Team 18F06 Sumobot

Preliminary Report

Saud Alabhoul

Mohammad Albaghli

Jasim Albenali

Rashed Alfadhli

Abdulaziz Kandari

2018-2019

NORTHERN ARIZONA UNIVERSITY
College of Engineering, Forestry & Natural Sciences
School of Forestry

Project Sponsor: Northern Arizona University

Instructor: Dr. Sarah Oman

DISCLAIMER

This report was prepared by students as part of a university course requirement. While considerable effort has been put into the project, it is not the work of licensed engineers and has not undergone the extensive verification that is common in the profession. The information, data, conclusions, and content of this report should not be relied on or utilized without thorough, independent testing and verification. University faculty members may have been associated with this project as advisors, sponsors, or course instructors, but as such they are not responsible for the accuracy of results or conclusions.

TABLE OF CONTENTS

Contents

1 BACKGROUND

1.1 Introduction

Sumo robots are used in Sumo Match competitions. The Sumo match is carried out by two teams with each having one or more contestants. Only one team member is allowed to approach the ring as the other team members watch from the audience. Each team competes on a sumo ring with a robot they have constructed as per the laid down specifications. Different weight classes and control systems are allowed. The sumo ring is the playing surface which is surrounded by and includes the border line. The ring is circular in shape and have appropriate dimensions depending on the class. There are starting lines centered in the ring also known as shikiri lines where the sumobots start their match. The distance of the shikiri lines is measured to the outside edges. The borderline is marked using a white circular line of a width appropriate for the given class on the outer edge of the playing surface. The ring area extends to the outside edge of this circular line. The goal of this project was to create an R/C sumobot that capable of participating in the sumobot competition that include two R/C bots to compete against each other to win the battle. When the project is completed successfully, it will be of great significance to sumo players since they will be able to participate in competitions in an efficient manner. The class that the team participating in is going to be the 3kg weight with an R/C.

1.2 Project Description

In this project, the stakeholder is the RoboGames while the sponsor is the Northern Arizona University.

> "Two robots compete in a head-to-head match following the basic system of traditional human sumo matches. Robots are allowed no weapons and are not allowed to flip each other. The sole purpose is a pushing match between the two robots to force the other from the arena. Multiple weight classes and control systems are allowed (autonomous compete against autonomous and R/C against R/C - they are separate classes and do not compete against each other.)". [1]

The goal of the team is to create an R/C sumobot that is capable of participating in the sumobot competition that include two R/C bots to compete against each other and win the battle. In order to ensure that the team succeeds in this project, the team read out the rules in RoboGames website thoroughly as to know their requirements. After the team understood the rules and requirements, they worked on designing the sumobot through brainstorming processes, research, analyses and presentations. Consultations were made in course of the project from the lecturers to ensure that we are proceeding in the right direction.

1.3 Original System

This project involves the design of a completely new sumobot since there was no original system at the start of the project. The current solution to the design problem is creating a sumobot that is able to participate in the sumobot competition that include two R/C bots to compete against each other to win the battle. However, the instructor gave the team a great deal of sources by providing the old sumobots from previous projects.

2 REQUIREMENTS

In this chapter the customer requirements and engineering requirements will be discussed. These requirements will be implemented in the final design system to ensure that the device operates in an effective manner. however, the requirements are weighted against each other in the House of Quality to determine the significance of each requirement.

2.1 Customer Requirements (CRs)

Customer requirements are regarded as the various forms of requests in which the clients and the users have regarding how the device can be designed so as to suit their needs. Details on the customer requirements were obtained from Robogames website. Since the team does not have a client all requirements were obtained from the website rules and regulations. The gathered customer requirements are weighted on a scale of 0-5 and are as presented in the table below.

Table 1: Customer Requirements for RC Sumobot

S No.	Customer requirement	Weight
1	Weight	5
2	Durability	3
3	Portable	4
4	Simplicity	2.5
5	Pausing capabilities	3
6	RC controlled	5
7	Safety	4
8	Cost	2

Discussion

1. **Weight**

Weight is one of the major requirements that must be fulfilled. The design should ensure that the laid down regulations on weight have been met. This is crucial since it will facilitate movement of the device while it is in operation. The weight must not exceed 3kg to fulfill the class the team participating in.

2. **Durability**

The device should last for a long period of time to regard it as economically viable. At the same time is should be able to withstand the roughness and toughness associated with the game.

3. **Cost**

The budget for making the sumobot should be pocket friendly and at the same time the team should ensure that the quality of the device is not comprised. In addition, the instructor provided the team with the previous project designs. The team can cut down the cost by using some of the parts in the old designs.

4. **Portable**

The device should be light in weight and this will enable the users to carry it from one position to another with ease. On a similar note the device should have a few assembly procedures so that less time can be taken to prepare it for the competitions.

5. Simplicity

Simplicity is another key requirement which mainly focuses on the need of designing a device which is not complicated but is able to complete its intended task in an effective manner. in this manner a few components and linkages should be used.

6. Pausing capabilities

Sometimes there is need to stop a bit during the game so as to set some rules or to correct an error. In this instance the ability of the device to have a pausing capability is crucial since it will ensure that the device stops when requires and resumes play when needed to do so.

7. RC controlled

The sumobot will be controlled by a remote control since the players are supposed to be far away from the competition field. With a better remote-control system, maneuvers in the field will be easy and this will increase winning chances.

8. Safety

The device should ensure that it does not damage or destroy opponent sumobot. In this regard, it should not have sharp edges or protruding components which may inflict damage on the opponent sumobot. Otherwise, the team is going to be disqualified.

2.2 Engineering Requirements (ERs)

From the customer requirements the team formulated engineering requirements. The engineering requirements are specific and measurable hence making it easy for later analysis and interpretation. When all the engineering requirements are fully met, the device will operate in an efficient manner. The engineering requirements are presented in Table 2 below.

Table 2: Engineering Requirements for RC Sumobot

S No.	Engineering Requirements	Target
1	Maintenance	N/A
2	Remote controlled	N/A
3	Restraint to knockback	N/A
4	Consistency	N/A
5	Safety	N/A
6	Cost efficient	<1000
7	Power source	12V
8	Weight	<3000g
9	Size	20 x 20 cm
10	Motor	N/A
11	Torque	N/A
12	Autonomous	N/A

Discussion

1. **Maintenance**

The maintenance of the device should be easy. Some of the areas which require maintenance are the moving parts such as the wheels and gears. These parts should be lubricated appropriately to ensure that they move with ease. Worn out parts and batteries should be replaced promptly.

