# Design of Autonomous Lagori Game Playing Robotics

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**Abstract.** Lagori is a traditional game with its roots in southern India and is still played today. It was one of the most popular games in India in the 1990 s. Satoliya, Pithoo, and Lagori are actually seven stones. It involves a ball and a row of stones, usually seven. So, in the proposed system, there are two teams competing. In the suggested system, two teams (Team 1: "Seeker" and Team 2: "Hitter") compete in a game in which the seeker tosses a ball in an attempt to topple the "Lagori" stone tower. To stop the searchers from trying to stack the stones once more, the batter throws balls. Tower Lagori is a semi-automatic system, so it uses a wireless joystick as a controller, making it easier for the user to control. The I/O port on the microcontroller is given logic (logic 1), while pneumatics rejecting and pulling the gripper arm, gripper motor, both ball drive motor, and logic dead ignition motor (logic 0). - an average of 45 ms from the entire process and get the procedure's accuracy to move perfectly in accordance with the command.

**Keywords:** Limit Switches · Capacitive proximity sensors · Omni Wheel Drive · BLDC motor · Arduino Controller

## 1 Introduction

### 1.1 A Background of the Study

The aim of project LPR is to make a robot that can play the lagori game in either a fully automatic or semi-automatic process [1]. The game of lagori is been played between two teams where operators are needed for breaking and making of lagori in the game and protect your robot from the opposite team in order to save from the out-of-game position [2]. For the robot to function properly, accuracy, recognition, and intelligence must all be excellent. Even a 1mm inaccuracy in the mechanical model's movement over time can cause an error. A requirement for the proper operation of the entire game is the precise identification of the hitting or pilling position of the lagori piece. The robot should also be designed to have enough intelligence to avoid being hit by an opponent and survive the game [3].


P. Pareek et al. (Eds.): IC4S 2024, LNICST 599, pp. 489–502, 2025.
https://doi.org/10.1007/978-3-031-77081-4_38

## 2 Mechanical Design

### 2.1 Seeker Robot 1 (Seeker R1)

The Seeker Robot1 appears to be a versatile and capable robotic platform designed for a range of tasks requiring mobility, manipulation, and interaction with the environment. Its combination of mechanical components, functional actuators, and electronic accessories suggests a sophisticated design optimized for performance and versatility. Additionally, the estimated weight of 24.5 Kgs indicates a substantial but manageable size, likely suitable for deployment in various environments (Fig. 2 and Fig. 3) (Fig. 1) (Table 1, Table 2 and Table 3).

**Table 1.** Specifications of Seeker Robot1

| Sr.No | Blue (B) | Black (Bk) Misc |
|---|---|---|
| 1 | Omni Wheels | Clamps |
| 2 | Compressed Air Bottles | Bearing |
| 3 | Hopper(faces) | Coupling |

**Table 2.** Specifications of Seeker Robot1

| Sr. No | RED (R) Assembly | GREEN (G) Actuators |
|---|---|---|
| 1 | Ball Throwing Wheels | Planetary Gear Motor |
| 2 | Kicking Rod | BLDC Motor |
| 3 | Guide Way | Pneumatic Cylinder |
| 4 | – | Servo |
| 5 | – | Solenoid Valve |

**Table 3.** Seeker Robot1 Accessories

| Sr. No | Yellow (Y) |
|---|---|
| 1 | Sensors |
| 2 | Circuit |

### 2.2 Types of Drive

Four Wheel Holonomic Omni Wheel Drive. The base of the Robot is designed with the help of a Four-wheel Omni drive to swift the position of the robot smoothly, which

