DIC's Terrace Farming Bot

Final Report

Introduction

The trend of maximizing agricultural resources, in a sustainable manner, is positively influencing farmers with its growing demand in the world's food supply chain. IoT has become a mainstream technology, driving several industries such as transportation, manufacturing, agriculture, and others. The increasing use of precision agriculture, among farmers, for collecting and processing data helps in making better decisions on fertilizing, planting, and harvesting crops.

The proliferation of IoT has revolutionized the agriculture industry that primarily depends on technology, engineering, and physical and biological sciences. Furthermore, the increasing labor wages and untrained labor have also propelled farmers to use a cost-efficient method for increasing productivity, which is likely to influence the industry growth over the projected period.

AGRICULTURAL BOTS MARKET SEGMENT ANALYSIS

The driverless tractor product segment is expected to have significant growth. Autonomous tractors have the ability of planting, seeding, and tillage for row and broad acre crop farming. The growing industrialization of the agriculture sector, across regions, including India, China are likely to influence the segment growth.

Based on application, the industry is segmented into field farming, dairy management, animal management, soil management, and crop management. The dairy management segment dominated the market in terms of revenue in 2015 and was valued at 585.6 Million. The soil management segment is anticipated to witness highest growth rate over the projected period. The growth is driven by growing deployment of mobile field robot, for weeding and fertilizing, is expected to drive the segment demand over the forecast period. Asia Pacific region is the fastest growing region, owing to the faster rate of adoption of autonomous technologies in the agriculture industry.

Some of the key points which are driving the market for agricultural bots in Asia-pacific region are:

1. Increasing adoption of automation technologies in terrace farming.
2. Declining availability of farm workers.
3. Growing demand for food and agricultural supply.
4. Increasing government support to adopt to new agricultural technologies.

EXISTING TECHNOLOGIES

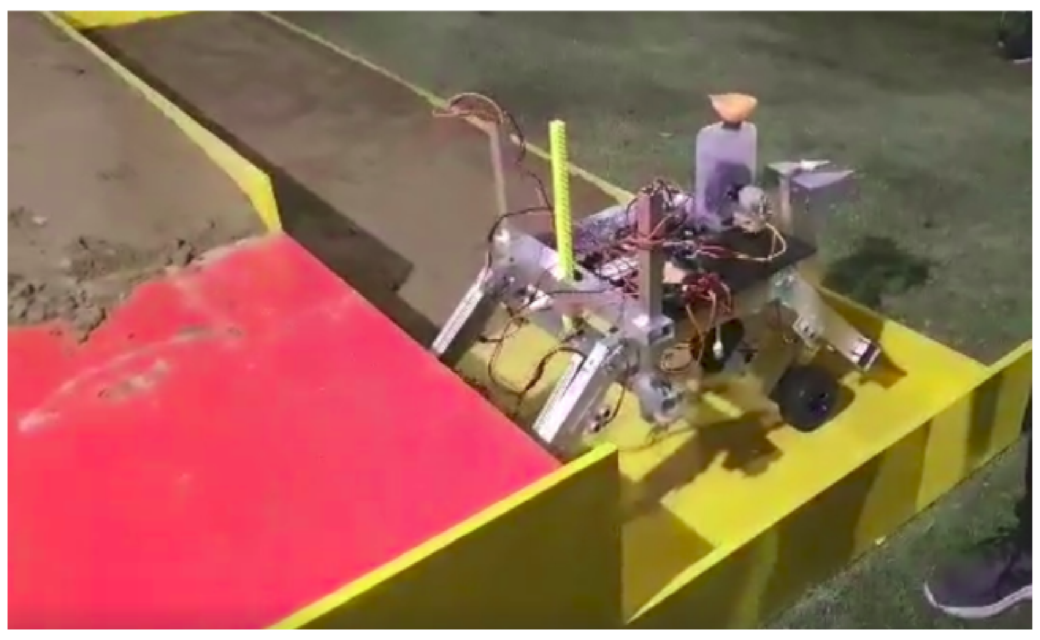
Swarm Robotics : Swarm robotics is an advent in the coordination and multitasking of multi-robot systems which consist of large numbers of mostly simple physical robots. This robot uses MSP430 family of ultra-low-power microcontrollers with built-in 16-bit timers, up to 24 I/O pins, a versatile analog comparator, and built-in communication capability using the universal serial communication interface.For the wireless communication of data, ZigBee is used. ZigBee is a low-cost, low-power, wireless mesh network standard. The motors for the movement of the robot is implemented using L293DNE quadruple high current H-Driver used to control 2 bidirectional motors. Example of Swarm robots being used in

Drones : There are also drones currently available and in development for crop spraying applications, offering the chance to automate yet another labor-intensive task. Using a combination of GPS, laser measurement and ultrasonic positioning, crop-spraying drones can adapt to altitude and location easily, adjusting for variables such as wind speed, topography and geography. This enables the drones to perform crop spraying tasks more efficiently, and with greater accuracy and less waste.

A drone called Agras MG-1 designed specifically for agricultural crop spraying, with a tank capacity of 2.6 gallons (10 liters) of liquid pesticide, herbicide or fertilizer, and a flight range of seven to ten acres per hour. Microwave radar enables this drone to maintain correct distance from the crops and ensure even coverage.

