Al-Najah National University

Faculty of Engineering & Information Technology Computer Engineering Department

Graduation Project II

Drill and Plow Machine

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Disclaimer Statement

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Abstract

This project focuses on developing a robot designed to assist farmers in ploughing and digging tasks, reducing the physical stress associated with manual labor, especially during extreme weather conditions. The robot is equipped with a plough and a digging tool and is powered by lithium-ion batteries. It operates through an application that provides two basic modes of operation: an autonomous ploughing mode where the robot ploughs the soil while avoiding obstacles, and a ploughing and digging mode that allows the farmer to have full control over the robot's movements. The digging mode also allows for precise control of the digging operations. In addition, the robot was tested in real field conditions, showing a significant reduction in the physical effort required from farmers and an improvement in the efficiency of ploughing and digging.

Keywords: (Autonomous Robot, Plowing Mechanism, Digging Mechanism, Obstacle Avoidance, Agricultural Automation, ESP8266 Module, Arduino Mega2560, 12V DC Motor, Lithium Battery, Moisture Sensor, Precision Agriculture, Servo Motor.)

Chapter 1

Introduction

1.1 General Background

The agricultural industry has had more difficulties recently with labor intensity and efficiency, particularly with digging and plowing. Traditional land preparation and upkeep techniques can call for a lot of hard labor, which can be very taxing in bad weather. Robotics technology advancements present opportunity to solve these issues by creating solutions that lessen physical stress and increase agricultural productivity and efficiency.

1.2 Objectives (Purpose or Aims) of the Work

The main objective of this project is to create a robot that can assist farmers in digging and ploughing tasks.

This robot is flexible and easy to use as it can operate either autonomously or under direct control.

The following are the objectives of the project: 1. Create and build a robot that contains a digging tool and a plough. 2. Include advanced features such as digging management, manual and autonomous ploughing. 3. Evaluate the performance of the robot in real field conditions to assess its effectiveness in reducing physical effort and improving efficiency.

1.3 Significance or Importance of Your Work

The importance of this project lies in its ability to change traditional agricultural practices. By reducing the physical labor required for plowing and digging, this robot can reduce the effort expended by farmers, especially during difficult weather conditions. This project addresses an urgent need in modern agriculture and has the potential to improve productivity in the agricultural sector.

1.4 Organization of the Report

The purpose of this report is to give a thorough summary of the project and its conclusions. The format of the report is as follows:

Chapter 1: Introduction
This chapter provides an overview of the project, outlining its goals, importance, and report structure.

Chapter 2: Theoretical Background and Previous Work
This chapter provides the context and background of the project by reviewing previous studies on agricultural robotics.

Chapter 3: Methodology
This chapter explains how the robot was designed and developed.

Chapter 4: Results and Analysis
In this chapter, the robot's performance results are presented, along with data analysis to determine the robot's effectiveness.

Chapter 5: Discussion
This chapter discusses the results, along with how they relate to the project objectives and significance. It also considers any shortcomings and potential improvements.

Chapter 6: Conclusions and Recommendations This chapter provides an overview of the project, draws conclusions from the data, and offers suggestions for further research.

References

Chapter 2

Theoretical Background and Previous Work

2.1 Review of Previous Work

Encouraged by the need for increased farming production and efficiency, the subject of agricultural robots has experienced major improvements in recent years. One of the most important advances is the rise of intelligent robots that can carry out different farming duties like tilling, planting, and watering. The robots Agrobot and FarmBot are two prominent examples of this type.

1. FarmBot:is a highly automated and open-source gardening robot designed for precision agriculture. It operates on a rail system that allows it to cover a large planting area with high accuracy. FarmBot is equipped with tools for planting seeds, watering plants, and weeding. Its integration of advanced sensors and a computer vision system enables it to perform these tasks autonomously while adapting to varying plant growth stages and environmental conditions. The use of FarmBot represents a significant advancement in precision farming, providing a scalable solution for both small-scale and large-scale agricultural operations[1].

