the robot of each team. The purpose of this book is to share and pass on valuable information of engineering and robotics for to other robotic enthusiasts, which can also be used as future reference. The preparation of this book is also to continue the culture from the previous ROBOCON Malaysia 2020 competition which compiles all reports for knowledge sharing.

It is our greatest hope that this book can be a valuable source of reference for all future robotic competitions, within and outside of Malaysia.

ROBOCON MALAYSIA 2022 CONCEPT

ROBOCON is a robotic competition organized by Asia Broadcasting Union (ABU) since 2002, and this year is the 16th competition of the game. The purpose of ROBOCON Malaysia is to select local national champions that will represent Malaysia at the international stage and compete against champions of other nations. The international ROBOCON competition of this year is slated to be held in New Delhi, India, in August 2022.

In conjunction with the culture of host country of the international ROBOCON, ABU has selected a local Indian traditional game – Lagori – as this year's competition theme. Lagori is a game of two teams. One team attempts to break a stone tower, known also as the "Lagori", by throwing balls and then pile up the tower. At the same time, the other team attempts to disrupt the piling process. During the game, the first and second teams are known as the "Seeker" and "Hitter", respectively. Both teams take turn to switch roles at the end of each round.

During the preparation of this event, the organizing committee of ROBOCON Malaysia 2022 examined the Lagori game, and discovered that the game is very similar to a local traditional game known as "Tuju Tin". Due to the similarity, the theme "Lagori" is renamed as "Lagori-Tuju Tin" to infuse our proud Malaysian flavor into this ROBOCON Malaysia 2022.

The simplified game rules of Tuju Tin are as follows:

A) Each team must build two robots.

B) There are two rounds per game.

C) The referee takes turn to assign each team as Seeker or Hitter, so that each team can play both roles. For example, the Seeker in the first round will become the Hitter in the second round, and vice versa.

D) At the start of each round, Seeker attempts to throw balls to break the Tin and then pile them up in the original order. Scores will be awarded based on the number of Tin that is broken and the number of Tin that is piled up.

E) During the piling process, Hitter attempts to prevent Seeker from piling up the Tin by throwing balls at the Seeker

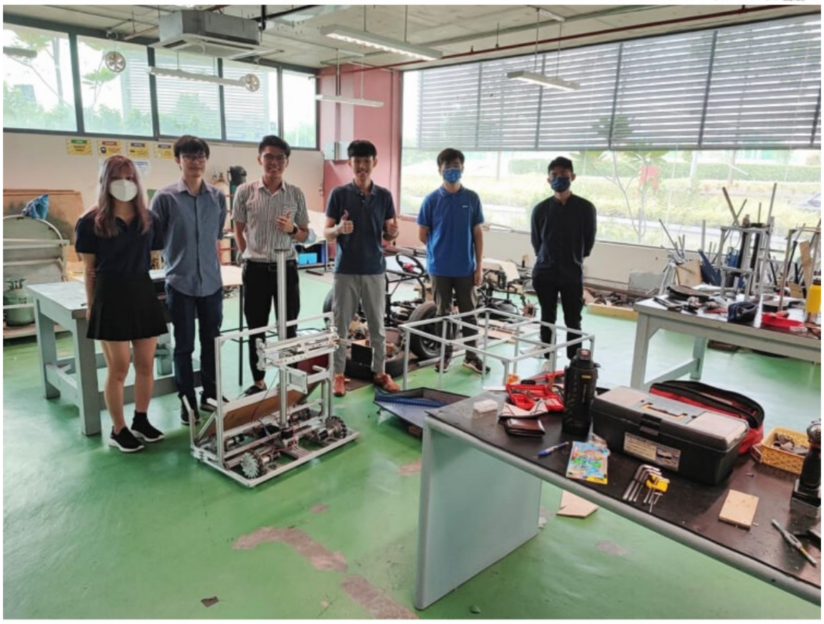
This page is intentionally left blank

This page is intentionally left blank

ASIA PACIFIC UNIVERSITY (APU) FIGHTERS

Arun Seeralan Balakrishnan, Chong Jie Cheng, Elvin Yeoh Kang Shen, Alan Chung Shen Kai, Wong Heng Ying, Chan Yue Kin, Chan Shou Wei, Ang Jia Ze, Ong Li Wen, Soh Ee Lok

Asia Pacific University, Jalan Teknologi 5, Taman Teknologi Malaysia, 57000 Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur



ROBOCON 2022

ABSTRACT

The robots designed for this competition are fully electric. R1 was designed to look like a table as movement is not necessary for the robot. To throw the ball, a wheel type launcher is used and the load the balls into it, conveyor belts are used. R2 was designed to move in all directions to ensure maximum mobility and a slave master architecture is used to allow the robot to execute tasks in parallel. To grip the Lagori pieces, a gripper is used, and conveyors are used to pick and place the balls from the ball rack into R1.

1. INTRODUCTION

R1's purpose is to shoot the ball to hit the Lagori pieces and to transport the balls from R2 to the launcher. The robot is designed to not move during the entire round. R2's purpose is to transport the balls from the ball racks to R1 and to pick up the Lagori pieces.

Both robots are controlled using PS4 controller which utilizes Bluetooth. Throughout the construction and design process, the main obstacle was trying to adjust transport the balls into R1.

2. DETAILED DESIGN

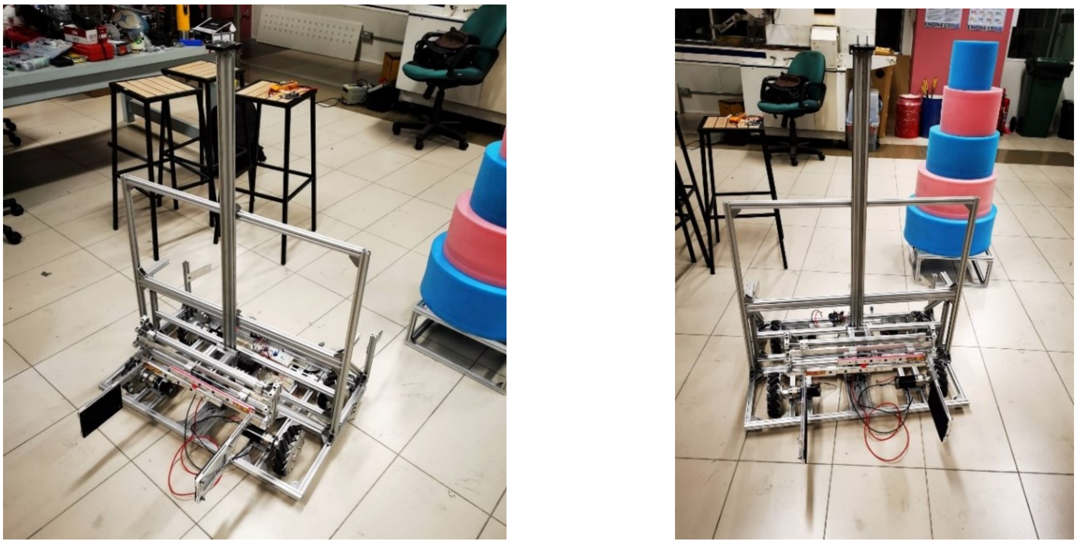


Figure 1: R2 Robot

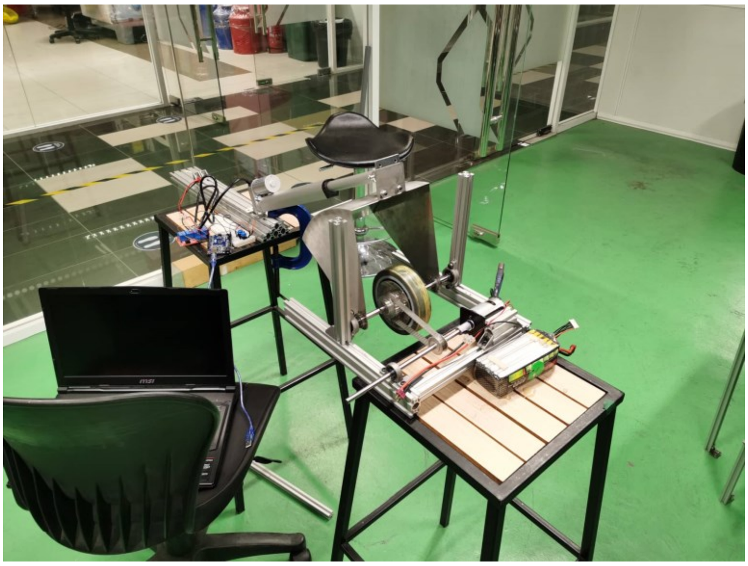


Figure 2: R1 Robot

Aluminium square profiles are used to construct the body of robots R1 and R2. The R1 robot uses wheel launcher design to launch the balls to hit the Lagori and Ball on Head. The conveyor is used to transport the ball to the launcher.

The R2 robot uses meconium wheels for omni-directional movement and stepper motor with lead screw to lift the gripper. The conveyors will be used to transport the balls into R2 and eject it into R1.

3. ELECTRONIC DESIGN

R1 Robot

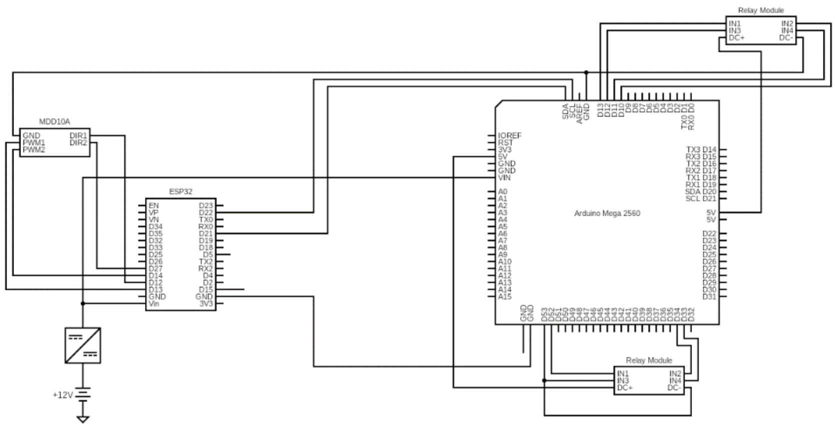


Figure 3: R1 Circuit

R2 Robot

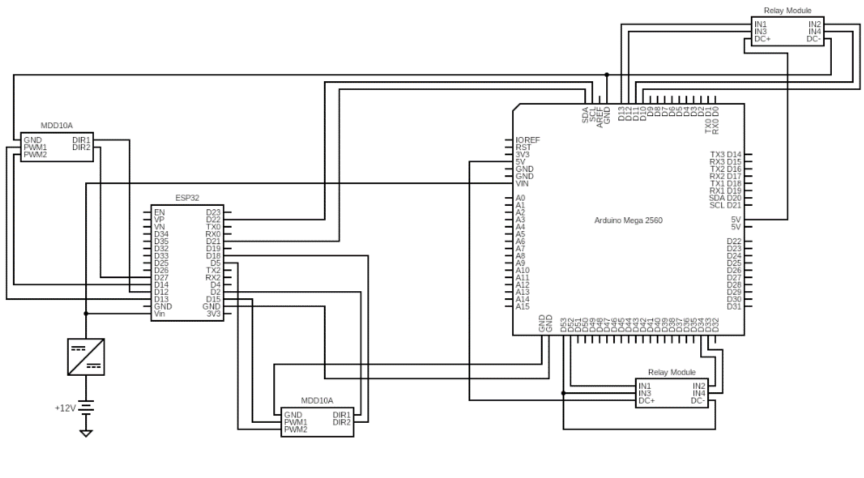


Figure 4: R2 Circuit

Both robots use the almost similar electronics as relays and motor drivers are required to drive most of the mechanisms.

4. SOFTWARE DESIGN

Several software was used to design our robots:

Arduino IDE – to code our robots

SOLIDWORKS – to provide accurate dimensions of parts for visualization purposes

Ultimaker Cura – to 3D print robot parts

5. PRESENTATION OF TESTING DATA

Currently, R2 robot is working on several parts which are pairing the PS4 controller to the robot, able the robot arm to pickup and place the lagori disc and collecting the ball from the ball area and pass the ball to robot R1. Based on the figure shown below, R2 robot was able to move around. Next, picking, placing, and stacking of lagori disc can be done by rotating the power screw. As for ball collecting, the system is still under progression.

When it comes to R1 robot, the shooting system was a success. Based on the figure shown below, the ball was able to shoot down the lagori discs. As for the ball transferring system from R2 robot to the head of the shooter, this system is still working.

6. DISCUSSION

During the discussion between the member, aluminum profile was used to build both robots. This is because aluminum profile is easier to install with the presence of bolts and nuts. Besides that, installing new component is easy as well. Besides that, power screw was used to build the robot arm as this mechanism has self-breaking features. Moving on, fly wheel is used in the shooting system to increase the speed of the ball shooting towards the lagori discs. Lastly, conveyer belt was used to transport the ball from the R2 robot to the shooter part.

During testing, there are many issues found and these issues had been encountered. First, due to the ball was unable to shoot down the lagori discs, the shooting mechanism was reconstructed by adding bigger flying wheel and stronger motor to shoot the ball out. Second, due to the dimension of robot R2 had exceed the requirement, discussion between the member was done and suggested to change the location of the robot arm to the center of the body. Therefore, this suggestion had improved multiple points which included weight distribution, dimension and many more.

Two microcontrollers were used for both the robots as I2C communication protocols are used. According to Mankar et al., I2C is simple, plug and play and cost effective and also universally accepted for microcontrollers. It allows the robots to run 2 or more processes at the same time [1].

7. SUSTAINABLE ENGINEERING PRACTICES

The construction of the robot in particularly the robot arm uses mostly leftover aluminium square profiles from last year's ROBOCON competition. Additionally, components for prototyping the early designs mostly used leftover wood and metal. Electronics components were also reused from previous year's robots to test for the codes and used in this year's robots.

8. CONCLUSION, LIMITATION AND RECOMMENDATION

In conclusion, the robots were constructed by using many aluminum profiles to reduce weight. The limitation of our robot is R2 robot are vibrating too much and suggestion to solve this issue is installing suspension system. As for R2 robot, the limitation of it is complex construction. The suggestion to solve it is to exchange the conveyer to linear actuators.

9. ACKNOWLEDGEMENT

We would like to express our gratitude towards Asia Pacific University for giving us support and facilities to develop the robots. Thanks to the supervisor of the team, Mr. Arun Seeralan Balakrishnan, to supervise us in terms of technical issue as well as conduction the management to the teams. Besides that, thanks to all the team member for continuously developing the robot for the competition. We also do not forget to thank the sponsors for supporting us along with the preparation for ROBOCON Malaysia 2022.

REFERENCES

[1] Mankar J., Darode C., Trivedi K., Kanoje M. and Shahare P. REVIEW OF I2C PROTOCOL International Journal of Research in Advent Technology, 2(1): 4747 – 479, 2014.

GERMAN MALAYSIAN INSTITUTE (GMI)

Muhammad Aiman Irfan Bin Mahadi[1], Mohamad Ariff Adli Bin Nasarudin[1], Muhammad Adli Rafie Bin Badarul Mukrim[1], Muhammad Noor Iqbal Bin Sulaiman[1], Muhammad Fakhrullah Bin Mohd Mohayudin[1], Mohammed Adam Zuhairi Bin Mohammed Zaidi[1], Muhammad Ariff Daniel Bin Suhairi[1], Ahmad Hakimi Bin Samnudi[1], Nur Maisarah Atiqah Binti Mohammad Rafizan[1], Sham Firdaus Md Ali[1], Ahmad Hafiz B Mohd Hashim[1], Afiq Faress Jamil[1]

German-Malaysian Institute, Jalan Ilmiah, Taman Universiti, 43000 Kajang, Selangor[1].

ABSTRACT

The ABU Asia-Pacific Robot Contest or ABU Robocon originated in 1991 where the competition was only restricted to the teams originated from Japan. The contest aims to create friendship among young people with similar interests who will lead their countries in the 21st century, as well as help advance engineering and broadcasting technologies in the region. Generally, the competition requires two or more robots to complete the designated tasks. This year both of the robots can either be manually controlled or autonomously. In 2022, the theme relates to traditional games known as "Lagori" or "Tuju-Tin". There are two robots prepared which include a semi-automatic robot (R1) and a manual robot (R2). R1 concept implements the throwing concept of balls for training purpose in volleyball and tennis game. The throwing

speed can be adjusted by the roller speed of the motor. It also equipped with a feeder and a ball screw mechanism to tune the shooting angle. R2 in the other hand implements the gripper concept with capability to manoeuvre in various motor directions. Base on the design concept, all Lagoris can be knocked down and re-assemble within the stipulated 3 minutes time. A few applications that can applied based on the robot concept includes on the development of a new training machine for several local sports including Sepak Takraw and others. In the other hand, the gripper mechanism can also be applied for military purpose such as in defusing explosive devices and others

1. INTRODUCTION

ROBOCON Malaysia was also created annually in the country to select the best 2 teams to represent Malaysia in the Asia Pacific competition. For this year's game, the theme is based on India's traditional way of transporting goods across countries called "LAGORI". The competition requires the teams to create 2 robots whenever autonomous or remotely controlled. The first robot prioritizes throwing balls at the Lagori while the second robot prioritizes the activity of picking up and replace the fallen Lagori after the shooter robot successfully tumble down the Lagori. With this information, GMi team prioritizes the shooter robot first.

2. PROJECT DESIGN

2.1 SHOOTER ROBOT (R1)

GMi team built the shooter robot with include 4 DC motors accompanied with 2 wheels. The wheels are installed to allow the robot to easily adjust the robot's aim which only prioritizes aiming of from left to right. The problem of aiming adjusts from top to below hinder the progress of creating a successful shooter robot. To solve the problem, GMi team installed a lifter which can go up and down at control to the robot's shooting mechanism. DC motors on the other hand is cheaper, fast, easier to code and can easily wired to the controller.

The team use a PlayStation 2 wired controller to manually control the robot. This controller is plugged into a Cytron PS2 Shield which is directly stacked on top of the Arduino Mega. The team choose a wired controller rather than the wireless controller to prevent unwanted signal interference and the response is much faster than the wireless controller. The movement mechanism for robot R1 and robot R2 will be built with similar concept which is as shown in figure 2.

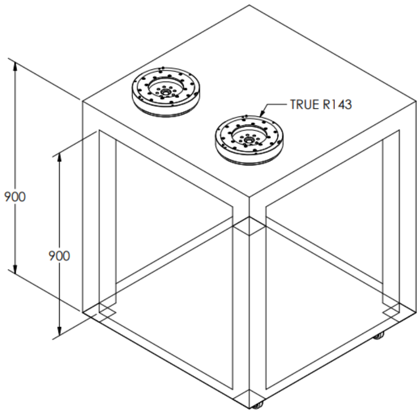


Figure 1: Shooting Mechanism

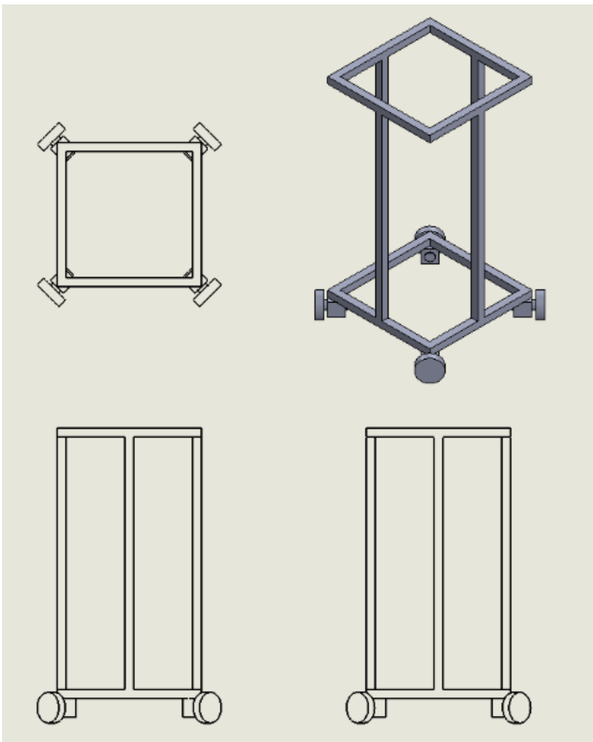


Figure 2: Movement Mechanism

2.2 GRIPPER ROBOT (R2)

GMi team built the gripper robot with include 4 DC motors accompanied with 4 wheels. The wheels are installed to allow the robot to allow easy manoeuvre. The problem of gripper robot is to select a suitable design for its gripping mechanism. To solve the problem, GMi team has decided to install a robotic arm structure with adjustments at the end of the structure contains pressure plates. In other words, the gripper robot's gripping mechanism is based such as the octopus's tentacle. This will allow for easy picking and rearrangement of the Lagori.

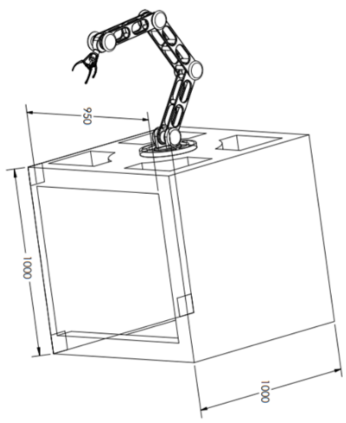


Figure 3: Robot Gripper Mechanism

3. PROJECT COMPONENT DESCRIPTION

The shooter robot consists of 4 DC motors, 2 motors for movement at the wheels and 2 motors for the shooting mechanism. The robot is connected to the Cytron PS2 Shield which is stacked above the Arduino Megacontroller by a PS2 controller which is connected to the Cytron PS2 Shield which is directly stacked on top on the Arduino Mega. A DC motor will control the movement of the mechanical hand. A servo motor is place at the edge of the mechanical hand to grip the Lagori. The list is as shown in Table 1.

Table 1: List of major component use in manual robot

ITEM	QTY	DESCRIPTION
DC Motor	5	Linear Motor with 15N/cm^3 torque. Max speed 250rpm
Servo Motor	1	Torque 15kg/cm
Arduino Mega	1	ATMega 2560 controller
PS2 Controller	1	Standard Sony PS2 Joystick
Cytron PS2 Shield	1	Interface between controller and joystick
Lipo ion Battery	2	11.1V 2500mah

Meanwhile, the gripper Lagori collecting robot R2 will consist of several servo motor for the gripper function with a servo shield. DC motor will also be utilized for the robot movement. The complete list is as shown in Table 2.

Table 2: List of major component use in autonomous robot

ITEM	QTY	DESCRIPTION
Servo Motor	12	Each leg consists of 3 servo motor.
U Joint bracket	18	Mounting for servo motor
Arduino Mega	1	ATMega 2560 controller
Stackable Servo Shield	2	Maintain the power
Lipo ion Battery	2	11.1V 2500mah
Slide Switch	3	Input signal to Arduino Mega
LED	1	Indicator light
Emergency stop button	1	Safety device
Resister (1K ohm)	1	Lower the voltage for indication lamp
HMC5883l (3-axis Magnetometer)	1	Sensor change of robot position
DC Motor	5	Linear Motor with 15N/cm^3 torque. Max speed 250rpm
PS2 Controller	1	Standard Sony PS2 Joystick

4. PROJECT CIRCUIT DIAGRAM

The project implements 2 complete circuit for the shooter robot and gripper robot. The shooter robot circuit diagram is as depicted in figure 4. The circuit consist of all the components use as mention the project in the component description. Finally, figure 5 shows the circuitry for gripper robot.

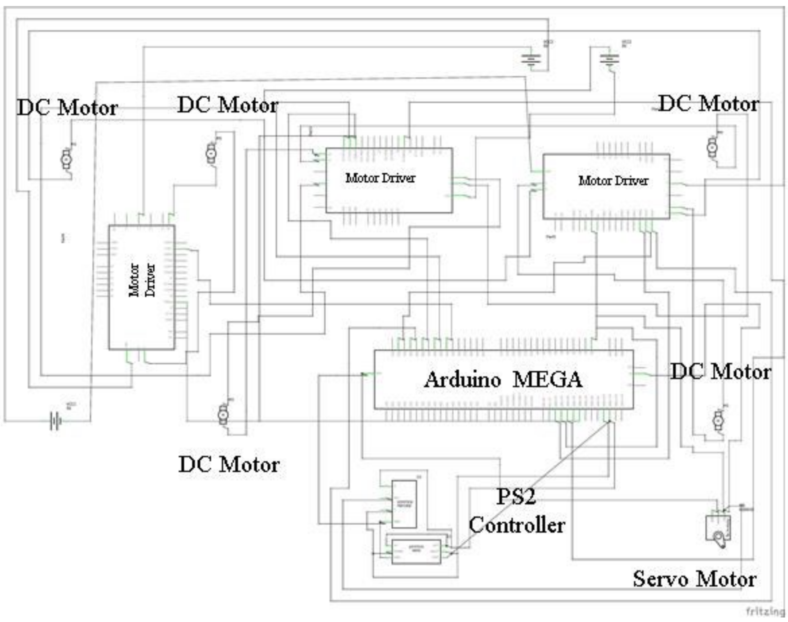


Figure 4: Shooter Robot Circuit

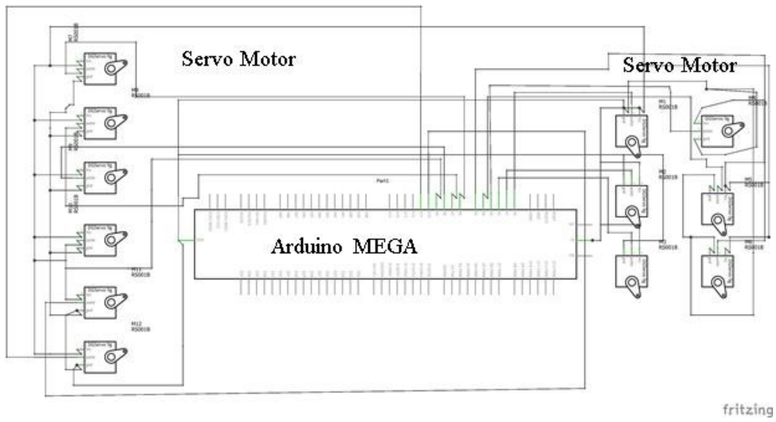


Figure 5: Gripper Robot Circuit

5. PROJECT FINDINGS AND ANALYSIS

The table shows in Table 3 depicts 4 types of motors. Each motor has its own description, torque, weight, pros and cons of the motor. Each motor analyse will be used for specific purpose for robot R1 and R2. The power window motor will be used as a drive mechanism, while the servo motor acts as gripper module.

Table 4: Comparison of different type of motors

Type of Motor	Item Description	Torque (kgf.cm)	Weight	Advantage	Disadvantage
Power Window Motor	Power window motor for proton	30	600g	-Large torque -Low cost around RM45 -Locking mechanism with worm gear -Easily attach to robot body	-Unable to control exact position -Must use encoder -Large in size -Heavy 600g
Planetary DC Geared Motor	24V 148RPM 18kgfcm 45mm Planetary DC Geared Motor	20	980g	-Large torque -locking mechanism with magnetic brake	-High cost around Rm220 -Heavy 980g -Not easily to attach to robot body -Large in size
Metal Gear Digital Servo	JX Servo PDI-	25.3	62g	-Large torque -locking mechanism with pinion gear	

	6225MG-300 Degree			-Low cost around Rm65 -Easily attach to robot body -light 62g -Able to control exact position -small in size	
Micro Linear Servo	L12-R Micro Linear Servo 100mm 210:1 6V	150	56g	-locking mechanism using ball screw -Large torque -Easily attach to robot body -light 56g -small in size	-High cost around Rm350 -Short stroke around 3 cm to 10 cm only

6. PROJECT FLOW / SEQUENCE

The concept of the whole game is to have the shooter robot to shoot down the Lagori. Each fallen Lagori will remark 5 points. Additional points will be rewarded if the gripper robot is able to rearrange the fallen Lagori. At the same time when the gripper robot is rearranging the Lagori, it is opportune moment to the competitor team for hence the competitor team's shooter robot are given chance to shoot the GMi team's gripper robot's vulnerable point which if successfully hit will nullify the GMi team's round of rearranging the Lagori. The shooter robot is given three chances the shoot the Lagori. In the end, which team that scores higher will be announced the winner. If there is a draw, the winner will be announced on which team that has a shorter time in the task completion.

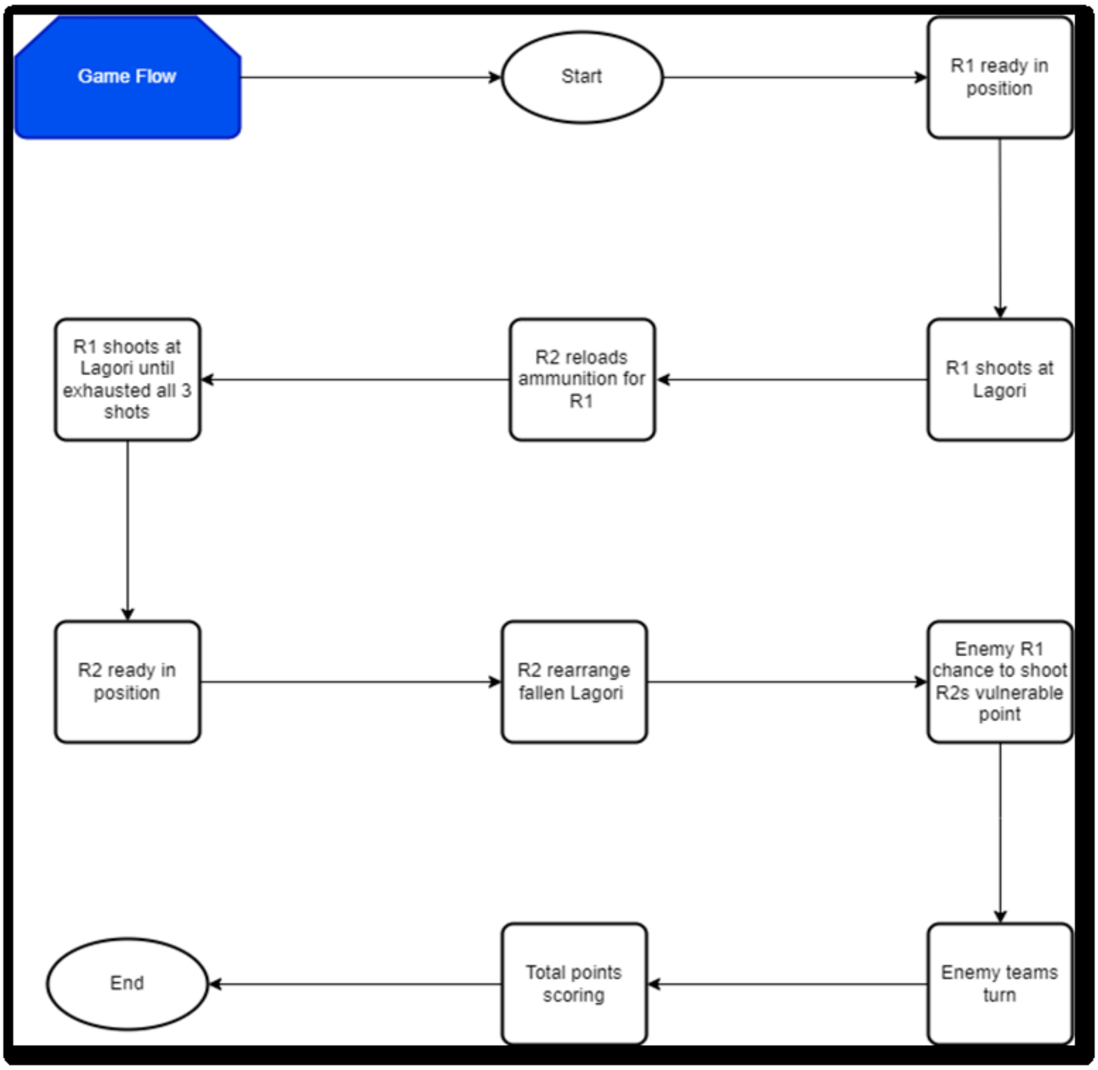


Figure 6: Concept of Contest

7. SUSTAINABLE ENGINEERING PRACTICES

In order to develop both robots for the purpose of the competition, several key measures have been taken to ensure sustainable engineering practices. These includes on the following steps taken

- Ensure that all components used for the robots are 100% recycle material, including hardware material and also robot electronics component.
- Next, the team will opted for less expensive material for robot body construction such as using wood material compare to metal and aluminium type of material.

8. CONCLUSION

As whole, the team are ready for the competition. The team had implemented all the knowledge, skills and time into this project. Each member played their part in terms of mechanical, electrical, programming, crafting skills and creative thinking into the creation of the 2 robots. The team have tested the robots countless of times using prototype to make sure that all the flaws had been corrected.

The robot requires aluminium material to be fabricated and constructed. Furthermore, most electronics components are recycled components to reduce the amount of cost required to complete the project. The most expensive parts are for the servo motor as high torque servo motor is required. Other than that, the team get to share experience, skills and knowledge with the team members.

The team learn more than in class because, building a robot requires different perceptions, knowledge and skills which are mixed up to form the project. The team can now look at things in a broader view because we know where to apply this knowledge and prove our understanding on the particular matter.

REFERENCES

[1] Aswinth Raj, Digital Compass Using Arduino and HMC5883L Magnetometer, CircuitDigest, November 2018.

[2] Ober, remote control with shield-ps2 + g15 as wheel, Tutorials by Cytron, October 2013.

[3] ModMyPi LTD, What’s the difference between DC, servo and stepper motor, ModMyPi LTD, August 2013

MONASH UNIVERSITY MALAYSIA

Dr. Mohammed Ayoub Juman, Dr. Khong Yin Jou, Andrew Joseph Ng Man Loong, Athul Sanjayan Chettipparambil, Avvienash Jaganathan, Daniel Wei Sheng Han, Foo Jiong Yang, Hing Jian Le, Huan Meng Hui, Kelvin Ku Yew Siang, Leong Jia Hui, Liew Zi Yi, Omar Hassan Omar Ads, Shoandeep Radhakrishnan

School of Engineering, Monash University Malaysia, Jalan Lagoon Selatan, 47500 Bandar Sunway, Selangor, Malaysia

ABSTRACT

This report summarises the mechanical design, electronic design and software design of the two robots, i.e. R1 Hitter and R2 Seeker developed by Monash University Malaysia to participate in ROBOCON 2022 in Malaysia. In this report, we discuss the design of the robots which carry out throwing of a ball from the R1 to the target which is the Lagori discs as well as the R2 which collects the balls, stores and passes it to R1. R2 also functions to collect and stack the Lagori discs. The connection between the motors/servos and electric board is displayed using pictures. This report also presents the data and discussion of findings. Before the conclusions, limitations and recommendation, sustainable engineering practices are covered in this report. The limitations and recommendations for both robots are provided to improve the design of the robots in the future.

1. INTRODUCTION

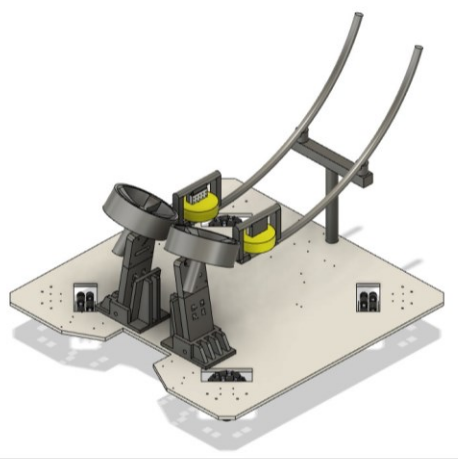
The Team was formed in March and it took one month to conduct research on the feasibility of each method for collecting, passing, storing, throwing and manoeuvring. After a few weeks, students started to build the robots starting from the base to all the necessary mechanisms for the robots. Due to the uncertainties on the delivery of items due to the COVID-19 outbreak as well as multiple public holidays throughout the entire semester, most of the items were ordered from local suppliers. The designs for throwing for R1 was inspired by the previous robots from the past year competition and most of the resources were reused and redesigned to fit this year's theme and requirement for the R1. As for R2, the design was advised by seniors that participated in Robocon 2020. From their advice, our team designed R2 according to feasibility. This sped up the research process and reduced the time taken to finalise the design for both robots. It is truly an honour for highly motivated and innovative students to build robots to compete with some of the top engineering institutes nationwide. Monash University Malaysia is looking forward to gaining more experience in robotics from this competition and will be able to pass it down to the next group and hopefully apply it for other robotics related competitions.

2. DETAILED DESIGN

This section discusses the mechanical design, electronic design and software design of both R1 and R2.

2.1 MECHANICAL DESIGN - R1 HITTER ROBOT

The R1 comprises two subsystems which are the Throwing Mechanism and the Receiving Mechanism. R2's base is made from MDF board and has mecanum wheels used for the robot's motion.



(a)

2.1.1 THROWING MECHANISM

R1 takes the ball and places it between its shooting mechanism. The shooting mechanism consists of 2 circular wheels that are powered by electricity from the power supply. These wheels rotate at very high speed and when the ball is placed in between the 2 wheels, it is shot out of the robot at a high velocity. This will help assist the team in shooting down the lagori tower and the target on the opponent's robot. The team members controlling the robot are well-versed in aiming the ball at the required location with precision and accuracy after countless practice sessions throughout the preparation time for the competition.

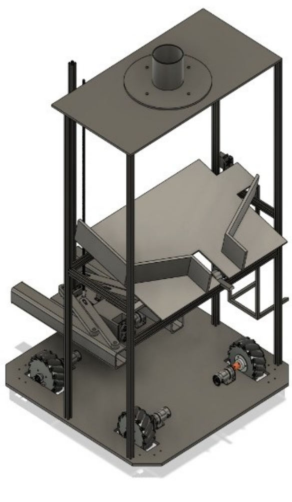
2.1.2 RECEIVING MECHANISM

The balls received from R2 will be transported to R1 through the opening and are stored within R2 before shooting the balls out.

2.2 MECHANICAL DESIGN - R2 SEEKER ROBOT

The R2 Seeker Robot comprises two subsystems namely the balls transport mechanism and the lagori discs stacking mechanism. The base is constructed using a square MDF board and Mecanum wheels used as the driving mechanism. R2 can be viewed as having 3 layers which is the first (ground), second and third (top) layer. The ground layer will house the gripper for the lagori discs stacking mechanism. The second layer belongs to the Balls Transport mechanism and the top layer consists of a holder to house the ball (target for opponent). The frame of R2 is made out of 4 aluminium extrusions which will support the second and third (top) layer of R2 as shown in the figures (b) and (c) below.

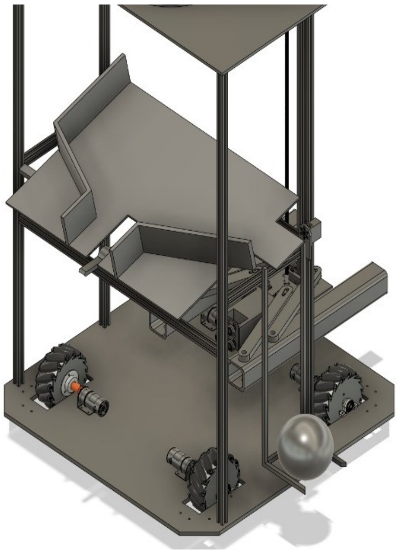
(b)

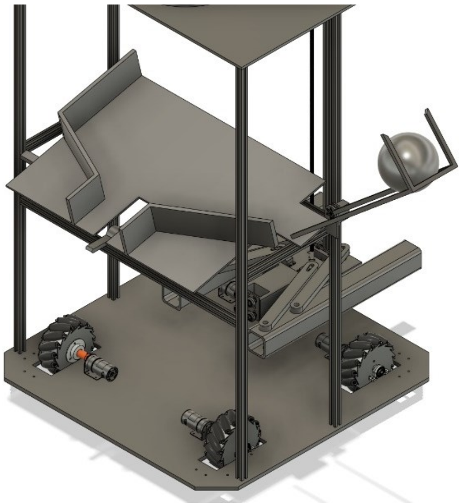


(c)

2.2.1 BALLS TRANSPORT MECHANISM

This subsystem will mainly function to collect the balls from the collection area, scoop them into R2, store, transport and pass all 3 balls into R1. The balls are collected by sliding them into an L shape scooper as shown in the figures (d) below. The scooper will then operate with a servo motor to rotate upwards as shown in figure (e), transporting the balls up into the second layer for storage. This second layer is made with a slanted surface and consists of a bottleneck path design whereby the balls will travel along the path and is secured in this area with a gate mechanism located at the opening. Once R2 is in close proximity to R1 and is ready for the balls transportation, the gate will open thus allowing them to slide down into R1's ramp subsystem.

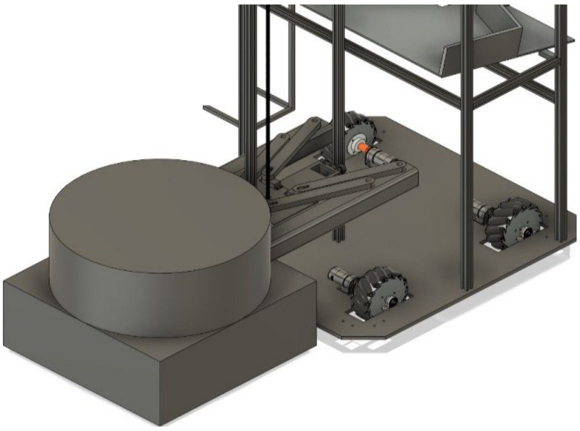




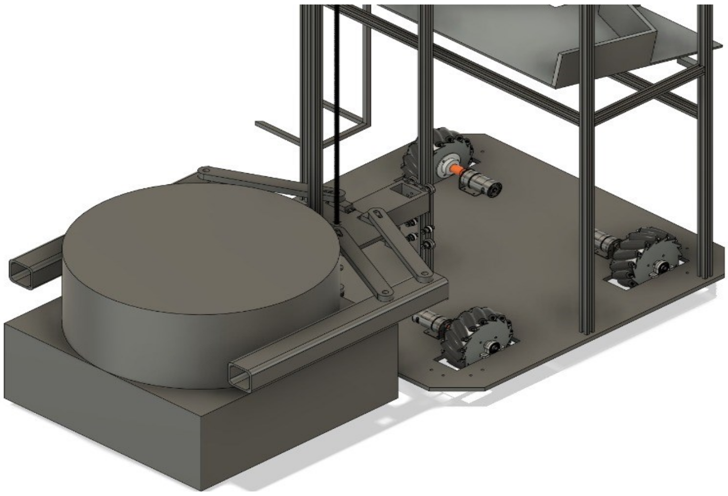
(d) (e)

2.2.2 LAGORI DISCS STACKING MECHANISM

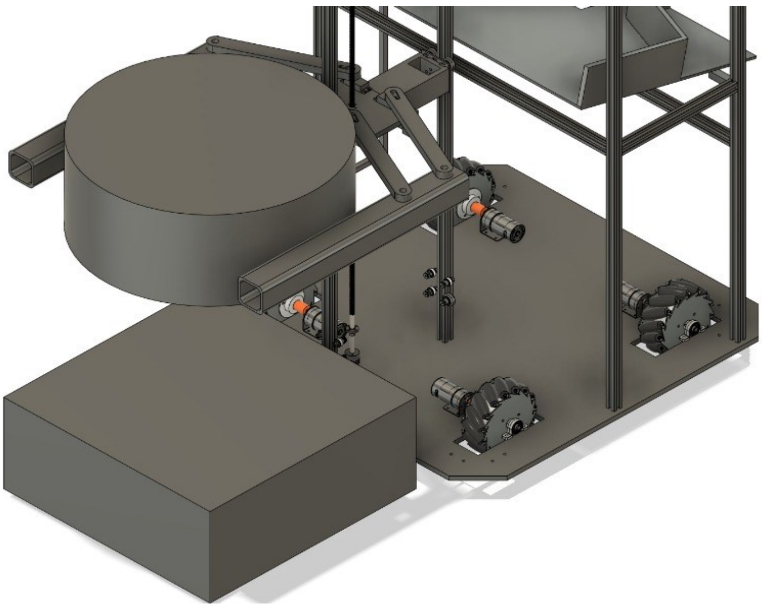
The mechanism will function to collect and stack lagori discs with a gripper. As shown below in sequence starting from figure (f), the gripper is in its first compacted position. Next the gripper extends as shown in figure (g) and will proceed to grip the Lagori discs as shown in figure (h).



(f)



(g)



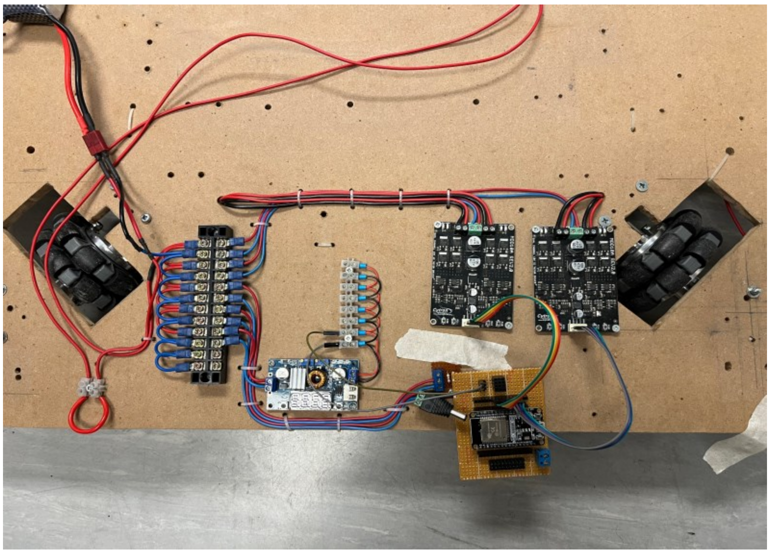
(h)

2.3 ELECTRONIC DESIGN - R1 HITTER ROBOT

R1 Hitter Robot utilises an ESP32 microcontroller, a lipo 11.1V battery for power supply and two DC motors for the throwing mechanism as well as 4 DC motors for the motion mechanism. Figure (i) below shows the circuit for motion controlling.

2.4 ELECTRONIC DESIGN - R2 SEEKER ROBOT

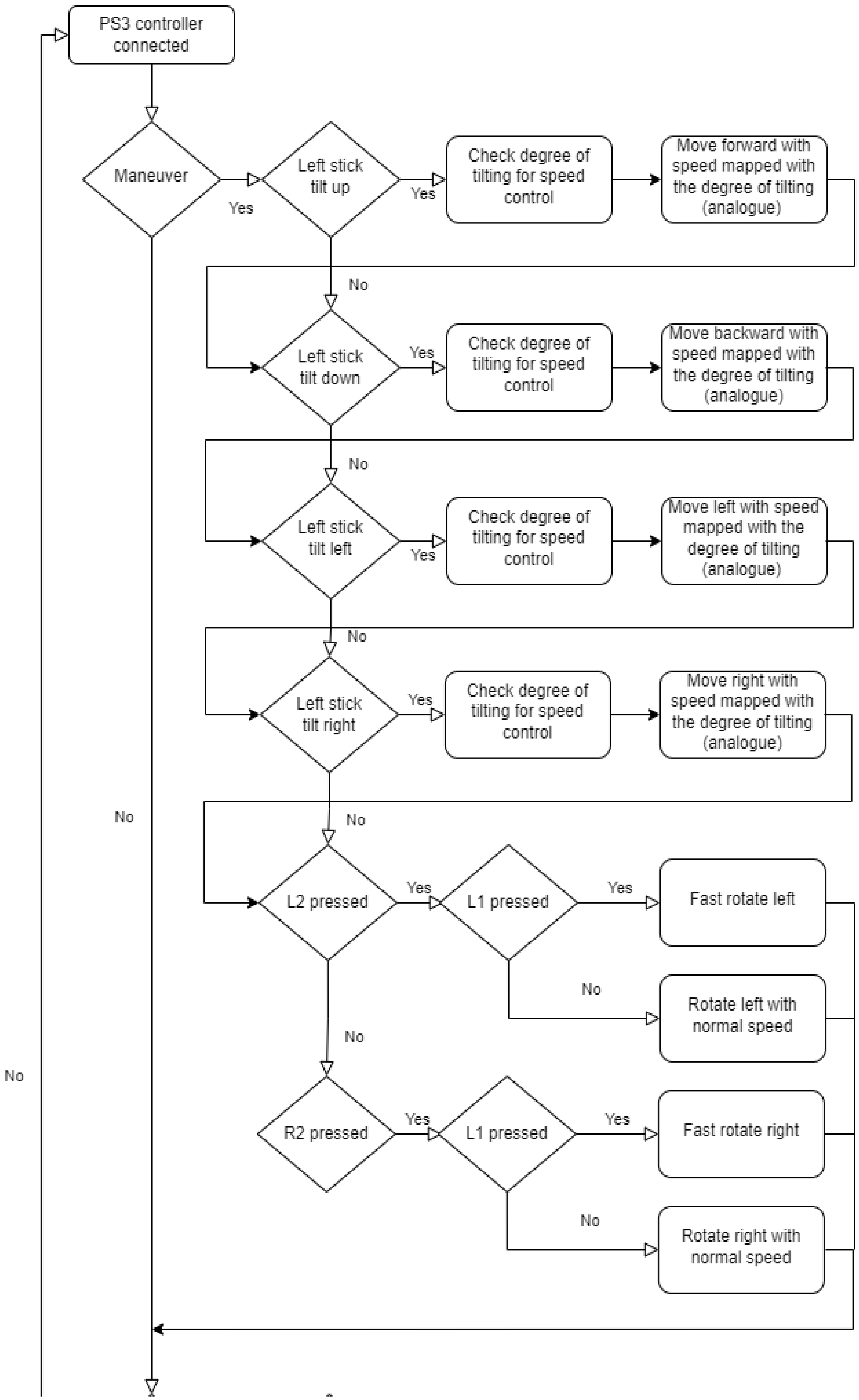
R2 Seeker Robot also utilises an ESP32 microcontroller, a lipo 11.1V battery for power supply, a NEMA17 stepper motor to control linear motion for Lagori gripper, a L298N motor driver, 4 DC motors for the wheels and 4 servo motors (SPT5435LV-180) which one is used for the L-shaped ball scooper, two for Lagori discs gripper and one more for gate controlling at the second layer of R2. Figure (i) below shows the circuit for motion controlling.

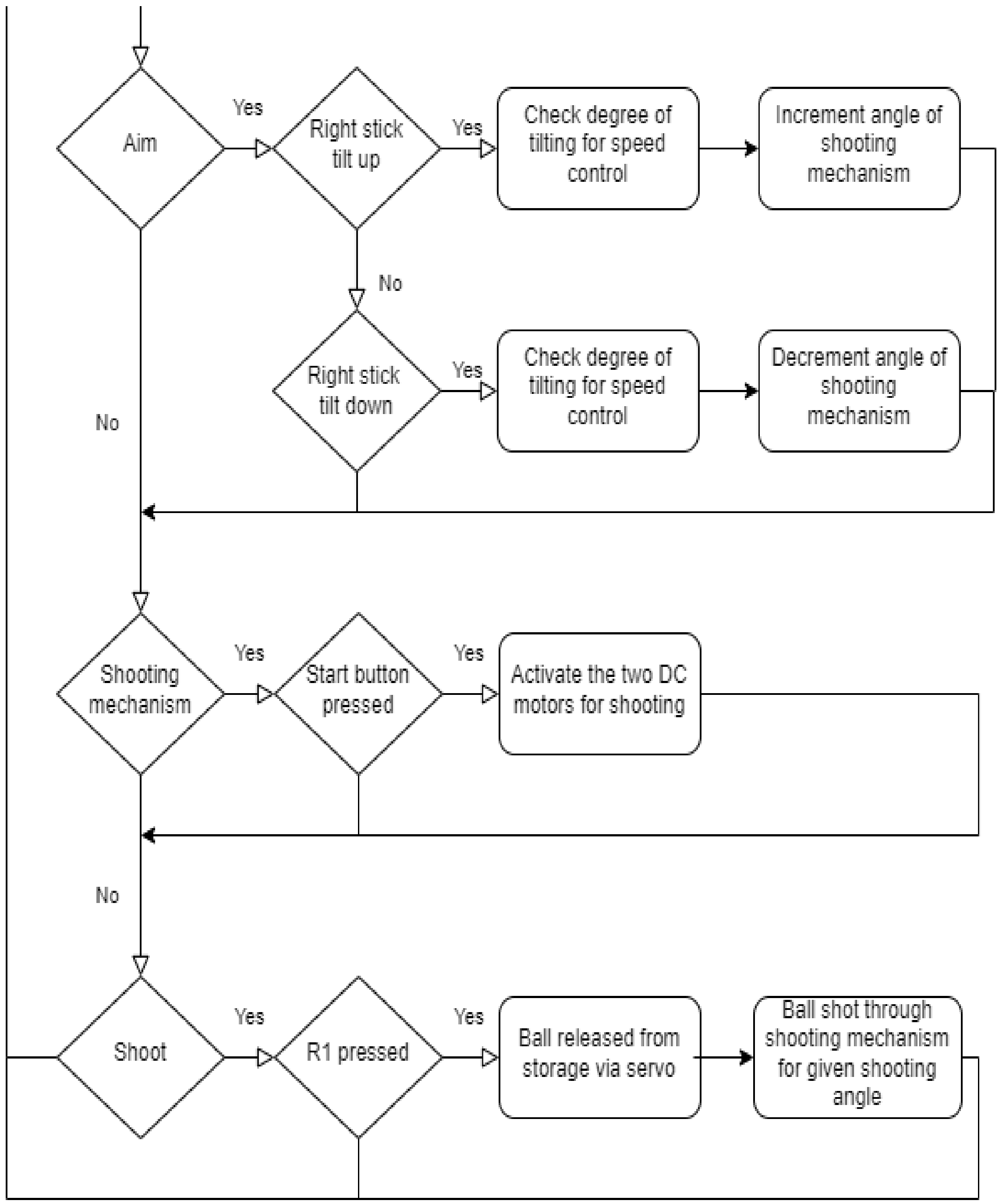


(i)

2.5 SOFTWARE DESIGN - R1 HITTER ROBOT

A polling loop was used to determine which buttons were pressed and which actions to perform.

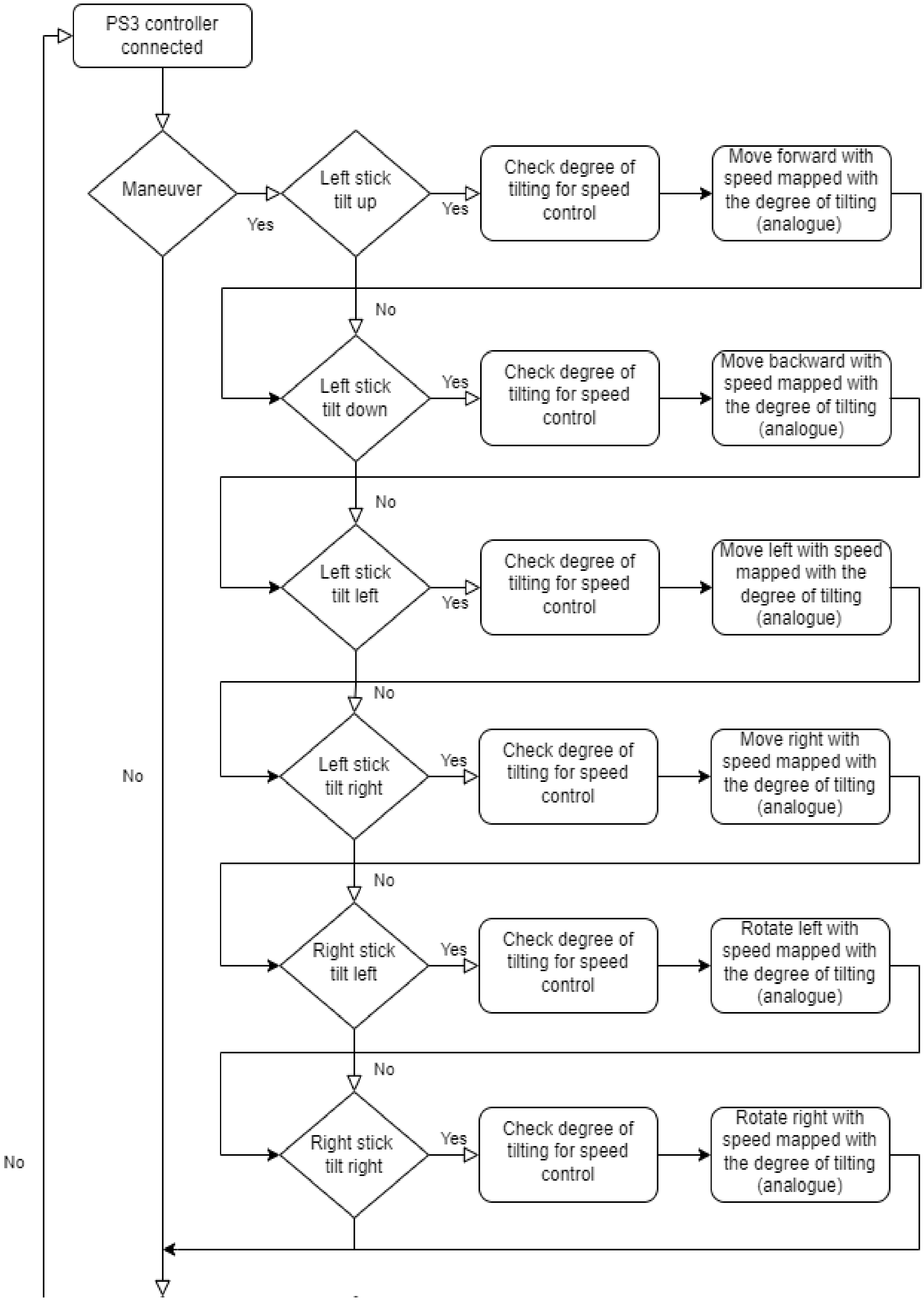

PS3 controller connected
Maneuver
Yes
Left stick tilt up
Yes
Check degree of tilting for speed control
Move forward with speed mapped with the degree of tilting (analogue)
No
Left stick tilt down
Yes
Check degree of tilting for speed control
Move backward with speed mapped with the degree of tilting (analogue)
No
Left stick tilt left
Yes
Check degree of tilting for speed control
Move left with speed mapped with the degree of tilting (analogue)
No
Left stick tilt right
Yes
Check degree of tilting for speed control
Move right with speed mapped with the degree of tilting (analogue)
No
No
L2 pressed
Yes
L1 pressed
Yes
Fast rotate left
No
Rotate left with normal speed
No
No
R2 pressed
Yes
L1 pressed
Yes
Fast rotate right
No
Rotate right with normal speed

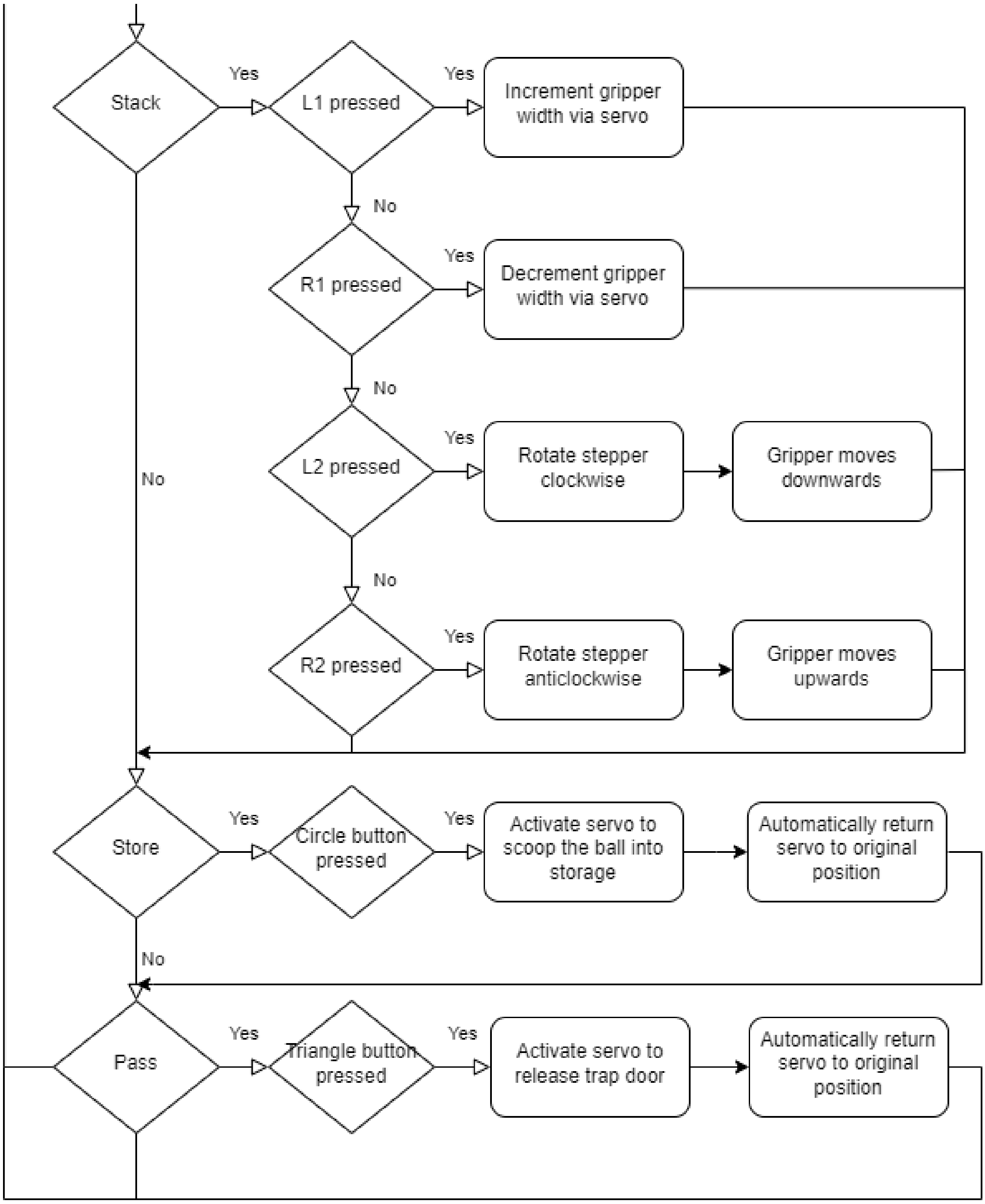


(j)

2.6 SOFTWARE DESIGN - R2 SEEKER ROBOT

A polling loop was used to determine which buttons were pressed and which actions to perform.


PS3 controller connected
Maneuver
Yes
Left stick tilt up
Yes
Check degree of tilting for speed control
Move forward with speed mapped with the degree of tilting (analogue)
No
Left stick tilt down
Yes
Check degree of tilting for speed control
Move backward with speed mapped with the degree of tilting (analogue)
No
Left stick tilt left
Yes
Check degree of tilting for speed control
Move left with speed mapped with the degree of tilting (analogue)
No
Left stick tilt right
Yes
Check degree of tilting for speed control
Move right with speed mapped with the degree of tilting (analogue)
No
Right stick tilt left
Yes
Check degree of tilting for speed control
Rotate left with speed mapped with the degree of tilting (analogue)
No
Right stick tilt right
Yes
Check degree of tilting for speed control
Rotate right with speed mapped with the degree of tilting (analogue)
No
No



(k)

3. DISCUSSION

Both robot designs have taken into careful consideration in regards of material, functionality, cost and efficiency. Combining all the electrical, mechanical and software aspects with ideas from each team section respectively, we can conclude that this is currently the best design up to date. Other designs were also discussed during the planning phase and were discarded due to several reasons. One of the designs was to implement a conveyor belt to the R2 robot to give it the functionality to pass the ball to the R1 robot. The design was discarded as it was too complex and expensive, however, the idea and functionality served as the base of the current design for ball transfering. Another design that was further changed was the method on collecting the balls. The previous idea was to implement a sweeper that will sweep the balls into the robot as the method for ball collection. However, the design would hinder the movement of the robot and cause redundancy that would clash with the other functions of the robot, the design served as inspiration for the current ball collecting mechanism.

4. SUSTAINABILITY ENGINEERING PRACTICES

Together with ABU ROBOCON, Monash University Malaysia advocates the sustainability engineering practices in robot development. We achieved such by reducing the consumption of electricity for the robots by reducing the weight of both R1 Hitter and R2 Seeker using MDF board rather than metal for its base. Moreover, we went for materials that were relatively lesser in weight amongst all options available, without compromising functionality to reduce weight of materials that were involved with motor driving thereby eliminating torque required which ultimately reduces the amount of electricity needed to drive the mechanisms involved. Moreover, for R1, we reused many materials from previous year's robots, such as acrylic and metal square hollow steel (SHS) as well as electrical components such as DC, servo and stepper motors.

5. CONCLUSION, LIMITATION AND RECOMMENDATION

R1 Hitter Robot is able to perform its required function but it still has room for improvement. A decoder can be added to the wheel to measure the distance travelled and automate the locomotion of the robot, thus human error while controlling the robot will be minimised and the robot can perform a throw quicker. R2 Seeker Robot is able to perform well however time taken to grip and stack the disc can be improved by further calibrations. Due to the limitation of time, we were unable to further modify and improve the second layer of R2 as it was unstable and this problem could be mitigated with using a sturdier material for the layer.

6. ACKNOWLEDGEMENTS

We would like to express our deep sense of gratitude to Dr. Ayoub Juman and Dr. Khong Yin Jou for supervising this competition and choosing us to be part of the team.

Throughout the process of making the robots, we also appreciate the help and guidance provided by the lab technicians who are Mr Khalid, Mr Khilal, Mr Panneer and Mr Tharmaa and the seniors who deserve our greatest gratitude. Finally, we would like to extend our thanks to Monash University Malaysia for the financial support.

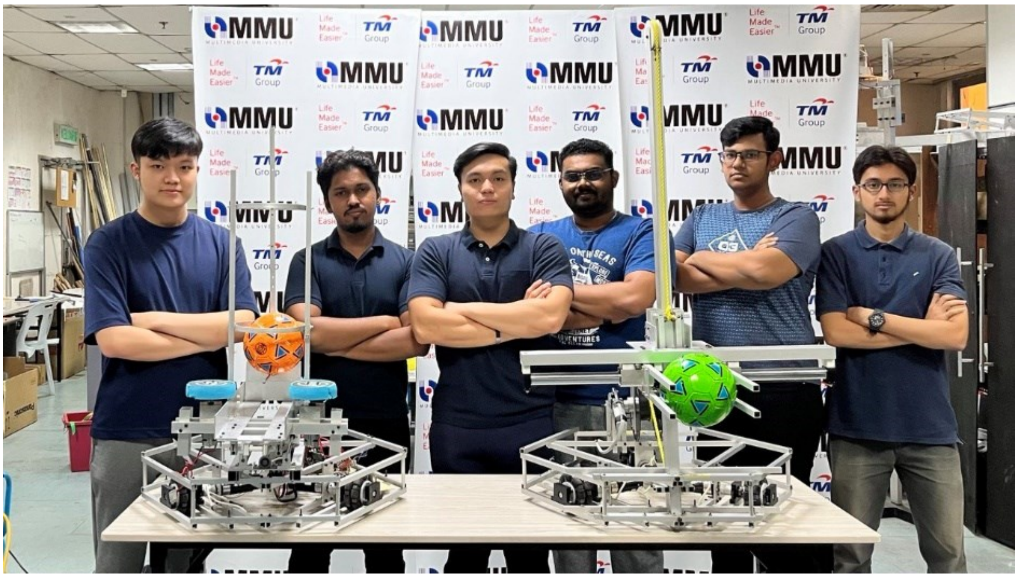
REFERENCES

[1] "ABU Asia-Pacific Robot Contest 2022 New Delhi, India," ABU Robocon 2022, September 2022. [Online]. Available: https://www.aburobocon2022.com/images/files/abu-robocon-2022-india-07feb2022.pdf. [Accessed: 11-May-2022].