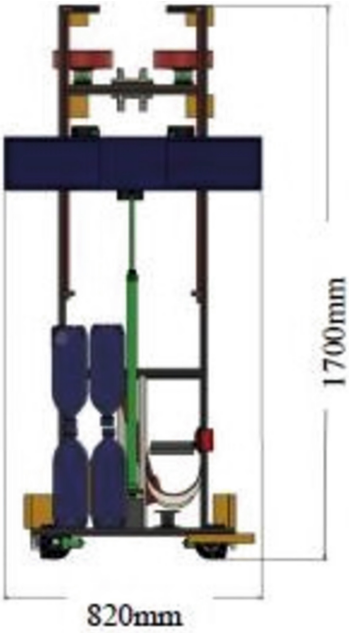


**Fig. 1.** Right hand side view

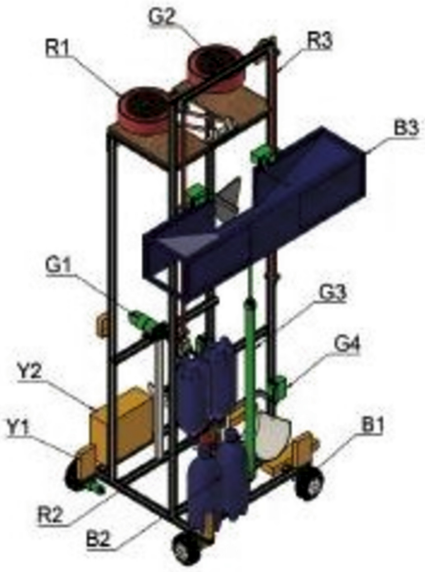


**Fig. 2.** Isometric View

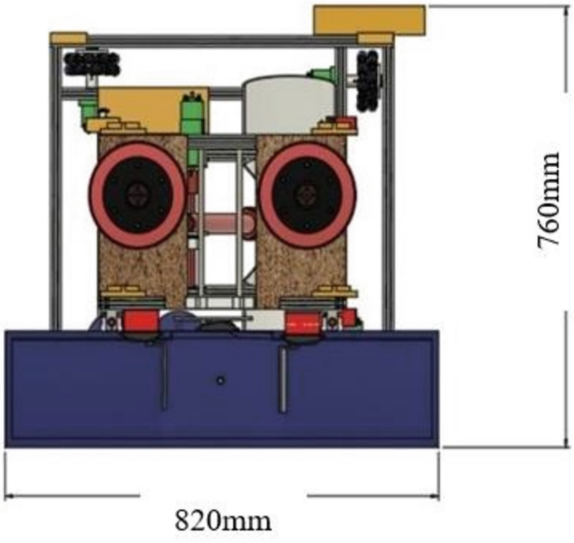


**Fig. 3.** Top View

resembles a swastika pattern. The Motor preferred is DC gear motor with a rating of (60 rpm, 12 v) DC having a rated Torque 15 kg-cm [4–6] (Fig. 4).

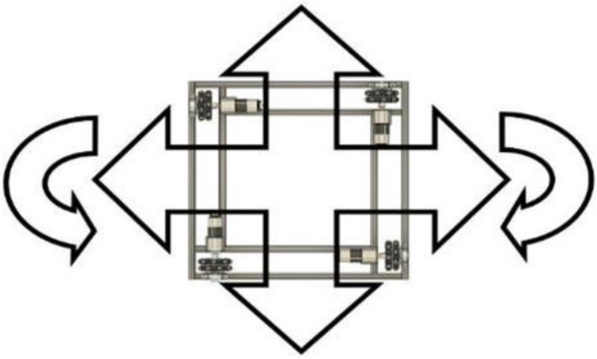

**Fig. 4.** Drive

### 2.3 Types of Actuators

To drive the robot in (Forward/Backward/Left/Right) motion a DC Gear Motor is selected (60 rpm, 12 v, 15 kg-cm) and for hitting the Lagori a Planetary gear motor (750 rpm, 18 v, 39 kg-cm) is selected [7, 8].

A Brushless DC Motor (400 kv) is used for the ball shooting mechanism. To displace the ball receiver (hopper) a pneumatic cylinder is used (57 cm Stroke length). To guide the ball to hit the target, we have chosen three servos (12 kg-cm continues rotation) [8, 9].

### 2.4 Type of Sensors

For height positioning in the ball receiver Limit Switches are used. Capacitive proximity sensors for Alignment of R1 and R2 and for detection of the fence on the Arena. To measure the distance and direction of the ball on the head the camera module is used. Infrared Sensors are used for Robot positioning and penalty zone detection. Encoders are used with planetary motor for kicking (Lagori breaking) mechanism to sense the displaced position. Accelerometer-Gyroscope Sensor used for R1 angular alignment for BOH shooting [9, 10].