2. Agrobot:is another advanced agricultural robot that focuses on automating soil tilling, seed planting, and irrigation. Integrated with an Arduino Mega 2560, Agrobot utilizes an ultrasonic sensor to detect the edges of the field, allowing for autonomous navigation. The robot is controlled via an Android application, which lets users input parameters such as seed spacing, initial movement direction, and the number of seeds per hole. Agrobot not only addresses labor and time constraints but also aims to reduce the use of petroleum products and minimize environmental pollution [2].

2.2 Theoretical Framework

The theoretical foundation for agricultural robotics involves several core principles:

Robotic Control Systems: Both FarmBot and Agrobot utilize sophisticated control systems to manage their operations. FarmBot's rail-based system and Agrobot's Arduino-based control unit demonstrate the evolution of robotic systems from simple mechanized tools to complex, autonomous machines capable of performing multiple tasks with precision.

Sensor Integration and Automation: The integration of sensors in these robots plays a crucial role in their functionality. FarmBot's computer vision system and Agrobot's ultrasonic sensors exemplify how advanced sensors are used to navigate, detect obstacles, and perform tasks efficiently. This automation reduces the need for manual intervention and enhances overall productivity.

Environmental and Efficiency Considerations: The design of both FarmBot and Agrobot reflects a focus on environmental sustainability and efficiency. FarmBot's precise gardening capabilities and Agrobot's reduction in petroleum use highlight the trend towards developing robots that not only improve agricultural productivity but also address environmental concerns.

2.3 Summary

2.3 Summary This chapter covers the development of agricultural robots, focusing on prominent examples such as FarmBot and Agrobot, which were used to develop our own robot running on Arduino Mega with sensors to avoid obstacles, combining weeding by plowing, soil improvement and movement, and digging the land in the area desired by the farmer.

Chapter 3

Methodology

This chapter covers the exterior design of our project, the hardware components we used, their functions, and how they were implemented.