MULTIMEDIA UNIVERSITY (MMU) CYBERTRON

Lo Yew Chiong, Muhammad Asif Bin Shaik Saffarudin, Lee San Hang, Manoj Kumar A/L G. Sivakumar, Liew Yong Hui, Abdullah Sayeed, Thaneeswaran A/L Shanmuga Sundaram, Sauryadeep Pal

Faculty of Engineering (FOE), Multimedia University, Persiaran Multimedia, 63100 Cyberjaya, Selangor



ABSTRACT

The theme for Robocon 2022 is “Lagori” in which we are required to construct two robots namely Robot 1 (R1) and Robot 2 (R2). The structure of both robots was constructed using aluminium bars and plates. Both R1 and R2 have a similar base structure with three omni-wheels coupled to DC motors. Both R1 and R2 use pneumatic systems to support the shooting and gripping mechanisms respectively. R2 consists of a gripping mechanism constructed using 2 rod less pneumatic cylinders with a gripper constructed using two parallel aluminium bars mounted on each cylinder. This gripping mechanism will be used to grip lagori discs with diameters ranging from 200 mm – 500 mm, as well as the balls. R2 also has a lifting mechanism supported by a power window motor to lift the gripper so that the lagori discs may be stacked. R2 is fully dependent on a pulley system to lift and vary the height of the gripper mechanism. For R1, it consists of a shooting mechanism made up of two DC motors with rollers mounted at the front and a pneumatic cylinder mounted at the back to provide an initial pushing force to the ball. This mechanism will be used to shoot balls at the lagori discs as well as the BOH. In an effort to promote sustainable engineering practices, we repurposed used aluminium

bars/plates from previous constructions wherever possible, hence reducing the amount of new aluminium materials used. The robots designed also consist of different mechanisms that have important real-world applications. The shooting mechanism may be used as a soccer ball launcher during training sessions. The tilting mechanism may be used in various applications to tilt heavy loads such as hospital beds.

1. INTRODUCTION

Robocon Malaysia 2022 follows a theme like the ABU ROBOCON 2022, which is "tuju tin". The game is played by 2 teams which are assigned the seeker and hitter roles. Each team consists of 2 robots, Robot 1 (R1) which will be shooting balls at the lagori discs and the "Ball on Head" as well as Robot 2 (R2) which will be lifting and restacking the lagori discs. The robots must be carefully designed to ensure that a stringent set of rules and regulations set by the organizer is adhered to while ensuring maximum performance and easy maintainability.

For R1, the two important mechanisms that was considered in designing the robot for this year's Robocon is the shooting and tilting mechanisms. The main objective of this robot is to displace lagori discs as well as the "Ball on Head" (BOH) on the opponent's robot. The shooting mechanism design is based on a soccer ball launching device [1]. In the research paper that was used as a reference, an economical soccer ball launcher capable of launching balls at a speed of 18 m/s was designed using two motors with wheels rotating in opposite directions [1]. Due to monetary restrictions, this design was practical to implement in our design as it is a low-cost solution that is able to achieve the objectives of the competition. In order to tilt the shooting mechanism to ensure that it can launch the balls at different heights so that it also able to target the BOH, a tilting mechanism is also implemented in the robot design.

For R2, there are also two mechanisms that we must focus on to mount on R2 to complete the tasks for the game, which are the gripping as well as the lifting mechanism. The main objective of R2 is to stack the lagori disks on top of the provided base in the middle of the game field. The next objective of R2 is to feed the hitter balls into R1. When the opponent team's R2 is piling up their lagori disks, our R1 will have to displace the ball on the opponent team's R2 head. The main mechanism in the gripper system for R2 is the rodless pneumatic cylinder where the "arms" of the gripper are mounted to grab the disks and balls. On the other hand, the main mechanism for the lifting system is a power window motor at the "effort" end to roll in and release the string, and the gripper system at the "load" end. Two pulleys will be used in this system: one at the top and one at the bottom of the main lifting bar of the gripper system.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

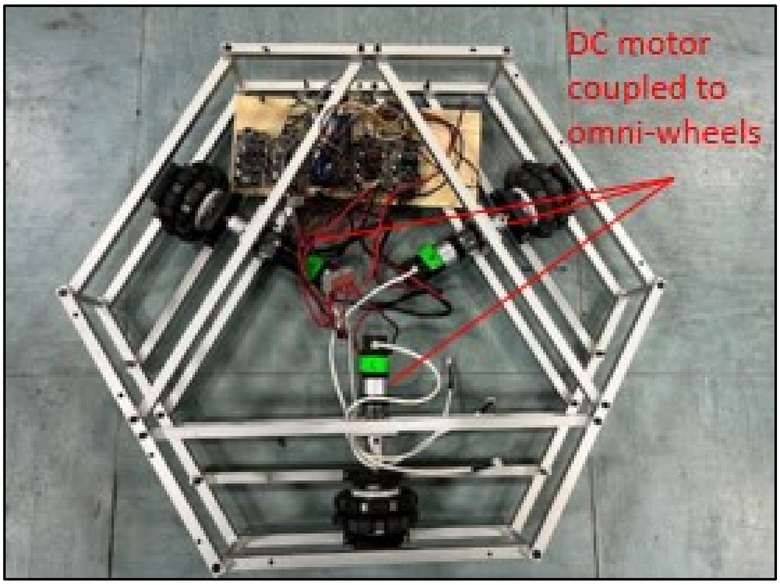


Figure 1: Base structure

The most critical part of the mechanical design is the base structure as it will eventually support all other mechanisms that are constructed and mounted onto it. The base structure is designed using aluminium to reduce the amount of weight contributed by the base.

Both R1 and R2 are using the same base as it is practical and suitable for both robots and their respective functions. As shown in Figure 1, The base is constructed to have a hexagonal shape with three motors coupled to omni wheels. The main purpose of using omni wheels is to enable holonomic motion of the robots R1 and R2. Holonomic motion is crucial in the design of our robot as it allows us to control each wheel independently to produce a net motion in the required direction while maintaining the orientation of the robot. The omni wheels are also an important aspect of the design as they can roll in more than one direction at a time [2].

2.1.1 ROBOT 1

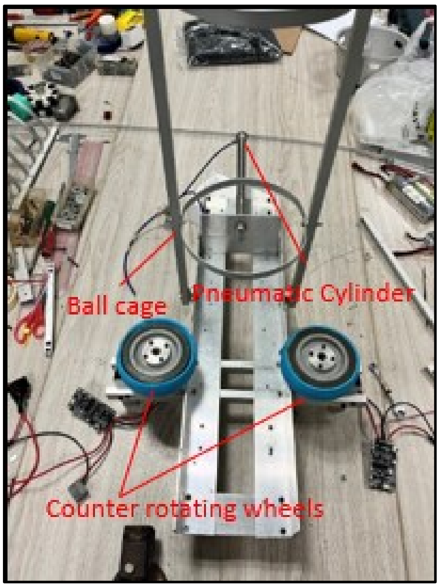


Figure 2: R1 Shooting Mechanism

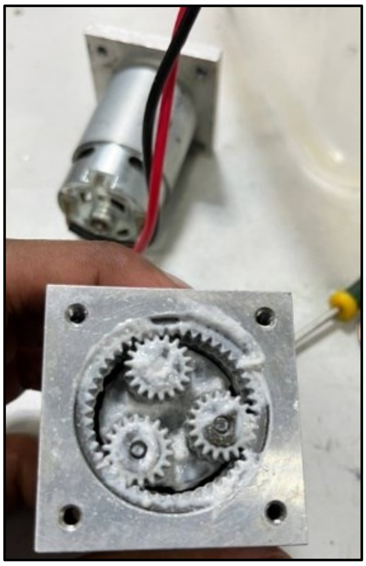


Figure 3: Single Stage Reducer

For R1, the most important mechanism to be implemented in the robot design is the shooting mechanism. The shooting mechanism is required to launch the balls at a relatively high speed so that the lagori discs may be knocked down and the opponent's BOH can be displaced. The shooting mechanism must also be able to store up to 3 balls at a time since we are allowed to load up to 3 seeker balls during the setting time. Various factors were considered in the design of the shooting mechanism such as the maximum speed of the ball (30 km/h) and the total weight and stability of the supporting structure.

The design of the shooting mechanism as shown in Figure 2 is based on a soccer ball launcher that launches soccer balls at high speeds to automate soccer training [1]. The structure of the mechanism is constructed entirely of aluminium and some parts such as the ball track was made using repurposed materials used in previous robot designs. The mechanism consists of two 12V DC motors coupled to wheels with diameter 9.7 cm and a spacing of 12.7 cm between the wheels. The DC motors were initially unable to produce a sufficient launch speed. This problem was solved by introducing a single stage reducer as shown in Figure 3, to both motors which successfully increased the launch speed to a level that is sufficient to displace the lagori discs.

A pneumatic cylinder is mounted at the rear end of the ball track to provide an initial pushing force for the ball to contact the rotating wheels. The pneumatic cylinder is also mounted at a height of 6.7 cm from the ball track so that it hits the centre of the ball to ensure smooth transition from the ball track to the rotating wheels.

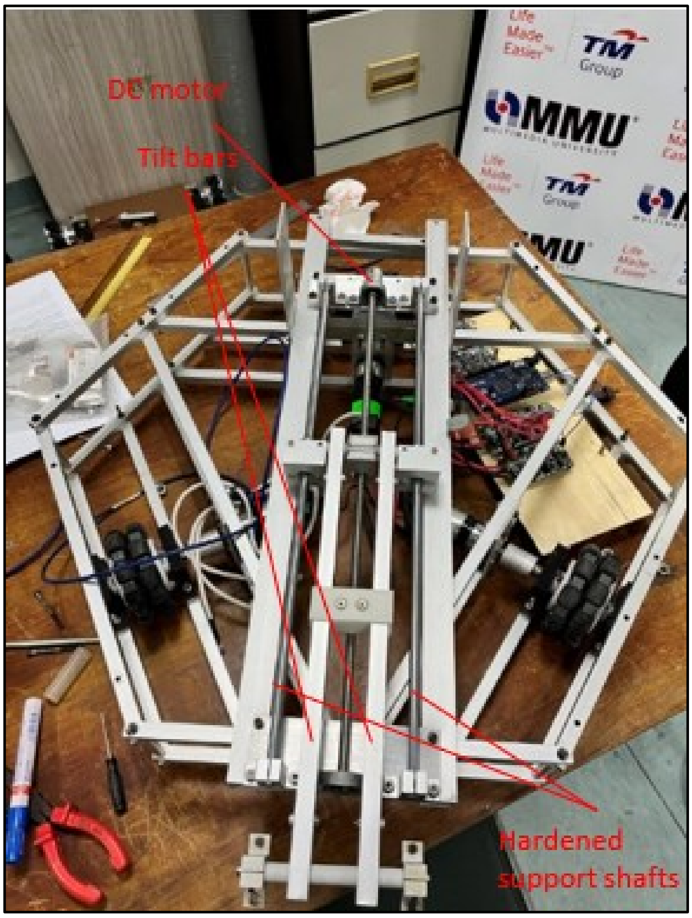


Figure 4: R1 Tilting Mechanism

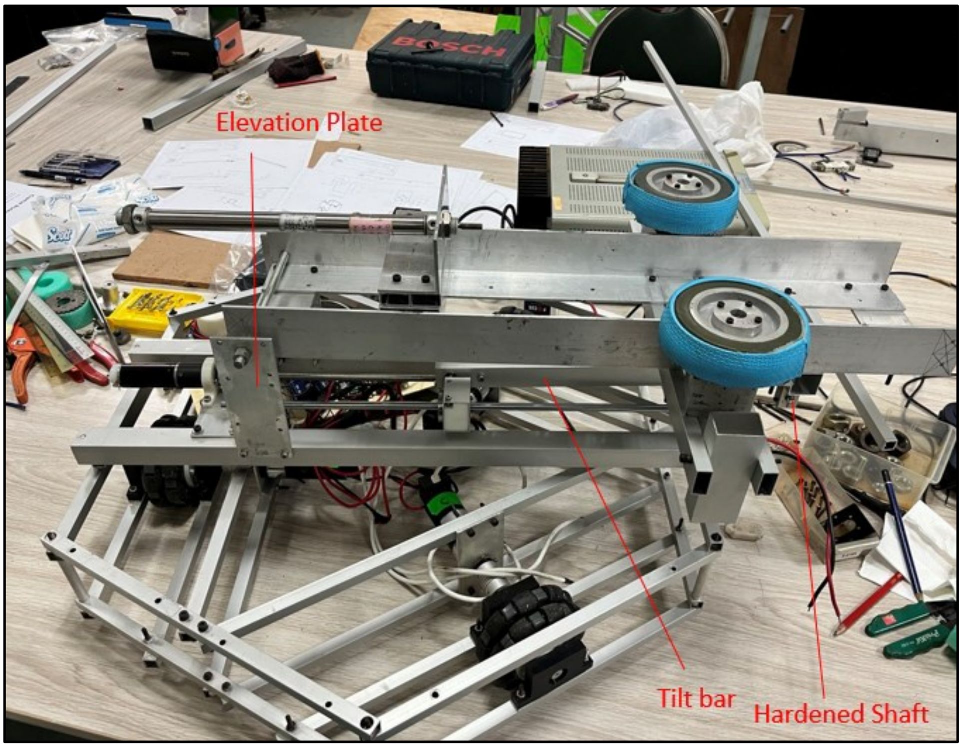


Figure 5: Mounting of Shooting Mechanism

The tilting mechanism is the next mechanism that is implemented in R1 in order to tilt the shooting mechanism so that the ball can be launched higher heights to target the top of the lagori stack as well as the opponent's BOH. One of the important factors that was considered during the design process was that it has to able to fully support the weight of the shooting mechanism while maintaining the overall stability of the robot. The tilting mechanism also must be able to tilt to required angle to target the BOH which will be positioned at a height of 1.2 -1.25 metres from the ground and approximately 3 -5 metres away from R1.

This mechanism design is based on a motorized linear actuator system. As shown in Figure 4, a DC motor is coupled to a lead screw that will rotate together with the motor moving the two tilt bars forward and hence tilting the entire shooting mechanism. The linear actuator system is supported by two hardened shafts (as shown in Figure 4) that are able to withstand heavy loads. These shafts will ensure that the entire weight of the shooting mechanism can be safely supported by the tilting mechanism. The other ends of the two tilt bars are connected to another hardened shaft as shown in Figure 5 which is in turn mounted to the bottom of the shooting mechanism. The shooting mechanism is also elevated by using two aluminium plates on the left and right side (as shown in Figure 5) to ensure that the pneumatic cylinder at the rear of the shooting mechanism does not obstruct the tilting process.

2.1.2 ROBOT 2

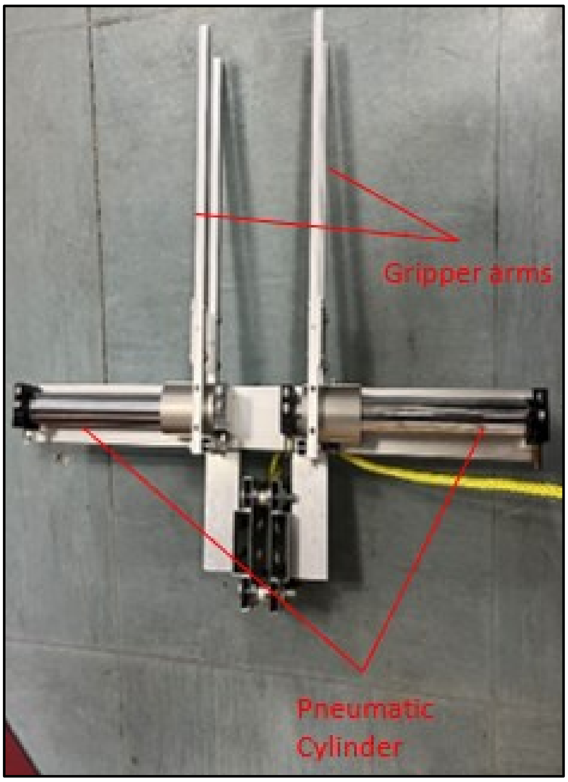


Figure 6: R2 Gripping Mechanism

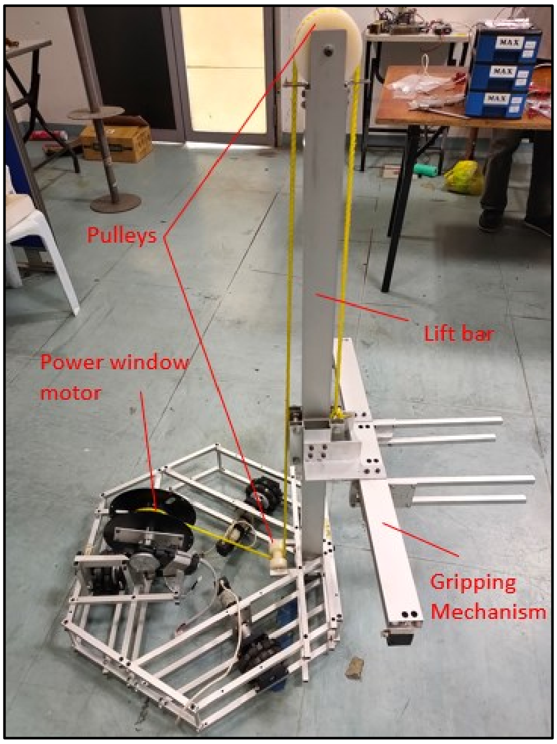


Figure 7: Lifting Mechanism

In R2, the gripping mechanism is one of the most important mechanisms for robot to complete the tasks as specified in the game rules. The gripping mechanism will be used to grip the lagori disks, and also the hitter balls that will be consequently loaded into R1. The design of the gripper that have to be considered are biggest lagori disk diameter, smallest lagori disk diameter, ball size, the weight of the total mechanism combined, functionality, efficiency, gripping speed, etc.

As shown in Figure 6, the gripping mechanism is designed in such a way that 2 rod-less pneumatic cylinders will be placed side by side. Aluminium bars will be attached to the moving part of the pneumatic cylinders. The distance to mount the 2 pneumatic cylinders is determined by knowing the travelling distance of the pneumatic cylinders and the diameters of the biggest and smallest lagori disks, as well as the hitter balls. The pneumatic is all mounted on a wide aluminium bar with some other spacers that were 3D printed. The force imposed by the rod less pneumatic cylinders were also considered, to ensure that it would be sufficient to grip 2 or more lagori disks whilst maintaining adequate stability. The whole gripper mechanism is mounted to a simple mechanism that acts like an “elevator” that is the slotted into the lifting bar.

The other crucial mechanism of R2 is the lifting mechanism. The lifting mechanism as shown in Figure 6 is used to lift as well as lower the gripping mechanism that is mounted on the “elevator” mechanism that is slotted into the main lifting/support bar. This will enable us to pick up lagori disks from the floor and lift it to stack the lagori pile on the base in the game field.

The mechanism uses a simple pulley system to lift and lower the gripping mechanism. This is due to the simplicity in design and efficiency of the lifting mechanism. The lifting mechanism consists of a few main components (as shown in Figure 7), namely the motor with the ravelling disk to ravel the string (made from a used 3D printing filament disk), two pulleys, a travelling bar with elevator mechanism and a string. The high torque has to consider a few criteria to ensure maximal efficiency while playing the game. Things

motor will be mounted at the back of the robot while the travelling bar with the slotted elevator mechanism is mounted at the absolute front of the robot. Pulleys are mounted on top and at the bottom of the travelling bar. The string is tied to the motor ravelling disk, below the lower pulley, over the top pulley and finally tied to the elevator mechanism. When the motor ravels the string in, the string will be pulled from the back and it will lift the whole gripper mechanism and vice versa: where when the motor turns the other way, the string will start to unravel and lower the gripping mechanism. The high torque motor is mounted at a position which is able to counter all the weight placed at the front side of the motor.

2.2 ELECTRONIC DESIGN

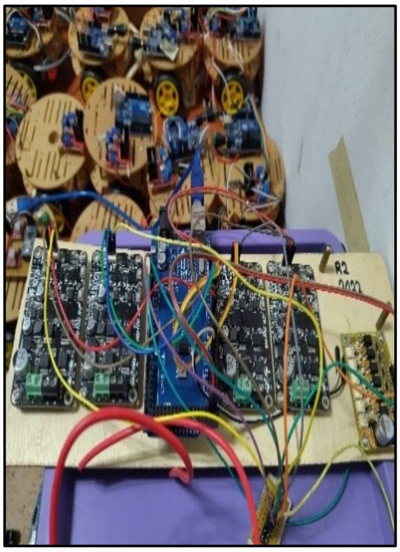


Figure 8: Arduino Mega 2560

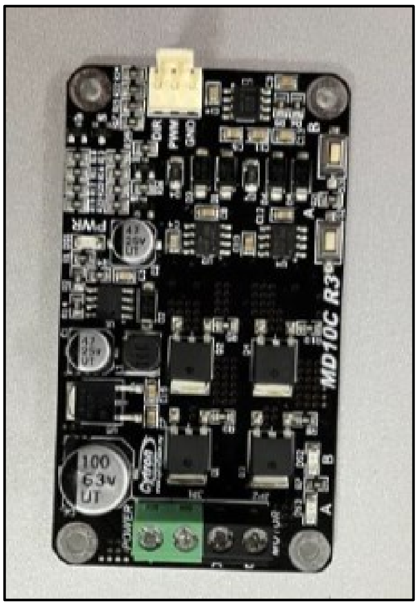


Figure 9: MD10C Motor Driver

For both R1 and R2, an Arduino Mega 2560 as shown in Figure 8 is used as the main board. It is used as the brain of our robot and other boards/modules are interfaced to it via wired connections. It has 54 IO pins and 16 analog inputs which allows us to interface a lot of modules as well as sensors required by the robot. The Mega in both R1 and R2 are powered using 12V

3000mAh rechargeable Lithium Polymer batteries. Rechargeable batteries are used instead of single-use batteries to reduce the negative impact toward the environment as rechargeable batteries may be reused multiple times as long as care is taken to not over-discharge them.

DC motor drivers are used in both R1 and R2 to allow more control over motors. A total of six motor drivers are used in R1, which are connected to the three motors used to move the robot base as well as the two motors in the shooting mechanism and one motor in the tilting mechanism. For R2, four motor drivers are used, three for motors used to move the robot base and one for the power window motor used in the lifting mechanism. For R1, the two motor drivers for the shooting mechanism are powered by two individual 12V Li-Po batteries. For R2, the motor driver for the power window motor is powered by a single 12V Li-Po battery. For both robot bases, they are powered by two 12V batteries connected in series to produce 24 V.

Finally, the robot is controlled via Bluetooth. A Logitech F310 wired controller is used by connecting it to a USB host, which in turn is connected to a Bluetooth module which is used to transmit signals to the Arduino Mega board. Figure 10 and Figure 11 below show the wire connections between all components in both R1 and R2 respectively.

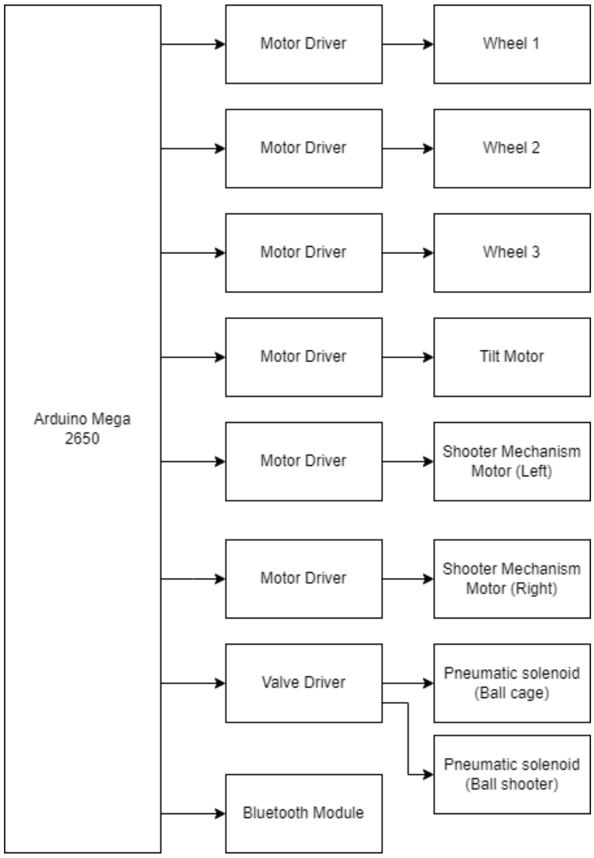


Figure 10: Wiring Diagram for R1

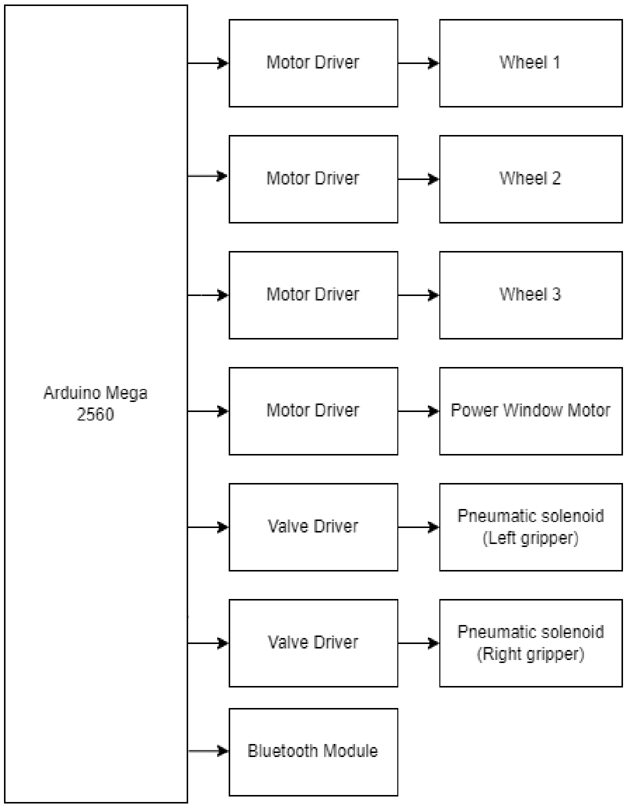


Figure 11: Wiring Diagram for R2

2.3 SOFTWARE DESIGN

Figures 12 and 13 below show the flowcharts for the software design for R1 and R2 respectively.

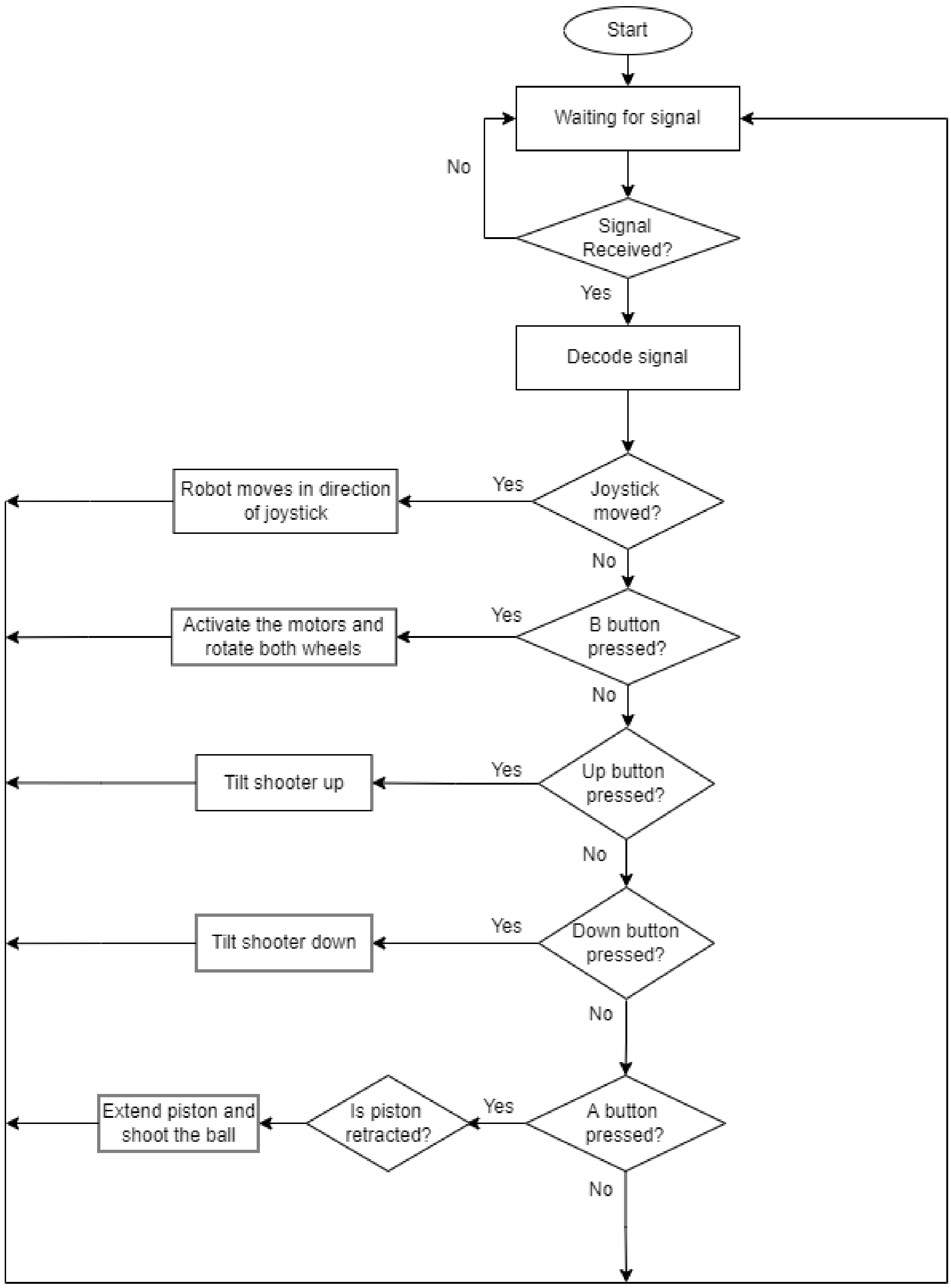


Figure 12: Robot 1 Program Flow

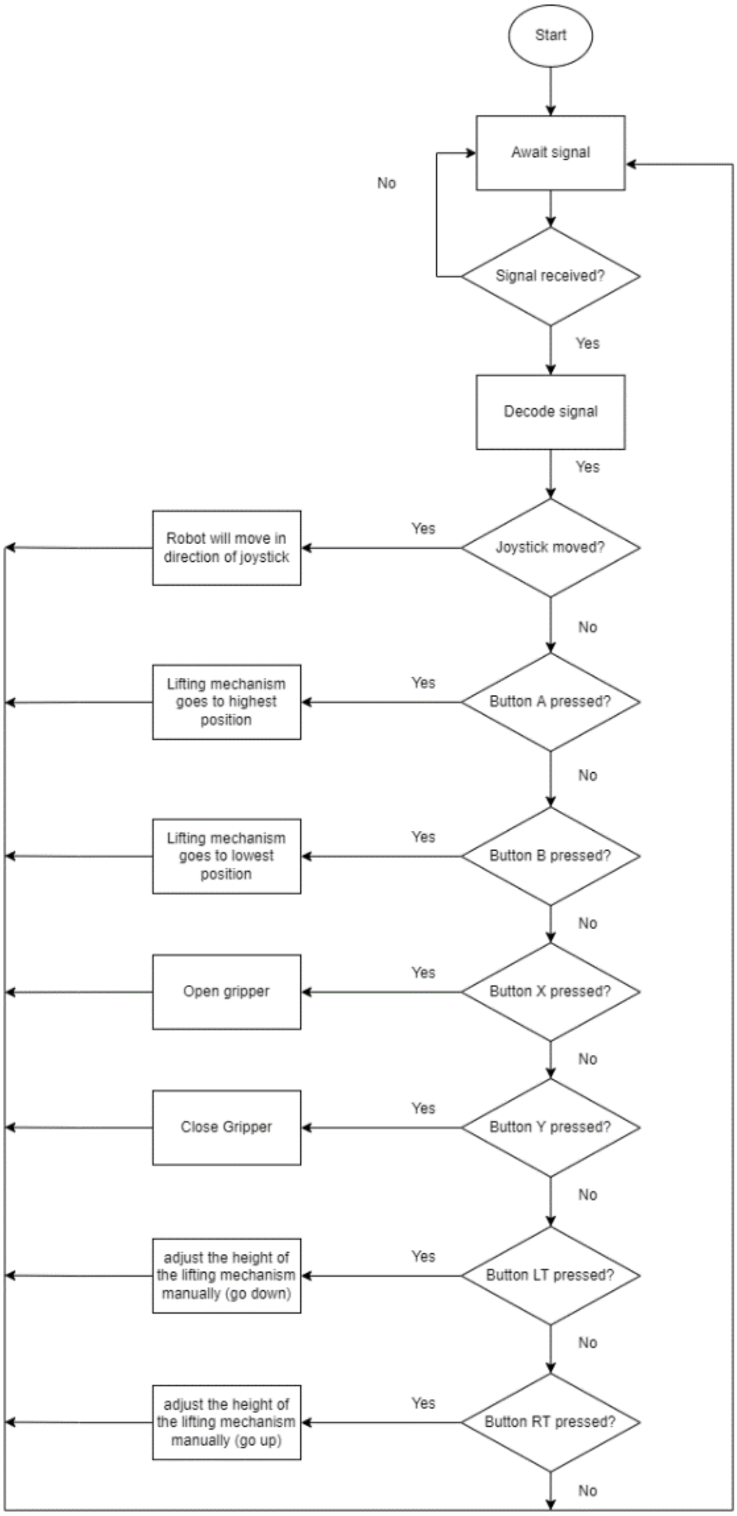


Figure 13: Robot 2 Program Flow

3. PRESENTATION OF DATA

Based on preliminary testing, while constructing the shooting mechanism for R1, it is able to knock down the lagori discs after three tries. With certain improvements in place, such as adding single stage reducers to both rotating wheels, the launch speed of the ball was significantly improved and the lagori discs was able to be knocked down in two tries. The tilting mechanism was also tested and was able to tilt the robot to be able to shoot down the BOH.

Based on testing of R2, it was able to successfully grip all lagori discs as well as the hitter ball without causing any damage to the items. The time taken for the gripper is also short and practical to be used in the competition. The lifting mechanism is also able to lift the full weight of the gripper with the lagori discs. The time taken to lower and raise the gripper using the lifting mechanism is also short and satisfies our requirements.

4. DISCUSSION

Both R1 and R2 are able to successfully complete the given tasks within the required time. R1 is able to displace the lagori discs within 2 tries and is also able to tilt to the required angle to displace the BOH on the opponent robot. R1 is able to grip all lagori discs and lift them without compromising the stability of the robot. R2 is also able to grip hitter balls and pass them to R1 within our required time.

The main advantage of our base design is the three omni-wheel concept implemented in our base. This configuration allows holonomic motion of the robot, which means that the robot will be able to move in different directions while maintaining its orientation. The tilt mechanism in R1 is also unique as it can easily withstand heavy loads and tilt them with lower effort using a 12V DC motor. The gripping mechanism of R2 is also built using 2 rodless pneumatic cylinder with each side of the gripper mounted on each side. This allows the gripper to snugly hold the ball which has a diameter of 14 cm and even the largest lagori disc which has a diameter of 50 cm with ease.

5. SUSTAINABLE ENGINEERING PRACTICES

Throughout the design and construction of the robots, sustainability was constantly factored into every decision made with regards to the robots. All structures and frames were constructed using aluminium as aluminium is not only lightweight and sturdy but also recyclable. Some structures in the robot were also made using aluminium bars repurposed from old robots in effort to prevent wastage and to conserve resources for the future generation. The pneumatic structure is also made using old plastic bottles to reduce the amount of plastic used overall. The batteries used are also rechargeable, which means that we can use them for a longer time before having to replace them. The batteries are also lead-free which reduces the negative impact on the environment. Any over-discharged batteries are also properly recycled and not directly disposed. All in all, we are confident that these steps will help to significantly reduce the depletion and wastage of materials and at the same time promote sustainable engineering practices.

6. CONCLUSION

In conclusion, the designed robots R1 and R2 meet all design requirements in order to successfully complete all the tasks. The movement of robot is smooth, and the holonomic motion of the robot is advantageous when completing the task. The shooting and tilting mechanisms of R1 are able to work together to launch the ball at a speed and trajectory sufficient to knock down the lagori discs as well as displace the BOH. For R2, the gripping mechanism and lifting mechanism can grip and lift the lagori discs so that they may be stacked. The use of pneumatic cylinders in both R1 and R2 allow the robot to function efficiently. All in all, both R1 and R2 are able to complete the required tasks within the targeted time.

7. LIMITATIONS

Robot 1: The shooting and tilting mechanisms are not autonomous and have to be controlled manually by player. This consumes time and increases the amount of time needed to complete tasks. The tilting mechanism is also rather slow due to heavy weight of the shooting mechanism itself.

Robot 2: The only limitation on R2 is that the travelling of the gripper mechanism is not enough to stack the lagori disks one by one. The gripper is a bit too low to stack the highest lagori disk due to our pulley on top of the travelling bar in our pulley system and depression of our gripper mechanism.

8. RECOMMENDATIONS

Robot 1: The robots may be designed to be autonomous to reduce possibility of human error. The weight of the shooting mechanism may be reduced by possibly using a different design to ensure a smoother tilt.

Robot 2: To counter the aforementioned problems, we will simply just stack the bottom 3 lagori disks first and for the last 2 disks, we will stack the smallest one on top of the second one and then we will pick both up at once and stack it on the lagori pile.

9. ACKNOWLEDGEMENTS

The MMU Cybertron team for Robocon Malaysia 2022 would like to thank our advisor, Dr. Lo Yew Chiong for his endless support and his dedication in assisting in the preparations for the competition. Without his assistance, our participation in Robocon Malaysia 2022 would not have been possible.

We would also like to thank the Faculty of Engineering, Multimedia University Cyberjaya for providing us with the necessary equipment and venue for us to be able to construct and test our designed robots. We hope that the faculty continues to support our team to participate in future Robocon competitions.

Our appreciation also goes out to all team members who spent countless hours designing and constructing the robots in order to prepare for the competition as well as friends and parents who have given their continuous support to us.

REFERENCES

[1] Hassan, M., Taha, Z., Shahruddin, M., & Lim, K. (2022). *Development of a Soccer Ball Launching Device.* Pekan: University Malaysia Pahang.

[2] Jaishree, M., & Kirubakaran, J. (2018). Design and implementation of omni-wheel robotic system under automatic height control and adaptation. *International Journal of Pure and Applied Mathematics*, 1625-1634.

POLITEKNIK BANTING SELANGOR (PBS)

Zulkarnain bin Jamak, Ahmad Shahrin Bin Rusdi, Muhammad Zulfaiz Bin Zamri, Muhammad Amin Faiz Bin Muhammad Zamri, Ahmad Izzat Asyarf Bin Mohammad Azam, Aniq Farhan Bin Jamsari, Muhammad Naim Bin Osman, Muhammad Firdaus Bin Othman, Muhammad Danish Isyraaf Bin Muhamad Fauzi, Muhammad Aiman Bin Zaidi, Muhammad Shahiman Bin Sapian, Dzarif Al-Bakri Bin Mustafa Al-Bakri, Muhammad Hadif Ilhan Bin Mohammad Akhmal, Muhammad Amar Bin Mohammad Rizduan, Nur Syazrina Binti Abdul Razak, Wan Nur Azmilia Binti Wan Nor Azmuddin, Mohamad Firman Hakim bin Zahrizam, Shahli Rizuan Bin Saipul Bahri, Muhammad Alim Bin Misran, Ahmad Faiq Ifwat Bin Azmam

Politeknik Banting, Persiaran Ilmu, Jln Sultan Abdul Samad, 42700 Banting, Selangor

ABSTRACT

The main purpose of producing this product is to enable mechanics and the public to make the process of function or robot more efficient and easier. It helps mechanics work because they no longer have to expend more energy to unscrew the motor cover screw on the bottom of the engine which can cause their backs to tense and ache. This product just needs to be pushed forward like the way a trolley works, for the safety purpose it’s already got the simple but efficient brake to the tire. Next, it comes with a long wire to facilitate the process. In conclusion, this product can help mechanics and the public in terms of comfort while changing engine and tyre position, reduce energy to moving, and use maintenance time effectively. Build the two robots by using the forklift technic that can pick up lagori and ball

with the high precision and bring the item to the hitter. Build hitter using the speeding tyre to launch the ball and hit the lagori.

10. INTRODUCTION

In the current era of globalization, there are many motorcycle workshops opened everywhere. There are workshops that are opened on a large scale but there are also workshops that are opened on a small scale. The equipment used for these two types of workshops is also different, larger workshops have more sophisticated and expensive equipment. Almost every high-end workshop has a sophisticated engine oil suction machine while most small workshops only use manual methods to extract engine oil from motorcycle engines as engine oil suction machines are quite expensive and require a high cost to maintain. Therefore, we discussed and proposed to design an engine oil suction device that is more affordable and easier to carry. The project is named Portable Motorcycle Lubricant Oil Changer. Robotics is also referred to as an invention that has become globally over the world. As we know, robotics is suited for heavy and dangerous tasks where it helps to decrease the injury or death due to accidents at the workplace. The development of robots has gradually expanded for various applications, especially in the defence and forces industries. On the industrial side, 422,000 robots were shipped in the year 2018 and 6% increase from 2017. ROBOCON 2022 theme is a traditional game. Our mission is to make both robots to be able to archive these competition rules and suit the theme. We also apply based on what we have learned in three years of our studies. Based on various resources such as pneumatic, electrical mechanical, and others.

11. DETAILED DESIGN

Based on the robot we create, there is two main materials for our design. Aluminium was used for Seeker, meanwhile metal was used for Hitter. Kinetic, momentum and mechanical energy techniques has been applied for both robots.

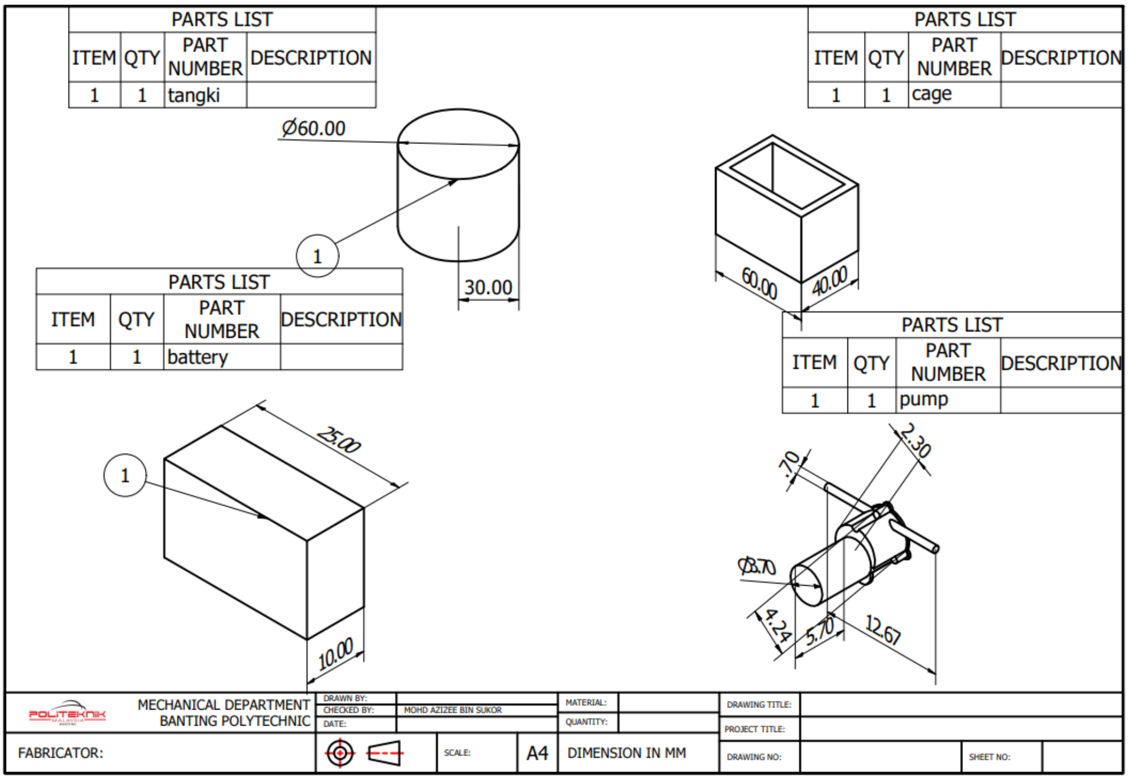


Figure 1: Design of Robot PBS

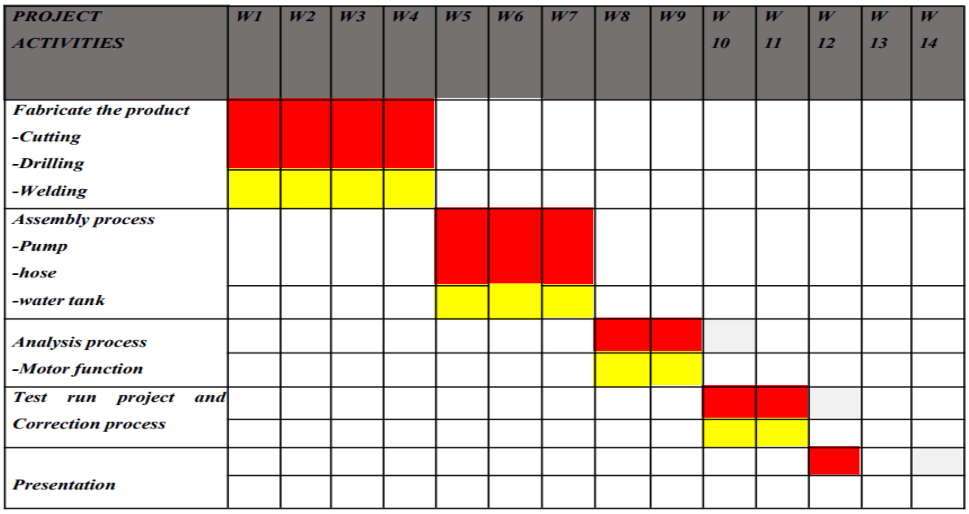
12. PRESENTATION OF DATA/SIMULATION/TESTING

Metal is applied on robot 1 (Hitter) because metal is more strong than aluminium. Hitter is used for shoot the lagori that need a strong and fast shoot momentum. Metal is known as one of the most strong metal and match with the price. The methodology is the methods or procedures used to implement a project in detail. These steps are very important in implementing this project to ensure that this project is completed on time. In producing a project, several steps need to be faced before the project is completed. These steps need to be done carefully in order to produce a quality project. In producing this project, a number of steps have been taken. The next description will describe the steps taken to complete this project. This is explained with the help of Figures that can improve the understanding of the work process of preparation and production of the project. The production process of a product starts from the stage of creation of concept ideas to the manufacturing process. The generation of this concept idea aims to overcome the problems that have been identified. The selection of the concept idea is based on the characteristics appropriate to the product to be produced. The manufacturing process begins with the selection of suitable materials for the product components. After that, all the materials were combined to produce the desired design. The usability and beautification of the outward appearance are also considered. In the design precision, this analyzer is extremely close to other expensive analyzers. Moreover, the analyzer also can be easily maintained, so it can be widely used (Chen et al., 2006).

All processes were done according to the planned procedures and the project will be completed according to the set time. This is because each of these work procedures has continuity with the objectives of this project. In producing or implementing something, careful initial planning must be made to produce a project of high quality, in good condition, functioning perfectly, neatly and more organized. This process is the earliest step carried out before starting work related to the project. In addition, the selection of appropriate projects helps to enhance creative and innovative thinking as well as it symbolizes the way of thinking of an individual in the mechanical aspect and also in the hydraulic system. The title chosen must also be able to attract attention in order to be an example to other students to learn more about the project in more detail.

The form of the constructed project is a more interesting form and has many advantages. This form of the project can make it easier for users to change motorcycle engine oil and this project is easy to carry anywhere, it can save users time to change black oil with a large quantity at one time. To make this project a success, there are several designs that we found to design this tool for its suitability for use in workshops. There are some basic components to build this Portable Motorcycle Lubricant Oil Changer for example, we chose to use silicone tubing because it is more flexible and cheaper. Ergonomics can be designed and redesigned according to user size; Mobile can be taken anywhere and light; Portable can be off pairs making it easier and lighter to carry and can be used (Nurmianto et al., 2019).

Gantt Chart:



Note:
Date planned
Date implemented

To make this project a success, several steps need to be done and also need to be followed to ensure that the project to be done is smooth and successful. If there is a problem, this flow chart should be referenced back to help before or during the project. This flow chart, encourages the use of time in a more orderly and systematic way because it can follow all the instructions so accurately and perfectly. Among the steps that need to be followed are as follows

13. DISCUSSION/EVALUATION OF FINDINGS

It is a description of the functional research on this machine in this analysis. This machine's main purpose is to grip the ball from the engine. The ball and lagori is sucked in through the first hose, which is attached to the pump's initial suction connection. The energy is drawn into the pump through a stepper motor, and the movement of the pump gear, which spins in the impeller case of the pump, provides a force that pushes the air out through the second pump channel, which is the outlet. The energy pours into a second hose, which is pushed back by the pump's pressure. Following that, the oil will continue to flow into the prepared oil tank. The power is generated by a 12volt power battery installed in the pump box, which allows the pump gear, which is also installed in the pump box, to function by being propelled by the rotational power of the motor connected to the pump. As a result, the operation for sucking can be accomplished. The suction procedure in the study begins with the hose in the suction duct.

The hose's purpose is to allow it to be placed into the engine and suck up the power energy. The power energy will be withdrawn from the hose and routed into the box to power energy waste tank after passing through the grip duct on the gear pump.

Table 1: Time Estimated

Types of Motorcycle	HONDA EX5	YAMAHA LC135
Time taken with the use of the machine	5 minutes	7 minutes
Time taken with the use of traditional method/ without machine	10 minutes	13 minutes

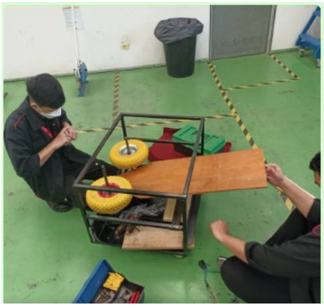


Figure 3: The model of robot PBS 2

14. SUSTAINABLE ENGINEERING PRACTICES

This is because the objective made is based on questionnaires and studies conducted where after research it was found that the old method of mechanics needed to collect the ball and lagori changed then need to lift the catch container and pour the ball into the waste bin. The change that has been made was to add trolleys and baskets to place the gear pump, and a waste tank so that it was no longer necessary to do the old method. After that, the objective that has been achieved is to provide new technological facilities to society. This is because the method of grip ball and lagori nowadays is still done in the old way even if there is only there is no longer used. In addition to other users other than mechanics, those who want to own this machine can also get it because the next objective is to make this machine as daily use with new technological innovations nowadays. So here it is proven that all the stated objectives have been achieved with the implementation of this project in line with the passage of time

Figure 4: The model of robot PBS

15. ACKNOWLEDGMENTS

Firstly, we would like to express our gratitude and thousands of appreciations towards our supervisor, Sir Zulkarnain Bin Jamak for his full supervision throughout our project. He has helped a lot by giving useful suggestions, great idea for invention and always give encouragements from the beginning until the end of the research of this project. We have gained many valuable experiences and knowledge while conducting this study. Moreover, we are beyond grateful to our parents and family for their understanding and moral support which motivates me to give our best in order to finish this project. Lastly, we would like to define our sense of recognition to everyone who contributing either directly or indirectly in this project

REFERENCES

[1] Chen, H., Cheng, M., Luo, Q., & Li, Y. (2006). Study on portable motorcycle exhaust gas analyzer. *IET Conference Publications*, *524*. https://doi.org/10.1049/cp:20060946

[2] Koteleva, N., Buslaev, G., Valnev, V., & Kunshin, A. (2020). Augmented reality system and maintenance of oil pumps. *International Journal of Engineering, Transactions B: Applications*, *33*(8). https://doi.org/10.5829/ije.2020.33.08b.20

[2] Miao, Y., Hynan, P., von Jouanne, A., & Yokochi, A. (2019). Current li-ion battery technologies in electric vehicles and opportunities for advancements. In *Energies* (Vol. 12, Issue 6). https://doi.org/10.3390/en12061074

[3] Nurmianto, E., Anzip, A., & Sampurno. (2019). Design of mobile, portable and ergonomic fish smoke machine on a motorcycle. *IOP Conference Series: Materials Science and Engineering*, *674*(1). https://doi.org/10.1088/1757-899X/674/1/012047

[4] Prasetyowati, R. (2016). VISCOSITY TEST OF VEHICLE ENGINE OILS. *Jurnal Sains Dasar*, *4*(1). https://doi.org/10.21831/jsd.v4i1.8440

UNIVERSITI ISLAM ANTARABANGSA MALAYSIA (UIAM) ROBOTEAM

Dr. Khairul Affendy Bin Md Nor, Dr. Hassan Firdaus Bin Mohd Zaki, Muhammad Syahmi bin A Rahim, Muhammad Khairul Anwar bin Ibrahim, Naufal Bin Muhammad Lofty, Muhammad Imran Bin Mardzuki, Muhammad Amirul Irfan Bin Mohd Yusmin, Muhammad Fareez Iqmal Bin Mohd Sharipuddin, Ahmad Huzaidi Bin Bahrom, Nursyafiqah binti Sobri, Norsalma Syamimi Binti Mohd Najib.

Centre for Unmanned Technologies, Block E2, Level 1, Kulliyyah of Engineering, International Islamic University Malaysia, Gombak, 53100 Kuala Lumpur, Malaysia

ABSTRACT

This year ABU ROBOCON's theme is - "Lagori". The game is between two teams (Team 1:" Seeker" and Team 2: "Hitter") and the game starts by throwing a ball by the seeker to break a stone tower called "Lagori". While the seeker tries to pile up the stones again, the hitter throws balls to interrupt them. IIUM Roboteam has successfully developed two robots to fulfil the tasks given for the competition. The Robot 1 (R1) is designed to receive the passed ball and throw the balls towards the lagori discs tower. On the other hand, the second robot, namely Robot 2 (R2) is responsible in taking the ball from the rack, pass the ball to the other robot, and pile up the lagori discs in the original order. Among the difficulties that we face is making sure the ball launches well to the targeted lagori discs tower, but the problem manages to be solved by repeating the number of trials until we get the designated angle and height to increase the number of possibilities for the lagori to fall. One of the unique characteristics of the robot is on the throwing part, in which our robot can move vertically and horizontally to

aim and break the lagori discs tower. For the horizontal movement we use the linear actuator to aim up and down while the lazy susan is used to move vertically. Our robot is not harmful as most of the components used are from recyclable and reused items from our previous robot in the laboratory. This robot mechanism can also be implemented in real life application by designing robots to despatch a fire extinguisher ball from afar ensure the ball reaches the desired area.

1. INTRODUCTION

ROBOCON is an annual competition that allows students from all institutions in Malaysia to showcase their talent in developing robots based on the theme of the year. The theme for ROBOCON'2022 is - "Lagori". Lagori is a traditional and one of the most played ancient games that originate in the southern part of India. This year's Robocon will be held in University of Science Malaysia (USM) for four days from the 2^{nd} until 5^{th} of June 2022. In despite of this, the competition will be conducted physically for the first time since the pandemic occurs in 2020. The participating teams need to develop a working robot (seeker) that is able to throw the balls to break the lagori discs and pile them up in the original order and (hitter) needs to throw the balls to prevent seeker from pilling up Lagori discs.

IIUM Robocon team has successfully developed a versatile Robot 1 (R1) and Robot 2 (R2) despite of the COVID-19 pandemic going on all over the world which is quite tough for the team to complete the development process. If we are assigned as the seeker first, the robot tasks begin when R1 starts to throw the ball towards the lagori discs tower, and R2 will collect the balls from the rack by using the gripping mechanism and passes the balls to R1. After that R2 will be assigned to arrange the lagori discs in the original order. On the other hand, if we are assigned as the hitter, R1 is supposed to shoot the ball on top of the opponent's robot. The robot is designed based on the designated tasks that the team believe will give benefit during the competition. Most of the mechanisms in the built robot are actuated using electric motors. Sensors, such as limit switches and encoders are also instrumented to the robots to enhance the performance of the system.

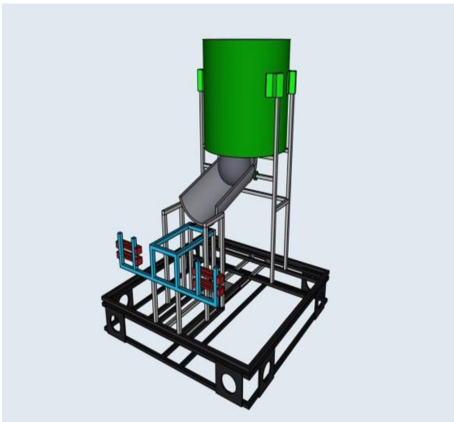
One of the main challenges that the team faced was figuring the throwing mechanism while finding the perfect height and angle of the throwing mechanism so that the ball can consistently hits the lagori discs at the most optimum position so that every lagori discs will collapse as intended. It is tricky as it must make sure the force is strong enough to launch the balls towards the lagori discs until it collapses. To ensure and demonstrate enough momentum for the robot to throw the ball, we studied a simple throwing mechanism by referring to the articles in [1], where the authors always threw to the same target and not to a moving target as in their study. Another challenge that we faced is to maintain the consistency of the gripping mechanism while lifting the lagori discs. It is a hassle in ensuring the lagori discs is stacked properly on one another.

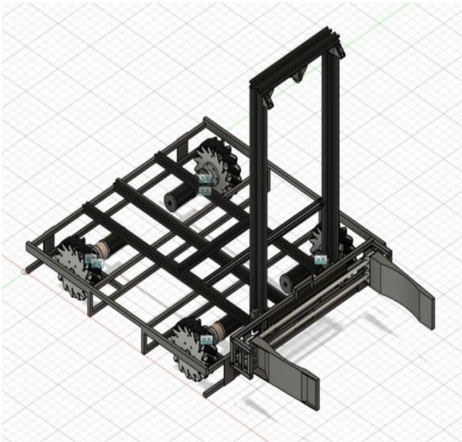
In this report, the drawing for mechanical design, circuit diagram and the flowchart for the programming is presented in the next section. The analysis on the throwing mechanism is presented in the following section.

2. DETAILED DESIGN

Our design comprised of three major parts, namely mechanical component, electrical and electronic component, and software design. We split the task to ensure the workflow for robot construction are organize and smooth.

2.1 MECHANICAL DESIGN

Robot	Mechanism	Drawing	Explanation Of Mechanism
R1	Throwing the ball	 Figure 1: robot 1	We selected this double flying wheels' design as our shooting method. When the balls are thrown into the rotating wheels. At their spinning velocity, two wheels on each side will catch the ball, compress it, and fling it out. The advantage of this design is that we can toss balls at a consistent velocity that can be readily modified since the velocity of the balls is governed by the spinning velocity of the wheels.
	Vertical and horizontal movement		For the vertical movement, the linear actuator is used to tilt the robot up and down for aiming purposes. Then, the lazy susan is utilized in our robot to ensure the horizontal movement occurs. For instance, to make the robot rotate towards left and right to ease aiming the lagori discs

<table>
<tr><td></td><td></td><td></td><td>and enemy’s ball on the seeker.</td></tr>
<tr><td rowspan="3">R2</td><td>Lifting mechanism</td><td rowspan="3">
Figure 2: robot 2</td><td>For the lifting mechanism, we apply the forklift concept on our robot. This mechanism uses pulley and belt system by attaching a motor at one end of the pulley. This mechanism function as to lift and stack the lagori discs.</td></tr>
<tr><td>gripping mechanism</td><td>The gripping mechanism is applied by using the concept of linear movement between two rods of steel in lifting and arranging the lagori discs in original order.</td></tr>
<tr><td>Robot movement</td><td>The robot wheel movement is controlled by dc motors attached to four omni wheels at every corner of the robot.</td></tr>
</table>

2.2 ELECTRONIC DESIGN

The electronics design the robot consist of power circuit, sensors and actuators connections, communication circuit and the controller. The schematic is shown in Figure 3 (R1) and Figure 4 (R2):

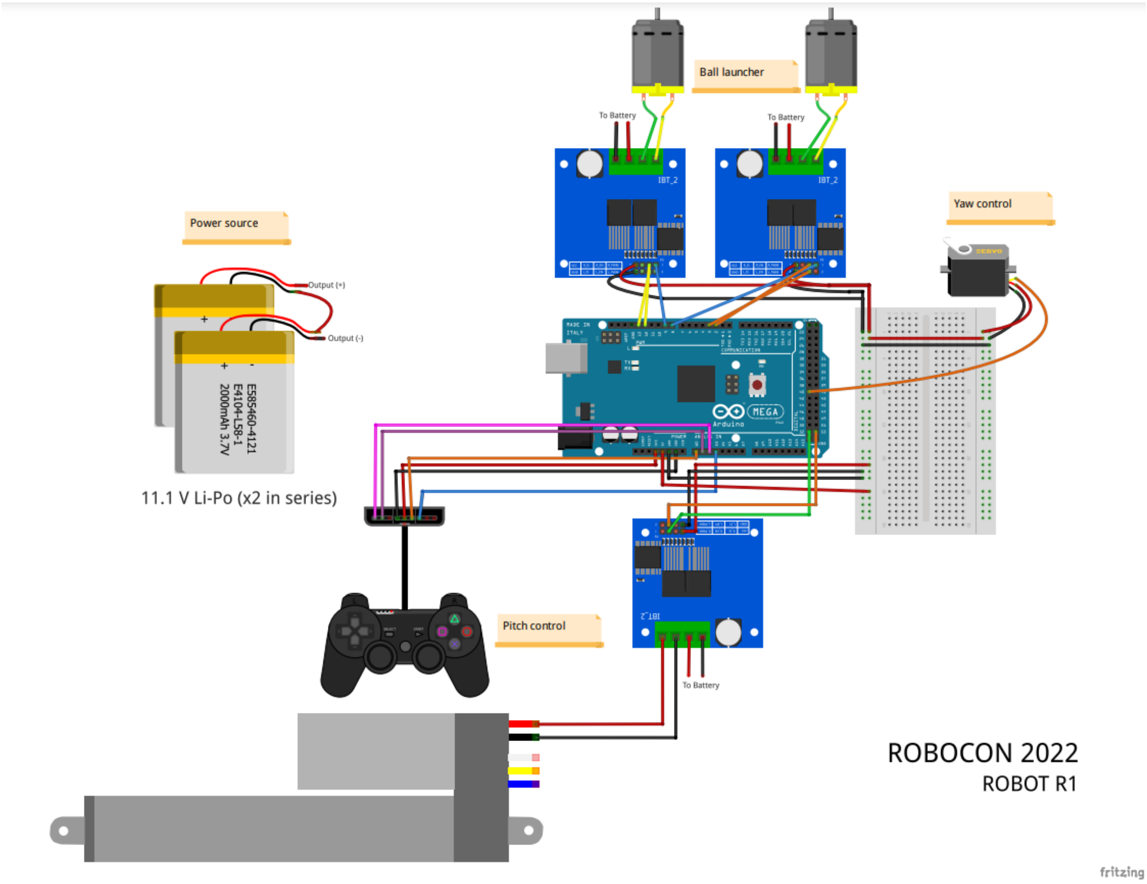


Figure 3: Schematic of main board design (R1)

2.3 SOFTWARE DESIGN

Figure 3(a)-(b) shows the flow chart of the robot algorithm.

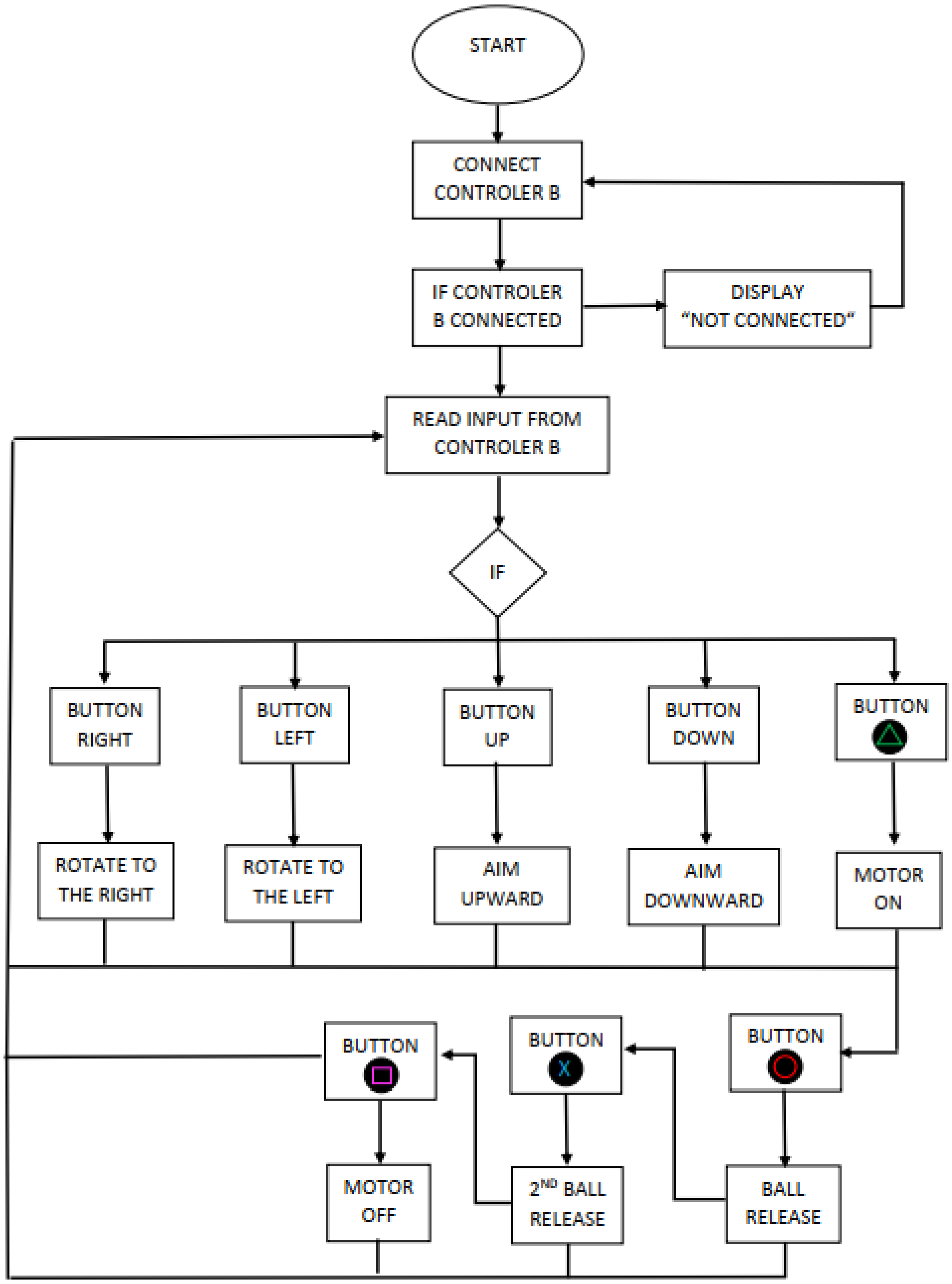


Figure 3(a): Flow chart of robot controller R1 algorithm

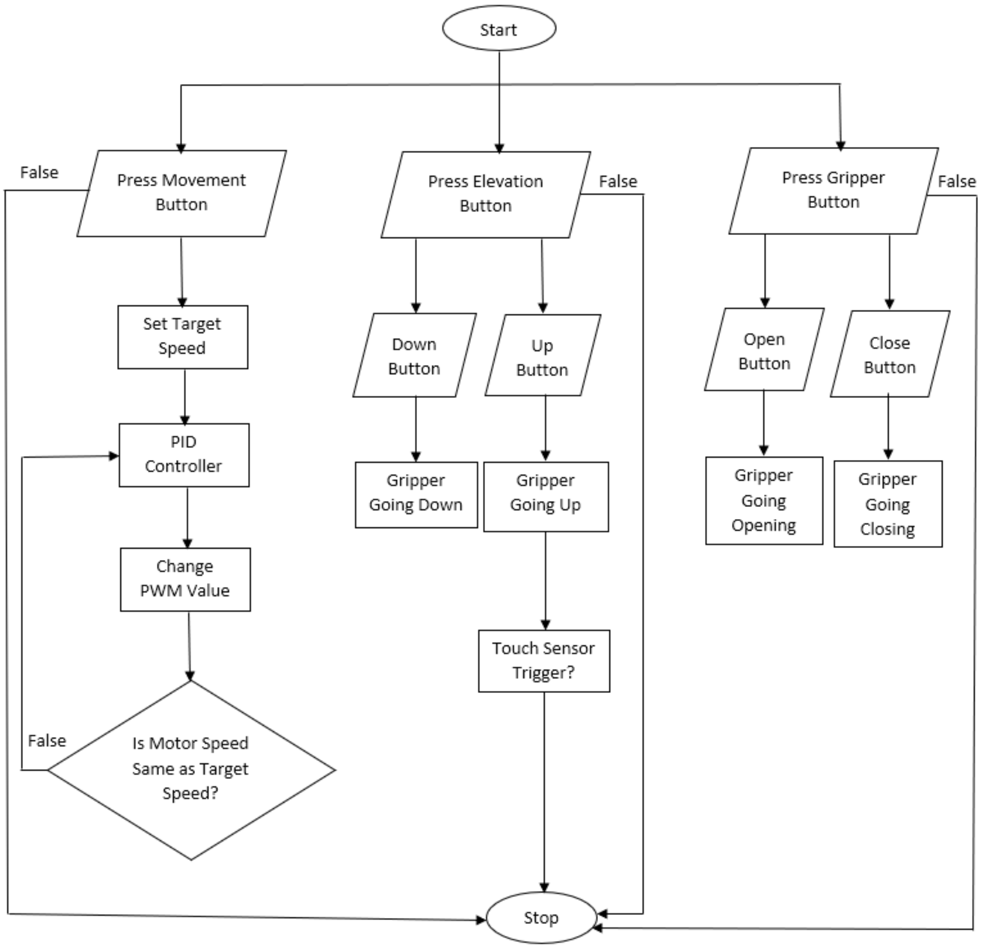


Figure 3(a): Flow chart of robot controller R2 algorithm

3. PRESENTATION OF DATA/SIMULATION/TESTING

Based on our studies of articles [2-4], the highest point and projectile motion of a thrown ball depending on the initial throwing speed as well as the angle of the throw. According to Hu et *al.* [3], in terms of the developed robotic throwing mechanism, the air pressure has the most impact on the throwing speed, while the gripping angle, beginning angle of the throwing rod and length of the tether have the most impact on the first throwing angle. Hence the projectile motion equation used in developing our robot is illustrated in Eq. (1) and Figure 4 below.

$$S = \sqrt{\frac{2hv_0^2 \cos^2\theta}{g} + (\frac{v_0^2 \sin 2\theta}{2g})^2} + \frac{v_0^2 \sin 2\theta}{2g} \tag{1}$$

Where, S = projectile distance, Vo = throwing speed, θ = throwing angle, h = throwing height, g = gravity acceleration (9.8m/s^2).

