AGRICULTURAL UTILITY VEHICLE WITH FIELD MONITORING USING IoT

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College ***:*** *Bapuji Institute of Engineering and Technology, Davangere*
Branch ***:*** *Department of Electrical and Electronics Engineering*
Guide(s) ***:*** *Dr. Shivakumaraswamy. G. M*
Student(S) ***:*** *Ms. Priyanka Ningappa Naregal*
Ms. Sahana Ramesh Meti
Ms. Sneha Ramesh Soratur
Mr. Suraj Prakash Kadur

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Smart agriculture, Internet of Things (IoT), Automation, Crop management, Sensor integration

Abstract — Agriculture plays a vital role in feeding the growing global population. To improve productivity and sustainability this project introduces a utility vehicle equipped with Internet of Things (IoT) technology. The utility vehicle is designed to perform tasks, such as removing weeds, spraying pesticides and applying fertilizers. The IoT system integrated into the vehicle provides real time data on temperature, humidity and soil moisture. This valuable information enables farmers to make informed decisions for optimized crop management. By leveraging automation and data driven insights this smart agriculture solution aims to reduce labor, enhance efficiency and ultimately boost crop yields. Through the integration of operations, with IoT based field monitoring this project seeks to revolutionize farming practices and contribute to the modernization of agriculture.

Introduction:

Agricultural Utility Vehicle merges simple locomotion with smart IoT technology, revolutionizing traditional farming. It handles tasks like weeding, pesticide spraying, and fertilizing while tracking vital crop metrics like temperature and soil moisture in real-time. Data is relayed to a central server for analysis and accessible to farmers, empowering informed decisions for optimal crop care. This innovation addresses the urgent need for sustainable agriculture, enhancing efficiency and crop yields. Its integration of IoT sensors ensures seamless data collection and transmission, supporting remote monitoring and decision-making. Powered by electric propulsion and renewable energy sources, it prioritizes environmental sustainability. With an intuitive interface controlled by the ESP32 microcontroller, it offers user-friendly operation for farmers. In conclusion, our project represents a pivotal advancement in agricultural technology, enabling data-driven decisions and fostering sustainable farming practices.

Objectives:

The main objectives of the system are:

- Enhancing farming efficiency by automating and optimizing agricultural tasks.
- To reduce the farmer's effort and labor cost substantially.
- To reduce use of fossil fuels by replacing it with solar power to operate the vehicle.
- Improving resource management by utilizing real-time data on soil conditions, crop health and environmental factors.

Methodology:

The methodology encompasses the careful integration of hardware and software components, starting with a detailed analysis of requirements and followed by systematic planning and implementation. The following block diagram illustrates the structured framework guiding the development phases, offering a visual representation of the interconnected components driving the functionality of the agricultural utility vehicle.