2. **Remote controlled**

The device should be controlled with the most appropriate remote control. In this case the effective remote control is the radio remote control since it has a higher sensitivity hence strong penetration ability.

3. **Restraint to knockback**

The device should have a mechanism set in place to ensure that it doesn't knock back during the actual competition.

4. **Consistency**

The device should be able to operate continuously without any signs of failing. In this regard, it should be strong and hence be able to withstand conditions associated with sumo games.

5. **Safety**

The device should be made in such a manner that during operation it does not exceed dangerous capabilities. In case there are hazardous parts they should be modified or be covered with a non-hazardous material.

6. **Cost efficient**

The cost of the device should be minimized such that the amount of money spent on the various components making up the device is within the set budget limit of $500 and $1000. In addition, the team should try to use as much as they can from the previous capstone project designs if possible.

7. **Power source**

The Sumobot should be powered by use of a 12V rechargeable battery. However, the standby time of the battery should be long enough such that it is able to power the device throughout the game.

8. **Weight**

The device should have a maximum weight of 3000 grams. This is crucial since this is a requirement to be able to participate in the competition.

9. **Size**

The device should have a standard size of 20 cm x 20 cm, for the device must be able to fit inside a 20 cm x 20 cm box to be able to participate.

10. **Motor**

The design should make use of a powerful motor to enable the sumobot to push the competitor away from the arena. This is a very important part in the design because the more powerful the motor is the better it can push the opponent.

11. Torque

The design should ensure that it has a great force that will ensure that it is able to rotate about an axis. This is crucial since it will ensure that the sumobot is able to make fast rotational moves and hence push its opponent from the arena just in time.

12. Autonomous

This could be achieved by installing sensors in the design with specific tasks like finding the opponent direction to help controlling the design.

2.4 House of Quality (HoQ)

This section discusses the House of Quality for the RC Sumobot, and its major aim is to determine the most important engineering requirements for this project. The customer requirements are listed on the left and weighted in order of their significance on a scale of 1 to 5. 1 is the least important whereas 5 is the most important. In the table,1 is used to represent a weak correlation, 3 a medium correlation, and 9 a strong correlation of the customer requirements to the engineering requirements. Then the factor of weight is multiplied by the correlation value. The value obtained is then summed up at the bottom so as to obtain the absolute technical importance (ATI). The engineering requirement that will have the largest ATI number will be placed first in Relative Technical Importance (RTI) and the process will continue until the lowest ATI s obtained at last. The House of Quality is presented in table 3 below.

Table 3: House of Quality for the RC Sumobot:

Customer Requirement	**Weight**	**Engineering Requirement**	Maintanance	Remote Controlled	Autonomous	Torque	Constancy	Cost	Minimizing Weigh	size	Power Source	Motor
Weigh	5		1	3	9		3		9	9	3	9
Durability	3		9	3		9	9	3	3	1	3	9
Portable	4		9	1			1	3	9	3	3	3
Simpicity	2.5		9	3	3	3	1	3	3	9	9	3
Pausing Capabilities	3		3	9	1		3		3		3	9
RC Controlled	5		9	9	3	3	3	9	1		3	9
Safety	4		3		3	1	1	3	1	1	9	9
Absolute Technical Importance (ATI)			156.5	107.5	82.5	53.5	76.5	85.5	115.5	86.5	103.5	199.5
Relative Technical Importance (RTI)												
target unit of measurment			no unit	no unit	no unit	N*m	no unit	USD	g	cm	Watt	TBD
Target ER values			N/A	N/A	TBD	TBD	N/A	1000	3000	20*20	TBD	TBD
Tolerances of Ers			N/A	N/A	N/A	± 0.1		<1000	<3000	<20*2	± 0.2	TBD

3 EXISTING DESIGNS

This chapter the details of research of existing designs related to this project have been discussed. The team ensured that it focused on designs which met the various customer requirements. Specifically, the major focus will be on how research was conducted, resources which were utilized used, information found, and analysis which made a comparison between the existing designs at the design at hand. In addition, a functional decomposition including a black box model and a hypothesized functional model has been included.

3.1 Design Research

There are a variety of RC Sumobot designs which have been created ever since the first Sumobot was made. As years pass by customer requirements change and as a result designers and engineers make improvements so as to make the designs fulfill the user's needs. In order to ensure that the team came up with the most appropriate designs they first checked on the already existing designs which had specifications which were almost similar to the client's requirements. They analyzed the designs by focusing on their pros and cons. The already existing designs related to the project were obtained from the internet and are as discussed below.

3.2 System Level

The following section describes existing designs which have requirements which are of relevance to the RC Sumobot design. Three designs which were selected have been discussed by focusing on their pros and cons.

3.2.1 Existing Design #1: Newest Generation Sumobot "Sand Flea"

The Newest Generation Sumobot "Sand Flea" was created by Boston dynamics [2] and is appropriate benchmarking design in relation to the project. Its specifications include: Battery and propane powered; has a weight of 5Kg, a height of 15cm, and 5 joints. It is able to make jumps of up to 10m and 25 bounces per charge. Its major pros are that it is powered by a battery, is safe to use, it is within the required size range of 20x20cm, and is durable. On the other hand, its major cons are that it has exceeded the weight of 3kgs since it weighs 5Kgs.

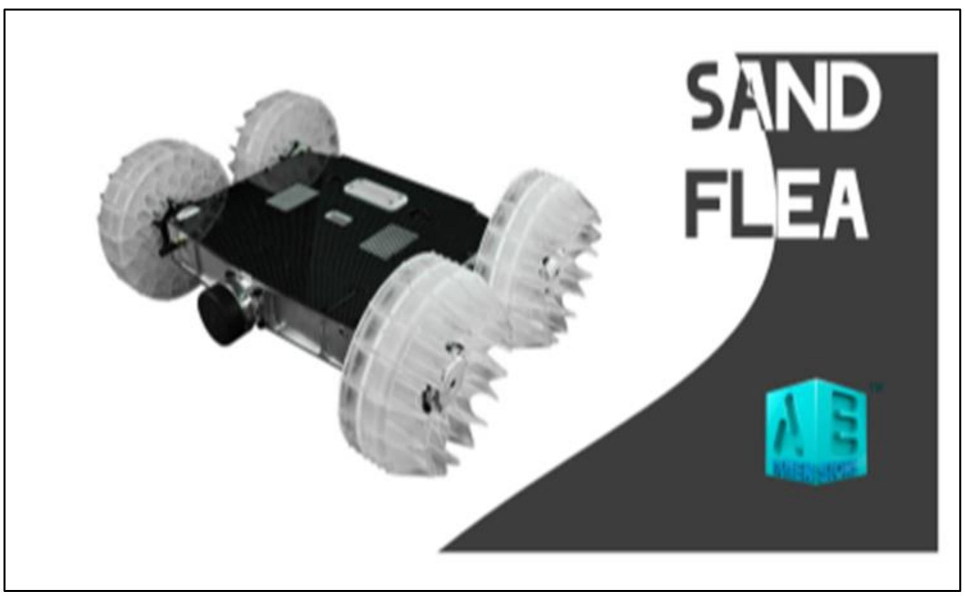


Figure 1: Newest Generation Sumobot "Sand Flea" [2]