HARDWARE MECHANISM

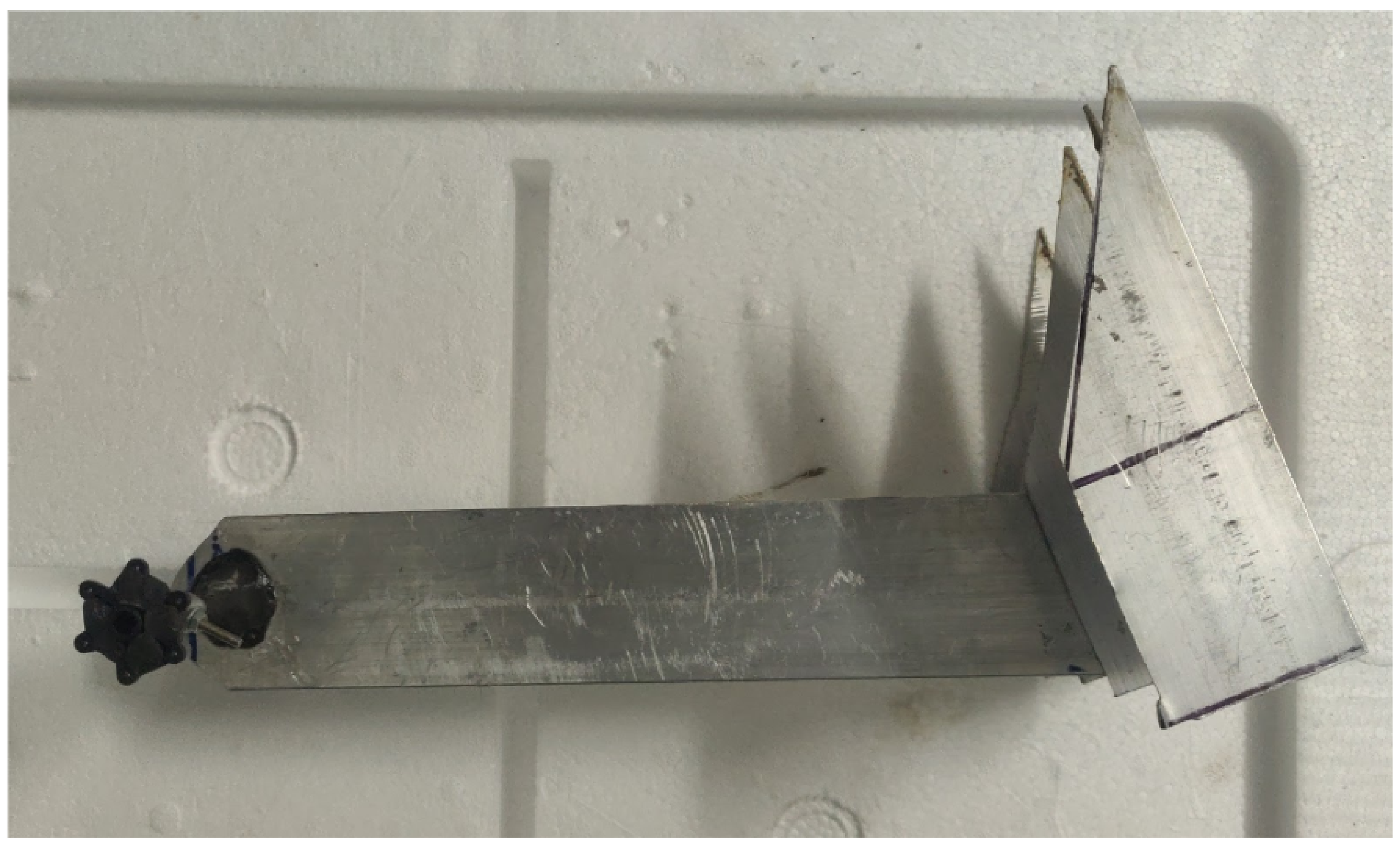
LOCOMOTION



UTILITIES

PLOUGHING:

The first and foremost step in the farming is ploughing. This process is done in order to loosen the soil and create a path or tracks on the farm land in order to sow the seeds uniformly . The structure and the design of the plough tool depends on the various constraints such as the type of soil to be ploughed and the depth required based on the type of crop that has to be grown and so on. We have designed a light weight Aluminium head for ploughing which is connected to a servo motor.. The design and dimensions of the plough tool are in accordance with the size of the bot.



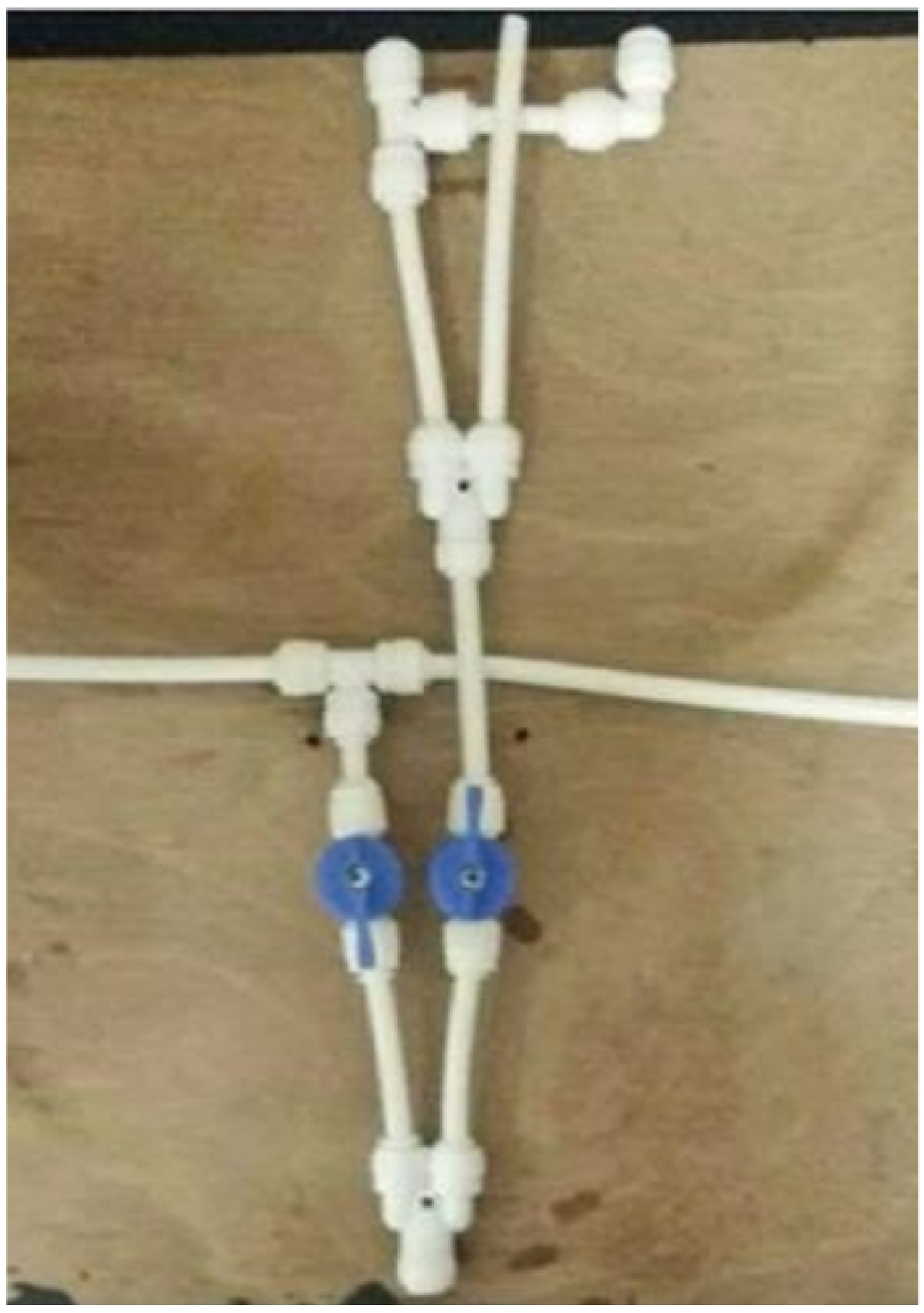
Usually, the plough tool’s angle of inclination and length of the tool are calibrated by considering the depth required for ploughing the soil and it varies with the type of crops and soil. The tool is operated using a dc servo motor. Instead of the conventional method, the torque generated by the servo is used for ploughing. Moreover, the weight of the bot is reduced by using an aluminium plough tool.

SEEDING :

The next major step in the process of farming is seeding. Seeding usually depends on the type of crops being grown and the type of seeding varies over a variety of crops. In case of robots, utmost care has to be taken to ensure uniform spacing and controlled flow of the seeds from the bot.

