A unified five-in-one smart farming system

Kalagotla Chenchireddy, P Vijay Shankar
Department of Electrical and Electronics Engineering, Geethanjali College of Engineering and Technology, Hyderabad, India

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ABSTRACT

Agriculture plays a pivotal role in the economy and demands mechanization to boost both productivity and efficiency. This project introduces an automated agricultural system capable of executing five essential tasks: automated seed planting, weed removal mechanism, plough operation control, targeted watering of planted seeds, and soil leveling. All of these features are combined into a single transportable machine that uses a remote control to carry out the tasks one after the other. Using a radio frequency (RF)-based remote control, the mobility system may navigate in multiple directions. The unit is initially positioned at the beginning of a row in which seeds are to be sowed at regular intervals. The system goes forward after pressing the start button, stops to plant a seed, and then proceeds once more to water it. Until the stop button is pressed, this procedure keeps going. To prepare the soil before planting, the plough mechanism, which is positioned at the front of the machine, can be remotely raised or lowered. It has three pouching instruments, the middle one designed especially for inserting seeds.

Corresponding Author:

Kalagotla Chenchireddy
Department of Electrical and Electronics Engineering, Geethanjali College of Engineering and Technology
Hyderabad, India
Email: chenchireddy.kalagotla@gmail.com

1. INTRODUCTION

In large-scale agricultural areas, this prototype is very helpful. An improved engineering version might carry out numerous sowing operations simultaneously across several places, whereas the existing model is made to plant seeds one at a time along a single row. These improvements would make it possible to carry out several farming activities at once, covering greater regions in a lot less time. Six direct current (DC) motors are positioned throughout the device and power the mechanical system; each motor is in charge of a distinct function.

To carry out multiple tasks at once, these motors cooperate with the main frame. The machine is completely controlled by a remote unit and is made for unidirectional movement, including its seed container and mechanical parts. Without requiring a conventional steering system, the machine can go forward, backward, and make directional turns thanks to the remote control's eight control buttons and microcontroller connection.

The machine starts carrying out a number of tasks, including plowing, seed planting, weed removal, soil leveling, and targeted irrigation, as soon as it is positioned on a planting row and the start command is activated. There is a specific order in which these duties are completed. Developing the hardware and software for a prototype that mimics the operation of an automated seed-sowing machine—an invention that farmers greatly value—is the main goal of this project. An 89C51 microprocessor controls the operations and reacts to input signals from the remote control unit. Because the system's software is written in low-level machine code, user inputs and pre-established logic can directly control the motors and mechanical transmission system. The foundation of many electrical and electronic devices, including robotics, appliances, cars, communication systems, and military gear, microcontrollers is essential to modern technology. The microcontroller performs a variety of functions in this project, demonstrating its adaptability and significance in automation and control applications [1].

Any nation's agricultural output is directly related to its development and progress. With the right equipment, farming may be done accurately and efficiently. Conventional farming techniques frequently take a long time and are prone to human error, which produces inconsistent outcomes. A 5-in-1 automated agricultural machine has been created to solve this problem by carrying out several farming duties with little assistance from humans. With the help of a remote control, the user can control this machine's movements and functions without having to go into the field in person. The user only needs a handheld remote to operate the machine as it performs different farming tasks. This system's capacity to guarantee constant seed placement, which greatly increases sowing efficiency, is one of its main advantages. Adopting new farming technologies is essential for increasing output, decreasing human error, and saving time. The requirement for human labor is significantly decreased and tasks are completed more precisely when these procedures are automated.

This system's primary goal is to integrate cutting-edge technology with agriculture. A functional prototype has been created in order to illustrate the idea. The machine can be expanded in the future, even if its current purpose is to plant seeds consecutively in a single row. The system can be enhanced to simultaneously plant many seeds in different locations in its complete engineering version, and other agricultural chores can be carried out in a similar manner. This would significantly cut down on the amount of time needed for cultivation by enabling farmers to more effectively cover enormous farming regions [2].

This work investigates the classification of various agricultural machinery types using multi-class supervised machine learning algorithms. Particularly in remote monitoring systems, accurate classification is essential to automating the verification of field activities. The likelihood of fraudulent conduct rises in the absence of a trustworthy method for recognizing machines. Five machine learning algorithms—K-nearest neighbor (KNN), support vector machine (SVM), decision tree (DT), random forest (RF), and gradient boosting (GB)—are used to identify different farm equipment in order to address this problem.

