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Design Improvement Study on a Mobile Rugby Ball Launcher Robot for Indoor Training Purpose

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Abstract: As the current design of MR Launcher, it was lack of storage mechanism which is not capable of sparing balls inside it.The lack of storage is affecting the time dilation in order to pick and pass the ball. Other than that, based on the existing rugby ball launcher there are no specific storage mechanism that are built in them. Due to the oval-shaped ball, it is difficult to design a structure of the storage and identified the appropriate mechanism improvement needed. Thus, this project propose design for the storage mechanism in MR Launcher which combined with an automatic ball feeder mechanism with high accuracy and precise as to reduce time dilation of the process control. Storage mechanism comes with less complex and low production cost design in its mechanical and electrical components. The methods used to construct a body frame of the storage mechanism includes process of cutting, welding, punching and drilling, and finishing. Besides, There were parts that manufactured by using 3D printing process. A simple sequences were constructed for Arduino UNO in Arduino 1.0.6 Software (IDE) as to control the operational flow of the MR Launcher integrated with storage mechanism. The overall data for this project was collected in terms of shooting parameter, and mobility of the robot. The shooting performances were blended with passed and failed result due to sensor limitation. However, the second test was perfectly done according to the multi-directional movement test necessity. Finally, the enhanced storage mechanism was manifested as the product upgrade instead of downgrade compared to the previous MR Launcher that using gripper mechanism in terms shooting and mobility parameter.

Keywords: Mobile Launcher Robot, Launching Ball Machine, Storage Mechanism, Automation System

1. Introduction

Rugby Sport was introduced as professional by International Rugby Board (IRB) in August 1995 [1]. This sport quite similar to American Football which is played with an oval-shaped ball on a

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rectangular filed but in different attire and rules. Behind a Rugby Sport game, there are many elite players that have an ability and insane capability of throwing, kicking, and grabbing with a vary ways and skills [2]. In order to have an extra-ordinary skill in this sport game, lot of training must be done by the players. In that case, with the help of sport engineers they have planned and designed the Rugby Ball Launcher machine as to use in training session [3].

A training device for rugby sports invention provides an apparatus and method for throwing football shaped balls that may be presented to a player or groups of players in need of rapid repetition in individual and team drills that are difficult to manually replicate repeatedly [4]. The apparatus and system for pitching balls includes a support for a ball throwing head, two opposing variable speed motor powered wheels that can be tilted in relation to each other to control spin and distance, a slide configured to present the ball into the wheels at different angles to provide right or left-handed spirals and end-over-end pitches.

According to previous project, Mobile Rugby Launcher Robot (MR Launcher) were designed for a primary school kid as a first introduction to a rugby sport game. The design of the MR Launcher is for indoor training purposes which is based on launcher concept and with a forklift arm as gripper mechanism. MR Launcher spent 1 to 1.5 minutes to complete the operation to load and pass the balls. The uniqueness of the robot is designed fully electrical power without using any hydraulic and pneumatic in all mechanism. The possible real-world applications of this robot are able to apply in any condition which related to rugby or ball-kicking event.

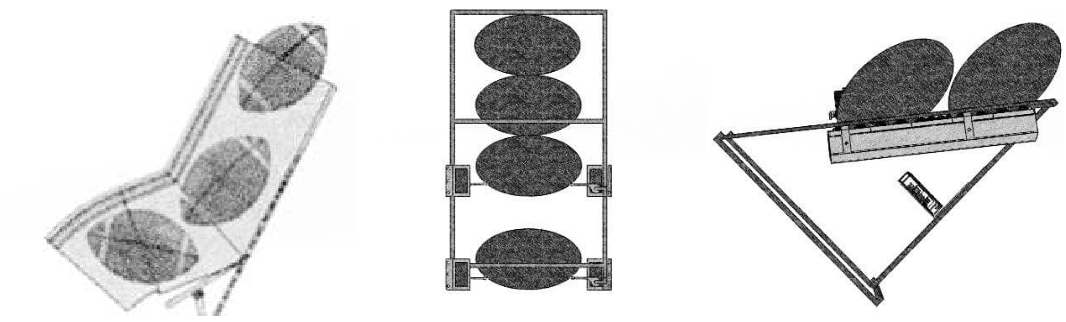
MR Launcher designed as a mobile robot structure with mecanum wheels that allowed it to move around in 8 different directions. As to work on it, MR Launcher can be controlled by a Radio Frequency (RF) remote control which is connected to the motor driver that has been installed in MR Launcher. As the result of previous project, it managed to achieves the previous aim of the project which is can help the coaches to deliver the rugby ball accurately and consistently to the players according to the targeted training intensity.