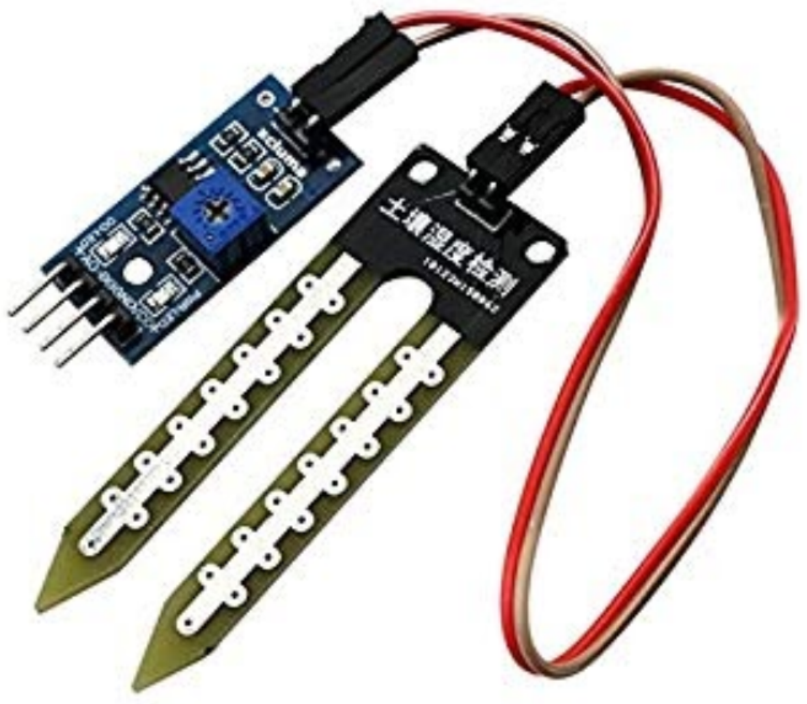
To ensure this, a cell-based seeding metering mechanism has been used in which seeds are collected and delivered by a series of equally spaced cells on the periphery of circular wheel. Considering the seed spacing required for different crops, the user can adjust the speed of the motor attached to the cell using a potentiometer to adjust the seed spacing.

IRRIGATION:



Based on the amount of water required for that particular crop suitable irrigation methods are adopted. The bot inculcate the drip irrigation for the irrigation process. The water required for the irrigation is stored in a container and is connected to the bot via a pipe. The frequency of drop of the water is controlled using water pump. The water from the container flows to the field through the structure provided for irrigation uniformly.There are two knobs, one for controlling central irrigation and another for controlling sideways irrigation. The same irrigation tool can be used for fertilizing by replacing the water with fertilizer.

A Moisture sensor has been used to test the moisture content in the soil. The sensor will be attached to a DC motor which will move the sensor in the z-axis to test the soil before irrigation. A reading of :

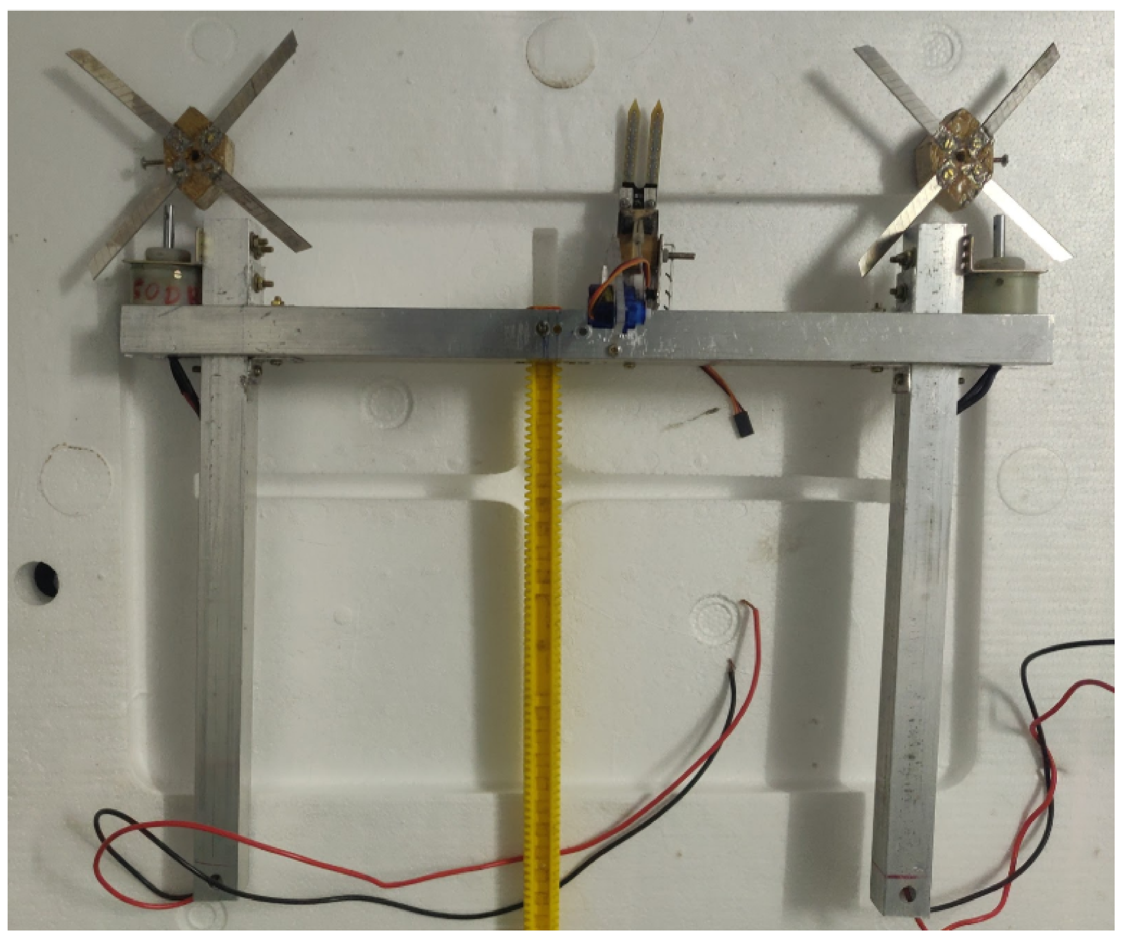


1) 35% indicates Dry soil

2) 55% indicates Wet soil

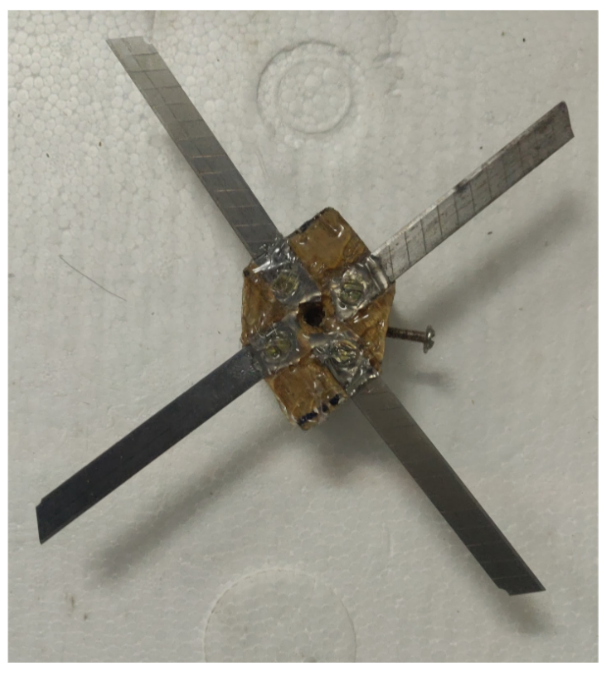
3) 80% indicates Extreme Wet soil.