3.1 Hardware Components

3.1.1 Arduino Mega2560

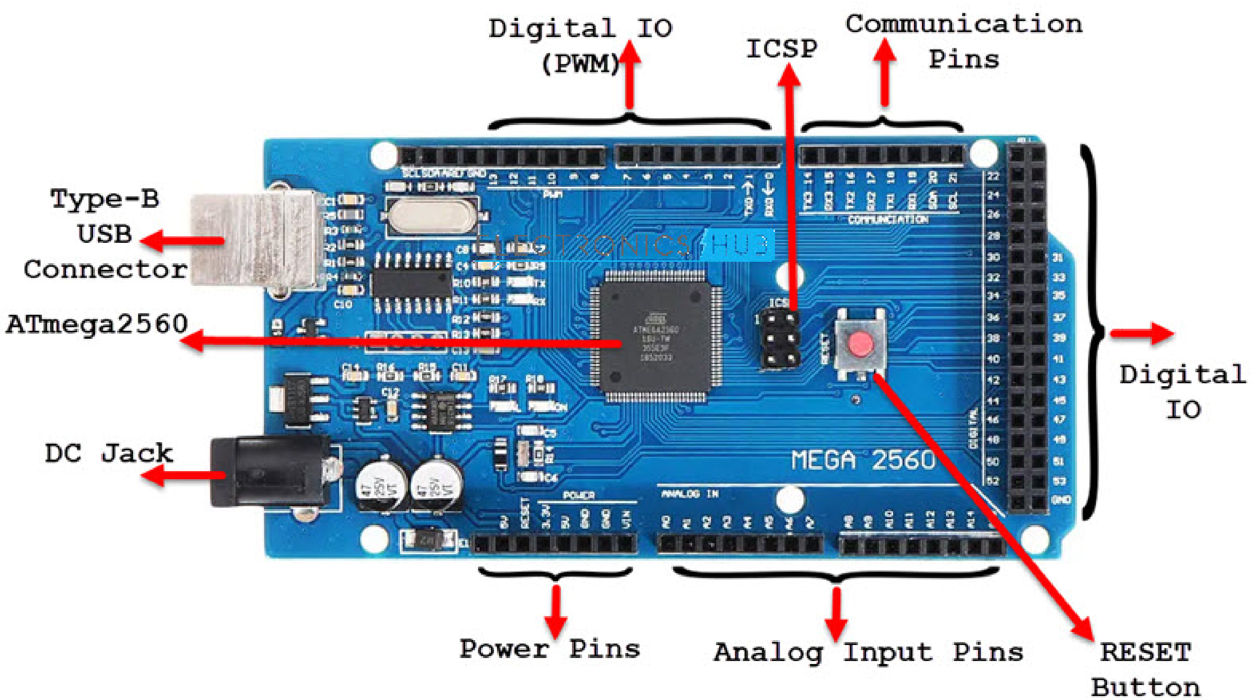


Figure 3.1: Arduino Mega2560

The Arduino Mega was used as the main controller for our robot for several reasons:

- **More Input/Output (I/O) Pins:** The Arduino Mega has 54 digital input/output pins and

16 analog input pins, making it ideal for a multitude of sensors and actuators, who need to manage multiple sensors, DC motors, servo motors, and communication modules.

- **More Memory:** It comes with 256KB of flash memory, allowing it to handle larger programs and more complex logic, ensuring that the robot can efficiently manage all its tasks such as obstacle avoidance, moisture sensing, plowing, and communication.
- **Multiple Communication Ports:** The Arduino Mega has 4 hardware serial ports (UARTs), which allow you to simultaneously communicate with multiple devices, such as the ESP8266 for wireless communication, while also handling other tasks without conflicts.

Using the Arduino Mega, my robot can efficiently coordinate its various functions, from motion control and digging to sensing environmental conditions.

3.1.2 12V DC Motor with Gearbox

Figure 3.2: 12v DC 34 RPM

Advantages of this type of motor:

- **Low speed:** The slow speed (34 rpm) makes this motor suitable for applications that require slow, precise movement, such as moving wheels in robots. The low speed helps improve control and steering.
- **Voltage:** Using 12 V DC is compatible with many robot power systems, making it easy to integrate with the batteries used.

- **Torque:** Motors with low speeds typically provide higher torque, meaning that the motor will be able to generate enough power to move the robot and wheels efficiently.

Why was this type of motor chosen?

- **Balancing speed and torque:** These motors provide a good balance between speed and torque, making them suitable for applications that require slow but powerful movement, such as moving wheels in agricultural robots. Motion control: With slow speed, you can better control the movement of the robot, which contributes to the accuracy of movement and avoiding collisions.
- **Electrical System Integration:** The 12V motor works well with the lithium batteries used in the robot. It consumes less current, which helps address the issue of rapid battery depletion. This choice enhances the robot's performance by providing the right speed and sufficient torque while managing battery life effectively.

