DD-Robocon 2019

Team IIT Bombay

August 2019

1 Design of MR1

1.1 Dimensions (in mm) and estimated weight (in kg) of the robot

The dimensions are under $800mm \times 700mm \times 600mm$ and after extension $1400mm \times 700mm \times 600mm$.
Aluminum extrusion has been used in most of the parts. Aluminium and acrylic sheets have also been used in some places.

Component	Total Estimated Weight (kg)
Motors	8
Pneumatic Actuator	1.2
Gerege gripper parts	0.5
Shagai gripper parts	3
Chassis	3
Other (electronics, nuts, mounts, etc)	2

The estimated weight is 17.7 kg. Allowing for some margin of error, total estimated weight does not exceed 20 kg.

1.2 Type of Drive

Driven by 4 high torque motors having encoders and omni wheels. The chassis has an octagonal shape as shown in Figure 1. Such an arrangement enables the robot to move forward, reverse, left, right with same speed as

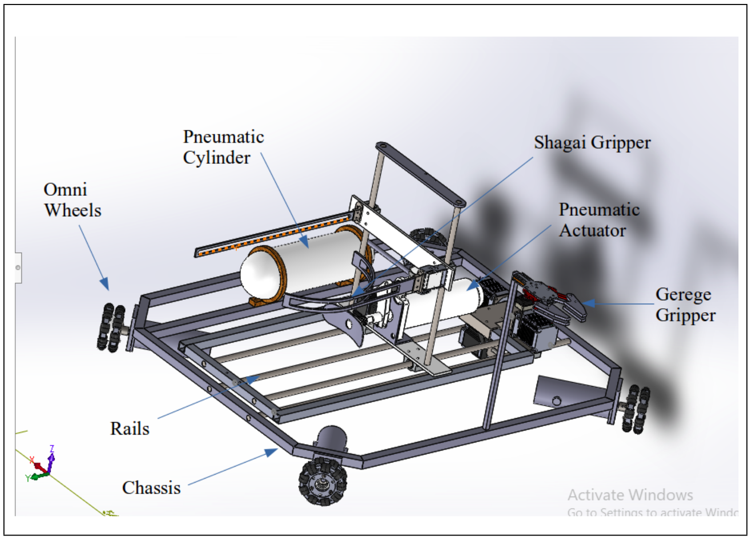

Figure 1: MR1

well as rotate on the spot by sending appropriate commands to the motor. Two dual channel Roboteq motor controllers are used for controlling the four motors.

1.3 Actuators and Sensors integrated

1. Brushed DC motors with encoder: For driving wheels.
2. Stepper motors: For linear motion of platform and gripper along rails.
3. Servo motors: For gripping and throwing mechanism of Shagai thrower.
4. Xbox controller and Wifi module : For wireless controlling of robot.
5. Roboteq controller: For controlling motors of wheels.

1.4 Gerege holding and passing mechanism

Parallel gripper mechanism is used in both MR1 and MR2 to hold Gerege at an adjustable height. Laser transmitter and receiver are mounted on gripper of MR2. Once MR1 is close to MR2 passing mechanism is initiated. This happens as follows:

1. MR1 brings the Gerege in the task space of gripper of MR2 by manual control.

2. Laser receiver senses an obstacle as the Gerege blocks light from laser transmitter.
3. On receiving a signal from laser receiver the autonomous sequence is intiated by the onboard computer.
4. Once MR2 has safely gripped Gerege, MR1 releases Gerege by manual control. MR2 is now free to carry out the rest of its autonomous sequence.

1.5 Shagai placing and throwing mechanism

Shagai is held by a gripper with arms specifically designed for holding it as shown in Figure 1. The gripper can moves in both forward and vertical directions on rails with the help of stepper motors and timing belts. The entire gripper lies on a platform which has a pneumatic actuator attached to it. This platform can rotate about a fixed axis parallel to base in order to control the angle of launch.

2 Design of MR2

2.1 Dimensions (in mm) and estimated weight (in kg) of the robot

The dimensions are under $800mm \times 600mm \times 700mm$ and after extension $800mm \times 600mm \times 900mm$. Aluminum extrusion, aluminum sheets, acrylic sheets, steel rods, wood have been used in MR2.

Component	Quantity	Estimated Weight per unit (kg)	Total Estimated Weight (kg)
Super200 High torque Servo Motor	8	0.9	7.2
Medium torque Servo Motor	2	0.2	0.4
Electric linear actuator	4	0.9	3.6
Other (leg parts, electronics, etc)	-	-	6

The estimated weight is 17.2 kg. Allowing for some margin of error, total estimated weight does not exceed 20 kg.

