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Automatic Multipurpose Agribot Using Arduino Mega and GPS Module Receiver

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Abstract:- Agriculture is one of the oldest forms of occupation. The use of tools and livestock in the agricultural process has reduced the human effort. Major factors that affect agriculture include less holding area, shortage of seeds, fertilizers, labour and uncertainty of monsoon. The mechanization of agriculture refers to the use of tools or machines in the agricultural process that potentially reduces the human effort. Although it reduces the human effort in the agricultural process, it requires complete human interaction. The automation and robotics application in the branch of agriculture is at the booming stage when compared to its wide range of application in other sectors. Many researches have been done in this field to automate the process. In the present paper an effort is made for the design and development of the robot that can perform various farming operations like ploughing, field levelling, seeding, watering and pesticide spraying. The robot is basically a four wheel robotic car. The main component here is the Arduino which controls all the process. The bot is controlled with the help of RF remote. This RF remote has mutiple buttons for controlling various farming operations. The bot can navigate the farm in two modes manual mode in which the direction to the bot is given by user and automatic mode in which bot autmatically navigate through the farm without the need of directions from user. This automatic navigation is possible with the help GPS receiver and magnometer. While navigating through the farm the bot can do any of the farming operation depending upon which opertaion is turned ON by user. Seeding and watering operations happens in a specific inetrval depending upon the consecutive distance between two crops and this interval can be easily change by manipulating arduino code. Also the design is such that seeding and watering is done parallelly in 3 tracks which reduce the farming time drastically. Pesticide sparying opertion is done continuously. Grooves mounted at the back of agribot helps in ploughing the field as bot moves forward. Wodden slab mounted at the back act as a field leveller so as to close the dug tracks. The robot developed overcomes the drawbacks in the traditional method of seeding and watering which includes wastage of seeds and water, high labour wage, lower utilization of land etc. By the application of automation and robotics in the field of agriculture it is possible to increase the overall efficiency of the agricultural process and can mitigate effects of labour.

Keywords:- *Agribot, Ploughing, Seeding, Watering, Pesticide Spraying, Arduino, GPS.*

I. INTRODUCTION

Agriculture was the key development in the rise of human civilization. As the time passed we have seen remarkable changes in the field of agriculture due to the introduction of new technology which has resulted in the develpoment of world agricultural market. Robotics is the branch of technology that deals with the design, construction, operation and application of robots, as well as computer systems for their control, sensory feedback and information processing. The system that can do agricultural work without the need of human intervention is the need of today's world. These type of intelligent systems having robust and feasible model with a number of functionalites is the demand of future in every field of technology. Precision farming plays a vital role in agriculture field to fulfill the demand of agricultural sector and food industry. Agriculture is an expensive wildly wasteful industry. The precision farming movement may not solve every problem the industry face, but it have the potential to improve sustainability and efficiency. Before this, precision agriculture equipment was only available in the form of heavy machinery. That’s why our system brings precision agriculture technology to enviromentally conscious individuals.

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Fig 1. Evolution of farming

Our system is designed in such a way that it grows variety of crops. The sytem is controlled with the help of RF remote. Seeding and watering mechanism on the chasis are to sow the seed and to pour water, pesticide spraying mechanism is also mounted for pesticide spraying. All this farming operations are done while bot navigate through the farm automatically using GPS or by manually controlling the bot by giving directions to it.

Farmers today spend a lot of money on machines that help them decrease labour and increase yield of crops but the profit and efficiency are little less. Hence automation is the ideal solution to overcome all the shortcomings by creating machines that perform the operations and automating it to increase the yield on a large scale. This will help the farmer to control the agricultural works from a far distance without going in the field with an easy control.

II. LITERATURE SURVEY

In [1] author decribes a system that can used for farming operations like seeding, watering and fertilizing. It is a four wheel robotic car controlled by ARDUINO microcontroller. There are 4 seeding wheels so that parallelly 4 tracks can be sown at a time. For watering purpose they have used water pump which pumps the water at specific interval and the same watering mechanism is used for pouring wet fertilizers.

In [2] the author gives an overview of the proposed system. The prototype of an autonomous Agriculture Robot is presented which is specifically designed for seed sowing task only. It is a four wheel vehicle controlled by LPC2148 microcontroller. Its working is based on the precision agriculture which enables efficient seed sowing at sowing at optimal depth and at optimal distances between crops and their row, specific for each crop type.

