DESIGN DETAILS DOCUMENT
ROBOCON INDIA, 2021
AKGEC, GHAZIABAD

1.Defensive Robot (DR)

1.1. Overall Dimensions $(L \times B \times H)$ **:**

Initial: $(600mm \times 600mm \times 600mm)$

Extended: $(920mm \times 600mm \times 800mm)$

Estimated weight (in kg): $11.5Kg(approx.)$

Material used : Aluminium 6061, plastic, mild steel, stainless steel AISI304

1.2. Type of Drive: Four wheel Holonomic Omni-wheel Drive.

Four wheeled drive is selected because of its precise control and rich manoeuvrability. The drive is semi-autonomous**.**The manual mode of this drive will be controlled wirelessly via PS2/PS4 controller.

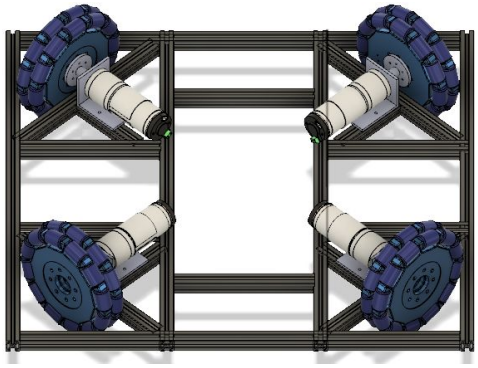

Fig - 1

The wheels used are of diameter 150mm. With this motor and wheel combination the robot achieves an acceleration of 2.3m/s^2 .

1.3. Actuators and Sensors:

The defensive robot is equipped with

- Two types of **Planetary DC geared motors** of 18V (750rpm, torque:3.83N-m) and 12V (350rpm, torque:0.29N-m), which are well suited for applications requiring higher torque.
- **Rotary Encoders** are used to sense angular orientation of the arm and desired angle of propagation during passing phase.
- **Servo motor** (rated:4.8V-6.6V, stalled torque 12kg-cm) is used to rotate arrows at precise angle**.**
- **Ultrasonic sensors** (HC-SR04) and **Gyroscope sensor** (MPU6050) is used with ultrasonic sensor for sensor fusion algorithm for performing state estimation.
- **Camera** is used in the perception stack for analyzing the motion and attitude of the arrow.

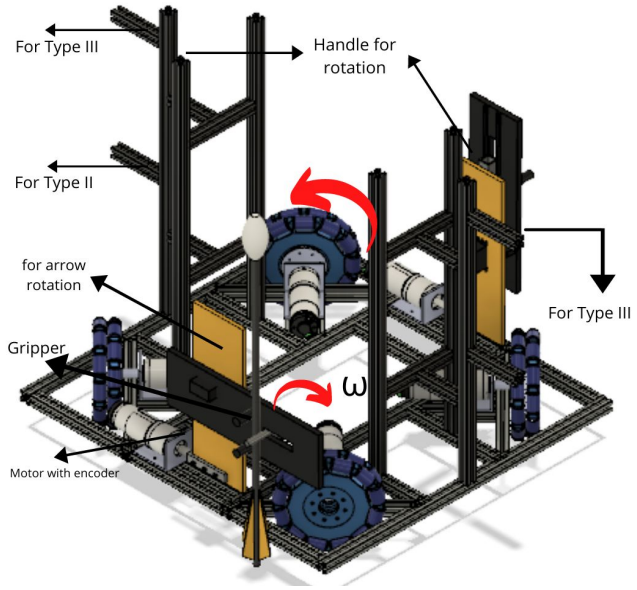

Fig - 2

1.4. Arrow Pick and Pass Mechanism:

Introduction:-

The **objective of the task** is to pick the arrows fallen on the inner area of the arena and pass it to the TR to throw them again in the pots. A **servo based gripper** is used to pick the arrows and rotate it in **head upside direction** which hold the arrows and TR can rotate its arm in opposite direction and can **throw that arrows directly from the DR.**