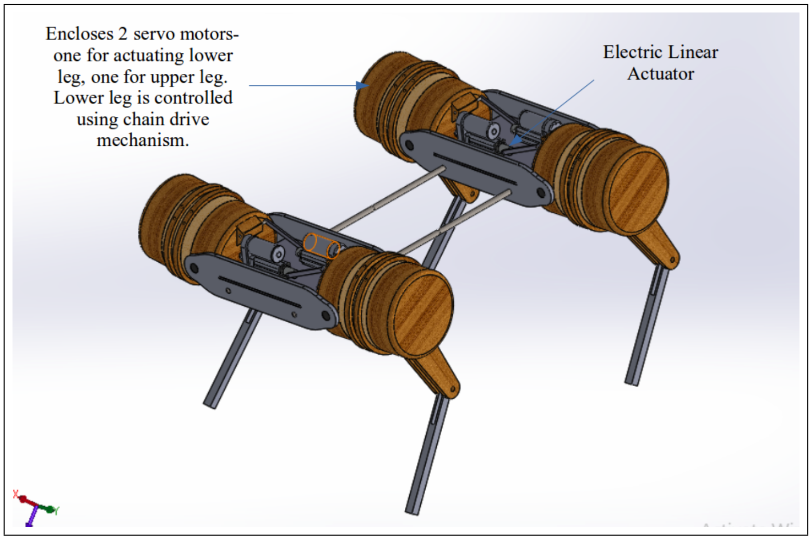

Figure 2: MR2

2.2 Drive mechanism (4 - legged mechanism)

This quaruped has 12 degree of freedom mechanism (3 DoF per leg). Two degrees of freedom are provided by two servo motors while the third degree of freedom is provided by an electric linear actuator per leg.
The movement of each leg in a desired trajectory is obtained by performing inverse kinematics calculations to find out required joint angles and controlling the actuators to attain them.
The robot will have three different walking gaits:

1. Fast walking - This will be used in the Gobi area where there are no obstacles. The legs will not be lifted very high. Speed will be maximum. Diagonal legs will be lifted together.
2. Climbing - This will be used for crossing over sand dune, tussock and mountain. The legs will be lifted around 20 cm above the ground. Diagonal legs will be lifted together.
3. Turning - This will be used when the robot needs to make a turn. The step size of two legs will be increased and other two legs decreased in order to achieve a turn. This is similar to differential mechanism in wheeled robots.

2.3 Actuators and Sensors integrated

1. Servo motors: For movement of legs in direction of locomotion.
2. Linear actuators: For sideways movement of legs to provide stability.
3. Intel NUC : Onboard computer to execute ROS programs
4. Intel Real Sense D435 depth camera : For computer vision to build autonomous navigation system.
5. IMU sensor (9 DOF Razor IMU) : For closed loop control of the robot, for making a self-balancing platform on which camera will be mounted.
6. Laser transmitter and receiver : For signaling MR2 to grip Gerege.

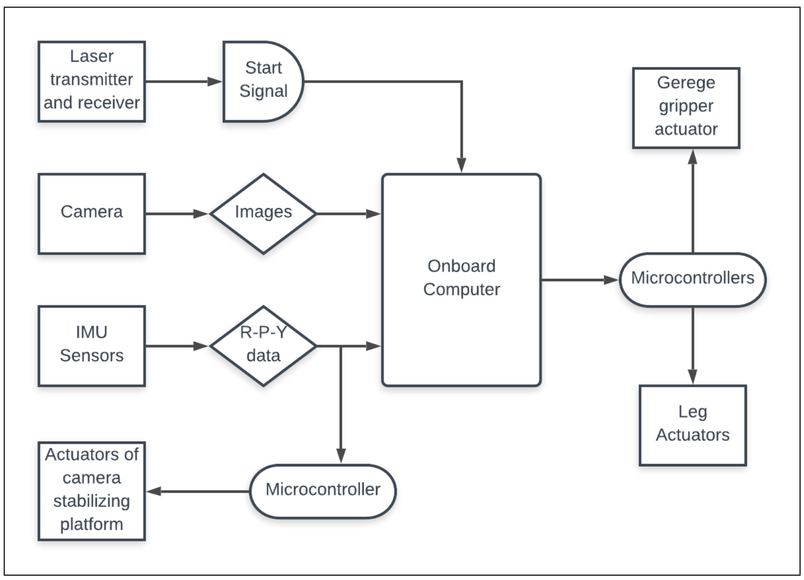

Figure 3: Control Strategy

2.4 Gerege holding and raising mechanism

A parallel gripper is used to hold gerege which has laser sensor in it to give signal for start. Exact mechanism has been described earlier (Design of MR1 → IV. Gerege holding and passing mechanism). To raise the Gerege we use a 2 degree of freedom arm. The aforementioned gripper is attached to the top of this arm. The arm will be autonomously controlled to raise Gerege when the robot reaches Uukhai zone.