### 2.5 Ball Receiving Mechanism

Three sets of the ball are preloaded into the ball loader, which is located at the bottom of the R1. This will act as a bullet to hit Lagori at the time of Lagori breaking (Knocking). It has 3 ball holders in which two are inclined to the ground side in such a way that if we open one of the holders, the ball must reach the middle slot (middle ball holder). For the opening and closing of the holder, servomotors are used. In this mechanism, major role is of the middle ball holder, which completes kicking/hitting mechanism [11, 12] (Fig. 5).

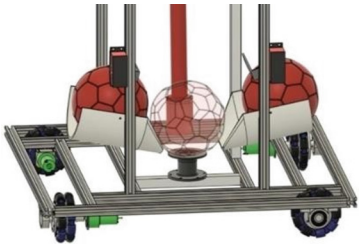

**Fig. 5.** Ball Loader for receiving ball and lagori breaking.

## 3 Brief Description of Lagori Breaking

### 3.1 Introduction

For breaking (Knocking) of Lagori we designed a kicking mechanism where the ball is kicked with certain momentum by a kicking rod [3] (Fig. 6).

**Fig. 6.** Kicking mechanism

### 3.2 Mechanism Working

The kicking rod is placed near the ball holder. The planetary-geared motor is used to power the kicking rod, which rotates in a clockwise direction with an angle of 315 degrees. The kicking rod produces momentum by rotating itself. That produced momentum is transferred from the rod to the ball by hitting. The ball gains certain momentum that will make it travel towards the Lagori with certain velocity demonstrated in following [2, 3] (Fig. 7).

**Calculation**

The Parameters given are as follows

Angular velocity of rod = 35.49 rad/s
Length of rod = 43.5 cm
Weight of ball = 200 gm
Weight of rod = 250 gm
Angel of Projectile = 6°

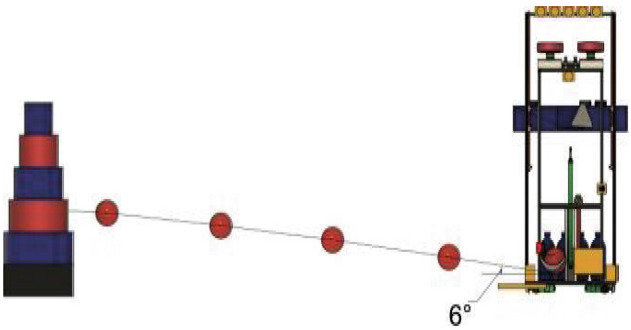


**Fig. 7.** Lagori Breaking

Velocity of Ball:
The linear velocity of the ball can be calculated using the formula:

$$V = \omega \times r \tag{1}$$

Substituting the values:

$$\text{v} = 35.49\,\text{rad/s} \times 0.435\,\text{m} = 19.3\,\text{m/s}$$

$$\text{Velocity of ball} = \frac{35.49 * 250 * 43.5}{200} = 19.3\text{m/s} \tag{2}$$

$$Range = \frac{(19.3)^2 * sin\,(2 * 6)}{19.3\,\text{m}} = 8 \tag{3}$$

## 4 Seeker Robot 2 (Seeker R2)

Overall dimensions (in mm) and estimated weight (in Kgs) (Fig. 8, Fig. 9 and Fig. 10) (Table 4, Table 5 and Table 6): -

### 4.1 Type of Drive: Four Wheel Holonomic Omni Wheel Drive

A Four-wheel Omni drive is used because of its rich maneuverability and design of base will help the driver to travel swiftly in the base. Planetary DC gear motor of 750 RPM 250 W 18 V DC with a rated torque of 3.8 Nm. This base is known as the Swastika type base. The wheel diameter is 152 mm [4] (Fig. 11).

### 4.2 Type of Actuators Integrated

To drive the robot DC gear motors are chosen using Omni wheels. Planetary gear motors are used for Z positioning of Lagori and ball gripper. For the moment of end-effector and Lagori gripper, we have chosen Pneumatic Cylinder (50 mm stroke length) used at ball gripper. DC gear motor (200 RPM) used in end-effector for Lagori gripper. Servo motor (12 Kgcm holding torque) for Lagori gripping end- effector roll movement [15].