Data on tilt and vibration of machinery, obtained using accelerometer and gyroscope sensors, respectively, are used to train the models. The equipment types under investigation include cultivators, rotavators, and levelers. According to preliminary data analysis, average vibration and tilt values were rather constant across various types of machinery, despite notable variations throughout operation. Both vibration and tilt data produced good classification accuracy when utilized alone, with vibration data marginally exceeding tilt. But when both features were combined, performance improved much further. Over 82% accuracy was attained by all five machine learning models, with RF producing the best outcomes. Despite showing some overfitting (about 9%), RF, and GB, both produced high test accuracy. GB took the longest to train, whereas DT took the shortest [3]. As we enter the fourth industrial revolution [4]. The world is changing. Innovative technologies like the internet of things (IoT) [5]. Cloud computing and machine learning [6] are being incorporated into more and more commonplace applications [6], [7]. These technological advancements have the potential to greatly help agriculture, which continues to be a key pillar of the world economy [8]. Predictive analysis categorization tasks were also completed using a DT approach [9]. These methods are frequently used to categorize agricultural tasks like strolling, transplanting, harvesting, bed preparation, and idle states. Additionally, studies have been done on using vibration signal analysis to diagnose problems in rotating machinery [10].

To the best of our knowledge, machine learning methods have not yet been widely used to agricultural farm equipment identification. We think that if such modeling is put into practice, it might greatly improve field operations efficiency and allow for more effective remote monitoring. Our objective is to create a trustworthy classification model that can recognize various kinds of farm equipment on its own. Prior studies have identified tilt and vibration as important characteristics for describing the behavior of machines.

2. BLOCK DIAGRAM

The Figure 1 shows block diagram represents how different parts of the 5-in-one agriculture machine work together to perform tasks. A 12 V DC battery powers the entire system. All motors and electronic parts are powered by it. When necessary, the battery can be recharged. The farmer uses a remote control with keys to give commands. These commands are converted into radio signals using an RF transmitter. The RF receiver is mounted on the machine. It receives the signal sent from the remote and passes it to the microcontroller. 89C51 microcontroller (main control unit) is the system's brain. It interprets the RF receiver's commands. It controls motors and other systems by turning on various relays based on the input.