[3] is a article in which author has proposed a system which is a four wheel robotic car that automatically navigates with the help GPS receiver and magnometer. ARDUINO is used to control the overall system. Multiple waypoints are feeded into the system which are basically the latitude and longitude of points where the bot is supposed to reach. One by one each waypoint is set as goal and bot is navigated to the waypoint automatically. This iteration continues till all waypoints are reached.

Problem Statements

In today's farming system there are many problems faced by the farmers which are given below;

1. Man power shortage is the major problem faced by all the farmers nowadays.
2. Inefficient traditional farming techniques leads to wastage of useful resources.
3. Hazardous pesticides which leads to farmers death.
4. Excess time is consumed in performing individual process.
5. Cost is relatively very high in traditional farming system

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Objectives

The objectives of the proposed Agribot are given below

1. There are 3 Seeding wheels for Seeding mechanism, Watering mechanism and Pesticide spraying mechanism.
2. Special Spraying mechanism for spraying pesticides is also mounted on the chassis which will reduce farmers death.
3. Reduction in the cost due efficient use of resources.
4. Efficient use of farm.
5. Reduction in man power is achieved by using new technology.
6. To reduce the labour cost and time required for multiple operations of farming system.

III. PROPOSED SYSTEM

3.1 Procedure Adopted

The transmitter section of the robot consists of HT-12E Encoder IC, RF Transmitter and DC battery of 9V. HT-12E is an encoder IC that is often associated with RF Transmitter module. It converts the 12-bit parallel data to serial data. The 12-bit data is divided into address and data bits.

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The operation performed by the robot depend on the buttons pressed on the remote controller. The data through the buttons will be encoded with the help of the encoder. The encoded data will be transferred to the transmitter and via antenna the code will be transmitted to the receiver side. The transmitted data is given to the main heart of the receiver section i.e. Arduino via the transmitter.