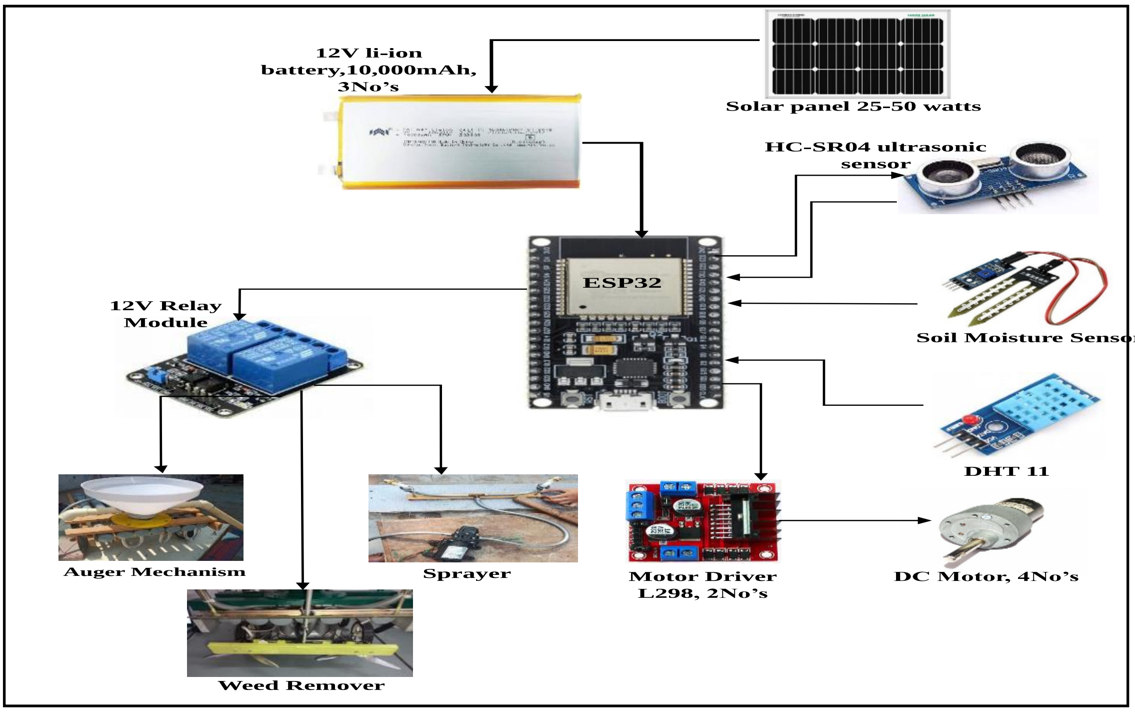

Fig.3 Block Diagram of Agricultural Utility Vehicle with Field Monitoring using IoT

Following the visualization of our system through the block diagram, our methodology delivers into the systematic implementation of sensor integration, data acquisition and communication protocols to facilitate seamless interaction between the agriculture utility vehicle and the IoT-based field monitoring system.

- Assemble a 4-wheel drive Rover with four DC Motors for movement.
- Integrate chopping, spraying and auger mechanisms for respective tasks. Utilize Motor Driver L298 for precise motor control.
- Power the vehicle with Lithium-ion Battery, supported by a Battery Charger and Solar Panel.

- Implement ESP32 for IoT control and connect sensors for Humidity, Temperature and Soil Moisture.
- Transmit sensor data wirelessly to a central database using IoT protocols.
- Design a user-friendly interface the ESP32 for real-time data display and user interaction.

The process commenced with a thorough analysis of project requirements, identifying key functionalities and components. Subsequently, a meticulous planning phase took place, outlining the integration of hardware and software elements. The implementation phase involved the assembly of components as per the design, ensuring seamless interaction. Rigorous testing and iterative refinement concluded the methodology, assuring the functionality and reliability of our innovative agricultural utility vehicle.

Circuit Diagram

The circuit diagram provides a comprehensive overview of the electrical connections and components utilized in the project. It visually represents the system's architecture, including sensors, actuators, microcontrollers and power sources, facilitating a clear understanding of the project's electronic implementation, as shown in the fig.3.1.