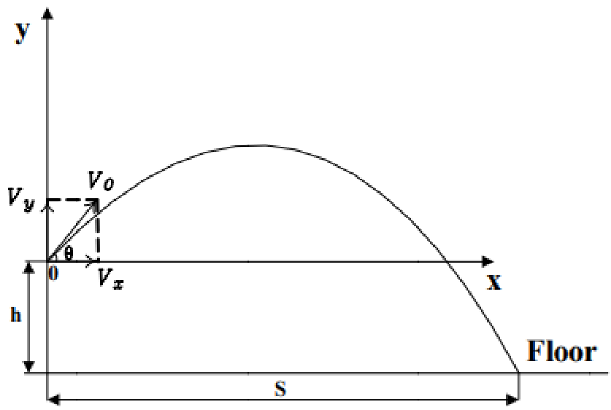


Figure 4: Projectile used for calculation

Table 1: Experimental result to determine optimum angle of attack

Trials	Angle of Attack	Velocity (km/h)	Number of Lagori Collapsed
1	0	23.4	0
2	5	23.4	0
3	10	23.4	1
4	15	23.4	3
5	20	23.4	2
6	25	23.4	0

Figure 4 describes the motion throwing diagram that we analyse each time we calculate the velocity of the ball launch by the robot. Next, in Table 1 shows the data collected from the experiment that we conducted to determine the optimal average initial velocity for the ball to reach the lagori.

From Table 1, it can be deduced that the optimal angle of attack of the ball is 15 degrees. This can be said that probability of ball to shoot and hit higher number of lagori is within this angle.

4. DISCUSSION / EVALUATION OF FINDINGS

Our robot is unique as our throwing part uses a simple but very effective mechanism which apply the concept of kinetic energy of a double flying wheel to launch the ball flawlessly by using dc motors. Meanwhile, for our lagori stacking robot, we apply the forklift concept. This mechanism uses pulley and belt system by attaching a motor at one end of the pulley. This device is responsible for lifting and stacking the lagori discs.

Moreover, we conducted an experiment that relates to the projectile motion that requires the angle and height of the throwing mechanism. From our findings, we have obtained the optimized height and angle that is required to hit the lagori discs. In despite of this, the best setting range for R1 is 15 degrees angle of attack. The robot is handled manually in which we successfully making the robot becoming more adjustable and easier to handle humanly besides manage to cut the robot making budget. Therefore, as it is operated manually, there is no complex and high maintenance level needed to operate the robot. In comparison to any other semi or fully automated robot, our Throwing Robot has less flexibility in terms of the outcome that may be produced, however we cannot deny that even the most adaptable automation robot is less adaptable than human, who is the most adaptable machines of all. Hence the reason why we practice our robot modus operandi manually as it really saves our time to finish the designated tasks and overcome our opponents by improvising the accuracy and consistency of our ball throwing mechanism.

5. SUSTAINABLE ENGINEERING PRACTICES

Coincide with sustainable development goal introduced by United States members in 2015, our robot had been built according to these goals. In terms of responsible consumption, our robot followed the aims which are eco-friendly, reduce waste and boost recycling. For instance, we reused the base of our previous robot creating it as our base robot. We also reused the used battery and motors for our Robot R1 and R2. Meanwhile, the production cost also is not too high, and it is reasonable and affordable. This concept heavily relates to the 12th Sustainable Development Goal which focuses on responsible consumption and production. This SDG is about managing the wastes by preventing them in other methods such as reuse, reduce and recycle.

Besides, the made robot is not harmful to the environment and humanity. The energy sources of the Robot R1 and R2 are lithium polymer batteries which are rechargeable battery. A silicon–graphene additive contains in those batteries helps to preserve the positive terminal during discharging, thus increasing the cell longevity and cycle-life**.**

6. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

Although this is the fourth time we join this competition, the task for ROBOCON this year is quite challenging especially in designing the best mechanism especially for crucial part such as passing, gripping, and throwing the ball to make sure it precisely hits the lagori discs tower. However, with guide from advisors and helpful teammates, we manage to build the robot successfully.

On the other hand, based on our test that was conducted we have finally found out the best configuration for the throwing mechanism in achieving the best results which is ensuring the most lagori discs that will collapse in one shot. From this competition, we have successfully enlightened ourselves which is improving each and everyone's hands on ability in conducting this robot. Furthermore, our teamwork has improved drastically in a positive way, and we get to apply the engineering application during constructing this robot.

7. ACKNOWLEDGMENTS

We would like to express our deepest appreciation to all those who provided us the support to complete this task. A special gratitude goes to our team members for their contribution in stimulating suggestions and helping in designing schematic diagram of circuit and modelling of the robots. Furthermore, we would like to acknowledge with much appreciation, IIUM Robocon advisors who are Dr Affendy, Dr Hasan Firdaus and Dr Farahiyah, who always advise and guide us in build the robot. We also thank IIUM Roboteam for giving us the permission to use the required equipment having in the laboratory. Finally, we want to thank and gratitude our beloved university and kulliyyah of engineering for supporting us in developing our robot.

REFERENCES

[1] B. Hove and J. Slotine, "Experiments in robotic catching," in Proceedings of the 1991 American Control Conference, 1991, pp. 380 – 385

[2] A. Gams, T. Petric, L. Zlajpah, and A. Ude, "Optimizing parameters of trajectory representation for movement generalization: Robotic throwing," 19th International Workshop on Robotics in Alpe-Adria-Danube Region (RAAD 2010), 2010.

[3] F. Hu, Q. Liu, J. Cheng, and Y. He, "Flight trajectory simulation of robotic throwing shuttlecock," 2018 WRC Symposium on Advanced Robotics and Automation (WRC SARA), 2018.

[4] B. Winarno, R. G. Putra, I. Yuwono, A. I. Gunawan, and B. Sumantri, "Control of Velocity Projectile on Multistage coil gun," 2018 International Conference on Applied Science and Technology (iCAST), 2018.

[5] Moghaddam, R. Y., Alitavoli, M., Chaibakhsh, A., Rezaiefar, A., & Bagheri, A. "Fabricating a Tennis Robot Based On The Counter Rotating Wheels," 2004.

[6] Hassan, Mohd Hasnun Arif & Taha, Zahari & Shaharudin, Mohd & Wee, Lim & Anuar, Zulfika. "Development of a Soccer Ball Launching Device," 2018.

UNIVERSITI KEBANGSAAN MALAYSIA (UKM) CYBORG

Imran Hakim Hamray, Lutfil Hadi Hendri Dwistrya, Badrul Amin Ramli, Muhammad Faiz Rufendy, Ahmad Faiz Fauzan Ahmad Zainudin, Aeisha Danella Lemi Gordon, Avinash Kumaresan, Ikmal Izzuddin Aziz, Muhammad Luqman Abdul Karim, Adam Danish Sopian, Muhammad Emirul Hakim Abdullah, Tuan Muhamad Affiq Aimullah Tuan Mohd Pauzi, Nurin Adriana Endri, Wan Ahmad Na'im Wan Muhammad Afifi, Muhammad Aiman Asyraf Mohd Farok, Amirul Aiman Abdul Rahman, James Fong Jia Lekh, Kho Jia Chyn, Edwin Rangga Ardhana, Loo Khai Ming

Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

ABSTRACT

ROBOCON Malaysia 2022 is a competition to give exposure to all IPT student to be innovative and critical thinking in solving any problem that been given. Two robots are compulsory for every teams to build and address all the problems that need to be solve for example, shooting the "lagori", sorting the "lagori back on the platform and aiming the ball on head of opponent. UKM team had address those problem with innovative and sustainable engineering.

1. INTRODUCTION

The ROBOCON Malaysia 2022 is a national level competition organized by the Ministry of Higher Education (KPT) that consist of many universities and higher-educational institutions in Malaysia. This robotic competition which is also known as ROBOCON is game for the students to design, create and innovate their robot according to the rule and regulation set by the organizer. This year theme's for ROBOCON Malaysia 2022 is inspired by a traditional game called Lagori-Tuju Tin. This game is a fair competition between two different teams in which each team will need to produce two robots, the "Hitter" and the "Seeker". The robots need to break a stone tower called "Lagori" and find a way to pile the "Lagori" up again with a minimum time spent.

Universiti Kebangsaan Malaysia (UKM) has formed a 2022 ROBOCON team that consists of 20 members named UKM Cyborg. There are two robots that had been produced, R1 which is responsible to break "Lagori" and R2 to pile up the "Lagori". The R1 is a much simpler robot while the R2 has a more complex mechanism as the team's main focus is to secure more points in piling up the "Lagori". The R2 uses pneumatic system to grip the "Lagori" because it can provide enough force while consume less electrical power. Besides, the R2 is also equipped with a defensive mechanism to dodge incoming ball from the opponent's "Hitter".

By participating in this competition, the students can apply those physics, mechanical and electrical theories that they have learned in-class as well as obtain more knowledge in today's ever-growing technologies. Other than that, it will also promote a good teamwork, brainstorming and they can learn on how to tackle a problem that might resurface with a potential solution. Furthermore, it can provide a new exposure to the students on robotic technologies that can be utilized to solve future problems. To add, the top winner in ROBOCON Malaysia 2022 will have their chance to participate in an international level robotic competition hence contributing to their university and Malaysia.

2. DETAILED DESIGN

2.1 R1 MECHANICAL DESIGN

R1 robot has main objective throughout the game which is to make sure all lagori that stack up will be fall to the ground within 3 balls during seeker role. However, during the hitter role, the R1 robot will be assigned to make sure the ball hit the ball on head (BOH) of opponent R2 robot. Therefore, we came out the design below to make sure all the objectives will be achieved.

For the shooting mechanism, we take our inspiration of the mechanism from the real-world application which is the goalkeeper training ball shooter. This mechanism is being choosing as it has the highest consistency compared to other mechanism

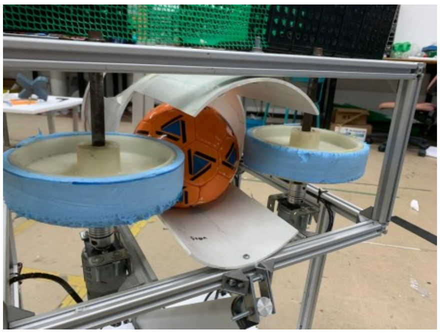


Figure 1: The ball shooter

The mechanism works when two wheels rotate in 2 opposite directions that will convert the energy throughout the wheel. This system has advantages as the ball can be adjusted to being shoot at difference speed. It can be achieved by increase/decrease the speed of the rotating wheel or widen/shorten the distance between the two-rotating wheel. However, this method leaves a mark on the ball that will the damage the ball over the time. So, we apply a layer of foam on the wheel that will reduce the friction force between the ball and the wheel

Figure 2: The defect on the ball

We also use a simple basket to contain the ball that will be receive from R2 Robot. This basket has an incline plane that will slowly roll the ball into the hole that later will be push by a pvc rod attached to the servo. This will make sure our shooting timing will be perfect and reduce the chances of uncontrolled shooting.

Figure 3: The simple basket

Figure 4: The servo

For the aiming, we need to make sure our robot able to make adjustment horizontally and vertically before making the shooting. A wheel will be attached to the motor, 2 caster wheels and a rod of shaft is use as the base of the robot. The robot will rotate towards left and right and up to 60 degrees. This configuration will make sure robot r1 can change the direction when needed. We choose to do this mechanism rather than other mechanism such as omnidirectional wheel because of the simplicity. In our opinion, the over engineered design will be leading towards the waste of resources and problems.

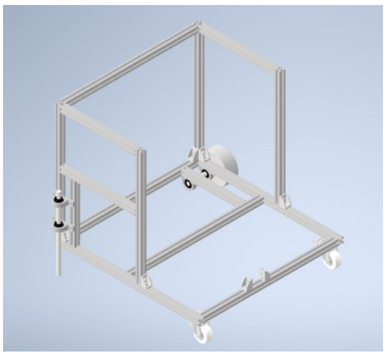


Figure 5: The aiming

To increase the angle of the shooter, we use a linear actuator that can extract and retracted steadily. It can hold up 15Kg while being operating. At the back of the shooter cage, we attached it to 3 hinge that will hold to the base of the robot. By theoretically, the weight of the upper cage will be hold altogether on the linear actuator that will stress the linear actuator over time.

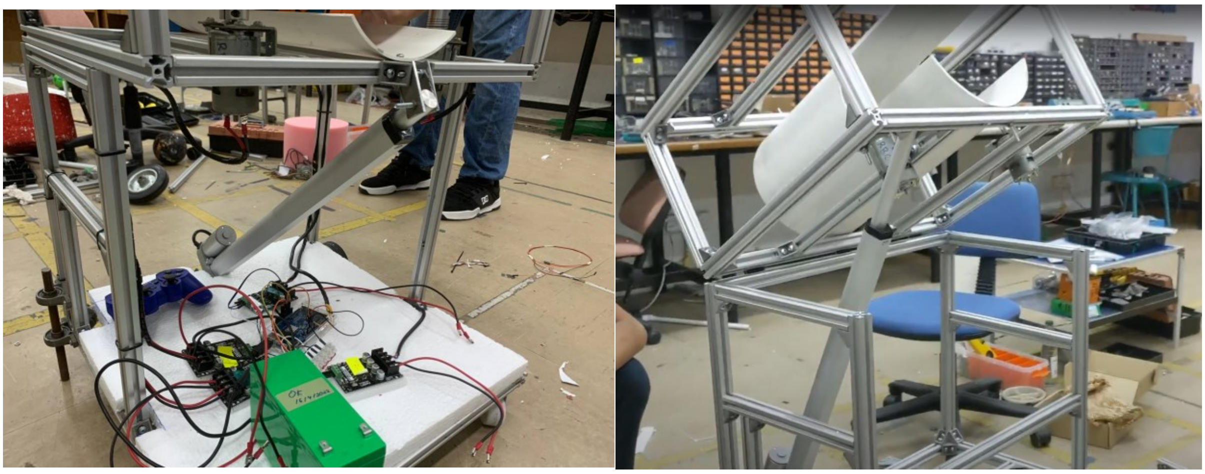


Figure 6: The linear actuator

2.2 R2 MECHANICAL DESIGN

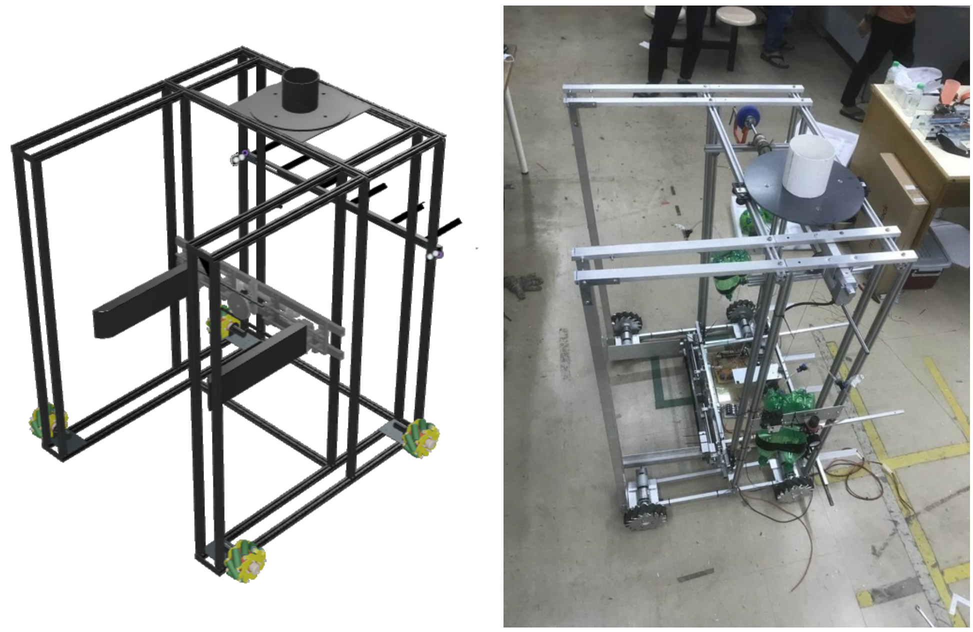
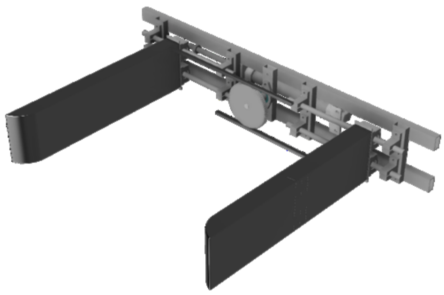


Figure 7: Robot R2

Our design for R2 consists of 4 mechanisms. The mechanisms are controlled manually by the controller. Figure 1 shows the design of R2 combined with all the mechanisms. Based on the rules book of Robocon 2022, Robot R2 needs to compile the lagori that have been shot by R1. Besides, R2 needs to hold a ball on the head of the robot while compiling the lagori. It also needs to collect balls from a rack and transfer to R1.



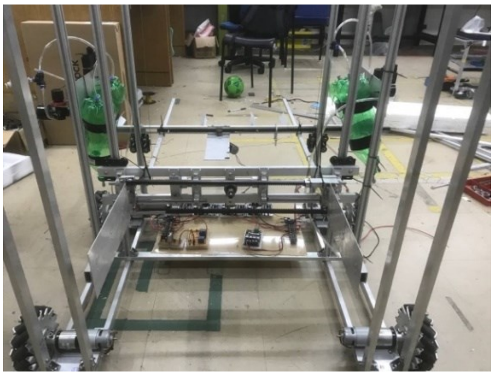


Figure 8: Lagori Gripper

The mechanism to compile the lagori is the gripping mechanism. It consists of a pair of hands that is moved by rack and pinion. The gripper is tight with the pneumatic cylinder. The pneumatic cylinder will push and pull one side of the gripper. Rack and pinion are attached to the gripper to make sure the movement of both gripper are the same. The pneumatic cylinder is connected to the cylinder valve to control the pressurized air from the bottle tank to the cylinder. The pneumatic system also has a pressure gauge to limit the pressurized air from the tank into the cylinder. At the beginning of the design, we plan to 3D print the gripper to hold the lagori. After doing a few testing and considering a few parameters such as size and weight, we change the gripper to the plate.

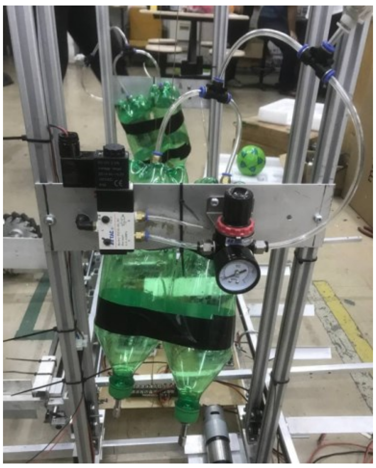


Figure 9: Bottle tank, pressure gauge and solenoid valve

The mechanism for R2 collecting the ball is the gripping mechanism. There are 3 pairs of grippers to grip the balls on the rack and transfer to R1. Each pair of hands has one fixed gripper and the other one is attached to the rack inside the aluminium hollow. The hands will move as the rack is moved by the pinion that is attached to a motor. Figure below shows the design of the ball gripper.

Figure 10: Ball Gripper

For the ball on head, the plate is attached to the linear motor and mounted on the v slot wheel on the aluminum extrusion. It is to make the plate moveable to avoid being shot by R1 seeker. The body of R2 is built by aluminum hollow and aluminum extrusion which is light in weight. The lagori and ball gripper need a lifting mechanism to make the robot more function. Hence, the two grippers are being lifted by a pulley system. The pulley is attached by a shaft to pull the gripper from above by a nylon string. Robot R2 also uses mechanum wheel to have a good movement of the robot because the robot needs to set up good position to grip the lagori and balls.

3. DISCUSSION

3.1 WHY YOUR DESIGN IS UNIQUE?

The designs of our robots are demonstrating the real-world application of the mechanical concepts. The RI is designed to shoot the balls at any desired angles. A pneumatic system is installed below the shooter to provide the uplifting force. The system is programmed and designed to allow us as the users to control the degree of lifting of the system.

While in the R2 which equipped with the gripper for balls and lagori, we applied the concept of pulley system. The pulley system is built with materials we could easily obtained which is the cotton thread. Earlier studies and analysis are conducted to ensure the strength of the chosen thread. Similar to the R1, the pulley system allows the users to have desire degree of lifting or lowering.

4. SUSTAINABLE ENGINEERING PRACTICES

There are two sustainable engineering practices in our robots. The materials for both R1 and R2 are selected and chosen on the criteria of recyclability. For example, the main materials our structural supports are aluminium and steels. The allows us to manage the robots after the competition in more sustainable options including recycling and reusing in futures to minimise the waste production.

Second, the R1 is wholly built from used and recycled parts and items found in our faculty. Recovering those items and parts as the materials for our R1 has lengthened the lifetime of those items. By solely using the recovered materials, we have reduced the need to obtain new materials, thus reduce the burden on resources of our mother Earth.

5. ELECTRONIC DESIGN

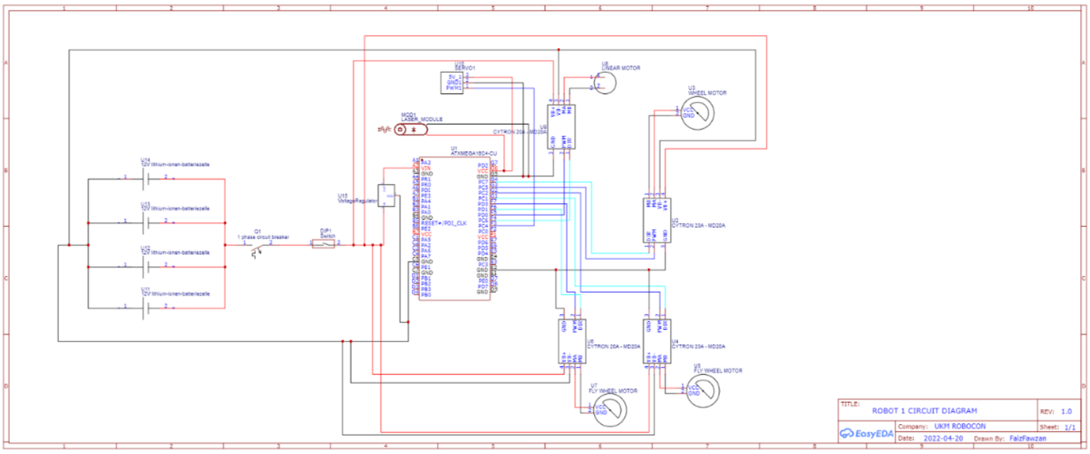


Figure 11: R1 circuit diagram

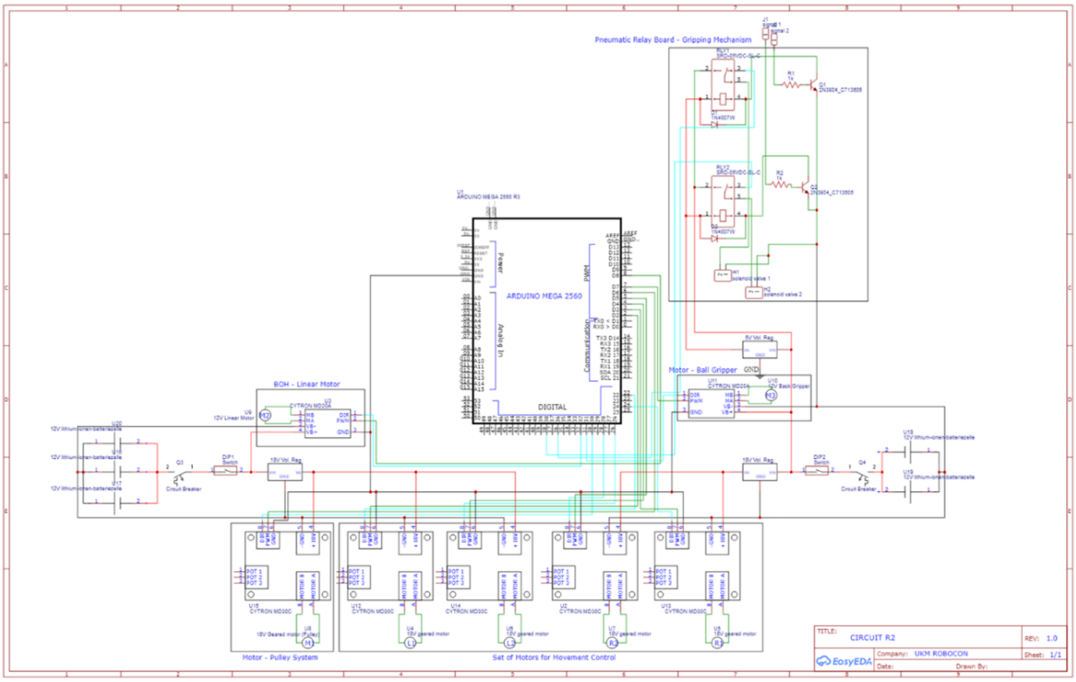


Figure 12: R2 circuit diagram

6. SOFTWARE DESIGN

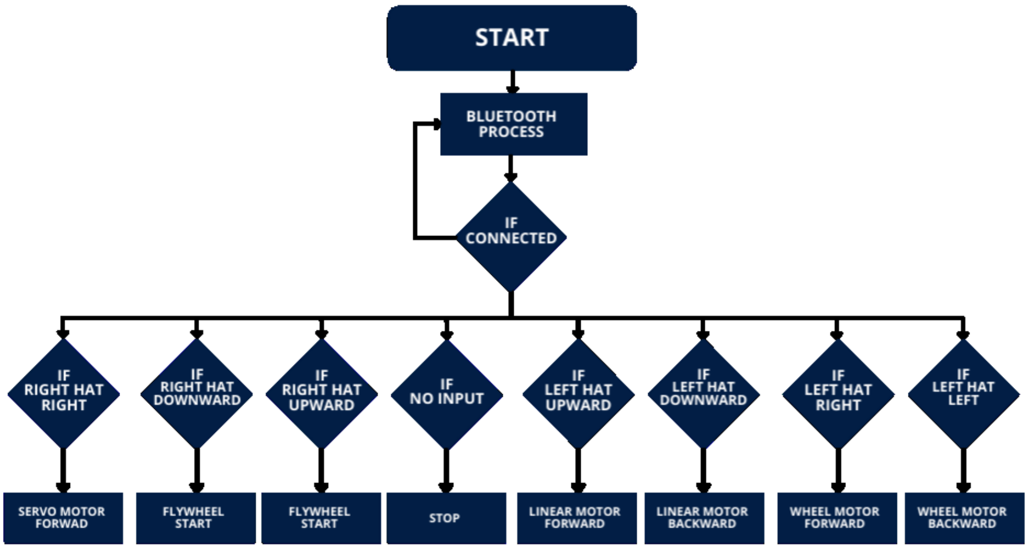


Figure 13: R1 software design

7. CONCLUSION, LIMITATIONS AND RECOMMENDATION

The R1 and R2 were successfully built by UKM Robocon Team should be praised. The robots build by the team are fully functioning robot and comply with all regulations provided by the organizer. The efforts and cooperation given by all team members are outstanding despite of the time constraints and difficulty faced by the team. The R1 was built as a static robot and was designed to be as simple robot, thus the team has more resources to give more focus in building R2. The R2 robot was built as a complex robot equipped with more advance mechanism such as pneumatic system. Even the robots was successfully built, more research and improvement are needed to achieve more satisfactory working robots.

8. ACKNOWLEDGMENTS

We would like to express our high appreciation to our advisors for giving us guidance with patience and help us in the making of both robot. We are gratefully acknowledge financial support provided by Universiti Kebangsaan Malaysia (UKM) and Fakulti Kejuruteraan dan Alam Bina (FKAB)

We Would also like to express our gratitude to everyone who has assisted us in the completion of the robots, whether directly or indirectly.

REFERENCES

[1] Izak Negron, Jose Perdomo, Richard Saco, Adrian Sinanan, Sabri Tosunoglu, *SkillCourt Autonomous Ball Launcher*, 2017.

[2] Yan Shi, Maolin Chai, Weiqing Xu, Yi xuan Wang. *Methods to Evaluate and Measure Power of Pneumatic System and Their Applications*, 2019

UNIVERSITI KUALA LUMPUR (MALAYSIAN FRANCE INSTITUTE) (UNIKL MFI)

Muhammad Yusof Bin Muhammad Fuzi, Muhammad Hariz Bin Mohamad Tarmidzi, AHMAD IZZAT AUZAIE BIN ZULKIFLY, MUHAMMAD ZAKI BIN KAMARUZZAMAN, Muhammad Yusof Bin Muhammad Fuzi, MUHAMAD ARIEF BIN MOHD, SYED FIRDAUS BIN SYED MOHD FAISAL, Amir Rizman Bin Razali

Universiti Kuala Lumpur (Malaysian France Institute) (UniKL MFI), Section 14, Jalan Damai, Seksyen 14, 43650 Bandar Baru Bangi, Selangor.

Abstract

Robocon Malaysia 2022 is a competition which challenged its competitor to create a new or innovate the existent robot into something more complex to help human with their daily life, at the same time increase the image of Malaysia in the eyes of the world. This competition will be held on 25th of May 2022 and it will last until 29 May 2022. This year, this competition will be held at University of Science Malaysia which located in Penang. The selected theme of this competition is lagori. Lagori or also known as “tuju tin” is a childhood game which consists of two teams against each other. One of the team will be the defensive team which they need to strike any player of the other team. The other team need to throw ball at the target which is the tin can. In order to win the game, they need to rebuild the tin can pyramid without being hit by the defensive team. In this competition, competitors are required to build robots as substitute of the players. The robots will be the one that throw ball to the target and to the player.

1. INTRODUCTION

Robocon 2022 consist of two different robots which are shooting robot, R1 and pick and place robot, R2. The main objectives of the game are to hit the lagori disc with the ball which will be done by the shooting robot and the R2 robot's will pick up the lagori disc and arrange according to the lagori disc sequence under a certain time. To achieve the objectives, the robots must have a good mechanism and systems. By using the high-speed dc motors and a rubber wheels as a spindle to shoot the ball, the ball will produce high momentum and high impact. High impact can cause the lagori disc to fall and separate far away from each other. This will cause the R2 a long time to get the job done by pick up the lagori and rearrange according to the sequence. So, by reducing the power of the motor and have a good angle of projectile before shooting can prevent the lagori disc from fall apart far away from each other and reducing the time taken for R2 to rearrange the lagori discs.

Basically, our shooting robot inspired by the ball launcher machine that used widely in sport industry today. The main parts for the shooting mechanism are high speed dc motor, rubber wheel and the frame. Pick and place robot called R2 inspired by a forklift which capable of picking, carrying and lifting an object. Besides, the ideas of making the robot are by doing the research based on the existed robot in social media.

2. PROTOTYPES

2.1 R1 DESIGN

Figure 1: Prototype R1

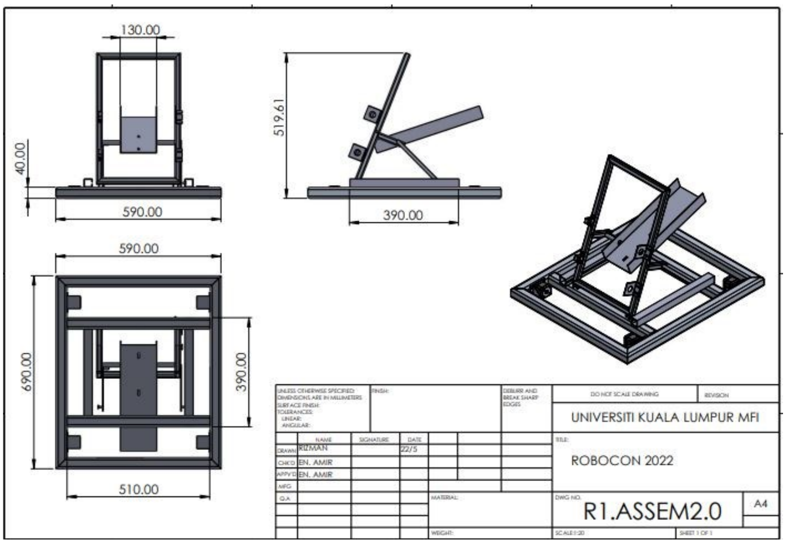


Figure 2: R1 diagram (the orthographic drawing for the R1 with different angle and sides)

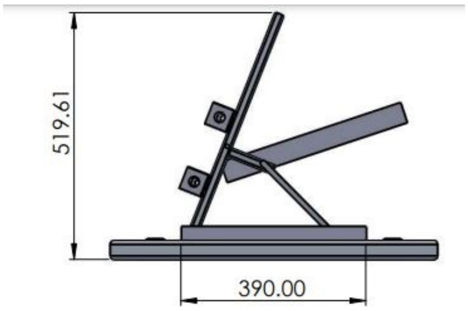


Figure 3: R1 diagram

Figure 3 shows the side view for the R1. From the side view there are mounting motor for the shooting mechanism and the pin connection for the angle shooting adjustment. The pin is used to adjust the shooting projectile to give a good aiming and the direction for the ball. The ball which are used to hit the lagori disc is controlled by the servo motor. The stopper is used connected to the servo motor can control the sequences before shooting.

2.2 R2 DESIGN

Figure 2: R2

Figure 2 show the design for the pick and place robot, R2. The robot inspired by the forklift. The rack and pinion mechanism are used for pick up and place the lagori discs. The rack and pinion basically are controlled by the servo motor to produce a high torque which capable to lift an object without damaging the component.

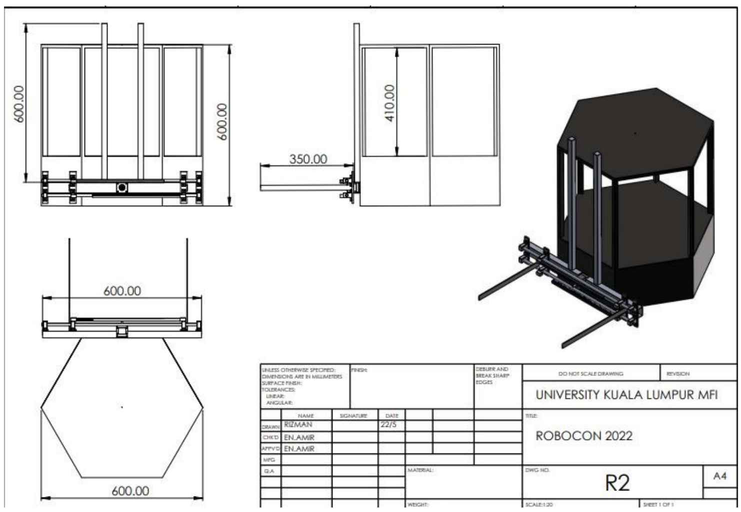
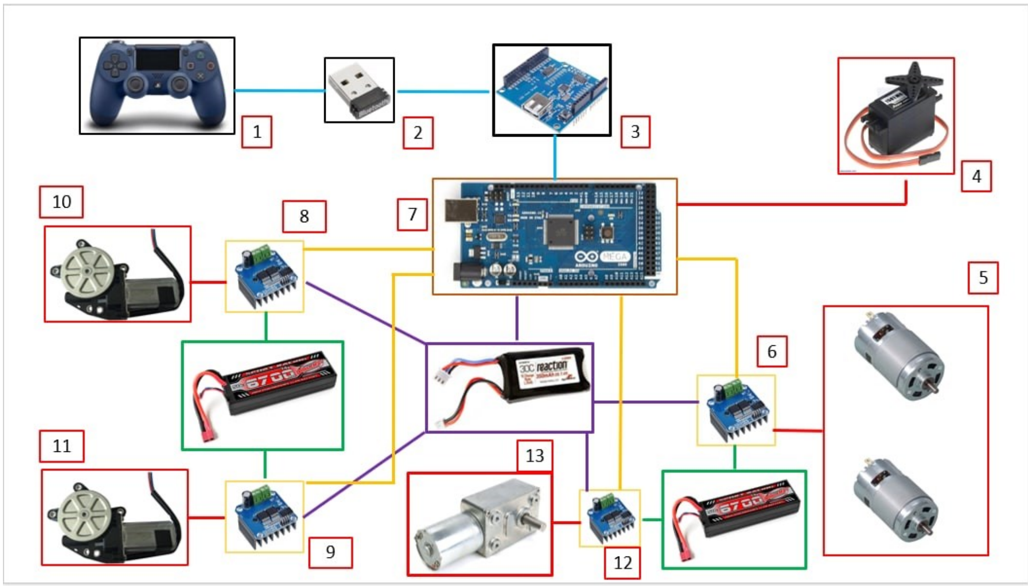


Figure 6: R2 diagram

Figure 6 shows the actual size for the R2. Basically, the components consist of servo motor, rack, gripper bracket and the fork to pick an object. The height limit for the R2 to lifting an object is about 700mm which is based on the height of the 5 lagori discs.

3. SYSTEM CONFIGURATION

3.1 SCHEMATIC DIAGRAM



Item:

PS 4 Controller

We use ps4 controller because it can simplify our work from installation and programming. In addition, there are many buttons and joysticks that can be used for certain functions

Bluetooth Dongle 4.0

We use a Bluetooth 4.0 dongle as an intermediary to send a signal from the PS4 to the Arduino by using a Bluetooth signal to control the output on the robot

USB host shield

We use USB host shield because it can be used as a slot to install a Bluetooth dongle to the arduino. In addition, the use of these components can also be easier and more tidy in terms of wiring

Arduino mega

We use atmega arduino because this component has many inputs and outputs. therefore, it can be used for installations that involve the use of numerous Inputs and Outputs on the robot

BTS796

We use BTS796 motor driver because this component can accommodate higher Amp than dc motor of 42 Amp. In addition, this motor can accommodate up to 27 volts of input voltage

Servo

We chose servo because it can facilitate the movement of the gripper. in addition, the high torque helps from the object held by the gripper falling

21000 rpm DC motor

We use this component because of its advantages in terms of motor rotation which can reach up to 21000 rotations per minute. With this advantage, it can shoot the ball farther

Power window dc motor

We use power window because of its advantage that it has a high torque and it can facilitate the movement of robots that have a heavy mass

3.2 I/O LIST

3.2.1 R2 SYSTEM

PROCESSING UNIT

NO.	COMPONENT	DESCRIPTION
1.	Arduino Atmega 2560	As a unit processing to control input and output robot

INPUT

NO.	COMPONENT	DESCRIPTION
1.	Joystick Controller	Control Robot
2.	USB Dongle 4.0	Signal intermediation from PS4 to Arduino via Bluetooth Signal
3.	USB Host Shield	As a slot for bluetooth dongle installation and processing bluetooth signal to signal input for arduino

OUTPUT

NO.	COMPONENT	DESCRIPTION
1.	Servo Motor	To control mechanism to feed the ball into the high speed shooter mechanism
2.	24V DC Motor	As a high speed ball shooter mechanism
3.	Motor Driver BTS796	To control shooter's DC motor
4.	Motor Driver BTS796	To control **RIGHT** side power window dc motor for robot movements.
5.	Motor Driver BTS796	To control **LEFT** side power window dc motor for robot movements.

6.	12V Power Window Dc Motor	Used as a motor to move robot tires for **RIGHT** side
7.	12V Power Window Dc Motor	Used as a motor to move robot tires for **LEFT** side
8.	Motor Driver BTS796	To control the angle of the shooter's Worm Gear DC motor
9.	12V Worm Gear DC Motor	To control angle of robot shooter's mechanism

3.2.2 R2 SYSTEM

PROCESSING UNIT

NO.	COMPONENT	DESCRIPTION
1.	Arduino Atmega 2560	As a unit processing to control input and output robot

INPUT

NO.	COMPONENT	DESCRIPTION
1.	Joystick Controller	Control Robot
2.	USB Dongle 4.0	Signal intermediation from PS4 to Arduino via Bluetooth Signal
3.	USB Host Shield	As a slot for bluetooth dongle installation and processing bluetooth signal to signal input for arduino

OUTPUT

NO.	COMPONENT	DESCRIPTION
4.	Servo Motor	To control Gripper's robot
6.	Motor Driver BTS796	To control power window DC motor
7.	Motor Driver BTS796	To control power window DC motor
8.	Motor Driver BTS796	To control power window DC motor
9.	12V Power Window Dc Motor	To control the movement of the robot omni wheel
10.	12V Power Window Dc Motor	To control the movement of the robot omni wheel
11.	12V Power Window Dc Motor	To control the movement of the robot omni wheel
12.	Motor Driver BTS796	To control worm gear DC motor for gripper
13.	12V Worm Gear DC motor	To control robot gripper movements
14.	Electro Pneumatic Valve	To control pneumatic vacuum mechanism

UNIVERSITI MALAYA (UM) ROBOTICS ENGINEERING COMMUNITY (REC)

Teo Jin Kang[1], Bryan Leong Weng Hong[1], Tan Chun Wei[1], Khaw Lin Koon[1], Chong Wen Liang[2], Ooi Sheng Wang[2], Tan Shi Hong[1], Ng Hao Wei[1]

[1]Department of Electrical Engineering, Faculty of Engineering, Universiti Malaya, 50603 Kuala Lumpur, Malaysia.

[2]Department of Mechanical Engineering, Faculty of Engineering, Universiti Malaya, 50603 Kuala Lumpur, Malaysia.

ABSTRACT

In conjunction with the ROBOCON Malaysia 2022, our team has built two robots, Robot 1 (R1) and Robot 2 (R2). The shooting mechanism of R1 consists of two flywheels powered by DC brushed motor. The shooting mechanism is equipped with encoder to control the angle of attack of the ball. R2 consists of ball gripping and Lagori gripping mechanism. R2 will pass the hitter balls to R1 by loading the balls onto the 3-way track attached on R1. After continuous testing, R1 successfully aim and shoot the Lagori with 75% accuracy. There were some modifications made to improve the shooting mechanism. The flywheel is designed with a parabolic shape and rubber foam was attached on its surface to increase the traction between

the flywheel and the ball. Besides, R2 successfully grips the hitter balls firmly and passes the balls to R1. One possible real-life application of our robots would be a ball launcher machine which can facilitate sports training session.

1. INTRODUCTION

Lagori or "Tuju Tin" is played by breaking a stone tower and piling up the stones while being interrupted by the opponents. Our team has designed and build two robots, namely Robot 1 (R1) and Robot 2 (R2). R1 is responsible for shooting the Lagori and the opponent's Ball on Head (BH). Whereas R2 is responsible for gripping the hitter balls and passing them to R1. R2 will also grip and pile the Lagori according to their diameters in the Lagori Area. The team achieves Perfect Lagori in the shortest period of time will win the game.

We aim to design and build efficient robots for the contest while considering environmental sustainability. We are keen to develop creativity, critical thinking, and problem-solving skills throughout the preparation for the contest.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

2.1.1 SEEKER R1 (R1)

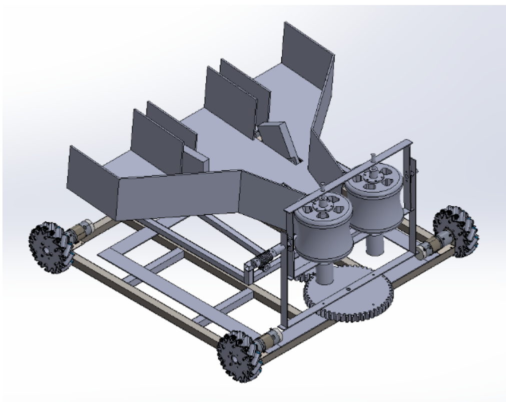
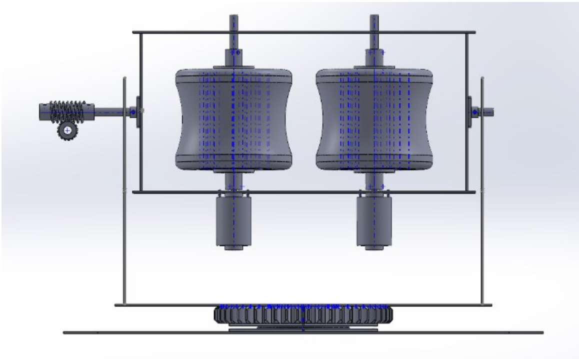


Figure 1: (a) Isometric View of R1



(b) Flywheel Mechanism

Figure 1(a) shows the detailed overall structure of robot R1. A flywheel mechanism is used to shoot the seeker balls. Laser distance sensors will convert the actual distance and angle between R1 and the target to provide input for better aiming. The rotational energy of each flywheel powered respectively by 2 DC brushed motors with maximum RPM of 3500 r/min will be transferred to as linear motion of the seeker balls. Motors with encoders will alter the rotation of the mechanism among the Z and X axis for aiming purposes. A 3-way track equipped with ball stoppers is used to store and load a maximum of 3 seeker balls at one time.

During trial runs using a cylindrical shaped flywheel, we noticed the traction between the flywheel and seeker ball is not high enough due to a less contact area. This will cause the seeker balls to slip from the flywheel and affects the accuracy of shooting. Thus, the shape of the flywheel is designed with a parabolic shape to increase contact area with the seeker ball as shown in figure 2. Rubber Foam was also used to increase friction, normal force and surface area of grip during the shooting motion. Furthermore, vibration was a huge issue especially when the flywheel is rotating at high rpm. To resolve this, we found out the most suitable solution is to install 2 ball bearings to secure the rod firmly and reduce its vibrations.

For locomotion, a four mecanum wheel system was utilised to provide multi-directional movement.

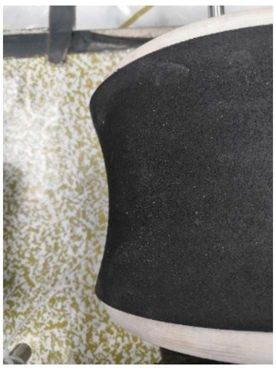


Figure 2: Parabolic-shaped flywheel

2.1.2 SEEKER R2 (R2)

Figure 3: (a) Isometric view of R2

Figure 3(a) shows the structure of R2. The structure's main frame is constructed using mild steel by welding for higher strength and durability. For hitter ball gripping action, it utilises a centralised raisable pneumatic system, providing uniform gripping action to save time. R2 will positioned itself behind R1 to pass the hitter balls to R1's 3-way track.

On the other hand, for Lagori gripping action, initially 2 types of system were tested for prototyping, which are the four-bar linkage and the rack and pinion, but the main drawback for both systems was they both provide insufficient torque and were overly challenging to be manufactured. Instead, a chain and sprocket system with a gear ratio of 1:10 is used to gear up and increase torque for the lifting action for Lagori gripping action. Linear actuators will grip the Lagori with varying diameters with the help of limit switches. This will prevent over gripping of Lagori by stopping the retraction of the linear actuators. For locomotion, a four omniwheel system was chosen to provide omnidirection motion because of its higher stability and lesser vibration when experiencing high acceleration.

2.2 ELECTRONIC DESIGN

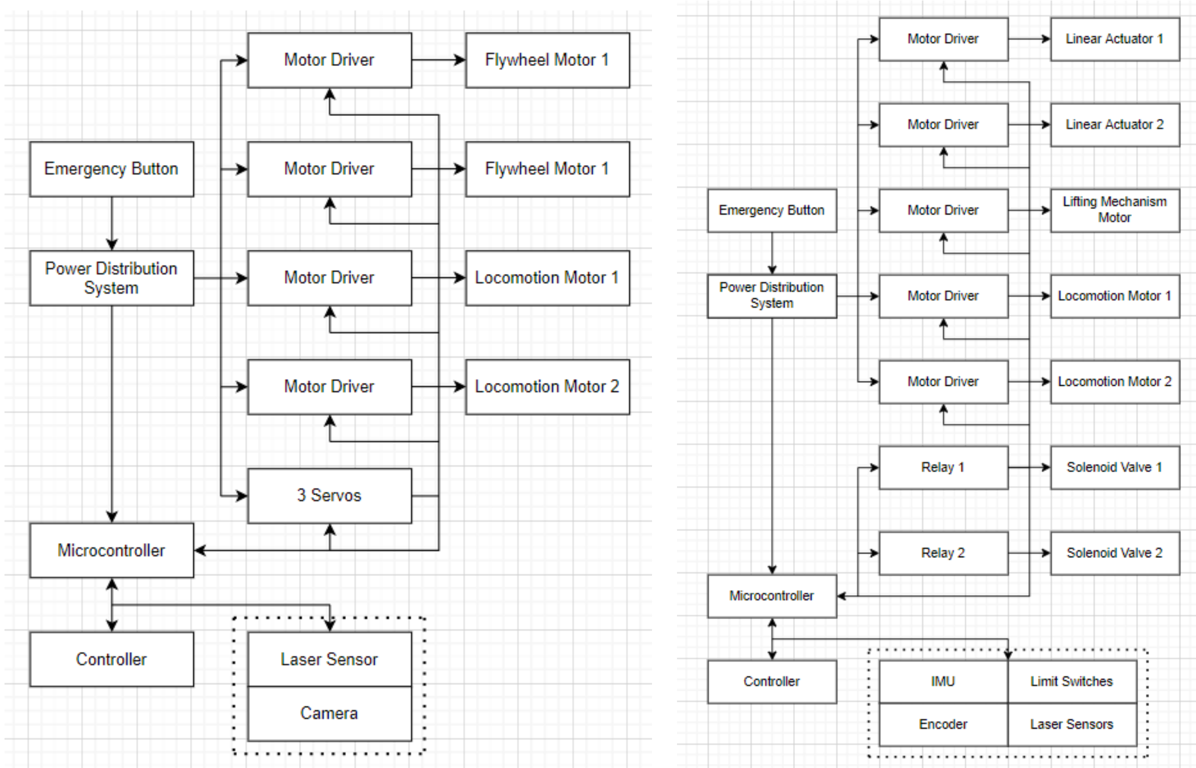


Figure 4: Electronics Block Diagram (a) Robot R1 (b) Robot R2

Figure 4(a)-(b) shows the electronic block diagram for robots R1 and R2 respectively. For both robots, they share the same locomotion design as both robots are 4 wheeled robots. In the locomotion system, 4 motors are paired with 2 dual channel of motor driver to move the robot. In our design, the motor driver MDD10A is used. It is a dual channel and reduces the amount of motor drivers by half.

For robot R1, the main components to connect is the shooting mechanism, which contains 2 flywheels attached to DC brushed motors and 3 servo motors to control the loading of balls. For robot R2, the main components to connect is the lagori and hitter ball gripping mechanism, which contain 2 solenoid valves with relays, a power window motor and 2 linear actuators. The relays connected to the solenoid valves are controlled by the microcontroller.

Various sensors are used to enhance the capabilities of the robots. Both robots use microcontrollers to process the information provided by the sensors. One of these sensors is the inertia measurement unit (IMU). It is used in both robots to provide feedback to PID control system in our microcontrollers to ensure that the robot is moving in the correct direction. Laser sensors are also used for distance measurement.

For the robot R2, external encoder is used for navigation on the game field. Encoders allow the robot to have more accurate positioning during navigation. Encoders convert the motion of the robot into electrical signals which will be received by microcontroller for processing. A pair of limit switches are also used to detect if the lagori disc has been firmly gripped by the gripper on robot R2.

2.3 SOFTWARE DESIGN

For both robots R1 and R2, the ARM microcontroller is used to perform the logical algorithm. The microcontroller controls the navigation of the robot and mechanisms used to perform different tasks during the game.

2.3.1 FEATURES FOR R1

Figure 5 depicts the algorithm flow chart for R1 in seeker mode and Figure 6 depicts the algorithm flow chart for R1 in hitter mode. In hitter mode, R1 will receive three balls from R2 and the balls will be loaded into the loading mechanism. The R1, with the aid of an aiming mechanism, will try to locate the seeker's Ball on Head (BH). It will shoot the ball when it targets the BH. In seeker mode, R1 will aim the Lagori disc and try to break the Lagori using the three balls loaded on it.

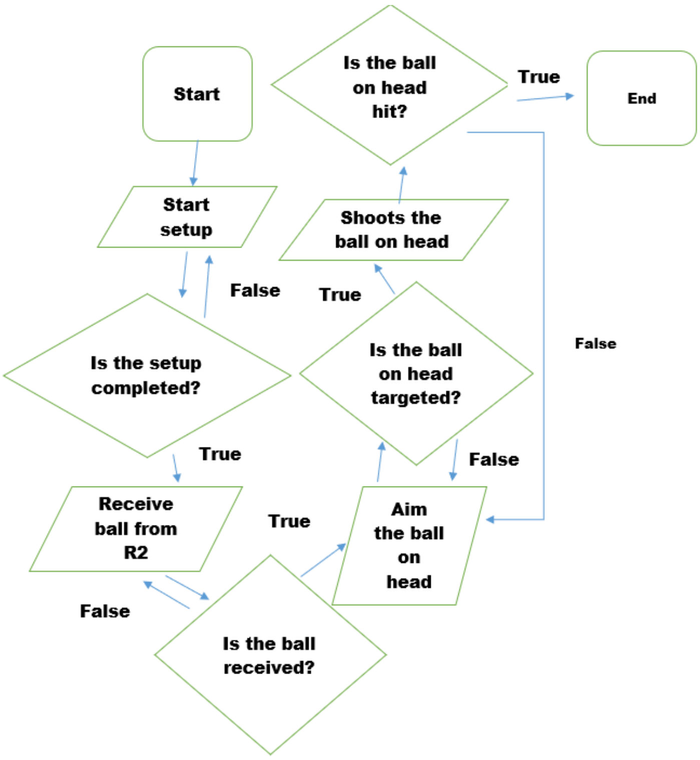


Figure 5: Algorithm flow chart of Hitter R1

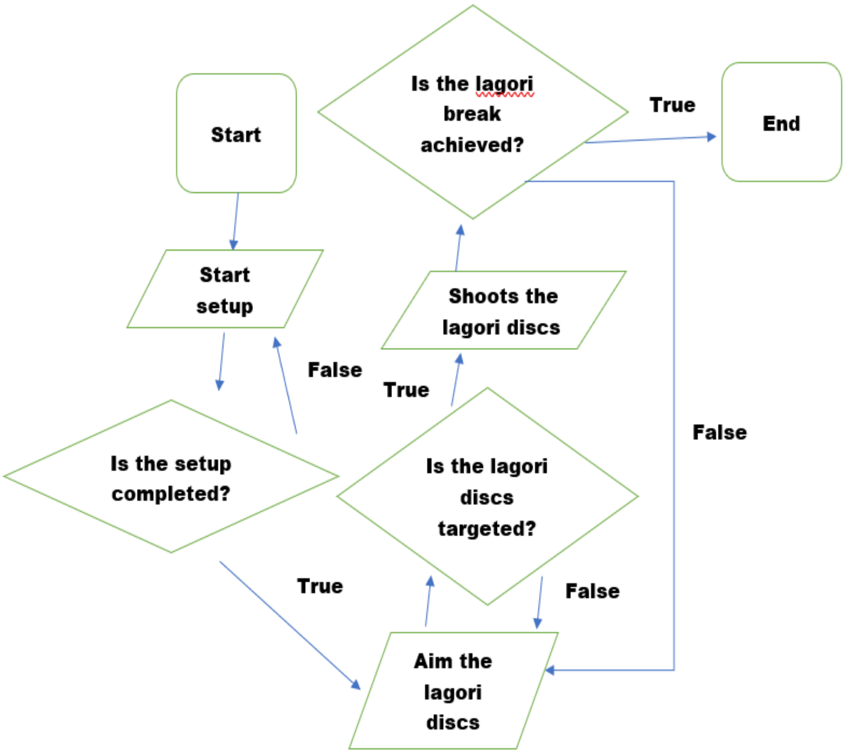


Figure 6: Algorithm flow chart of Seeker R1

2.3.2 FEATURES FOR R2

Figure 7 depicts the algorithm flow chart for R2. In hitter mode, the R2 is responsible for gripping the hitter balls and loading them into Hitter R1's loading mechanism using its gripper. In seeker mode, the R2 is responsible for gripping the Lagori discs which are scattered on the Lagori Area and piling them back to their original position according to their respective size.

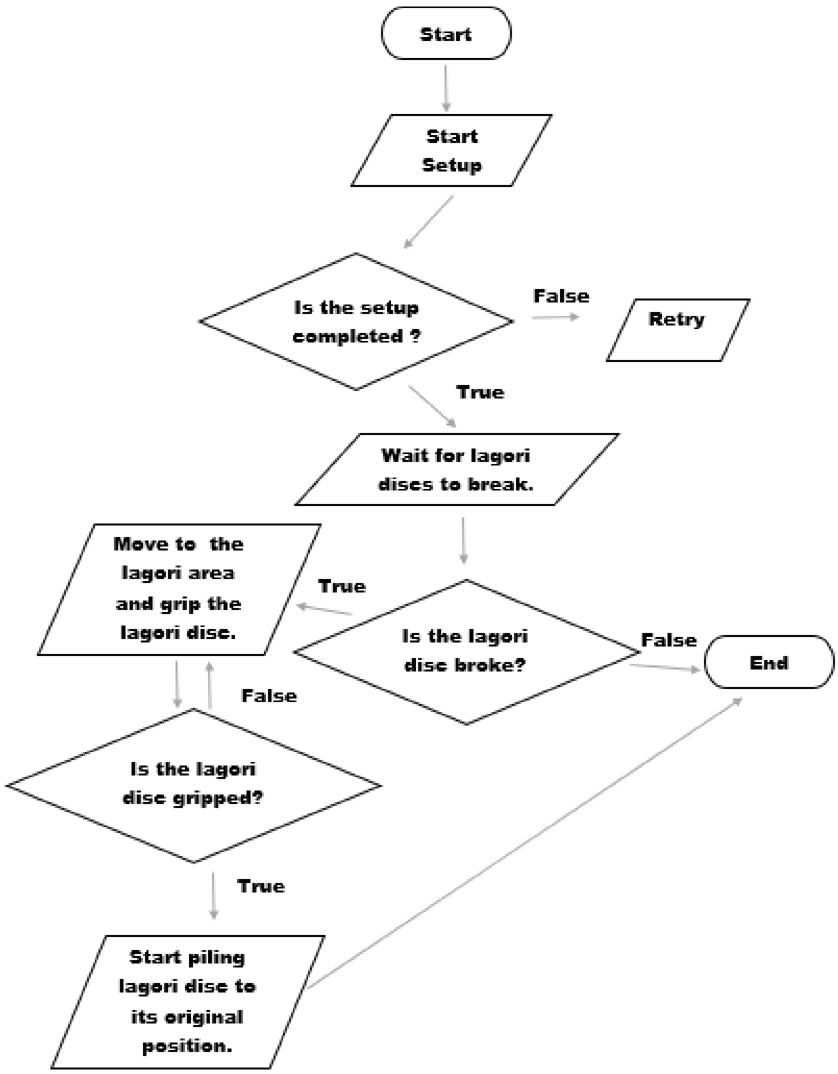


Figure 7: Algorithm flow chart of Seeker R2

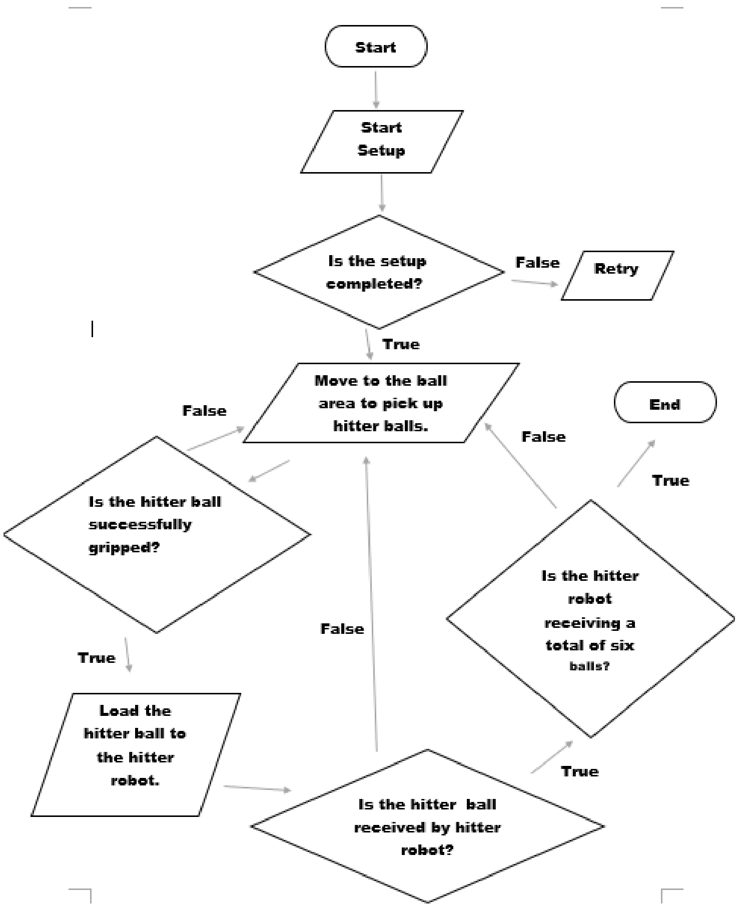


Figure 8: Algorithm flow chart of Hitter R2

3. PRESENTATION OF DATA

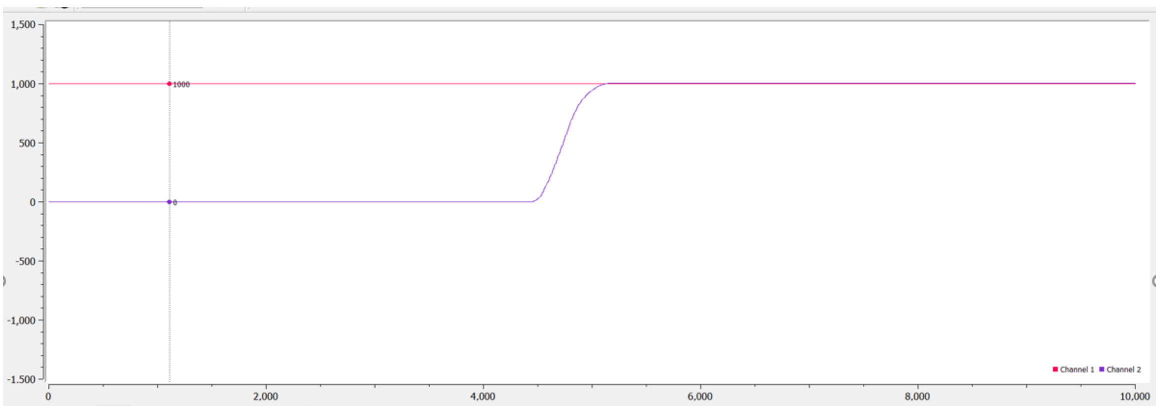


Figure 9: Graph Output vs Time Elapsed

Figure 9 depicts the tuning process carried out to determine the parameters needed for Proportional, Integral and Derivative (PID) Control in robot's locomotion. By adjusting the PID parameters, different responses have been observed and analyzed. After performing several tuning processes, the most suitable PID parameters have been determined and recorded. From the figure above, greater stability with reduced error is achieved for the robots accompanied with the design limitations.

4. DISCUSSION/EVALUATION OF FINDINGS

Our robot uses a chain and sprocket to lift the gripper of Lagori disc during the process of pilling the Lagori disc. Due to the heavy weight of the gripper mechanism, we utilize the 1:10 gear ratio to increase the torque of the motor. When our robot is gripping the Lagori disc, a pair of limit switches will stop the retraction of the linear actuators once the Lagori disc is firmly gripped by our robot. The use of linear actuator allows our robot to grip Lagori disc with different diameters without the limitation of the stroke length of pneumatic cylinder. Besides, our shooting mechanism integrates encoder to precisely adjust the angle of attack to make the aiming of Lagori disc easier. Laser sensor also helps to obtain the distance between the flywheel and our target so that the velocity of the ball can be adjusted according to the position of the target.

5. SUSTAINABLE ENGINEERING PRACTICES

Ensuring sustainable engineering development has always been the principle of REC UM Team. Our robots are built based on the 3R principles – Reuse, Reduce and Recycle. Majority of the components and materials used to build our robots are from past year's robots. Electronic components such as motors, connecting wires and circuit boards from previously built robots are reused to save cost and reduce undesired electronic waste. Moreover, our team perform simulation using CAD software to reduce material waste during fabrication. As a result, the development of our robots utilizes existing resources to prolong the materials' life and minimize the metal waste in our projects.

6. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

Throughout the preparation for the ROBOCON Malaysia 2022, we have learned and practiced robotics knowledge such as simulation software and pneumatic systems in our projects. The development of robot R2 is a great challenge for us because the lifting mechanism is required to lift the heavy Lagori gripping mechanism during the process of pilling the Lagori disc. Materials with lighter weight could be used so that the motors can lift the gripper quicker. Another limitation would be the vibration caused by the flywheel rotating at high rpm. Using two bearings to secure the rod attached to the flywheel would help to stabilize the structure.

7. ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to the Faculty of Engineering, Universiti Malaya for providing financial and management support to our team. We appreciate the facilities provided by university for us to build our robots. We owe a deep sense of gratitude to our advisors Prof. Mahmoud Moghavvemi, Dr. Wong Wei Ru and Dr. Sharifah Fatmadiana binti Wan Muhammad Hatta for providing supports in terms of technical issues and team management throughout the process. Finally, we would like to thank Penco Eelctronics (M) Sdn. Bhd. for the continuous support and valuable advice you have shared to help us in the preparation for Robocon Malaysia 2022.

REFERENCES

[1] Cadence. (2020, August 27). What is a star ground layout and why do you need it? PCB Design & Analysis. Retrieved September 19, 2021, from https://resources.pcb.cadence.com/blog/2020-what-is-a-star-ground-layout-and-why-do-you-need-it.

[2] Ericvoje (2017, October 17) Creating a DualShock 4 Controlled Arduino Retrieved September 19, 2021, from https://www.instructables.com/Creating-a-DualShock-4-Controlled-Arduino/.

[3] Last Minute Engineers. (2020, December 18). In-Depth: How rotary Encoder works and interface it with Arduino. Retrieved September 19, 2021, from https://lastminuteengineers.com/rotary-encoder-arduino-tutorial/.

[4] PBC Linear. (n.d.). Belt Drive or lead screw? Retrieved September 19, 2021, from https://www.pbclinear.com/Blog/2020/February/Lead-Screw-or-Belt-Drives.

[5] Teknic. (2020, October 20). Securing mechanics to motor shafts. Retrieved September 19, 2021, from https://www.teknic.com/securing-mechanics-motor-shafts/#set-screws.

UNIVERSITI MALAYSIA PAHANG (UMP) BOT

Nazwa Najmuddin Bin Mohd Nizwaruddin, Nur Amni Qistina Binti Muhammad Zawawi, Muhammad Najmi Bin Abdul Shukor

Fakulti Teknologi Kejuruteraan Pembuatan dan Mekatronik, Universiti Malaysia Pahang, Pekan, Pahang, 26600

ABSTRACT

Robocon Malaysia 2022 participants required to design robots that can break the Lagori accurately and stack the Lagori according to its sizes. There are two robots for this year's competition which is the R1 Hitter and Seeker, and R2 Hitter and Seeker. UMPBOT R2 robot is inspired by the forklift and elevator mechanism. UMPBOT R2 uses claw mechanism for the gripper to grip and stack the Lagori on the Lagori base. Meanwhile, UMPBOT R1 robot is inspired by the football launcher mechanism. The simulation and the testing were as expected. There are several fine tuning and optimization need to be made to ensure the robot's high accuracy and power to break and stack the Lagori. UMPBOT R1 utilises 30 seconds of break shot time to break all the Lagori. Next, UMPBOT R2 uses fully 90 seconds to stack all five (5) Lagori on the Lagori Base. UMPBOT robots are unique because all the mechanical parts were designed and fabricated by UMPBOT. Other than that, UMPBOT also designed the PCB (Printed Circuit Board) to ensure the simplicity of the electronic wiring by applying professional practice to the robots. The sustainable engineering practice was applied by using metal and aluminium scraps to create the robot. Rechargeable batteries were also used to power the robot. This is because UMPBOT aims to apply the sustainable engineering practices such

as use reusable alternatives. Finally, UMPBOT also aims to prevent any error or produce waste materials during the fabrication process.

1. INTRODUCTION

First and foremost, it is important to understand the rules of the game. Later, the mechanisms are developed to simplify the task of each robot and make them as efficient as possible. Based on these mechanisms, the robots are designed to fully compromise the tasks and rules according to the rulebook.

The task assigned to each robot varies depending on the strategy of each team. UMPBOT developed throwing ball mechanism for R1 as a Hitter and Seeker. Considering the task for R2 which is to lift and arrange the Lagori back on their base, there are additional mechanisms for R2. In other words, R2 task mainly focused on picking up the balls and Lagori disks.

There are few problems arise during accuracy test of hitting point for R1, which are the designing process and defects after fabrication. To compensate these issues, modifications were made for the parts involved. The designing process was started by doing few research on the best method to throw the ball to the designated point on the Lagori disks. The disadvantages of rejected methods are the lack of sustainability and complex design. Complex design is impractical and difficult to fabricate especially without proper machine and equipment. Once the method is decided, the mechanism is upgraded by tuning the angle to produce the best result.

As for R2 there are 2 major mechanisms, collect the balls from ball rack and piling up the Lagori disks. The challenges in developing R2 are finding the best electrical components and create a compatible mechanical part that would not interrupt the objectives of each mechanism. Even the smallest part of a mechanism would affect the whole system. Hence, the details of each part are considered during designing especially when the mechanical part is attached with electrical components.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGNS

2.1.1 MECHANICAL DESIGN FOR ROBOT 1

The mechanical part of the Robot 1 (R1) has one major part, which is the launcher mechanism. The entire robot design is fabricated using scrap metals and aluminium.

The base of this robot is made up of mild steel that was designed to fit the omni wheels at each corner for robot movement. Compared to normal wheel that could only move in one direction, omni wheels allow the robot to move freely in two directions.

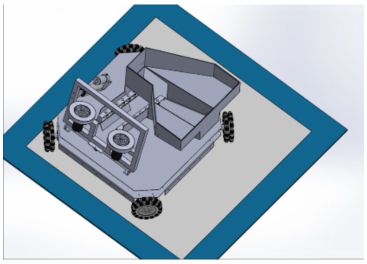


Figure 1: R1 Mechanical Design

2.1.2 MECHANICAL DESIGN FOR ROBOT 2

A key aspect of R2 is Ball on Head (BOH) and the mechanisms of Robot 2 (R2) may be highlighted into 2 sections, which are ball fetch mechanism and gripper mechanism. Both mechanisms were assigned for two different tasks, collecting balls from ball rack and stacking up the Lagori disks respectively.

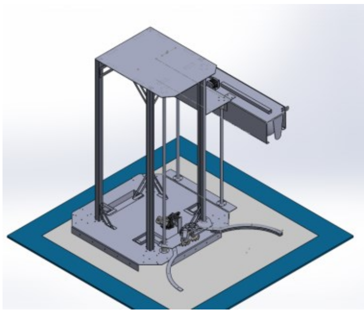


Figure 2: R2 Mechanical Design

2.2 ELECTRONIC DESIGN

2.2.1 PRINTED CIRCUIT BOARD (PCB)

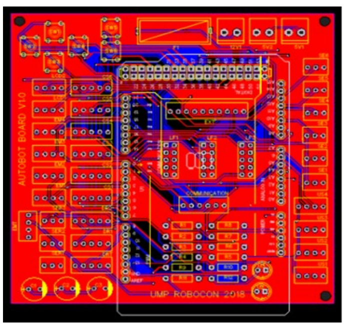


Figure 4: PCB for Main Controller

Both robots are controlled using Arduino Mega microcontroller and powered using 12V Lithium Polymer (Li-Po) batteries. To avoid excessive voltage, a voltage regulator is included in the electrical design. The microcontroller connects all electronic components for each robot mechanism.

2.3 PS2 SHIELD

Robot movement is controlled using PS2 controller thus, Cytron PS2 shield is required for communication between the robot and PS2 controller. This enables an easy data reading from PS2 controller signals which are then transmitted into Arduino to execute instruction based on program codes.

2.4 SOFTWARE DESIGN

Software design is divided into two parts, specifically to fulfil tasks and objectives of each robot. Figure 2 and Figure 3 shows the flowchart on task execution for each robot based on PS2 controller buttons.

2.4.1 FLOWCHART FOR R1

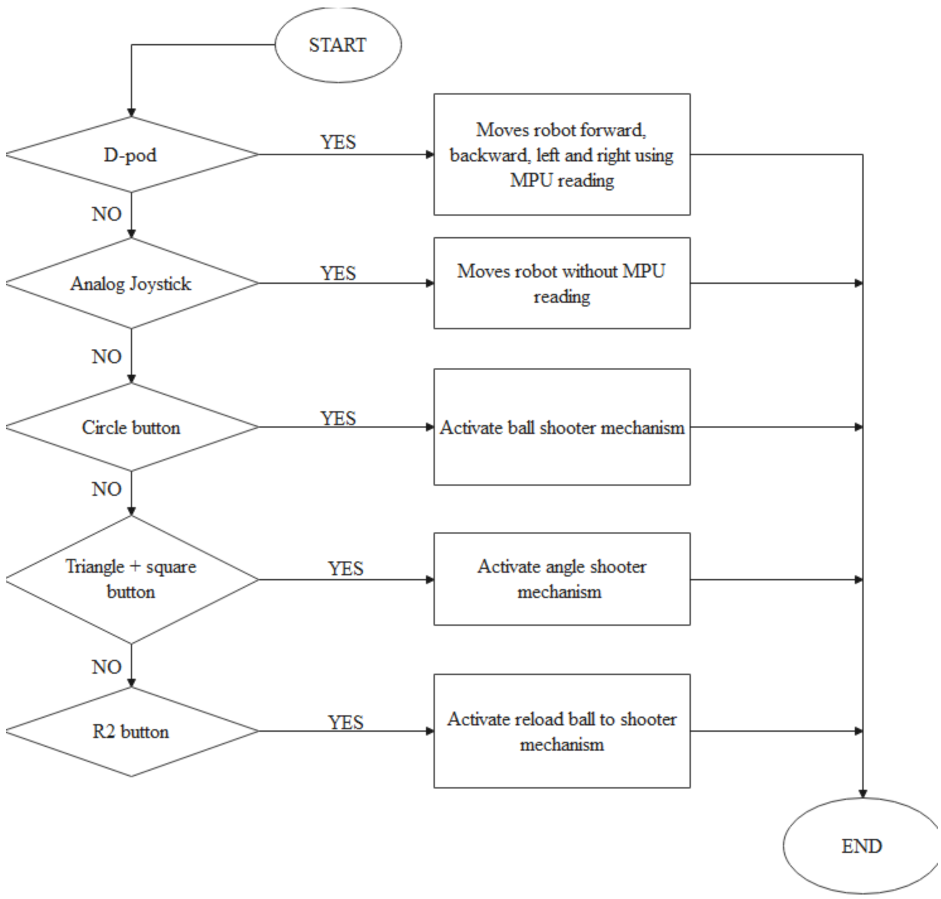


Figure 3: Flowchart for R1

2.4.2 FLOWCHART FOR R2

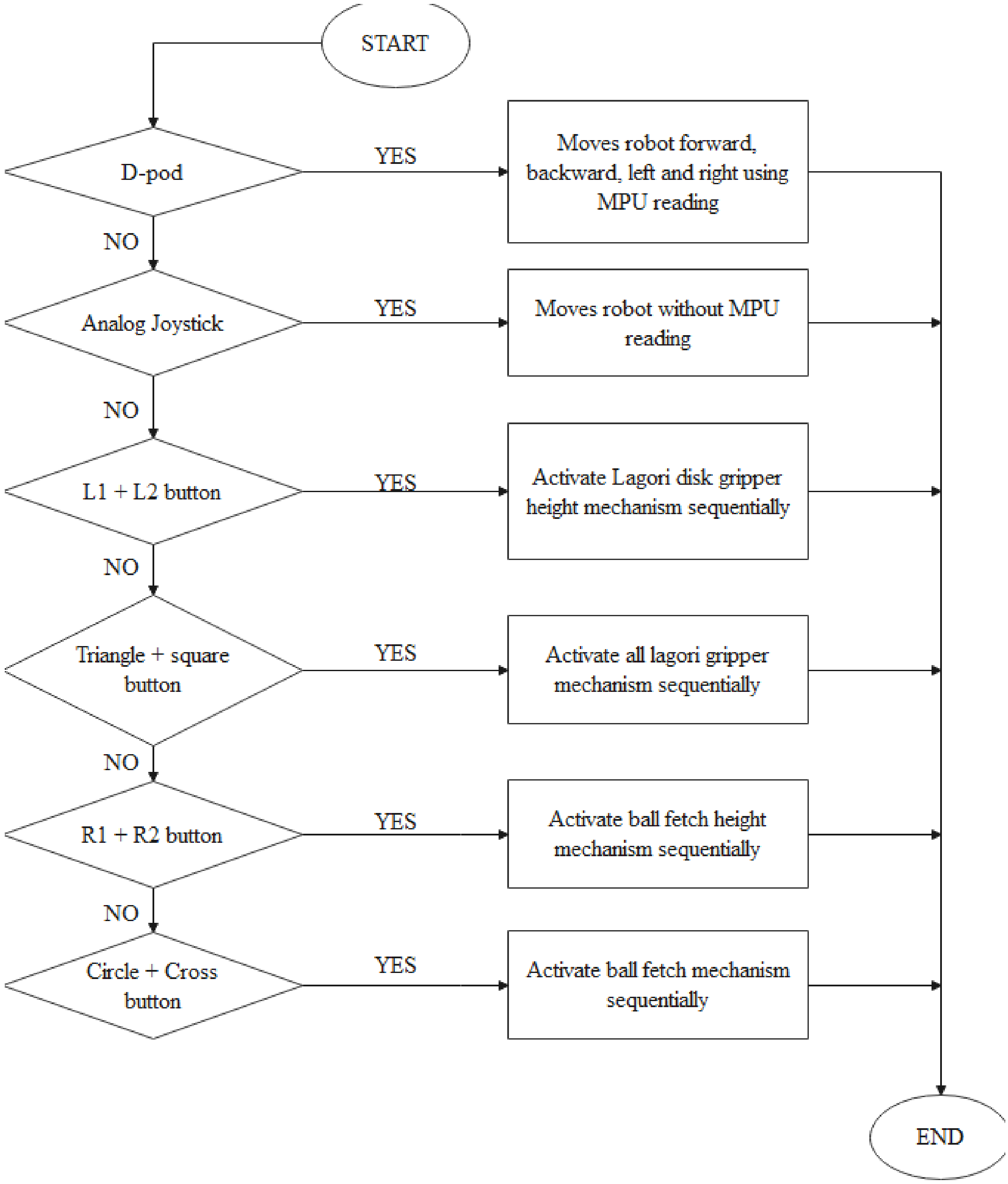


Figure 4: Flowchart for R2

3. PRESENTATION OF DATA/SIMULATION/TESTING

To achieve the objectives for each mechanism, several tests were made to collect data by changing the shooter angle. Before each mechanism is finalised, a prototype was designed to list out all of the possible outcomes.

Table 1: Results of R1 Shooter Mechanism for Lagori Break

Parameters				
Shooter Angle (°)	10	20	30	40
Initial Height (m)	0.5	0.5	0.5	0.5
Lagori Hit	2	3	1	1

Table 2: Results of R2 Gripper Mechanism for Lagori Pile

Method	**Gripper Material**	**Time taken (s)**
Actuator	Mild Steel	78.95
DC motor	Mild Steel	85.67
Stepper motor	Mild Steel	91.25

4. DISCUSSION

A possible explanation for the results obtained in Table 1 may be the lack of compatibility between the variables. For instance, the shooter mechanism needs to consider the height of the mechanism and the fixated angle to shoot the ball. However, the main concern during this test was the speed of the ball. Using the method tested for shooter mechanism, the projectile motion varies depending on the angle and height of the shooter. Hence, changing this variable would also affect the velocity of the ball and resulting a low number of Lagori hit. In simpler terms, the speed of the ball is affected because of the density of the Lagori disks. Shooting the ball with a low speed could not hit the Lagori disks effectively at the designated point. To counter this setback, it was figured that the height of the mechanism is the key parameter to maintain a high-speed ball that could break the Lagori disks. Changing the angle would only increase the maximum height and thus cause a parabolic curve and the ball lands on lower point of the Lagori disks with lower speed.

Gripper mechanism is more focused on the methods that would be able to hold the Lagori disks firmly and able to stack them back on Lagori base. If the gripper mechanism is weak and cause the Lagori to slip, additional time is required and it would increase the chances of Ball on Head (BOH) to be hit or falls by itself. Due to practical constraint, the main concern for R2 is BOH as the robot would move in a dynamic motion to collect the Lagori disks and pile them up.

5. SUSTAINABLE ENGINEERING PRACTICES

To ensure that the development of these robot does not harm the environment in any way, the material used for mechanical design are made of scrap metals and aluminium. It might seem preposterous on how using scrap metals would avoid harming the environment, but scrap metals would cause a major change in the ecosystem which includes plants, animal and humans.

According to Chukwu et. al (2019), dumping scrap metals without a proper disposal could lead to a high concentration of heavy metals in soil and water. For which, WHO has sets limit for heavy metal concentration in drinking water for safe consumption. If this issue is ignored, unknowingly human could consume a toxic drinking water especially in long term. The study proves that at a dumping area of scrap metals, the soil quality would be degraded.

6. CONCLUSION, LIMITATIONS, AND RECOMMENDATIONS

After almost 5 months and more of completing both robots R1 as Seeker and Hitter and R2 as Seeker and Hitter, finally the robots accomplish all task given on Robocon Malaysia 2022. Each robot has unique mechanism, which is each mechanism required more detail in part to ensure properly working design. There are several parts that was hard to complete which is gripper mechanism which use to grip Lagori. Secondly, Ball launcher mechanism is to launch the balls to break the Lagori, and to stack the Lagori in the area given. The limitation of we faced is the strength versus weight of material used. The design for the foundation using hollow bars has been replaced to mild steel plate, it is one of the innovations with the concept of "plug and play". This concept will be linked to other mechanisms. This concept is used to be applied for future robots to compete in Robocon competition.

There are also several recommendations that can be made to improve for both robots. Firstly, the robot can be improved by adding sensor to go through the obstacles gently. Secondly, auto set the angle for R1 as function to hit the Lagori and hit ball at head opponent by using mathematical calculation and encoder motor to set the actual angle for several function.

7. ACKNOWLEDGEMENTS

UMPBOT Robocon Team would like to extend our gratitude to our alma mater which is the Universiti Malaysia Pahang (UMP) for giving us the opportunity to participate in Robocon Malaysia 2021. UMPBOT Robocon Team also is grateful to our UMPBOT advisors: - Dr. Ahmad Najmuddin Ibrahim, Dr. Mohd Razali Daud, Dr. Asrul Adam, Dr. Muhammad Aizzat Zakaria, Dr. Saifudin Razali, Dr. Nurul Hidayah Razak, Mr. Idris Mat Sahat and Dr. Ir.

Addie Irawan Hashim for their guidance throughout the completion of this Robocon project. Finally, UMPBOT Robocon Team cherish to every team member for their enormous contribution to complete and participate in Robocon Malaysia 2022.

REFERENCES

[1] Dustin J. Welbourne, Andrew W Claridge, David Paull, Andrew Lambert, June 2016, from https://www.researchgate.net/publication/304608153_How_do_passive_infrared_triggered_camera_traps_operate_and_why_does_it_matter_Breaking_down_common_misconceptions

[2] Jost D. (2019, July 30). What is an IR sensor? Fierce Electronics. Retrieved September 18, 2021, from https://www.fierceelectronics.com/sensors/what-ir-sensor

[3] Brief Introduction of Omni-Wheel, 2021

[4] Mega 2560 Rev3. (n.d.). Arduino Documentation. https://docs.arduino.cc/hardware/mega-2560/

[5] Chukwu, Victoria & Anoliefo, Geoffrey & Ikhajiagbe, Beckley. (2019). Environmental Impact of Scrap Metal Industries: Examination of Vertical Seepage of Scrap Metal Effluents (Heavy Metals) into the Aquifer ARTICLE INFORMATION ABSTRACT. 118-127. From https://www.researchgate.net/publication/343278454_Environmental_Impact_of_Scrap_Metal_Industries_Examination_of_Vertical_Seepage_of_Scrap_Metal_Effluents_Heavy_Metals_into_the_Aquifer_ARTICLE_INFORMATION_ABSTRACT

UNIVERSITI MALAYSIA PERLIS (UNIMAP) A

Ts. Ismail Ishaq Bin Ibrahim[1], Dr. Sukhairi Bin Sudin[1,] Mohammad Asyraaf Bin Ibrahim[1], Ahmad Hasif Izzudeen Bin Ahmad Tazudin[1], Zakirah Binti Zaludin[3], Nureen Faqihah Binti Zumardi[1], Mohamad Amir Hamzah Bin Md Yusof[1], Sufi Suraya Binti Halim[2], Muhammad Shafwan Bin Anis[1], Allice Tan Mun Yin[2], Zareq Iskandar bin Zuhaidi[1], Syahrul Anwar Bin Shahabuddin[1], Shujairi Bin Shahdzar[1]

[1] Faculty of Electrical Engineering Technology, FTKE 1 Building, Kampus Pauh Putra,Ulu Pauh, 02600 Arau, Perlis

[2] Faculty of Mechanical Engineering Technology, Kampus Pauh Putra,Ulu Pauh, 02600 Arau, Perlis

[3] Faculty of Electronics Engineering Technology, Kampus Pauh Putra,Ulu Pauh, 02600 Arau, Perlis

ABSTRACT

This robot was built to participate in the ROBOCON Malaysia 2022 with the theme “Merempuh Cabaran Membina Impian”. According to the rules, 2 robots are needed for this competition. One robot is called R1 and another robot is known as R2. To fulfil the task of this competition, UniMAP team decided to use manual robots for both R1 and R2. R1 is designed as a receiving and shooting robot where the robot can both receive the ball and shoot the ball to the ‘lagori. The design for R2 was adapted from a catapult design using a pneumatic system

as the source of catapulting force. During testing session, both R1 and R2 successfully throws and shoot the balls at the 'lagori'. For this year, our team successfully utilized the pneumatic system for throwing and DC motor for shooting the ball thus makes our robot unique. In term of materials, both robots were made by reusing aluminium taken from previous robots and we managed to cut back in buying new aluminium. Almost all of the material used in building this robot was taken and reused from older and non-usable robots. Furthermore, these robots can be utilized for agriculture application where the throwing and shooting mechanism can be adapted to gather fruits from a tree and can be placed at the designated gathering area.

1. INTRODUCTION

The design of the R1 robot is targeted to be accurate and precise as the robot needed to shoot the ball at the 'lagori'. Hence, the main strategy is to equip the robot with a 24V DC motor with high torque for the shooting mechanism. By doing this, the robot can shoot harder and faster than a 12v DC motor. In addition, it is powerful enough to shoot the ball at least 2.5 metres away. R1 will shoot 3 balls at the 'lagori' as fast as possible. For R2, this robot were made to be precise as well as fast in manoeuvrability to make sure it picked up the fallen 'lagori' as fast as it can.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGNS

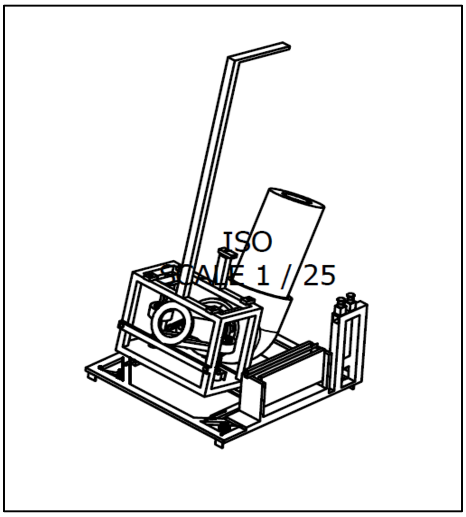


Figure 1: Design of R1

The design for R1 is as in Figure 1, it consists of a shooting mechanism powered by two DC motors to release the ball fast and hard at the target. After a few upgrade, finally the R1 robot manages to shoot the balls with high accuracy and high repeatability.

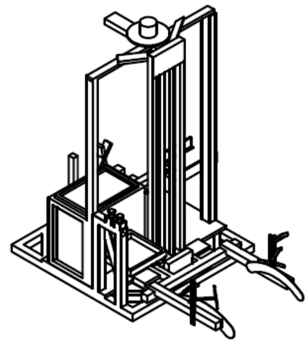


Figure 2: Design of R2

The first design of R2 is just equipped with a throwing mechanism. The accuracy of this robot is very high and the manoeuvrability is quite good. There were not much modifications made to the R2 except for the size of the base and the ‘lagori’ gripping mechanism.

3. PRESENTATION OF DATA / SIMULATION / TESTING

The testing that were done by our team was more to trial and error kind of test. The first design was built as a template or a prototype for testing the force needed for R1 to shoot at the ‘lagori’. It is also a prototype to test the speed and the manoeuvrability of R1.

Table 1: First design task completion time

Design	Robot	Time to Complete Task
1st Design	R1	1 minute 40 seconds
	R2	2 minutes 30 seconds

As can be seen in table 1, it clearly shows that the time taken to complete the task for both roots are quite high and out of the limit time allocated for the tasks.

Table 2: Final design task completion time

Design	Robot	Time to Complete Task
Final Design	R1	30 seconds
	R2	2 minutes

Table 2 shows the time taken after improvement in designing and systems for both robots, R1 and R2. As we can see from Table 2, R1 manage to throw all the balls at the 'lagori' within 30 seconds range and R2 manages to throw the balls to R1 successfully or finished picking up the 'lagori' in 2-minute range.

4. DISCUSSION / EVALUATION OF FINDINGS

From the results we managed to complete all the tasks given within the allocated time. With more practice, the result could get even better with time.

5. SUSTAINABLE ENGINEERING PRACTICES

The most common sustainable engineering that we always practiced is we would try to reuse as much as possible the materials from older and non-usable robots. We try to never buy materials more than what is needed. By reusing these materials, we could cut down the usage of new materials and eventually cut down the materials that is thrown away.

6. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

In conclusion, the robot that we build manages to complete the task for ROBOCON Malaysia 2022 successfully. The limitations for this team is that the parts to build the robot was really scarce as UniMAP is located in a rural area where the technology in building robots is not readily available. The scissor style gripper is quite unstable and because of the protrusion of the gripper, making gripping the 'lagori' becomes a challenge. As for recommendations, we would recommend using a more high torque DC motors for the shooting mechanism of R1 and the use of sensors to make the R2 robot more accurate in throwing the balls.

7. ACKNOWLEDGMENTS

First of all we would like to thank Allah S.W.T for His mercy and graciousness, we were blessed with a wonderful team. Thank you team members Mohammad Asyraaf Bin Ibrahim, Ahmad Hasif Izzudeen Bin Ahmad Tazudin, Zakirah Binti Zaludin, Nureen Faqihah Binti Zumardi, Mohamad Amir Hamzah Bin Md Yusof, Sufi Suraya Binti Halim, Muhammad Shafwan Bin Anis, Allice Tan Mun Yin, Zareq Iskandar bin Zuhaidi and Syahrul Anwar Bin Shahabuddin for the relentless effort in researching and building the robots. Without such dedicated students, completing the robots would be just a dream. Thank you Ts. Ismail Ishaq Bin Ibrahim, Manager of ROBOCON 2022 Team, for the dedication in teaching the students on building the robots. Dr Sukhairi Sudin, Head of ROBOCON 2022 Team, for the commitment and time given for the team. Dr Nasir Ayob, Secretary of ROBOCON 2022 Team, for the guidance. Associate Professor Dr. Haziah Abdul Hamid, Dean of Faculty of Electrical Technology Engineering, for being very supportive of the team and Dr Abdul Halim Ismail, Program Chair of Mechatronic Engineering Program, for the ongoing support given.

REFERENCES

[1] Scisoor Grab Gripper, https://www.handlingconcepts.co.uk/scissor-grab-grippers/

[2] Ball Launcher. https:// https://www.ball-launcher.com//

[3] DIY Football Shooter | Soccer Ball Launcher Machine, https://nevonprojects.com/diy-football-shooter-soccer-ball-launcher-machine/

[4] Francisco Rubio, Francisco Valero, Carlos Llopis-Albert. A review of mobile robots: Concepts, methods, theoretical framework, and applications. International Journal of Advanced Robotic Systems, April 2019.

[5] Nidec Motor Corporation. https://www.roboteq.com/applications/all-blogs/5-driving-mecanum-wheels-omnidirectional-robots

[6] Storm Castle Catapults. How to Build a Catapult. Kalif Publishing, 2001-2019. http://www.stormthecastle.com/catapult/how-to-build-a-catapult

UNIVERSITI MALAYSIA PERLIS (UNIMAP) B

Ts. Ismail Ishaq Bin Ibrahim[1], Dr. Sukhairi Bin Sudin[1], Haliza Binti Zulkifli[2], Noor Farzanah Binti Mohamed Ishak[1], Nur Arisya Husna Binti Sahriman[3], Lee Chang Hong[1], Putera Nuradery Hakimi Bin Nordin[1], Muhammad Irfan Bin Yahya[2], Tan Hock Weng[1], Muhammad Faiz Bin Othman[1], Mohammad Firdaus Bin Rejab[1], Mohd Nasir Bin Ayob[1]

[1] Faculty of Electrical Engineering Technology, FTKE 1 Building, Kampus Pauh Putra,Ulu Pauh, 02600 Arau, Perlis

[2] Faculty of Mechanical Engineering Technology, Kampus Pauh Putra,Ulu Pauh, 02600 Arau, Perlis

[3] Faculty of Electronics Engineering Technology, Kampus Pauh Putra,Ulu Pauh, 02600 Arau, Perlis

ABSTRACT

This robot was built to participate in the ROBOCON Malaysia 2022 with the theme “Merempuh Cabaran Membina Impian”. According to the rules, 2 robots are needed for this competition. One robot is called R1 and another robot is known as R2. To fulfil the task of this competition, UniMAP team decided to use manual robots for both R1 and R2. R1 is designed as a receiving and shooting robot where the robot can both receive the ball and shoot the ball to the ‘lagori. The design for R2 was adapted from a catapult design using a pneumatic system as the source of catapulting force. During testing session, both R1 and R2 successfully throws

and shoot the balls at the 'lagori'. For this year, our team successfully utilized the pneumatic system for throwing and DC motor for shooting the ball thus makes our robot unique. In term of materials, both robots were made by reusing aluminium taken from previous robots and we managed to cut back in buying new aluminium. Almost all of the material used in building this robot was taken and reused from older and non-usable robots. Furthermore, these robots can be utilized for agriculture application where the throwing and shooting mechanism can be adapted to gather fruits from a tree and can be placed at the designated gathering area.

1. INTRODUCTION

The design of the R1 robot is targeted to be accurate and precise as the robot needed to shoot the ball at the 'lagori'. Hence, the main strategy is to equip the robot with a 24V DC motor with high torque for the shooting mechanism. By doing this, the robot can shoot harder and faster than a 12v DC motor. In addition, it is powerful enough to shoot the ball at least 2.5 metres away. R1 will shoot 3 balls at the 'lagori' as fast as possible. For R2, this robot was made to be precise as well as fast in manoeuvrability to make sure it picked up the fallen 'lagori' as **fast as it can.**

8. DETAILED DESIGN

8.1 MECHANICAL DESIGNS

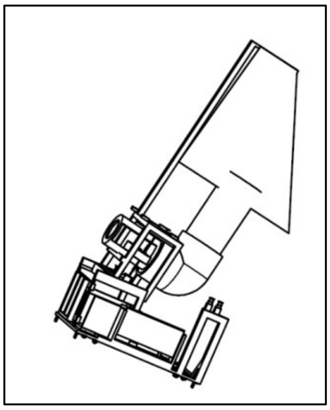


Figure 1: Design of R1

The design for R1 is as in Figure 1, it consist of a shooting mechanism powered by two DC motors to release the ball fast and hard at the target. After a few upgrade, finally the R1 robot manages to shoot the balls with high accuracy and high repeatability.

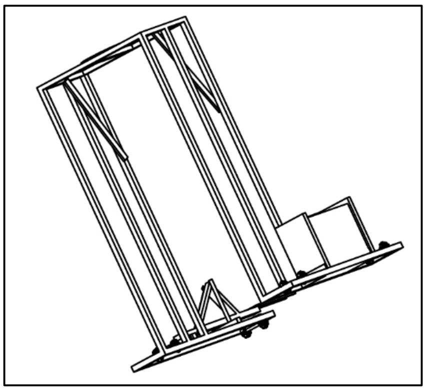


Figure 2: Design of R2

The first design of R2 is just equipped with a throwing mechanism. The accuracy of this robot is very high and the manoeuvrability is quite good. There was not much modifications made to the R2 except for the size of the base and the 'lagori' gripping mechanism.

9. PRESENTATION OF DATA / SIMULATION / TESTING

The testing that were done by our team was more to trial and error kind of test. The first design was built as a template or a prototype for testing the force needed for R1 to shoot at the 'lagori'. It is also a prototype to test the speed and the manoeuvrability of R2.

Table 1: First design task completion time

Design	Robot	Time to Complete Task
1st Design	R1	1 minute 50 seconds
	R2	3 minutes

As can be seen in table 1, it clearly shows that the time for finishing the tasks is very high.

Table 2: Final task completion time

Design	Robot	Time to Complete Task
Final Design	R1	1 minute
	R2	2 minutes 15 seconds

Table 2 shows the score taken after improvement in designing and systems for both robots, R1 and R2. As we can see from Table 2, R1 manage to throw all the balls at the 'lagori' within the allocated time and R2 manages to throw the balls to R1 and finished picking up the 'lagori' successfully.

10. DISCUSSION / EVALUATION OF FINDINGS

From the results we managed throw the arrows with good accuracy. The crane design is a big advantage because with this design, the 'lagori' pickup is very stable and robust. The design also helps in the stability of moving around with the 'lagori'. With the size of the design it is quite hard for the 'hitter' to hit the 'ball on head'.

11. SUSTAINABLE ENGINEERING PRACTICES

The most common sustainable engineering that we always practiced is we would try to reuse as much as possible the materials from older and non-usable robots. We try to never buy materials more than what is needed. By reusing these materials we could cut down the usage of new materials and eventually cut down the materials that is thrown away.

12. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

In conclusion, the robot that we build manages to complete the task for ROBOCON Malaysia 2022 successfully. The limitations for this team is that the parts to build the robot was really scarce as UniMAP is located in a rural area where the technology in building robots is not readily available. The crane design is quite hard to build as the design is not connected at the base level and thus making it hard to control when moving. As for recommendations, we would recommend using a higher torque DC motors for the shooting mechanism of R1 and the use of sensors to make the R2 robot more accurate in throwing the balls.

13. ACKNOWLEDGMENTS

First of all, we would like to thank Allah S.W.T for His mercy and graciousness, we were blessed with a wonderful team. Thank you team members Haliza Binti Zulkifli, Noor Farzanah Binti Mohamed Ishak, Nur Arisya Husna Binti Sahriman, Lee Chang Hong, Putera Nuradery Hakimi Bin Nordin, Muhammad Irfan Bin Yahya, Tan Hock Weng and Muhammad Faiz Bin Othman for the relentless effort in researching and building the robots. Without such dedicated students, completing the robots would be just a dream. Thank you Ts. Ismail Ishaq Bin Ibrahim, Manager of ROBOCON 2022 Team, for the dedication in teaching the students on building the robots. Dr Sukhairi Sudin, Head of ROBOCON 2022 Team, for the commitment and time given for the team. Dr Nasir Ayob, Secretary of ROBOCON 2022 Team, for the guidance. Associate Professor Dr. Haziah Abdul Hamid, Dean of Faculty of Electrical Technology Engineering, for being very supportive of the team and Dr Abdul Halim Ismail, Program Chair of Mechatronic Engineering Program, for the ongoing support given.

REFERENCES

[1] Port Cranes: Everything You Need to Know, https://www.freightcourse.com/port-cranes/

[2] Ball Launcher. https:// https://www.ball-launcher.com//

[3] DIY Football Shooter | Soccer Ball Launcher Machine, https://nevonprojects.com/diy-football-shooter-soccer-ball-launcher-machine/

[4] Francisco Rubio, Francisco Valero, Carlos Llopis-Albert. A review of mobile robots: Concepts, methods, theoretical framework, and applications. International Journal of Advanced Robotic Systems, April 2019.

[5] Nidec Motor Corporation. https://www.roboteq.com/applications/all-blogs/5-driving-mecanum-wheels-omnidirectional-robots

[6] Storm Castle Catapults. How to Build a Catapult. Kalif Publishing, 2001-2019. http://www.stormthecastle.com/catapult/how-to-build-a-catapult

UNIVERSITI MALAYSIA SABAH (UMS)

Low Tian Jie, Santhia A/P Kasewani @ Kesavan, Ung Shuh Chien, Clarence Jimru, Raymond Chiam Heng Liang, Yeoh Kean Teong, Joyce Lu Kuan Yee

UMS Robocon Team, Faculty of Engineering, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah

ABSTRACT

Universiti Malaysia Sabah ROBOCON Team consists of 15 members from the Engineering Faculty and the Computing & Informatic Faculty led by Mr. Rahmat Hidayat Arifai, the President of UMS Robotics Club. To achieve the goal of the theme of ROBOCON 2022, Lagori-Tuju Tin, 2 robots (R1 and R2) were developed to accomplish the two tasks which are to break down the lagori by using a ball and rebuild the lagori on the platform in the middle of the game field when disturbed by the opponent's balls. R1 is designed to use roller shooters to launch the preloaded balls with the desired speed. R2 has a gripper powered by 2 DC motors to pile up the lagoris after it is being shot. Both robots, R1 and R2 have a gripper each to get the balls from the ball racks. The design of UMS robots has been unique as it uses different types of materials fabrication such as mild steel, aluminium, and PLA. The highlight is the construction that accommodates air travel whereby, the completed robots need to be disassembled and reassembled again before the competition. This poses complex problems, but the team managed to create robots to accomplish all tasks. To comply with sustainable engineering practice, all electronics used in the robots were from previous robots and certain structures were fabricated using used or recycled material. The undivided support from the

Vice-Chancellor, Dean, and staff of both faculties, Students Affairs Dept, and U-Science enabled the team to participate in ROBOCON 2022.

1. INTRODUCTION

As each year ROBOCON has unparalleled technical challenges and difficulty, the theme of ROBOCON this year is not an exception too. The theme requires two robots to complete a number of tasks by shooting down the lagori and rebuilding it. To complete several tasks, a brainstorming session was organized in February 2022 to decide optimal design which can be fabricated with the resources (material and budget) available in the lab.

The design phase had been challenging as many ideas were suggested but there was limited time to try each idea out. For example, to implement a shooting mechanism, one of the ideas was similar to ROBOCON 2017 which is using two spinning rollers at two sides to land the disc on the pole. This year, after discussion with the programming department, the idea will be modified in order to shoot the lagori down.

The motivation to participate in this competition is to improve engineering knowledge and practice among lab members. Moreover, this competition can also promote team spirit among lab members to work together as a team.

The design of two robots has its own pros and cons. The robots after fabrication are able to complete all the tasks but we found some weaknesses in the design during testing. One of the weaknesses is that the robot is not robust and solid enough to complete the tasks in a shorter time. This is due to the fact that the material used is quite heavy such as mild steel for the base. Moreover, the motion planning of the two robots is not delicate enough especially on turning corners or being forced to stop immediately.

The objectives of this project are listed below:

i. To design and develop two robots to compete in ROBOCON 2022
ii. To optimize the performance of robots after fabrication

2. DETAILED DESIGN

This chapter consists of three segments which provides much more details on design on the aspect of mechanical, electronics, and programming.

2.1 MECHANICAL DESIGN

2.1.1 ROBOT 1 (S1/H1)

R1 has different roles which are based on the round we are playing, where S1 indicates the Seeker 1 while H1 is the Hitter 1. As an S1, it requires breaking down the lagori pile using the pre-loaded balls. Hence, during the S1 section, we decided to design a shooting mechanism using two motors. This design was inspired by the mechanism of a baseball shooter machine. The baseball shooter machine uses 3 motors as the actuator (or 2 motors) to shoot the baseball. Using the same concept, the Seekers Ball can be shot using two motor actuators. While as a role of H1, it requires shooting the Ball On Head (BOH) of our opponent team. Since it is also a ball shooting task, the mechanism is also similar to the design of S1 but mounted at a higher position due to the BOH plate being placed at around 1200-1250mm distance from the ground. Besides, the H1 is also equipped with a ball picking and passing mechanism. The ball picking mechanism was designed using a 3D printing technique to fabricate the ball picker's hand.

For the movement of Robot 1, the Omni Wheel is chosen. According to Terakawa et *al*. (2019), omnidirectional vehicles that can move in the crosswise or diagonal directions directly are required. Oliveria et *al*. (2018) stated that Omni-directional robots provided greater maneuverability and efficiency at the expense of extra complexity It is easier for the programmer to tune the robot if the robot has slightly deviated from the desired path. There are 4 Omni wheels that are mounted with DC motors respectively.

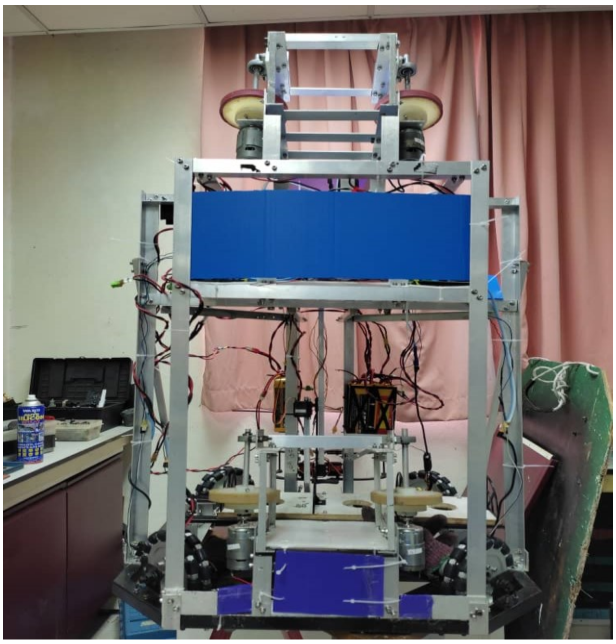


Figure 1: R1

2.1.2 ROBOT 2 (S2/H2)

The movement of Robot 2 is Similar to robot 1, the omni wheel is chosen because of the tuning if the planned path deviates from the desirable path. Robot 2 will act as the S2 (Seeker 2) and H2 (Hitter 2). When it is S2, the main task is piling up the lagori that breaks down by the S1. Two motors will act as the actuator two grab the lagori. A temporary lagori platform was designed in the S2, where it is foldable and will be opened when S2 goes into the field. The lagori will be picked up by S2 and positioned at the temporary platform inside the S2. Once the lagori is piled up in the temporary platform, the lagori will be pushed by the S2 using a DC motor into the lagori platform in the game field. For the passing mechanism, a similar design to the ABU ROBOCON 2012, where the robot needs to be lifted. The mechanism is similar to a lift system. For our design, the lift system was fabricated with a aluminium column, rope, roller and DC Motor as an actuator to lift up the lagori that picked up and put inside the temporary lagori platform in the S2. While turning, we use a lazy-susan bearing to rotate the gripper hand.

Figure 2: R2

2.2 ELECTRONIC DESIGN

2.2.1 ROBOT 1 (S1/H1)

Table 2.1: Electronics of Robot 1 (S1/H1)

No	Electronic devices	Quantity	Uses
1	Arduino Mega	1	Execute operations which are 13 motors
2	Motor driver	4	Used to control the direction and speed of the motors in gripping, shooting turning mechanism.
3	Power Distribution Board	2	Used to distribute the power of different motor and component
4	Limit switch	4	Use to let the mechanism of the robot moved autonomously when it is pressed

2.2.2 ROBOT 2 (S2/H2)

Table 2.2: Electronics of Robot 2 (S2/H2)

No	Electronic devices	Quantity	Uses
1	Arduino Mega	1	Execute operations which are 13 motors
2	Motor driver	5	Used to control the direction and speed of the motors in gripping, shooting turning mechanism.
3	Power Distribution Board	1	Used to distribute the power of different motor and component
4	Limit switch	4	Use to let the mechanism of the robot moved autonomously when it is pressed

Arduino Mega was chosen as the microcontroller (MCU) in this competition. The reason behind choosing this MCU is that it provides a lot of PWM pins and Digital pins (Aqeel, 2018). Other than that, with the help of Arduino IDE, the programmer is able to program the S1 and S2 easily. In this competition, 16 motors were used for both robots. 8 motors were used to control the movement of the robot while 8 motors were used for specific mechanisms built for completing the task. For S1, the 2 motors were used for completing the throwing the ball, the other 2 motors were used for taking and positioning the ball. For the S2, 4 motors were used to complete the task which required the robot to pick up the lagori.

Other than that, the other electronics used are a power distribution board. The purpose of using the relay is to control the “ON” and “OFF” of the pneumatic cylinder which were used to complete the task of passing the ball to the try bot. Other than that, the power distribution boards were used to distribute the power from batteries to other electronics components such as Motors, Arduino MEGA and pneumatic cylinders. The other electronics which operate at 5V will be powered through the 5V power supply supplied by the Arduino MEGA. Limit switches were installed on the side of the R1 and R2 to detect the contact between the robot and the sidewall of the game field. This will ease the programmer and the operator in controlling the movement. Below are some of our electronics used on the 2 robots.

2.3 SOFTWARE DESIGN (PROGRAMMING)

The programmer before writing any code and embedding it into MCU, the flow for each motion is planned as below.

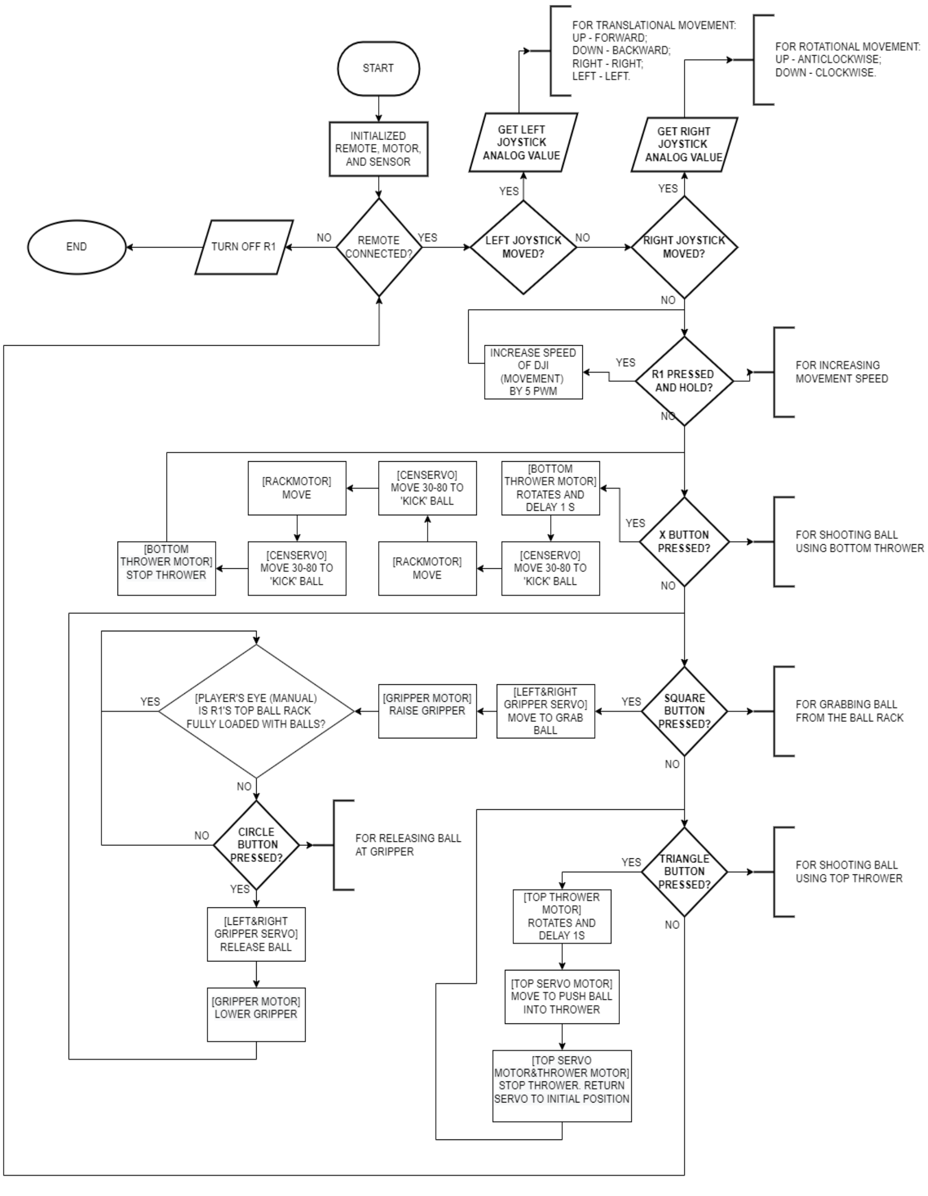


Figure 3: Overall Movement Flow for R1.

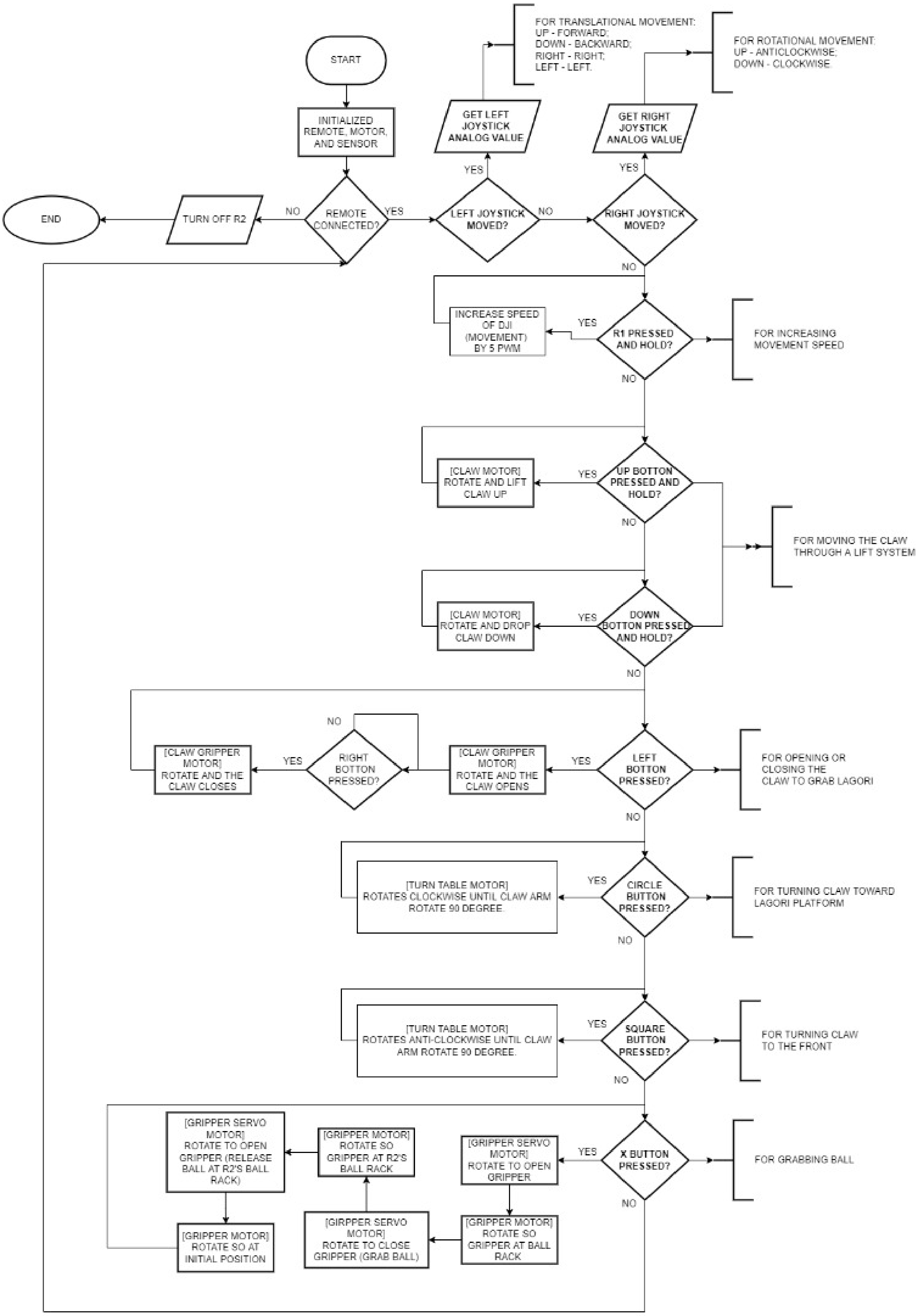


Figure 4: Overall Movement Flow for R2.

3. PRESENTATION OF DATA/SIMULATION/TESTING

The performance of robots were recorded in Table 3.1 below. In Table 3.1, functionality refers to successful attempts out of total 5 attempts.

Table 3.1: Performance of Robots During Testing

Task		Functionality	Approximated Time (s)
R1	Shooting 1	3	3
	Shooting 2	4	3
	Ball Gripping	5	2
	Ball Passing	3	3
R2	Lagori Gripping	5	2
	Gripper Turning	5	3
	Lagori Lifting	3	7
	Lagori Pushing	4	5

4. DISCUSSION

During testing, the Robot 2 speed is limited due to the BOH on it will fall down if moving too fast. This is due to the support structure of the BOH which is not firm enough, and shock or vibration absorbers are not installed. While for Robot 1, the ball picking mechanism has some vibration and deflects the beam. This might be due to the mechanism being too heavy and some miscellaneous errors for the fabrication. A proper study of the structure and connection of materials should be carried out. Some shock absorbers should be developed and installed on it. On the other hand, the surface of the game field did affect the travel path of robots, which is the quality and type of paints for the game field. This needs further investigation from the team to resolve this issue.

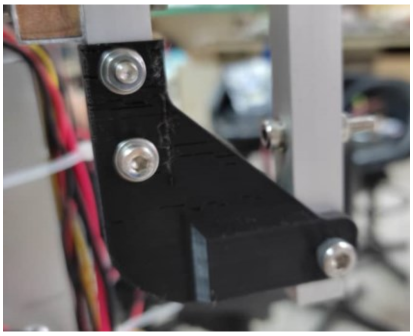


Figure 5: R2 Lagori Platform Hinge version 2.

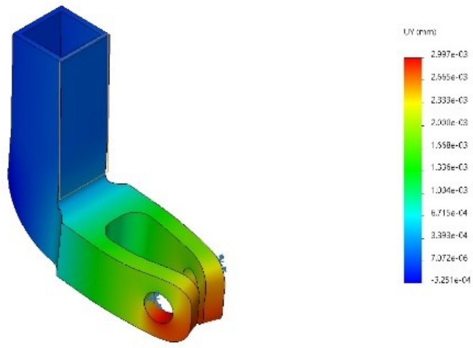


Figure 6: R2 Lagori Platform Hinge version 1 simulation

Figure 4.1 is the R2 lagori platform hinge version 2 designed and fabricated using 3D printer. Version 1 of it was tested failed due to the pressure and force acted on it was too high until it was broken and the corner part. Hence, a version 2 was designed after version 1 was simulated using SolidWorks with computational static analysis.

5. SUSTAINABLE ENGINEERING PRACTICES

The fabrication of robots has fully complied with sustainable engineering practices where all the electronics and batteries were reused from previous robots for ROBOCON as well. Besides, some mechanisms and parts are fabricated using 3D printing techniques which save a lot of budget in material acquisition and prevent waste of material. The main 3D printing material we use is polylactic acid (PLA), which is a thermoplastic monomer derived from renewable, organic sources such as corn starch or sugar cane (What is PLA? (Everything You Need To Know), n.d.).

6. CONCLUSION, LIMITATIONS & RECOMMENDATIONS

To conclude, our UMS Robocon Team has fabricated two robots which are R1 (Hitter) and R2 (Seeker) for ROBOCON Malaysia 2022. These two robots are able to complete assigned tasks such as hitting the lagori stack, collecting and piling up the lagori as well as hitting the ball on the head of the opponent within the design basis. The ROBOCON UMS team spent almost 6 months completing these two robots from scratch with endless improvisation. It is safe to say that the team conducted countless experiments to test the functionality of the robot which indeed required relentless sacrifice. Through each of these trials, we were able to rectify the tiniest problems and develop our critical thinking skills and troubleshooting skills. Though there were numerous challenges we faced along the way, we are proud to say that the UMS ROBOCON Team indeed stood their ground and had each other's back in making this project a success.

Throughout the execution period of the project, there were several limitations. Firstly, we had financial constraints in terms of additional components purchase and logistics. Oftentimes we have insufficient finance and due to this some mechanical elements could not be purchased on time. For instance, we have to resort to aluminium bars in order to fabricate our robot which subsequently adds up to the weight of the robot whereas material such as carbon fibre can be used to replace it. Besides, being a participant from the Land of Wind, we do in times face additional challenges, one of which is the budget for transportation, accommodation and more. Moreover, we also have to disassemble our robot prior to boarding the flight and assemble it again before the competition which is a little tedious. Plus, we also do not have our own space for a game field and due to this we have to find different locations on campus each year. However difficult the journey, it is undeniable that the team members have learnt and sharpened their technical skills in their respective field over the course of time. Since most of the problems stem from financial assistance we hope that in future we would be able to obtain more support financially. Nonetheless, this is indeed a fruitful journey to us and would be a great stepping stone to improve our UMS Robotic Club.

7. ACKNOWLEDGEMENTS

This technical report has been completed successfully with the help and support of many individuals. We would like to express our profound gratitude to every single one of them. First and foremost, we praise and thank God, for His showers of blessings throughout our project work to complete this robot fabrication during the Covid-19 unprecedented times. We would also like to extend our heartfelt thanks to Universiti Malaysia Sabah and Student Affairs Department (HEPA) UMS for aiding us financially to be part of ROBOCON 2022. Their immense support for our Robotic Club has been helping us a lot in terms of robotic structure preparation. Besides, we also owe a debt of gratitude to U-Science, UMS for providing us necessary space for the game field. In this instance we would also like to thank the Faculty of Engineering for constantly supporting us and allowing us to work late at night in the lab as preparation for the competition. Moreover, we would like to express our deep and sincere gratitude to our supervisor, Assoc Prof. Ir. Dr. Muralindran Mariappan for providing us with invaluable guidance throughout this project especially his encouragement and suggestion on robot fabrication which has been crucial to us. We would also like to profusely thank Mr Irwan and Mr Muslee who put an effort into building our game field. We truly appreciate their diligence and commitment to making this project a success. Plus, any attempt at any level can't be satisfactorily completed without the support, guidance and constructive criticism of our seniors. We also cannot express enough thanks to our team members for their continent support, contribution, and days and months of sacrifice. Last but not the least, we are overwhelmed in all humbleness and gratefulness to acknowledge our debt to all those who have helped us to put these ideas above the level of simplicity and into something concrete. Their continuous encouragement provided us strength and motivation to accomplish the robot fabrication.

REFERENCES

[1] Adnan Aqeel (2018). Introduction to Arduino Mega 2560. Retrieved from https://www.theengineeringprojects.com/2018/06/introduction-to-arduino-mega-2560.html

[2] Oliveria, H.P., Sousa, A.J., Moreira, A. P. and Costa, P.J. (2008). Dynamical Models for Omni-direction Robots with 3 and 4 wheels. Paper presented at the 5th International Conference on Informatics in Control, Automation and Robotics. Retrieved from https://www.researchgate.net/publication/256089847_Dynamical_Models_for_Omni-directional_Robots_with_3_and_4_Wheels

[3] T. Terakawa, M. Komori, Y. Yamaguchi and Y. Nishida (2019). Active omni wheel possessing seamless periphery and omnidirectional vehicle using it. Precision Engineering. 56, 466-475. Retrieved from http://www.sciencedirect.com/science/article/pii/S0141635919300479

[4] What is PLA? (Everything You Need To Know) - TWI. (n.d.). Retrieved May 12, 2022, from https://www.twi-global.com/technical-knowledge/faqs/what-is-pla

UNIVERSITI PERTAHANAN NASIONAL MALAYSIA (UPNM) ROBUST ROBOTICS

Chen De Shen, Nisa Maisarah Binti Mazni, Nur Aufa Afiqah Bt Salihuddin Baqi, Muhammad Akhmal Hakim Bin Alias, Muhammad Khairil Bin Norressan Helmee, Nur Fatin Izzati Bt Tajudin, Muhammad Faiz Bin Mohd Fauzi, Muhammad Syahmi Bin Mohd Shamshul, Nur Ahlina Najiah Binti Sahra, Najwa Binti Sabarudin

Robust Robotics Club, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur

ABSTRACT

ABU Asia-Pacific Robot Contest (ABU ROBOCON) is a robotic 'challenge and exposition' founded in 2022 by Asia-Pacific Broadcasting Union to accelerate social implementation, research and development of robots working in realistic daily life, society, and industrial fields. By designing, building, and operating autonomous robot, students learn key engineering subjects and develop systems-thinking, problem-solving, and teamwork skills. Such events as ROBOCON offer rich opportunities for students to apply their skills by requiring design, and implementation of autonomous robots that are tested during competition. Started in 2018, Robust Robotic UPNM participate in ROBOCON to offer engineering students, working in teams, to demonstrate their knowledge in developing robots as per ROBOCON theme every year. Therefore, this document presents the design and development of robots for Robust Robotics team from UPNM in the ABU ROBOCON 2022 competition.

1. INTRODUCTION

The theme for ABU ROBOCON 2022 is Lagori, an ancient game originated in the southern part of India. The game is played between two teams that will be represented by two robots for each team, namely “Seeker” and “Hitter”. The game begins with the seeker tossing a ball to shatter a stone tower known as "Lagori". While the searchers try to re-arrange the stones, the batter tosses balls to keep them from doing so. Each team must build two Robots (R1, R2). There are 2 rounds per game. The referee will give each team the role of Seeker or Hitter. The role will be switched for each round, i.e., in the 1st Round, the Red Team will be Seeker and the Blue Team will be Hitter. The UPNM Robust Robotics team will be competing in this contest by having a group of students comprising of Mechanical and Electrical Engineering Programmes that will be in charge of developing the robots. The robots will be competing in the ABU ROBOCON 2022 contest that will be held at Kompleks Sukan Azman Hashim, USM Penang in 2-5 June 2022.

2. DETAILED DESIGN

This section will describe the Detailed design consists of several aspects namely mechanical, electrical, electronic and software design.

2.1 MECHANICAL DESIGN AND MECHANISM FOR R1 AND R2

Both robot R1 and R2 are made of 4-linkage structure made of 2×2 cm aluminium profile and used a set of 15 cm Mecanum wheels, an omnidirectional wheel Mecanum wheel design for a land-based vehicle to move in any direction. The Mecanum wheels are capable of moving the robot to any direction instantaneously by the combination of independent wheel directions which are controlled by a 24 V DC motors with dimension of 80 mm x 80 mm x 151 mm.

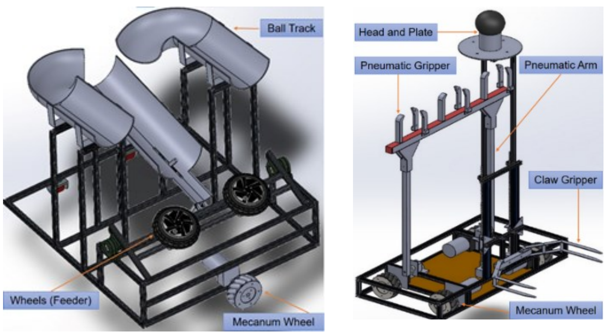


Figure 1: Isometrc view of R1(left) and R2(right)

2.2 MECHANISM OF R1

For the role of Seeker R1 and Hitter R1, the ball is placed on the track. The ball will be going down the track until it reached the stopper at the end of the track. The stopper will be controlled by servo motor. It will rotate 180^{o} counter-clockwise to stop and release the ball. Two wheels will be placed at the end of the track that will rotate in opposite direction controlled by DC brushless motor. The wheels will act as feeder and shoot the ball at a velocity of 30 m/s in projectile motion at an angle below 70^{o} to break the Lagori. For the role of Hitter R1, the wheels that acts as feeder will be variable, controlled by linear actuator to move the wheels up and down in order to aim the opponent's ball in the right direction.

2.3 MECHANISM OF R2

Once Seeker R1 break the Lagori, Seeker R2 will take place to piles up the broken Lagori according to the sequence from the largest Lagori to the smallest. A claw gripper will be used to grab the Lagori as shown in Figure 1. The closing and opening of the gripper will be controlled by servo motor. The gripper will be attached to a horizontal aluminium profile(AP) that will be moving up and down via a screw thread. The motion along the screw thread will be based on a pulley connected to DC Geared Motor.

Hitter R2 will pick up 3 balls simultaneously from a ball rack located in the Ball Areas. This action will be done by using a pneumatic gripper that have 3 pairs of claw gripper and will act simultaneously to pick up the balls. Each pair of the claw gripper will have only one of the claw moving to clamp the ball in position while the other claw will be fixed in position. The arm of the pneumatic gripper will be controlled by using two power window motor each on both side. The arm will be able to be controlled up to an angle of 180^{o}. The ball will be passed to Hitter R1 directly onto the track.

2.4 ELECTRICAL AND ELECTRONIC DESIGN

The electrical and electronic elements in R1 and R2 serve as network synapses, allowing signals from the microcontroller to be sent to the mechanical parts. Both Robot R1 and R2 are divided into two types which are seeker and hitter in each of the robots. The main electrical components used for the mechanism in both robots are shown in Table 1 and Table 2.

Table 1: Electrical components for R1 Robot

Components	Function
DC Motor	• Brushed DC: Mecanum Wheel Movements • Brushless DC: To move the wheels as a shooter
Servo Motor	• To stop the ball from entering the shooting part
Linear Actuator	• To control the robot's arm angle for ball shooting during hitter only

Table 2: Electrical components for R2 Robot

Components	Function
DC Motor	• Brushed DC: Mecanum Wheels Movements • Power Window: Robot's arm movement for lifting the ball during hitter • DC Geared motor: To lift the Servo ups and downs during seeker
Servo Motor	• As a hand to hold the Lagori during seeker
Pneumatic	• As a finger to hold the balls during hitter

2.5 POWER SOURCE

In this project, the same battery type is used which is Lithium Polymer (LiPo) battery in both robots. Both robots are powered by a 22.2V 6S LiPo Rechargeable Battery. However, the minimum power capacity of both batteries differs, with R1 Robot being 6000mAh and R2 Robot being 5200mAh. This is due to the fact that R1 Robot requires more power capacity than R2 Robot.

2.6 CONTROLLER

For R1 Robot, the controller used is PS2 wired Controller. Internally, this controller was lighter than PS1 controller and all the buttons (except for the Analog mode, start, select, L3 and R3 buttons) were readable as analog values.

R2 Robot is controlled using a regular PlayStation 4 (PS4) controller. The front of the controller has a light bar with three LEDs that glow when all three are lit in conjunction. The PS4 controller features the following buttons: PS button, SHARE button, OPTIONS button, directional buttons, action buttons (triangle, circle, cross, square), shoulder buttons (R1/L1), triggers (R2/L2), analog stick click buttons (L3/R3), and a touchpad click button.

2.7 CIRCUIT DESIGN

Figure 2 is a schematic circuit design for R1 Robot and Figure 3 is a schematic circuit design for R2 Robot.