HARVESTING:



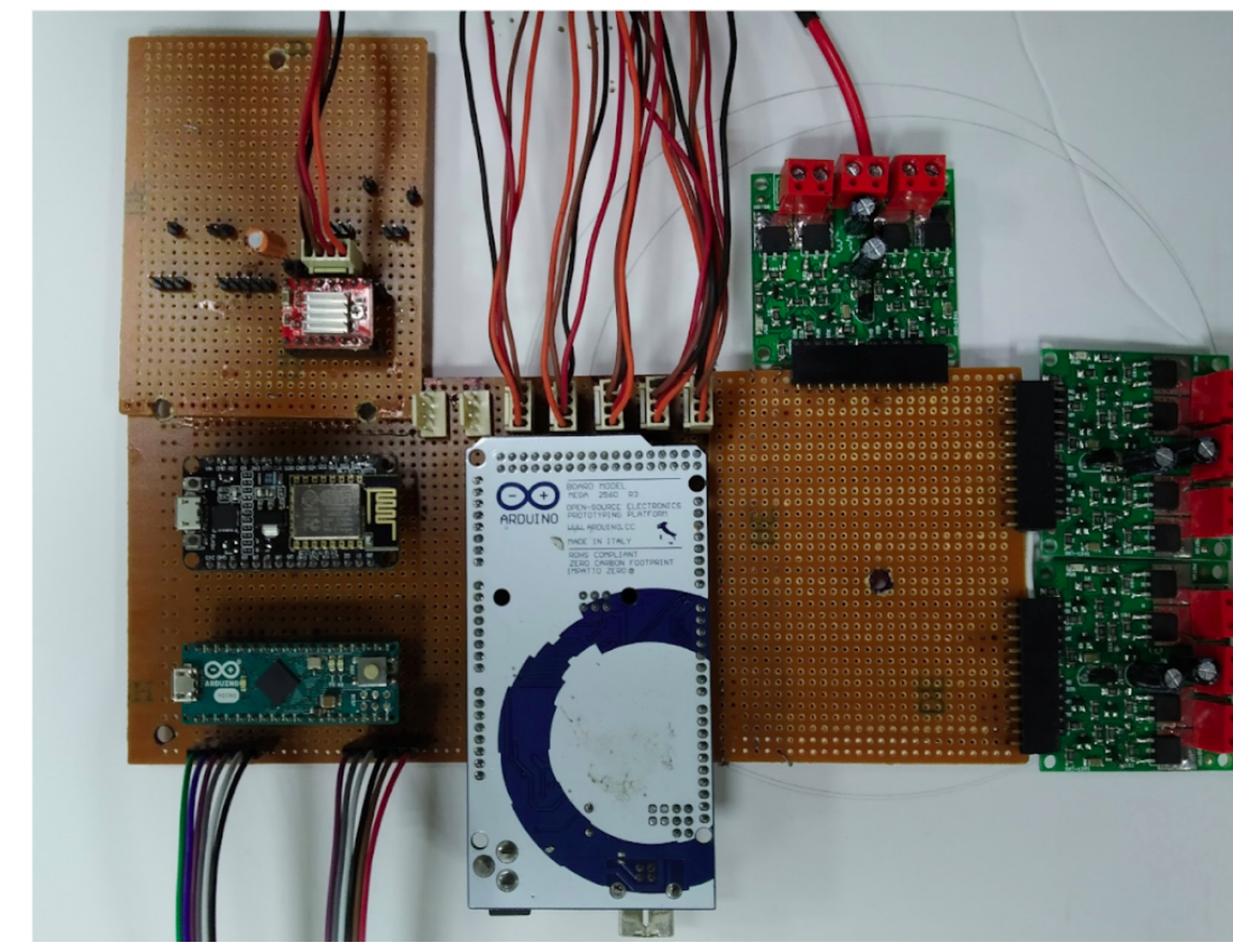
The final process under farming is harvesting where in the crops are cut down or chopped using the designed harvesting tool. The harvesting tool used in our bot is driven by a dc motor which rotates the harvesting tool at a sufficiently high rpm to cut down the crops. Harvesting tool consists of blades which are attached to the periphery of a circular wheel.

Rack and pinion mechanism has been used to move the harvesting head in the Z-axis. The height of the head can be varied during operation in accordance with the type of crops.