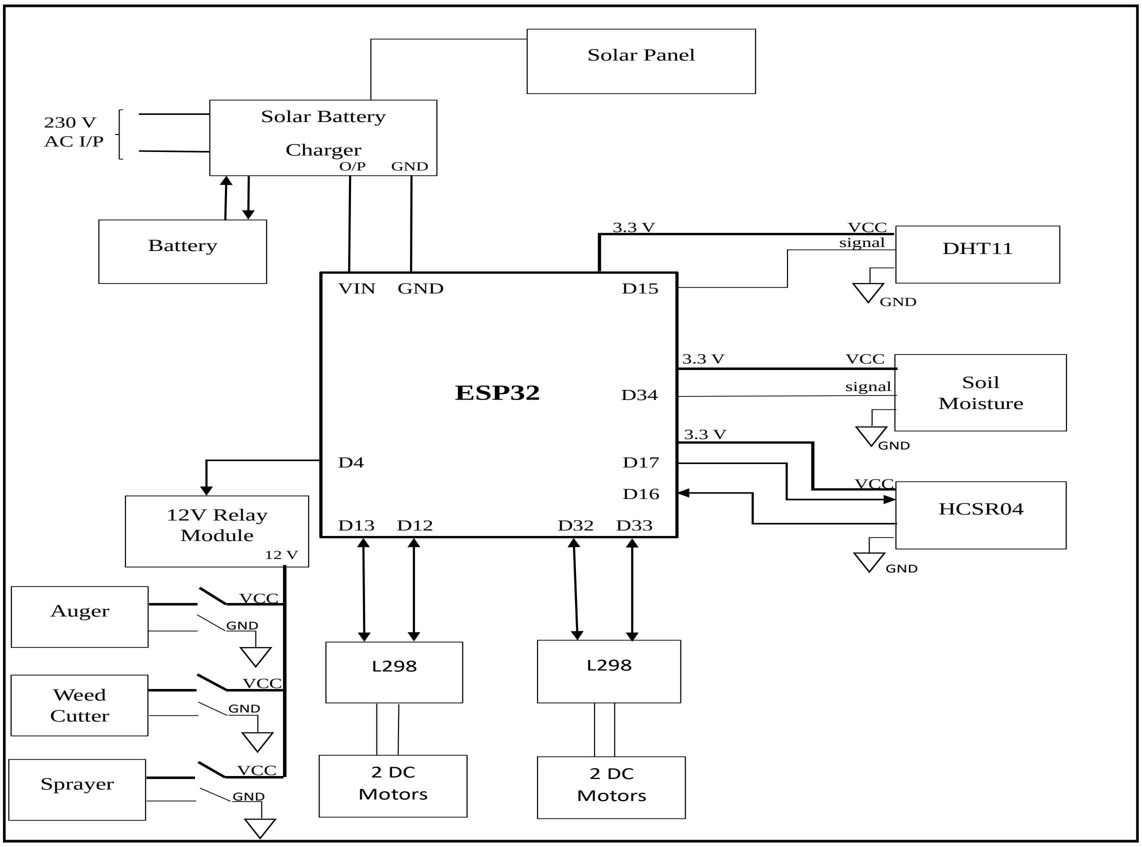

Fig.3.1 Circuit Diagram of Agricultural Utility Vehicle with Field Monitoring Using IoT

The connection setup involves several key components. Firstly, the solar panel's positive terminal is attached to the input (230V AC) of the solar battery charger, while the negative terminal grounds to the charger. This charger's output then connects to the positive terminal of the battery, with the battery's negative terminal linking to the system's ground (GND). Moving on, the DHT11 sensor's positive terminal (VCC) is wired to the ESP32's 3.3V pin, while its negative terminal (GND) is securely connected to the ESP32's ground (GND) pin.

For data transmission, the DHT11's signal pin is precisely connected to pin D15 of the ESP32. Continuing, the ESP32's power management involves linking its positive terminal (VCC) to the battery's positive terminal, while its ground (GND) pin is effectively connected to the battery's negative terminal, ensuring proper power distribution. For controlling external devices, such as a relay, the relay's positive terminal (VCC) is carefully wired to the ESP32's D4 pin, with its control pin connected to a designated pin of the ESP32 (D13, D12, D32, D33, depending on the design). Ensuring proper grounding, the relay's ground (GND) pin connects to the ESP32's ground (GND) pin. Finally, for actuating functions, such as driving a DC motor, the motor's positive terminal is connected to the relay's positive output (12V), while its negative terminal securely grounds to the ESP32's ground (GND) pin.

Working

The Agricultural Utility Vehicle starts up with the ESP32 initializing components like Wi-Fi, sensors, and motors. It collects real-time data on temperature, humidity, soil moisture, and obstacles using sensors. Farmers interact with the vehicle's interface to choose tasks like weeding or fertilizing based on field observations. The ESP32 then controls mechanisms and adjusts vehicle direction and speed accordingly. It constantly monitors conditions and obstacles, making adjustments for optimal performance and safety. Sensor data is sent to a central server for analysis, aiding informed decision-making for crop management. Remote operation via mobile app or web interface adds flexibility for farmers. Safety features like obstacle detection and emergency stops ensure safe operation. In summary, this smart vehicle streamlines farming tasks, improving productivity and sustainability.