3.1.3 12V DC motor for For the drilling rig to go up and down

Figure 3.3: 12V DC motor

3.1.4 L298N motor drivers (x2)

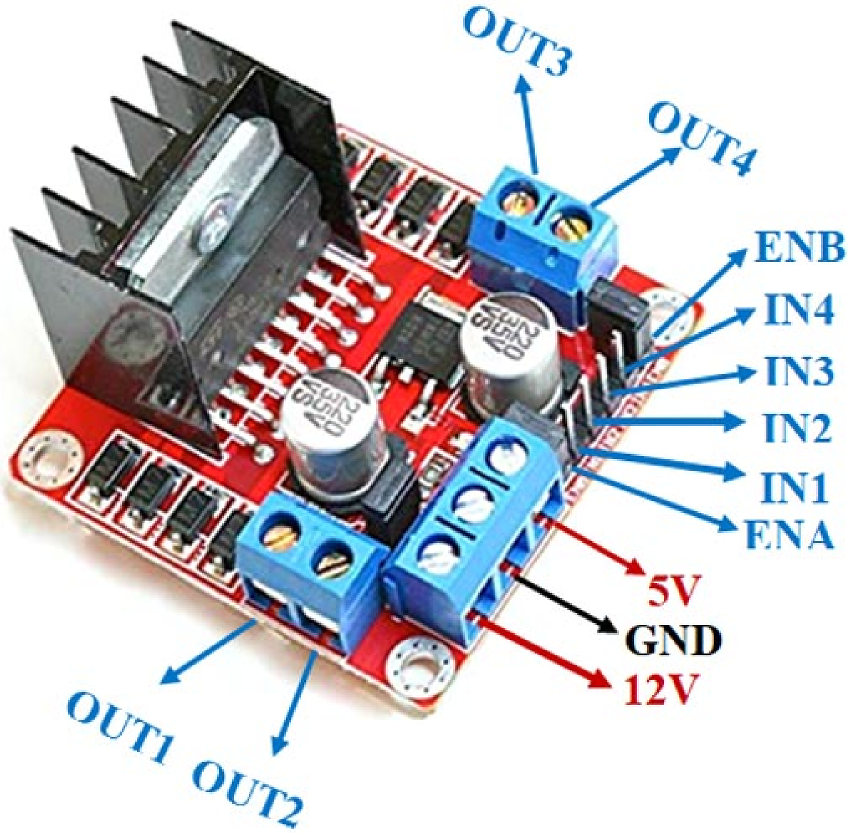


Figure 3.4: L298N motor drivers

These drivers are responsible for controlling the DC motors, allowing the Arduino to manage motor speed and direction.

3.1.5 ESP8266

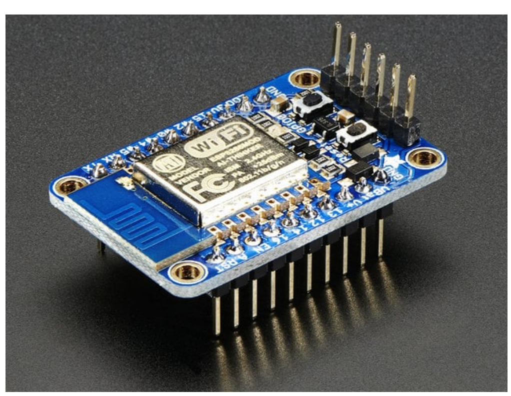


Figure 3.5: ESP8266

The Wi-Fi module enables wireless communication between the robot and the control application on the smartphone, where the start and stop during plowing are controlled, and sometimes the robot is fully controlled in digging and plowing mode, and a notification is sent to the application about the soil moisture.

3.1.6 DC converter (5V)

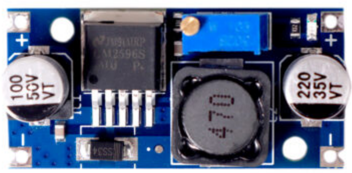


Figure 3.6: DC converter (5V)

It is used to convert voltage from 12 to 5 volts so that it reaches the Arduino and does not burn out.

3.1.7 Standard servo motor

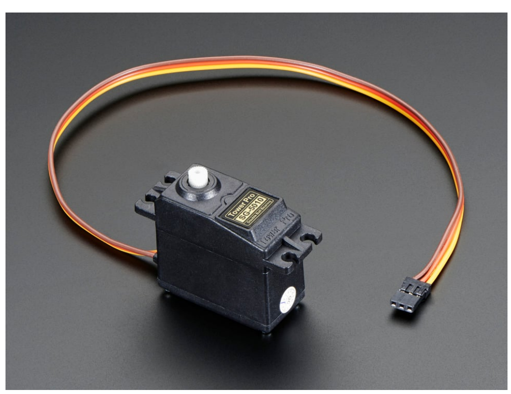


Figure 3.7: ESP8266

Servo motors provide precise control of angular position, speed and acceleration so you can set the exact angle at which the tiller operates, ensuring consistent tillage.

3.1.8 DC-DC converter (6V):

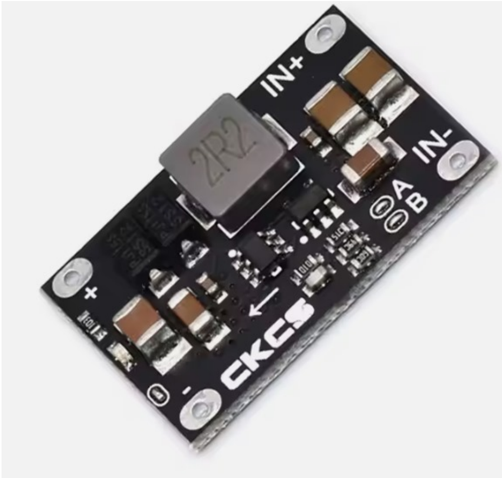


Figure 3.8: PowerBank

It is used to convert voltage from 12 to 6 volts because the servo operates on 6 volts,here is no possibility of connecting it to the Arduino because it causes noise, so it was placed.