**Table 4.** Specifications of Seeker Robot2

| Estimated Weight: 23.89 kg | | |
|---|---|---|
| Sr. No | RED (R) Assembly | GREEN (G) Actuators |
| 1 | Ball Support (Ball G) | Planetary Gear Motor |
| 2 | Lagori Support (Lagori Gripper's Fingers) | Pneumatic Cylinder |
| 3 | Timing Belt | Servo Motor |
| 4 | Gantry Assembly | Solenoid Valve |
| 5 | Lead Screw | Linear guide is attached to B1 for free motion |

**Table 5.** Specifications of Seeker Robot2

| Sr No | Blue (B) | Black (Bk) Misc |
|---|---|---|
| 1 | Ball on head | Clamps |
| 2 | Compressed Air Bottles | Nut Block |
| 3 | Omni Wheels | Bearing Housing |

**Table 6.** Seeker Robot2 Accessories

| Sr. No | Yellow (Y) |
|---|---|
| 1 | Circuit |
| 2 | Sensors |

### 4.3 Type of Sensors Integrated

We have chosen Limit switches to orient the lead screw mechanism when the Lagori gripper along with the end-effector grips the Lagori. For detecting the arena boundaries and alignment of robots R1 and R2, we had used a capacitive Proximity sensor [16].

### 4.4 Piling up the Lagori Disks

Grabbing of the Lagori disks by the Gripper: - For piling up of the lagori disc, we need to place all the distracted Lagories in the exact positions with the help of Robot R2. Thus, we are here placing the lagori with the help of a gripper called Lagori gripper, which is actuated by Lead screw actuation for linear translation that helps us the opening and closing of the gripper.

The finger of the gripper rotates 90° with servos to pick up the Lagories irrespective of its angle and direction of discs fallen after hitting as shown in the figure:[1] Vertical


**Fig. 8.** Right hand side

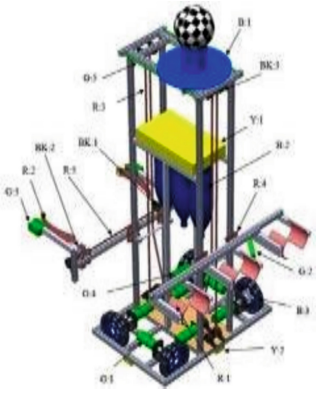

**Fig. 9.** Isometric View

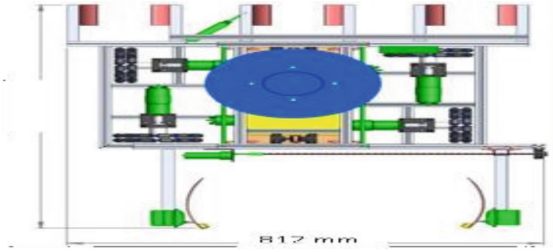

**Fig. 10.** Top View

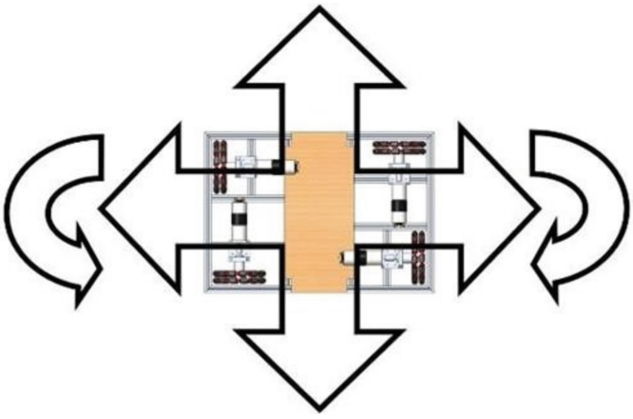

**Fig. 11.** Drive

movement of the Gripper along with the slider frame: - After picking up the lagori we need to place it one by one with the height concerning the ground will increase for each single Lagori. Therefore, the Lagori carried out on to the other Lagori with the help

of a Timing belt-pulley that provides vertical translation after placing each Lagori [12] (Fig. 12 and Fig. 13).