Results And Discussion:

Solar-powered automatic irrigation systems are revolutionizing how we water our plants. By harnessing the sun's power, these systems are environmentally friendly, reducing reliance on fossil fuels. Smart sensors ensure plants receive the exact amount of water needed, preventing waste and promoting healthier growth. Automation frees up time and labor costs, while scalability allows the system to fit small gardens or vast fields. Advanced features like smartphone apps and weather integration offer further optimization. Although the initial investment might be higher and sunlight availability is a factor, the long-term benefits and minimal maintenance make solar-powered automatic irrigation systems a sustainable and efficient choice for a thriving, green landscape.

Fig.4 Agricultural Utility Vehicle with Field Monitoring using IoT

4.1 Keys to Rover Controller:

The following are the keys and functions to Control the Vehicle:

Key	Functions
Forward	To move the vehicle in forward/straight direction
Backward	To move the vehicle in backward/reverse direction
Left	To turn the vehicle in left direction
Right	To turn the vehicle in right direction
Stop	To stop/pause the vehicle
Utility Relay	To start the different mechanisms (Auger mechanism, Weed Cutting and Spraying)

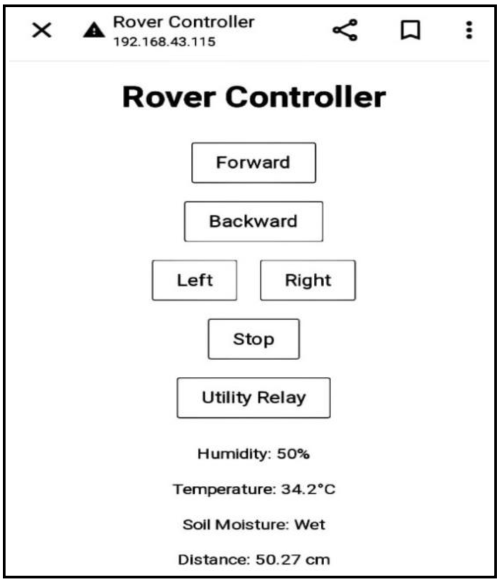

Fig.4.1 Page of the Controller

4.1.1 Starting of Vehicle

The Vehicle is started by switching ON the toggle switch. Now the vehicle will display the name in the OLED screen as “Agri Rover Controller” and display the IP address then by connecting through Wi-Fi using mobile then the vehicle is started, as shown in the fig.4.

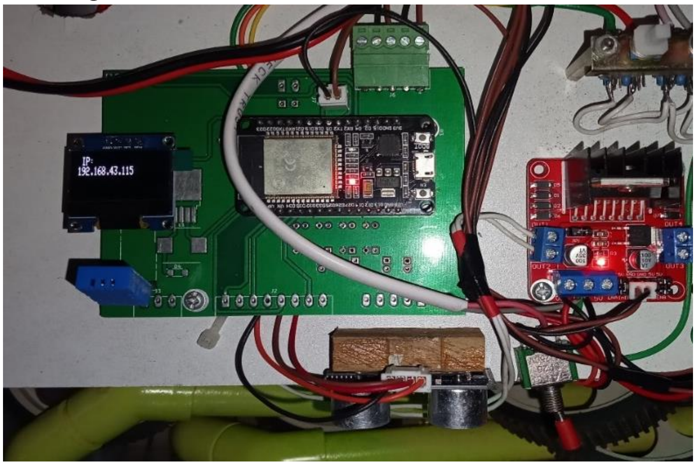

Fig.4.1.1 Starting of Vehicle

4.2 Functions of the Vehicle

4.2.1 Auger Mechanism

The fertilizer spreader employs an auger mechanism to evenly distribute fertilizer between rows of plants, ensuring optimal nutrient dispersion and plant growth, as shown in the fig.4.2.1.

Fig.4.2.1 Auger Mechanism

4.2.2 Fertilizers and Pesticides Sprayer:

Nutrients essential for plants growth are supplied by fertilizers and pesticides kill pests that may affect crops, helping boost production, as shown in the fig.4.2.2.