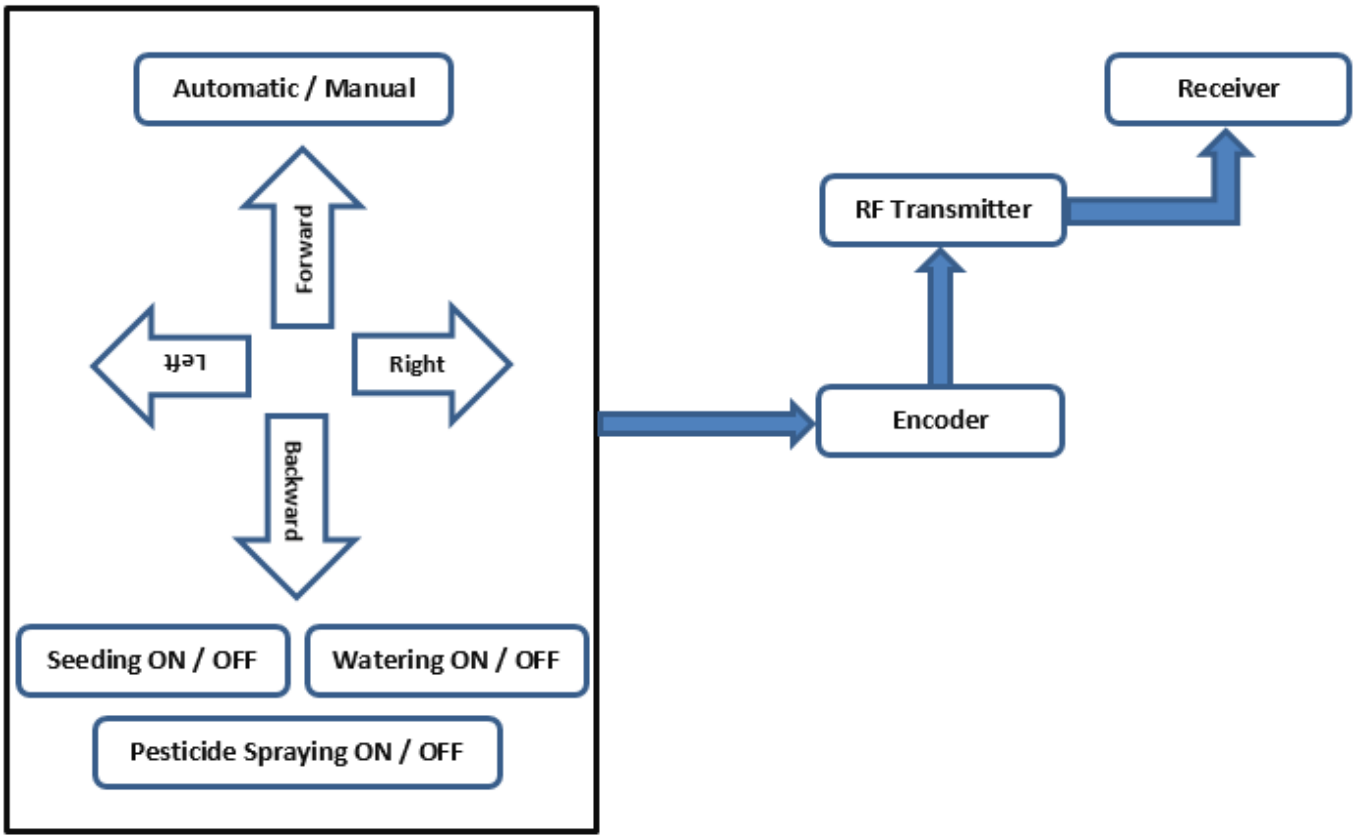


Fig 2. Block diagram of Transmitter Section

To choose between two different modes (Automatic or Manual mode) a SPST (Single Pole Single Throw) switch is used. If we choose the maunal mode the bot can be navigated with the help of the 4 push buttons (Forward, Backward, Right and Left) which are for directions. If we choose the automatic mode the bot will automatically navigate through the farm without the need of directions from the user. There are 3 SPST switches used to control the 3 farming operations which are Seeding, Watering and Pesticide Sparying. Each of these farming operations can be turned ON/OFF using there respective switches.

The receiver section of robot consists of RF receiver, HT12D decoder IC, Arduino, GPS, magnometer and the various components required for various farming opertaions. For movement of bot there are four motors used and they are controlled by a L293D motor driver IC. For seeding a DC motor is used which helps in movement of shaft which is associated with the seeding operation and for pesticide spraying a water pump is used. Both seeding motor and water pump is controlled by a single motor dirver IC. Watering mechanism consists of a solenoid valve which is mounted at the bottom of water tank.

GPS receiver and magnometer mounted on robot helps in automatic navigation while minimizing the deviation. While navigating automatically the robot stops after a certain regular intervals where it find out its current location from GPS receiver module and calculates the deviation w.r.t the destination location and the distance between the bot position and destination location.The deviation calculated helps in minimizing deviation thus keeping the robot on the track.

The Arduino forms the brain of the machine and controls all the operations like seeding, watering and pesticide spraying. Arduino is programmed in such a way that when it receives the decoded message from the receiver, it gives the given command from the remote-control buttons to the respective sections which operation needs to be performed.