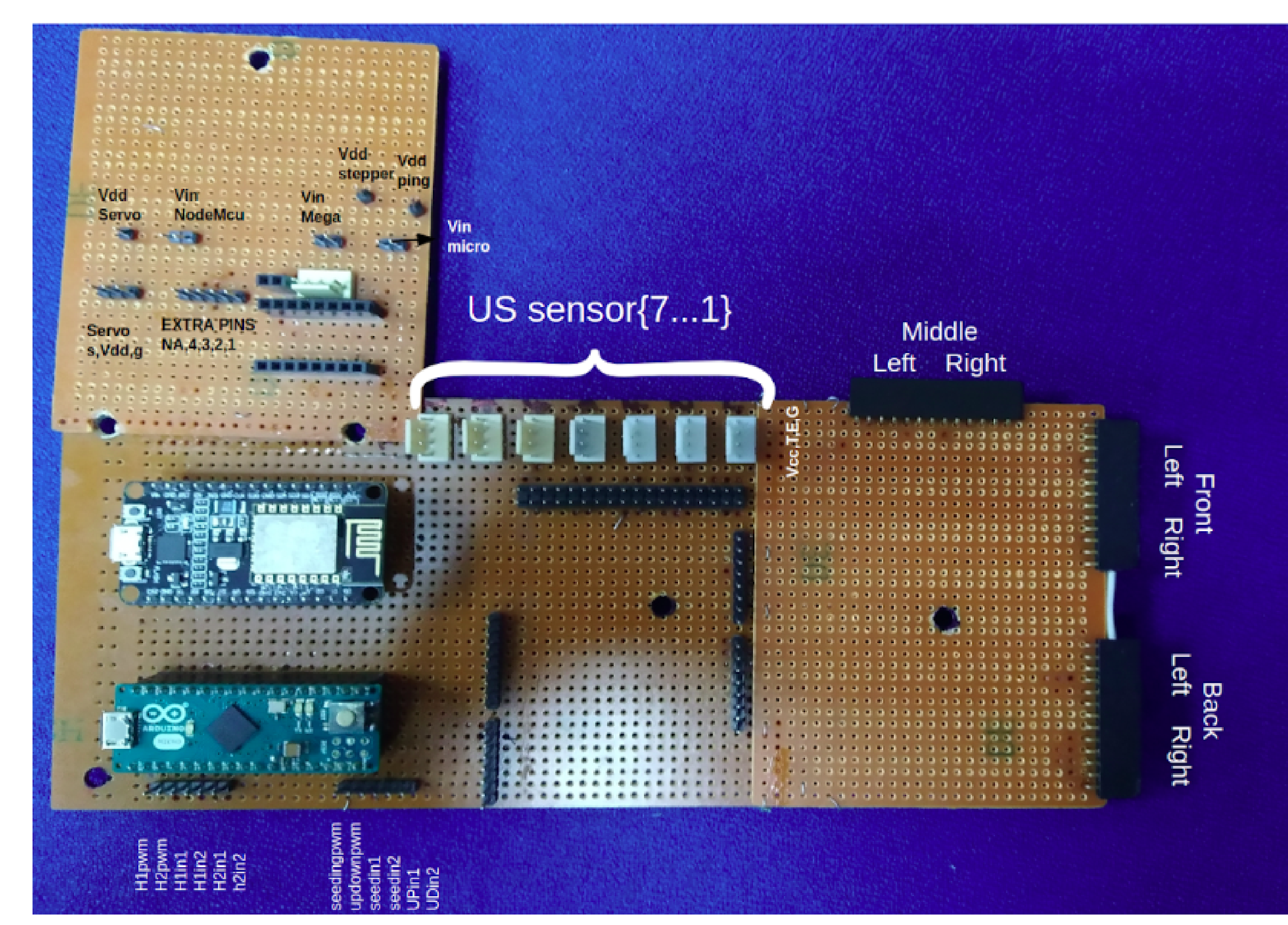


ELECTRONICS

For the wireless communication of data, we have used NodeMCU ESP8266. It helps us to communicate with Arduino MEGA and Arduino MICRO using serial pins The Node MCU is an open source firmware and development kit that helps us to prototype our IoT product with ArduinoIDE. It includes firmware which runs on the ESP8266 Wi-Fi SoC. And hardware which is based on the ESP-12 module. . Serial is used for communication between the Arduino boards and NodeMCU. All ESP boards have at least one serial port (also known as a UART or USART): Serial. It communicates on RX and TX.