3.2.2 Existing Design #2: Bluetooth Powered Sumobot

The Bluetooth Powered Sumobot is a recent technology which enables the users to operate it using Bluetooth. The design has some specifications which are beneficial to our design such as a low cost of 90$. This is because it is made up of a few components which are cheap. Also, the device is light in weight hence can be carried from one point to another with ease [3]. The fact that it is Bluetooth controlled makes it to qualify as a device which is RC controlled.

Figure 2: Bluetooth Powered Sumobot [3]

3.2.3 Existing Design #3: Parallax SumoBot

Parallax SumoBot is manufactured by Trossen Robotics and has specifications which are useful to our design. The sumobot is controlled by use of a remote control, a 4AA power pack and servo motors. In addition, it has 2 module and infrared sensors to detect your opponent and the edge of the Sumo Ring. The device has high levels of safety since it has sensor inputs [4]. The major cons are that the device is made up of numerous components hence making its assembly to be too complicated. The device is not hardy and hence has no guarantee on durability.

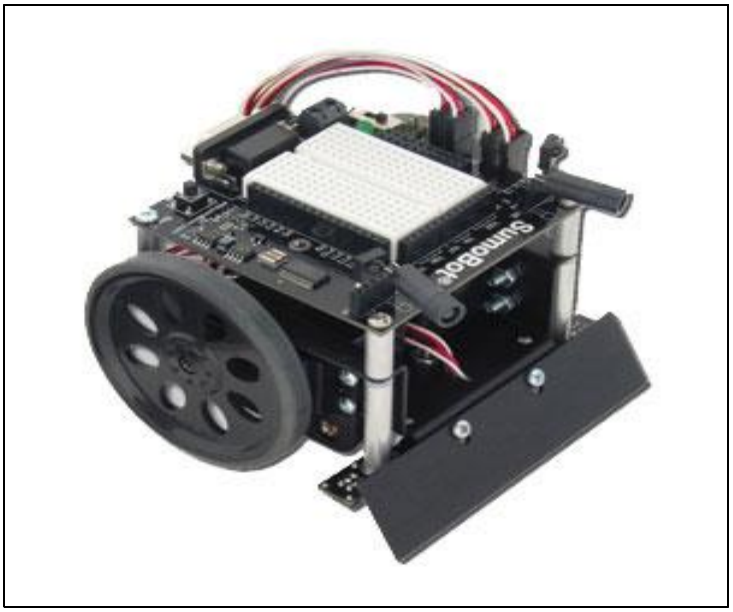


Figure 3: Parallax SumoBot by Trossen Robotics [4]

3.3 Functional Decomposition

In this section, there is a description of the black box model and the functional model. The black box gives a simplified analysis of the functioning of the sumobot in terms of inputs and outputs while the functional model gives details of the various steps which are involved in various components to ensure that the sumobot operates in an efficient manner.

3.3.1 Black Box Model

Black Box model entails a general overview of how the sumobot functions. At the centralized box the general functioning of the device is given. On the left-hand side, inputs were indicated whereas on the right-hand side the outputs were indicated. The thick black line, the thin line and the dotted line represents materials, energy, signals respectively. In this manner, the audience is able to have a rough idea of how the sumobot works.

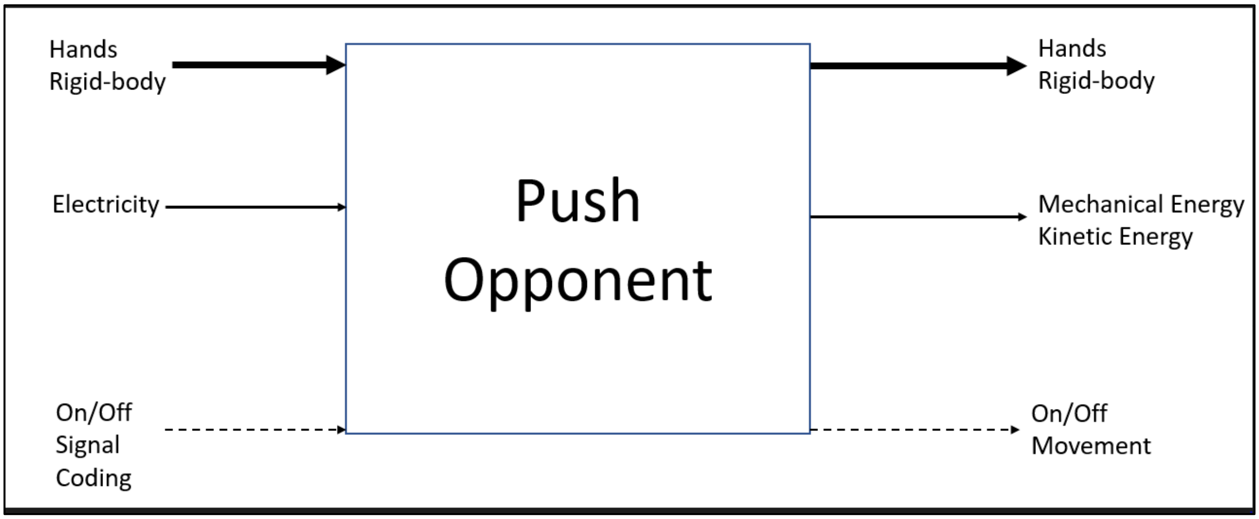


Figure 3: Black Box Model

3.3.2 Functional Model/Work-Process Diagram/Hierarchical Task Analysis

This section gives a description of how the sumobot operates in a detailed manner. in this manner one gets a more detailed understanding of how the device operates. The functional model shows the required inputs and outputs as was initially shown in the black box model to facilitate effective functioning of the device. Detailed presentation of how various forms of energy interact with various components of the sumobot have been shown. In order to operate the sumobot is put on so that can flow through the microcontroller and initiate the motor. The movement of the sumobot is controlled by use of a remote control using human hands. The remote control sends signals to the microcontroller which in turn initiate the motor which makes the wheels rotate thus moving the device. The functional model is presented in the figure below.