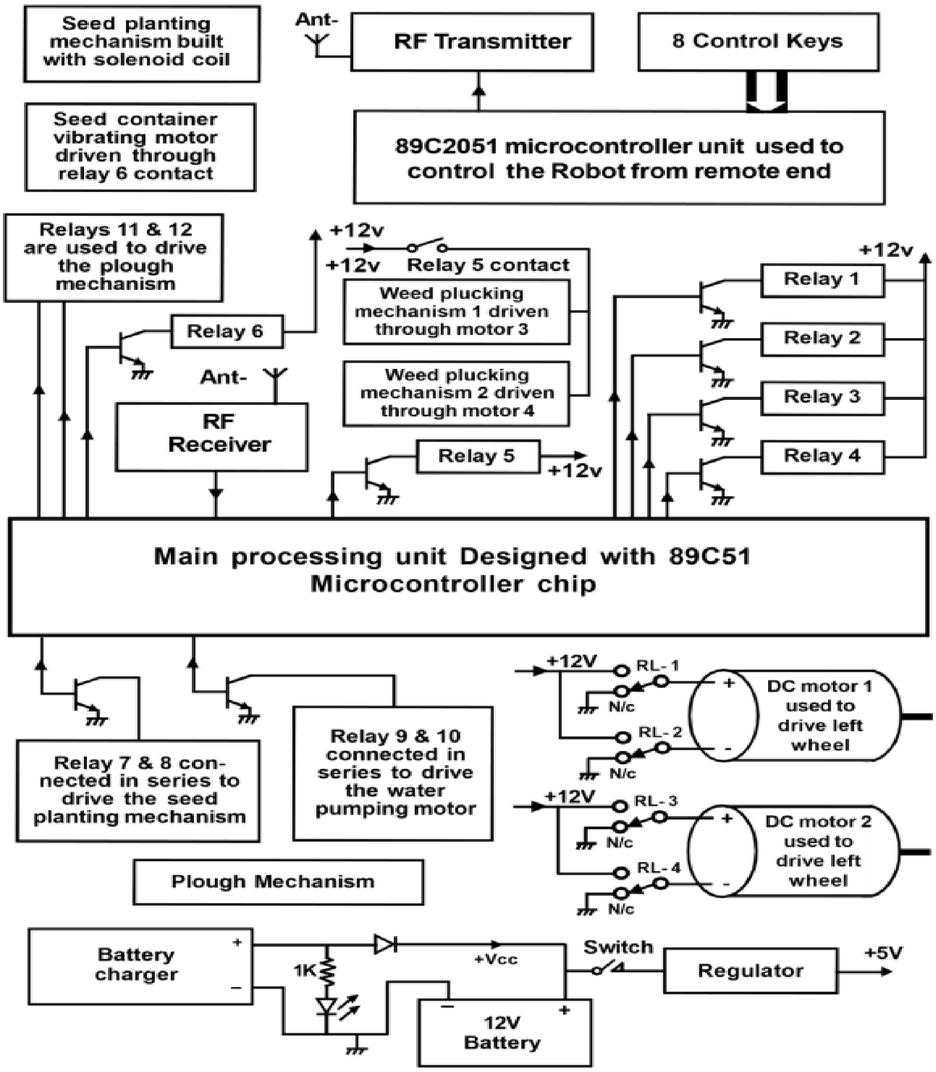

Figure 1. Block diagram of five in one automatic farming device

Relays act like electronic switches. They receive signals from the microcontroller to turn specific motors on or off. Plough mechanism: prepares the soil for planting. Seed sowing mechanism: drops seeds at regular intervals. Water pump motor: pumps and sprays water after seeds are planted. Soil leveling mechanism: levels the soil after seeding and watering. Weed plucking mechanism: removes unwanted plants around the seed area. All these functions are handled by separate motors controlled by relays. DC motors for movement: these motors move the machine forward, backward, left, and right. They make the machine mobile so it can cover more ground easily. This block diagram shows how each component contributes to automating the farming process. Everything is linked and controlled smoothly through the microcontroller and remote signals.

3. MECHANISM

The Figure 2 is a small, manually adjustable plough is part of the ploughing unit of the 5-in-1 automatic agricultural machine. The user can adjust the plough's position to manage the depth and angle of soil tilling, even though it stays stationary while in use. In order to prepare the land for planting, the plow splits and twists the earth as it moves. To help regulate seed flow, the seed planting system makes use of a vibrating motor and a solenoid coil. You can see inside the seed pipe since it is divided into two transparent portions. The solenoid coil is connected to a tiny metal component that serves as a gate between the two parts. When seeds can travel through is controlled by the solenoid. A relay with a generally open contact is used to supply power to it. The solenoid pushes the metal fragment out of the way when the controller activates the relay, enabling a seed to fall into the ground. This seed planting is shown in Figure 3. Table 1 shows the system components.

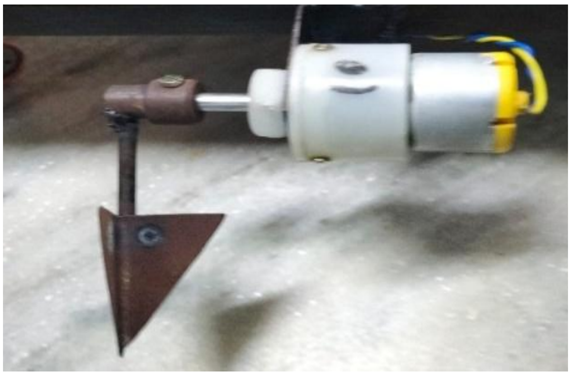

Figure 2. ploughing mechanism

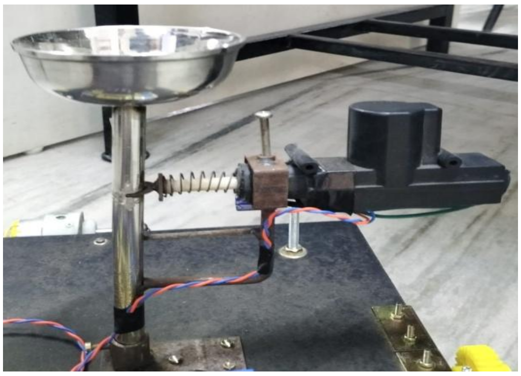

Figure 3. Seed planting

Table 1. System components

No	Component name	Specification/model	Quantity
1	Microcontroller	Arduino Mega/ESP32	1
2	Soil moisture sensor	Capacitive soil moisture sensor	2
3	Soil pH sensor	Analog pH sensor module	1
4	Temperature and humidity sensor	DHT22	1
5	Light intensity sensor	LDR/BH1750	1
6	Rain sensor	Rain detection module	1
7	Water level sensor	Ultrasonic/float sensor	1
8	Water pump	12 V DC submersible pump	1
9	Solenoid valve	12 V DC	1
10	Relay module	5 V, 4/8 channel	1
11	Pest control unit	Ultrasonic repeller/spray unit	1
12	Crop protection system	DC motor+net/shade mechanism	1
13	Fertilizer sprayer	DC pump+nozzle	1
14	Gas sensor	MQ-135	1
15	Camera module	ESP32-CAM	1
16	Global system for mobile (GSM) module	SIM800	1