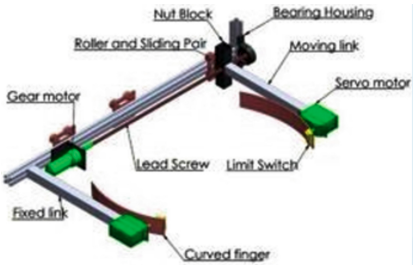


**Fig. 12.** Lagori gripper

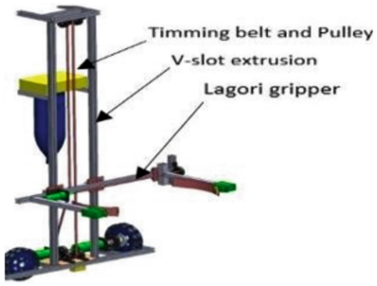


**Fig. 13.** Vertical axis motion of gripper

This is illustrated in the Fig. 14: -

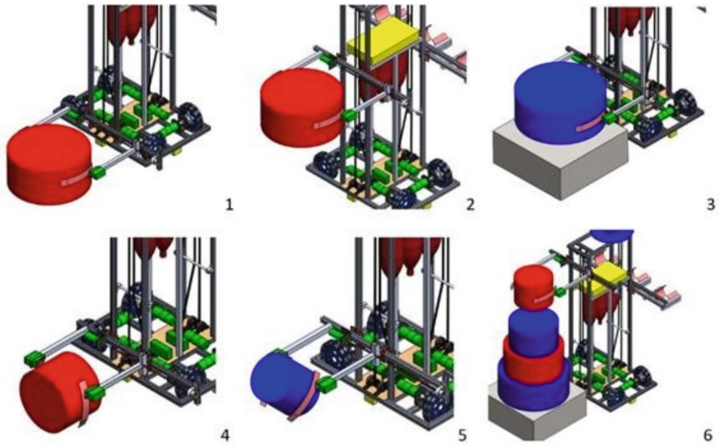


**Fig. 14.** Piling up the Lagori disks

## 5 Hitter Robots (Hitter R1 and Hitter R2)

### 5.1 Hitter R1 for Hitting of Ball on Head (BOH)

Introduction: - The task of BOH is accomplished by two horizontally mounted wheels (Diameter = 180 mm) rotating beside each other at the same speed, in opposite directions. For the rotation motor of the wheel, we are using a BLDC motor of 400 kV to get the speed and more torque [10].

Working of Mechanism: - While the opponent team is arranging the lagori. We need to hit on to the opponent BOH. For that, we need to design a hitting mechanism that can hit the ball on the head of the opponent. Thus, we designed a hitting mechanism for our

hitter R1 as shown in fig. Our hitting mechanism consists of two wheels (13.5 cm gap between 2 wheels) that rotate at the same speed in opposite direction. The wheels are mounted on a BLDC motor that rotates between 3500 RPM to 8500 RPM it also consists of an inclined surface with 6° to the ground that brings balls near to the wheels passed by the hopper. The hopper will pass the ball to the inclined surface of the hitting mechanism by opening the membrane with a servo. The speed of the wheels would depend on the distance and direction of the opponent, which is calculated by using Image processing. With the help of Image processing, the velocity of the ball is computerized calculated by projectile range equation. According to the velocity of the ball, the rpm is calibrated automatically, and direction is adjusted automatically with the line of action. After hitting one ball, the hopper will send another through it [3, 4] (Fig. 15).