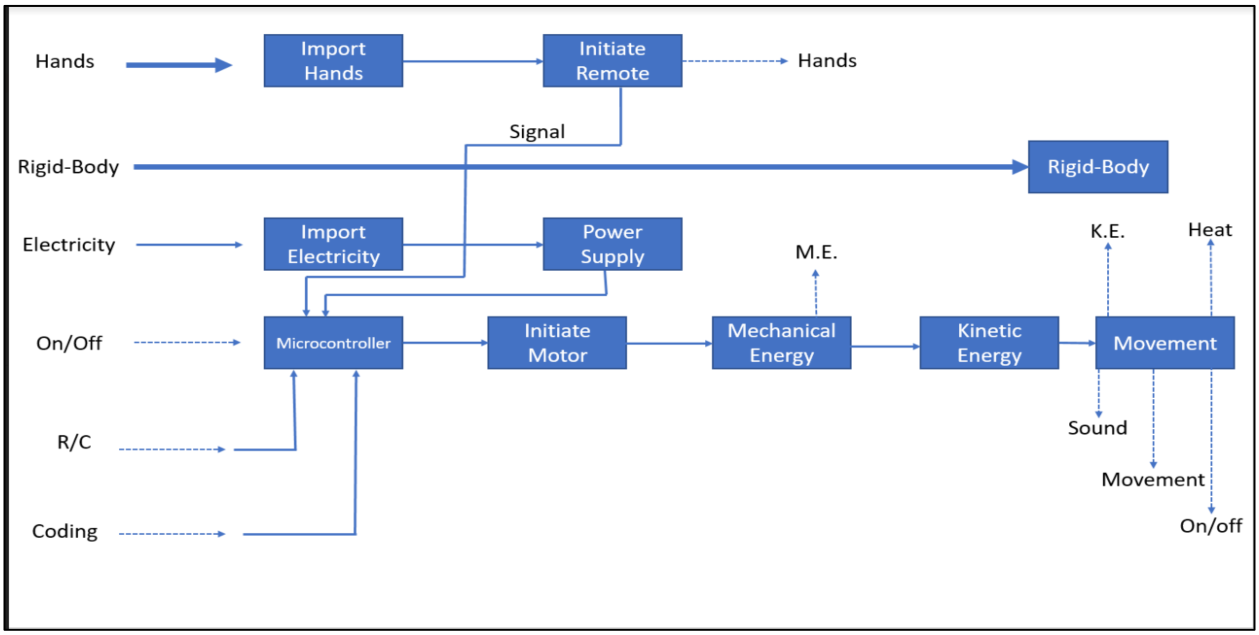


Figure 4: Functional Model

3.4 *Subsystem Level*

The main function of this project is to create an RC sumobot that capable of participating in the sumobot competition that include two R/C bots to compete against each other to win the battle. In order to power the sumobot it must have a battery which is placed in a certain compartment. The motors facilitate movement of the robot by use of wheels fixed on the sides. The movements of the sumobot are controlled by use of a remote control. The content of the section below will be discussing the existing designs for (1) motors, (2) batteries, and (3) remote control system.

3.4.1 Subsystem #1: Motor

Motors are crucial in the sumobots since they facilitate effectiveness in movements within the device. Motors in the device also helps in improving the quality use as the sumobot is able to move freely while being operated.

3.4.1.1 Existing Design #1: Brushed Maxon DC Motors

Brushed Maxon DC motors are high-quality DC motors and are comprised of powerful permanent magnets. The motor is made using the ironless rotor cutting-edge technology which ensure that the motor has powerful drives and low inertia. In addition, it has a high rate of acceleration [5].

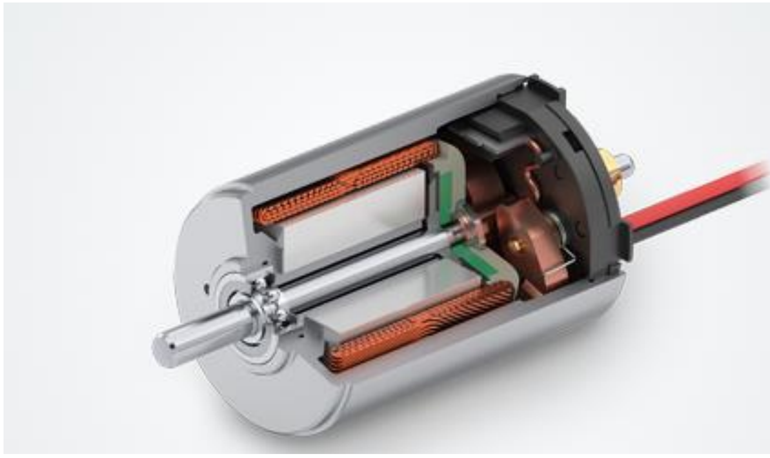


Figure 5: Brushed Maxon DC Motors [5]

3.4.1.2 Existing Design #2: Brushless Maxon DC Motors

Brushless Maxon DC Motor is electronically commutated and is characterized by excellent torque characteristics, a wide range of speed, high power, and an outstandingly long-life span. Its exceptional controllability makes high-precision positioning of drives possible [5].

Figure 6: Brushless Maxon DC Motors [5]

3.4.1.3 Existing Design #3: Robot DC Gearhead Motor - 6v 180rpm w/ Encoder

The motor is characterized by an operating voltage of 6-8.4v; a gear ration of 4:1; a rated load speed of 163RPM+/- 10%; a rated current of 3A and stall current of 6A. in addition it has an encoder output resolution of 520 ticks/ revolution and encoder voltage of 5v [6].

Figure 7: Robot DC Gearhead Motor - 6v 180rpm w/ Encoder [6]

3.4.2 Subsystem #2: Batteries

Batteries are very crucial in sumobot device since they provide energy that is needed to power the device. There are a number of existing battery designs such as Li-Ion—lithium-ion battery; Li-Poly—lithium polymer batteries and NiMH—nickel–metal hydride battery which are as discussed below.