The purpose of this device is to clear the field of weeds or grass. There are two spur gears in each of its two sections. Located on the machine's left and right front sides, the weed removal units are driven by two DC motors. Two spur gears with the same size and tooth count are included with every unit. Weed plucking shown in Figure 4. The motor runs on 12 V DC, and one of the gears is directly attached to the motor shaft. Because the two gears are connected, the second gear rotates in the same (clockwise) direction as the first gear when the motor turns it. The soil leveling mechanism is positioned at the rear end of the moving unit, where basic leveling plates are employed. These levelers function to cover the planted seeds with soil and ensure the surface is evened out after planting. The machine's capacity to precisely water the seeds that have been planted is another important aspect. A tiny water tank is attached to a DC motor, which serves as the water pumping mechanism. Soil leveling process shown in Figure 5.

In order to disperse water across the soil where the seeds are planted, this motor is made to automatically turn on using relay switches as necessary. Two relay switches connected in series cause this system to briefly activate. A 5-in-1 multipurpose agricultural robot prototype has been successfully created and tested, proving its capacity to help farmers carry out necessary farming duties effectively. This cutting-edge device is intended to greatly assist farmers by lowering the amount of manual effort required in the field. It is environmentally sustainable and appropriate for off-grid and rural locations because it runs only on unconventional energy sources, including solar and battery power. All user types can utilize the robot because it is safe to handle, easy to control, and user-friendly. Sprinkler of water shown in Figure 6. Farmers can use this technology to do a variety of agricultural tasks at once, including tilling, fertilizer and pesticide spraying, watering, and sowing. This capacity to multitask enhances productivity and raises income while saving time and effort. In the end, putting such technologies into practice benefits farmers as well as the nation's agricultural industry and economy as a whole. Five in one robot shown in Figure 7.

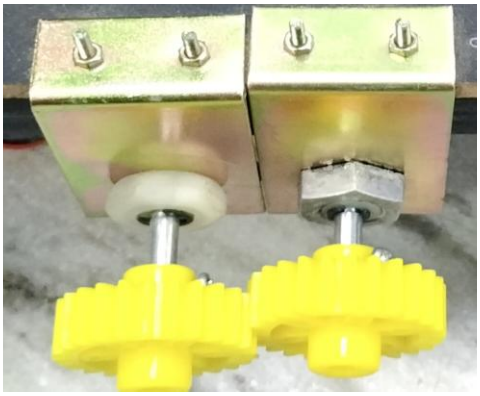

Figure 4. Weed plucking

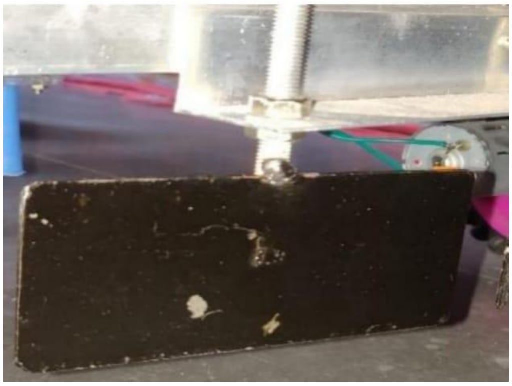

Figure 5. Soil leveling

Figure 6. Sprinkler of water

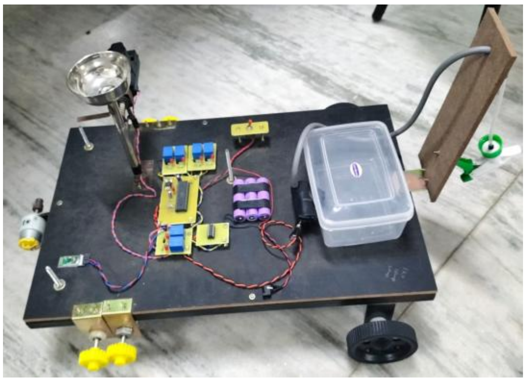

Figure 7. Five in one robot

4. CONCLUSION

Farmers can save time and effort by using this gadget to conduct multiple tasks at once. Additionally, it increases their income, which benefits the national economy. To make the machine intelligent, we can include sensors like cameras and infrared. After then, it can decide for itself and follow its own way over the field. Additionally, very tiny RF communication components can be used in place of conventional ones. These reduce the machine's space requirements and facilitate construction. The machine may develop further in the future and be able to function without the farmer present. It might also improve its ability to interact with humans and learn from mistakes.

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