As the current design of MR Launcher, it was lack of storage mechanism which is not capable of sparing balls inside it. The lack of storage is affecting the time dilation in order to pick and pass the ball. Other than that, based on the existing rugby ball launcher there are no specific storage mechanism that are built in them. Due to the oval-shaped ball, it is difficult to design a structure of the storage and identified the appropriate mechanism improvement needed. Thus, this project propose design for the storage mechanism in MR Launcher which combined with an automatic ball feeder mechanism with high accuracy and precise as to reduce time dilation of the process control.

2. Materials and Methods

2.1 Design Variations

The In this study, the design concept of the storage mechanism focused more on principle of the gravitational force as it was a major concept of the design. There were 3 different designs have been proposed in order to make a better selection.



(a) (b) (c)

Figure 1: 3 sketches of design variations: (a) Design 1, (b) Design 2, and (c) Design 3

2.2 Materials Selection

Table 1: Design selection comparison

No.	Criteria	Design 1	Design 2	Design 3
1	Material	Aluminium	ABS (Acrylonitrile Butadiene Styrene)	Stainless Steel Hollow
2	Body Structure	Inclined	Vertical	Inclined
3	Approximate Weight (kg)	10.0 kg	2.5 kg	3.0 kg
4	Capacity	3 balls	4 balls	2 balls
5	Complexity	High	Medium	Low
6	Driving Mechanism	-	-	Roller
7	Driver System	Pneumatic	Servo Motor (Hi-Tech, HS-805 MG)	Servo Motor (Hi-Tech, HS-805 MG)
8	Power Supply	Battery Lipo (7.4 V, 1100 mAh)	Battery Lipo (7.4 V, 1100 mAh)	Battery Lipo (7.4 V, 1100 mAh)
9	Sensor	Analog Distance	Analog Distance	Analog Distance
10	Control System	Remote Controller	Arduino UNO	Arduino UNO
11	Cost Estimation	RM 896.90	RM 1435.50	RM 535.00

As the final design of the storage mechanism, Design 3 as shown in Table 1 has been selected as it complemented to the specification requirements and the workflow of the process. The material used as the framework was square hollow stainless steel which has a lightweight and higher strength compared to ABS, material used in 3D printer. The inclined posture allowed the gravity to pull the ball towards the launch room. Plus, with supported by roller mechanism, it reduced the friction of the moving ball. The idea of roller mechanism was created from a concept of the conveyer however, it much better to applied on storage mechanism in terms of saving power energy, lightweight, low complexity built, and least cost effective.

2.3 Procedure of Fabricating and Manufacturing.

Fabrication is the process of making items by putting together diverse, generally regulated elements. Manufacturing, on the other hand, is the process of converting raw materials into completed things on a small or big scale. The most important contrast between fabrication and manufacturing is this [5]. Both operations began with the preparation of materials.

There were several suggested materials to choose from and each of them with their own set of pros and cons. Some materials are more suited towards the work than others, depending on the specific aims for the model or component production. Both choices of material and its preparation can have a large impact on the quality of the model produced. In fabricating and manufacturing, there were two parts that applied these methods to finalize the product. The material used basically took from the recycled material and some of them was bought from e-shopping such as Shopee, Lazada, and Amazon in order to have a good quality and long-lasting product.

i. Body Frame

To construct a body frame of the storage mechanism, several methods of metal fabrication process were applied. The methods include;

a. Cutting Process
b. Welding Process
c. Punching and Drilling Process
d. Finishing Process.