3.4.2.1 Existing Design #1: Li-Ion—lithium-ion battery

The specifications of this battery are as follows. A nominal cell voltage of 3.7-3.8V; an operating cell voltage of 3.0-4.2V; a maximum charging voltage of 4.1-4.2V; a maximum charging current of 3C; maximum discharging current of 5C-30C; specific energy of 100-150Wh/kg and specific power of 400-5000W/kg [7].

Figure 8: Li-Ion—lithium-ion battery [7]

3.4.2.2 Existing Design #2: Li-Poly—lithium polymer battery

The specifications of this battery are as follows. A nominal cell voltage of 3.6-3.7V; an operating cell voltage of 3.0-4.2V; a maximum charging voltage of 4.2- 4.3V; a maximum charging current of 1C; maximum discharging current of 1C-2C; specific energy of 150-250Wh/kg and specific power of 100-400W/kg [7].

Figure 9: Li-Poly—lithium polymer battery [7]

3.4.2.3 Existing Design #3: NiMH—nickel–metal hydride battery

The specifications of this battery are as follows. A nominal cell voltage of 1.2V; an operating cell voltage of 1.0-1.4V; a maximum charging voltage of 1.4-1.6V; a maximum charging current of 0.1C; maximum discharging current of 1C-30C; specific energy of 40-120Wh/kg and specific power of 100-1000W/kg [6].

Figure 10: NiMH—nickel–metal hydride battery [7]

3.4.3 Subsystem #3: Remote Control (R/C)

A remote-control system is crucial in the sumobot as it facilitates easy control by the operator when they are at a distance. The remote-control systems discussed include voice remote control, infra-red remote control and radio remote control.

3.4.3.1 Existing Design #1: Ultrasonic remote control

This remote-control system makes use of voice control. It is complicated and only requires a light tap, a whistle or a voice input [7].

Figure 11: Ultrasonic remote control [8]

3.4.3.2 Existing Design #2: Infrared remote control

Infrared remote control makes use of light in order to operate a device. It also requires a line of sight to operate the device and hence there is need to aim to the direction of receiver. However, it is cheap and easy to encode with a multi-function remote control [8].

Figure 12: Infrared remote control [8]

3.4.3.3 Existing Design #3: Radio remote control

Radio remote control is used to control distant objects by use of radio signals which are transmitted using the remote-control device. This kind of remote control has a complex circuit; is expensive but has the best performance since it has farthest control distance and strong penetration ability [8].

Figure 13: Radio remote control [8]

4 DESIGNS CONSIDERED

The team generated a total of 10 different designs during the brainstorming process based on the various customer and engineering requirements. The designs considered are as discussed below.

4.1 Design #1: Pyramid design

This design resembles a pyramid. Its pros are that it has less weak points and moves in every direction. Its cons are that it has weak axels and complicated coding.

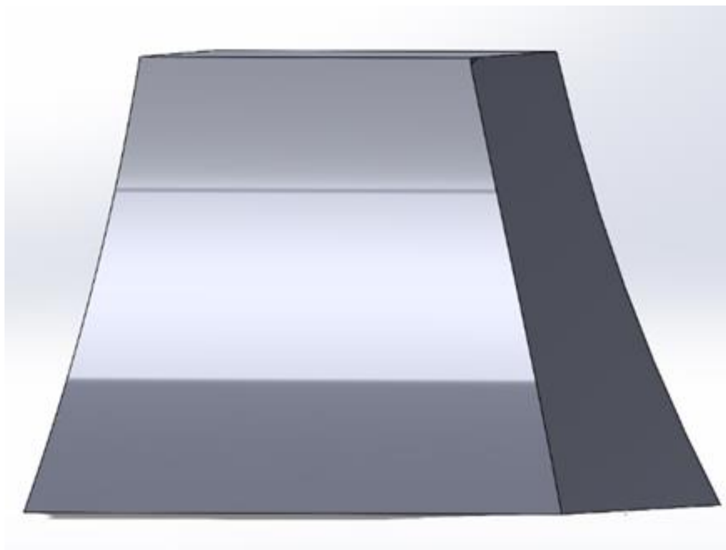


Figure 14: Pyramid design

4.2 Design #2: Tank bot

This design resembles a military tank. Its pros are that it has a large contact area hence a high grip and has defenses capabilities. Its major cons are that it has a high weight hence hard to control and has slow movement.

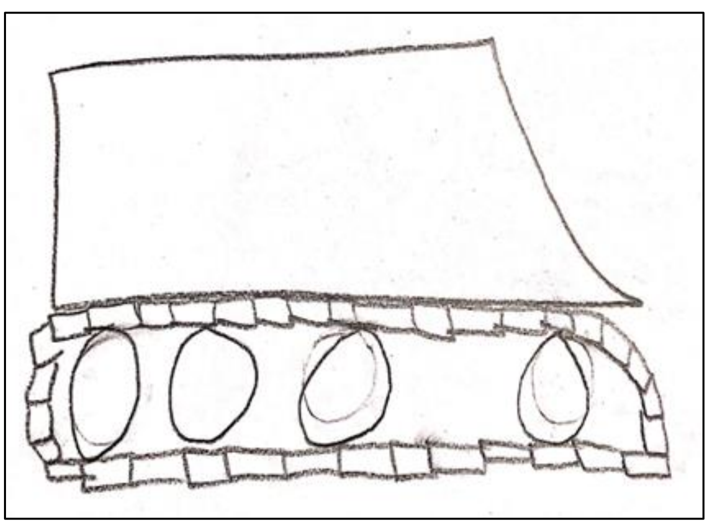


Figure 15: Tank bot

4.3 Design #3: Gripper

This design is made in such a manner that it has a magnetic field which results into a firm grip. Its major pros are a strong magnetic field and anti-flip tires. Its major cons are that it has tires which can break easily and an opponent sumobot may not fit.