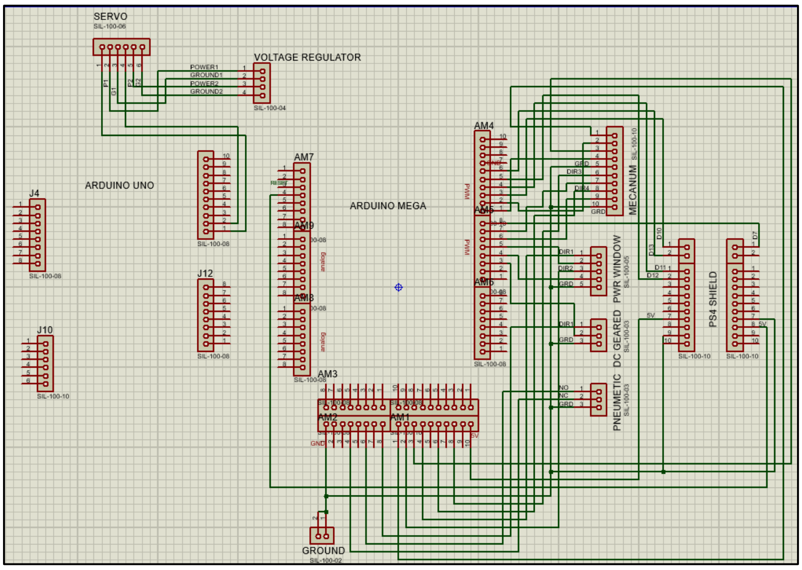


Figure 2: Schematic Circuit Design for R1 Robot

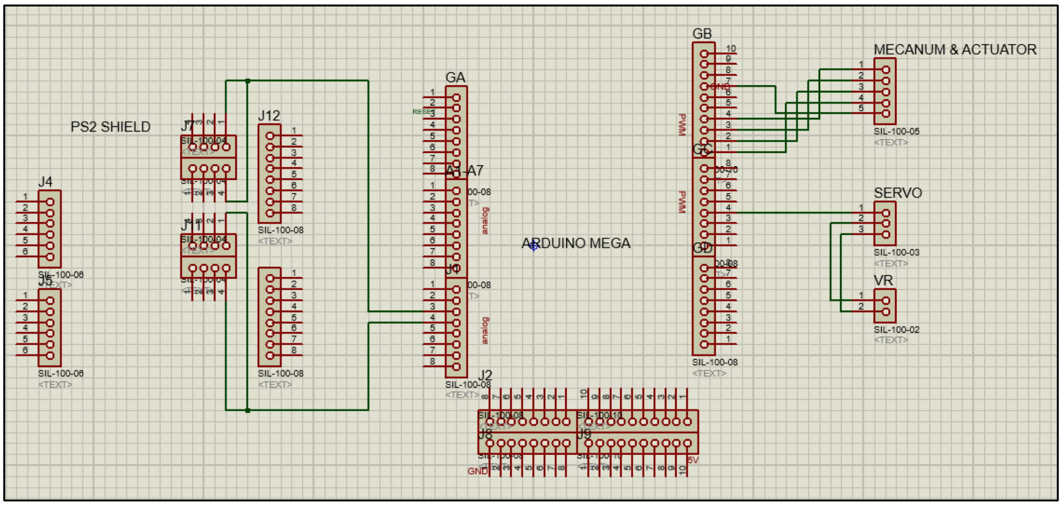


Figure 3: Schematic Circuit Design for R2 Robot

2.8 SOFTWARE DESIGN

For each activity, a flowchart is created to assist the coder in assigning buttons to specific actions. For R1 Robot, there is 1 flowchart representing seeker and hitter and for R2 Robot, there are 2 flowcharts, each of them representing hitter and seeker. Figure 4 shows Flowchart for R1 Robot (seeker and hitter), Figure 5(a) shows Flowchart for Seeker R2, and Figure 5(b) shows Flowchart for Hitter R2.

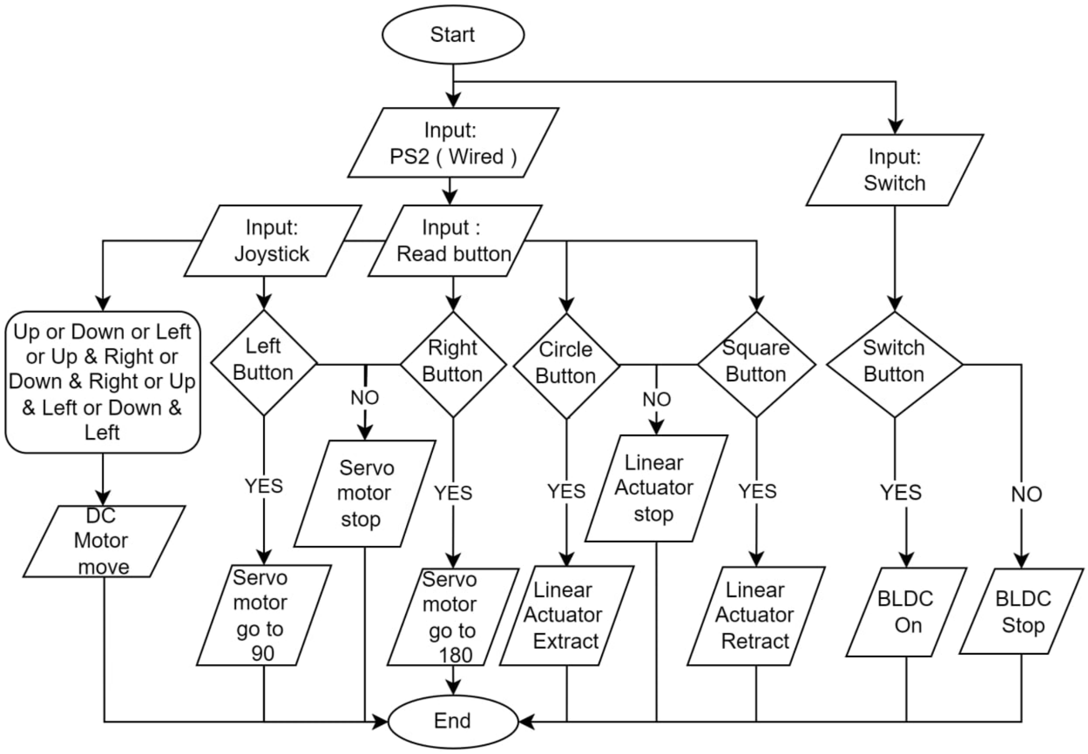


Figure 4: Flowchart design for R2 Robot

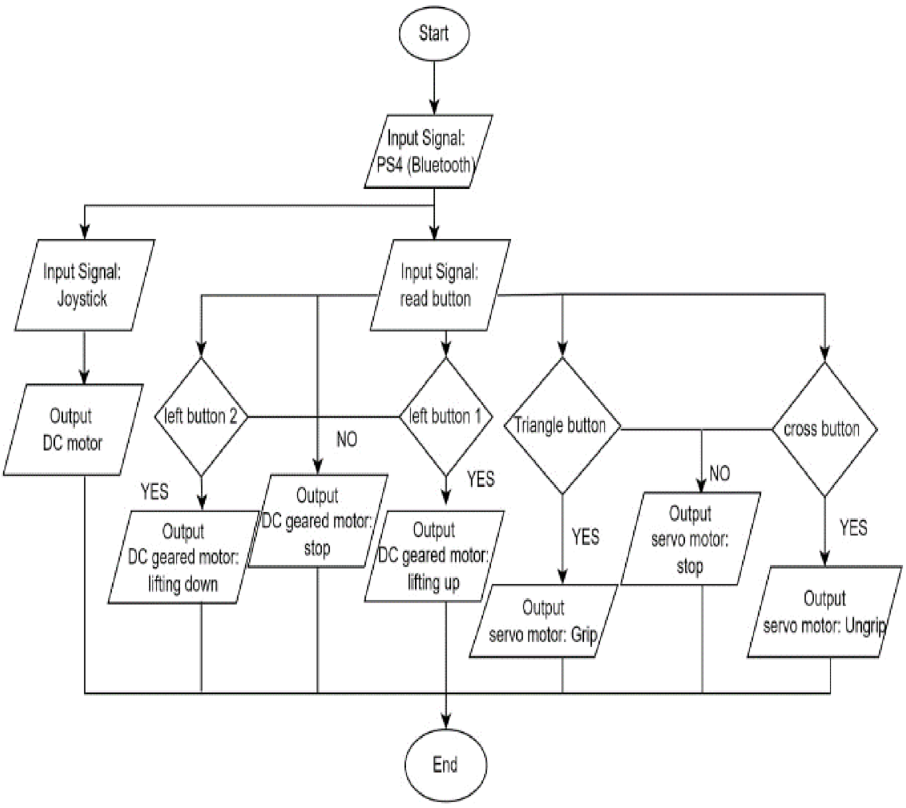


Figure 5(a): Flowchart design for R2 Seeker

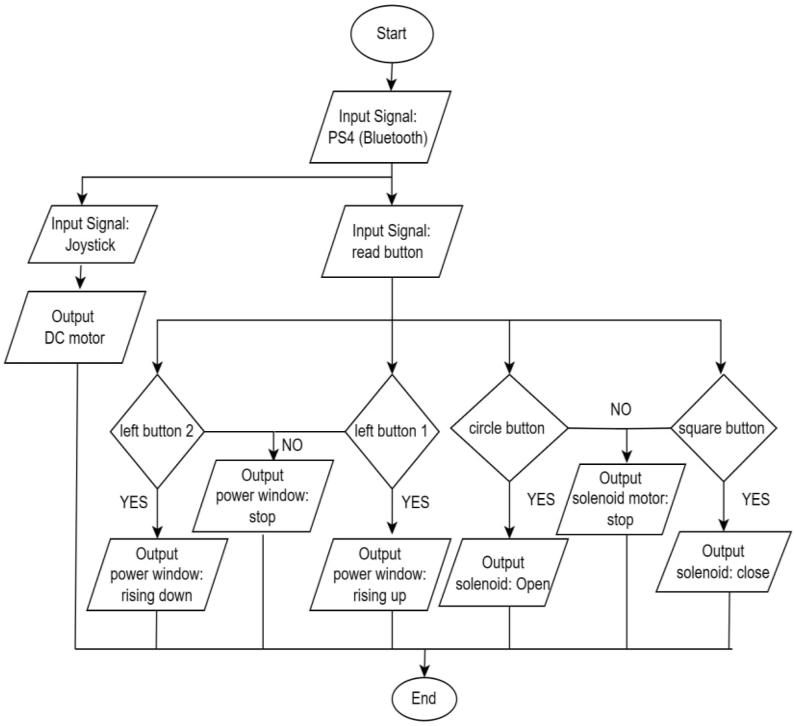


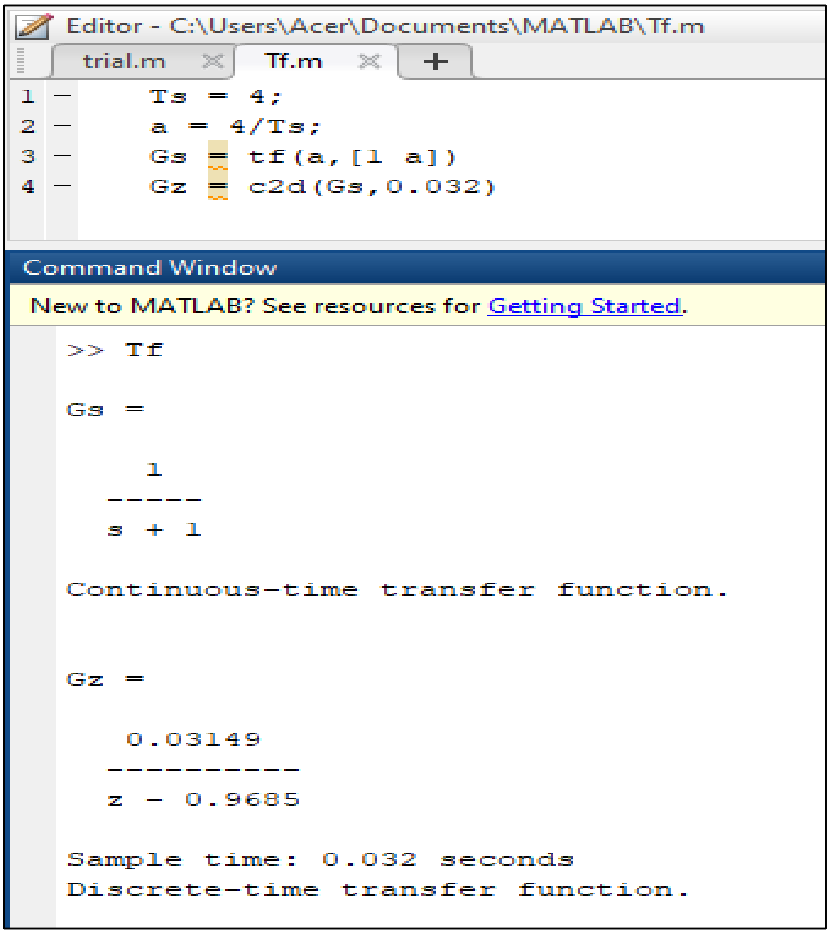
Figure 5(b) Flowchart design for R2 Hitter

3. PRESENTATION OF DATA

The robot's movement had a jerking effect since the motors were turned on at maximum speed and then abruptly stopped when there was no power source. The calculations for the jerk reduction of the motor utilized for the movement of both the Try Robot and the Pass Robot from zero to maximum speed and from maximum speed to zero using a step-response first-order system are shown in Equations (1) and (2) below. From zero to maximum speed,

$$T_s = 4\,, a = \frac{4}{T_s}\,, G(s) = \frac{a}{s+a} = \frac{1}{s+1}$$

After solving the problem using MATLAB as in the Figure below,



The following is obtained:

$$G(z) = \frac{\text{Output}}{\text{Input}} = \frac{0.03149z^{-1}}{1 - 0.9685z^{-1}} \tag{1}$$

Where,

$$\text{Output} = 0.9685(z^{-1} * \text{Output}) + 0.03149(z^{-1} * \text{Input})$$
$$\text{Output} = \text{Speed of Motor}$$
$$z^{-1} * \text{Output} = \text{Previous Output of Speed of Motor}$$
$$z^{-1} * \text{Input} = \text{Previous Input of Speed of Motor}$$

By changing its settling time, T_s to 2 seconds, the same method was used to obtain equation (2) below to calculate jerk reduction from maximum speed back to zero.

$$\text{Output} = 0.938(z^{-1} * \text{Output}) + 0.062(z^{-1} * \text{Input}) \tag{2}$$

4. EVALUATION OF FINDINGS

Robust Robotics team applied the concept of simple physics that is used to meet the requirements of the game rules. The use of Mecanum wheels in the movement of R1 and R2 is one of the application of the concept. This is because the high friction against the ground while turning requires high-torque engines or motor to overcome the friction. The design of the Mecanum wheel allows for in-place rotation with minimal ground friction and low torque. Other than that, R2 is using projectile motion instead of straight motion to break the lagori. The linear actuator is used to adjust the angle of projectile motion so that the team able to aim from the lowest to highest lagori.

In the mechanism of lift gripper, screw thread is used to lift the gripper to the required height. Screw thread is used as the main mechanism as it is more efficient and require less torque. Typically, these screw threads are used to drive changes in the linear motion and it is controlled by stepper motor. In addition, the pneumatic gripper in R2 uses an attached of 3 pairs of claw grippers that are to pick up 3 balls from the Ball Area simultaneously which serves the purpose to the reduce operating time.

5. SUSTAINABLE ENGINEERING PRACTICES

In the development of robot R1 and R2, 90% of the whole body of the robots were built using the 2×2 cm Aluminium Profile that is being reused from the previous robots. Sustainable mechanical properties of aluminium makes aluminium profile as the main material in the development of R1 and R2. It can be recycled time and time again with no degradation of properties. This infinite recyclability, combined with light weight, high strength-to-weight ratio, corrosion resistance and formability, make an important element in many sustainable solutions. This supports the practice of Robust Robotics team that always practice the usage of recycled materials so that none of the materials used in previous competitions are not wasted and the team able to minimize the production cost in building the robots. Other than that, the use of Mecanum wheels also serve the purpose of environmental friendly where it requires lower energy because Mecanum wheel allows for in-place rotation with minimal ground friction and low torque, hence lower energy.

6. CONCLUSION

ROBOCON sets an international platform for the engineering student to enhance their technical skills and knowledge. Although the team's work was for the particular competition, tackling the competition specific problem undoubtedly had an impact on the overall technical knowledge. Applying the ideas and materializing the designs right from the scratch enhanced the hands-on experience of the members. Working out different approaches and analysing the performance helped understand the actual dynamics and to build in-depth understanding.

Building Robots enhanced our technical knowledge and skills as well as taught us team work and professionalism.

7. ACKNOWLEDGEMENTS

The team would like to thank the National Defence University of Malaysia for continuous support towards the success of this project. This work also credits the direct involvement of the affiliated team members and supervisors:

Muhammad Akhmal Hakim Bin Alias
Nur Fatin Izzati Binti Tajudin
Nisa Maisarah Binti Mazni
Nur Aufa Afiqah Binti Salihudin Baqi
Suria Prakash Timothy Toulsimani
Muhammad Khairil Bin Norressan
Ahmad Hafizuddin Bin Muhammad
Chen De Shen
Nur Hafizah Binti Mohd Norhan

Dr. Syed Mohd Fairuz Syed Mohd Dardin
Dr. Ahmad Shukri bin Abu Hasim
Dr. Noor Hafizah binti Amer
Dr. Asnor Mazuan bin Ishak
En. Akram bin Abdul Azid
Muhammad Afiq Bin Mohamad Alimi
Nurulhani Adlina Binti Madzan
Nur Ainaqilah Binti Juma’in
Mohamad Huzairi Bin Mohamad Yusri

REFERENCES

[1] Choi, H., Jung, W., & Kim, N. (2017, February). “Development of autonomous ball launcher system on surface vehicle for detect and deliver mission” *in 2016 Maritime RobotX Challenge. In 2017 IEEE Underwater Technology (UT) (pp. 1-5). IEEE.*

[2] Hirose, S., & Umetani, Y. (1978). The development of soft gripper for the versatile robot hand. Mechanism and machine theory, 13(3), 351-359.

UNIVERSITI SAINS MALAYSIA (USM) THE APEX TEAM

Nor Rizuan Mat Nor, Justin Chia Vern Shuen, Chuah Chun Khai, Kee Jiunn Liang, Lim Jun, Ooi Chen Liang, Too Jun Zheng, Ng Zi Jun, Lee Sze Yuan, Phang Wei Jia, Lim Wei Jien, Teow Wei Seng, Natalie Low Xhin Yuen, Ong Soon Liang, Nalathurkarsh A/L Paramesivan, Lai Thing Fei, Francis Lau Jun Xiang, Yew Yao Ming, Tan Chiou Zhen, Tan Yi Wen, Keh Jing Yang, Tong Wai How, Ong Qian Hui, Harivindran A/L Ramalingam, Jeevarani A/P Salvanathan, Amirul Jeffry Lau bin Muhammad Asraf Lau

School of Electrical and Electronic Engineering, Engineering Campus, Universiti Sains Malaysia, Penang

School of Mechanical Engineering, Engineering Campus, Universiti Sains Malaysia, Penang

ABSTRACT

In ABU ROBOCON 2022-ROBOCON Malaysia 2022, the theme of the contest is “lagori”. This contest is to throw ball to break the Lagori. This year, this contest will be held in Universiti Sains Malaysia (USM) main campus. The contest will start by control the robot seeker R1 to throw balls from R1SZ to break the Lagori while the Seeker R2 will piles up broken Lagori discs in the Lagori Area. After that, a ball will be placed on top of the Seeker R2 before the round begins. In the next round, both robots R1 and R2 will go to the Ball Area to pick up Balls. This time, the Hitter R1 will throw balls to knock down the ball that is on top

of the Seeker R2. Hitter R2 can pick up Balls from the Ball Areas and pass them to Hitter R1 without the ball touching the field surface. For the robot design, the throwing ball mechanism of Robot R1 is using motors system and pneumatic system. The mechanism is very consistent and reliable. Based on the testing result, it shows that the Robot R1 can throw the balls to knock down the Lagori. For the design Robot R2, we use the motor system to control the up and down of the clamp and pneumatic system for the clamp. The material in the pneumatic system used in both R1 and R2 are environmental friendly as the wasted plastic bottles was reused as the gas tank to fill the gas in order to operate the pneumatic system. Some electronic parts are also being reused as the base system of the robot which can be modified in order to perform the given task.

1. INTRODUCTION

This contest is to break the lagori. This year, the contest is held physically at Kompleks Sukan Azman Hashim, USM from 2 June 2022 to 5 June 2022. The game will start by letting Seeker R1 from the first team to do the task "Lagori Break". Then, Seeker R2 from the same team will do the “Lagori Pile”. At the same time, the Hitter 1 from the opponent team will throw the balls to the Ball on Head of Seeker R2. Hitter 2 will pick up the ball and pass it to Hitter R1 for throwing.

There are two robot R1 and R2. R1 robot are in semiautonomous while R2 are manual. Both robots are using pneumatic system. In R1, the pneumatic system is used for pushing the ball towards the rolling motor to shoot the Lagori. On the other hands, the R2 are using pneumatic in the clamping mechanism. The mechanism is very consistent and reliable.

Basically, this competition is to shoot to break the Lagori and the opponent’s ball. While another robot R2 needs to build the Lagori back and reload it to R1. This year will be face to face contest, thus, the R1 can shoot the opponents R2 ball in head. The score will be counted if the ball successfully breaks the Lagori. The team with highest average scoring point will become the winner of this contest.

To make the robots to successfully shoot the balls, the robot must be well designed with many considerations being take account. For example, the robot that been designed must be ensure that it can shoot balls onto the Lagori precisely. The software of the robot needed to code so that it can perform the task. In order to achieve the task, the shooting ball of the R1 to break the Lagori from throwing area is tested. Next, high-quality sensor need to use on the robot in order to complete the task in short time and precisely. Furthermore, the body of the R2 has to be designed in lightweight in order to move faster in getting ball and fixed its position precisely at throwing area without any delay.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

As the competition is to shoot ball to break the Lagori down, the design of the shooting mechanism are using the basic two motor spinning mechanism to launch the ball to break the Lagori. The two motor is placed horizontally with a ball track and a reload bucket. Next in this shooting mechanism there will have a motor to adjust the shooting angle to shoot the Lagori. Moreover, due to the robot R1 cannot leave the R1SZ but is allowed to extend in the space above the R1 is then mounted with four motors.

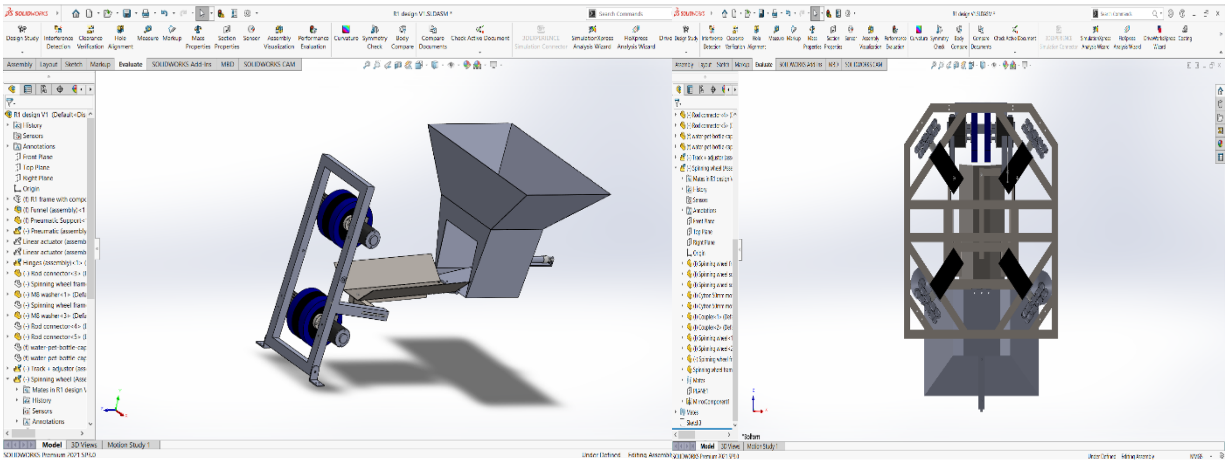


Figure 1: Shooter and movement mechanism

The R1 robot is then assembly with a funnel to receive ball from R2 hitter easily that combine with a ball tracker to allow the ball to roll to the shooting mechanism and easily to launch fire the ball.

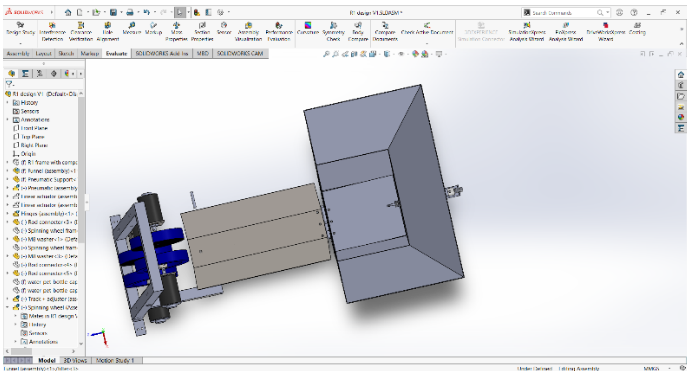
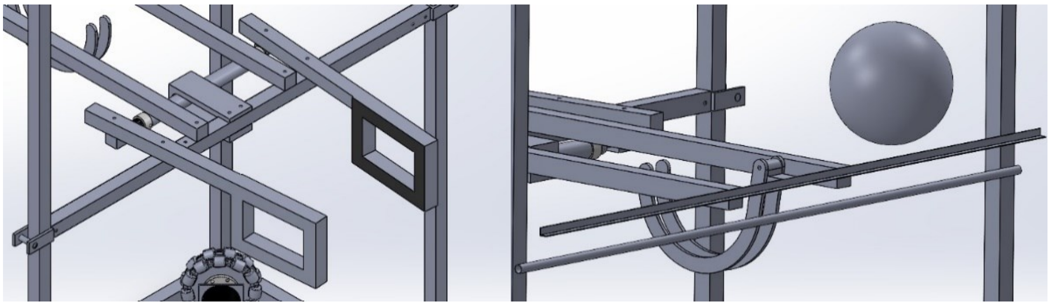


Figure 2: The funnel

As for the hitter (R2), the mechanism will be arrange back the lagori as usual and need to grab and reload the ball. Thus, the mechanism that will clamp the lagori and arrange it will using a simple clamping mechanism that shown in figure (a) while the figure (b) will be grabbing the ball and reload the ball to the seeker (R1)



(a) (b)

Figure 3(a): The clamping, Figure 3(b): Grabbing

2.2 ELECTRONIC DESIGN

There electronic design used for both R1 and R2 are a microcontroller, power supplies, sensors, actuators, and electrical components for the R1 and R2.

The microcontroller used for the R1 and R2 is the Arduino Mega 2560 Rev3 as shown in Figure. It is the brain of the operation and it is used for reading the inputs from the sensors or buttons and respond with the appropriate output for controlling the actuators. It is an 8-bit board which has 54 digital inputs, 16 analog inputs and 4 serial ports for communication. The operating voltage used for operating this microcontroller is 5 V.

Figure 3: Arduino Mega 2560 Rev3

The R1 and R2 uses two separate power supply to run the electrical gadgets, actuators, and sensors: 3S and 6S Lipo (Lithium polymer) batteries. Both of these batteries can be recharged. The 3S Lipo battery provides around 12.0 V, while the 6S Lipo battery provides approximately 24.0 V, which is the suitable storage voltage for both.

The Arduino Mega 2560 Rev3 is equipped with a USB host shield that has a 3.3 V regulator and MOSFET level shifting. It's utilised to communicate between the microcontroller and the PS4 controller in order to manually regulate the robot's overall performance.

4 electrical motors control the omni wheel, which determines the direction in which the R1 and R2 will go, and 9 single solenoid valves 5/2 pneumatic control the arrow clamping, firing, and TR mechanism. The 4 electrical motors are powered by a 5V supply, while the pneumatic is powered by a 6S Lipo battery.

The electrical components used in this R1 and R2 are a toggle switch 3 Pin 3 ways to turn on the sensor board for regulating the 5 V to be used for other components and devices, an emergency stop switch to turn off all components, a buck convertor to step down the voltage of the 3S Lipo battery from 12.0 V to 5 V in the sensor board, and a Mega shield for the Arduino Mega 2560 Rev3 to tighten the wire connections for all devices.

After introducing the Arduino in both R1 and R2, we now discuss more deeply in robot R1. In R1 the robot is using raspberry pi and Arduino with serial communication. Most probably the raspberry pi will be using as a microprocessor while the Arduino is the microcontroller. In this microprocessor we are introduce Open CV to the raspberry pi to process the image for the opponent ball and the lagori to aim more accurate.

Figure 4: Raspberry Pi 4

Serial communication is nothing more than a means of transferring data. In contrast to parallel communication, which sends multiple bits at once, the data will be transferred sequentially, one bit at a time (1 byte = 8 bits) Protocol UART

When utilising Serial with Arduino and Raspberry Pi, you're really using the UART protocol. "Universal Asynchronous Reception and Transmission" is what UART stands for. It's essentially an asynchronous multi-master protocol based on Serial communication that allows to communicate between two boards. There are libraries that will take care of all the low layers the term "multi-master" refers to the ability for all linked devices to deliver data whenever they choose. This is one of the most significant differences from master-slave protocols, in which only the master device may begin communication. When it require master-slave arrangements, such as when one Arduino board and numerous sensors or actuators, it usually utilise alternative protocols like I2C and SPI. the Arduino Mega board's single UART either using a USB connection or from the RX/TX ports (but not both at the same time). Some boards have more UARTs than others. The Arduino Mega, for example, has many serial ports. Many Serial devices can be connected to the Raspberry Pi's USB ports. Each will have its own device name (which we'll discover later in this course). The GPIOs (RX0/TX0) may also be used as an extra UART.

2.3 SOFTWARE DESIGN

Solidworks, a CAD programme, is used to create robot designs. Before manufacturing the robots, the motion of the robots is simulated in the software. This is to guarantee that the robot's mechanism functions properly and runs smoothly. At the same time, since there is less mistake, the time it takes to build the robot may be lowered. The robots' total size was calculated using the dimensions specified in the rules.

R1 is 800mm by 880mm by 1 metre in size, whereas R2 is 900mm by 980mm by 1230mm in size. R1 and R2 have a compressed air capacity of 16.5 litres and a 5 bar compressed air pressure.

3. FLOW CHART

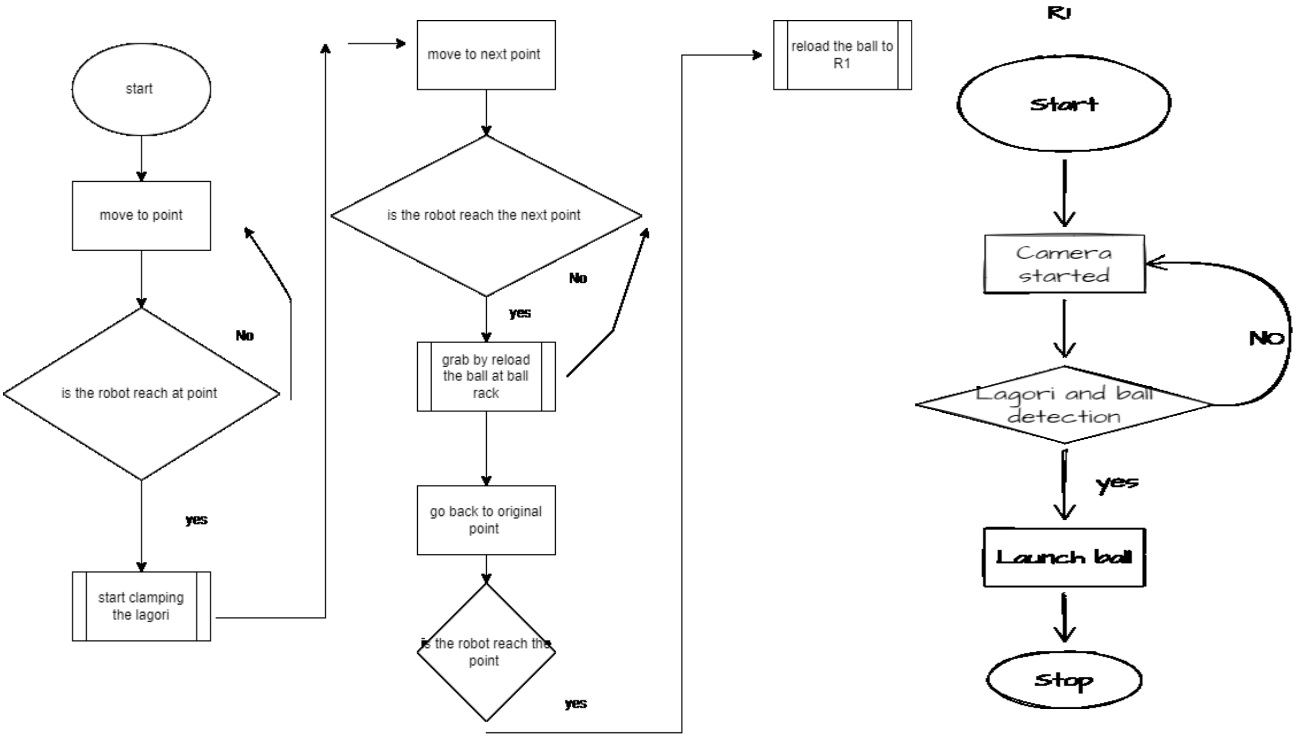


Figure 5: The flow chart of R2 and R1

4. ROBOT TESTING

Solidworks, a CAD programme, was used to create R1 and R2. Before constructing a robot, the motion of the robot is simulated in software. This is to guarantee that the robot's mechanism runs smoothly and efficiently. Simultaneously, since there is less mistake, the time it takes to build the robot may be lowered. The robots' total size was calculated using the rulebook's dimensions.

R1 is 22 kilogrammes, while R2 is 26 kg. R1 measures 800mm by 880mm by 1 metre, whereas R2 measures 900mm by 980mm by 1230mm. R1 and R2 have a 5 bar compressed air pressure and a compressed air volume of 16.5 litres.

5. DISCUSSION

The robots R1 and R2 have been built to have the largest feasible base area. This lowers the robot's centre of gravity, increasing its stability while travelling. Next, since it is ecologically benign, used plastic bottles are used as gas tanks. At the same time, the weight of the discarded plastic bottles is less than that of the petrol tank. As a result, both robots can complete the work quicker since their weight has been lowered. As we all know, the mass of an object is inversely related to its acceleration. As a result, we are developing the robot employing this physics connection.

Furthermore, a high-quality sensor is employed to finish the work quickly and accurately. In a short amount of time, the sensor will navigate the location of the throwing robot (R2) at the throwing region. At the same time, the robot's (R2) light weight will allow it to stop more easily at the region where the job has to be completed since its inertia is lower. This is because we know that an object's mass has an impact on its inertia. As a result, we are making both of their masses lighter in order to lessen the robot's inertia.

6. SUSTAINABLE DESIGN

One of the most essential factors in robot design is sustainability. We built the robots out of discarded materials like plastic bottles and regenerated polyester. For pneumatic cylinders, the rejected plastic bottles serve as a pressure tank. Furthermore, the robot's foundation has been rebuilt since the platform that we used last year at ROBOCON MALAYSIA 2021 and ABU ROBOCON 2021 was heavier than the weight allowed by the regulations, therefore the body and base are made of aluminium, which is lightweight and recyclable.

Some electrical components are also being utilised as the robot's basic system, which may be customised to complete the mission. Instead, than utilising a new electronic board, certain electronic boards are reused by simply replacing malfunctioning electronic components with working components. An emergency button is also fitted on the robot for safety reasons.

Following that, we utilised rechargeable LiPo batteries as the robot's primary power source. Because rechargeable LiPo batteries may be reused several times, they do not damage the environment. In contrast, the chemical liquid within disposable batteries will leak into water and contaminate the environment if they are not properly disposed of. From this perspective, the usage of rechargeable LiPo batteries will have no negative impact on the environment while simultaneously improving technology. As a result, our robot may be considered ecologically friendly.

This R1 and R2 may help you enhance your quality of life. R1 and R2 may be utilised by athletes as training equipment to enhance their athletic abilities. It might potentially become crucial military concept in order to secure the nation from hostile invasion.

7. CONCLUSION

To summarise, R1's job is to fire the ball to shatter all of the Lagori with a precise angle to shoot and the valuable ball recognition using a camera to shoot the opponents ball, while R2's purpose is to clamp the Lagori and seize three balls at once. As a result, the robot is well-designed, with various considerations made in order to do all of the tasks. For example, the potential of firing the ball to break the Lagori with a constant 30ms by using a boost converter to lower the voltage to a constant 30ms of the speed was evaluated using a speed gun. At the same time, the system's angular momentum is maximised by placing the centre of mass on the robot's base. After several tests and modifications, the robot is capable of doing all of the ta

8. ACKNOWLEDGEMENTS

First of all, we would like to express our greatest gratitude to our supervisor, Dr. Rizuan Mat Noor for his guidance and assistance throughout the execution of whole project. Dr. Rizuan Mat Noor had been continuously reaching us to solve our problem from time to time and provide the valuable guidance for us to complete the project. We also appreciate the financial support from Universiti Sains Malaysia. Without the help from the university, we would not come to the success of the project. Besides, we would also like to acknowledge to those who have guided us either directly or indirectly with some useful suggestions to improve the robots. This is a great experience for us and also enrich our knowledge.

REFERENCES

[1] Robocon Malaysia 2022 Rules (n.d.). Retrieved on April 27, 2022 from https://roboconmalaysia.com/rulebook-2022-updated/

UNIVERSITI SUNWAY SUNNY WAY

Chan Xuan Ying, Lilian Ung Wei Fang, Nurhana Saleha Binti Mohammad Zofian, Ooi Ke Vin, Soong Jia Le

Department of Computing and Information Systems, School of Engineering and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, 47500 Petaling Jaya, Selangor.

House of Multimodal Evolution Lab, Level 3, Sunway University, Bandar Sunway, 47500 Petaling Jaya, Selangor

Student LIFE Level 1, Sunway College KL, No.2 Jalan Universiti, Bandar Sunway, 47500 Petaling Jaya, Selangor

ABSTRACT

This report documents the development of two robots for ROBOCON Malaysia 2022. The first robot, R1, has two pitching wheels supported by a frame that houses the microelectronics and batteries. The second robot, R2, has mechanical arms attached to its frame. Movement for both robots are enabled by the fixture of two wheels and one castor wheel to the robots' bases. Over a course of six trials, R1 was able to break two lagori discs in three trials. Both robots are controlled using Playstation 2 (PS2) controllers, which demonstrates the precision and robustness of both of the robots. All of the materials used in constructing both robots are corrosion-resistant, able to be reused safely, and most importantly, can be recycled without leaving a significant carbon footprint. The pitching mechanism of R1 follows the

concept of an American football pitching machine in which two wheels spin at high speed in order to project the ball far away from the point of projection. The subsequent motion of the ball after pitching can be explained using trajectory analysis as a tool.

1. INTRODUCTION

Robocon 2022 is an Asian-Oceanian college-level robotics competition based on the concept of the traditional game from India, known as Lagori. For this gameplay, each team has two robots that are named R1 and R2.

The objective of this competition is to compete with other teams and earn the most points. Hence, the strategy to accomplish this objective is to integrate several mechanisms into different parts of the robots. As the main duty of R1 is to launch the balls to break the Lagori, it has mechanisms such as ***pitching, turning*** and ***moving.*** Subsequently, the duty of R2 is to pass the balls to R1 and to pile up the Lagori discs that have been broken. To achieve this, it includes ***clamping, rotating*** and ***moving*** mechanisms.

The first task is completed by R2, where it clamps the ball from the ball rack to hand to R1. There are two types of clamping mechanisms adopted in the arms of R2. One of the arms of R2 will stay still while another will be moving inwards and outwards to clamp the objects. The passing mechanism passes the ball to R1 on the other side after grabbing the ball using the clamping mechanism. The ball will then roll down to the placement set to reach the shooting point and wait to be pitched towards the Lagori. The final task will be for R2 to pile up the Lagori discs that have been broken by R1. At this stage, the rotating mechanism will rotate both of the arms in sync to lift the discs up and down.

To conclude, a total of five mechanisms are required in the development of R1 and R2. This report will focus on the technical details of both robots, variables and data obtained through the testing phase, findings from the members, the sustainable engineering practices that have been developed, the capabilities and limitations of the robots, as well as some recommendations to improve them in the future.

2. DETAIL DESIGN

R1 and R2 are both designed to be semi-automatic robots. A member will be controlling each robot’s trajectory activities through buttons on a PS2 controller to start a series of actions.

This chapter discusses the various design aspects of both robots, including the mechanical, electronic, and software design.

2.1 MECHANICAL DESIGN

The focus of the mechanical design section is to detail the mechanisms employed by the robots to perform the tasks discussed in the introduction. This section will focus on the mechanisms of ***pitching, clamping, rotating, turning*** and ***moving***.

2.1.1 PITCHING MECHANISM

For this project, the design of a soccer ball launching machine was used as the reference for R1. There are two spinning wheels installed at the top of the R1 frame. By attaching motors to the spinning wheels, both of them can spin at a high speed in opposite directions. When a ball is channelled into the tube that was made from polyvinyl chloride, it is pushed between the two wheels where the friction along the surface accelerates the ball in order to launch it. This action produces kinetic energy to hurl or throw the balls towards the target — the Lagori pile.

The motion of the ball after being pitched can be explained by using the trajectory equation which is:

$$y = (tan\alpha) * x - [g/(2\,v^2cos^2\alpha)] * x^2$$

where y is the vertical distance of the ball from the ground, $\boldsymbol{\alpha}$ is the angle of the projectile to the line parallel to the ground, x is the horizontal distance of the ball from the point of the projectile, *g* is the gravitational force acting on the ball, and v is the initial speed of the ball.

Figure 1: A soccer ball launching machine

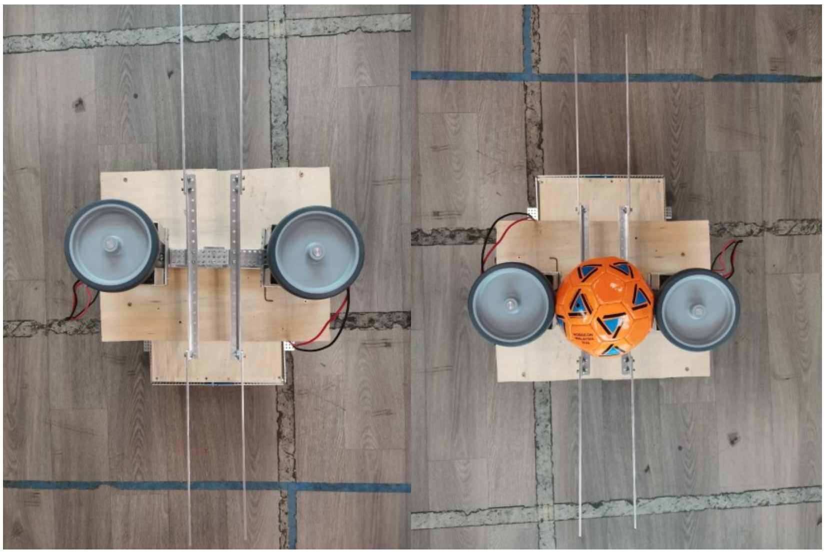


Figure 2: Top view of the pitching mechanism

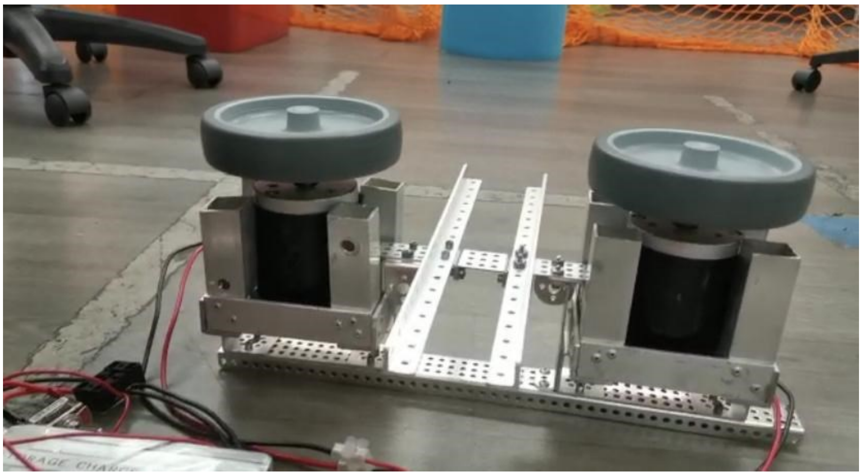


Figure 3: Front view of the pitching mechanism with motors

2.1.2 CLAMPING MECHANISM

R2 has a pair of arms to clamp the Lagori discs and to pick up the ball for R1. The clamp will have a minimum internal diameter of 10 cm and a maximum of 60 cm. The right arm functions as the fixed jaw and remains static during clamping. The left arm functions as the moving jaw, controlled by a servo motor. This arm consists of the holder and the jaw, connected via two aluminium sticks. The servo motor was placed on the arm and attached to one of the connecting aluminium sticks. When the servo motor rotates the aluminium stick, the other connector moves in a similar manner. Therefore, the jaw is kept in parallel with the holder while moving diagonally inwards or outwards towards the right arm.

2.1.3 ROTATING MECHANISM

R2 uses a rotating mechanism to position its two arms while arranging the Lagori discs and picking up the ball. The two arms are connected via a 70 cm aluminium stick. This aluminium stick was connected to a servo motor. The motor rotates the aluminium stick, thus lifting and lowering both arms.

2.1.4 TURNING MECHANISM

The turning mechanism is not the most important mechanism in building R1. However, it contributes to the role of aiming and shooting by rotating the robots to different angles. To detail this, members will use the controller to change the value of the degree of offset for the upper part of the robot. Most of the time, the body of the robot will stay in the start zone as only the upper parts of R1 are turning in the range from 0 to 359.9 degrees.

2.1.5 MOVING MECHANISM

Both robots share the same design for the moving mechanism. Their movement is regulated by two motors together with two wheels on the left and right sides. There is also one caster wheel attached to the front part of the robot as support. This enables the robots to move within the allowed regions.

Figure 3: Front view of the moving mechanism of R1

2.2 ELECTRONIC DESIGN

The electronic aspect deals with the circuit designs for the interfacing between the microcontroller with the remote control and the motors.

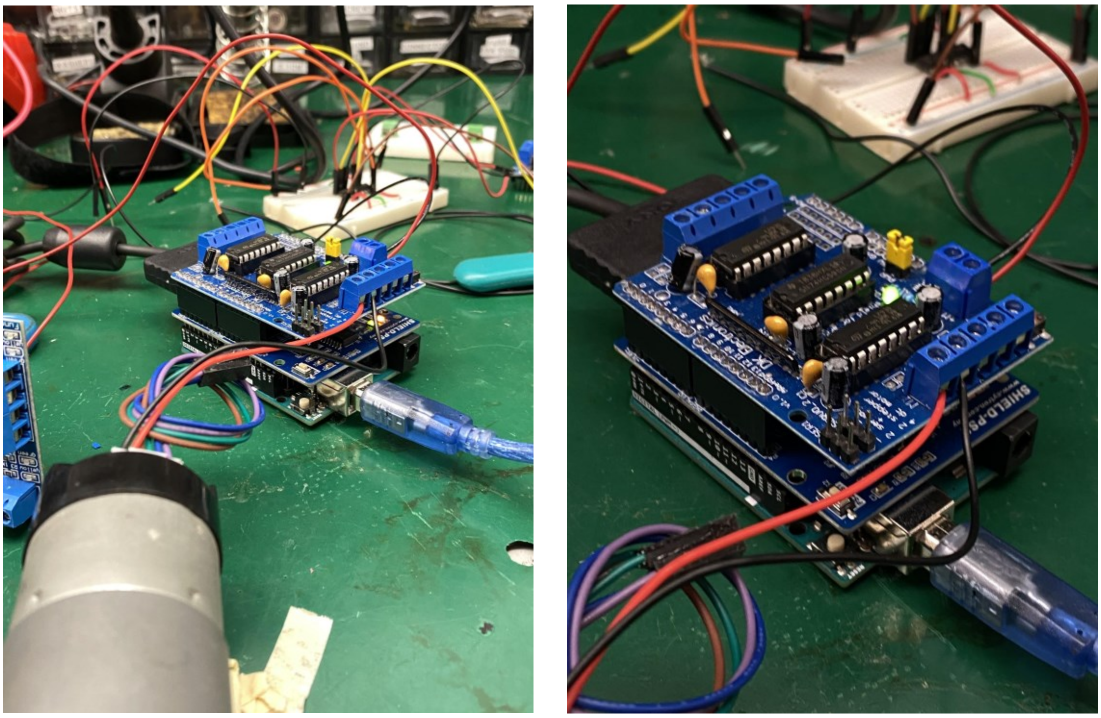


Figure 4: Arduino Uno with Cytron PS2 Shield and HW-130 motor driver

Arduino Uno is chosen as the microcontroller for the systems of both robots as it offers sufficient flexibility to fulfil the requirements of the system.

The microcontroller is required to process the signals received from the Cytron PS2 shield which is attached to the PS2 controller to receive input from the two joysticks and the available buttons. Upon receiving the signals for R1, the microcontroller will translate the signals into control statements to enable the two motors to control the robot in terms of the pitching, moving and turning mechanisms. For the R2, the microcontroller will control the two motors for the manoeuvring of the robot, the servo motor to rotate the arms, and the DC motor attached to the base wheels to move the robot. Besides the functions on the joysticks, there is also a button on the PS2 controllers to switch the power supply of the robots on and off.

2.3 SOFTWARE DESIGN

The software aspect explains the principles of controlling the mechanical components based on the input from the remote controls.

Figure 5: Playstation 2 (PS2) controller

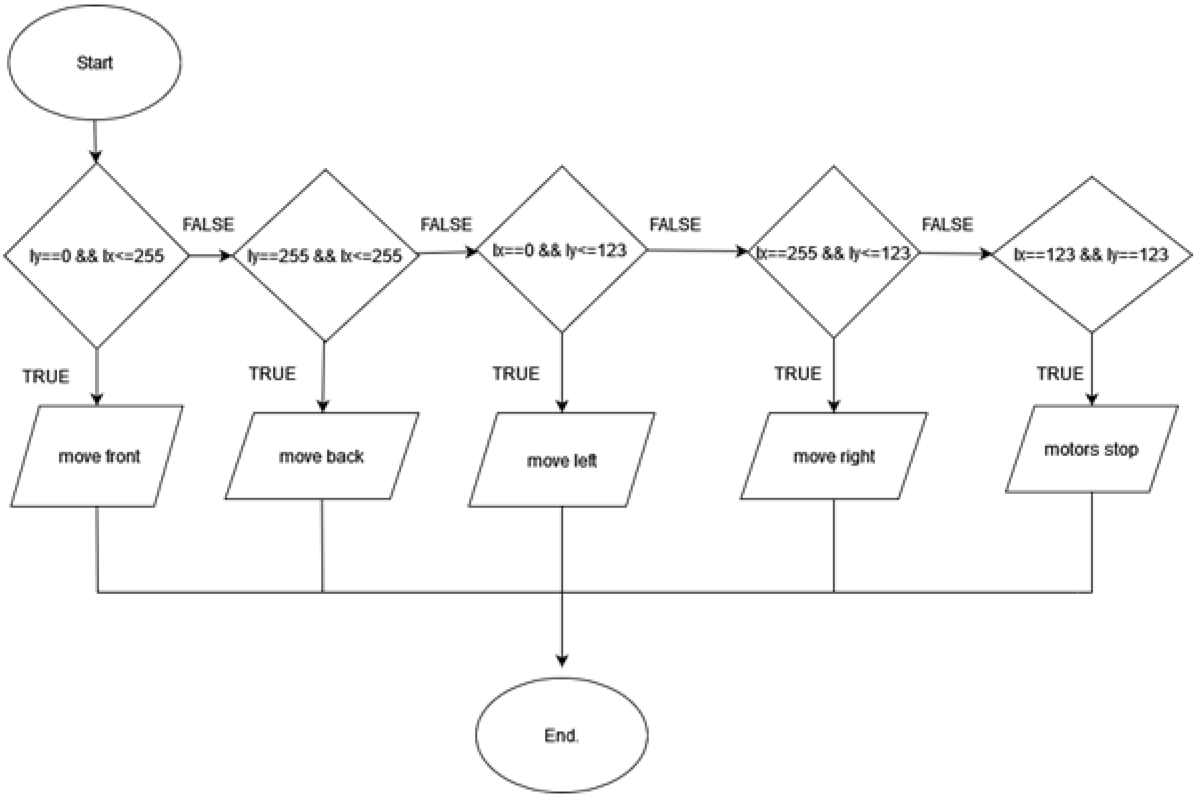


Figure 6: Flowchart detailing the software design for the base motors of R1

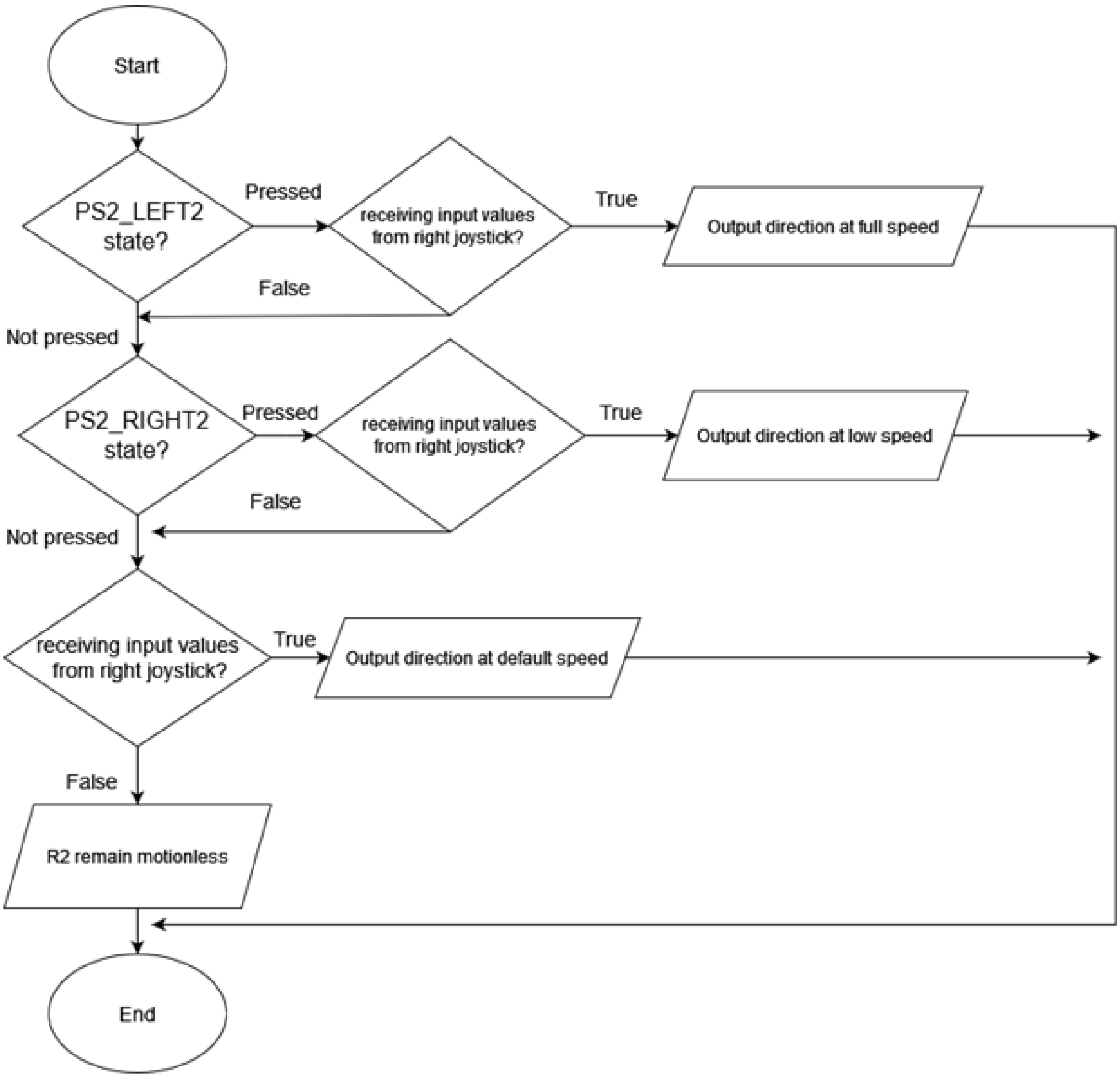


Figure 7: Flowchart detailing the software design for the base motors of R2

The software design for the motion control of R1 and R2 consists of receiving input values from the PS2 controller joysticks to determine the intended direction, and the PS2_LEFT2 or PS2_RIGHT2 buttons to determine the intended speed.

In R1, the left joystick values control the different directions (front, back, left, right and motionless) at a default speed of 255/255; where 255 is the maximum speed. The default speed is a fixed value in the program, hence no additional buttons are required to trigger the default speed.

In R2, the right joystick values control the different directions (front, back, left, right and motionless) at default, full and low speed. The default speed is fixed to 155/255, the full speed is fixed to 255/255 and the low speed is fixed to 90/255. The full speed is triggered by pressing the PS2_LEFT2 button only and the low speed is triggered by pressing the PS2_RIGHT2 button only.

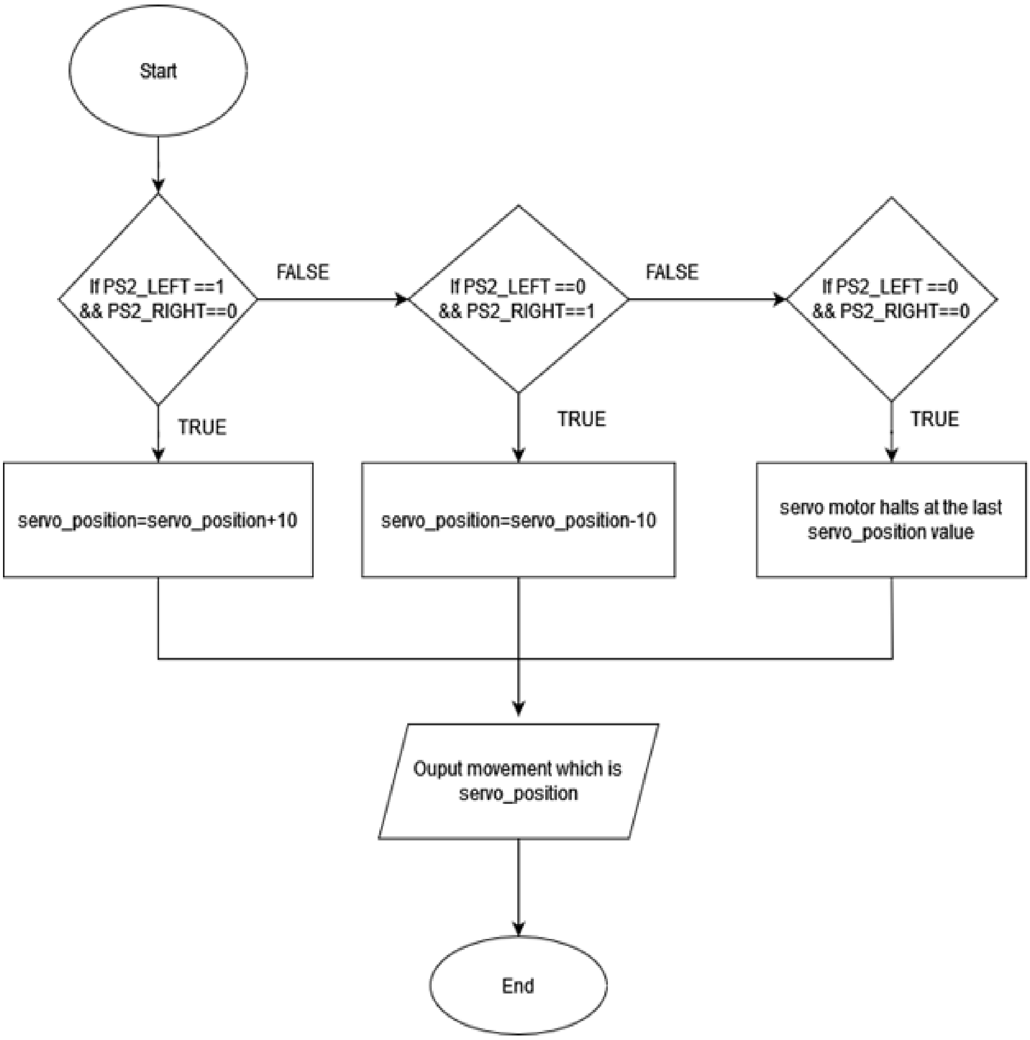


Figure 8: Flowchart detailing the software design for the clamping mechanism.

In R2, the clamping mechanism and the rotation of the arm are determined by the position of the servo motor. As the PS2 button is pressed, the servo position will continuously move according to the value of the servo motor's position that is being increased or decreased and this depends on the button that is pressed. When the button is released, the servo position will remain motionless. This design applies to both servo motors that are utilised by R2.

3. PRESENTATION OF DATA / SIMULATION / TESTING

For the testing phase of the robot, the launching mechanism used by R1 to break the Lagori pile was tried six times. The tests were carried out with the variables and procedures as follows.

Aim:

To make sure the robot is able to pitch and shoot the balls successfully.

Variables:

Controlled variable: Height of projection, h

Independent variable: Angle of projection, d

Dependent variable: Number of Lagori disc broken, n

Apparatus and Materials:

Five Lagori discs, 140 mm ball, tape measure and protractor.

Procedure:

2. The height of the projection, h was measured 1 metre from the ground vertically.
3. The angle of projection, □ was measured in degrees. The basis of the measured angle was ensured to be parallel to the ground.
4. The ball was placed in the channel tube leading to the pitching wheels for shooting.
5. The number of Lagori discs broken, n was recorded.
6. Steps 3 and 4 were repeated six times using $a = 45°$.

Data:

Table 1: Results of robot testing

Angle of projection, (°)	Number of Lagori disc broken, n
45	2
45	2
45	0
45	0
45	2
45	0

Conclusion:

Using a pitching angle of 45 degrees, R1 managed to break the Lagori pile three out of six times, each time displacing two discs.

4. DISCUSSION / EVALUATION OF FINDINGS

Based on the current progress, each of the mechanisms will be able to achieve the desired outcomes. The game should be completed within 90 seconds with minimal mistakes. In this case, both the robots are uniquely designed in that they apply and integrate several concepts from real-world applications.

For instance, the team was inspired by the soccer ball launcher to build the pitching mechanism for R1. Initially, the speed at which the ball could be shot was found to be insufficient. According to the laws of physics, the force of impact decreases when the speed of an object decreases. As a result of the low speed, the balls did not have enough force to break the Lagori pile precisely. To rectify this issue, the pitching wheels were independently controlled by an action button, allowing for the speed of both wheels to remain at the same high speed and constitute a more accurate curvature when launching the ball. It was also crucial to ensure that the operating voltage for the pitching wheel was sufficient to avoid any decrease in the speed.

Additionally, the rotating mechanism in R2, mainly the going upward and downward motion of the arms for lifting, was inspired by the barrier arms of a toll booth. One of the concerns at the beginning of building R2 was that the disc could not be placed in between the arms. The disc falls easily as the arms rotate up and down. This would affect the process of piling up the discs as each disc must be placed horizontally on the ground. By adding a servo motor at the front of the arms to increase the tension for clamping, the discs can be moved in between the arms and be arranged back in their original order.

Instead of using existing designs from real-life applications, the team constantly researches for better mechanisms to fulfil the requirements. We use an alternative approach where the strengths of different mechanisms are integrated to perform a specific task. Hence, it maximises the effectiveness of the robots and our creativity in developing suitable robots for the competition.

5. SUSTAINABLE ENGINEERING PRACTICES

To develop sustainable engineering practices, both the robots are designed to be eco-friendly by ensuring that the components are reusable after the competition.

Firstly, the robots only use lithium-polymer batteries. These batteries are rechargeable and therefore they can be salvaged and reused for other purposes. The connectors, microelectronics and motors used in the electronics are also reusable.

Secondly, the mechanism of robots is designed as separate modules. By using conventional connectors, we are able to swap out different modules while building the robots. This can help to increase the reusability of the parts and the flexibility for design modifications.

Thirdly, the overall structures of the robots are built from scrap metal. These materials were being disposed of by different factories and were collected by previous members of the H.O.M.E. Lab. The team members also scavenged for raw materials from previous robotics competitions. As a consequence, the robot uses a combination of different types of metals which can help to save cost and increase the efficiency of development.

Overall, the type of materials used, the designs of the mechanisms implemented, and the sources of materials are the major considerations for the sustainable engineering practices in developing R1 and R2.

6. CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

In conclusion, the robots R1 and R2 are capable of functioning according to the specifications designated by the competition. Every member of the team understood the electronic designs, which met the objectives of this competition: getting new hands-on experiences and gaining valuable knowledge through the development of competitive robots. The software is designed in such a way that certain tasks can be performed simultaneously to reduce the time taken to finish an attempt.

However, there are a few limitations that the team has encountered. Firstly, the mechanism of R1 is limited. Ideally, adding a grabbing mechanism to R1 that would enable it to grab the ball from R2 would save the overall time taken in the first task. This mechanism can also help to improve the precision of controlling and positioning the ball in the following tasks. The second limitation is the time delay encountered while carrying out the tasks. Since most of the mechanisms are not autonomous, time is required for the member to aim the shooting mechanism for the balls. This process may constitute human error and consequently slow down the process. Lastly, the movement of the robots is being limited significantly. Owing to the fact that both of the robots are equipped with normal wheels and castor wheels, it is difficult to freely position the robot in the right spots.

In order to overcome these limitations to make the robots better, there are a few recommendations to take note of. It is recommended to automate most of the mechanisms for maximum precision and consistency. More research on how to accurately capture the impact and outcomes should be done. Furthermore, software modelling tools and extended theoretical equations are needed to produce better simulations to prevent exceptional errors from the surroundings. Installing an omnidirectional wheel would be an ideal solution for the situation above as the member can easily navigate between obstacles and tackle the given tasks in a short time.

Though the robot is built and functional, the limitations identified from the testing results will now need to be further explored and improved in the future.

7. ACKNOWLEDGEMENT

We would like to express our sincere gratitude to Student Life at Sunway University for the financial support. With the provision of instruments, tools, and space from the House of Multimodal Evolution Laboratory (H.O.M.E Lab) at Sunway University and Sunway's Research Centre for Human-Machine Collaboration (HUMAC), we were able to develop the robots for the game. Besides, we have the feeling of thankfulness to Prof Dr Yap Kian Meng, Dr Richard Wong, Dr Eu Kok Seng and Ms Shazrina Razi who offered advice, guidance, and continuous support to us. We are also like to use this opportunity to thank our friends and families whose names are not mentioned for their support in various aspects. Lastly, we want to celebrate all the team members for their contributions to the design and construction of the robots, as well as the fun we have shared along the journey.

REFERENCES

[1] Ang. J et al. (2020) Sustainable Robot Design From Reused Materials With Reusable Modules. [online] Available at: https://pubhtml5.com/izqo/hdrq/basic [Accessed 10 May 2022].

[2] Marquette (2013) Design and Construction of an Omni-Directional Soccer Ball Thrower. [online] Available at: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1601&context=honors [Accessed 10 May 2022].

UNIVERSITI TEKNOLOGI MALAYSIA (UTM) A

Najmul Islam[2], Tam Zhan Quan[2], Ephraim Teh Khai Ee[2], Chia Ming Lok[1], Geam Yong Sean[1], Mohamad Daniel Haziq Bin Haswadi[1], Chong Zhi Sheng[1], Cheah Kar Wai[1], Wong Pei Sen[1], Beh Zhen Xian[1], Lim Shao An[1], Muhammad Irfan Rahman Bin Mohd Khaidzir[1], Fong Yupeng[2], Lee Jia Quan[1], Su Ee Siang[1], Tan Yong Sheng[3], Abdulrahman A Ludeen[1], Pua Kian Yang[1], Chan Tai Jie[1], Yu Jinx Xian[1], Dickson Chong Yung Haw[1], Mohd Ridzuan Ahmad[1]

[1]School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia.