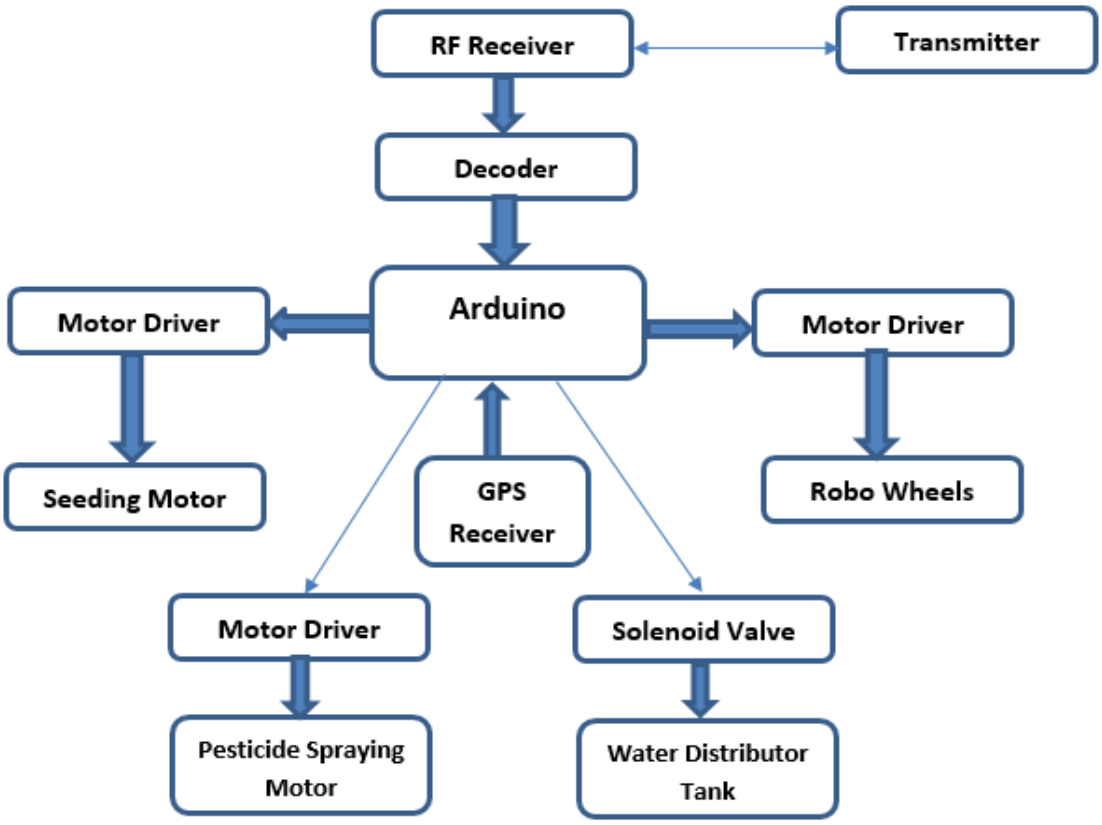


Fig 3. Block Diagram of Receiver Section

3.2 Technical Development and Methodology Adopted

3.2.1 Technical Development

I. Motor calculations:

For selecting appropriate motors required for performing different operations we have the done the following calculations: (NOTE: 0.66 factor in the formula is consider due to environmental resistance)

$v_{max} = Velocity\ of\ agribot = 0.15\,m/s$

$a_{max} = Acceleration\ of\ agribot = 0.30\,m/s^2$

$r_{wheel} = Radius\ of\ wheel = 0.07m$

$m = Mass\ of\ agribot = 6kg$

$n_{wheel} = Speed\ of\ motor$

$M = Torque\ of\ motor$

$$v_{strafing} = \frac{v_{max}}{0.66} = \frac{0.15}{0.66} = 0.22\,m/s$$

$$a_{strafing} = \frac{a_{max}}{0.66} = \frac{0.30}{0.66} = 0.45\,m/s^2$$

$$n_{wheel} = \frac{v_{strafing}}{2\pi r_{wheel}} * 60 = \frac{0.22}{2\pi * 0.07} * 60 = 30RPM$$

$$F = ma = 6 * 0.45 = 2.7N$$

$$M = F_{wheel} * r_{wheel} = \frac{2.7}{4\ wheels} * 0.07 = 47.25mNm$$

On the basis of this calculation we have selected a **12V DC gear motor** with **30RPM** speed and **2kg-cm** torque.

II. Battery calculations:

For selecting appropriate battery required for robot to drive the all opertions we have done the following calculations: Below is the table that gives the illustration about the current requirement of main components of bot with the total current requirement of bot.

Table 1: Battery calculations

Components	Current Requirement in mA
Arduino Mega	200mA
DC motor (x5)	1500mA
Pumping motor	220mA
Solenoid valve	400mA
GPS module receiver	45mA
Motor driver(x2)	100mA
Total cuurent requirement	2465mA ~ 2500mA

Thus, Battery capacity = Total current requirement * Amount of time = 2500 * 2 = **5000mAh**.
On the basis of this battery calculations we have selected a **12v lithium - ion battery** with the capacity of **5000mAh.**

IV. NAVIGATION VECTOR CALCULATION

Most important factor that we need to calculate for automatic navigation is Navigation Vector. Calculation of navigation vector involves finding two parameters. This two parameters are distance error and heading error.

Distance error:

Latitude of longitude of current location of bot can be found using GPS reciver and the latitude and longitude of destination is already feeded into the system. Thus by knowing all the parametrs shown in the figure we can calculate "d" which is distance error using Haversine formula.