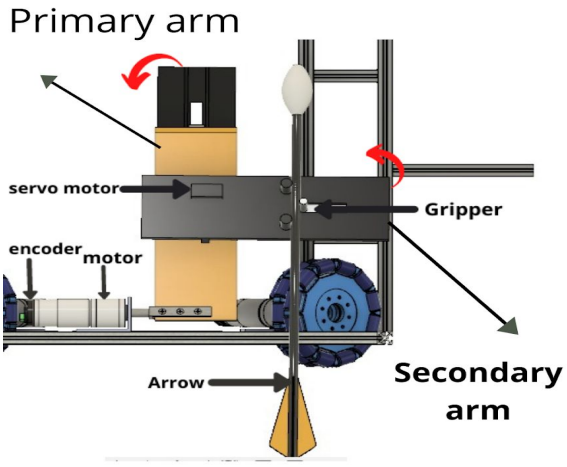

Fig - 3

1.5. Working of Mechanism:

The Pick and Pass mechanism is based on **2-axis Robotic Arm.**

- The servo-based gripper fastened to the arm is used to pick the arrows which have fallen on the arena.
- The primary panel coupled to the **planetary DC geared encoded motor** will rotate on the same axis as that of the motor.
- The gripper assembly is mounted on a **servo shaft affixed** to the primary panel,so that the primary panel can rotate about its second axis with an arrow.
- After the arrow head is set perpendicular to the ground, TR can hold the arrow directly from DR.

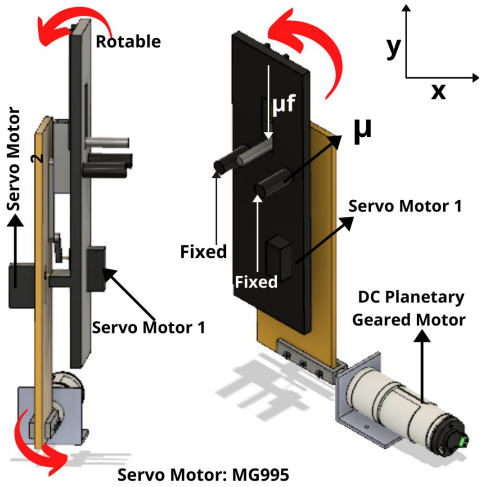

Fig - 4

1.6. Justifications/Calculations:

The dimensions for gripper is selected such that when it is opened, fallen arrows can get into it.The gripper is designed to grip the arrow using it's shape as restriction for a better grip.
The gripper engages with the arrow just above the plume wings and rotates it at an angle of 90°. Mass of an arrow is 107gms.Total mass of the gripper assembly together with the arrow is 560gms.
Distance at which the gripper is pivoted is 10mm approximately.
Hence, the required torque by the servo motor is calculated as:

$$\tau = F \times r = Fr\,Sin\theta$$
$$FrSin\theta = mgr \quad (Final\ Condition)$$
$$\tau = 0.56 \times 9.81 \times 0.01 = 0.054\ Nm$$

2.Throwing Robot (TR)

2.1.Overall Dimensions $(L \times B \times H)$

Initially: $(1000mm \times 1000mm \times 910mm)$
Extended: $(1000mm \times 1500mm \times 1560mm)$
Estimated weight: $16.8Kgs\ (approx.)$
Materials used: Acrylic sheet, Aluminum 6061, Stainless steel and Aluminium sheet.

2.2 Type of Drive

Four wheel Holonomic Omni-Wheel Drive is used.

The reason for selecting a four wheel drive for the throwing robot is the same as for the defence robot.The robot is **semi - autonomous** whose manual part is controlled via PS2/PS4 controller.

The drive of a throwing robot is designed such that both the picking/loading and throwing mechanism can be attached to it in order to have even weight distribution and maximum average speed for the movement of the robot.

2.3. Actuators and Sensors:

TR is equipped with:

- **Planetary DC geared motors** (rated:18V, 750RPM) for chasy movement.
- **Encoded motors** are used for controlling the motor rotation by detecting rotor speed for the throwing

mechanism, and to make a throw at specific position or angle, that will depend on the targeted pot.

- **Ultrasonic sensors (**HC-SR04) along with **MEMS** (MPU-6050) are used to detect distance and rotational angle per unit time, for a high speed and smooth movement of robots in the arena.
- **Servo Motors** are used in gripping mechanism, to pick the arrows from the ground.

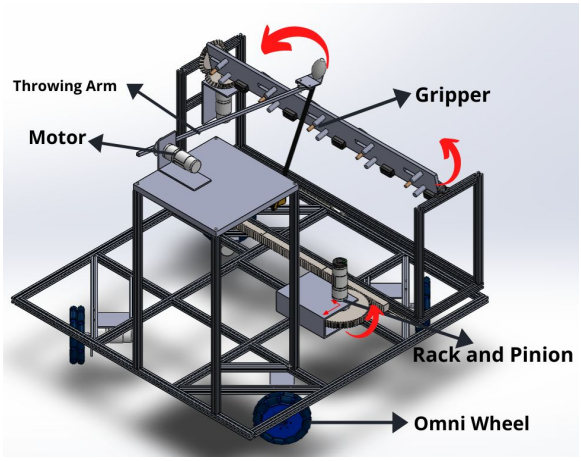

Fig - 5

2.4 Arrow Pick and Receive Mechanism:

The objective of the task is to pick the arrows from the arrow rack and to receive the arrows from DR.The task is achieved by a **servo based gripping mechanism,** also TR can receive the arrow from DR through a fork like attachment.