[2]School of Mechanical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia.

ABSTRACT

This report sums up all three aspects which are the mechanical, electronic, and software design considerations of the two robots, i.e., Robot 1 (R1) and Robot 2 (R2) of Universiti Teknologi Malaysia (UTM) Robocon Team A. To accomplish this year's game, R1 must be able to shoot down all the Lagori discs and the Ball on Head (BOH) on the opponent's R2 Seeker whereas R2 must be capable to restack the fallen Lagori discs as well as assist R1 in

picking up the Hitter Balls from the Ball Rack during its Hitter Round. In terms of the robots' design, R1 is equipped with a flywheel shooting mechanism while R2 uses a set of custom grippers that specialises in piling the Lagori disc and as well as an extended back claw to collect the Hitter Balls. R1 is a static robot with no navigation whereas R2 incorporates a 4-point omni-wheel base. Based on repeated testing, R1 as Seeker was able to shoot down the Lagori pile in three to five seconds and as Hitter, it is able to detect and shoot its opponent's BOH most of the time. R2 as Seeker was able to pile back most of the fallen Lagori discs and was able to pass the Hitter Balls with a 90% success rate to R1 Hitter majority of the time. Although both robots still comprise of 90% of metal, the team members did put effort into reducing metal usage as an initiative to protect the environment. Not only that, the potentials of these robots are not limited to only the tasks in this competition but also applicable to real-life scenario such as sensing and detecting object motion and piling and lifting objects.

1. INTRODUCTION

UTM Robocon Team was established in the year 2002 with the main focus to develop robots and to train young and talented engineers into becoming experts in the field of robotics and automation which is in align with the IR4.0 proposed by the government. Participating in Robocon Malaysia 2022, the team is required to develop two robots, R1 and R2. With two different roles for each robot, both R1 and R2 must collaborate in synchrony in order to complete the tasks successfully. In our strategy, R1 will remain a static robot in order to provide firm consistency in shooting while R2 will function with its customed grippers designed to pile the Lagori discs as fast as possible.

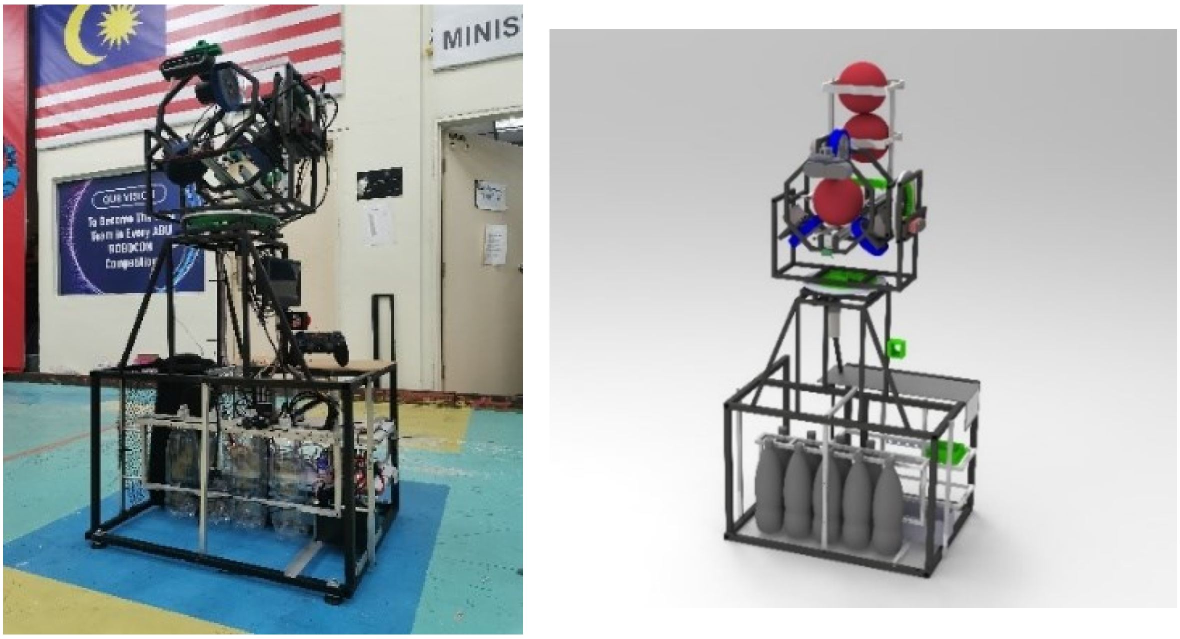
2. MECHANICAL DESIGN (ROBOT 1)

Figures 1(a)-(b) show the picture and the CAD design of R1. R1 incorporates a four-point static base system in order to ensure that the robot does not moves when it shoots the ball. This robot has an initial dimension of 650 mm (L) x 519 mm (W) x 1450 mm (H) and the width of the robot may extend up to a 550 mm (W) when its shooting mechanism rotates in the y-axis direction. The overall weight of the robot is 22.1 kg and it consists of two main parts, which are the loading and shooting mechanism and ball receiving mechanism.

Starting from the loading mechanism which is connected to the octagonal shooting design, the loading can take up to a maximum of three balls at once. The loading area uses a servo motor to ensure that only one ball is fed to the shooting mechanism one at a time. The shooting mechanism is a 3-wheel flywheel mechanism, placed at an angle of 90º, 165º and 285º.

For the feeding of the ball to the flywheel, a rodless pneumatic cylinder is incorporated to ensure uniform feeding. For the pitching movement of the shooting mechanism, R1 uses a servo motor whereas the yawing movement uses a brushless motor with encoder that is able to provide feedbacks for accurate angle positioning.

Furthermore, this robot also implements the usage of multiple various sensors for purposes such as, verifying the presence of a ball inside its loading area and tracking the Ball on Head (BOH) on the opponent's R2 Seeker. Not only that, all autonomous computations are done via an on-board computer placed on R1.



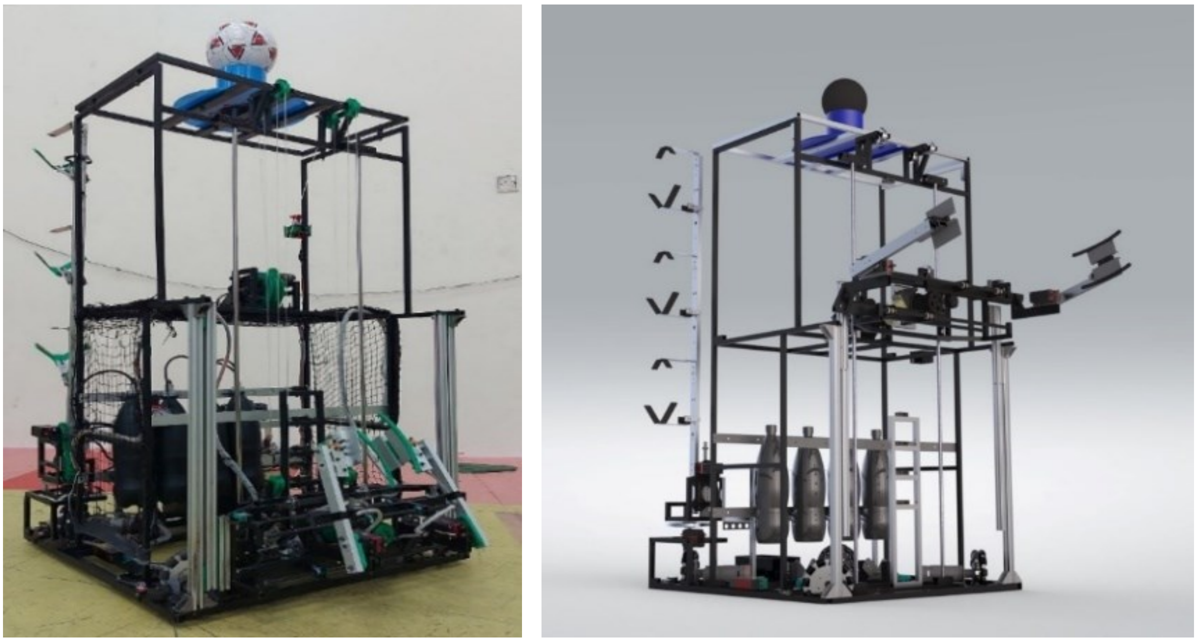
(a) (b)

Figure 1: (a) Photo and (b) CAD Design of R2

3. MECHANICAL DESIGN (ROBOT 2)

Figures 2 (a)-(b) show the picture and the CAD design of R2. R2 incorporates a 4-point omni-wheel navigation base system which allows R2 to move faster and at the same time maintaining its stability. Next, different various sensors which functions to provide feedbacks are also used to get precise positioning and accuracy of the robot's functions. This robot has an initial dimension of 956 mm (L) x 746 mm (W) x 1231 mm (H) and can extend up to 1621 mm (L) x 1129 mm (W) x 1231 mm (H). The weight of the robot is 27.4 kg and this robot consists of two main parts, which are the Lagori gripper and ball gripper.

The Lagori gripper consists of a power window motor, an external encoder, two servo motors, several limit switches and analog sensors. The extension and retraction of the gripper is controlled via the power window motor and analog sensors. The servo motors used function to increase the flexibility of the gripper, which enables the gripper to grip even Lagori discs which fall on its curved surface. This gripping method has high flexibility as it is able to grip different sizes and orientations of the Lagori discs.



(a) (b)

Figure 2: (a) Photo and (b) CAD Design of R2

As for the piling mechanism, it is made up of compound pulleys that are controlled by a power window motor attached with an external encoder whereby the motor will turn and raise the gripper to certain heights once it grips a Lagori disc. The advantages of using compound pulleys are that their weight reduction ratio helps to make lifting up heavy things lighter and faster.

Moving on to the ball gripping mechanism, the components used are two servo motors, a pneumatic cylinder and inelastic fishing lines. The pneumatic cylinder used will help in the retraction and extension of the 3D printed grippers and as for the servo motors, one of it will lift the lever of the ball gripper while the other will change the orientation of the whole mechanism to pick up the Hitter Balls from the other side.

4. ELECTRONIC DESIGN

Figure 3 and 4 show the distribution of sensors and architecture of the processing units within R1 and R2 respectively. Since R1 is a static robot, no Robot Navigation System is required whereas R2 highly depends on it.

The mainboard with ARM microcontroller is used to run the logical algorithm of the program while the Robot Navigation System is used to drive the four navigational motors. The H-bridge power distribution module is connected to the mainboard to control the motors through motor drivers, equipped with an emergency button enabling power cut-off in the case of an emergency. Besides, the mainboard will also send PWM signals to the servo motors in order to control them.

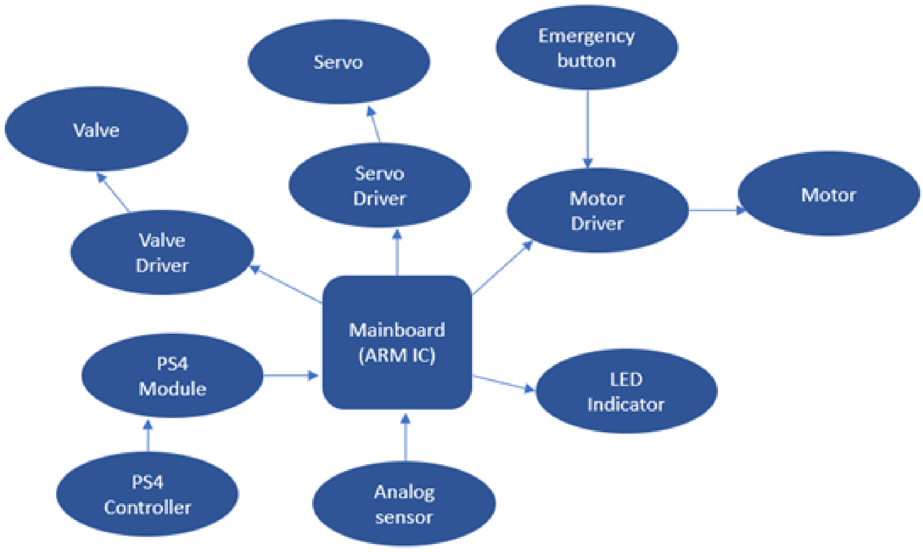


Figure 3: Electronic block diagram of R1

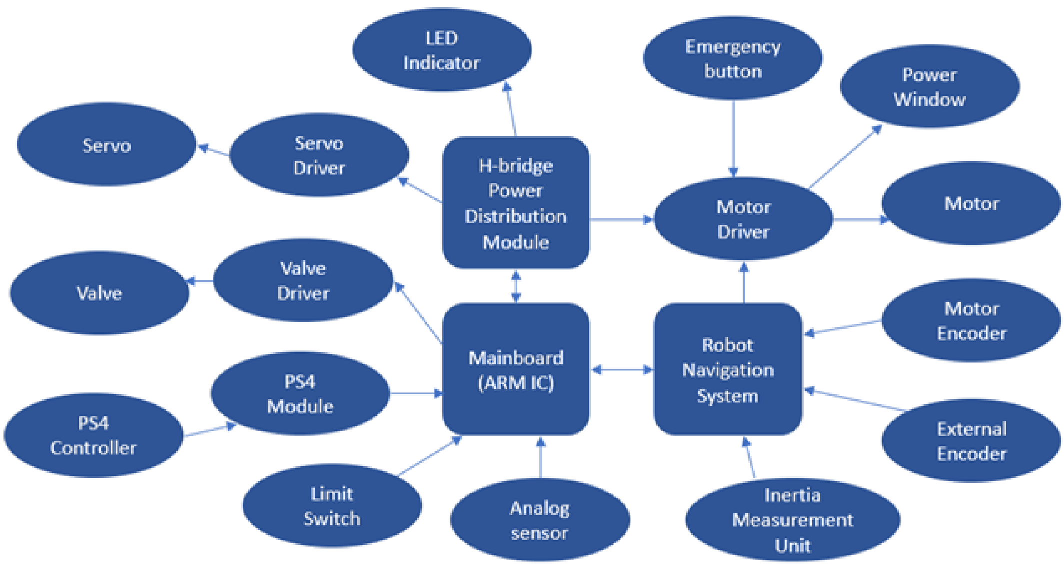


Figure 4: Electronic block diagram of R2

Several sensors such as analog sensors, limit switches, encoders, and the inertial measurement unit are also used in the robots for accurate positionings whereby all the sensor feedbacks will be sent to the mainboard or Robot Navigation System for processing. Not only that, a PS4 module is also designed to communicate with the mainboard for controlling the robot via using a PS4 controller.

5. SOFTWARE DESIGN

Figure 5 shows the programming flow chart of R1. When R1 is in Seeker Round, R1 initializes its shooting platform, specified motors speed and position for Lagori Break. When the game starts, R1 shoots the Seeker Balls to break down all the Lagori discs. As for R1 in Hitter Round, after R1 receives the Hitter Balls from R2, R1 starts to either automatically track or manually aim the opponent's BOH. If opponent's BOH is aimed, R1 shoots the Hitter Ball.

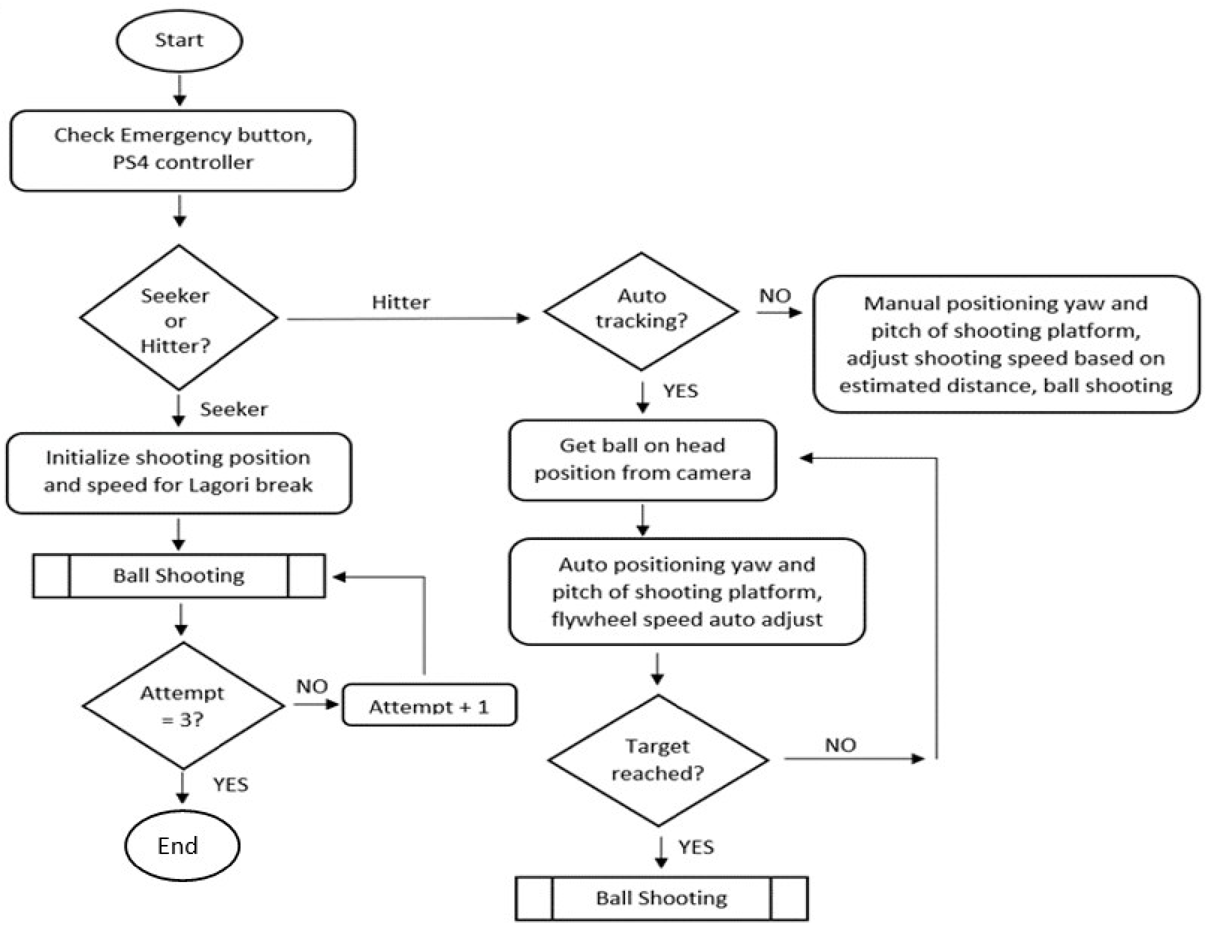


Figure 5: Programming flow chart of R1

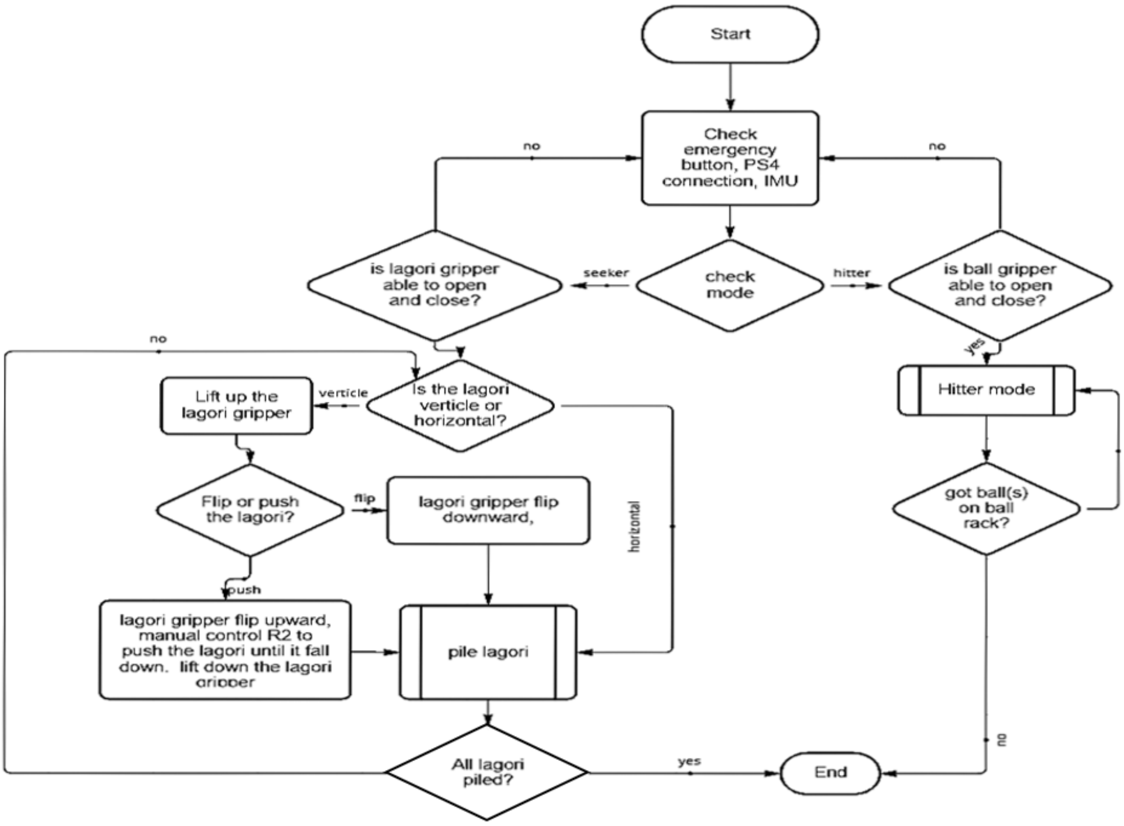


Figure 6: Programming flow chart of R2

Figure 6 showed the programming flow chart of R2. For the R2 in Seeker Round, once Lagori Pile session begins, R2 moves into Lagori Area to start piling up the fallen Lagori discs. The piling sequence starts from the biggest Lagori disc. If the targeted Lagori disc is at a horizontal position, R2 will just grip the targeted Lagori disc and if the targeted Lagori disc is at a vertical position, R2 will flip the targeted Lagori discs by changing the angle of the servo motors. Once R2 grips a Lagori disc successfully, the pulley will lift the Lagori gripper to its respective level of placement. At the same time, R2 will navigate as it moves towards the Lagori Base. Once there, R2 will release the Lagori dics, move backwards and repeat the same process for the remaining Lagori discs. R2 during the Seeker Round operates semi-autonomously.

During the Hitter Round, R2 moves autonomously to the Ball Rack. Once it reaches there, R2 will to stick to the fence and the Ball Rack. Then, the lever of the ball gripper goes down and closes its grippers to grip the Hitter Balls, goes up and starts moving back autonomously as well to pass the Hitter Balls to R1. By using laser pointing, R2 positions itself behind R1 and releases the Hitter Balls to R1 by opening the its ball gripper. Then, R2 restarts at its R2 Start Zone and starts another path plan to the other Ball Rack.

6. PRESENTATION OF DATA/SIMULATION/TESTING

6.1 ROBOTS SIMULATION

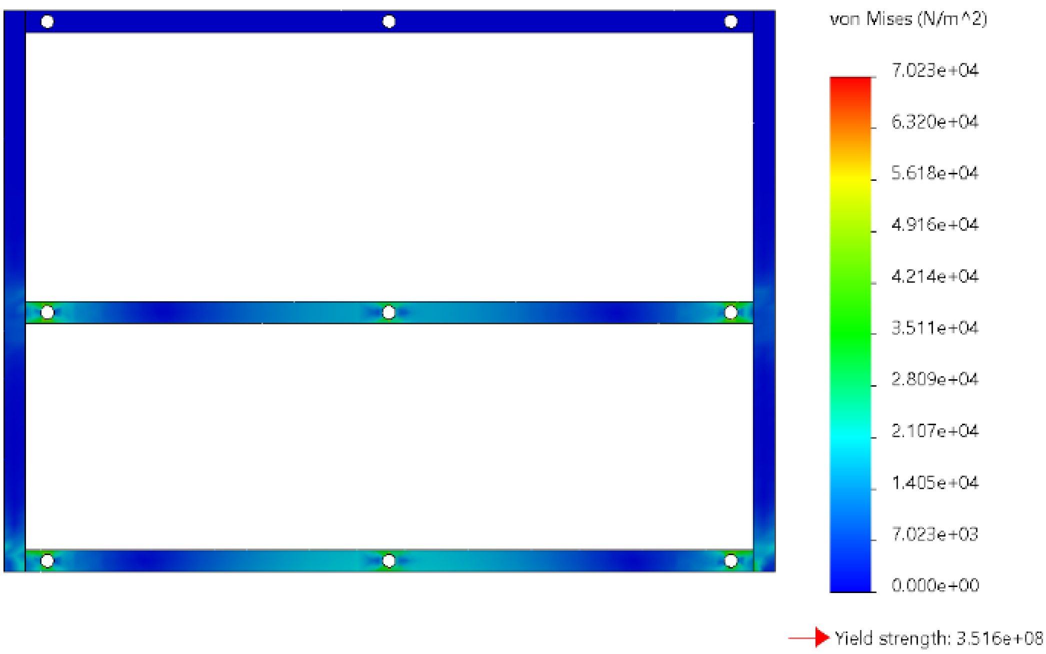
Before the fabrication process of both robots begin, stress analysis on the base of each robot is done as shown in Figure 7. The result simulated helps to determine the critical breakpoints, the maximum stress that the robot base can withstand and also the minimum tensile strength of the material that should be considered and used. Testing have been done to evaluate the robots' performance while adjustments were made for better improvements.

6.2 TESTING DATA OF R1

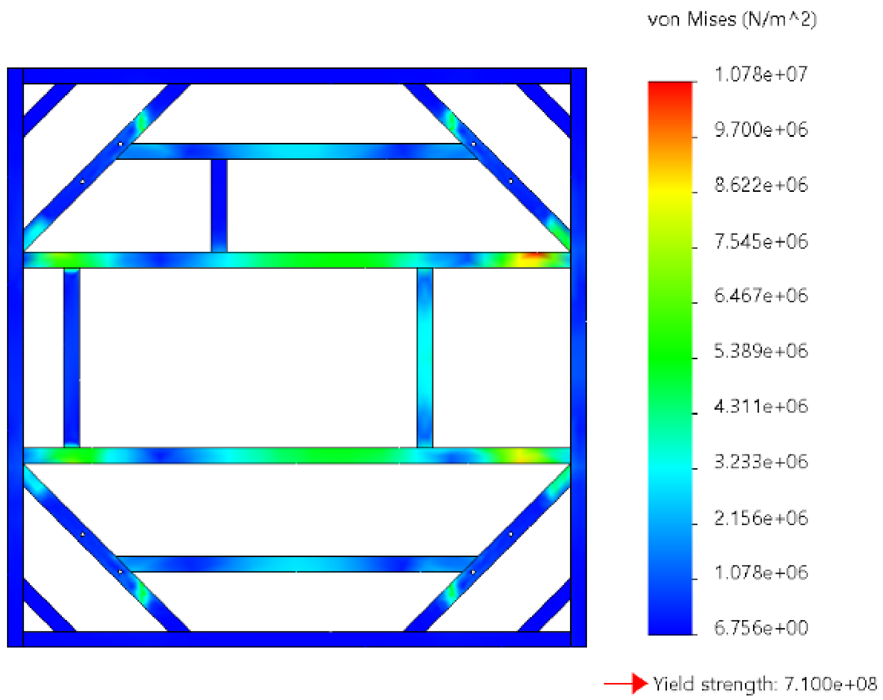
Figure 8 presents its accuracy percentage in shooting down the BOH of Seeker R2 at different ranges. This data was collected during our training sessions and it can be seen that the shooting accuracy of R1 is more than 70%.

6.3 TESTING DATA OF R2

Figure 9 shows the passing success rate of the Hitter Balls to Hitter R1. This data was also collected during the time span of our training sessions and from these sessions it can be noticed that R2 has high percentage of successful Hitter Ball passing rate to R1.



(a)



(b)

Figure 7: Stress Analysis on the Base of (a) R1 and (b) R2

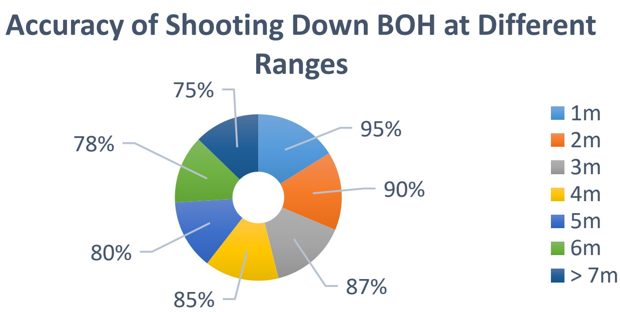


Figure 8: Accuracy of Hitter R1 in Shooting Down BOH at Different Range

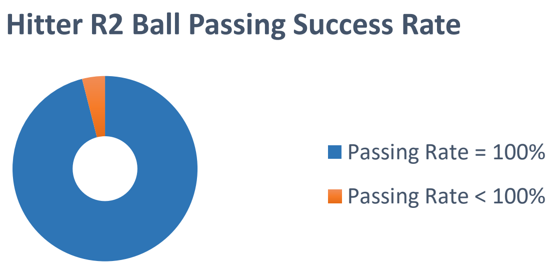


Figure 9: Hitter R2 Ball Passing Success Rate

7. DISCUSSION/EVALUATION OF FINDINGS

From the testing results after and over several designs and modifications, it is evident that for R1, the accuracy of shooting using its flywheel motors is highly dependent on the speed of the motors and also on the angle of the pitch and yaw of the shooting platform. On the other hand, a versatile gripper which has more than one degree of freedom attached to a height variable pulley is found to help gripping and restacking the Lagori disc with much ease for R2. Besides, have a separate ball gripping mechanism which picks up all three Hitter Balls at once is found to be best solution in assisting R1 in terms of having more chances to shoot down the BOH in the least amount of time.

8. SUSTAINABLE ENGINEERING PRACTICE

Sustainable engineering practices have always been our top emphasis since the establishment of UTM Robocon Team. Here in UTM Robocon, we apply the 6Rs of sustainability which are Rethink, Refuse, Reduce, Reuse, Recycle and Repair into everything that we do. In our rethinking habits, we make sure to always take into consideration the impact of our decisions towards the well-being of the environment. For instance, in our planning, we made sure that the process outcome of each robot does not emit any harmful effects that might pollute the environment. Next, in terms of refusing, we strictly refuse to use any substances or products that will cause harm to the environment and also to ourselves no matter how convenient they are. Furthermore, for this year’s game we had also reduced the usage of metals on our robots by first doing computer-aided simulations on our robots’ designs in order to determine the unwanted metals that will only generate more waste. Next, since aluminium does not rust, we will reuse the aluminium disassembled from previous robots and reuse them for our next robots. In addition, carbonated bottles are also reused as gas reservoirs for pneumatic actuators instead of simply being thrown away. As for metals that are not reusable, we will simply send them to the recycling centre which also helps us to generate a few extra incomes. Not only that, as engineering students of UTM we also repair components that are spoilt or broken as this will not only help to prevent the depletion of natural resources but also help us to enhance our tinkering capabilities. In short, we as the younger generation do care about our environment and thus will always try to do our best into minimizing the impacts of our actions towards the environment.

9. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

In conclusion, the task for shooting both the Seeker and Hitter Balls respectively onto its target and as well as piling the Lagori discs were able to be accomplished based on our robots' prototypes and models. However, even with such completion, there are a few limitations that we had encountered by ourselves. For instance, when things become very complex, we are required to identify and resolve the new problems that might arise due to the complexity and as well as fine-tune it later on in order to achieve the best performance. Besides, another limitation is the insufficient budget of the team which hinders the members from being able to explore new and better options that can help to bring our robots to the next level. Finally, in terms of recommendations and improvements, we suggest a multi-shooting mechanism for R1 which can help increase its options of shooting. As for R2, our recommendation is to have more incorporation of various industrial style pick and lift mechanism which can help to pile the Lagori discs faster and more precise.

10. ACKNOWLEDGMENTS

We would like to express our gratitude towards Universiti Teknologi Malaysia, Faculty of Engineering for giving us the support and facilities to develop our robots. Next, we would also like to sincerely thank our team manager, Prof. Madya Ir. Dr. Mohd Ridzuan bin Ahmad, who have always been there since day one to advise us in terms of the technical issues as well as conducting the management in our team. Not forgetting, thank you to all of our team members for never endingly striving in developing better robots for this competition. Last but not least, a huge appreciation to our sponsors for supporting us along the way with the preparation for this Robocon Malaysia 2022.

REFERENCES

[1] ROBOCON MALAYSIA 2022. (n.d.). Retrieved May 9, 2022, from https://roboconmalaysia.com/.

[2] ROBOCON MALAYSIA 2022 GAME RULES. Retrieved Jan 15, 2022, from https://roboconmalaysia.com/wp-content/uploads/2022/03/Malaysia-Robocon-2022-Theme-and-Rules-V2.pdf.

[3] ABU ROBOCON 2022. (n.d.). Retrieved September 30, 2021, from https://www.aburobocon2022.com/.

[4] ABU ROBOCON 2022 Game Theme & Rules "LAGORI". Retrieved February 7, 2022, from https://www.aburobocon2022.com/index.php/game-rules.

UNIVERSITI TEKNOLOGI MALAYSIA (UTM) B

Abdulrahman A Ludeen[1], Beh Zhen Xian[1], Chan Tai Jie[1], Cheah Kar Wai[1], Chia Ming Lok[1], Chong Zhi Sheng[1], Dickson Chong Yung Haw[1], Ephraim Teh Khai Ee[2], Fong Yupeng[2], Geam Yong Sean[1], Lee Jia Quan[1], Lim Shao An[1], Mohamad Daniel Haziq Bin Haswadi[1], Muhammad Irfan Rahman Bin Mohd Khaidzir[1], Najmul Islam[2], Pua Kian Yang[1], Su Ee Siang[1], Tam Zhan Quan[2], Tan Yong Sheng[3], Wong Pei Sheng[1], Yu Jinx Xian[1], Mohd Ridzuan Ahmad[1]

[1]School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia.

[2]School of Mechanical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia.

[3]School of Computing, Faculty of Engineering, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia.

ABSTRACT

This report is a summary of three aspects, the mechanical, electronic, and software design considerations of the two robots, i.e., Robot 1 (R1) and Robot 2 (R2) of Universiti Teknologi Malaysia (UTM) Robocon Team B. To accomplish this year's game, R1 must be able to shoot down all the Lagori discs and the Ball on Head (BOH) on the opponent's R2 Seeker whereas R2 must be capable to restack the fallen Lagori discs as well as assist R1 in picking up the Hitter Balls from the Ball Rack during its Hitter Round. In terms of the robots'

design, R1 is equipped with a flywheel shooting mechanism while R2 uses a set of custom grippers that specialises in piling the Lagori disc and as well as an extended back claw to collect the Hitter Balls. R1 is a static robot whereas R2 is equipped with a 4-point omni-wheel base. Based on repeated testing, R1 as Seeker was able to shoot down the Lagori pile in three to five seconds and as Hitter, it is able to detect and shoot its opponent's BOH most of the time. R2 as Seeker was able to pile back most of the fallen Lagori discs and was able to pass the Hitter Balls with a 70% success rate to R1 Hitter majority of the time. The whole team members are always aware of sustainable practices such as avoid wasting any material while designing the robots as we hope we can protect the environment. Furthermore, we believe that our development isn't limited to the competition only, it also can be applied in real life such as sensing and detecting object motion and piling and lifting objects.

1. INTRODUCTION

UTM Robocon Team was established in 2002 and the main focus is on developing robots and being active in Robocon activities to train the young and talented engineers to become the expert in the fields of robotics and automation which is aligned with the IR4.0 proposed by the government. Participating in Robocon Malaysia 2022, the team is required to develop two robots, Robot 1 (R1) and Robot 2 (R2). How the two robots collaborate to shoot down the Lagori tower and Ball on Head (BOH), as well as piling up Lagori to complete the game are the highlights of the game. To end the game, the team needs to shoot down the Lagori tower and complete the Lagori piling within the time given. At the same time, R1 can shoot down the BOH of opponent R2 to stop the piling time, and R2 must be aware of opponent R1, preventing the BOH from getting hit. Thus, this game not only focuses on the robot itself but also on the strategy used by the team to complete the game.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN ROBOT 1 (R1)

Figure 1 (a)-(b) show the R1 design which has a body with a dimension of 714 mm (L) x 532 mm (W) x 1448 mm (H). The weight of the robot is 23kg. This robot base does not have a navigation system since it is not assigned to accomplish movement tasks. The wide base is to ensure the robot sustains the recoil of the shooting mechanism after every shot. It has two main mechanisms which are shooting and loading mechanism and ball passing mechanism.

(a) (b)

Figure 1: (a) Photo and (b) CAD Design of R1

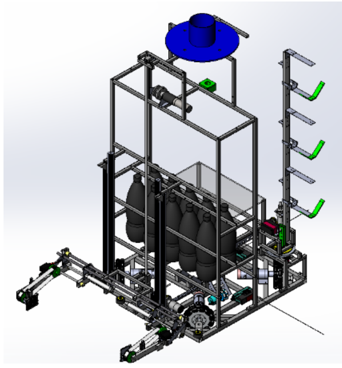
For the shooting mechanism, we used three flywheels which have three symmetrical angles of 120 degrees so that an equal force will be exerted onto the ball and shoot it out towards a target at a high speed consistently and accurately. The flywheels will be rotated using three high-speed motors. The shooting angle of the shooting mechanism can also be adjusted with our two high torque servos to adjust the yaw and pitch respectively. Hence, it can be adjusted to shoot both the ball on head and break the Lagori discs. For the loading mechanism, to load the ball from our ball magazine, we used two pneumatic cylinders, one for feeding and one for stabilisation. The ball will be loaded from the magazine and fed to the flywheels at the exact moment after aiming.

As for the ball passing mechanism, R1 will cooperate with R2 to pass the green shooting balls from the ball racks on each side of the game field. R1 will have a mechanism to catch and load the ball to be used for the ball on head shooting. A scissors mechanism is also used to extend a lift to ease the loading process and aim faster to have an advantage for the hitter session.

2.2 MECHANICAL DESIGN ROBOT 2 (R2)

R2, as shown in Figure 2 has a minimum dimension of 728 mm x 950 mm x 1243 mm and a maximum dimension of 1630 mm x 970 mm x 1243 mm. The weight of the robot is 26.2kg. It has mechanisms including four-point navigation, ball pickup and passing, lagori picking and pilling mechanism. External encoders, limit switches, and laser sensors are attached for feedback in robot positioning. The four-point Omni-wheel base is chosen because it can provide a stable movement to prevent the ball on head from falling easily.

(a)



(b)

Figure 2: (a) Photo and (b) CAD Design of R2

Besides that, this game required high velocity so a four-point Omni-wheel base will be sufficient. The ball pickup and passing body are made of aluminium to reduce the body weight and ensure the stability of the whole system. The bottom part of the ball pickup and passing is made of mild steel to make sure it can provide good support when attach to the base. The bottom part of the ball pickup consists of two servo motors to provide two axis rotation when picking up balls from two sides of the ball rack. The servo can control the angle of the body to provide a more precise angle. The 3 ball grippers are actuated by a pneumatic cylinder with a linkage connection to grip three balls at once. This system is located at the top right corner of the robot so that it can reach the ball easily.

The lagori gripping mechanism is made of one gripper and actuated by 4 pneumatic cylinders. The cylinder will contract to grip the lagori according to the size of the lagori. There are two servo motors connected with a timing belt at each side of the gripper to change the orientation of the lagori. After gripping the lagori, there will be one motor which actuates the pulley system to lift the lagori to the respective position on the base. This pulley mechanism is supported by three linear guides to prevent the shakiness of the gripper. The whole gripper is made up of mild steel to prevent the metal from bending and ensure the stability of the robot.

3. ELECTRONIC DESIGN

Figure 3 and 4 show a distribution of sensors and architecture of the processing units within R1 and R2 respectively. For R2, the mainboard with an STM32 chip is used to run the logical algorithm of the program while the Robot Navigation System is used to drive the four navigational motors. The H-bridge power distribution module is connected to the mainboard to control the pneumatic valve and navigation motors through motor drivers equipped with an emergency button enabling power cut-off. The mainboard also sends PWM signals to the servo driver board to control the servos.

Several sensors such as analog sensors, limit switches, laser sensors, encoders, and Inertial Measurement Unit are used in the robot for real-time feedback from the robot and accurate positioning. All sensor feedback will be sent to the Mainboard or Robot Navigation System for processing. A PS4 module is designed and communicates with the mainboard for controlling the robot using a PS4 controller.

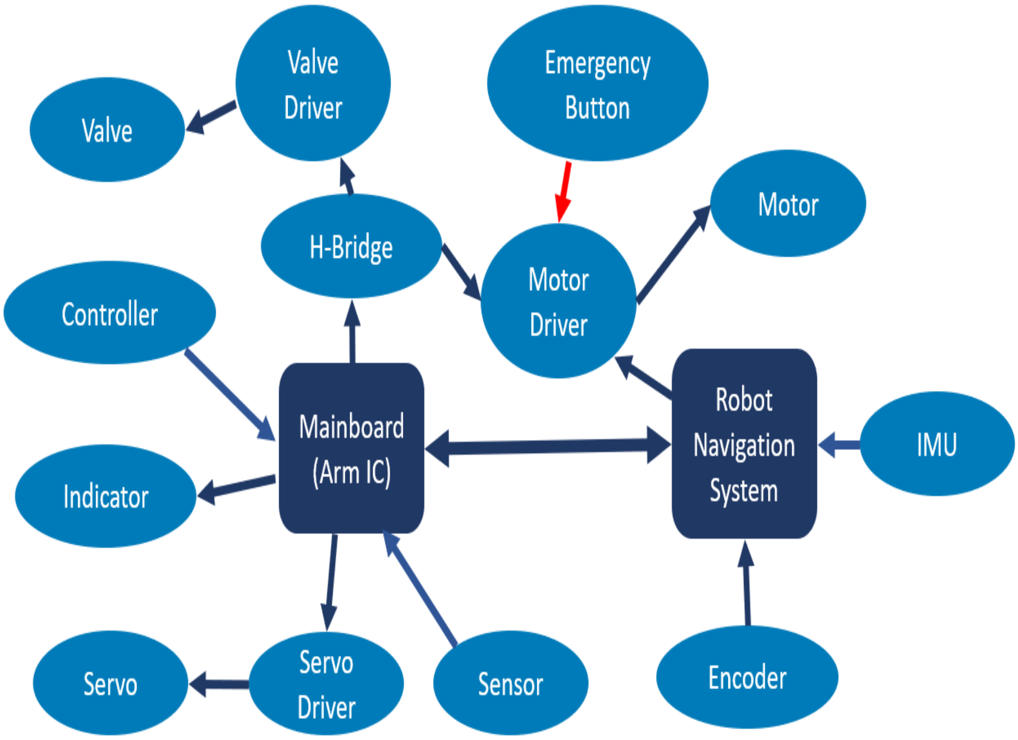


Figure 3: Electronic Block Diagram of Robot 2(R2)

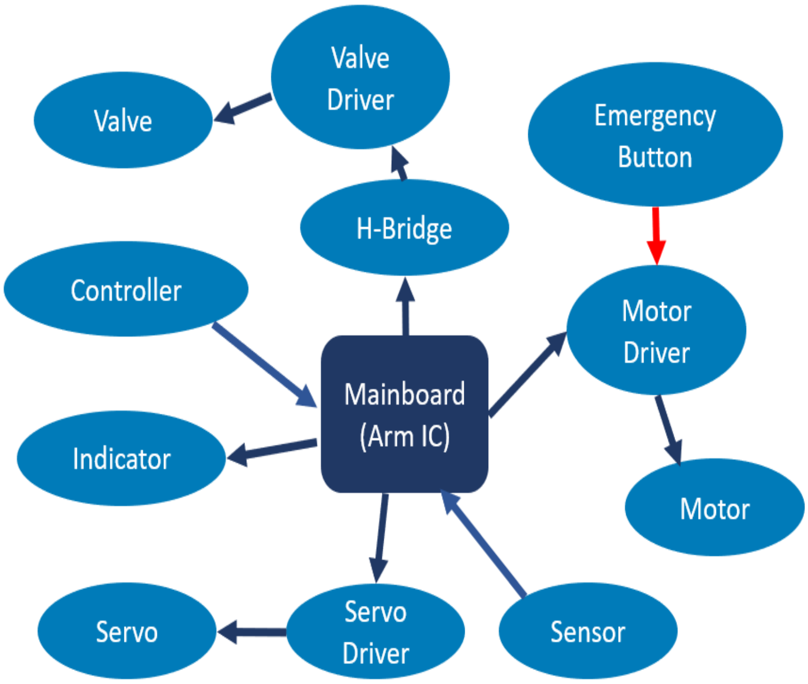


Figure 4: Electronic Block Diagram of Robot 1(R1)

For R1 wise, as our R1 is a static robot without a navigation system, it does not require the Robot Navigation system. Thus, the electronic block diagram of R1 and R2 are similar, except for R1 is not equipped with the Robot Navigation System while R2 have it.

4. SOFTWARE DESIGN

The programming flow chart of R1 is shown in Figure 5. The software of R1 is designed so that the robot can be changed from autonomous to manual or vice versa. The operator will check whether the balls are loaded in the robot. If yes, the robot is ready to shoot, else the robot will load the ball into the shooting mechanism.

The programming flow chart of R2 is shown in Figure 6. The software of R2 is designed in a way that the operator of R2 can change the mode of the robot from Seeker to Hitter and vice versa seamlessly using a controller. During Seeker mode, the robot will be operated manually. Whereas during Hitter mode, the robot can be operated using autonomous or manual mode. During autonomous mode, the robot’s position will be determined using 2 pairs of external encoders and laser sensors. Thus, by using the feedback from the sensors, autonomous navigation can be achieved. In the case of an emergency, the operator can stop the robot immediately and switch back to manual mode by using software for safety purposes.

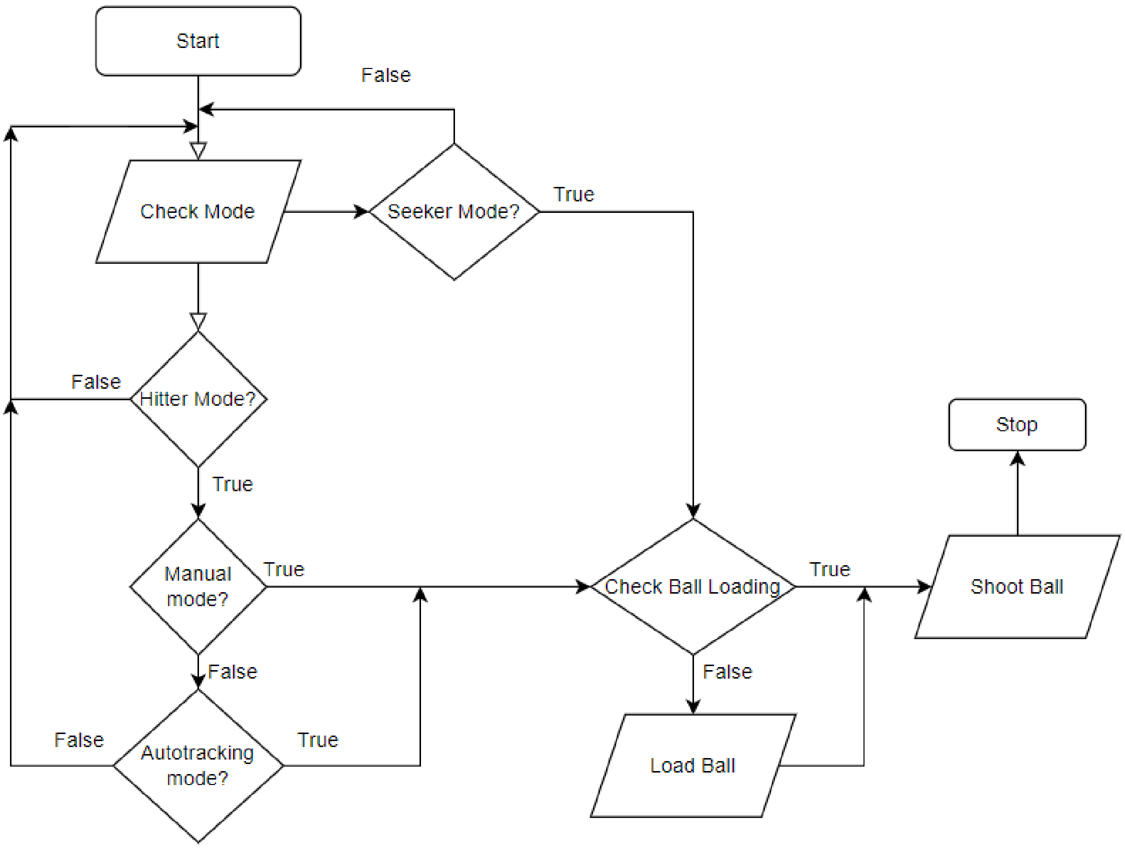


Figure 5: Programming flow chart of R1

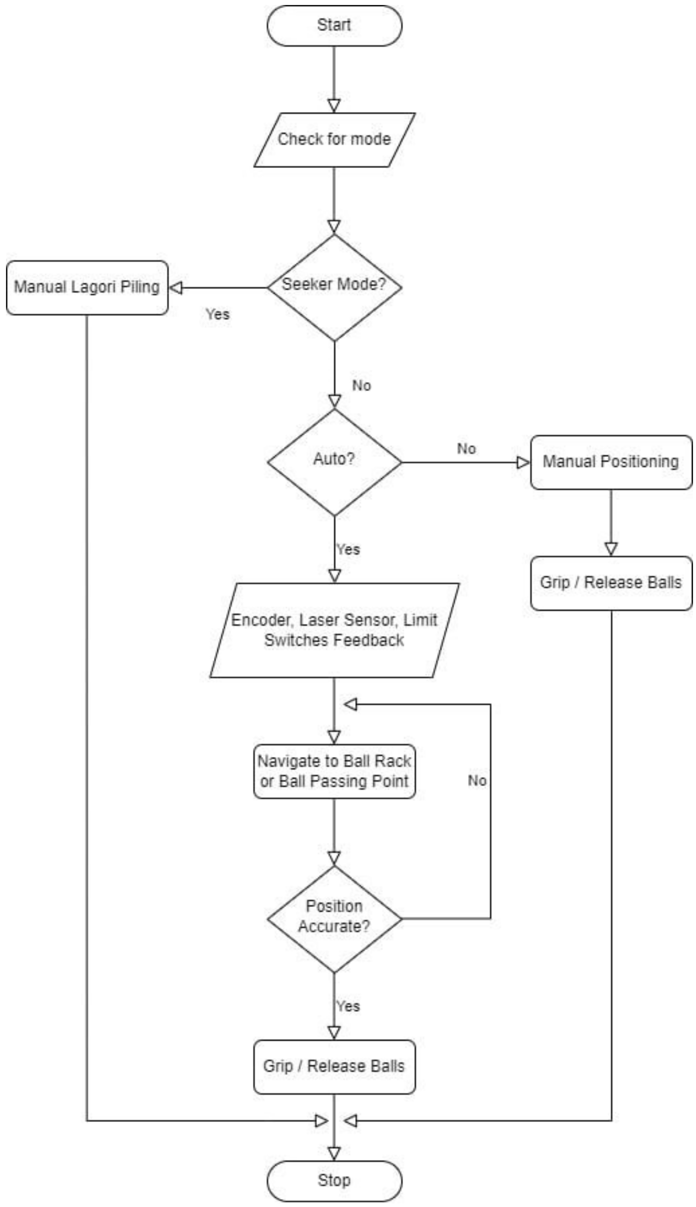


Figure 6: Programming flow chart of R2

5. PRESENTATION OF DATA/SIMULATION/TESTING

5.1 TESTING DATA OF R1

Figure 7 shows the percentage of lagori broken down by Seeker R1 while the Figure 8 shows the accuracy of Hitter R1 shooting down the opponent's BOH in the latest 30 training sessions. For seeker R1, it has a relative consistency with a 93% success rate to break down all 5 lagori from the platform during lagori breakdown sessions. However, for Hitter R1, the success rate to shot down the BOH of the opponent’s seeker R2 is lower with a success rate of 17%.

5.2 TESTING DATA OF R2

Figure 9 shows the number of Lagori discs piled back onto Lagori Base by seeker R2 while Figure 10 shows the success rate of Hitter R2 passing balls to Hitter R1 throughout our latest 30 training sessions. It can be seen that the Seeker R2 have the highest piling capability of 2 lagori discs (43%). For hitter R2, it achieved a 70% of success rate to pass the ball to R1.

Figure 7: The percentage of lagori broke down by seeker R1

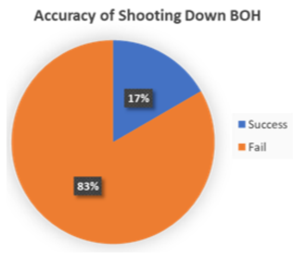


Figure 8: The accuracy of shooting down BOH of seeker R2

Figure 9: Lagori Piling Success Rate

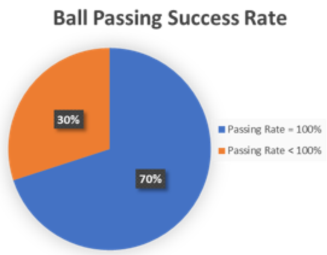


Figure 10: Hitter R2 Ball Passing Success Rate

6. DISCUSSION/EVALUATION OF FINDINGS

From the testing results after and over several designs and modifications, we can observe that the shooting accuracy of flywheel motors mechanism is highly relying on the speed of the motors used and the angle of the shooting platform. On the other hand, a pneumatic gripper attached to a height variable pulley is found to help gripping and restacking the Lagori disc with much ease for R2. Furthermore, a separate ball gripping mechanism that can pick up all three Hitter Balls at once is the best way in assisting R1 in terms of having more chances to shoot down the BOH in the least amount of time.

7. SUSTAINABLE ENGINEERING PRACTICE

Ever since the establishment of the UTM Robocon Team, sustainability has always been emphasized in our team culture. The 6Rs of sustainability including recycle, reuse, reduce, repair, rethink, and refuse certainly helped us in maintaining our sustainability key values. For instance, a virtual simulation of the weight distribution of the base of each robot is done before starting the fabrication to ensure that the base is strong enough to withstand the weight of the whole robot without any bending issues. This is because we intentionally reduce the usage of metal due to design errors as the production of metal releases carbon dioxide that triggers the greenhouse effect globally. Furthermore, recycling scrap metal such as aluminium, mild steel, and stainless steel monthly has been our team culture as this provides us to work in a cleaner environment and help the globe in metal mining. On top of that, sustainability as our top key value has been implemented in our R&D activities. Recently, we have been trying to use carbon fibre as the connectors for metals. Since the carbon fibre is reusable, indirectly this will help in reducing the consumption of welding gas (carbon dioxide). In addition, pneumatic systems that are supplied from recyclable carbonated bottles such as 100 Plus filled with pressured gas are also used in both of our robots. Hence, we are encouraged by our team members not to throw away any carbonated bottles which were bought for further applications. As future engineers, we refuse to use any non-recyclable materials for our robots that might be hazardous to our environment. We care about our environment and always try to minimize the impact on the environment.

8. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

In conclusion, based on our robots' prototypes and models, we are able to accomplish the task for shooting both the Seeker and Hitter Balls respectively onto its target as well as pilling the Lagori Discs. However, the combination of all mechanisms in the robots has been a difficult and complex task as it required troubleshooting and solving the problem constantly especially in fine-tuning. Moreover, one of the problems we faced throughout this year is the robot weight. We were forced to make scarification by taking away the auto loading mechanism of R1 which potentially slowed down the whole ball shooting process. Another limitation is the budget of our team which restricts us from using the more expensive sensors like lidar, camera and so on which hindered us in R&D activities such as image processing for the robot. Finally, in terms of recommendations and improvements, we suggest a BOH balancing mechanism which allows R2 to move at a higher speed without worrying the falling of BOH. As for R1, our recommendation is to have a height adjustable shooting mechanism so it can change its shooting height when shooting the lagori tower or BOH of R2.

9. ACKNOWLEDGMENTS

We would like to express our gratitude towards Universiti Teknologi Malaysia, Faculty of Engineering for giving us the support and facilities to develop our robots. Thanks, our team manager, Prof. Madya Ir. Dr. Mohd Ridzuan bin Ahmad, advised us in terms of technical issues as well as conducting management in our team. Thanks to all our team members for keeping developing better robots for the competition. Huge appreciation to our sponsors for supporting us during the preparation for Robocon Malaysia 2022.

REFERENCES

[1] ROBOCON MALAYSIA 2022. (n.d.). Retrieved May 9, 2022, from https://roboconmalaysia.com/.

[2] ROBOCON MALAYSIA 2022 GAME RULES. Retrieved Jan 15, 2022, from https://roboconmalaysia.com/wp-content/uploads/2022/03/Malaysia-Robocon-2022-Theme-and-Rules-V2.pdf.

[3] ABU ROBOCON 2022. (n.d.). Retrieved September 30, 2021, from https://www.aburobocon2022.com/.

UNIVERSITI TEKNOLOGI MARA (UITM) SHAH ALAM

Muhammad Aidilazhar Bin Anuar, Muhammad Nur Iman Bin Mohd Zuhaimi, Marsya Basyirah Binti Norazmira, Muhammad Ifham Bin Muhamad Zuri, Nur Hadirah Hannani Binti Azionn, Muhammad Haffizol Bin Suffian, Mohammad Aidil Fahmi Bin Norazhar, Muhammad Darwis Bin Abdul Habib, Muhammad Mustaqim Bin Mohamed Muhizam, Nur Emiliya Adriana Binti Suhaisham, Muhammad A'fiq Bin Jamaluddin, Nik Azmi Bin Nik Shairuzli, Hariz Izzuddin Bin Mat Halmi

Sekolah Pengajian Kejuruteraan Elektrik, Kolej Kejuruteraan, Universiti Teknologi MARA, 40450, Shah Alam, Selangor

ABSTRACT

This paper presents the development of robot for Robocon competition. The method used for this project consists of shooting mechanism by using motor with 3500 rpm, gripping mechanism and elevation mechanism. All supply of robots mostly comes from used spares except the part that may contain harmful material to avoid decommissioning of robots. The proposed robot can be multiple task such as delivery and cleaning robot.

1. INTRODUCTION

Robocon Malaysia 2022 is a robot competition between colleges in Malaysia. The purpose of this competition is to select a team that will represent Malaysia to compete in ABU Asia-Pacific Robot Contest 2022 that will be held in New Delhi, India. The contest theme for

Robocon Malaysia 2022 was Lagori that is a traditional and one of the most played ancient games that originate in the southern part of India. It was one of the most popular game in India around the 1990s. In the competition, robot from each team must complete a task within a set period of time.

Some problems have been examined while constructing the robots. One of the problems is the determination of mechanical and electronic design of the robots. Frequent changes in design can affect the workflow of constructing the robots. Next, the lack of focus in individual task may lead to problem in time management.

The objective of work is to build two robots which are Robot 1 (R1) and Robot 2 (R2). The game will be based on the game of Lagori. In this game, each team will take turn playing as seeker and hitter. The task of R1 is to throw the ball and break the Lagori but R1 can only throw the ball when it stays on R1 Start Zone area while the task of R2 is to piles up the broken Lagori. R1 has been designed to be able to deliver high power output so it can break more Lagori. While R2 has been focused on picking up and piling up Lagori with shorter amount of time. Each team will obtain point based on the broken Lagori by R1 and piled up Lagori by R2, with the teams scoring the highest points will be declared as a winner.

The motivation for this design is to gain more experience in this field. By joining this competition, it helps to develop and discover the potential in hardware and software skills. Moreover, it’s also increased the knowledge on the robot design including electrical and mechanical parts. This will prove to the society that even young people are capable of making or constructing robot. Besides that, this competition can be one of the medium to expose about The Fourth Industrial Revolution (IR 4.0) widely among the students as the construction of robots will surely involve digital technology.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

2.1.1 ROBOT 1 DESIGN

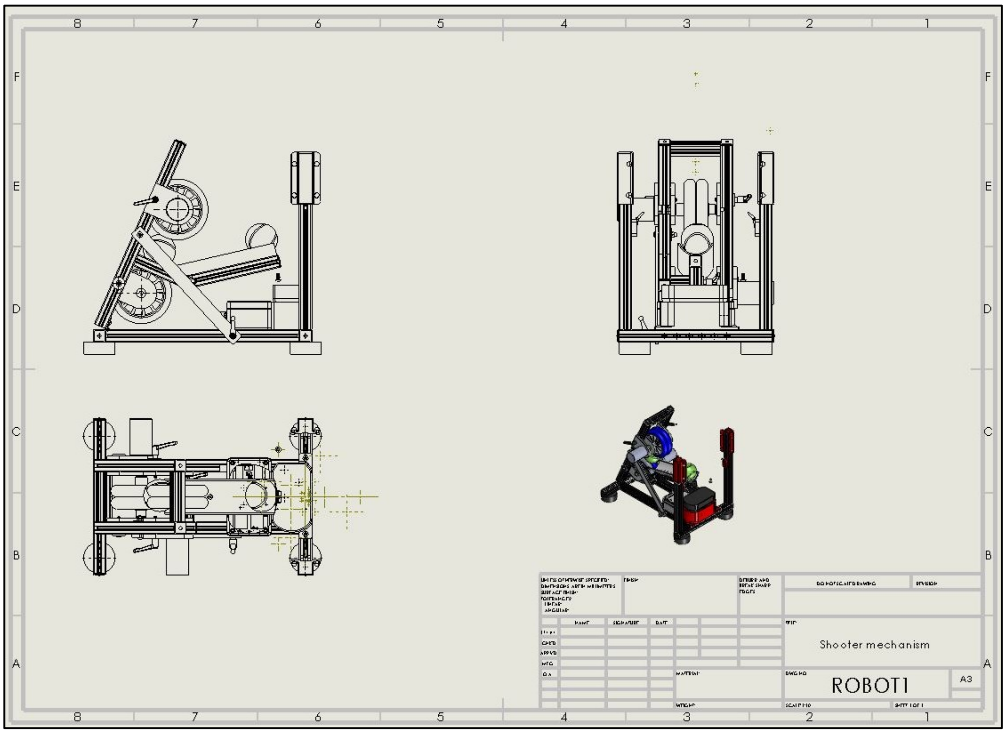
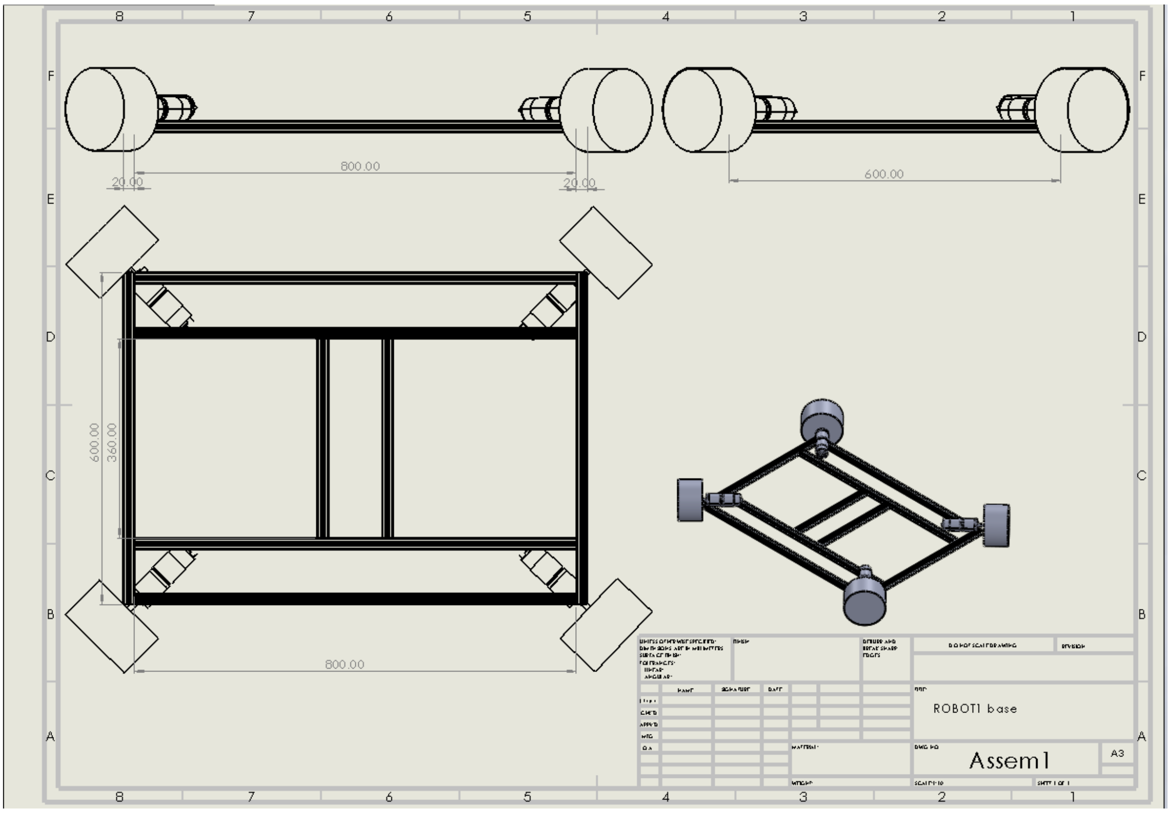


Figure 1: Shooting mechanism

This mechanism for Robot1 mainly revolve around shooting the ball onto Lagori, using only 2 (3500RPM) motors attached into aluminium profile which being set up 45* above the base of the Robot. Base on this design, the mechanism must be set up manually to adjust the trajectory of the ball.