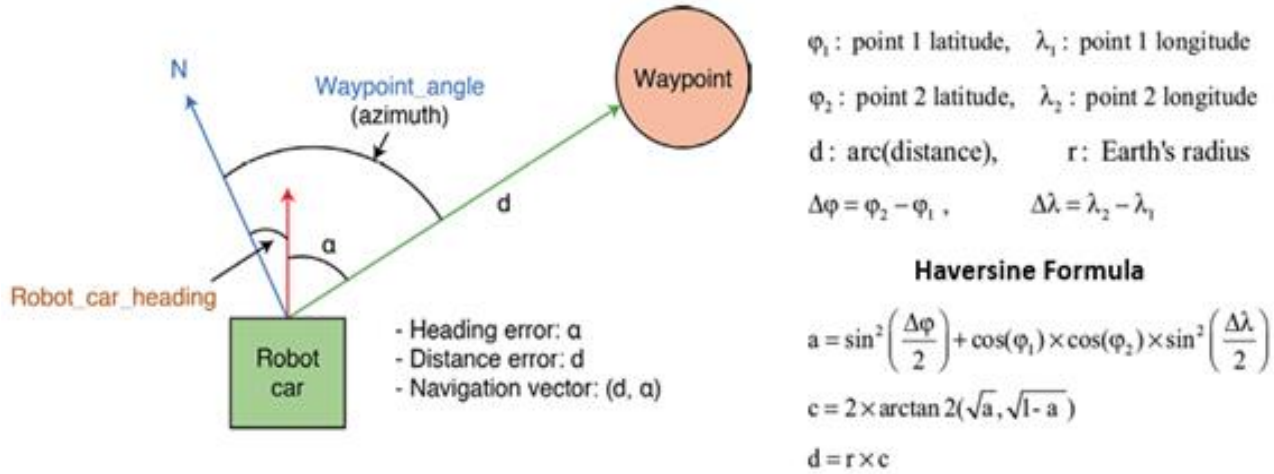
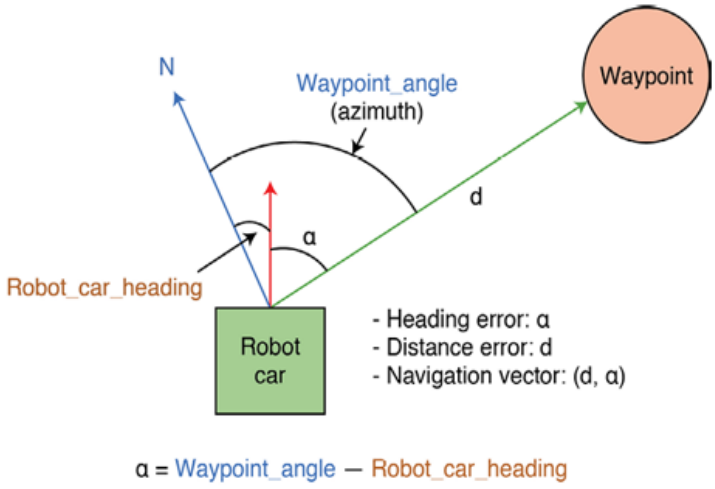


Fig 4. Distance Error

Heading error:

Latitude of current location can be known through GPS reeciver, latitude of destination is already feeded into system and Robotic_car_heading is known through magnometer. Thus by knowing all the parameters shown we can calculate the devation of goal w.r.t magnetic north i.e Waypoint_angle using Forward Azimuth Formula and then by subtracting the Robotic_car_heading from the Waypoint_angle we will get heading error.



φ_1 : point 1 latitude, φ_2 : point 2 latitude

θ : waypoint angle or azimuth

$\Delta\lambda = \lambda_1 - \lambda_2$

Forward Azimuth Formula

$$\theta = \text{a tan 2}(\sin \Delta\lambda \times \cos \varphi_2, \cos\varphi_1 \times \sin\varphi_2 - \sin\varphi_1 \times \cos\varphi_2 \times \cos\Delta\lambda)$$

Fig 5. Heading Error

2.2.2 Methodology Adopted

In the designed system, entire robot set up is controlled by Arduino Mega. The seeding, watering and pesticide spraying mechanism can be controlled using remote. The speed of the dc motor is controlled by Arduino.

1. Seeding: The seeding mechanism consists of a seed container to store the seeds. This seed container is divide into three equal sections. Each section is equipped with a seeding wheel which has grooves at regular inetrvals. This grooves on seeding wheel are there so as to hold the appropriate amount of seeds. All this wheels are connceted to each other via single shaft. The shaft is attached to a DC motor via coupler. Thus as the motor starts the coupler attach to the shaft starts rotating which in turn rotates the seeding wheel resulting into the seed to fall outside the container through small container opening. At the outlet of seed container there are flexible pipes attached so that seed can directly fall from container to the ground throngh the pipes. Each crop has different consecutive distance between two crops so as to plant the crop according to that inetrval RPM of motor needs to be changed which can be easily done via manipulation of arduino code.

2. Watering: The watering mechanism takes place with the help of solenoid valve. This inlet of valve is mounted at the bottom of water tank and the outlet of it is attached to the water distrbutor tank. The water distrbutor tank has three outlets so that water is distributed into three equal amounts. This valve works on the principle of electromagnetics.Whenever the current flows through the valve the valve open ups thus pouring water into water distributor tank which distributes water into three equal amounts thus pouring water for the crops. The Arduino is programmed in such a way that it open ups the valve at the regular interval.