2.5 Working of Mechanism:

It works on the principle of Conservation of Momentum.The mechanism of picking is arranged in such a way that all the five arrows are picked at once

- TR is aligned in front of the arrow rack by using ultrasonic sensors,in such a way that every servo gripper on a rectangular slit can be aligned exactly in front of their respective arrows.
- Then TR moves towards the rack so that arrows come in range of gripping and servos are actuated to grip the arrows.
- The rectangular slit is rotated such that the arrow's head gets aligned in an upward direction, and brings them in a throwing position.
- After arrows are brought in a throwing position, they are released individually at their time of throw**.**
- The whole assembly for gripping arrows is attached to a telescopic channel connected with a **Rack and Pinion assembly** for sideways movement.
- **To receive arrows from DR**, Dr must pick fallen arrows and arrange them in head upside position.
- TR and DR come closer and TR try a throw in the opposite direction and t**hrow an arrow directly from the DR.**

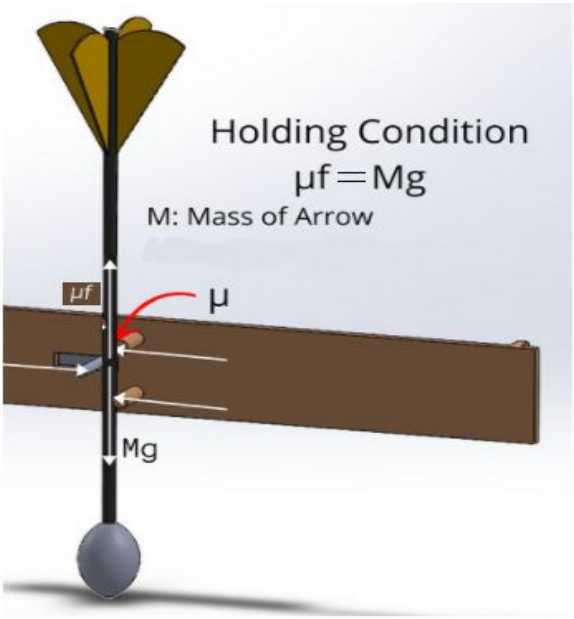

Fig - 6

3. Throwing Mechanism:

The objective of the task is to throw arrows in the pots present in the inner area of the arena. It is achieved using an arm made up of an **aluminium hollow section** and a fork-like attachment made up of an **aluminium sheet** which will be mounted on the arm so that it can hold the arrow and throw it more precisely.

3.1 Working of Mechanism:

- Planetary geared motor is placed on a platform at a certain height that at 0

position,hook at the end of the arm holds the arrow from the head.

- The arm is rotated about the axis with the help of a encoded Planetary DC geared motor.
- Hall effect magnetic encoder and PID controller is used to sense the angular orientation of the arm at a specific angle, so that the arrow gets a proper angle of elevation to complete the projectile.
- When the rotating arm is suddenly stopped the momentum is transferred to the arrow and the arrow gets a certain speed at a certain angle which leads to a specific height and distance.

$$\text{Range} = \frac{V^2 Sin2\theta}{g}$$

*** Range will be maximum when theta(θ) is 45°**
Considering arrow as point Mass.

Justifications/Calculations:
Range is calculated using an equation derived from projectile motion.

V_0 = initial velocity of arrow
X = horizontal range
y = Height of pot
y_0 = initial height of throw
θ = angle of throw