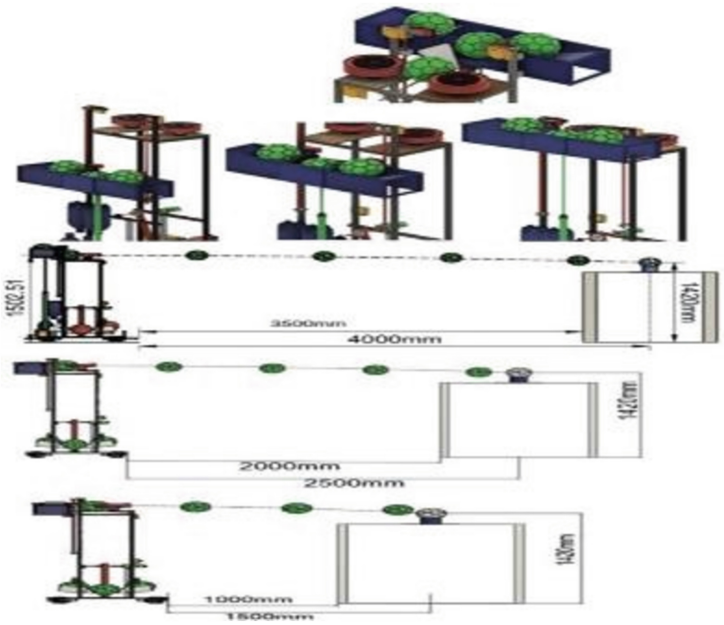


**Fig. 15.** Ball receiving to BOH shooting mechanism and shooting of that ball at an opponent

**Calculation/Justification: -**
(Table 7)

### 5.2 Ball Picking and Passing Mechanism (Hitter R2)

The objective of this task is to bring out balls to the R1 collector, which we named the hopper as shown in fig that sends the ball to the hitting mechanism to hit opponent BOH. Therefore, we designed the ball picking mechanism in such a way that it picks up three balls at a time with the help of three grippers that actuated by a pneumatic cylinder [5] (Fig. 16 and Fig. 17)

**Table 7.** Dynamic Motion of Seeker Robot 2 Observations

| Sr. no | Distance between Seeker R2 and Hitter R1 | Speed of Ball shoot form BOH shooting mechanism (RPM) |
|---|---|---|
| 1 | 4 - m | 4400−4442 |
| 2 | 3.5 - m | 4400−4420 |
| 3 | 3 - m | 4275−4337 |
| 4 | 2.5 - m | 4275−4316 |
| 5 | 2 - m | 4232 |
| 6 | 1.5 - m | 4190 |
| 7 | 1 - m | 4120 |

* Note: - Here the observation in the above table is taken manually and set according to Seeker R2 for Dynamic motion.

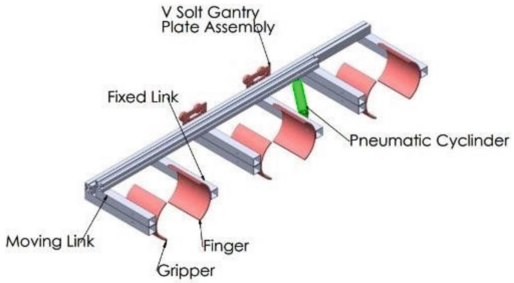


**Fig. 16.** Ball gripper

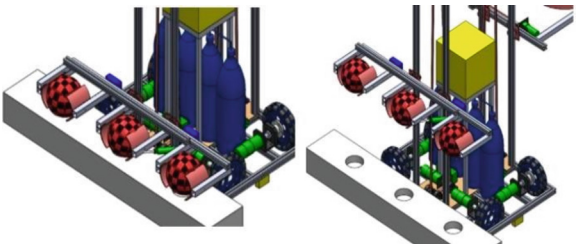

**Fig. 17.** Ball picking and vertical axis

These three holding balls will travel vertically up to 108 cm, from the ground with the help of a Timing belt & pulley mechanism guided by a v slot wheel mounted on a gantry plate that is fixed to v slot extrusion, which drops those balls into a hopper, which is situated at 105 cm from the ground. The hopper and gripper have a clearance of 3 cm to drop the balls The ball in the hopper is separated by 2 servos placed on both sides of the middle and another servo will act as a membrane to allow the ball to the hitting mechanism. This hopper will travel 580 mm (1630 mm from the ground) and

pass the ball to the hitting mechanism with the pneumatic cylinder of stroke 570 mm [6] (Fig. 18).

**Fig. 18.** Ball passing to R1 robot after picking

## 6 Conclusion and Recommendation

It is accurate to state that humans and robots will interact more regularly and intimately in the future during the age of robot civilization. Artificially intelligent robots are expected to play a significant role in the military, government, business world, educational institutions, entertainment industry, etc. One stride in this direction is the lagori-playing robot with primary intelligence. We have covered one way of creating a robot that can play Lagori in this discussion. We are successful in using this robot to play games. Future generations will experience a robotic revolution. In the entertainment industry, the Lagori Playing robot has a bright future [1, 2].

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