3.1.9 11.4V lithium battery

The robot is powered, providing enough power for the motors, lithium batteries are placed, the batteries are placed in series and every two batteries in parallel to give a voltage of 11.4 Battery 1 and Battery 2 in parallel. Battery 3 and Battery 4 in parallel. Battery 5 and Battery 6 in parallel. Then connect the three groups (group 1, 2, 3) in series.

Figure 3.9: lithium battery

3.1.10 HC-SR04 Ultrasonic sensor

Figure 3.10: HC-SR04 Ultrasonic sensor

Three sensors were used. When the robot moves forward, it sees from the side that is 10 cm or more away. It sees forward, then right, then left. If there are obstacles in each of them, it moves back.

3.2 Constraints

3.2.1 The Cost

We had to use products that fit the project because of the problems we had with lithium batteries. Regular batteries were causing problems to power the robot, so we resorted to using lightweight lithium batteries, which caused another problem, which was the need for a switch that used less current and provided more power, which was also very expensive.

3.2.2 Battery life

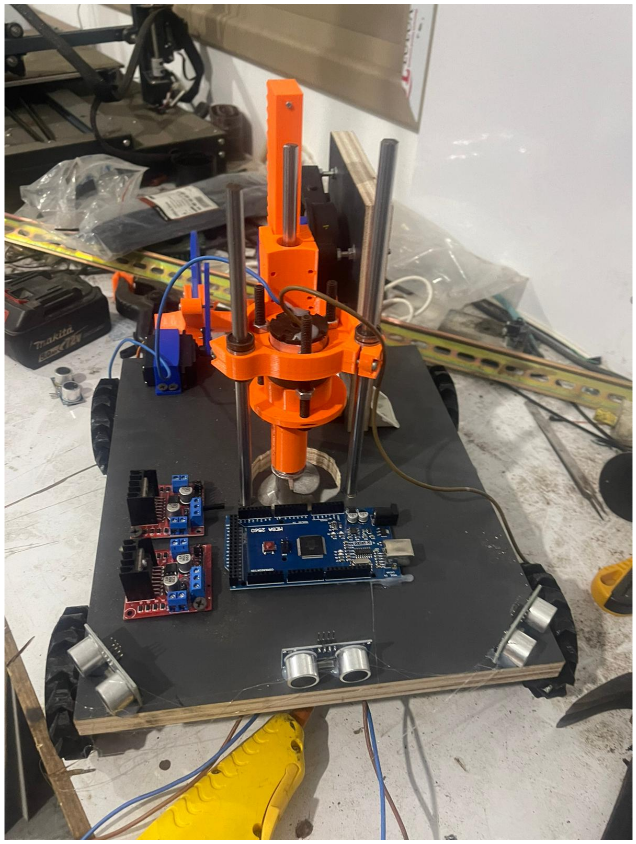
The robot has a limited battery life, which requires frequent recharging or a more efficient power management system due to the high power consumption of the sensors, motors and processing units.

3.3 Steps to build the structure

The development of the project followed a systematic process, starting with the selection and assembly of the basic hardware components, designing and building the mechanical structure of the robot, integrating the electronic systems, and finally implementing control through a mobile application.

3.3.1 Hardware Preparation

Construction of the base and structure: A wooden board was used as the base of the robot, with wheels attached to provide mobility. The board served as the foundation for mounting all other components.



1. 3D Printed Plow: The plow was designed using 3D modeling software and manufactured using a 3D printer. This approach was taken due to the lack of a commercially available option that met the exact specifications required for the project.

2. Digging Tool: A portion of a meat grinder was repurposed to act as a digging tool, providing an efficient way to dig the soil.

3. Motors: Initially, DC motors were used for movement and digging. However, they consumed more power than expected. They were later replaced with more energy-efficient motors that provided the required torque while consuming less current. Motor drives (L298N) were used to control the speed and direction of the motors.