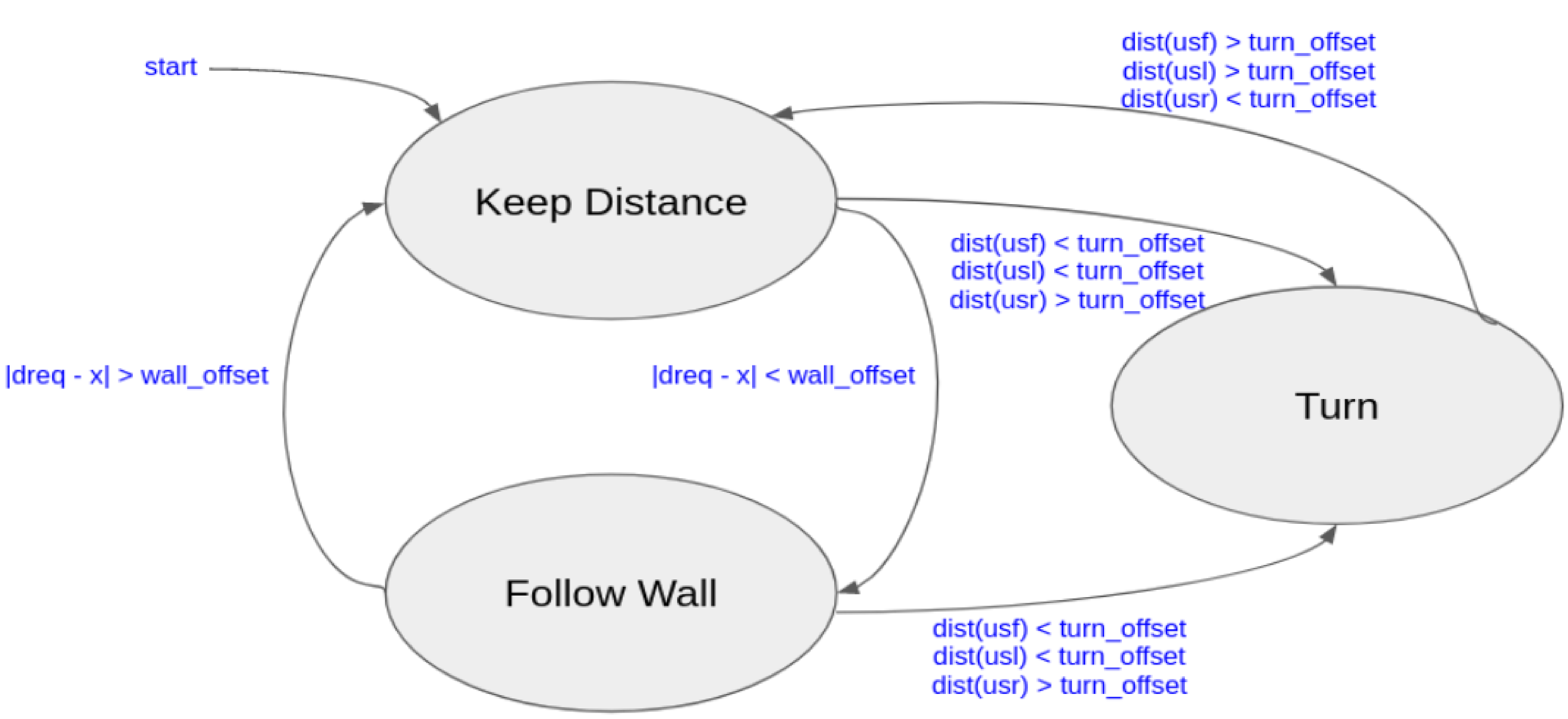


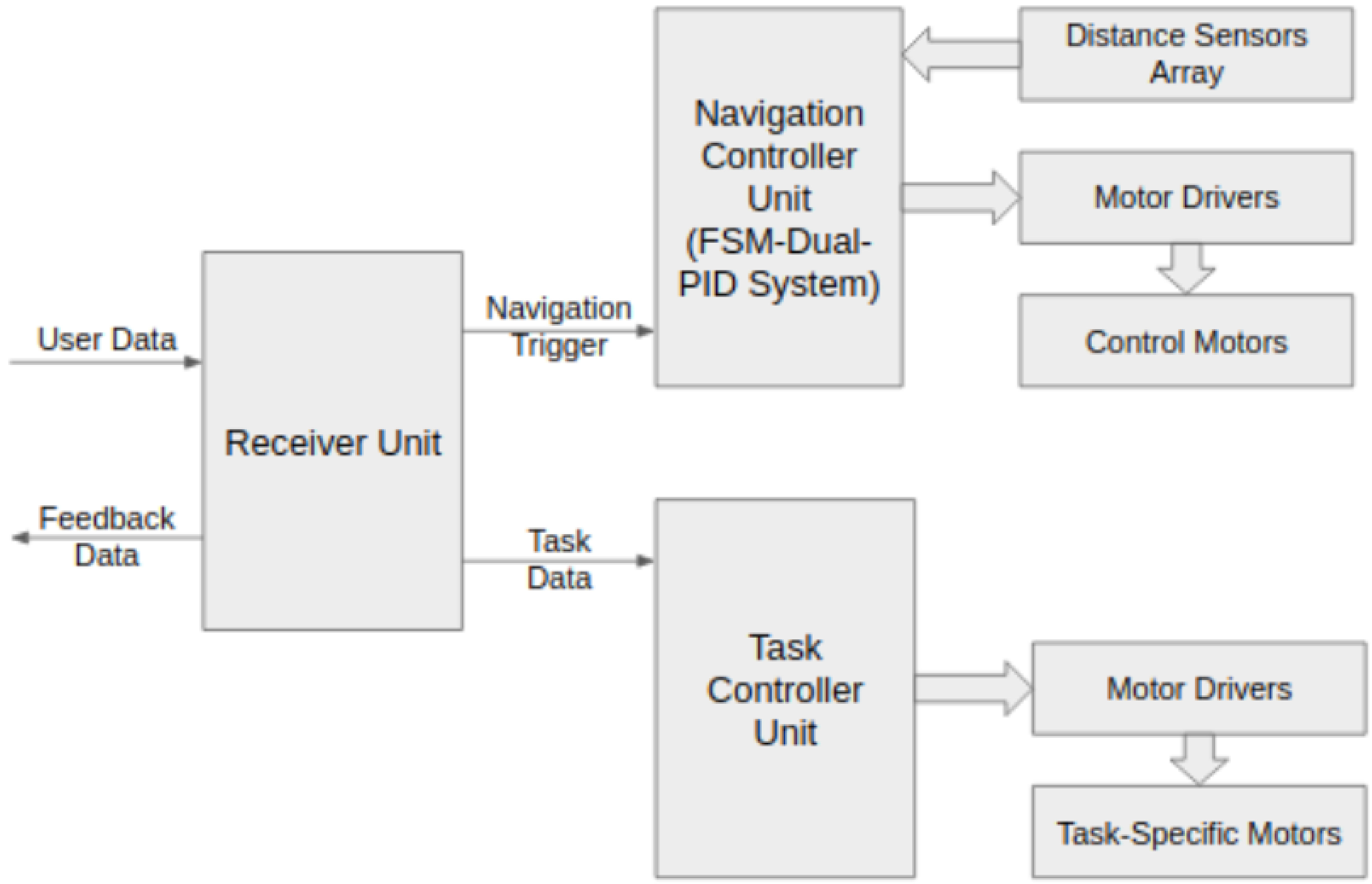
Arduino MEGA takes care of the Autonomous Navigation whereas Arduino MICRO controls Seeding and Harvesting. NodeMCU creates a WiFi Hotspot. The user connects to that WiFi using a device. Opening the dedicated IP address, the user will see the shown window, where the user can give the required commands. NodeMCU will then give serial commands to the Arduinos.



CONTROL AND NAVIGATION

The Robot’s control architecture follows a Finite State Machine(FSM) formulation with different behaviours as the corresponding states. The complete structure is explained below -





Where,

d_req → distance to be maintained from side wall

X → robot's current distance from wall

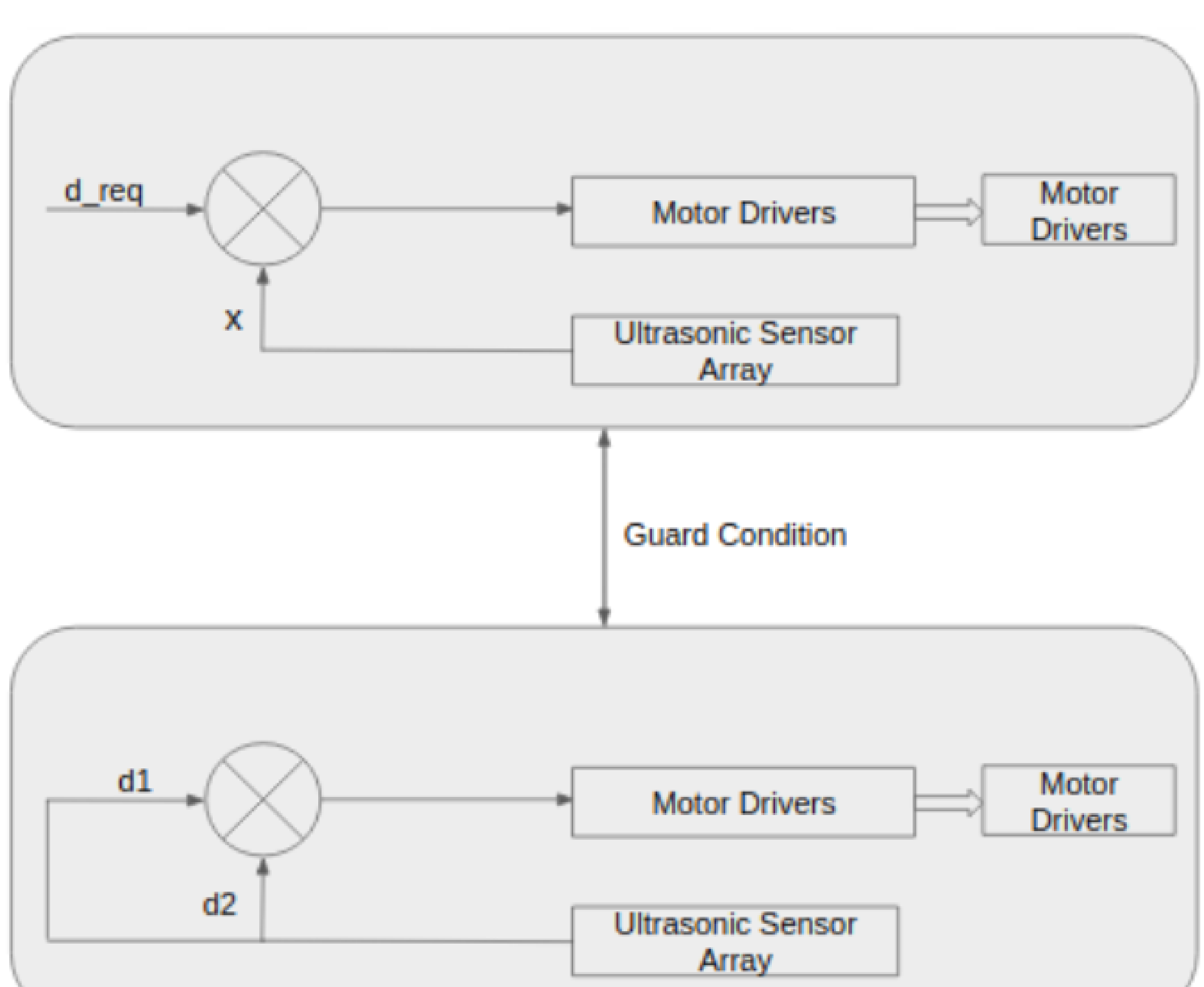
Wall_offset → minimum error

dist(usf) → distance values from front sensor(s)

