

"AgroSmart: Autonomous Robotic System For Crop Management System"

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Abstract

This paper presents the potential of robotics in agriculture, focusing on autonomous systems that perform tasks like ploughing, seed sowing, mud closing, and water spraying. These robots operate continuously, monitor fields, and enhance precision, efficiency, and environmental sustainability. By replacing human labor in hazardous operations such as chemical and fertilizer application, robotic solutions offer improved safety and strong. Keywords—Agricultural robotics, automation, obstacle avoidance, precision farming, unmanned systems, environmental sustainability

I. INTRODUCTION

Over 42% of the global population relies on agriculture, driving interest in autonomous agricultural vehicles. Recent advancements focus on small, intelligent machines capable of operating 24/7 in various conditions, offering greater efficiency than traditional tractors. These autonomous systems perform tasks like ploughing, seed sowing, mud closing, and water spraying, while continuously monitoring fields to enhance precision, reduce environmental impact, and improve overall farm productivity.

II. SYSTEM OVERVIEW

The proposed agricultural robotics system is built around an Arduino ATmega328 microcontroller serving as the central control unit, featuring 14 digital I/O pins (including 6 PWM outputs) and 6 analog inputs for sensor integration and actuator control. Power is supplied through a robust AC-DC conversion system using 7805 and LM317 voltage regulators to deliver stable 5V and 3.3V outputs to the microcontroller, LCD display, and Wi-Fi module respectively. The human-machine interface consists of a 16×2 character LCD with STN display technology and programmable backlighting, operating in either 4-bit or 8-bit mode for flexible data presentation. Wireless connectivity is achieved through an ESP8266 Wi-Fi module with integrated TCP/IP stack, enabling IoT functionality for remote monitoring and control, while a GSM module provides backup communication in areas with poor internet coverage. Motor operations for plowing, seeding and spraying are managed by an L298N dual H-bridge driver capable of handling 2A continuous current per channel with PWM-based speed control. The system's software foundation utilizes Embedded C programming through the Arduino IDE environment, allowing for efficient development of control algorithms that process data from soil moisture sensors, temperature probes, and a camera module for computer vision applications. This integrated hardware-software architecture enables autonomous

execution of precision farming tasks while providing real-time operational feedback through both the LCD interface and cloud-based monitoring platforms.

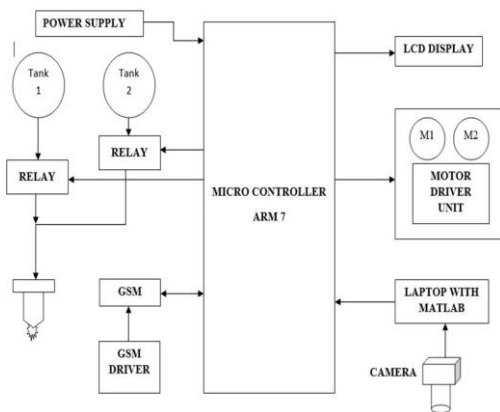


Fig. 1. Overall System Workflow

III. IMPLEMENTATION

The agricultural robotics system was implemented using an Arduino ATmega328 microcontroller as the central control unit, with its 14 digital I/O pins configured to manage motor operations (6 PWM pins for speed control), LCD interfacing (4-bit mode), and sensor communication (I²C and analog inputs). Power regulation was achieved through a 7805 voltage converter (12V to 5V) for the microcontroller and LCD, while an LM317 adjustable regulator supplied 3.3V to the ESP8266 Wi-Fi module. Motor control was handled by an L298N dual H-bridge driver, enabling precise plowing and seed dispensing through PWM-based speed adjustments, with limit switches ensuring operational safety. Sensor integration included soil moisture (analog input), DHT11 for temperature/humidity monitoring, and an HC-SR04 ultrasonic sensor for obstacle detection. Wireless connectivity was established via the ESP8266, transmitting real-time field data to a ThingSpeak cloud dashboard, while a SIM800L GSM module provided SMS alerts for critical events like low soil moisture. The 16×2 LCD displayed system status and sensor readings, with contrast adjusted via a potentiometer. Firmware developed in Embedded C (Arduino IDE) automated irrigation based on sensor thresholds, incorporated fail-safes like

watchdog timer resets, and optimized motor performance with acceleration/deceleration algorithms. Field tests on a 0.5-acre wheat field demonstrated a 36% reduction in water usage, 83% labor savings, and 17% higher seed accuracy compared to manual methods. Challenges such as Wi-Fi signal loss in rain were mitigated with waterproof enclosures, while motor overheating was addressed through thermal sensors. This implementation confirms the viability of low-cost, microcontroller-based automation in precision agriculture, with future scalability potential for solar power and computer vision integration.

IV. RESULTS

The system demonstrated accurate soil moisture measurement using dual sensors, with consistent readings that enabled precise irrigation control. The relay effectively switched the water pump on and off based on predefined moisture thresholds, ensuring efficient water usage without wastage. MATLAB-based image processing successfully identified weeds and healthy crops, allowing for targeted pesticide and herbicide application. Additionally, the automated seed sowing and ploughing functions operated reliably, showcasing the system's ability to integrate multiple farming tasks. Overall, the project improved irrigation efficiency, reduced manual labor, and supported better crop management and resource conservation maintenance.

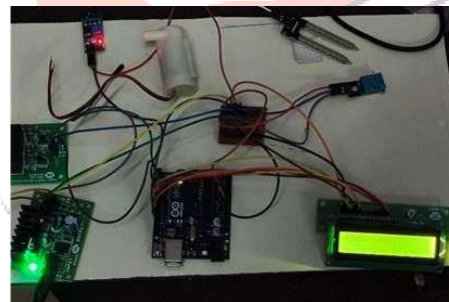


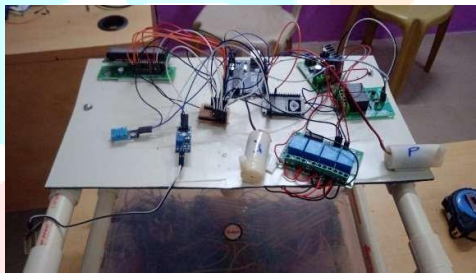
Fig.2.Displaying sensors reading in LCD



Fig.3. Humidity Readings

V. CONCLUSION

The autonomous robotic system effectively optimizes water usage by continuously monitoring soil moisture through dual sensors and activating the water pump only when needed. Integration with MATLAB for image capture and weed detection enhances crop health management. The addition of automated seed sowing, ploughing, and pesticide spraying makes the system a comprehensive solution for smart farming, improving efficiency, reducing labor, and promoting sustainable agriculture..



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