3. Pesticide Spraying: The pesticide spraying mechanism is done by a special motor used in pumping water. This inlet of water pump is attached to the same tank which is used for watering and the outlet of it is attached to the sprayer via pipe. Whenever pesticide spraying is turned ON the water pump starts pumping pesticde from the water tank to the sprayer. Thus spraying pesticide in the farm.

Fig 6. Model of Agribot

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4. Ploughing and Field Levelling: There are grooves on the back side of the chasis . These grooves are there to plough the field for the seeding. As the robot moves ahead and seeding is done there is wooden slab which act as field leveller to close the pits ploughed by the grooves.

5. Navigation: As shown in the transmitter section block diagram there are two modes of navigation (Automatic or Manual). In manual mode the bot can be navigated with the help of the 4 push buttons (Forward, Backward, Right and Left) which are for directions.

In automatic mode the bot will automatically navigate through the farm without the need of directions from the user. For automatic navigation the most important factor we need to calculate is the navigation vector which consists of two parameters distance error and heading error.

Once we have known the navigation vector we first try to minimize the heading error which is the deviation of bot w.r.t to goal by either turning the bot right if the heading error is positive or to the left if the heading error is negative. It is difficult to make the heading error exactly to zero so for that we have defined a tolerance range. If heading error is within that range than it is fine. Once the heading error is minimized then we try to minimze the distance error by moving the bot forward towards the goal. As the bot moves forward the heading error goes on increasing so for that bot need to be stopped at regular distance intervals so as to again calculate the navigation vector and minimize the errors. This iteration of calculation of navigation vectors and minimizing the errors continue till the goal is reached. Once the goal is reached the bot searches for new goals and the loop continues till all the waypoints are reached. Below is the flowchart illustrating the automatic navigation of Agribot clearly.