dist(usl) → distance values from left sensor(s)

dist(usr) → distance values from right sensor(s)

turn_offset → minimum distance for turning

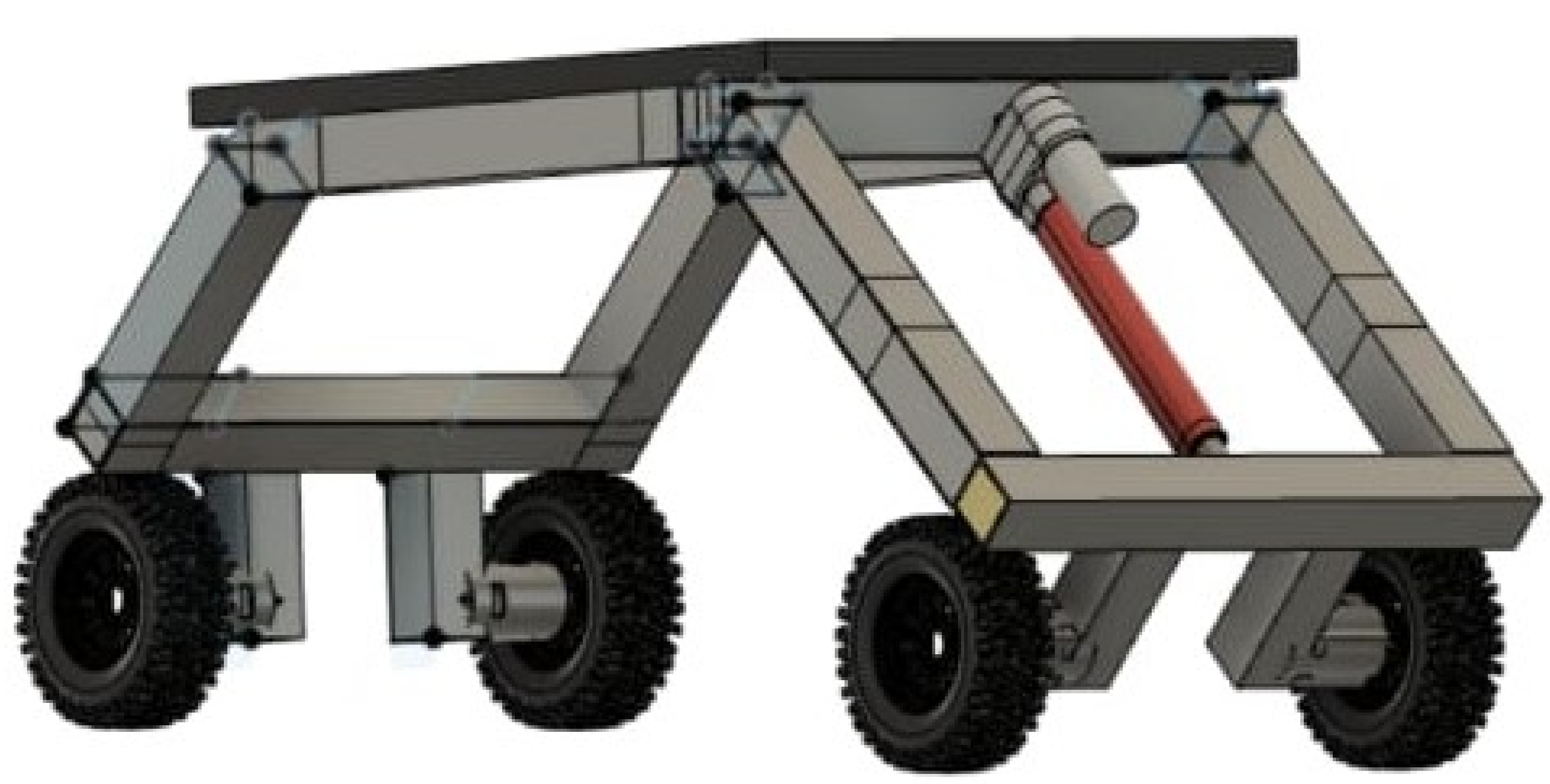


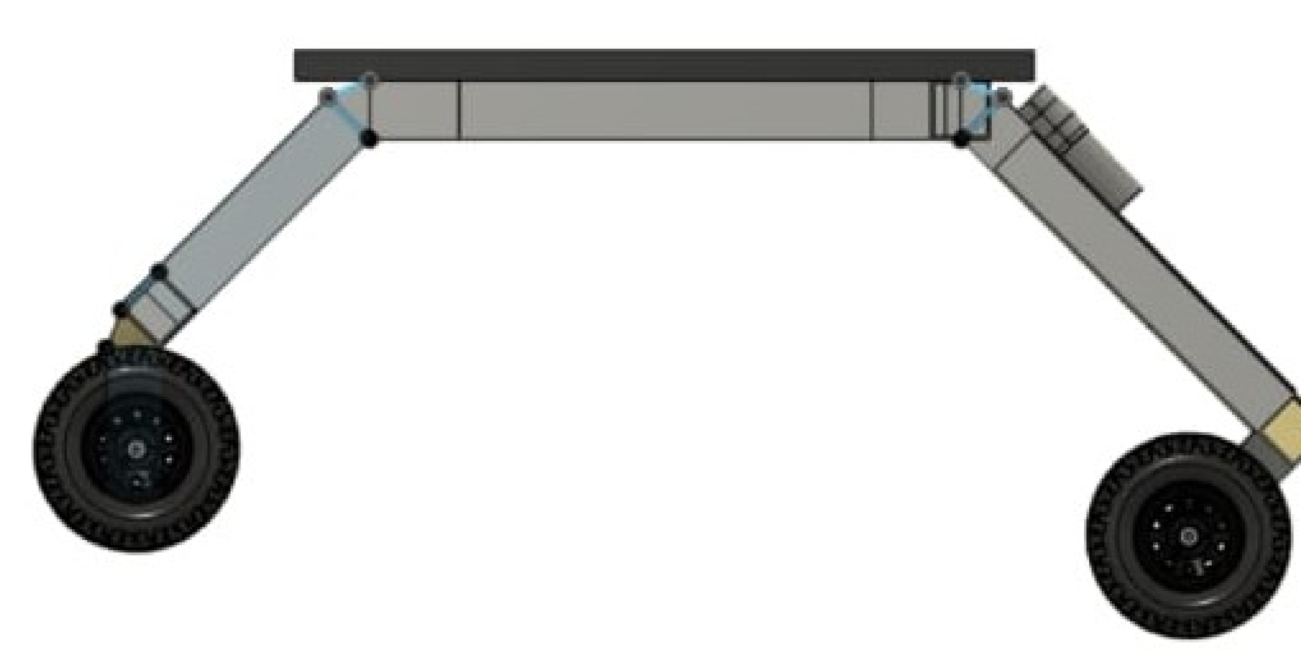
The entire autonomous navigation system starts at the “Keep Distance” node and runs until the robot reaches the required distance. When the guard condition is turned on, “Follow Wall” node is switched on maintaining the wall’s curve along the entire path. The two nodes switch between themselves to maintain the required path.