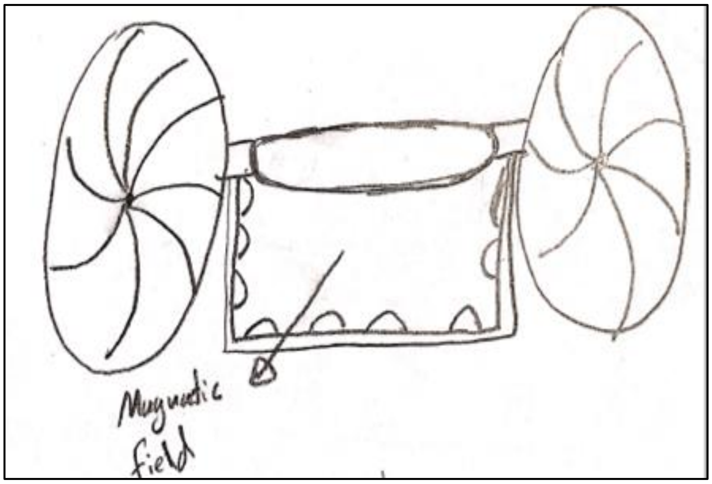


Figure 16: Gripper

4.4 Design #3: Seoi Nage

The design is comprised of rear and front protrusions for attacking the enemy bot. The components are controlled by use of hydraulic springs. Its major pros are that it has a rear stick which acts as a stabilizer. Its major con is that the hydraulic springs may not handle opponent sumobot weight.

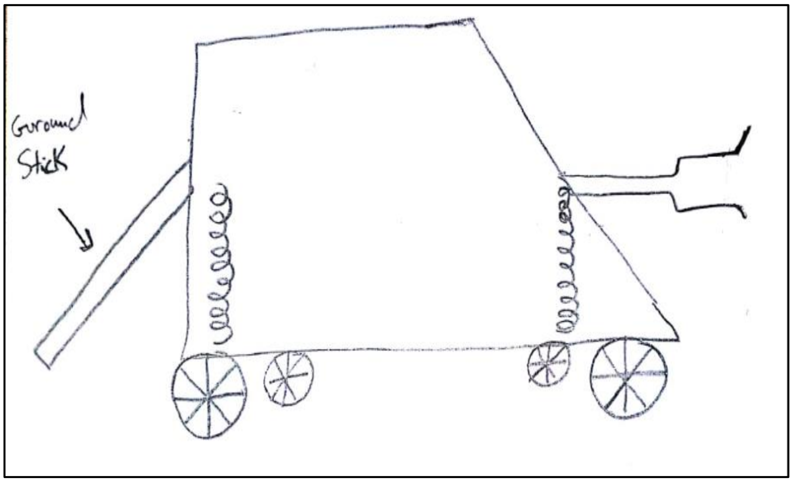


Figure 17: Seoi Nage

Other designs which were considered are presented in Appendix A.

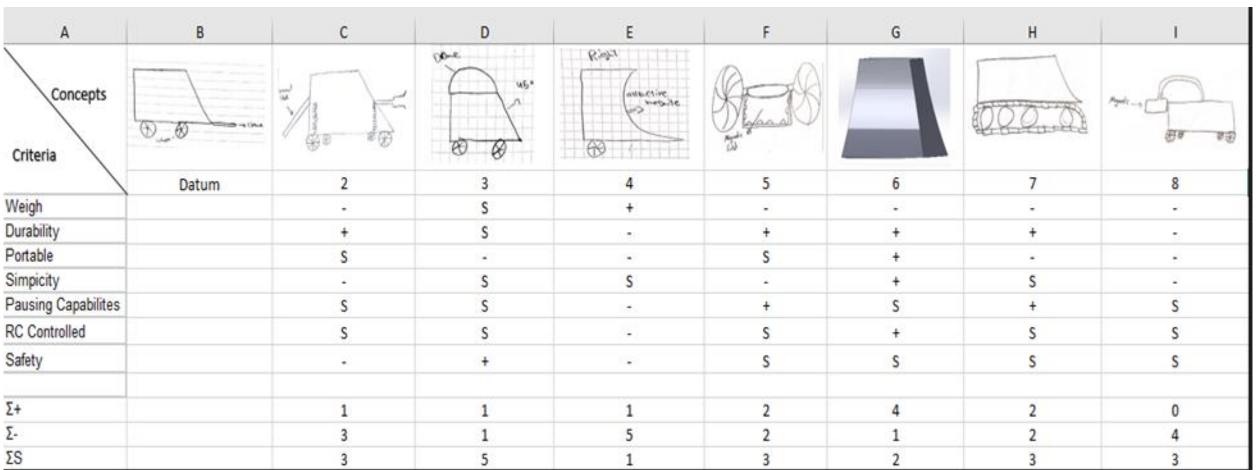
5 DESIGN SELECTED

This chapter gives description of a design that was selected for this project and the process used to select it.

5.1 Rationale for Design Selection

The two processes which were administered in the design selection include Pugh Chart and Decision Matrix. The Pugh Cart enabled narrowing down of used first to narrow the number of designs down to four. Then from the four designs a selection was done so as to get the design which meets most of the customer requirements.

On using the Pugh Chart sets one design was set as a datum for meeting the customer needs. It was in this manner used to rate the other designs. The design which surpassed the datum in a customer requirement was given a plus (+) but if it didn't, it was awarded a minus (–). In case the requirements were at the same level an "S" was given. Eventually a summation of the pluses, minuses and "S" was done below each design. The four designs with the highest number of pluses were considered to be the best design were selected for further analysis using the Decision Matrix. The Pugh chart which was used is represented in the figure below.



A	B	C	D	E	F	G	H	I
Concepts / Criteria	Datum	2	3	4	5	6	7	8
Weigh		-	S	+	-	-	-	-
Durability		+	S	-	+	+	+	-
Portable		S	-	-	S	+	-	-
Simpicity		-	S	S	-	+	S	-
Pausing Capabilites		S	S	-	+	S	+	S
RC Controlled		S	S	-	S	+	S	S
Safety		-	+	-	S	S	S	S
Σ+		1	1	1	2	4	2	0
Σ-		3	1	5	2	1	2	4
ΣS		3	5	1	3	2	3	3

Figure 18: Pugh Chart

The four designs which were selected from the Pugh Chart to be analyzed using the Decision Matrix include pyramid design, tank bot design, dome design and umbrella design. The customer requirements are listed on the left and weighted in terms of importance on a scale of 1 to 5. 1 is the least important while 5 was the most important. Then each of the four designs were rated on a scale of 1 to 5, whereby 1 was the design which least fulfilled customer requirements and five the design which completely fulfilled the customer requirements. The rating was then multiplied by the weighting on the customer requirement and added together to get the total score. This is shown in the table 4 below.