(a) (b) (c) (d)

Figure 2: Methods applied in fabricating process; (a) Cutting process using handsaw; (b) Welding process; (c) Post drilling process; (d) Covering holes using rapid steel epoxy

ii. Servo Motor Housing and Ball Stopper

The specification design for servo housing and ball stopper was intensely inflexible to the market production due to the complexity and sizing of the required design. In that case, customized design was created. 3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file [6] Thus, an invented design in the Solidwork used to convert into Ultimaker Cura, which is 3D printing software. An item was built using an additive process by putting down consecutive layers of material until the product was complete. Each of these levels is a finely cut cross-section of the item.

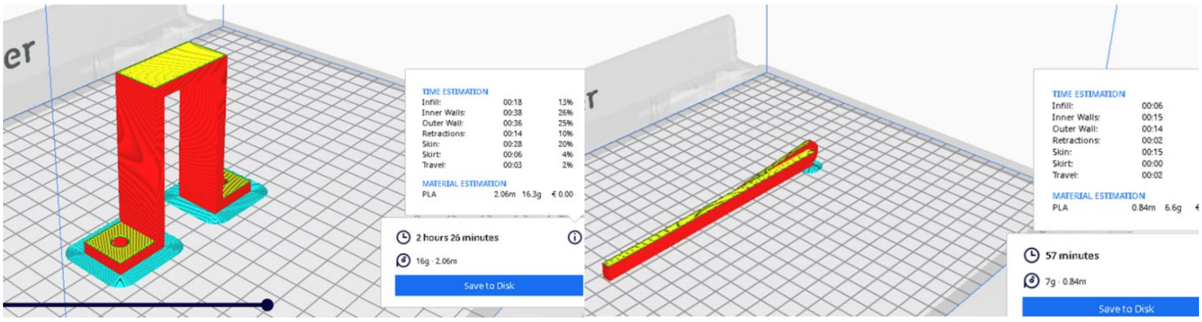


Figure 3: Servo Housing and Ball Stopper reviewed in Ultimaker Cura during process

Based on the figures showed, the time taken of the process making 3D printer for both of them were extremely divergent as the servo housing took 2 hours 26 minutes to produce while the ball stopper took 57 minutes only.

2.4 Final assembly of the storage mechanism

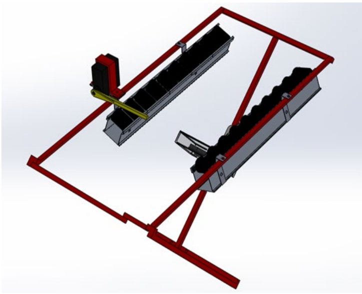


Figure 4: Storage mechanism review in Solidwork software

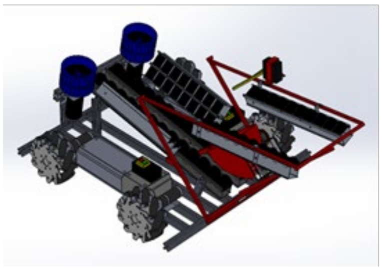


Figure 5: MR Launcher integrated with storage mechanism

2.5 Testing Method

i. Shooting Test

MR Launcher was designed with an inclined posture of the launch room along with launching wheels. The angle of the launching wheels was built as an invariable, however the shooting distance can be adjusted through the rpm of the launching wheels. The trajectory function transformed the motor angular speed to a ball velocity and spin. The shooting test basically conducted to perform a few shootings from marked point to the target. It required at least 2 participants to begin the test.

The procedure of the test started by moved the MR launcher to the marked point. User set the maximum rate of the launching wheels to perform 3 shots as the storage fit up to 3 balls.

Each of the speed came up with 3 attempts of shot. The shots required to perform with 3 different rpm of the launching wheels which were 800 rpm, 1000 rpm, and 1200 rpm. With the help of the catcher, the distance parameter also was set in 3 different range. The test was considered as pass as the sensor succeed to detect the motion of the ball after shooting process.

ii. Multi-directional Movement Test

MR Launcher was designed with mobile structure which implemented with mecanum wheels that can moved in 8 different trajectories. Related to the structure built, testing method used was multi-directional test. The objective of the test was to make sure that MR Launcher can be moved to each trajectory instructed by the user.