4. Servo Motor: A servo motor was installed to control the mechanism of the plow. Since the plough needs to be rotated at an angle to lower or raise it off the ground, a servo motor was the ideal choice for precise control.

5. Sensors: Obstacle avoidance sensors are placed around the robot to detect field edges and any obstacles, such as trees, ensuring the robot does not collide with or cross the boundaries.

6. Lithium-ion battery: An 11.4V lithium-ion battery was chosen as the power source due to its lightweight nature and sufficient power capacity. However, the challenge was managing the high current consumption of the primary motors, which led to the decision to switch to lower current motors. 7. The DC motor of the car window is used to control the ability of the excavator to go up and down.

3.3.2 Mobile application

The control app is built using the Blynk platform, allowing users to operate the robot over Wi-Fi. The app offers two modes: full manual control of the robot's movements while plowing, and an autonomous mode that allows the robot to plow and dig while avoiding obstacles.

How the application works?

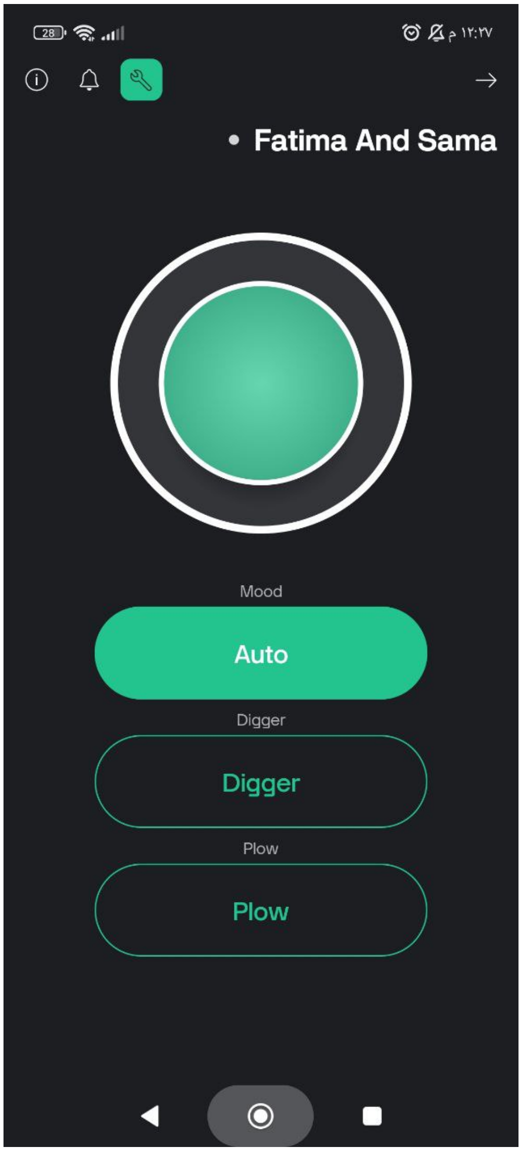


Figure 3.11: Auto Mode

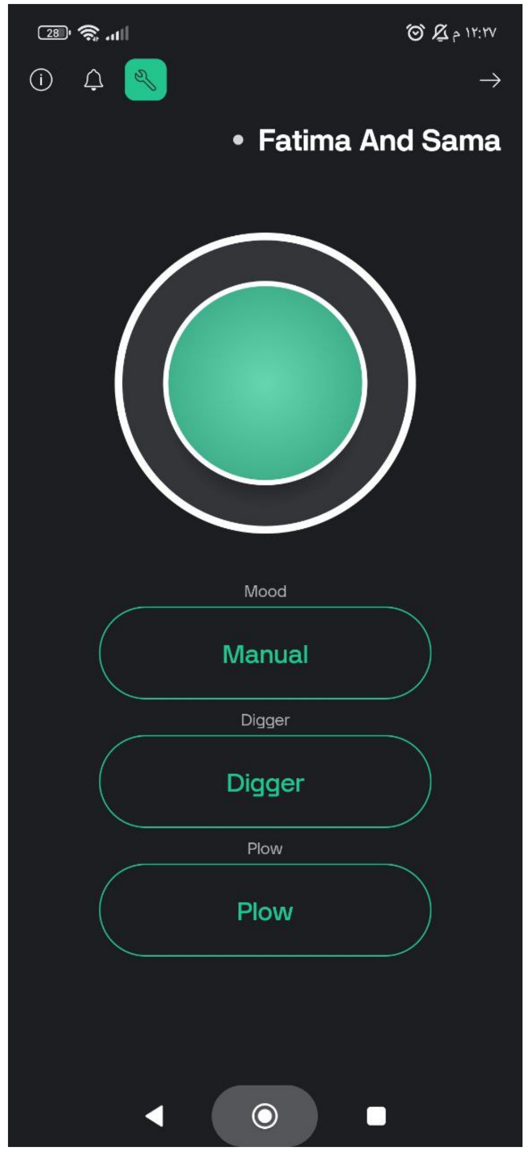


Figure 3.12: Manual Mode

There are two types of control:

1- automatic control: which is for automatic plowing without the farmer's intervention, as the robot moves by itself and plows the land. It moves forward and plows when it sees an obstacle, avoids it, and sees the best path to take. If it moves to the right, left, or backward, it raises the plow so that it does not break.

2- Manual : The farmer controls how the robot moves and where it goes. If he wants to plow the land, he presses the plow button and plows. If he wants to dig, he presses the digger button to dig.

Chapter 4

Results and Analysis

The performance of the ploughing, digging and obstacle avoidance mechanisms was tested in a field environment. The following results were obtained:

4.1 Plowing and digging

1. The servo motor effectively operated the plough, adjusting its angle to plough the land. The plough was raised and lowered with minimal rotation due to the precise and smooth movement. The robot was able to cross the experimental plot. 2. The digging mechanism was tested for its ability to dig the soil, powered by a 12V DC motor with gearbox and motor to raise and lower the digger, and the torque of the motor was sufficient to dig into the soil accurately and control the depth, proving that the choice of motor was appropriate as it ensured efficient digging without draining the battery.

4.2 Obstacle avoidance