Table 4: Decision Matrix

Criteria	**Weight**	**Design 1 Tank bot**		**Design 2 Pyramid**		**Design 3 Dome**		**Design 4 Shovel**	
		Score	**WS**	**Score**	**WS**	**Score**	**WS**	**Score**	**WS**
Weight	5	2	**10**	5	**25**	3	**15**	4	**20**
Durability	4	4	**16**	4	**16**	3	**12**	2	**8**
Safety	3	3	**9**	3	**9**	4	**12**	3	**9**
Simplicity	2	1	**2**	4	**8**	3	**6**	4	**8**
Cost	1	2	**2**	4	**4**	3	**3**	3	**3**
Total			**39**		**62**		**48**		**48**

Design 2 i.e. the pyramid design had the highest score of 62 in the decision matrix and hence was selected to have met most of the customer and engineering requirements.

6 REFERENCES

[1] Robogames.net. (2018). *Unified Sumo Robot Rules*. [online] Available at: http://robogames.net/rules/all-sumo.php [Accessed 15 Oct. 2018].

[2] AE Dimensions Pvt Ltd. (2017). *'SAND FLEA' THE JUMPING ROBOT - AE Dimensions Pvt Ltd*. [online] Available at: http://blog.aedimensions.com/sand-flea-the-jumping-robot/ [Accessed 15 Sep. 2018].

[3] Scribd. (2017). *Voice Activated Arduino (Bluetooth + Android) - All | Arduino | Google Play*. [online] Available at: https://pt.scribd.com/document/367601734/Voice-Activated-Arduino-Bluetooth-Android-All [Accessed 15 Sep. 2018].

[4] Robot, S. (2018). *SumoBot Robot*. [online] Trossenrobotics.com. Available at: https://www.trossenrobotics.com/parallax-sumobot-robot.aspx [Accessed 15 Oct. 2018].

[5] Maxonmotor.com. (2018). *DC motors and drive systems by maxon motor*. [online] Available at: https://www.maxonmotor.com/maxon/view/content/index [Accessed 15 Oct. 2018].

[6] Encoder, R. (2018). *Robot DC Gearhead Motor - 6v 180rpm w/ Encoder*. [online] Trossenrobotics.com. Available at: https://www.trossenrobotics.com/p/Robot-DC-Gearhead-Motor-6v180rpm.aspx [Accessed 15 Oct. 2018].

[7] Jarema, R. (2018). *Batteries — choose the right power source for your robot*. [online] Medium. Available at: https://medium.com/husarion-blog/batteries-choose-the-right-power-source-for-your-robot-5417a3ec19ca [Accessed 15 Oct. 2018].

[8] Windsor, S. (2018). *3 main types of remote control and their applications | GearBest Blog*. [online] GearBest. Available at: https://www.gearbest.com/blog/how-to/3-main-types-of-remote-control-and-their-applications-2769 [Accessed 28 Jun. 2018].

[9] Nau.edu. (2018). *Print Logos - School of Forestry - Northern Arizona University*. [online] Available at: https://www.nau.edu/CEFNS/Forestry/Student-Resources/Information-Technology/Print-Logos/ [Accessed 16 Oct. 2018].

7 APPENDICES

7.1 Appendix A: Designs considered

Trapezoid design

This design resembles a trapezoid. Its major pros are that it has a strong wheel base, and a crane in the front to lift the opponent to make it easier to push them outside the ring. However, the cons were that the crane could be useless since most sumobots were very low in the front and made it hard to utilize the crane.

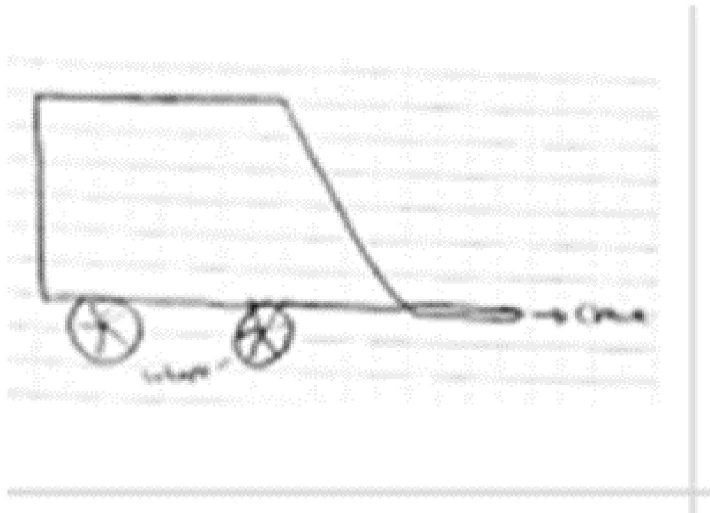


Figure 19: Trapezoid design

Dome design

This design mimics a dome on its upper part. On the lower section it is wide to facilitate stability. Its pros are that it is has higher levels of safety, durable, and its unflippable. Its cons are that it is hard to create it within the weight limit. In addition, the team found out its not allowed to flip the opponents which makes this design impractical which makes the team avoid thinking about how to counter getting flipped.

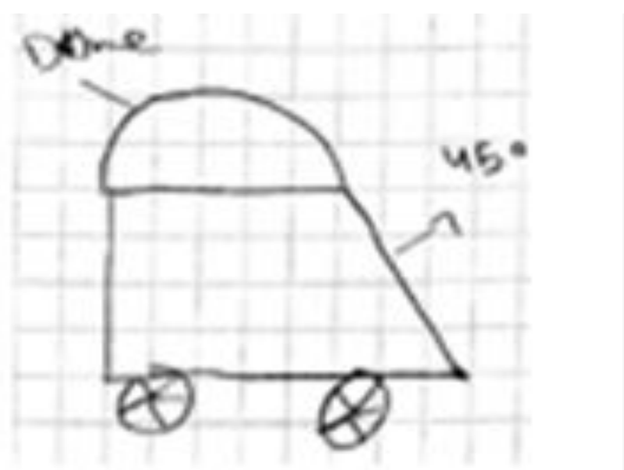


Figure 20: Dome design

Crescent design

This design resembles the crescents moon on one side where there is a magnetic attraction. The design has several pros including having sharp and very low blade to be able to lift the opponent easily. In addition, it has a magnetic field in the body to hold the opponent after lifting them. On the other hand, its cons were having lower than average defensive capabilities since it’s hard to get enough weight with this design.