The procedure began with MR Launcher was brought to an open space as to meet the safety precaution for the testing field and the floor type was mosaic tile concerned to the wheel limitations and safety. The wheels were checked one by one since they have been mounted to the DC motor for each of them. Once the checked finished, user started to control MR Launcher to the required trajectory per instruction given.

3. Results and Discussion

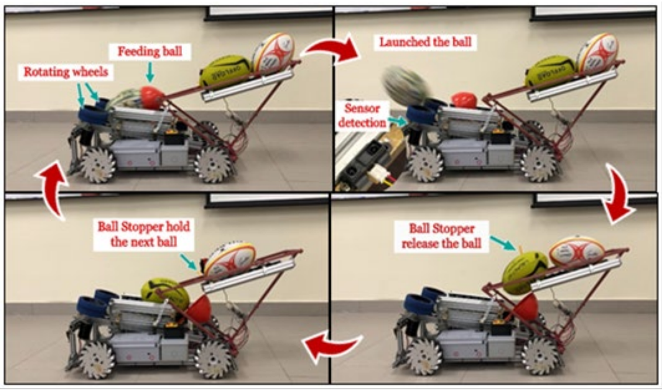


Figure 6: Actual working steps of the MR Launcher

Table 2: Data collected for Shooting Test

No.	Motor Speed (rpm)	Distance (m)	Attempt 1	Attempt 2	Attempt 3
1	800	1			
2	1000	3			
3	1200	6			

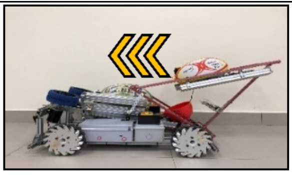
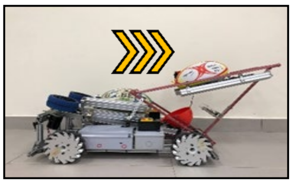
Pass

Fail

As the result table 2 showed above, there have two colors which are green and red, green means the attempt passed while red means the attempt was failed. Based on the result showed, with 800 rpm and 1000 rpm of the motor speed, all the shots were successfully made by the user, however shots made by 1200 rpm of the motor speed was failed three out of three shots. It was because the higher rpm of motor speed, the longer distance of the shot made. Due to high displacement created, the distance of the projectile of the ball between the sensors increased. Therefore, the sensor does not detect any motion from the ball and it were considered as a failed attempts. The figure below showed the projectile of the ball during the test.

Table 3: Data collected for Multi-Directional Movement Test

No	**Direction**	**Visualization**	**Pass (√) / Failed (X)**
1	Forward		

			√
2	Backward		√
3	Right		√
4	Left		√
5	Forward-right		√
6	Forward-left		√
7	Backward -right		√

			
8	Backward-left		√

Based on the result in table 3, MR Launcher passed the test which able to move in 8 different trajectories without any obstacles. Through the test result, it was proved that an invented of the storage improvement does not affecting the ability of MR Launcher to be moved in multi-directional movement. The stability of MR Launcher has been observed as a stabilized structure however, the structure of the storage room still has a trembled issue when making a move especially a sudden change in direction. Overall, it was stabled enough to kept the ball from falling out of the storage room since the design of the storage mechanism was compatible to the current body of MR Launcher.

4. Conclusion

The project was conducted by designing an improvement of the storage mechanism as to upgrade the ability of the MR Launcher to accommodate more rugby balls. By developing the Arduino UNO and analog distance sensor, the sequences of the storage mechanism were completely achieved as the essential of the project aim. All the materials and component used were simply met the criteria needed. From early production process was finely conducted until to the finishing process. The overall data for this project was collected in terms of shooting parameter, and mobility of the robot. The shooting performances were blended with passed and failed result due to sensor limitation. However, the second test was perfectly done according to the test necessity. Finally, the enhanced storage mechanism was manifested as the product upgrade instead of downgrade compared to the previous MR Launcher that using gripper mechanism in terms shooting and mobility parameter.

For further improvement to MR launcher, the recommendations were suggested as to increase the capacity of the storage room, according to the current design of storage mechanism can only fit up by 2 balls. Besides, Increase the stability of the structure. MR launcher can be more stable by upgrading the component used to attach the storage mechanism to MR Launcher. In addition, test the function and ability of the MR Launcher in real training session with actual player.

Acknowledgement

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