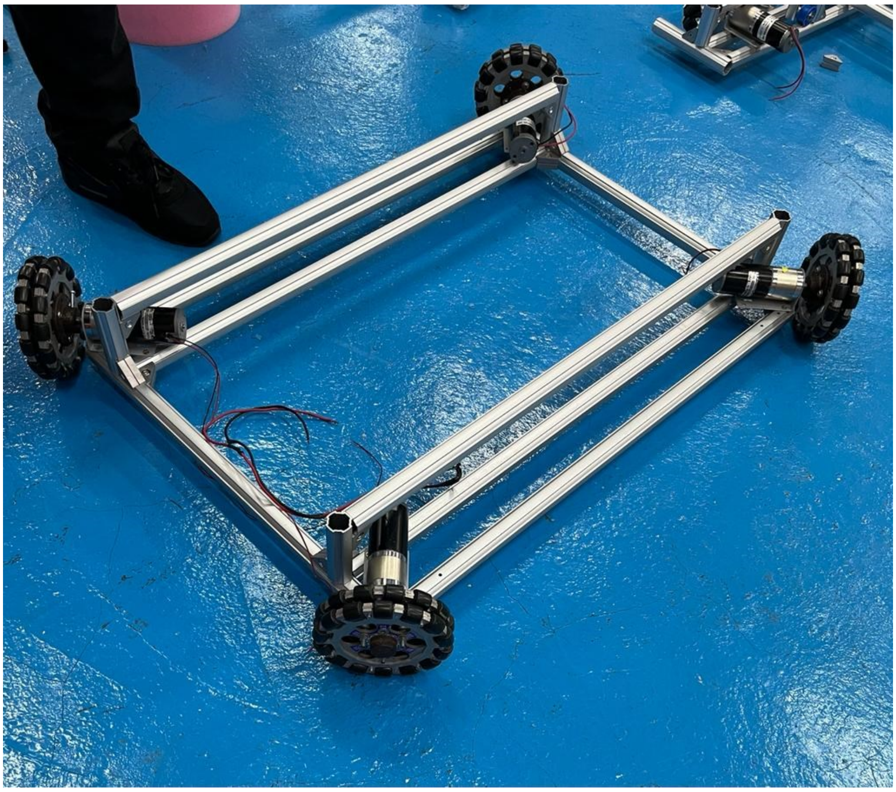


Figure 2: Robot1 Base

This is the basic design for the base of the robot 1, Using 4 motors that is attached 45 degrees on every corner of the base

Figure 3: Gripping Mechanism

Figure 4: Elevation Mechanism

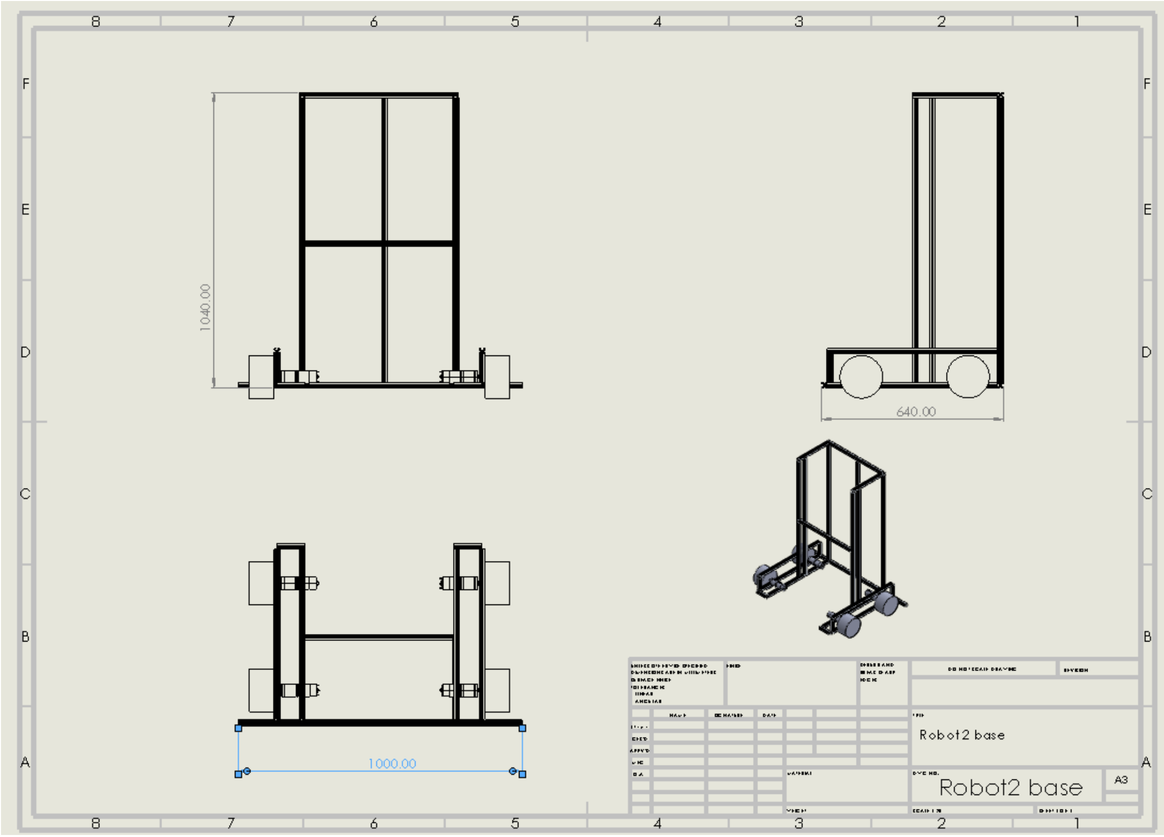
2.1.2 ROBOT 2 DESIGN

Robot 2 Gripping Mechanism

The gripping mechanism for Robot 2 uses motor rotation that is attach to multiple aluminium that is design for gripping the Lagori.

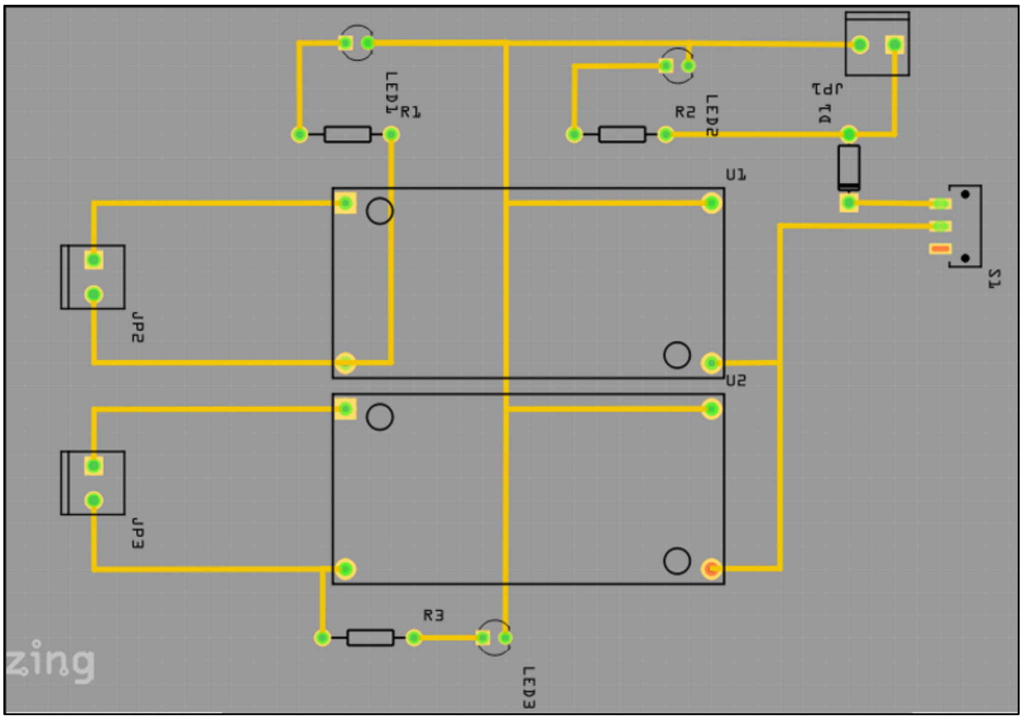
Robot 2 Elevation Mechanism

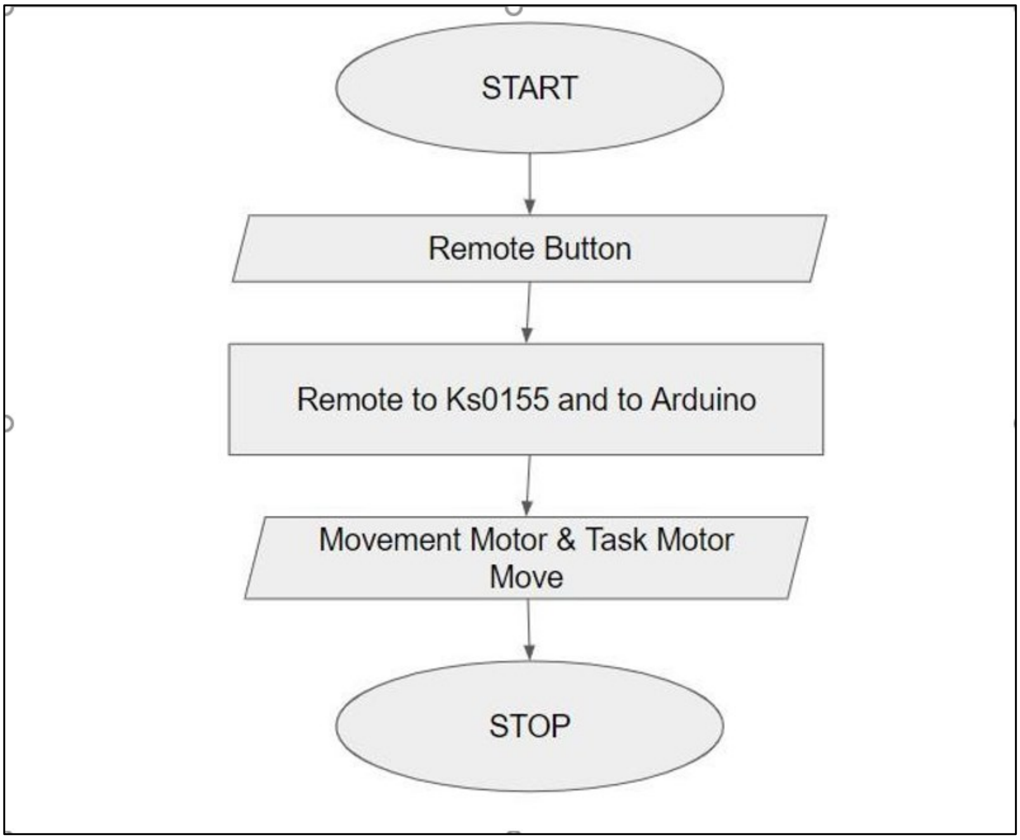
The elevation mechanism for Robot 2 mainly is a DIY design that is referred to linear guide motor in the current industry, the mechanism of DIY linear guide motor consists of 3500RPM motor that is attached with 1meter Threaded Rod that connected by coupling that connects both Motor and the Rod. It also uses 3 rollers that is attached with an aluminium sheet, this part will be used for the placement of the gripping mechanism that is attached with aluminium profile.



This is the base of Robot 2, the objective of this design is to achieve the highest stability when gripping and elevating mechanism for Lagori

2.2 ELECTRICAL DESIGN





3. SUSTAINABLE ENGINEERING PRACTICES

It has always been our team culture to minimize the amount of new material used in any of our project. During the development of our robot, most of the parts were recycled from our previous projects. Other than economically viable in short-term, this practice will also contribute to a sustainable engineering practice in the long run. This project gives the opportunity for young engineers to explore and improve their knowledge. Hence, it will produce many high-quality future engineers. Ultimately, the application of robotic in industries will increase. The application of robotic in the can increase efficiency in production which produce less waste and reduce the polluting by-products in productions.

Robots are always driven by extra demand of the global of pandemic. One of the possible real-word application is delivery robot with developed skills. There is strong market potential for transportation robots in outdoor environment. It also can be flexible working with another robot or human. Next is cleaning robots. The whole world is having hygiene problem due to Covid-19 pandemic, this robot could offer to provide disinfection service and spraying disinfectant. The function is really helpful for cleaning professional such as hospital and public places.

4. CONCLUSION

Most robot working for people in factories, industries, and laboratories. Robots are useful in many ways. Furthermore, it boosts economy because businesses need to be efficient to keep up with the industry competition.

During the project, there are many areas of engineering involve building a robot. It evolved in mechatronics such as electronic, mechanical and computer engineering. The robot design is match with an ability to perform tasks.

5. ACKNOLEDGEMENT

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged. However, the team would like to express their deep appreciation and indebtedness particularly to the following:

The ministry of higher education Malaysia, Universiti Sains Malaysia and RTM for giving this great opportunity for us by organising the Robocon 2022. School of Engineering Universiti Teknologi Mara Shah Alam for sponsoring our team. Dr. Noorfadzli Bin Abdul

Razak and Dr. Najidah Binti Hambali for their endless support, kind and understanding spirit during our project development. To all UiTM Shah Alam team members that put all their blood, sweat and tears in completing this project. To all relatives, friends and others who in one way or another shared their support, either morally, financially and physically. Above all, to the Great Almighty, the author of knowledge and wisdom, for his countless love. We thank you.

REFFERENCES

[1] G. Bugmann, M. Siegel, and R. Burcin, "A role for robotics in sustainable development?" IEEE Africon '11, Sep. 2011, doi: 10.1109/afrcon.2011.6072154.

[2] P.Agnivesh, M. Sabya, G.Mihalis and F.Miguel, "Evaluating public acceptance of autonomous delivery robots during COVID-19 pandemic", Dec. 2020, Volume 89. https://www.sciencedirect.com/science/article/pii/S1361920920307860#bi005

[3] Felderman, M. (2019, January 16). Designing And Building A Robot. Retrieved from Ponoko: https://www.ponoko.com/blog/how-to-make/designing-and-building-a-robot/

UNIVERSITI TEKNOLOGI PETRONAS (UTP) PETROBOTS

Kenneth Chong Yih Haur, Khor Gee Pei, Low Chen Khang, Nur Amelina Binti Ismail

UTP PETROBOTS Team, Universiti Teknologi PETRONAS, 32610, Seri Iskandar, Perak Darul Ridzuan, Malaysia.

ABSTRACT

This technical report clarifies the progress and mechanism for robots from UTP PETROBOTS team in the participation of ROBOCON Malaysia 2022. UTP PETROBOTS team have manufactured 2 robots, namely Lagori Break Robot (R1) and Lagori Pile Robot (R2) for this competition. R1 uses wheel shooting mechanism to launch the ball to break the lagori pile. As for R2, the mechanism used is 2 linear slide lifting system and claw and gear system that grab and lift the lagori pile in certain level of the position. The robots are unique in such ways that R1 uses 4 vertical high-speed wheel to shoot the ball to the pile as the whereas R2 uses linear slide to lift the pile at certain of height. Most of the component and part were using 3D printing technique to model up specific and concise parts. The manufacturing of the robots is sustainable in a way that most materials used on the robots are recycled or dismantled components from previous projects.

1. INTRODUCTION

For Robocon Malaysia 2022, UTP PETROBOTS have gone with the plan of using 2 robots for the competition. For R1, 4 wheeled shooting mechanism is used where for R2, claw mechanism is used and equipped on the linear slide lifting mechanism.

For the 4 wheeled shooting mechanism, the system basically works based on wheels spinning at extreme high speeds with a ball compressed against them. There are several reasons why we choose 4 wheels which vertically arranged. This is because based on the game set by this year ROBOCON, we need to break the pile which arranged from bottom to the top. There are not suitable for us to use spring-loaded shooting mechanism. This mechanism basically works based on mechanical energy stored in the spring [1]. With the mechanism arranged in vertical, the error of the ball launched by the mechanism are still high chances to hit the lagori pile. Not only that, the concept of double flywheel at both top and bottom offer easier adjustment of compression significantly when shoot the ball. The 4 wheeled shooting mechanism is set to a fixed position, as different angle of projectile motion to shoot the pile can be achieved by manipulate the speed of the motors. This can be explained by using "Magnus effect" theory. This theory defined that the pressure of the fluid increase at point where the speed of the fluid increases. When the ball is spinning through the air caused by the torque of the motor, the turning ball drags more air around with it. So, if the rpm of the wheel decrease, less air will be dragged and the pressure will increase, this affect the ball tends to move to the low pressure region (higher rpm wheel region) and varying the angle of the shooting projectile motion.

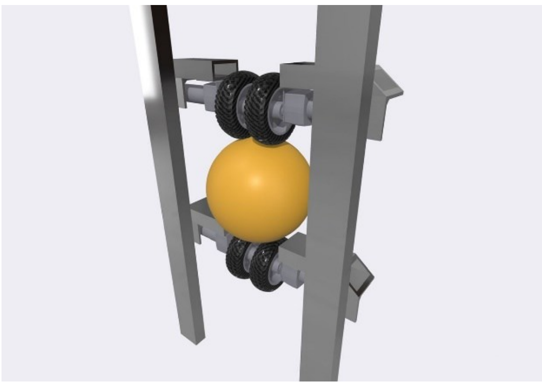


Figure 1: 4-wheeled shooting mechanism

Next, for the linear slide lifting mechanism, Linear slides and stages provide precision linear motion with gear and positioning for many different types of automated machinery, and it is one of the simple linear motion devices composed of a fixed base and a moving carriage to carry the claws and pile during piling process. For R2, linear slide lifting mechanism is used to lift up the lagori pile so that the broken pile can be placed on its original position with the specific arrangement. We planned to design 2 parallel linear slides in order to support the load and withstand with greater force during piling process.

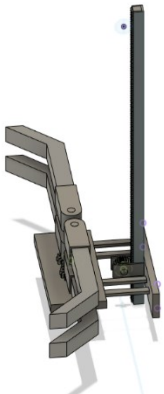


Figure 2: Linear slide lifting mechanism

Besides that, for the claw mechanism, 2 finger-like grippers is construct and connected to the gears, along with the shaft connected with a 60kg of servo motor at the bottom of the claw platform. The claw is designed based on the mechanical method instead of hydraulic method. By using gear system, mechanical clamping provides better fit to grip the lagori pile, made of polyform, produces around 10% of accuracy in the clamping force, and the most important thing is, this mechanism is way cheaper compared with hydraulics system which also have higher accuracy. The claw is designed to only use a 60kg servo motor is because of the biggest pile only have mass of 0.8kg compared with a total mass of pile, 1.8 kg. This servo motor provides sufficient force and torque applied to the shaft, connected with the gear.

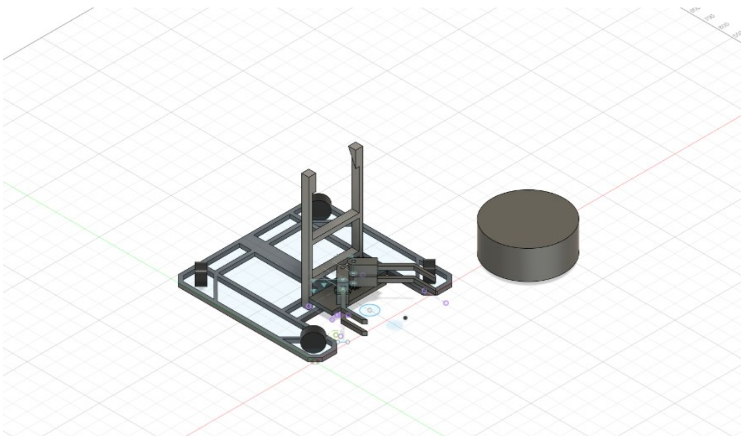


Figure 3: Claw mechanism attached on the R2.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

2.1.1 R1 BASE

This first base is made specifically for the ball shooting mechanism for the 1st robot, which is known as Base 1. For this base, the type of material proposed will be aluminium metal, due to its lightweight properties, reasonable price, high strength, high durability, and does not corrode easily, which can last long. The structure or shape of the base will be in hexagonal shape, and the reason this structure is proposed is due to its high stability, stable enough for the placement of the shooting mechanism on top of the base, and because omnidirectional wheels of diameter 12.5cm and thickness 5.5cm, will be used in motion of the robot, it is made to be in 45 degrees for the ease and smooth motion in various directions, without any restrictions or limitations. The diagram shown below is how the omni wheels directional motion work:

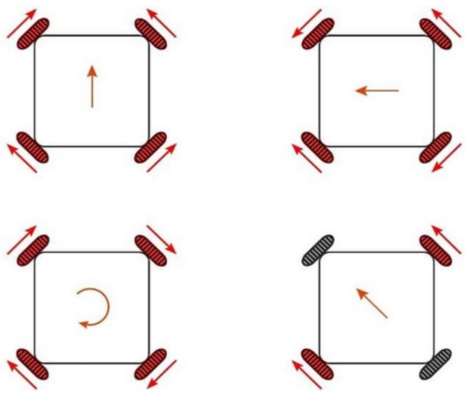


Figure 4: Directional motion of the omni wheel.

The figure below shows the proposed structure or shape of Base 1:

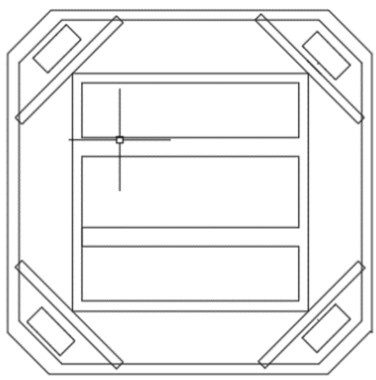


Figure 5: Base structure design for R1.

The required dimension for the robot is (1m×1m×1m), and hence, the base needs to have at most 1m×1m in dimensions. Before creating the base, the base is sketched first to get a rough idea or develop a draft for further design usage. After that, the 3D design is modelled using AutoCAD and Fusion 360 software to get a better view on the design structure, shape, and dimensions, with a scale of 1:1, being drawn in cm units. For the placement of the wheels, the gap or space must be large enough to install the wheels, dimensions of gap exceeding thickness and diameter of wheels, to avoid motion obstruction or restriction. The design is then being laid out in a layout with orthographic projections, using third-angled projection with top view, front view, and right-side view, to summarize the design up in a 2D form. All 2D and 3D modelling are as shown below:

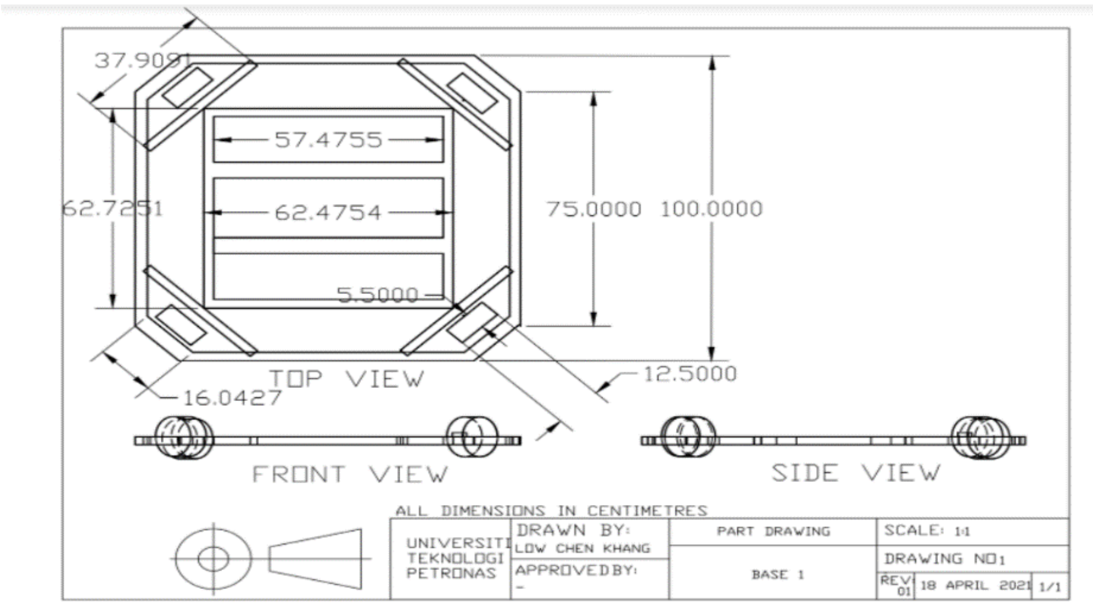


Figure 6: 2D drawing for base structure R1.

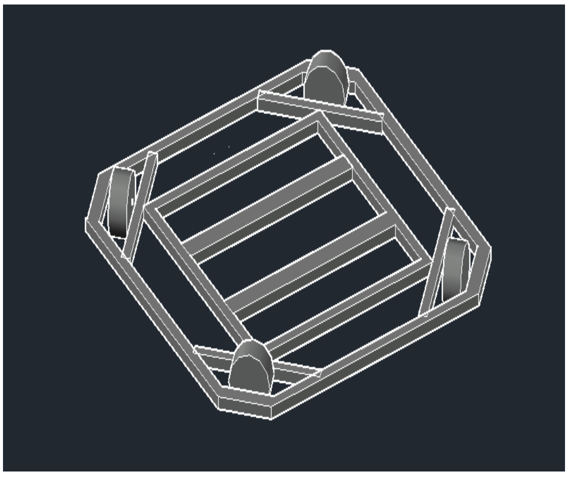


Figure 7: 3D drawing for base structure R1.

After designing using the AutoCAD and Fusion 360 software, the hands-on work on the base can be started. Aluminum bars of (1cm×1cm) with length 100cm is prepared. The bars are then measured and cut using a grinder based on the desired dimensions in the drawing. After the bars have been cut, the bars can be joined using either rivet method or welding. Initially, rivet method is used, but due to the long-time usage to complete the base, welding is used to speed up the process. After cutting and joining of aluminum bars are completed, the process of installation of motors and circuitry onto the base as well as the shooting mechanism are proceeded. Base 1 is as shown below:

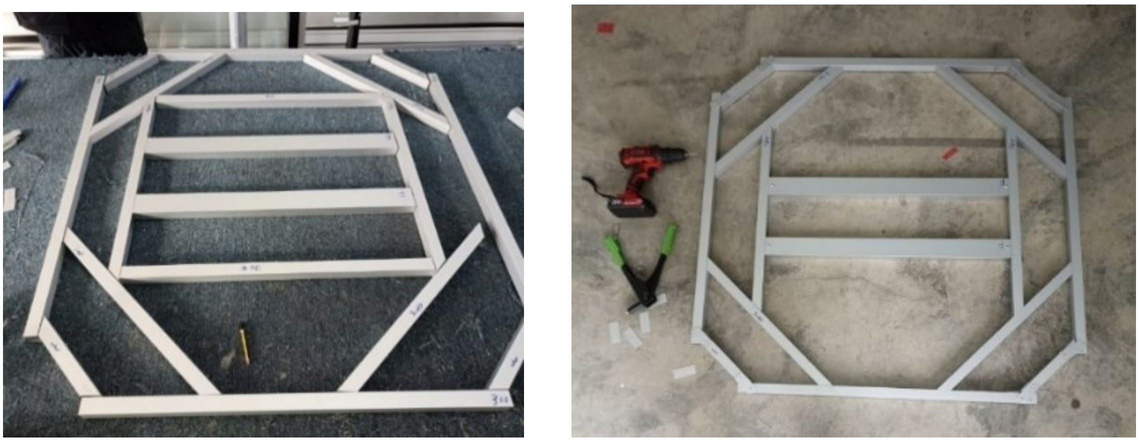


Figure 8: Base structure R1.

2.1.2 R2 BASE

This base is made specifically for the pilling mechanism for the 2nd robot, which is known as Base 2. For this base, the type of material proposed will also be aluminum metal, due to its lightweight properties, reasonable price, high strength, high durability, and does not corrode easily, which can last long. The structure or shape of this base will be in W-shape, and the reason this structure is proposed is due to its high stability, stable enough for the placement of the pilling mechanism on top of the base, and in the middle will be left with spaces, at least a 50cm to 60cm gap, so that process of lagori pilling can be implemented with ease (there will be a claw to grab hold of the lagoris to be pilled in the middle of the base). Besides, because omnidirectional wheels will also be used in motion of the robot, the four corners of the base are made to be in 45 degrees for the ease and smooth motion in various directions, without any restrictions or limitations. The figure below shows the shape and structure of Base 2:

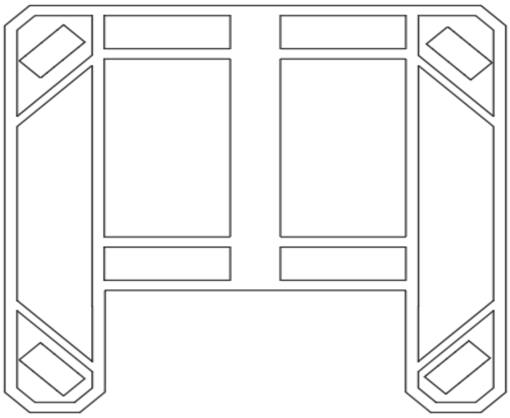


Figure 9: Base structure design for R2.

2.1.3 PILING MECHANISM

Mechanism has been redesigned from scissor lift and forklift hands to robotic arms with claws and ultimately ending up with linear slides and claw design.

The mechanism uses a linear slide to move the claw vertically (up and down). In the linear slide, its main components are the rack and pinion. The rack (linear gear) engages with the pinion (circular gear) which operates and translates rotational motion into linear motion. Driving the pinion into rotation causes the rack to be driven linearly. Actuators such as servo motors or DC motors are attached to the carriage which is attached to the pinion. Therefore, as the pinion rotates due to the actuator attached to it, the carriage moves vertically (upwards and downwards).

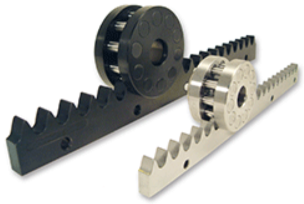


Figure 10: Linear slide- Gear and gear rack.

For the claw mechanism, it grabs the game objects such as the Lagori Disks and balls. The claws are 2 finger grippers and are designed to be able to grab the game objects of all sizes. There are 2 motors that attached to each hand of the claw. The motors are also attached to an encoder to precisely calculate the angle of rotation when opening and closing the claw. This is important in the piling mechanism as the game consists of objects with various diameters. Other than that, using an encoder is also crucial if the team wishes to implement an autonomous coding. This will ease the programmer and player when developing the code.

2.2 ELECTRONIC DESIGN

For moving mechanism, the robot is required to move in different direction to allow the changing position of the robot to launch the ball to break the pile. Thus, the moving mechanism consists of ohmic wheels, DC motors, motor drivers, voltage regulators, power supplies and microcontroller. However, Arduino Mega is act as a brain to deliver the command and instruction to carry out the process. Four ohmic wheels are used with connection of DC motors to provide torque to the wheel for rotation purpose, thus moving the whole robot. To control the direction of the motor, motor drivers are used with microcontroller to send the command and signal to the motor. Moreover, two 12V Li-Po batteries are used for four motor drivers. A battery can be used to power up two motor drivers with parallel circuit. Two voltage regulators are used to step down the voltage to 5V, thus, to control the speed of motor.

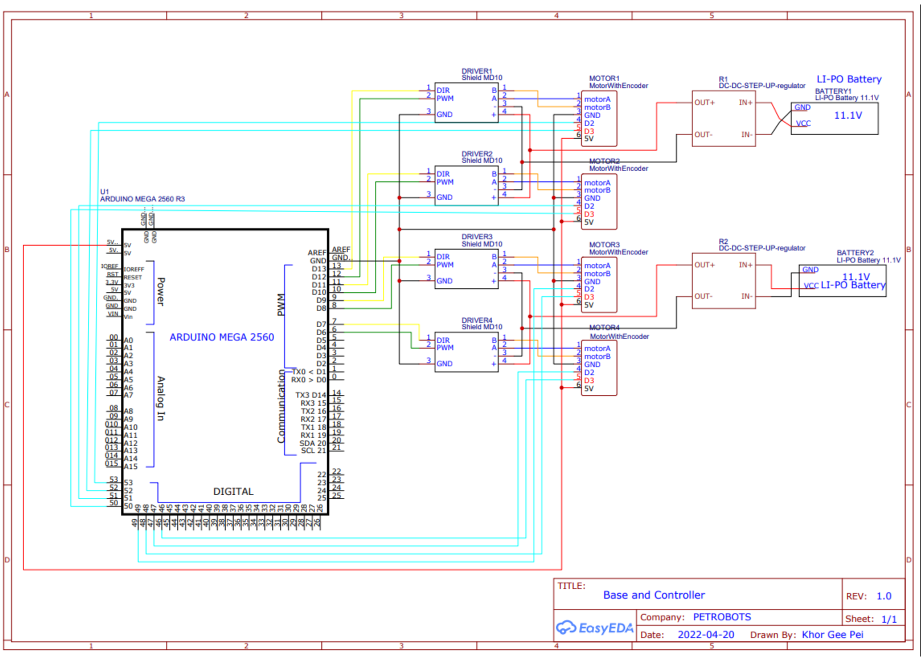


Figure 11: Schematic Diagram for base structure.

For shooting mechanism, flywheel method is used to shoot the ball to break the pile. The system required higher power system to provide enough torque to shoot the arrow into the pots. In this case, a higher torque of 4 DC motor is used to enable a high force of shot ball. At the same time, it requires a higher voltage to power up the motor drivers for enabling the shooting process. Hence, a 11.1V of Li-Po battery is used for it along with the step-up regulator.

For piling mechanism, 2 power window motor are used to lift the pile during "Lagori Pile" round due to the high torque provided when statically stick onto the linear slide mechanism. The motors are connected to the MDD10A motor driver before it is executed using Arduino Mega. For the claw, a 60 kg of servo motor is applied. Hence, a motor driver shield for servo motor is further used to program the servo motor.

2.3 SOFTWARE DESIGN

The mechanical control of the robot is programmed on an Arduino. The robot is controlled wirelessly via a wireless DualShock Controller. The PS2X_lib.h library is used to establish communication between the Arduino and the wireless DualShock Controller.

3. PRESENTATION OF DATA AND COLLECTION

Table 1: Number of trail and number of lagori break

Trail	1	2	3	4	5	6
Number of Lagori break	3	2	2	3	2	2

Table 2: The caption should be placed before the table

Trail	1	2	3	4	5	6
Number of lagori pile	1	2	1	2	1	1

4. DISCUSSION

Based on the 6 trials of lagori break, the result is somehow not satisfied, as not more than half of the pile is broken when average is taken based on these 6 trials. This is due to the lack of calculation on how the speed of motors affect the angle of projectile motion when game testing starts. To resolve this issues, more research and calculation should be performed with several iterations to achieve the most accurate speed of motor for the angle.

Based on the 6 trials of lagori pile, the result is also not satisfied, as 1 to 2 pile is arranged when average is taken based on these 6 trials. This is due to the unsynchronized gear motion in the linear slide lifting mechanism. When the gears cannot turn simultaneously, the lifting system will be performed slowly and affect the time duration of the game. Therefore, a long shaft can be added into both gears so that both gear will share the same torque and rpm produced by the power window motor.

5. SUSTAINABLE ENGINEERING PRACTICES

In the making of R1 and R2, most of the metal that made up the frame of the robots are recycled from previous projects and past ROBOCON competition. The faulty or inaccurately dimensioned components are also dismantled and stored for future usage.

6. CONCLUSION AND RECOMMENDATION

In conclusion, UTP PETROBOTS team have manufactured 2 robots to participate in ROBOCON Malaysia 2022, which are Lagori Break Robot (R1) and Lagori Break Robot (R2). R1 focused on the ball launched whereas R2 focused on the lagori piling process. The limitation faced by UTP PETROBOTS team can be divided in terms of preparation and mechanism. For preparation, the recent pandemic had causes troubles in gathering manpower and buying materials for the manufacturing of robots. The booking and usage of certain labs and locations within the university are also harder and it have numerous procedure. As for mechanism limitation, both robots have slight issue in manoeuvring due to the robots moving slightly slanted instead of in straight direction, especially in short bursts. For recommendation, more consultation with experienced and professional personnel like seniors or lecturers can be done to further improve the quality and efficiency of the manufacturing and preparation of robots. Besides, better equipment needs to be ensured or booked beforehand to smoothen the process and quality.

REFERENCES

[1] C.J. Zandsteeg, “Design of a RoboCup Shooting Mechanism”, Department of Mechanical Engineering, Eindhoven University of Technology, Rep. 147, 2005.

UNIVERSITY TUN HUSSEIN ONN MALAYSIA (UTHM) INGENIEURS

Budiman A.B, M. Idriss. M, A. Haziq A.Y, M. Zulhilmi Naim.A, M. Izzat.A, A Syarizal.M.Z, A. Zaim Amin. S, M. Azharruddin. A, N. Aina. J, N. Fazrina. A.H, A. Fatina. M.K, N. Husni. A, N. Syahirah. A.S, N. Fazlin. M.I

Persiaran Tun Dr. Ismail Jalan Kluang Parit Raja, 86400 Batu Pahat, Johor

ABSTRACT

This report summarized the design of two robots which are the R1 and R2. The overall design fulfils the team game strategy for each robot to carry its task successfully which are the shooting ball to Langori pile and Ball on Head (BOH) and reloading shooting ball from the ball rack. The design is based on modular design concept which are the mobile based module, controller module and game module. Each module is then design into sub-modulethat can be assemble by ‘Plug and Play’ concept. The R1 robot drive using swerve drive mechanism and the shooting mechanism is attached to 2 degree of freedom (DOF) base that able the shooting mechanism to easily target the opponent BOH. The R2 robot drive used omni wheel drive and equipped with cascade lifter mechanism that able the be position at desired level. The R1 also equipped with mechanical gripper that able to grip all sizes of the Langori with its special feature of extra grasp power by four single acting pneumatic cylinders. Both robots have shown good performance during testing and training especially R2 with its capability to perform lifting and piling and its agility. Furthermore, both robots design is unique which features some mechanism that have not been used in Robocon Malaysia and do offer some knowledge in its design. The modular concept design is proved of its sustainable engineering practices and the

swerve module, the cascade module concept can be used as mobile robot based and light weight moving mechanism. The detail of the mechanical design, controller design and PCB design are also described in this report.

1. INTRODUCTION

Ingenieurs Robocon Team was established in 2020 as a second Team from UTHM main campus and focus on nurturing future Professional Engineer in fields related to robotics fields. In Robocon 2022 teams is required to design and develop two robots whichare R1 and R12. The designs are based on modular design concept. The modules are the mobile based module, controller module and game module. Each module is then design into sub-module that can be assembleby 'Plug and Play' concept. By using this design concept, the design, fabrication, assemblyand testing can be done separately and conveniently.

The team design philosophy' is 'Unique and Efficient Engineering Design' and the design strategy is to shoot the ball to the target effectively and piling up the Langori effectively. Therefore, we designed both robots that are able to perform the game strategy effectively. In mobile base module,we designed two types of mobile based, the Omni based and the Swerve based module. The detail of the design will be discussed in this report.

2. DETAILED DESIGN

The modular design concept that we used divide into two main modular modules. The first modular module which is the mobile based modular consist of two main sub-modules,the Omni mobile base module and the Swerve mobile based module. Each of the main sub-modules have another sub-module which is the controller module. The second modular module is the game module. The second module consist of three sub-modules, the aiming rotation and angle elevation module, the shooting barrel mechanism module and the reloadmechanism module.

2.1 MECHANICAL MODULAR DESIGN

Every modular design module will be discussed in this chapter. The first modular module is the mobile based module for R1 and R2. Both having embedded wire harness and pneumatic tubing inside the based frame, 7 litres air tank and onboard mini air compressor.

Figure 1: (a) Omni mobile based

Figure 1: (B) Swerve mobile based

Figure 1 shows the Omni mobile based and Swerve mobile based. Omni mobile based used 4-inch omni wheel for its wheel's drives. Swerve mobile based used four 3D printed wheels and RC Servo motor for its steering. Figure 2 shows the swerve mechanismused for swerve mobile based module.

Figure 2: Swerve mechanism

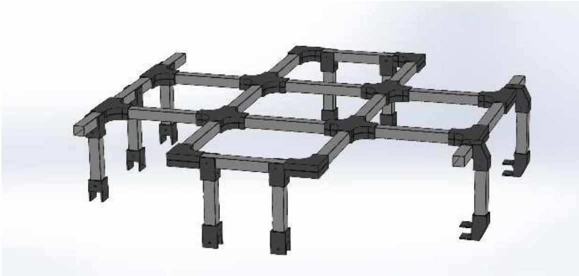


Figure 3: Second platform

In second module is the game modular module. We designed a second platform to install all the game module on top of this platform. Figure 3 shows the second platform basefor the game module. The second module consists of three sub-modules. In aiming mechanism, we used 2 DOF base drive by 12V DC motor for rotation and angle elevation. Figure 4 shows the aiming rotation and angle elevation modules. In shooting barrel mechanism, we used spring kineticenergy to launch the ball with approximately 30Kn force. Figure 5 show the shooting barrel module.

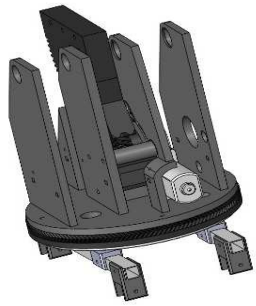


Figure 4: 2 DOF Base

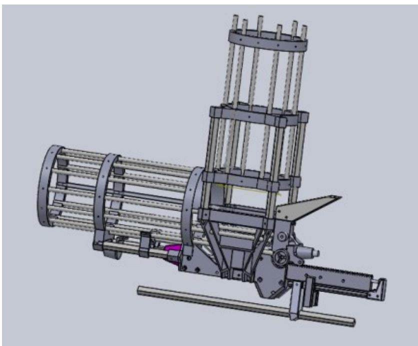


Figure 5: Shooting Mechanism

In reload mechanism we used two pneumatics cylinders to extend the reload arm and to open close the grippers. The wrist of the reload arm, a RC Servo is used to nicely position the gripper to a ball buffer and released the ball into it. Figure 6 shows the reload module.

In R1 and R2 we designed a cascade lifter and variable gripper to perform the task given. Figure 7 and 8. In controller module, we designed that both controllers are compatible for both mobile based modules. We integrated two controllers in the controller module, Arduino Mega and Arduino Uno. The idea of integrated these two is to separate the coding according to its task. Figure 9 and 10 shows an actual full assembled on R1 and R2 respectively.

Figure 6: Reload mechanism

Figure 7: R1 controller module

Figure 8: R2 controller module

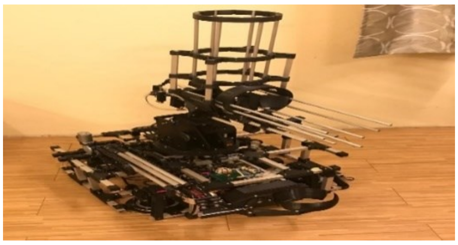


Figure 9: R1 Full Assemble

Figure 10: R2 Full Assemble

2.2 ELECTRONIC DESIGN

The electronic design of this project includes schematic circuits for AR and TR. The schematic diagram will consist of the printed circuit board for IR-EIO-03, IR-EIO-04, IR- ICB-01, and IR-CP-01. IR-EIO-03 and IR-EIO-04 boards responsible for managing the external input-output of the robots.

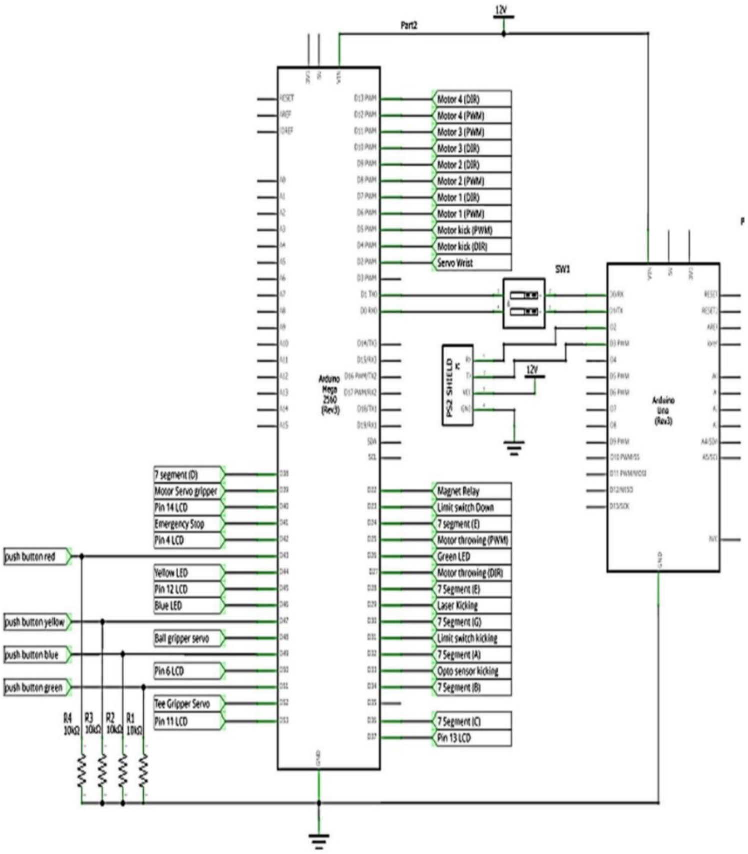


Figure 9: Schematic circuit for IR-EIO-03 board

The IR-EIO-03 and IR-EIO-04 have the same schematic circuit design as shown in Figure 9. Both used three microcontrollers which are Arduino MEGA 2560, Arduino UNO,and Play Station 2 (PS2) shield but have different pin assignments. The PS2 shield was usedto receive an input signal from the PS2 controller and send it to Arduino UNO. Based on the input signal, Arduino UNO will send specific instructions to Arduino MEGA to utilize various connected output devices to do specific tasks. The reason MEGA was used to provides many digital pins that can be used to assign to various output devices.

In R1, the IR-EIO-04 board was used to control four RC servo motors for its swerves function and one for its wrist function in reload mechanism, four IG42E DC motors for its swerve drives, and four 12V DC motor for its mechanism drives.

IR-EIO-04 board was used in R2 to handles the movement and the trying mechanism. The cascade lifter mechanism used 24V DC or its drive. Figure 10 show the schematic circuit for IR-CP-01 whichthe CP present the control panel. The control panel consist of Liquid Crystal Display (LCD)16x2, 7 segment display, battery indicator and three push buttons. The push button is used to control the modes create by the program and the LCD used for displaying the current modes of the program. 7 segment purposes are to display the robot movement speed. Push button and the battery indicator used 12V DC to operate and the 7 segment and LCD only used 5V DC. The board also consist of four ports encoder connector which can easily powered the encoder inthe DC Motor.

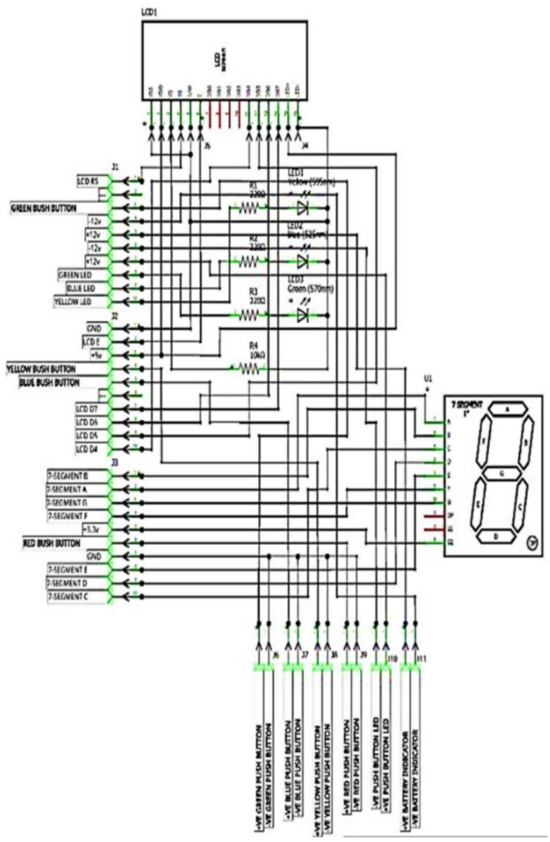


Figure 10: Schematic circuit for IR-CP-01 board

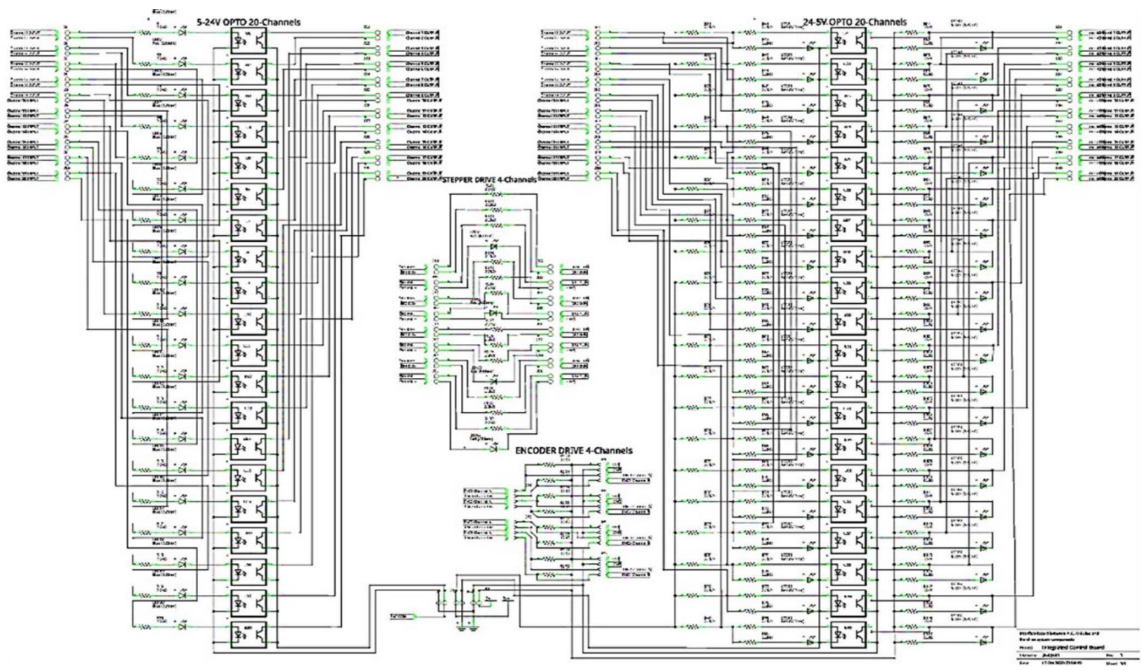


Figure 11: Schematic circuit for IR-ICB-01 board

3. DISCUSSION/EVUALTION OF TESTING

3.1 DISPLACEMENT AND STRESS ANALYSIS

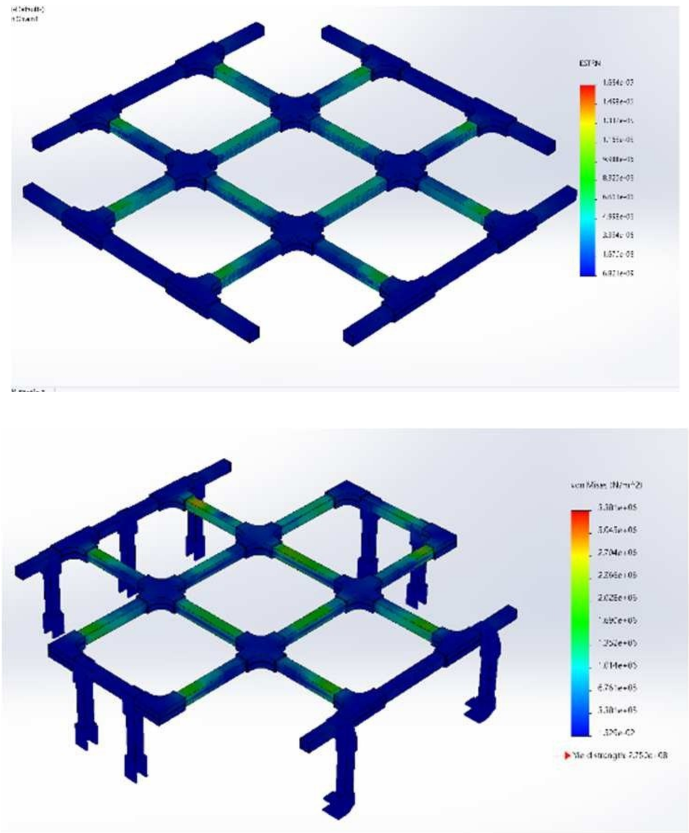


Figure 12: (a) Mobile based frame and (b) Second platform

We conducted displacement and stress analysis for both mobile based module and also for the second platform. The results show that the new frame design method able to withstand the estimated game module. Figure 12 (a) Mobile based frame and (b) Second platform shows the analysis results.

3.2 SHOOTING ANGLE TRAJECTORY AND CASCADE LIFTER TESTING

The objective of the game is to knock down the Langori pile and piling back the Lagori as fast as possible without the BOH being hit by the opponent, therefore the important aspect is to determine the angle trajectory of the ball to its precise point. In our mechanism, since the speed limit of the shooting is set to 30km/h the only variable that we are able to control is the angle elevation mechanism. The data we obtained from the testing is analyzed to determine the correct position of the mobile robots for optimum chance getting the ball hit the right point of the Langori pile. By observation we noticed that the best descending angle for the elevation is when the barrel is between 5^0 to 10^0. Table 1: shows partsof the testing data gathered.

Table 1: Show distance traveled by the ball for the passing and kicking

Test	Springs Force Kgf/cm	Elevation Angle Degree	Ball Accuracy Angle Degree (approx.)
1	25	0	Satisfactory
2	25	2	Good
3	25	5	Excellent
4	25	7	Good
5	25	10	Satisfactory
6	25	15	Not Good
7	25	20	Not Good
8	25	25	Not Good
9	25	30	Not Good

4. SUSTAINABLE ENGINEERING PRACTICES

Our team emphasize on sustainable engineering practices, not for only environmental aspect but also the sustainable for future use. In term of environmental aspect, most of the parts are scrap from previous mobile robots and most parts designed using polylactic acid (PLA) filaments such as grippers, joints and etc. while the frame consists of aluminum. The aluminum frame of the body can be recycled or reused while the PLA designed part can be safely discarded into the trash if its damaged. The reason is both materials are biodegradable. Hence, around 80% of the body part of the robot can be safely recycled and remove without harming the environment. In terms engineering design sustainability, we design a modular concept which it is easily change to suit future Robocongame theme, thus reduce the use of new material significantly.

5. CONCLUSIONS, LIMITATION, AND RECOMMENDATION

In conclusion, the R1 and R2 were able to be completed the given tasks within thetime frame. In mobile based module the swerve motor mechanism used in R1 having fasterand higher accuracy in mobile robot positioning, however the drawback using printed TPU tires has its effects on the mobile robot depending on floor surface. The shooting mechanism using two springs pulled by a 24DC motor produced a loud 'Bang' when shooting, thus the opponent will take advantage of its 'warning'. Thus, it is recommended using a suitable shock absorber to reduce the impact sound.

6. ACKNOWLEDGMENTS

This work was conducted under the approval and support of University Tun Hussein Onn and Faculty of Electric and Electronic.

REFERENCES

[1] Tianran Peng, Jun Qian*, Bin Zi, Jiakui Liu, Xingwei Wang "Mechanical Design and Control System ofan Omni-directional Mobile Robot for Material Conveying" School of Mechanical and Automotive Engineering, Hefei University of Technology, Hefei230009, China

[2] Marco Ceccarelli "Service Robots and Robotics: Design and Robots Application" University of Cassino, Italy

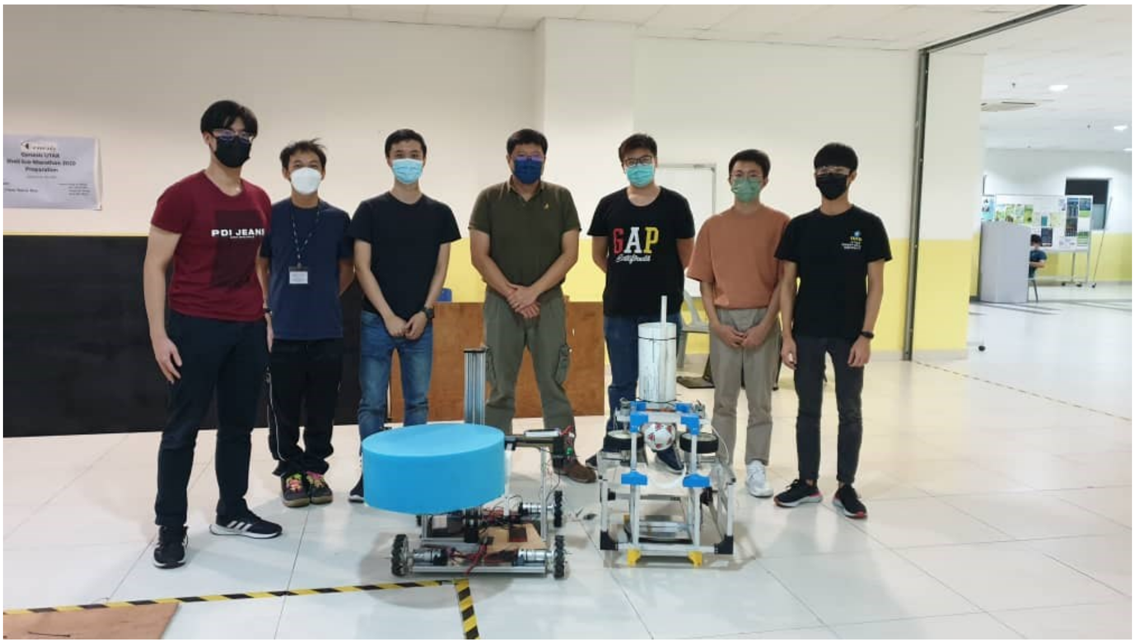
[3] Marco Ceccarelli "Service and Robotics: Design and Application" University of Cassino, Italy

[4] Dr. J. L. Minase Assistant Professor, "Design of a differential drive mobile robot platform for use in constrained environments" Department of Mechanical Engineering, Sinhgad College of Engineering, Pune Maharashtra, India

[5] Farhan A. Salem "Dynamic and Kinematic Models and Control for Differential Drive Mobile Robots"Department of Mechanical Engineering, Faculty of Engineering, Taif University, 888, Taif, Saudi Arabia

UNIVERSITI TUNKU ABDUL RAHMAN (UTAR)

Elton Mah Song Zhe, Leong Khai Shuen, Leong Qi Ye, Wong Yee Hang
Engineering, LKC FES, Jalan Sungai Long, Bandar Sungai Long, 43000 Kajang, Selangor



ABSTRACT

This report summarises the mechanical, software, electrical and electronic design of the two robots, Robot 1(R1) and Robot 2 (R2) by Team UTAR. This document outlines the approaches taken by the team UTAR to prepare for ROBOCON Malaysia 2022. Our team comprises of members from various science and engineering background with the majority being mechatronics students. Ever since the hiatus from the recent 2 years of pandemic, UTAR's ROBOCON team have since been declining in members and seniors to guide the newcomers due to the several facts such as ex-ROBOCON seniors graduated and declining interest in robotics among freshmen. This year, 2022, as the pandemic restrictions have been lifted, we have gathered new and inexperience but enthusiastic members to compete in this year's competition. We aim to reignite our annual ROBOCON team activity and it starts from this small effort. We have built two robots, R1 to shoot the balls and R2 to pick up the Lagori disks. Crude versions of the robots were built and tested. Within a short span of 2 months, we are able to fabricate two functioning robots R1 and R2, each being able to perform their tasks adequately but not fast enough. Due to the lack of experience in pneumatic system, we decided to omit pneumatic from the design and only reuse electronics already made-available for us. Our robot is unique as it is simple and easily repurpose. For sustainable engineering, we have

scrap previous ROBOCON's robot parts and use ready-made electronics and materials such as pre-built linear guides and aluminium profile. These parts can then be reuse for future projects. The linear guides can have possible real-world applications as they make possible lifting and transporting candidates for forklift design.

1. INTRODUCTION

The theme of this year's ROBOCON competition was decided to be Lagori, a popular traditional game, also known as Tuju Tin or Baling Tin here in Malaysia. The game is between 2 teams, Seeker and Hitter, and the game starts by Seeker throwing a ball to break the Lagori disks pile and try to pile up the stones again while the Hitter throws balls to interrupt them. Due to the lack of experience, limited time and limited members, 3D modelling and simulations were not performed prior to building the robots, thus our robots weren't properly optimized. However, we plan to implement 3D modelling and simulations for next year's ROBOCON as we are aware that this step is crucial for systematic and effective designs

The first task of R1 is to throw 3 pre-loaded balls to break the Lagori disks pile 3.5m away in the middle of the field. This action is done by utilising two roller wheels powered by DC motors. In order to reduce weight and save material, the R1 base will be fixed in the R1 Start Zone (R1SZ) without movement controls. The whole base can be rotated using a gear wheel from Lazy Susan and titled using pulley.

R2's task is to move around the field and pick up the fallen Lagori disks. The robot's movement is fully controlled by WiFi controller. Two linear guides, one lead screw and one belt driven, are used to grab and lift the Lagori disks. With specially designed grippers, the up-down-left-right movement can be easily controlled and performed as command with a press of a button. However, due to the height limit of the z-direction linear guide, the robot can only pile up to 3 disks, hence our strategy is to pile the last 3 smaller disks together before placing them onto the rest of the pile. Not only that, the R2 is also used to pick up the balls from the ball area and reload into the R1 for continuous shooting if the previous 3 misses.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

To play the game, our team have built two robots, namely, Robot 1 (R1) and Robot 2 (R2). The robots are semi-automatic.

2.1.1 ROBOT 1 (R1)

R1 is responsible of throwing or shooting balls to break the Lagori pile and also knocking down the Ball on Head (BOH) from opponent's R2.

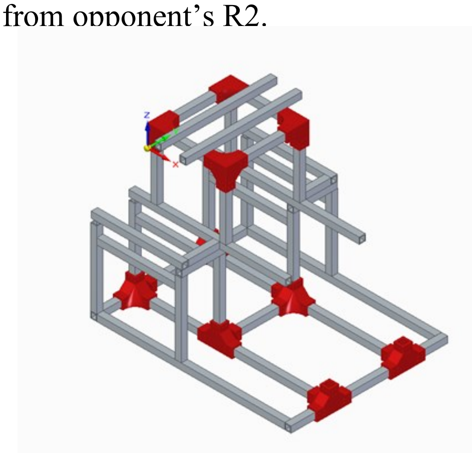


Figure 1: R1's aluminium profile structure

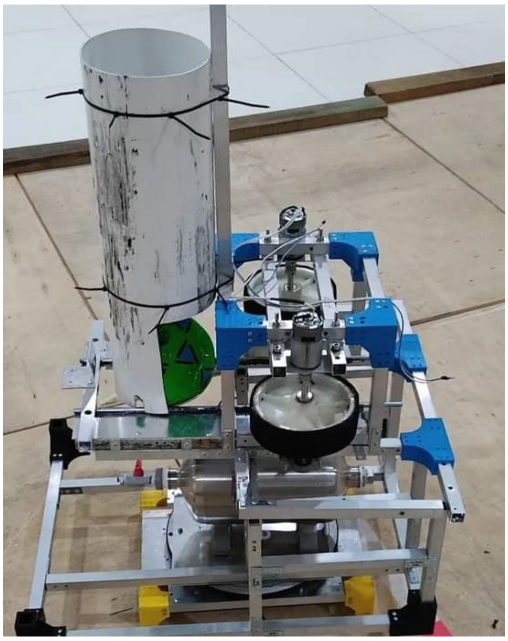


Figure 2: Reloading Mechanism without the pneumatic system installed

The two wheels are responsible of throwing the balls. This shooting mechanism is constructed using two DC motors connected to the roller wheels to provide sufficient torque to project the ball over a certain distance to hit the Lagori pile. The platform can be tilted using a pulley mechanism.

2.1.2 ROBOT 2 (R2)

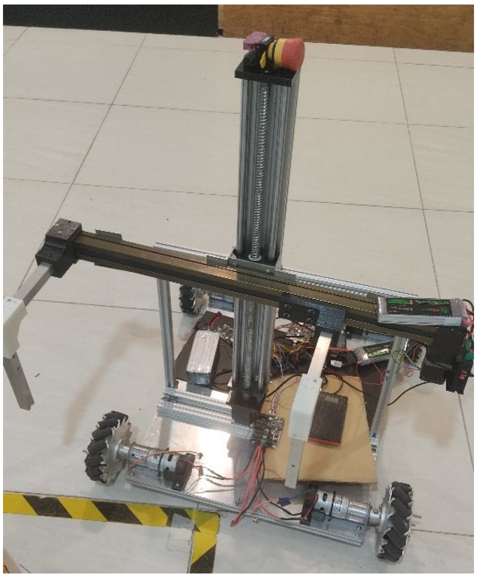


Figure 3: Lagori Disk Gripping Mechanism on R2

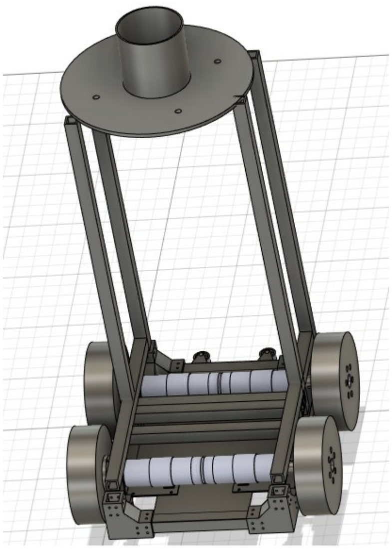
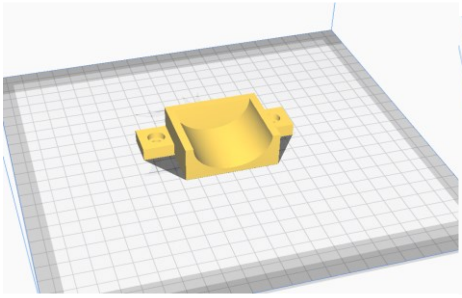
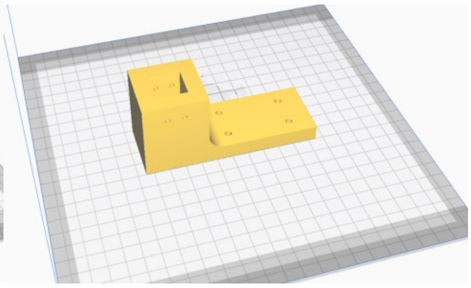


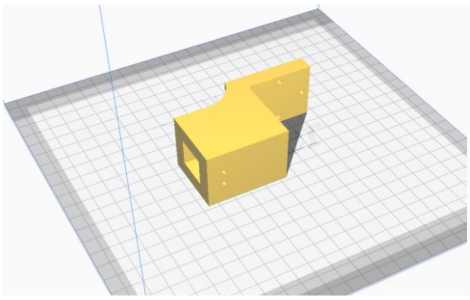
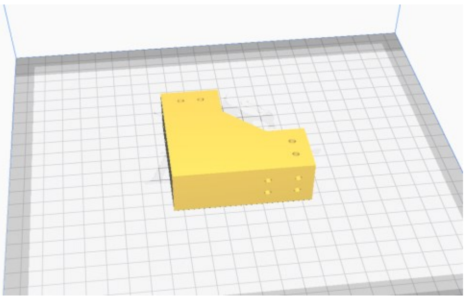
Figure 4: Ball on Head (BOH) on R2

R2 is responsible for picking up the Lagori disks that have been broken by R1. A lead screw linear guide is used in the middle to provide the z-axis direction motion for lifting both the belt driven linear guide and Lagori disks. A belt-driven linear guide is used for the x-axis direction motion for moving the gripper left and right. Mecanum wheels are used at the base for the robot's whole movement. The structure of R2 is fully made out of aluminium profile as they are easy to use and we are able to use them to construct our desired shapes and dimensions. Lastly, the Ball on Head (BOH) will go on top of R2 following the rules of being 1.2 m above ground level.

In addition, we also utilise 3D printing to fabricate the connectors and holders for our parts. Figure 5 below shows the 3D models and their specific functions.

(a) (b)

(c) (d)

Figure 5: Design for 3D printing (a) R2 Mecanum wheel motor holder (b) R2 Actuator arm joint (c) R2 Stator arm joint (d) 2 l junction connector25,5

3. ELECTRONIC DESIGN

R2 The electrical and electronic design used are for the wheels, wireless control, and linear guides.

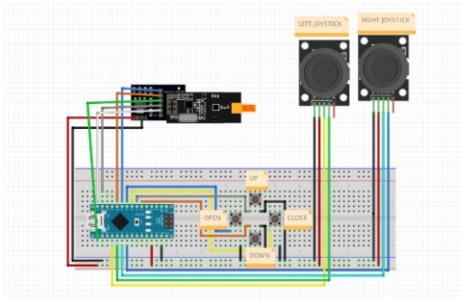


Figure 6: The circuit diagram for the remote control of robot R2.

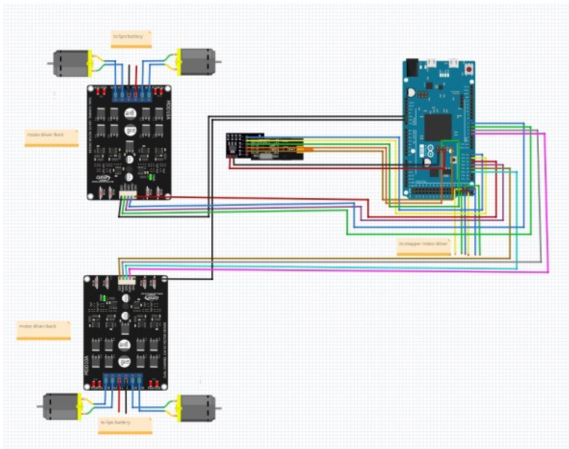


Figure 7: The circuit diagram for the robot R2.