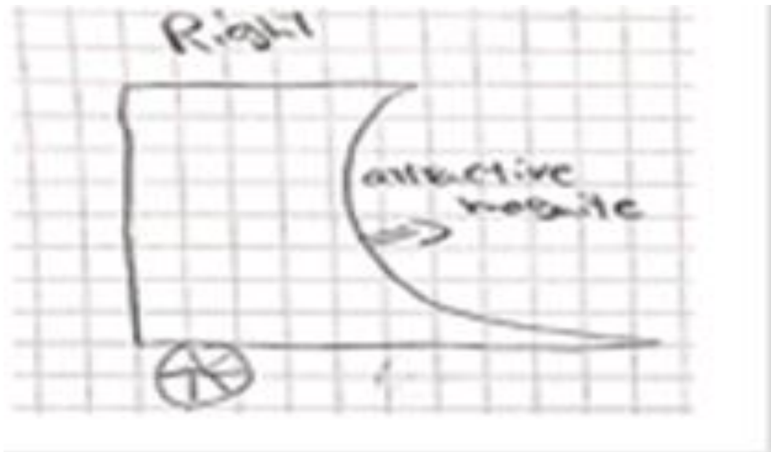


Figure 21: Crescent design

Cuboid design

This design is composed of a cuboid with four wheels. While the upper part has a curved arm, which has a magnetic edge. The pros associate with the device is that it has a high level of stability. However, the cons were that it was hard to fit this design in the required size. Moreover, it was hard to find a strong enough magnet to be able to lift the opponents from above.

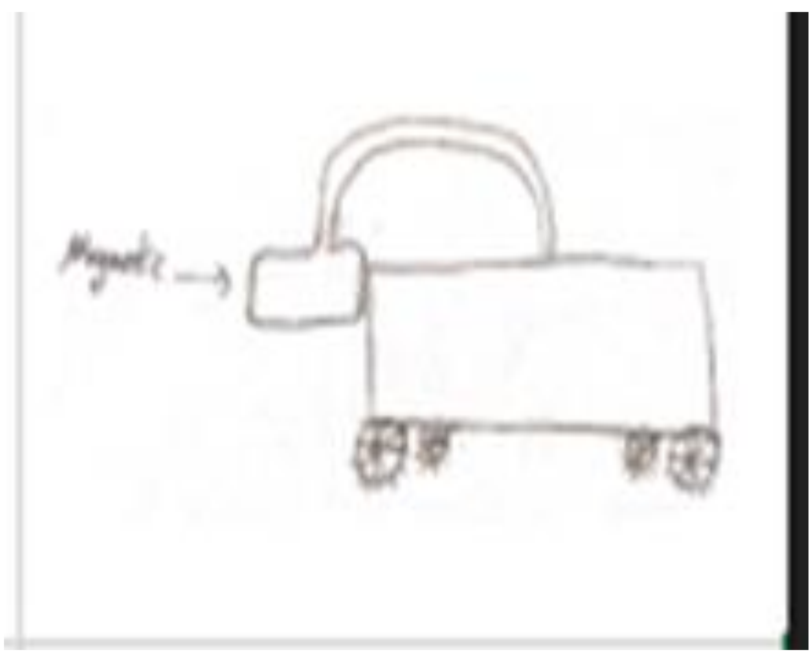


Figure 22: Cuboid design

Shovel design

The major pros in this design that it has two stances which were from utilizing the shovel shape. For attacking the shovel will lean forward and act as the design blade to push the opponent. In addition, the shovel is also used in a defensive way as the shovel will lean back to act as a drag mechanism to make it hard for the opponent to push the design. The cons for this design were begin light weight and having only two wheels which makes it unstable.

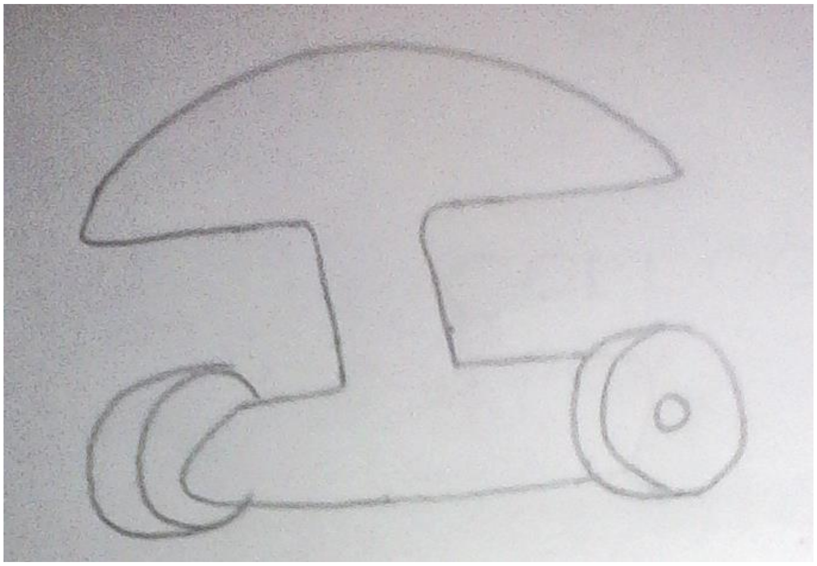


Figure 22: Shovel design

Scissors design

This design utilizes a unique mechanism to counter being lifted. The front blades will be able to move sideways as a defensive technique which helps getting recovered after getting lifted from the opponent. However, the cons of this design is the weight limit in the competition since the design will get a lot of weight to accomplish this idea.

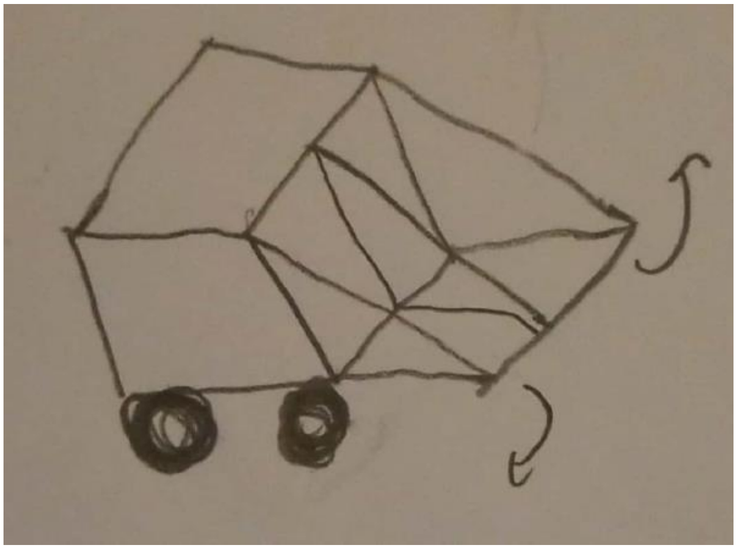


Figure 22: Scissors design