Formula used,

$X = V_{ox}(t) + 1/2a(t)^2$

Since,
$a = 0$
$X = V_{ox} \times (t)$
$t = \frac{X}{V_{ox}}$

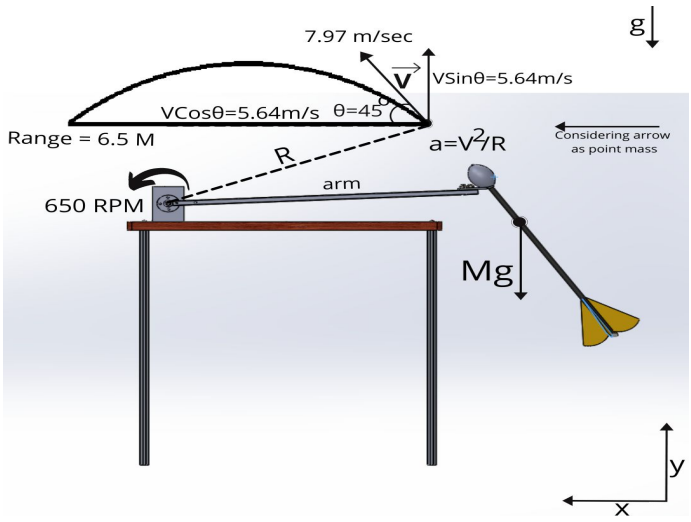

Fig - 7

As we are throwing from the baffle point we get different horizontal distances for different pots.
Distance for 1st type table , $x_1 = 4.47\text{m}$
Distance for 2nd type table , $x_2 = 1.5\text{m} \ \& \ 6.5\text{m}$
Distance for 3rd type table , $x_3 = 4\text{m}$
Height of 1st type table, $y_1 = 0.5\text{m}$
Height of 2nd type table, $y_2 = 0.62\text{m}$
Height of 3rd type table , $y_3 = 0.85\text{m}$

$$y = y_0 + V_{ay}(t) + \tfrac{1}{2}g(t)^2$$

$$y = y_0 + (V_0 sin60) \times (\tfrac{4.47}{V_{ox}}) + \tfrac{1}{2}(9.81)(\tfrac{4.47}{(V_0 COS\,60°)})$$

$$0.5 = 1.1 + (1.732V_0)(\tfrac{4.47}{0.5V_0}) + \tfrac{1}{2} \times 9.81 \times \tfrac{4.47}{(0.5V_0)^2}$$

Solving the above equation,
We get, $\mathbf{V_o = 3.6m/s}$ (approx.)
Similarly,

2nd type table $\mathbf{V_o = 1.58m/s}$(approx.)
3rd type table $\mathbf{V_o = 3.3m/s}$(approx.)

And all these velocities can be calculated by changing the position of the throw arm or speed of the motor.

4.Table Push and Arrow Interception Mechanism:

4.1 Table Push Mechanism

For pushing the tables, two 180mm lengths made of aluminium profiles are extended from the outer sides of a 'U' section. Each of these extensions are at the heights of handle bars of type 2 and type 3 table respectively. A similar attachment is made on the opposite side of the DR Bot.

Justification:

We provide an impulsive force to the handle of the Type-2 and Type-3 tables which results in rotation of tables respectively .This impulsive force is provided with the 18mm extension rod mounted on the U - section of DR. Our 18mm extension rod provides more than the minimum force required to counter the friction force to generate enough torque for the rotation of the table.

4.2 Arrow Interception Mechanism

The arrow picked by DR from ground is lifted up vertically using the picking arm and is rotated using a servo motor that is mounted on this arm to act like an interceptor i.e. to block the opponent's arrows.

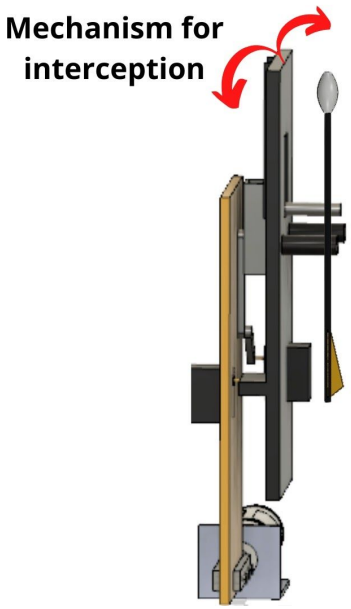

Fig. 8

Justification/Calculations:

Picked arrow can be rotated from -45° to 45° along the vertical axis . To cover an angular coverage of 90° above the Type-1 pot. Thus, resulting in movement of an arrow acting as an interceptor.

$$frictional\ force = f_{act} = \mu N = (4-7)Nm$$

$$force\ acting\ on\ the\ pot\ = F_{applied\ force} - f_{act}$$

$$= (mass\ of\ DR)\,(acceleration\ of\ bot) - f_{act}$$

$$= (11.5)\,(2.3) - 7$$

$$= 19.45N$$

Conclusion:

The complete design, fabrication and testing of the two robots was completed in a period of two months.The prototype of TR was able to pick and throw the arrows into the pots from the throwing zone. Moreover, the DR defending the opponent's arrows from falling into pots and picking up and passing the arrows from the scoring zone and giving it to TR. Both the TR and DR are able to successfully complete their tasks.