Sensors positioned all around the robot were used to evaluate its obstacle avoidance system. The robot was prevented from causing harm to crops or straying beyond the designated boundaries by the sensors' detection of the perimeter of the field and adjacent obstructions like trees. When obstructions were spotted, the avoidance algorithm effectively rerouted the robot's path, guaranteeing uninterrupted operation free from collisions.

4.3 Power Consumption and Efficiency

The initial DC motors used in the design consumed more power than expected, resulting in rapid depletion of the lithium battery. This was mitigated by replacing the motors with more efficient ones that provide higher torque while drawing less current. After modification, battery life was significantly improved, allowing the robot to operate for extended periods without the need for frequent recharging.

4.4 App Control and Performance

The robot was programmed to perform various tasks such as digging, ploughing, and obstacle avoidance using the Blynk app. Through the interface, users can remotely control the robot's movements and during testing, the wireless connection remained stable and the robot responded quickly to commands, ensuring trouble-free operation.

Chapter 5

Discussion

In this chapter, the results from Chapter 4 are interpreted and compared to the project objectives and existing knowledge in the field of agricultural robotics. The discussion will highlight the strengths and limitations of the system, assess whether the original problem has been solved, and suggest potential improvements or further studies.

5.1 Problem Solving

The primary goal of this project was to design and implement an autonomous agricultural robot that can plow, dig, and avoid obstacles while minimizing the physical effort of farmers.

Based on the results, the robot successfully performed the basic tasks of plowing, digging, and avoiding obstacles. The plowing mechanism worked efficiently, and the digging mechanism, driven by a specific 12V DC motor with a gearbox, provided sufficient torque for digging.

As a result, the research mainly succeeded in resolving the targeted issue by offering a useful prototype that might support agricultural operations, particularly digging and plowing.

5.2 Project Contributions

This project contributes to the field of agricultural robotics by providing a practical solution for small and medium-sized farms. The main contributions are:

5.2.1 Enhanced efficiency

The robot reduces physical strain on farmers by increasing output through the use of accurate plowing and digging mechanisms in conjunction with efficient motors.