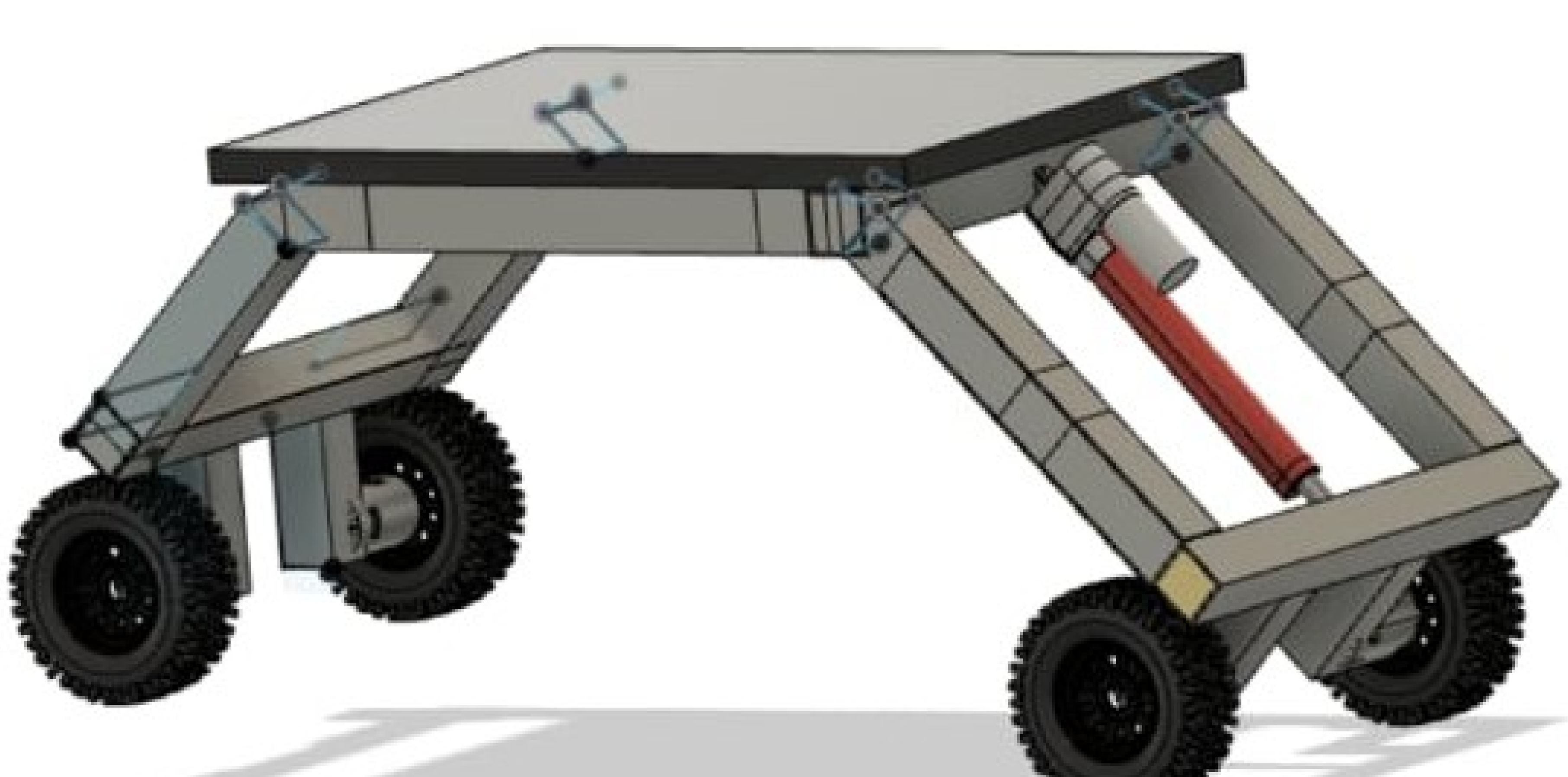
When the robot reaches the end wall i.e. front sensor provides a distance less than the given offset, the robot switches to the “Turn” node and hence performs a ~180o rotation. The rotation is kept in check using the sensor values and offsets. At the end of the turn it switches back to the “Keep Distance” node and the steps repeat thereafter until it reaches the red zone.

The “Keep Distance” node uses a Proportional Gain Controller to maintain the distance while the “Follow Wall” node uses a Proportional-Differential Gain Controller for the wall-following behavior. This ensures a smooth trajectory for the Robot.

CAD Model







Components and Cost Analysis

Name	Qty	Price
Mechanical		
Wheels	4	3200
Dc Motors (type 1)	5	4500
Dc Motors (type 2)	3	750
Servo	1	350
Servo Mini	1	150
Water Pump	1	500
Aluminium Case	4 meters	1000
		10450
Electrical		
Ardiuno Mega	1	750
Node MCU	1	300
Arduino Mini	1	150
Ping Sensor	5	500
Motor driver	4	1600
		3300
Power Supply		
Lipo Batteries	5	**12000**

The cost of the proposed bot is Rs. 25750 and the cost can be reduced to 15000 by using a single power source instead of 5 lipo batteries. Under mass production the cost can be further reduced to around Rs 12,000. Commercially available bots or drones performing a particular utility, cost around Rs 80,000-1,00,000. Considering cost-effectiveness and versatility, the bot proves to be a much better option than the existing commercial agricultural bots owing to the economic conditions of the regions where terrace farming is performed.

AGRO-ECONOMIC ANALYSIS AND IMPACT

Terrace farming is carried out in the hilly areas. Usually, these are the most under-developed regions in a country. The challenges of terrace agriculture include lack of quality land area for agriculture, erosion and loss of soil fertility, low yield, poor access to agricultural inputs and services, lack of mechanization, labor shortages, and poverty. Agronomic strategies that could help address these concerns include intensification of terraces using agro-ecological approaches along with introduction of light-weight, low-cost, and purchasable tools and affordable inputs that enhance productivity and reduce female drudgery.

By providing a quite versatile, efficient and cost-effective solution, this bot tries to cater the requirement of the farmers. The bot enhances the yield by using minimal human labour. Considering a country like India, where agriculture employs 50% of the work force and contribute 17-18 % of the country's GDP, the impact created by such a bot is huge.

Conclusion

Thus, this bot has the potential to replace all the existing robotic systems or those systems which still require a lot of manpower; hence change the course of the future. Its simplicity and cost effectiveness have been its major weapons. Limited hardware use makes it easy to handle and maintenance free. A simple communication protocol enables the system to function without any technical problems and also provides real time solutions. In a broader sense, this bot can be configured and programmed to suit any modern day system environment.

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