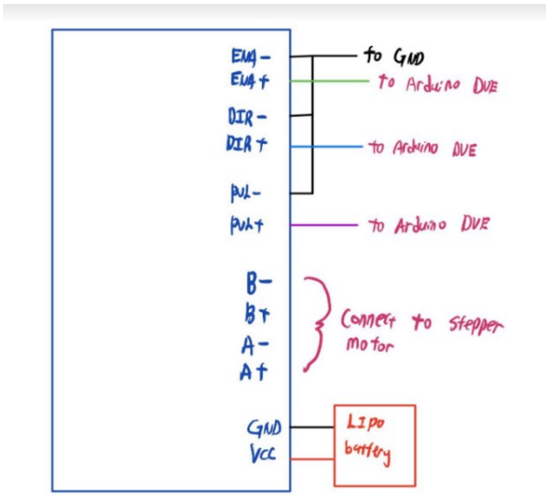


Figure 8: the connection of the stepper motor driver.

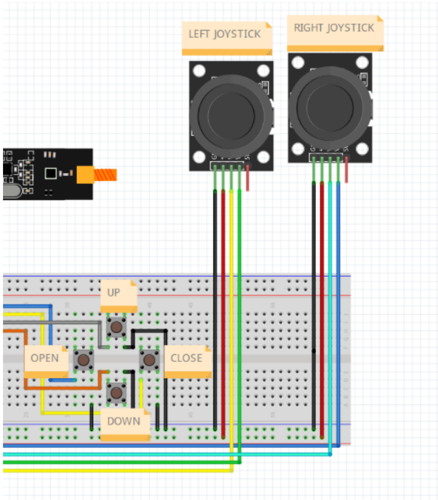


Figure 9: the function of the joysticks and push buttons of transmitter.

R2 The electrical and electronic design used are for the wheels, wireless control, and linear guides. For the wheel, 12 V DC motors are used as the main drive motor to drive the 4 mecanum wheels on robot R2. MD10C motor driver (Figure 10) is used to control the motor powered by providing PWM signals to control the motor speed. The motor (Figure 11) is also equipped with a rotary encoder which operates at 5V.

Figure 10: MD10C Cytron Motor Driver

Figure 11: 12 V 170RPM 2.7kgfcm 32mm Planetary DC Geared Motor with Encoder

4. SOFTWARE DESIGN

The coding and controller for the transmitter of the robot R2.

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>

RF24 radio(7,8); // ce,csn
const byte address[6] = "00001";


int actuator_open_button = 6;
int actuator_close_button = 5;
int actuator_up_button = 4;
int actuator_down_button = 3;


struct SIGNAL_PACKAGE{
  byte joystick_x_1;
  byte joystick_y_1;
  byte joystick_x_2;
  byte joystick_y_2;
  byte actuator_up_state;
  byte actuator_down_state;
  byte actuator_open_state;
  byte actuator_close_state;
  };

SIGNAL_PACKAGE signal_package; // create a stucture data to store all the data
```

Figure 10: The Arduino code of the transmitter

Based on the Arduino code of the transmitter. Firstly, the RF24 library by TMRh20 was included in order to control the nrf24l01 transceiver module. Next, an object 'radio' is defined with the variable taken is the CE and CSN pin of the transceiver to the Arduino followed with an address for the communication of the transceiver. After that, the pins of the tactile button are defined followed by the structure of information to be send as a signal package.

In the setup() function, the radio.begin() is used to start the transceiver module. Then, the radio.openWritingPipe(address) is to open a pipe to send the information to the address. After that, the radio.stop Listening() is to put the transceiver into transmitter mode. After that, all the pin mode of the tactile push button were set to INPUT_PULLUP. In this mode, the pin would read a '1' or "HIGH" when the tactile push button is not pushed and read a '0' or 'LOW' if the tactile push button is pushed. Then, the elements inside the signal package are given their respective default value.

In the loop() function, the Arduino nano would read the analogue value of the joysticks and map the value from 0 – 1023 to 0- 255. Next, it would read the state of each of the tactile push buttons. In the end, the signal package would be transmitted out by the radio.write ( ) function.

5. DISCUSSION

The design and fabrication process were done by trial and error, due to our lack of designing and modelling skills, we are unable to utilise the benefits provided from 3D simulation software. As a result, our robots have been scrapped and rebuilt multiple times and have several prototypes.

6. SUSTAINABLE ENGINEERING PRACTICES

All of the parts used in the robots are scrapped from previous works or unused electronic parts. The linear guides used in R2 are repurposed from other projects and can be dismantled and reused for future robots.

7. TESTING

From the test run that had been done, both robots are able to perform the tasks correctly with small margin of error. All tasks from shooting the ball, picking up the Lagori disks can be carried out by the two robots. The robots are able to finish the challenge within 90 seconds.

8. CONCLUSIONS, LIMITATIONS & RECOMMENDATIONS

In conclusion, the robots are able to carry out their tasks correctly with proper control. The robots designed are within the rules and regulatons fixed by organizer. However, there are some room for improvements that can be made to enhance the performance of the robots.

The limitations faced during the process of building were the limited access to the site and workshop due to physical activity restrictions imposed by the university. There are also a limited span of time we are able to carry out the fabrication and testing as the campus have limited time slot for us. As for recommendations, an external sensor can be used to allow the robot to have feedback on its location and throwing speed. In the future, we should plan to use 3D modelling and simulation before fabricating instead of trial and error process in order to ease the labour and save more time.

UNIVERSITY TUNKU ABDUL RAHMAN (UTAR) KAMPAR A

Dr Teh Peh Chiong, Ong Ting Yi, Crement Ong Wen Yao, Lee Yoong Jeng, Lim Jee Hean, Jovin Ooi Choo Chuan, Ng Yi Van

Universiti Tunku Abdul Rahman Kampar Campus, Jalan Universiti, Bandar Barat, 31900 Kampar, Perak

ABSTRACT

In this report, we present the design and development of robots for the competition of ROBOCON Malaysia 2022.The work here consists of two robots which is Robot 1 (R1) and Robot 2 (R2). There are consists of 2 round per game with the role of Seeker and Hitter. During the competition, each team role will be reversed for each round by the referee. With basic concept when the game round starts, Seeker will throw balls to break the Lagori discs and pile them up in the original order. The team will get points according to the number of broken Lagori discs and the piled-up Lagori discs. Also, with the Hitter throws balls to prevent Seeker from piling up Lagori discs. The robots mainly structured by aluminium profile. The robots upper part consists of high speed motor servo with tunnel and protected frame mounted on octagon base shape with actuated by stepper motor with 100mm Omni wheel. Both robot had added on relays on it to control and increase the level of moving speed. The Seeker and Hitter robots used 3D printed materials to contain the Lagori and actuated by servo motor and 97mm

mecanum wheel for the movement of the robot to make sure they move flexible in all directions. This makes both of our robots are in lightweight with the help of aluminium profiles which are rigid and light. The user-friendly robot is one of the most important element to consider for in a robot so that people do not need to spend much time to learn how to control it. Components used on the robots are mostly easy to assemble and recyclable which are good in sustainable practices. It is fast-moving, controllable, fast response. This concept can apply to other sports such as tennis also.

1. INTRODUCTION

The advancement of technology is increasing at a fast rate; it can be said that we live in a world driven by technology; many things around us are related to technology. Technology is basically the application of science or invention of tools that make our lives more convenient. One of the leading technologies in the world is robotic technology. Due to previously COVID-19 issues, the ROBOCON 2020 competition had canceled, that was our team first time participate in ROBOCON 2020. While in 2022, this is our team second time to participate in ROBOCON 2022 competition organized by the National Asian Broadcasting Union (ABU).

Our team goal is to gain the highest points as we can and to avoid mistake happen during the competition with total game time is 3 minutes. Firstly, if the referee set our team's role as Red Team, Seeker, our robot will load up 3 seeker ball on the seeker R1 during the setting time. Our team goal for 1st round is to make sure finish the three successful tries to break the Lagori discs and pile them up in the original order to get as many number of broken Lagori discs and the piled-up Lagori discs. Besides that, when the role change as Blue Team, Hitter, our robot will throw balls to more accuracy and efficient our team's robot can to prevent Seeker from piling up Lagori discs. However, if we done any mistakes, our team will apply for a retry under the permission of the referee.

Furthermore, the speed of our Seeker robot (R1) is faster than our Hitter robot (R2). This is because the weight of R1 is lighter than the weight of R2. In conjunction with that, we come out with a small strategy related to it. Since the speed of the R1 is faster, it is more efficient and time-saving for its movement over the game field. Besides that, our team decided to score the 3 point by throwing the Seeker Balls up to 3 times during the Break Shot Time with the number of broken Lagori discs with throwing the Seeker Balls to break the Lagori. From Seeker R1 can throw the balls only when all of its contact surfaces with the field are in the R1SZ. Then, for the second round with strategy of Hitter robot throw balls to prevent Seeker from pilling Lagori disc, from here we try to spots the maximum of the getting points advantage and refrain opposite side to win the game. We will try to increase the probability of us winning the contest as high as possible and try our best to win the competition.

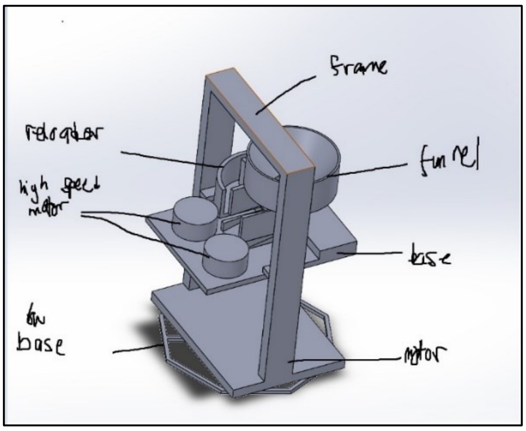
We get the main idea robots design from different country previous Robocon competition which has the similar theme and rules as Robocon Malaysia 2022. We had done the research and found that most of the teams are commonly using pneumatic system, however due to safety issue our team had select different concept. While for our team's robots R1 and R2 upper part consists of high speed motor servo with tunnel and protected frame mounted on octagon base shape with actuated by stepper motor with 100mm Omni wheel. Both robot had added on motor speed controller and large power MOSFET on it to control and increase the level of moving speed. The Seeker and Hitter robots used 3D printed materials to contain the Lagori and actuated by servo motor and 97mm mecanum wheel for the movement of the robot to make sure they move flexible in all directions. Eventually, we decide the design of the Seeker robot (R1) and Hitter robot (R2) together after the discussion among the team members.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

The main framework of the Seeker robot (R1) and Hitter robot (R2) are made by using aluminium profile as it can be cut and put together easily. The material is light weight and can be formed into a very strong structure by L-brackets together with screws and nuts. Both of the upper abd base part of the robot is using aluminium profile which are light weight. The Seeker and Hitter robots also used 3D printed materials for containing the Lagori.

2.1.1 SEEKER ROBOT (R1) AND HITTER ROBOT (R2) LOCOMOTION



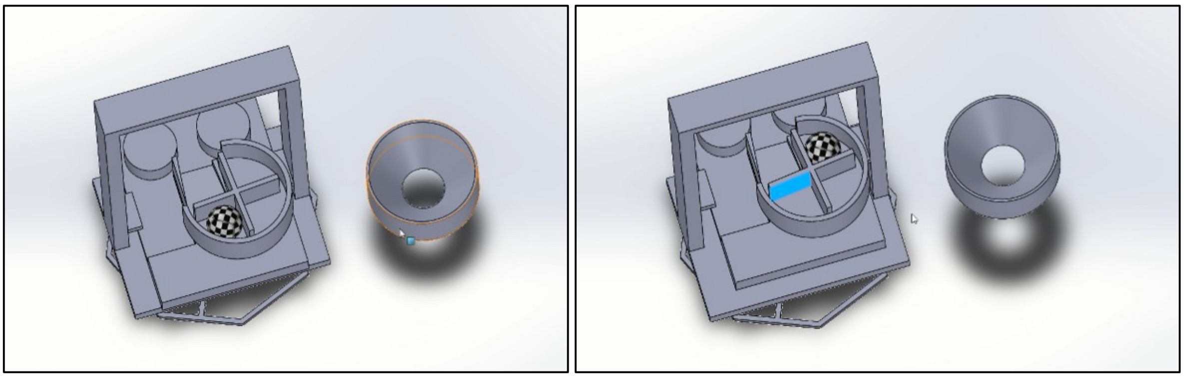


Figure 1: The final design of Seeker robot (R1) and Hitter robot (R2).

2.1.2 MECHANISM OF SEEKER ROBOT (R1) AND HITTER ROBOT (R2)

Figure 2: Mechanism of Seeker robot (R1) and Hitter robot (R2) for Lagori.

Essentially, the will be two heavy duties 4-inch PU wheel spinning at RPM to provide a driving force to the Lagori. The surface of the PU wheel is high friction rubber which will provide a better grip for the Lagori. To provide extra momentum for shooting goal, we are using a Motor Gear Shaft Conversion to Belt Drive Kitcylinder to do so. When it comes to the shooting, the two high rpm brushless motor will be on to increase the momentum of the ball for certain distance Seeker to shot the ball through Lagori pile and throw balls to prevent Seeker from pilling the Lagori disc. For the robot locomotion, it will be the same as both robots. The only difference is the type of the wheel used, which are the 100mm omni wheels. It is larger in diameter and it provides a true omnidirectional motion. This aims to have a more precise positioning during passing and goal shooting.

2.2 ELECTRONIC DESIGN

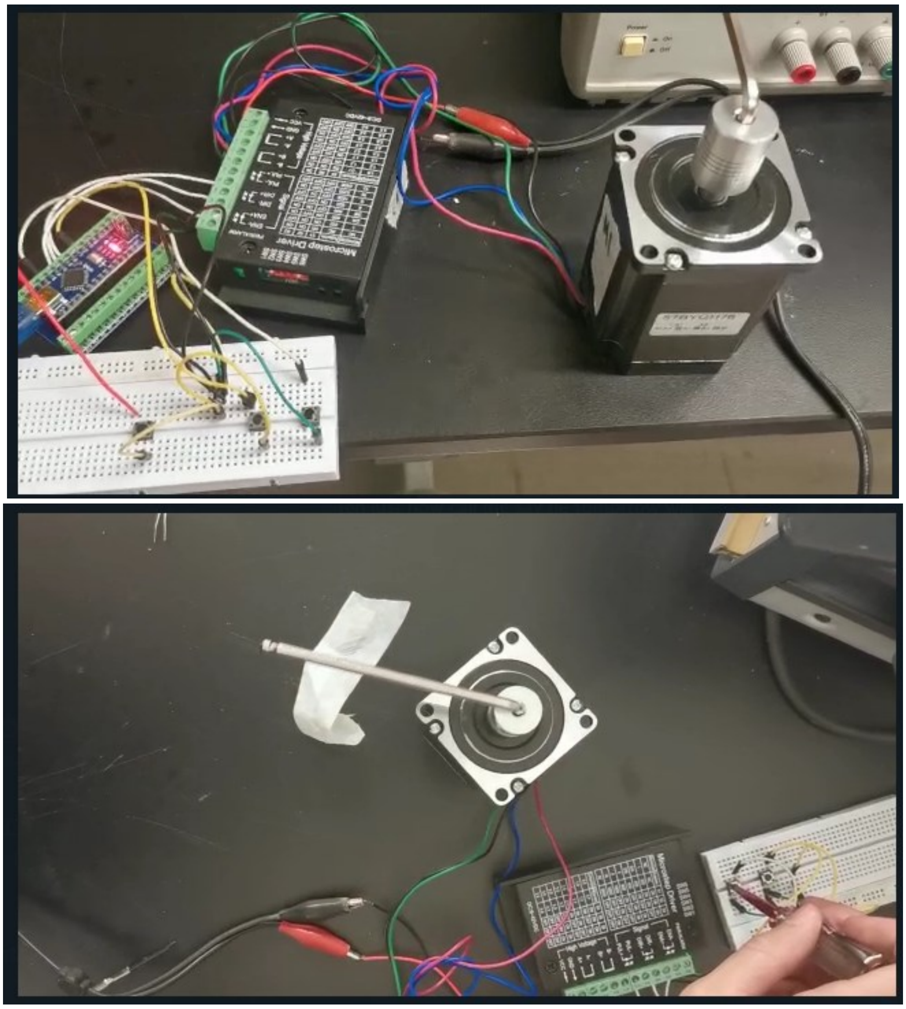


Figure 3: The movement mechanism of robot.

The whole robot is powered by the Arduino which are connected to relays, servo motors and four 100mm Omni wheel for robot R1 while four 97mm mecanum wheels for robot R2. The mecanum set up that we are using is a tank drive set up. This set up allows the robot to move in all direction as shown in figure. The Arduino is connected to a PS2 controller to give command on the locomotion of the robot. The motor is connected to motor speed controller and large power MOSFET to raise the level of current, in order to get more sensitive responses. For R1 and R2 upper part consists of high speed motor servo with tunnel and protected frame mounted on octagon base shape with actuated by stepper motor with 100mm Omni wheel. Both robot had added on motor speed controller and large power MOSFET on it to control and increase the level of moving speed. The Seeker and Hitter robots used 3D printed materials to contain the Lagori and actuated by servo motor and 97mm mecanum wheel for the movement of the robot to make sure they move flexible in all directions.

2.2.1 CIRCUIT DIAGRAM FOR SEEKER ROBOT (R1) AND HITTER ROBOT (R2)

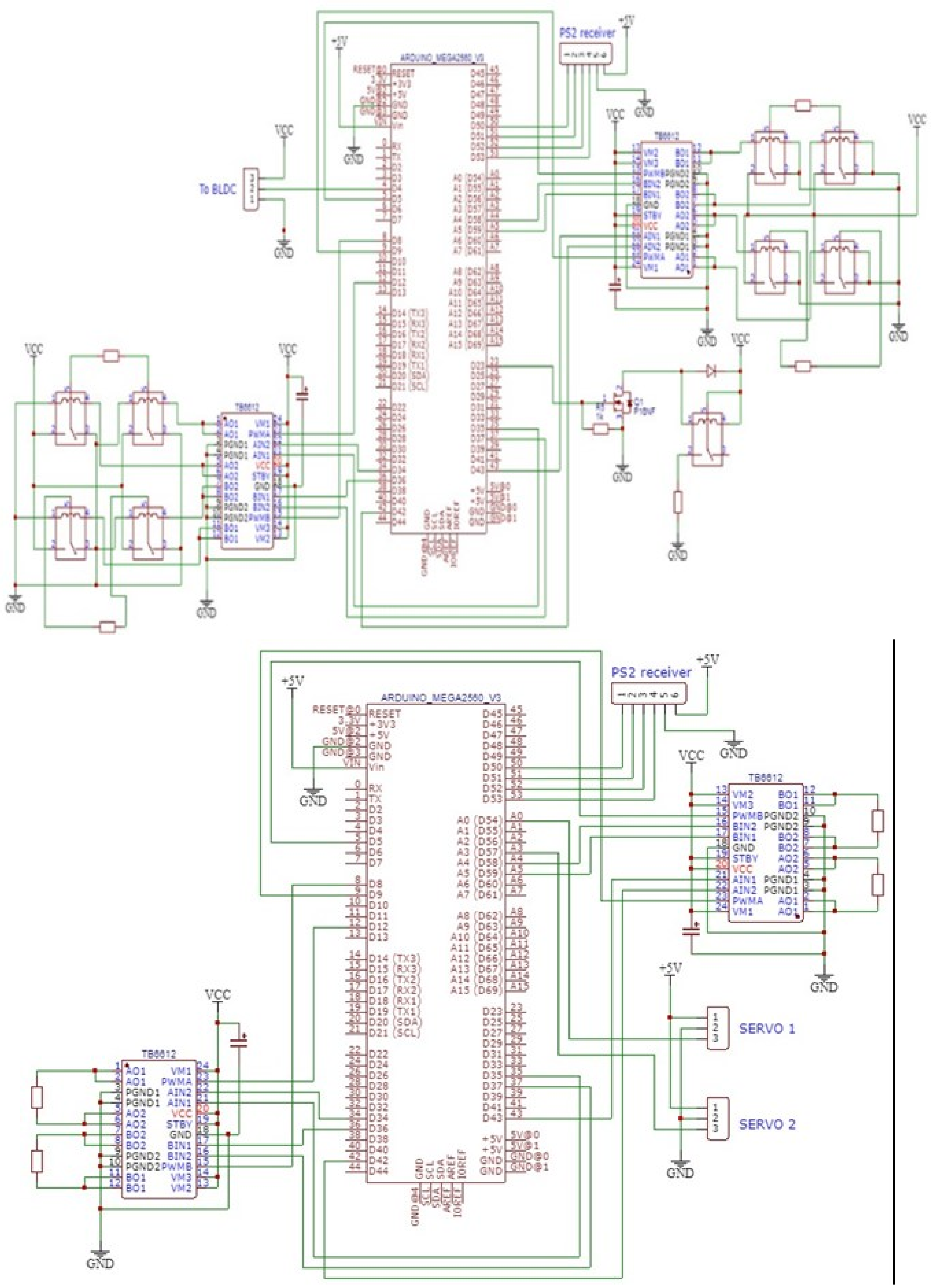


Figure 4: Circuit Diagram for Seeker robot (R1) and Hitter robot (R2).

2.2.2 ARDUINO MICROCONTROLLER AND POWER SOURCE

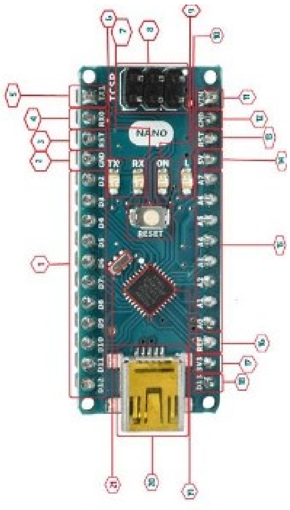


Figure 5: Arduino Nano and Rechargeable Battery.

Arduino Nano is a micro controller with Atmega328p microchip. It has 14 digital Pins and 8 Analog pins on your Nano board. The Arduino Nano is another popular Arduino development board very much similar to the Arduino UNO. They use the same Processor and they both can share the same program. One big difference between both is the size. UNO is twice as big as Nano and hence occupies more space on your project. Also, Nano is breadboard friendly while Uno is not. To program an Uno, you need a Regular USB cable; whereas for Nano, you will need a mini USB cable. Both robots are using the same type of power source as shown above the figure. It is rechargeable battery and with 12V 2000mAH. This battery is mainly used as power supply to Arduino Nano and other components.

2.2.3 DC MOTOR, STEPPER MOTOR AND PS2 CONTROLLER FOR SEEKER ROBOT (R1) AND HITTER ROBOT (R2)

Figure 6: DC motor, Stepper Motor and PS2 Controller for Seeker robot (R1) and Hitter robot (R2).

The DC motor attached on both robots is 12V DC motor with 3500 RPM rated speed. This is used for rotate the four 100mm Omni wheel for R1 and 97mm mecanum wheel for R2 move its base smoothly. This type of DC motor achieves the high rated speed and torque which produce more efficient and smoother movement robot motions. Besides that, the stepper motor, it has 76mm Nema 23 CNC stepper motor has a strong torque 1.9Nm (269oz.in) and with 4 wires, each phase draws 2.8A, very suitable for medical equipment and milling machines. With TB6600 Stepper Motor Driver is an easy-to-use professional stepper motor driver, which could control a two-phase stepping motor. It is compatible with Arduino and other microcontrollers that can output a 5V digital pulse signal. TB6600 stepper motor driver has a wide range power input 9~42VDC power supply. It is able to output 4A peak current, which is enough for the most of stepper motors. While for the controller we used for both robots is a Plat Station 2 (PS2) controller. It used as the primary user-input-interface for R1 and R2. The main advantage of it is that the 15 buttons and 2 analogue joysticks can be programmed for different tasks.

2.2.4 MOTOR SPEED CONTROL REGULATOR, MOSFET TRIGGER SWITCH DRIVER AND MOTOR CONTROLLER

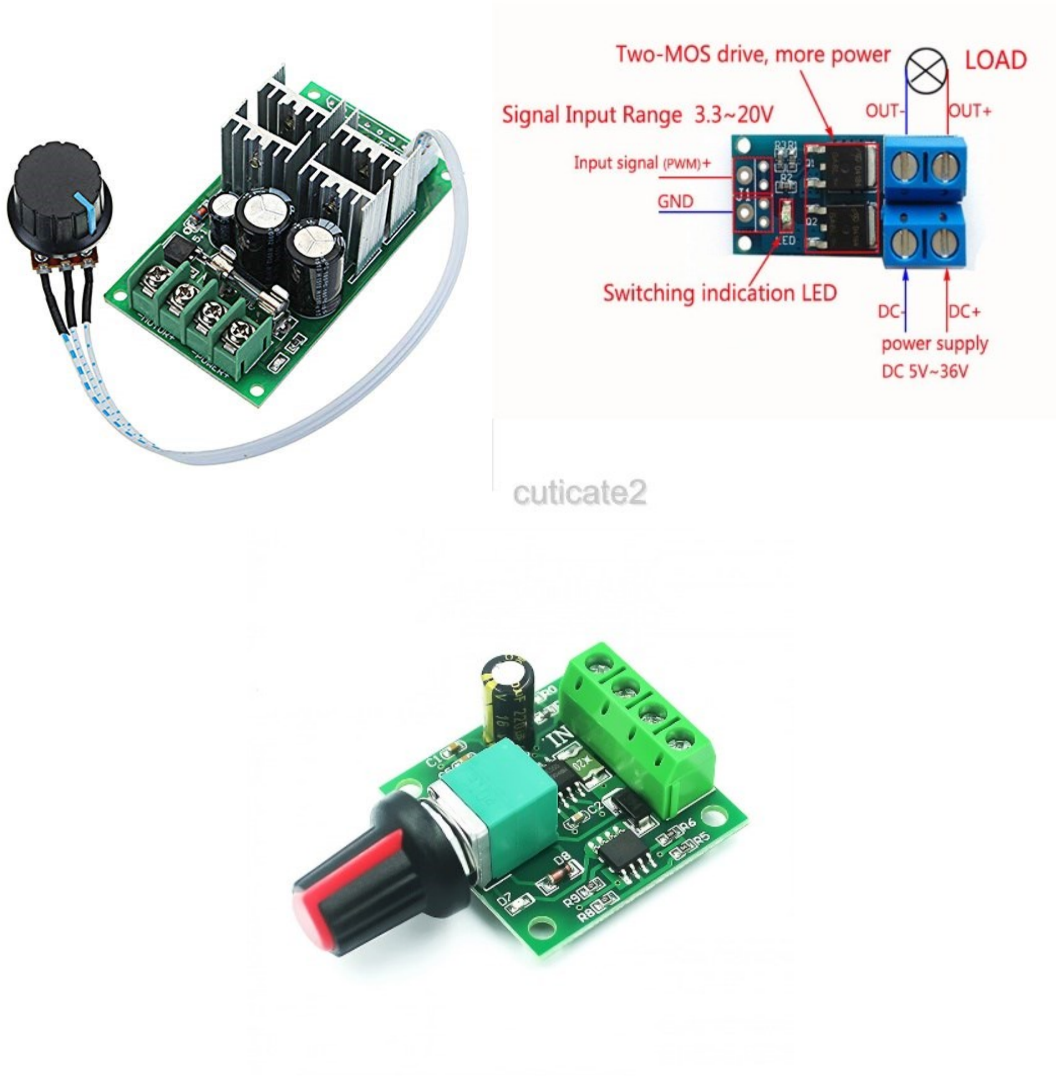


Figure 7: Motor Speed Control Regulator, MOSFET Trigger Switch Driver and Motor Controller.

First, it is the Original DIY more DC10-60V DC 10-60V Motor Speed Control Regulator PWM Motor Speed Controller Switch 20A Current Regulator High Power Drive Module for Arduino. Then, it is a high power MOS field effect tube trigger switch driver module PWM regulating electronic switch panel. Adopts imported large power dual-mos transistor parallel active output, lower resistance, higher current and strong power. With perfect support PWM signal: the PWM controller can access PWM signal, which can perfectly supported the frequency of 0-20khz. This motor control module can tolerate wide input Voltage (DC 5-36v) it can be applied in various high power equipment's, Applications: motor, lamp bulb,LED lamp strip, micro water pump etc. Besides that, the DC PWM 2A DC Motor Controller Module allows controlling the direction of a DC the motor using a Pulse-Width-Modulated (PWM) DC voltage with a duty cycle adjustment from 0%-100%. It also has an on-board self-recovery fuse 2A and a Power-On LED light.

2.3 SOFTWARE DESIGN

Arduino is one of the most popular and easy to use platforms for electronic projects and for this competition, Arduino was chosen as the microcontroller for both robots. The controller we used to control the robots are wireless PS2 controller and to simplify the coding, a template with a library for the wireless PS2 controller was used as the base coding for the Arduino. After the coding uploaded to the Arduino, all the buttons on the wireless PS2 controller was tested by using the serial monitor to ensure the wireless PS2 controller can establish a stable connection to the robot. Each of the robot has four wheels and four motors. To control the motor, a H-bridge motor driver was used, it will require three signal wires from the Arduino to control the direction of rotation and speed of the motor. After all the connection from the H-bridge to the Arduino had been made, the coding to control the motor was also added to the previous coding and uploaded to the Arduino to test the rotation of the motor to ensure that the motor is turning in the right direction when a button on the PS2 controller was pushed. The same coding was used for both the try robot and pass robot to control the movement of the robot.

For the pass robot, there will be two servo motor to push the ball out. The green and blue button was programmed to control the movement of the servo. When the green button is pressed, the value that written into the servo motor will increase, and the servo motor will rotate counter clockwise. When the blue button is pressed the value written into the servo motor will decrease, the servo motor will rotate clockwise. So, blue button will be used to push the ball out of the robot, and to retract the mechanism green button will be used.

For try robot, the Arduino will need to control a solenoid valve for the pneumatic cylinder and two ESC for brushless motor. The brushless motor will need to run in full speed before shooting the ball. The start button on the PS2 controller had been set to run the BLDC at maximum speed when it was pushed. To stop the motor, select button was programmed to stop the motor when pressed. For the solenoid for the pneumatic cylinder, it requires a high current which is more than the Arduino can provide, so the Arduino will first control a MOSFET which can handle the high current that needed by the solenoid. The green button on the PS2 controller was used to control the movement of the solenoid, when it is pressed, the solenoid will be activated and the cylinder will be extended, when the button was released, the solenoid will close and the cylinder went back to its original position.

2.3.1 PROGRAMMING FOR SEEKER ROBOT (R1) AND HITTER ROBOT (R2)

```
#include <PS2X_lib.h>
#include <Servo.h>
Servo bldc;

#define PS2_DAT        52
#define PS2_CMD        53
#define PS2_SEL        51
#define PS2_CLK        50
#define PWMD    5
#define DIRD    A4
#define DIRDD   A5
#define PWMC    9
#define DIRC    43
#define DIRCC   42
#define PWMB    8
#define DIRB    37
#define DIRBB   36
#define PWMA    12
#define DIRA    34
#define DIRAA   35
#define BLDC   4
#define SOLENOID 23
int a = 0;
char speed;

#define pressures   false
#define rumble      false

PS2X ps2x;
```

```
delay(300) ;

error = ps2x.config_gamepad(PS2_CLK, PS2_CMD, PS2_SEL, PS2_DAT, pressures, rumble);
if (error == 0) {
  Serial.print("Found Controller, configured successful ");
  Serial.print("pressures = ");
  if (pressures)
    Serial.println("true ");
  else
    Serial.println("false");
  Serial.print("rumble = ");
  if (rumble)
    Serial.println("true)");
  else
    Serial.println("false");
  Serial.println("Try out all the buttons, X will vibrate the controller, faster as you press harder;");
  Serial.println("holding L1 or R1 will print out the analog stick values.");
  Serial.println("Note: Go to www.billporter.info for updates and to report bugs.");
}
else if (error == 1)
{
  Serial.println("No controller found");
  resetFunc();
}
else if (error == 2)
  Serial.println("Controller found but not accepting commands.");
type = ps2x.readType();
switch (type) {
case 0:
```

```
    Serial.println("turn right");
    speed = 255;//200
    turnRight(speed);
  }
  if (ps2x.Button(PSB_SELECT)) {
    Serial.println("stop");
    stop();
  }
  if (ps2x.Button(PSB_PINK)) {
    Serial.println("motor_pmove_left");
    motor_pmove_left();
  }
  if (ps2x.Button(PSB_RED)) {
    Serial.println("motor_pmove_right");
    motor_pmove_right();
  }
  if (ps2x.Button(PSB_BLUE)) {
    Serial.println("servo_increase");
    digitalWrite(SOLENOID, HIGH);
  }
  if (ps2x.Button(PSB_GREEN)) {
    Serial.println("servo_decrease");
    digitalWrite(SOLENOID, LOW);
  }
  delay(20);
  stop();
 }
}
```

```
    Serial.print("DualShock Controller found ");
    break;
  case 2:
    Serial.print("GuitarHero Controller found ");
    break;
  case 3:
    Serial.print("Wireless Sony DualShock Controller found ");
    break;
  }
}
void turnRight(int speed) {
  digitalWrite(DIRA,LOW);
  digitalWrite(DIRB,LOW);
  digitalWrite(DIRC,LOW);
  digitalWrite(DIRD,LOW);
  digitalWrite(DIRAA,HIGH);
  digitalWrite(DIRBB,HIGH);
  digitalWrite(DIRCC,HIGH);
  digitalWrite(DIRDD,HIGH);
  analogWrite(PWMA, speed);
  analogWrite(PWMB, speed);
  analogWrite(PWMC, speed);
  analogWrite(PWMD, speed);
}

void turnLeft(int speed) {
  digitalWrite(DIRA,HIGH);
  digitalWrite(DIRB,HIGH);
  digitalWrite(DIRC,HIGH);
```

```
  analogWrite(PWMB,255);
  analogWrite(PWMC,255);
  analogWrite(PWMD,255);
}
void motor_pmove_right()
{
  digitalWrite(DIRA,HIGH);
  digitalWrite(DIRB,LOW);
  digitalWrite(DIRC,HIGH);
  digitalWrite(DIRD,LOW);
  digitalWrite(DIRAA,LOW);
  digitalWrite(DIRBB,HIGH);
  digitalWrite(DIRCC,LOW);
  digitalWrite(DIRDD,HIGH);
  analogWrite(PWMA,255);
  analogWrite(PWMB,255);
  analogWrite(PWMC,255);
  analogWrite(PWMD,255);
}
void servo_increase()
{
   servoValue++;
    if(servoValue > 180){
      servoValue = 180;
    }
  servoValue1 = 180 - servoValue;
  servo1.write(servoValue);
  servo2.write(servoValue1);
  Serial.print(servoValue);
```

```
    servoValue = 0;
  }
  servoValue1 = 180 - servoValue;
  servo1.write(servoValue);
  servo2.write(servoValue1);
  Serial.print(servoValue);
  Serial.print("\n");
  delay(20);
}
void loop() {
if(a==0){
  servoValue1 = 180 - servoValue;
  servo1.write(servoValue);
  servo2.write(servoValue1);
  Serial.print(servoValue);
  a++;
  }
  if (error == 1)
    return;
  if (type == 2) {
    return;
  }
  else  {
    ps2x.read_gamepad(false, vibrate);
    if (ps2x.Button(PSB_START))  {
      Serial.println("Start is being held");
      speed = 100;
      forward(speed);
    }
```

```
if (ps2x.Button(PSB_PAD_LEFT)) {
  Serial.println("turn left ");
  speed = 255;//200
  turnLeft(speed);
}
if (ps2x.Button(PSB_PAD_RIGHT)) {
  Serial.println("turn right");
  speed = 255;//200
  turnRight(speed);
}
if (ps2x.Button(PSB_SELECT)) {
  Serial.println("stop");
  stop();
}
if (ps2x.Button(PSB_PINK)) {
  Serial.println("motor_pmove_left");
  motor_pmove_left();
}
if (ps2x.Button(PSB_RED)) {
  Serial.println("motor_pmove_right");
  motor_pmove_right();
}
if (ps2x.Button(PSB_BLUE)) {
  Serial.println("servo_increase");
  servo_increase();
}
if (ps2x.Button(PSB_GREEN)) {
  Serial.println("servo_decrease");
  servo_decrease();
```

Figure 9: Programming for Seeker robot (R1) and Hitter robot (R2).

3. PRESENTATION OF DATA/SIMULATION OF TESTING

In this presentation of data and simulation of testing, the launching of the Seeker robot (R1) and Hitter robot (R2) has been tried for 10 times. To make sure the robots function well for throwing and receives the ball successfully.

Table 1: Data and rate of the testing for Seeker robot (R1) and Hitter robot (R2)

Trials / Tasks	Seeker	Hitter	Rate
1	0	1	50%
2	0	0	0%
3	0	0	0%
4	0	1	50%
5	1	1	100%
6	1	0	50%
7	1	1	100%
8	1	1	100%
9	0	1	50%
10	1	1	100%
Total:	5	7	51%

4. DISCUSSION/EVALUATION OF FINDINDS

Our design is innovated in a way that our robots are unique and take every aspect into consideration. We will first discuss about the Seeker robot (R1), as we can see from the design above, we take the R1 will throwing balls to break the Lagori disc and pile them up in the original order. Initially, we thought of making a catapult to throw the ball. However, we found that the shooting range is not consistent, and the shooter will break easily. So, our final decision so that the robot is robust enough to handle numerous times of shooting. Rollers are added so that the speed is adjustable which indirectly affects how high and distance the ball can go. To break the Lagori disc and the piled-up Lagori disc, the robot can be repaired with ease and low budget. There are no needs to buy the special roller with heavy metal which will also bring a consequence of extra burden (weight) to the robot itself which in turn slows down the speed of robot moving. Therefore, we can say that our robot is eco-friendly.

Most importantly, a robot must be easy to use and control by others even though he/she is not clear about the magic that happened in the system itself. Our robot is worked in simple mechanism. The people who is controlling must move the robot with a controller just like playing an RC car. When a button is triggered, the robot that holds the ball will pass the ball to the plastic holder as a throwing platform. The ball will then be pushed and thrower to only one direction in front of the robot, that's it! Our aim is to build the robots that can be used by public but not creators themselves only.

Then continue with Hitter robot (R2), the first selling point of the robot is light weighed material is used. The whole robots are made from aluminium profile. This means that the robot will be much lighter compare to other robots. With the basic concept of Newton's Second Law of motion, we know that the smaller the mass of the object, the faster the acceleration. Therefore, the robot has the ability to move in a greater velocity. This detail will improve the accuracy of the robot to throw the object. Lastly, mecanum wheel is used in the robot making where it provides a flexible movement for the robot to go anywhere in any direction. So not only the robot is able to travel faster, the friction in the movement will be reduced as well.

5. SUSTAINABLE ENGINEERING PRACTICES

Our robots are mainly construct with aluminum profile and with 3D printed materials. The main reason we choose aluminium is it can be recycled and reuse. Thus, we can say that recycle of aluminium is energy saving and environmental saving. Besides a good recyclable material, it also a nontoxic material and does not contribute to metallic pollution. We can conclude that use of aluminium in the development of our robots does not contribute to environmental issue. Moreover, the battery we used in the development of our robots is rechargeable battery. Rechargeable batteries are better for environment than disposal batteries. This is because rechargeable batteries are capable of being used for many times since they can be recharged after used while disposable batteries can only be used once. Rechargeable batteries produce less waste than disposable batteries we can reuse it repeatedly instead of buy a new one. According to Jarrett [2], rechargeable batteries perform better disposable batteries. Rechargeable batteries dissipate 1.2 volts of energy whenever it is in use while disposable batteries will dissipate 1.5 volts of energy at start and gradually get lower until they are dead. Thus, rechargeable batteries use less energy than disposable batteries. It is more energy efficient than the cost and energy of making new batteries since recharging of batteries use less energy.

6. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

In conclusion, the experience is building to robots which are the Seeker robot (R1) and Hitter robot (R2) helps to strengthen the bond between teammates as it requires a lots of sacrifices and the sharing of knowledge. With the robots mainly structured by aluminium profile. The robots upper part consists of high speed motor servo with tunnel and protected frame mounted on octagon base shape with actuated by stepper motor with 100mm Omni wheel. Both robot had added on relays on it to control and increase the level of moving speed. The Seeker and Hitter robots used 3D printed materials to contain the Lagori and actuated by servo motor and 97mm mecanum wheel for the movement of the robot to make sure they move flexible in all directions. This makes both of our robots are in lightweight with the help of aluminium profiles which are rigid and light.

Throughout the whole preparation for the Seeker robot (R1) and Hitter robot (R2), some limitations had been discovered. There were three stages for our preparation, which were drafting, buying, and building. Firstly, for the layout drafting step, we can say that our design was quite good but since most of the components and material were purchased online, our final product was slightly different from our original designs. These caused some minor problems such as lack of screws and building materials. The most troubleshoot problems is all of our members are having final examination during the period of building the robots. Therefore, our time were in short and progress were not as expected. The solution for us to solve the issue is reduced our time to practice on difference movements that can be performed by our robots, one of the difficulties faced is manual controlling of the robots. The materials bought are not enough. These problems and limitations consumed lots of our time and energy. There are a lot of rooms for improvement in this project.

7. ACKNOWLEDGEMENTS

The author will like to thank the Faculty of Green Technology and Engineering (FEGT) and UTAR (Kampar campus) for financial support and lab providing supply helps that we need for the project. Finally, we would like to express our gratitude to our lecturers, parents and friends who had helped and given us encouragement. We hope that we can achieve great results in Robocon 2022 competition.

REFERENCES

[1] Robocon Malaysia 2022 Theme and Rules are adopted from ABU Asia-Pasific Robot Contest 2021 Game Theme and Rules. http://www.robocon2022.com.

[2] J. Jarrett. The benefits of battery chargers and rechargeable batteries. *Top Ten Reviews,* November 2019. https://www.toptenreviews.com/battery-chargers-and-the-benefits-of-rechargeable-batteries

UNIVERSITY TUNKU ABDUL RAHMAN (UTAR) KAMPAR B

Dr Teh Peh Chiong, Matthias Yee, Gan Pei Yi, Shaharyar Shahab, Sim Zhen Teng, Wong Yan Jun, Boey Zhi Xuan

Universiti Tunku Abdul Rahman Kampar Campus, Jalan Universiti, Bandar Barat, 31900 Kampar, Perak

ABSTRACT

In this report, we present the design and development of robots for the competition of ROBOCON Malaysia 2022. The work here consists of two robots, namely the Robot 1 and Robot 2 with both manual configurations. The robots mainly structured by a hollow aluminium tube. The Robot 1 utilizes pneumatic servo mounted on octagon base shape with actuated by servo motor with 100mm Omni wheel. The R2 had add on relays on it to control and increase the level of moving speed. The Robot 1 uses a net to catch the ball and is actuated by servo motor and 97mm mecanum wheel for the movement of the robot to make sure they move flexible in all directions. What makes the robots so special is that the robots are both having lightweight with the help of aluminium profiles which are rigid and light. The user-friendly robot is one of the most important element to consider for in a robot so that people do not need to spend much time to learn how to control it. Components used on the robots are mostly easy to assemble and recyclable which are good in sustainable practices.

1. INTRODUCTION

The advancement of technology is increasing at an astonishingly high rate, it can be said that we live in a world driven by technology; many things around us are related to technology. Technology is defined on the basis of the application of science or invention of tools that make our lives more convenient. One of the leading technologies on earth is robotic technology. This is our team first time to participate in ROBOCON competition organized by the National Asian Broadcasting Union (ABU).

Our team is to design two robots , which are R1 and R2 , they are capable of shooting balls to either destroy the lagori pile or to shoot down the ball on the head of the opponent's robot . When Round 1 starts, Seeker R1 throws Seeker Balls to break the Lagori. However, Seeker R1 can throw the balls only when all of its contact surfaces with the field are in the R1SZ. The seeker will score points according to the number of broken Lagori discs. Seeker can throw Seeker Balls up to 3 times during the Break Shot Time which is 30 seconds . The speed of the ball must be less than 30km/h.When all 5 Lagori discs are broken or the Break Shot Time is finished, after the referee's signal, the Seeker R2 can start piling up the Lagori discs in the remaining time in the Round. The seeker will earn points according to the number of Lagori discs piled up.

When all Lagori discs have been broken or the Break Shot Time is finished, after the referee's signal, Hitter's R1 and R2 can start moving to pick up the Hitter Balls. Hitter R1 can throw the Hitter Balls at the Ball on Head of Seeker R2 to displace it. Hitter R2 can pick up Hitter Balls from the Ball Areas and pass them to Hitter R1. While passing from Hitter R2 to Hitter R1 the balls should not touch the field surface. Hitter R1 can throw the balls only when all contact surfaces with the field are in the R1SZ. The speed of the ball must be less than 30km/h. Hitter R1 must displace the Ball on Head directly using a Hitter ball. If the Hitter Ball thrown by Hitter R1 does not hit the Ball on Head directly and the Ball on Head is displaced, the Hitter will be forced to retry and cannot restart for 15 seconds. The Seeker team members reset the Ball on Head immediately.

2. DETAILED DESIGN

2.1 MECHANICAL DESIGN

There will be two robots, Seeker robot and Hitter robot. The main framework of the Hitter Robot and Seeker Robot is made by using aluminium profile as it can be cut and assemble together easily. The material is light weight and can be formed into a very strong structure by L-brackets together with screws and nuts. The upper part of the robot is using hollow aluminium tube which are light weight too.

2.1.1 HITTER ROBOT AND SEEKER ROBOT LOCOMOTION

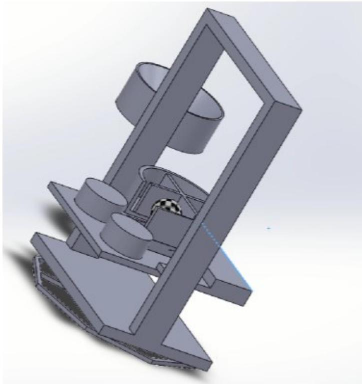


Figure 1: The final design of Hitter Robot

2.1.2 MECHANISM OF HITTER ROBOT AND SEEKER ROBOT

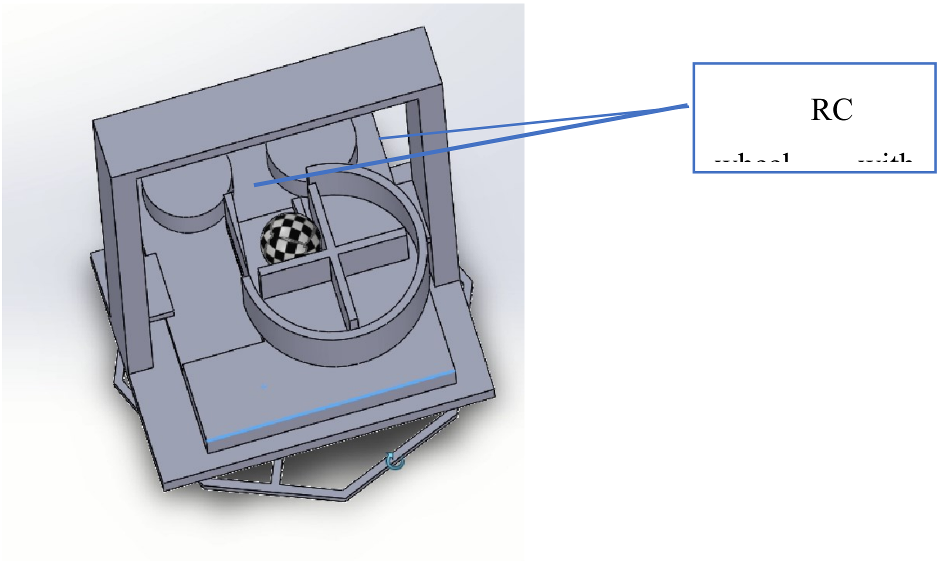


Figure 3: ball shooter.

Basically, there will be two RC wheel spinning at relatively high RPM to provide a driving force to the ball. The surface of the RC wheel is high friction rubber which will provide a better grip to the ball. When it comes to shooting, the two high RPM brushless motor will be on to increase the momentum of the ball for a much higher and long goal pass.

The general view of the shooter robot (ball shooting machine) can be seen in Figure 3. The body of the shooting machine consists of an iron sheet and beam. Boxes made of iron sheets are designed to protect electrical or electronic equipment from impacts during the game on.

The seeker and hitter robot have square base wheeling system to prevent tipping over and towing arm for easy transportation are used. For the shooting, there is two DC gear motor that can produce high torque at low speed is used to let the ball from the sorting canister. A motor drive circuit is used to control permanent magnet DC motors and also for the vertical movement for aiming to shoot higher lower for the target.

Between the ball loading canister and ball thrower wheels, there is a ball sorting canister with diverted with four box to contain the ball before shooting. The part which is connected to the loading canister is designed as a roller bearing so that it can rotate easily. Thus, and so a ball can be sent to be thrown after the ball thrower wheels adjust their positions and get another ball to get ready to shoot out.

2.2 ELECTRONIC DESIGN

The whole robot is powered by the Arduino Mega which are connected to relays, servo motors and four 100mm Omni wheel for R1 while four 97mm mecanum wheels for R2. The mecanum set up that we are using is a tank drive set up. This set up allows the robot to move in all direction as shown in figure. The Arduino Mega is connected to a PS2 wireless control to give command on the locomotion of the robot. The motor is connected to four relays to raise the level of current, to get more sensitive responses.

The ball releasing method for R2 is using pneumatic servo to pass ball and just using a servo motor pushing a square metal frame to push the ball out from the nylon net for R1. The servo motor is also controlled by the Arduino Mega.

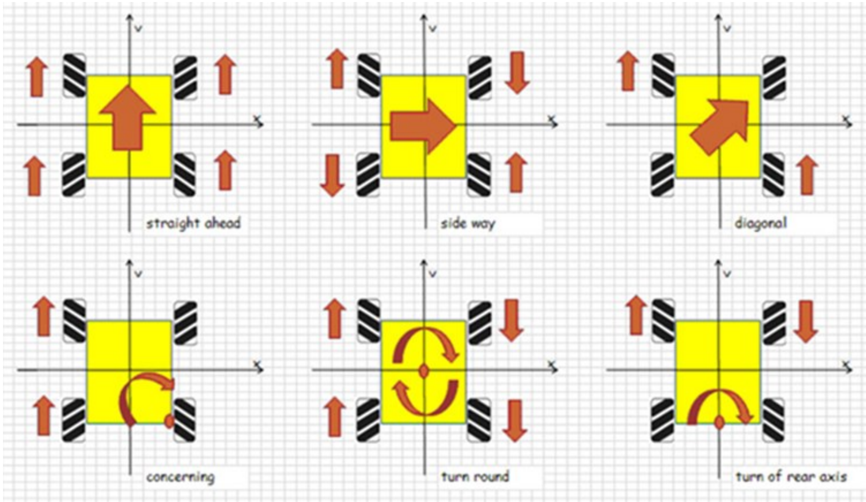


Figure 4: The movement mechanism of robots

2.2.1 CIRCUIT DIAGRAM FOR R1 AND R2

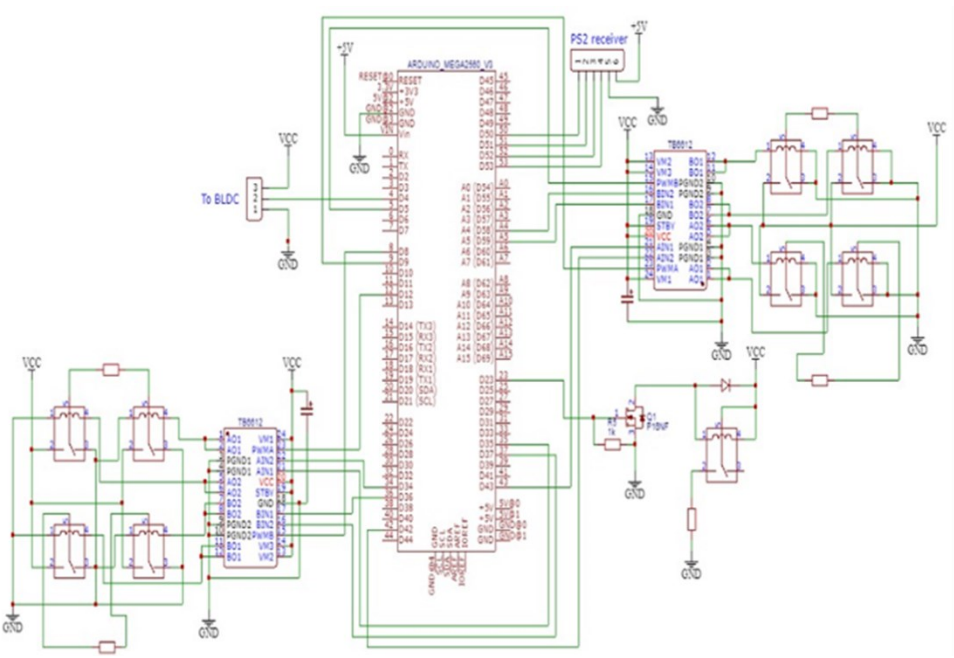


Figure 5: Circuit connection of R1

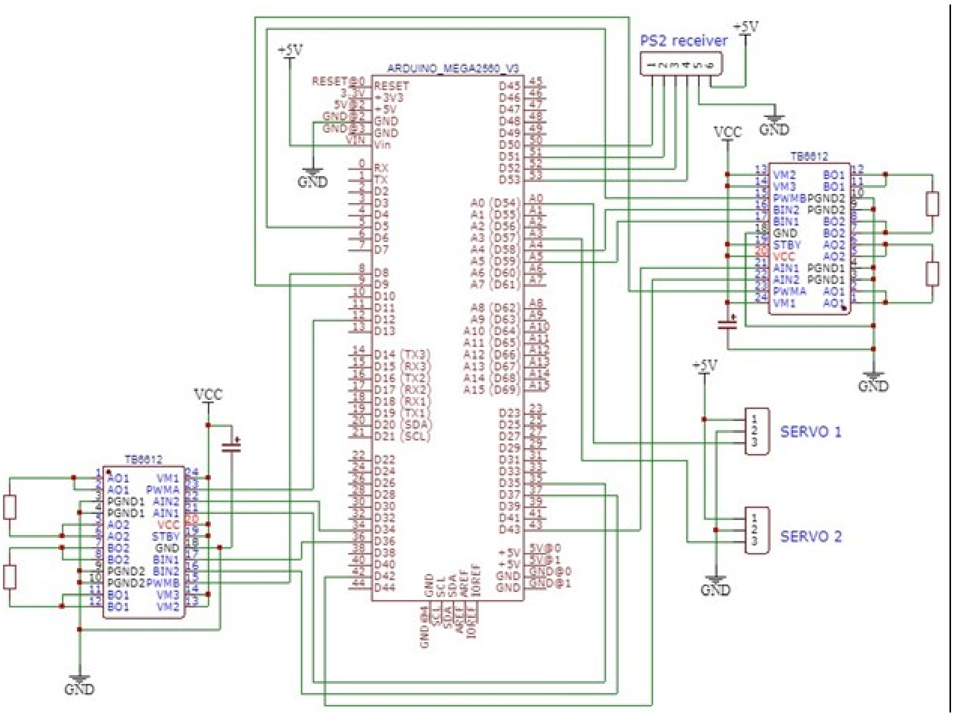


Figure 6: Circuit connection of R2

2.2.2 ARDUINO MICROCONTROLLER AND POWER SOURCE

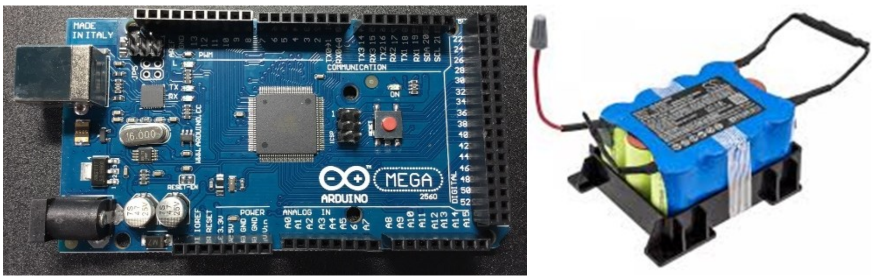


Figure 7: ARDUINO_MEGA2560_V3 and NiMH battery

Arduino Mega is a micro controller that uses ATmega2560 microchip. It has 54 digital input/output pi in which 14 pins can be used as digital (PWM) outputs, 16 pins for analog inputs and 4 pins for UARTs (hardware serial ports)with a 16Mhz crystal oscillator, USB connection capability, an ICSP header, and a reset button. The capability of the Arduino Mega is considered sufficient in both manual and auto robots. Thus, it will ease the implementation phase. Both robots use the same type of power source which is NiMH battery. It is rechargeable battery and with 12V 5000 mAH. This battery is mainly used as power supply to Arduino Mega and other components.

2.2.3 DC MOTOR AND CONTROLLER FOR R1AND R2

Figure 8: DC Motor and PS2 Controller

The DC motor attached on both robots is 12V DC motor with 300 RPM rated speed. This is used for rotate the four 100mm Omni wheel for R1 and 97mm mecanum wheel for R2move its base smoothly. This type of DC motor achieves the high rated speed and torque which produce more efficient and smoother movement robot motions. While for the controller we used for both robots is a Plat Station 2 (PS2) controller. It used as the primary user-input-interface for R1 and R2. The main advantage of it is that the 15 buttons and 2 analogue joysticks can be programmed for different tasks.

2.2.4 ACTUATOR, BRUSHLESS MOTOR AND RELAYS

Figure 9: Actuator, Brushless Motor and Relays

The solenoid valve used to regulate pressure input on each pneumatic system for the R1. It has operating pressure range of 0.1 to 0.7 MPa and 12 V operating voltage requirement for operation. The Arduino will supply power through the use of four-way relay module as a switch due to restriction of 5V supply voltage of the Arduino. The basic function of the relay is to allow a low power control voltage operate a high power switch, as the solenoid required 12V to operate. Thus, we used brushless motor as the high speed of shooting and passing the rugby ball out on the R1. While for the relays we used SRD-12VDC-SL-C Relay to control and managing the speed of our robots.

2.3 SOFTWARE DESIGN

Arduino is one of the most popular and easy to use platforms for electronic projects and for this competition, Arduino Mega was chosen as the microcontroller for both robots. The controller we used to control the robots are wireless PS2 controller and to simplify the coding, a template with a library for the wireless PS2 controller was used as the base coding for the Arduino. After the coding uploaded to the Arduino Mega, all the buttons on the wireless PS2 controller was tested by using the serial monitor to ensure the wireless PS2 controller can establish a stable connection to the robot. Each of the robot has four wheels and four motors. To control the motor, a H-bridge motor driver was used, it will require three signal wires from the Arduino to control the direction of rotation and speed of the motor. After all the connection from the H-bridge to the Arduino had been made, the coding to control the motor was also added to the previous coding and uploaded to the Arduino to test the rotation of the motor to ensure that the motor is turning in the right direction when a button on the PS2 controller was pushed. The same coding was used for both the try robot and pass robot to control the movement of the robot.

For the R1, there will be two servo motor to push the ball out. The green and blue button was programmed to control the movement of the servo. When the green button is pressed, the value that written into the servo motor will increase, and the servo motor will rotate counter clockwise. When the blue button is pressed the value written into the servo motor will decrease, the servo motor will rotate clockwise. So, blue button will be used to push the ball out of the robot, and to retract the mechanism green button will be used.

For R2, the Arduino will need to control a solenoid valve for the pneumatic cylinder and two ESC for brushless motor. The brushless motor will need to run in full speed before shooting the ball. The start button on the PS2 controller had been set to run the BLDC at maximum speed when it was pushed. To stop the motor, select button was programmed to stop the motor when pressed. For the solenoid for the pneumatic cylinder, it requires a high current which is more than the Arduino can provide, so the Arduino will first control a MOSFET which can handle the high current that needed by the solenoid. The green button on the PS2 controller was used to control the movement of the solenoid, when it is pressed, the solenoid will be activated and the cylinder will be extended, when the button was released, the solenoid will close and the cylinder went back to its original position.

2.3.1 PROGRAMMING FOR R1 AND R2

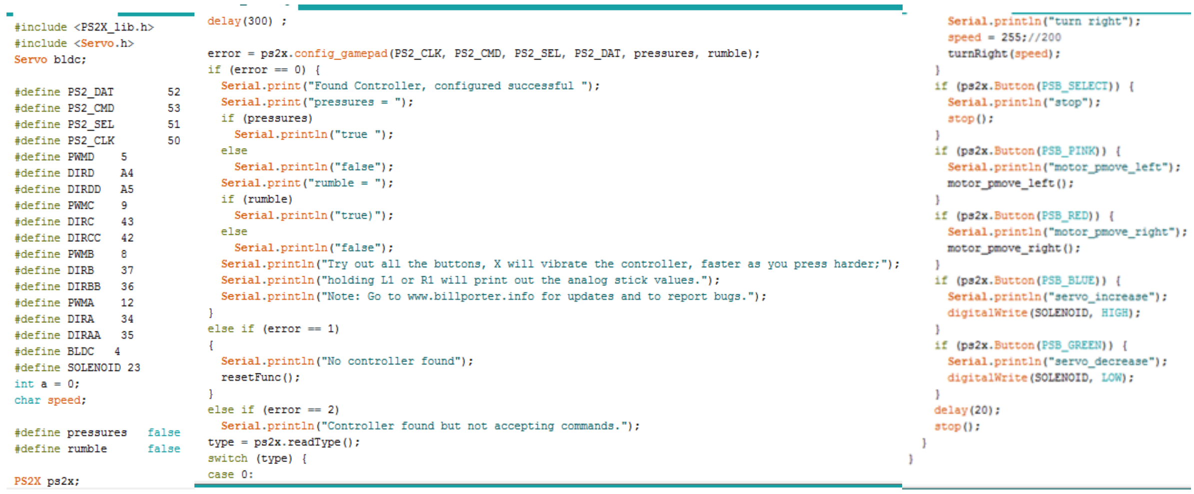


Figure 10: Programming for R1

Figure 11: Programing for R2

3. DISCUSSION/EVALUATION OF FINDINDS

Robot must be easy to use and controlled by others even though he or she is not clear about the things that happened in the system itself. Our robot works in simple mechanism. The people who is controlling must move the robot with a controller just like playing an RC car. When a button is triggered, the robot that holds the ball will pass the ball to the plastic holder as a shooting platform. The ball will then be pushed to the rollers and shoot to only one direction in front of the robot. We aim to develop the robots that can be used by public, not creators themselves only.

The R1 is used to catch the ball. The feature of the robot is that light weighed material is used. The supporting system of the catching net is made of aluminium profile. So robot will be much lighter compare to other robots. With the basic concept of Newton's Second Law of motion, we know that the smaller the mass of the object, the greater the acceleration. Therefore, the robot can move faster. The second reason why this robot is so different is because not only we designed a net to catch the object, but we calculated to adjust its display position as well. The net has a big surface area and is in a slanted position, allowing the object to drop into the net directly. This detail will improve the accuracy of the robot to catch the object. Lastly, mecanum wheel is used where it provides a flexible movement for the robot to go wherever we designate. So not only the robot is able to travel more swiftly, the friction in the movement will be minimized as well.

4. SUSTAINABLE ENGINEERING PRACTICES

Our robots are mainly constructed with aluminium profile and hollow aluminium tube. The main reason we choose aluminium is it can be recycled and reuse. Thus, we can say that recycle of aluminium is energy saving and environmental saving. Besides a good recyclable material, it also a nontoxic material and does not contribute to metallic pollution. We say that the use of aluminium in the development of our robots does not contribute to environmental issue.

Moreover, the battery we used in the development of our robots is rechargeable battery. Rechargeable batteries are so much better for environment than disposal batteries. This is because rechargeable batteries are capable of being used for many times since they can be recharged after used while disposable batteries can only be used once. Rechargeable batteries produce less waste than disposable batteries we can reuse it repeatedly instead of buy a new one. According to Jarrett [1], rechargeable batteries perform better disposable batteries. Rechargeable batteries dissipate 1.2 volts of energy whenever it is in use while disposable batteries will dissipate 1.5 volts of energy at start and gradually get lower until they are dead. Thus, rechargeable batteries use less energy than disposable batteries. It is more energy efficient than the cost and energy of making new batteries since recharging of batteries use less energy.

5. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

In conclusion, the experience is building to robots which are the R1 and R2 helps to strengthen the bond between teammates as it requires a lots of sacrifices and the sharing of knowledge. The R1 is to perform pass mechanisms. To shoot the balls accurately and high enough, Intensive practice was done. Besides, the R1 is to perform shoot mechanism. To fulfil our objectives of having an accurate landing position of the ball, fast and flexible moving robots, calculations and predictions are made during the progress. In a nutshell, priceless experience and knowledge are gained during this whole project. Although it is a tough task for us since we are new on it, but these skills had provided us a strong platform in future career.

Throughout the whole preparation of the R1 and R2, some limitations had been discovered. There were three stages for our preparation, which were drafting, buying, and building. Firstly, for the layout drafting step, we can say that our design was quite good but since we were not managed to have a look on the materials before bought, our final product was different from our original designs. These caused some minor problems such as unfit screw holes, unexpected size of materials. The most troubleshoot problems is the size of the catcher net. Since a larger catcher net supplied us a greater advantage on catching the ball, so we planned to have a larger size, but it came out the materials were not as expected. Besides, the size of our pneumatic cylinder connector is also unfit, this caused trouble in connecting the tube to pneumatic cylinder.

There are a lot of rooms for improvement in this project. The time and budget restraint of this project had limited the performance of the robot. Firstly, the improvement can be done to catch the ball more accurately and effectively. The easiest way is to introduce a bigger catcher net, to have a bigger catcher net, a larger base is needed. Although this way is simple, but it is not the most effective way, so with the introduction of ball tracking program, this project can be improved. By introducing this program, our robots can recognise the motion of the ball through a camera. Since videos are made up of continuous frames of pictures, so we take each picture and split it into pixels. Then, location of ball can be found from the comparison of pixel colour with colour of ball. This will surely improve the accuracy and success rate of the system. Secondly, obstacles avoidance using machine vision and artificial intelligence is preferable to improve the robot's capability since our robots were controlled remotely. With obstacles avoidance and intelligent path planning, the robot can fully move in track that is planned. Furthermore, the robot could navigate itself to avoid obstacles along the planned track to complete its task. Thirdly, to solve the problem of insufficient workforce, we reallocated our tasks. Some of the team members are distributed to build the robot and some are distributed to test out the robot. These not only can increase our productivity but also supply us more time to finish our project. Moreover, speed is important to win this competition, so we tried many ways to improve the speed of our robots. Firstly, we tried with reducing the weight of loads, but our robots ended up with lesser functions. Therefore, we finally made up our mind with adding relays on each of our wheels and motors. Since the functions of relay is to control the opening and closing of the circuit. Therefore, when the circuit have high voltage, arc is reduced. When the circuit is in low voltage, the overall circuit noise is reduced to minimum.

6. ACKNOWLEDGEMENTS

The author will like to thank the Faculty of Green Technology and Engineering (FEGT) and UTAR (Kampar campus) for financial support and lab providing supply helps that we need for the project in this period. Finally, we would like to express our gratitude to our lecturers, parents and friends who had helped and given us encouragement.

REFERENCES

[1] J. Jarrett. The benefits of battery chargers and rechargeable batteries. Top Ten Reviews, November 2019. https://www.toptenreviews.com/battery-chargers-and-the-benefits-of-rechargeable-batteries