5.2.2 Increased energy

The robot's battery life and overall energy efficiency have increased as a result of the choice to swap out the primary motors for motors with higher torque and lower current. With this change, the robot will be able to function for longer stretches of time without requiring frequent recharging.

5.2.3 Obstacle avoidance

The robot's sensors, combined with an avoidance algorithm, successfully protected crops by detecting obstacles and rerouting its path, a feature of great importance in agricultural applications.

5.3 Limitations

Although the project was deemed successful overall, a number of shortcomings were noted:

5.3.1 Restricted field size

A comparatively limited field was used for testing the robot. The degree of success in scaling up to larger farms is still unknown. Its operational range can also be restricted by the Wi-Fi module's range.

5.3.2 Power supply

Even though the motor was replaced with a lithium battery that was enough for operation, more advancements in battery science might be required to increase the battery's lifespan for larger farming plots.

5.4 Implications of the results

The project's performance indicates that employing autonomous robots for labor-intensive and repetitive agricultural chores is feasible. The findings imply that comparable robots might be employed more extensively to boost agricultural productivity while lowering the need for human labor.

5.5 Suggestions for further study

5.5.1 Enhanced autonomy

Future iterations of the robot could incorporate GPS-based navigation to improve control over larger agricultural plots. This would also eliminate the need for Wi-Fi, extending the robot's operating range.

5.5.2 Multifunctional design

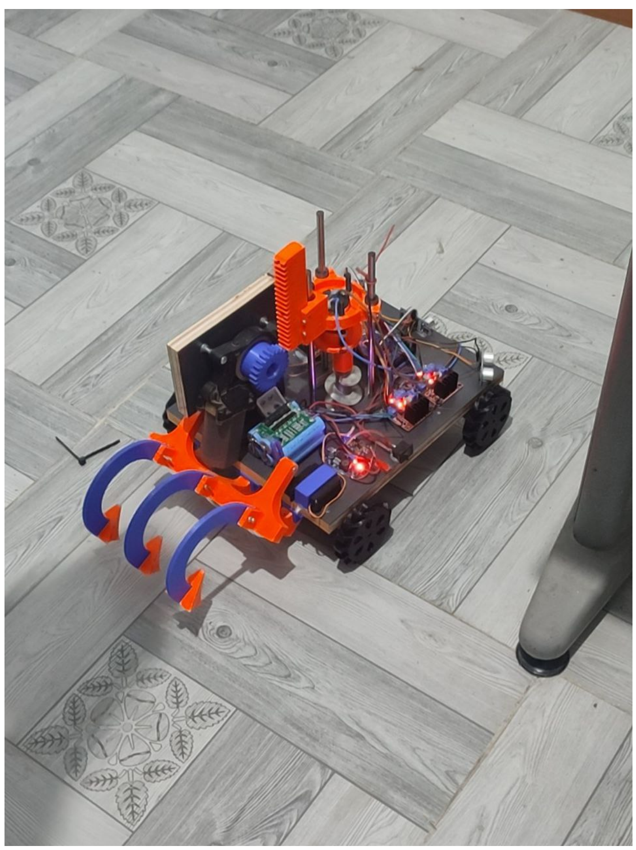
Incorporating additional tools or interchangeable mechanisms could increase the versatility of the robot, allowing it to perform more diverse agricultural tasks, such as seeding or harvesting.

In summary, the project successfully achieved the goals of creating an agricultural robot capable of autonomous plowing, digging, and obstacle avoidance. While there are some limitations, the prototype has shown promising results that contribute to the continued development of robotic systems in agriculture.

Chapter 6

Conclusions and Recommendation

Overall, the agricultural robot performed well in Conclusions and Recommendations Overall, the agricultural robot performed well in its intended tasks. The plowing and digging mechanisms worked efficiently, the obstacle avoidance system ensured safety and accuracy, and improvements made in the selection of the motor improved the energy efficiency of the robot, making the system more sustainable for long-term use. These results demonstrate the potential of the robot to help farmers reduce labor and improve agricultural productivity.



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