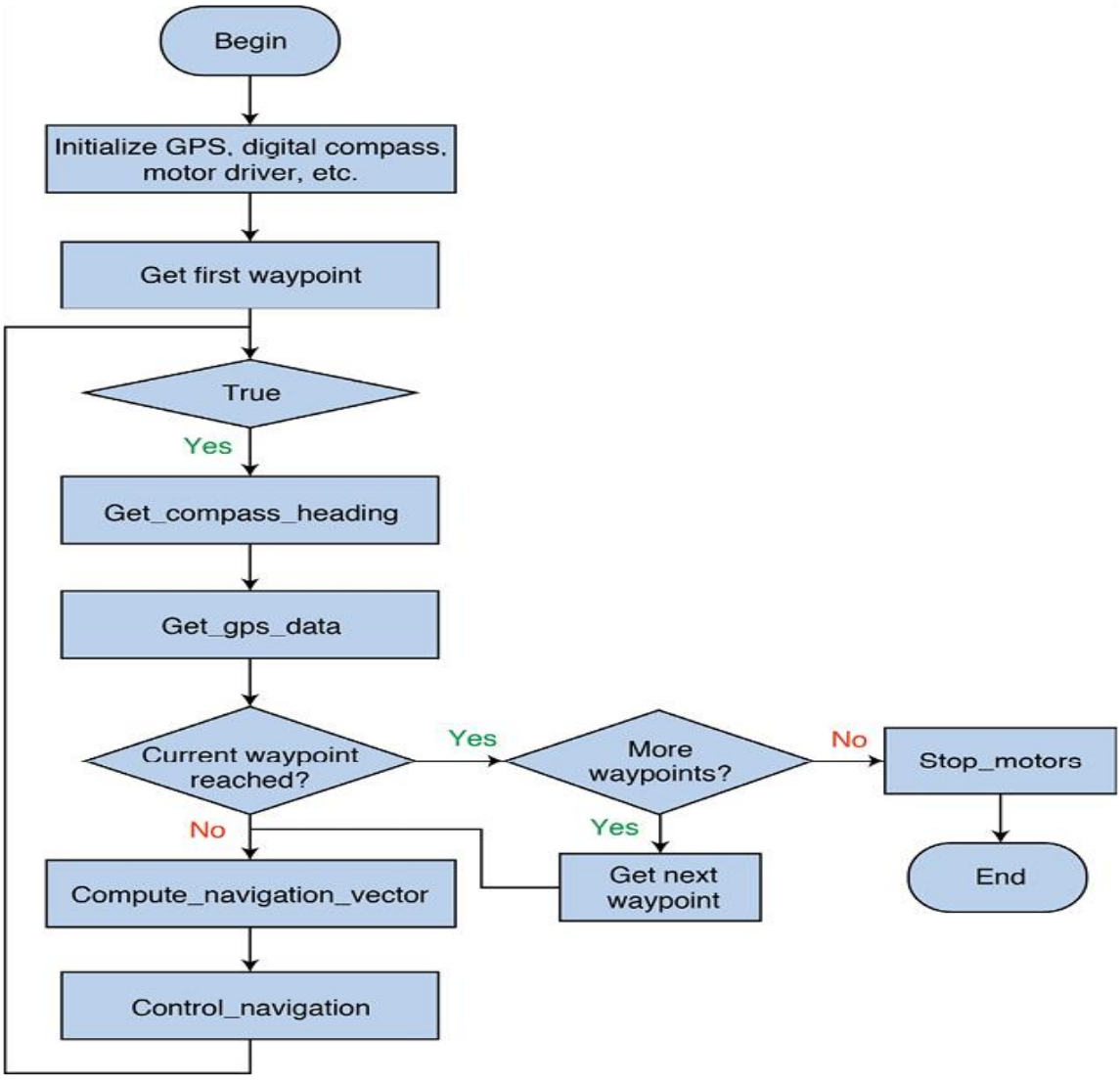

Fig 7. Flow chart of Automatic navigation

6. Farm Layout: Our Agribot will cover three tracks. Three tracks we are collectively calling as lane. Below is the pictorial representation of farm layout which gives clear idea about the farm and navigation of agribot.

