Agriculture automation system

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Abstract. Agriculture is one of the very old human occupation, but it is not a stranger to automation. The world population is increasing exponentially and with it comes the need to produce more food. Conventional methods require more manpower and water. This paper deals with a scaled down model of an agriculture automated system. The hardware employs linear guides in the x, y and z directions that allow agricultural processes like seed injection, humidity sending and watering with required precision thereby maintaining the crop and so it economically. The whole system is fully controlled and automated from the sowing of seeds to watering them. The hardware developed was tested for its functioning with the scaled down plantation model integrated to it.

1. Introduction

The purpose for developing Agricultural Automation System is to decrease labours and the related socio-economic condition prevailing. Artificial intelligence achieves many solutions in agriculture to processes related to seed sowing and harvesting, to improve efficiency and productivity. Currently there is less professional manpower in this sector which thereby leads to decline of the economy of the country. This is the main cause for automating the agriculture sector. In India 70% people totally dependent on agriculture[1]. Undoubtedly there is no substitution of food and better farming process is the only way to increase the production of food. In order to produce sufficient amount of food we must have to find some ways to make agriculture easier, time saving and computerized. Once, more than sixty percent of our total occupied people were directly and indirectly involved in farming. As time passes by, we can now see a completely different scenario. Nowadays, in many countries people are more centralized towards towns because farming is not an easy task and farmers don’t get enough earnings through farming. Recent statistics shows us that the growth rate of farmers in India has slowed down overlast decade and causing the fall in rice production. By automation of agricultural processes, people can easily monitor cultivation process from time to time even when they are not available in the field.

The proposed automated agriculture system involves precision agriculture and the integration of advanced technologies to existing farming practices in order to increase quality of agriculture products and production efficiency [2]. It also adds up to one more advantage of reducing heavy labour. Almost every part of farming can be automated by the technological advancements, from seed sowing to harvesting. Most of agricultural technologies fall into three categories that are
expected to become the support of the smart farm: autonomous robots, drones or UAVs, and sensors and the Internet of Things (IoT)[3][9].

Most industries are shifting towards automation and agriculture is also becoming a part of it. Almost every part of farming is labour intensive with similar process being repeated again and again, ideal for automated system. There is already been development of AgriBots, beginning to do various farming activities including sowing, watering, harvesting and monitoring [4 -8]. This new era of smart farming is the answer to increasing food production need with less man power. This paper deals with one of such automation processes involving dedicated hardware and integrated software that can be benefitting agricultural activity.

2. Methodology
2.1 Overview of the Agriculture Automation System

The overview of the proposed Agriculture automation system is shown in the Figure 1 and the explanation is given below.

![Figure 1. Block Diagram of Agriculture Automation System](image-url)

The master controller for this agricultural automation system is an Arduino ATmega2560 processor which is used as the main controller in this project. It is programmed to accept the inputs from the sensors and generate control action depending on the input magnitudes. The Arduino works with a 12V DC source. It also sequences the operations and monitors the complete system. Soil moisture sensors are used as input device to the processor. Four stepper motors are involved to derive the mechanism in X, Y and Z directions and motor driver 4998 is used to control the motors. Two motors for X-direction; one motor for Y-direction and one motor for Z-direction are used. Solenoid valve is used for control of the watering process. Relay is used to control solenoid valve and relay gets energised depending on the input from soil sensor to the Arduino.
2.2 Design of agriculture automation system

The overall design of the Agriculture Automation System is shown Figure 2.

![Agriculture Automation System](image)

**Figure 2.** Agriculture Automation System [5]

2.3 Motor torque and power calculation

There are 4 motors in the overall system, 2 motors in x-axis 1 motor in y-axis and 1 motor in z-axis respectively. Considering the weights of axes bars, motor’s screws, aluminium plates, solenoid valve, vacuum pump, and thereby calculating the torque and power calculations.

- Weight of Y-Axis bar=1500gm
- Weight of Aluminium plate=200gm
- Weight of Solenoid valve and vacuum pump=300gm
- Weight of 4 Motors=250*4=1000gm
- Total weight=3500gm {Rotational part handle by motors}
- Acting Torque=3.5*9.8*1.5cm=51.45Ncm
- Holding Torque=5.45kg-cm
- Power=10.44*100*(2*3.14/60)=5.33W {speed=100rpm}

2.4 Hardware Components

Based on the design procedure and the obtained specifications, the hardware components are selected for the automation scaled down model as shown in Table 1.

| Major components of the Agriculture Automated system |
|-----------------------------------------------------|
| **Components** | **Specifications** |
| NEMA17 Stepper Motor | Step angle: 1.8degree  
Weight: 250gm  
Rated current: 1.68A, 5V  
Holding Torque: 7.5kgcm |
| Electric Solenoid Valve | Mode: Normally closed  
supply voltage: 12V DC |
| Soil Moisture sensor | supply voltage: 3.3V or 5V  
operating current: < 20mA |
| Relay Module | Supply voltage: 3.3V or 5V |
3. Hardware Setup

3.1 Plywood Base Arrangement
For the model the cultivation land is scaled down to a 2.5m x 1.5m plot using a plywood box. Plywood with required dimensions Length: 2.5m, Width:1m and a Depth of 25 cm was cut out for fillings and fixing the tracks.