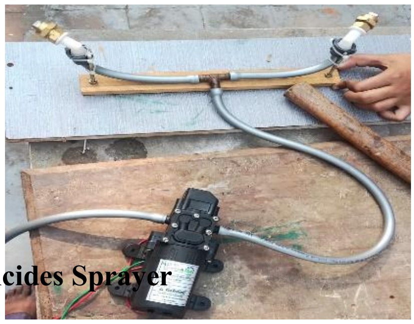

Fig. 4.2.2 Fertilizers and Pesticides Sprayer

4.2.3 Weed Remover:

The fig.4.2.3 shows, the weed removal system efficiently clears weeds between rows of plants using a specialized mechanism, ensuring thorough weed management without harming crops.

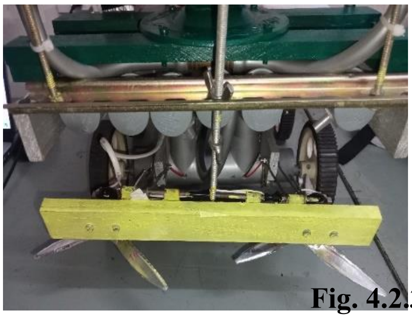

Fig. 4.2.3 Weed Remover

4.2.4 Field Monitoring

- **Soil Moisture:** Measures moisture levels for precise irrigation scheduling, preventing water wastage and optimizing crop health and yield.
- **Temperature:** Tracks ambient temperature to adjust crop management strategies, identifying stressors and enhancing growing conditions for better yields.
- **Humidity:** Monitors humidity levels to prevent diseases and stress on plants, aiding in irrigation and ventilation adjustments for optimal growth.

The following are the sensors output as shown in fig.4.2.4.

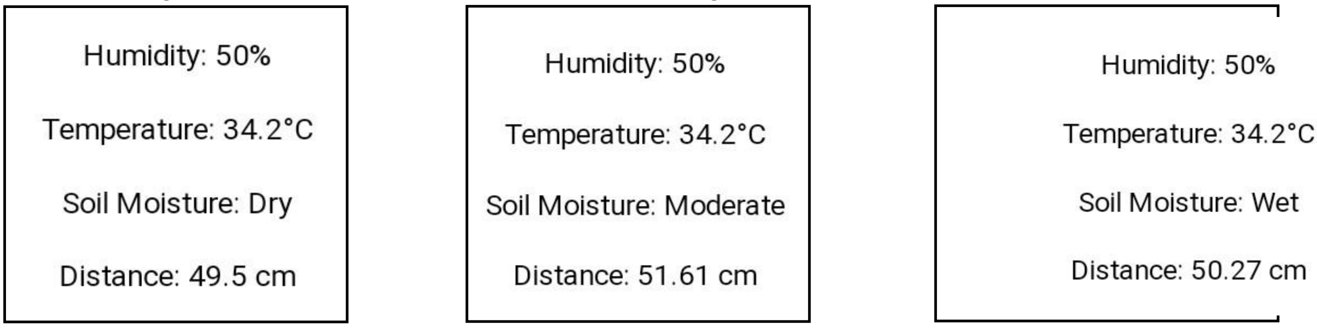

Fig. 4.2.4 Field Monitoring

Conclusion And Future Scope:

Conclusion

Solar-powered automatic irrigation systems utilize renewable energy, reducing reliance on fossil fuels and minimizing environmental impact. Equipped with smart sensors, they monitor soil moisture, humidity, and temperature, delivering precise watering to promote healthy plant growth and conserve water. This data informs user decisions, optimizing tasks like weed removal and fertilizer application based on field observations. Automating irrigation saves time and labor costs, allowing focus on other farm tasks. With scalability, these systems suit both small gardens and large agricultural fields.

Future Scope

- Our project may be implemented through GSM, the distance may be improved via GSM.
- It involves refining and expanding these capabilities, potentially incorporating AI algorithms to automate decision-making processes for improved crop yield and resource efficiency.