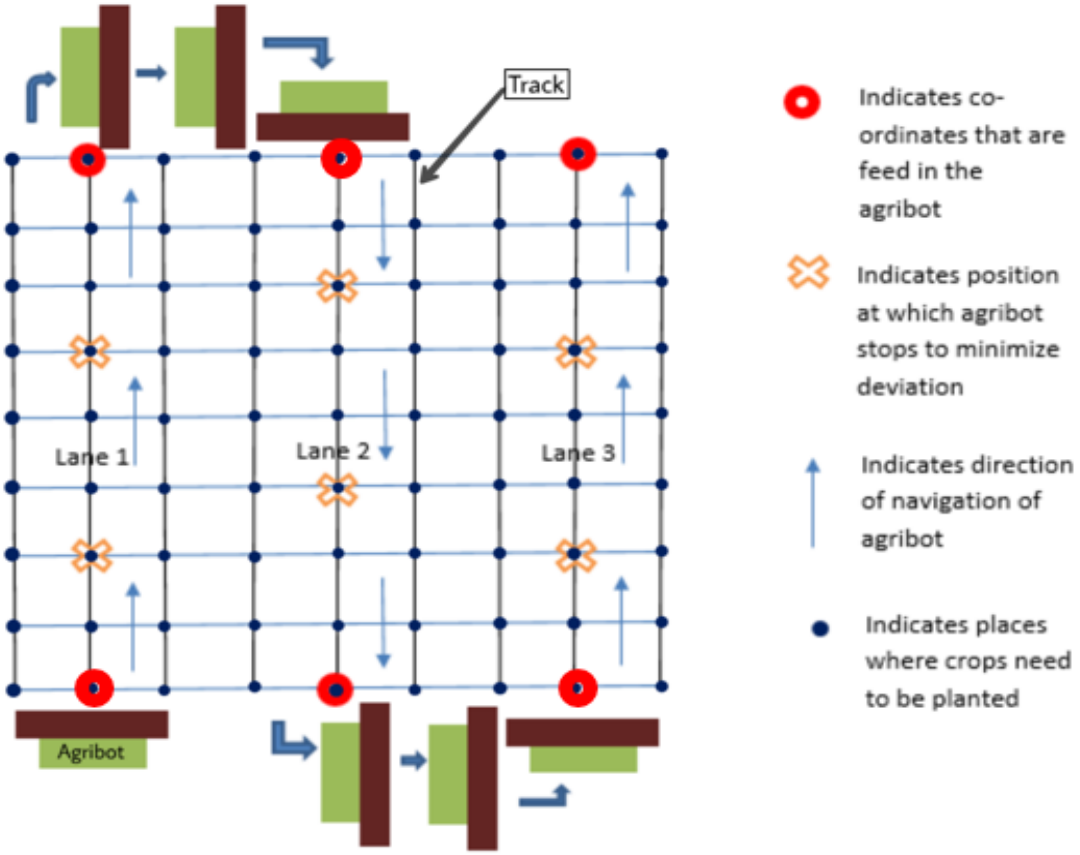

Fig 8. Farm Layout

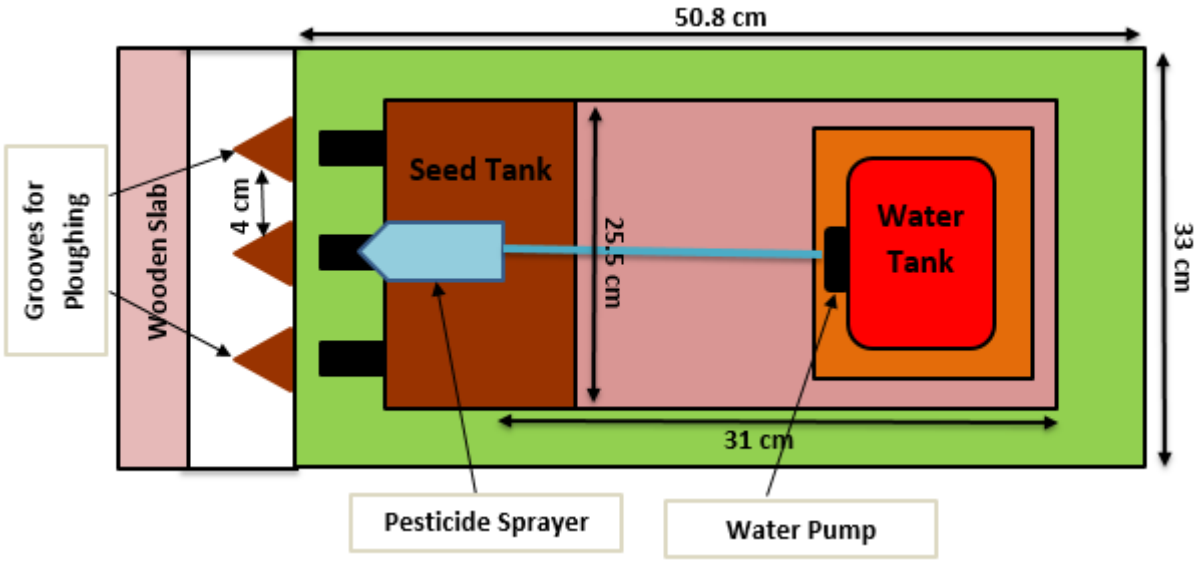

Fig 9. Design of Agribot

V. RESULT

The Agribot works in manual and automatic mode. In forward mode the seeding and watering is ON. Only in forward direction both seeding and watering are ON, unless in backward or sideways movement the seeding and watering is OFF. The seeding and watering will happen in a specific interval according to the code in the ARDUINO. This bot is universal with respect to the crpos used, the interval between two consecutive seed drop and water pouring can be changed in the code of ARDUINO.

Table 2: Agribot Parameters for Different Crops

SR. NO.	Crop Type	Interval	RPM of Seeding Motor	Delay between opening and closing of valve	Watering Interval
1	Wheat	2 inch	40	1 sec	1 sec
2	Toor	3 feet	10	2 sec	8 sec
3	Cotton	3 feet	10	2 sec	8 sec

Table 3: Comparsion of Our Proposed System with Refernces

Reference	Ploughing	Field Levelling	Seeding	Watering	Pesticide Spraying	Manual Navigation	Automatic Navigation
[1]	YES	NO	YES	YES	NO	YES	NO
[2]	YES	NO	YES	NO	NO	YES	NO
Proposed System							
	YES	YES	YES	YES	YES	YES	YES

VI. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

In this project we have built a farming robot which can perform multiple functions such as ploughing, field levelling, seeding, pesticide spraying and watering. We have efficiently build the proposed robot to reduce man power and health hazards caused by chemicals during pesticides spraying. The 3 seeding wheels reduces the time taken for sowing the seeds manually and 3 outlets of water helps in spraying water in less time. Also the automatic navigation implemented helps in doing all the farming operations without human intervention. Thus the skill labour required is less and the health hazards to the farmers is reduced significantly.

6.2 Future Scope

Apart from seeding, watering, pesricide spraying, the bot can be implemented with functions like monitoring, fruit picking etc. With the help of IOT we can have more efficient bot with the use of mobile applications. Lastly using Image processing and GSM the farm conditions and atmosphere condtions can be monitored making the bot highly efficient.

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