3.2 Overall layout with X-axis and Y-axis.
The X-Axis tracks and Y-Axis tracks made of aluminium is fitted on to the plywood base as shown in Figure 6 X-Axis tracks tiers are used to move in X direction. Y-Axis tracks were framed tiers which hare connected with the help of sheet metal fixed with bolt and nuts on to the X-axis tier. Motor is held by sheet metal for Y direction. And pulley is connected through shaft of motor to tiers so that when motor is rotate in any direction, the system will move in Y-direction.

3.3 Z-axis with solenoid valve and soil sensor connections.
The Z-Axis control is made possible by a Lead screw which was motorised as shown in Figure 7. Depending on the system programmed the lead screw drives down the sensor and watering mechanism. The soil sensor will check for the moisture content in the soil. Based on the measured value the relay connected to solenoid valve opens or closes accordingly from the Arduino controllersignal.

Figure 3. X-axis and Y-axis Tracks

Figure 4. Movement in Z-axis
3.4 Soil Sensor Connection

Solenoid valve and soil sensor is connected on to the Z-axis component using Lead screw. The soil sensor is placed little more down than solenoid valve so that when the lead screw moves in Z-Axis, it will go down first inside soil and it will check for the humidity. A delay is given to enhance the soil sensor to measure the value and is read by the Arduino controller which will give signal to relay to solenoid valve to turn it on or off as shown in Figure 8.

![Figure 5. Solenoid Valve and Soil Sensor](image)

4. Algorithm

4.1 Flowchart of Agriculture Automation System:

The A4988 driver board, relay, soil moisture sensor are connected to the Arduino ATmega2560. Both relay and A4988 motor driver uses only digital pins to get signals from Arduino ATmega2560 whereas the soil moisture sensor can operate on both digital and analog signal. So relay and motor driver is configured to digital pins where as soil moisture sensor is configured to analog pins of the Arduino. Both step and direction pin is assigned to different digital pins of Arduino accordingly.

For the scaled down model, it needs to sow seeds and irrigate in 4x4 places. This 4x4 setup was taken according to the plant and measurements of the hardware setup done. The diameter of motor was 7cm. Since both diameter and hardware setup measurements are predefined, the steps signal can be given accordingly to cover the 4x4 position. This 4x4 setup can be guided having a count variable for all position it covers. So, two different loops are created, guided by the count variable for X and Y axis. As both the count variable becomes maximum limit i.e., 4, count variable is reinitialized. The outer loop is used to run the system in X direction. At the increment of each “Count_x” variable, the Z axis motor operates to drive the lead screw connected to it to reach the soil for either seed sowing or soil moisture check. But if the count variable is not maximum the respective motor step signals will be given to drive the motor to move the system in X or Y direction.

As the system traversed to any one of the spot in 4x4, the Z axis motor step signal is given to move the system downward to reach the soil. After the system reaches the soil, either the seed sowing or soil moisture content is checked for watering. For irrigation an electric solenoid valve and relay is used to control the flow of water. Based on the pot test performed the threshold value
of the soil taken was about a threshold value. If the soil moisture sensor value is greater than the threshold value (dry soil), relay should turn on the electric solenoid valve till it becomes lesser than the value (wet soil). After completion of this process Z-axis motor direction pulse is given so that motor rotates in opposite direction to bring back to starting position. This process repeats after every six hours so that the plants do not run out of water. The system is totally automated and isolated with battery as power source for all the motors and components. The system reaches end only if there is power failure or external force stops it, until then the process keeps on continuing. The flowchart of the is shown in Figure 9

\[\text{Figure 6. Flowchart for the Agriculture Automation system}\]
5. Conclusion

5.1 Hardware Result and Discussion:
The motive of this work is to "Create an open and easy accessible technology for everyone in country to grow food and make better farming ". In order to complete this mission our aim is to "Grow a community that able to produces free and open-source hardware plans, data and enabling everyone to build and operate an agriculture automation system". And the mission is accomplished by the Agriculture automation system. Agriculture Automation system performs mainly processes prior to farming including sowing, and watering. The system performs many different tasks by automatically adding different tools to a universal tool mount, including a seed injector and a watering nozzle. It requires mainly electricity, Internet connection and water supply. The system is able to collect all data to take into account factors such as moisture content of the soil and senses it and then does the watering. System will be always in ON condition without any human interface and it will be checking all plants in gap of preset timing. Soil sensor will be checking condition either water is needed or not for a particular plant. Farming area is a structured like grid at the intersection part of column and row planting is carried out and watering is done on that particular area with the help of solenoid valve. Demonstration of the model automation system is shown in below Figure 10

![Scaled Down Lab Model of Agriculture Automation System](image)

Figure 7. Scaled Down Lab Model of Agriculture Automation System

5.2 Future Improvement
One way to solve our farming challenges is by practices collectively known as precision agriculture. Agriculture automation system can help to bring more precision techniques to farmers—beginning with small home gardens. Precision farmers can use technology like automation system to more efficiently use water, fertilizer, and other resources. They can give plants precisely the right amount of water, etc. Agriculture automation system, can make technology more advance and more capable

Next improvements of the project :-Sensing age of the a particular plant and weather conditions from both system sensors and external data from the internet and through Wi-Fi configuration utility allowing to access of the system from home with Wi-Fi enabled devices-laptop, smart phones,etc.
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