Solar Autonomous Agritech Tractor

Authors: [1]Professor Abitha T E, Dept of ISE, The Oxford College of Engineering, Bengaluru,
[2]Student Adhayan Sharma, Ise Dept, The Oxford College of Engineering, Bengaluru,
[3]Student Muhammed Zain Jambagi, Ise Dept, The Oxford College of Engineering, Bengaluru,
[4]Student Nazish Jamal, Ise Dept, The Oxford College of Engineering, Bengaluru,
[5]Student Vishnumurthy Hegde, Ise Dept, The Oxford College of Engineering, Bengaluru

---

Abstract: This project focuses on the development and implementation of an Autonomous Robotic Tractor with Smart Agriculture Features, utilizing an ATmega328p microcontroller, a DHT11 sensor for temperature and humidity measurement, and a Bluetooth module for data transmission to a mobile app. The successful interfacing of these components allows for real-time monitoring of farm conditions and the ability to spray pesticides autonomously.

The integration of a DHT11 sensor with the ATmega328p microcontroller enables accurate measurement of temperature and humidity, crucial factors in agricultural planning. The Bluetooth module facilitates seamless communication between the microcontroller and a mobile app, providing farmers with instant access to sensor data.

The expected outcomes of this project include improved farmer safety by reducing exposure to pesticide vapours, increased operational independence as farmers can now manage their farms without relying on external drivers, and enhanced security measures to protect crops from wild animals and theft.

In conclusion, the implementation of this Autonomous Robotic Tractor holds the potential to revolutionize traditional farming practices. By combining smart technology with agriculture, the project aims to provide farmers with a reliable and efficient solution for farm management, contributing to a more sustainable and secure farming environment.

Keywords: Autonomous Robotic Tractor, Smart Agriculture, Real-time Monitoring, Pesticide Spraying, Farmer Safety, Operational Independence

1. INTRODUCTION

The independent GPS-guided mechanical tractor could be a cutting-edge advancement outlined for keen farming, particularly custom fitted to address the modern challenges confronted by the rural division in India. With a noteworthy parcel of the rustic populace relocating to urban areas, there has been a decay within the accessibility of talented work for conventional cultivating hones. This has driven to delays in fundamental assignments such as watering, collecting, and pesticide application, jeopardizing edit wellbeing and yields. Large farm owners often struggle with unreliable tractor drivers who may miss critical dates and times, resulting in potential damage to crops. The autonomous tractor project aims to revolutionize farming practices by integrating advanced technologies to ensure precision and efficiency in agricultural operations.

The automated tractor comes prepared with a extend of highlights outlined to upgrade rural efficiency. The independent GPS-guided route framework guarantees precise and convenient execution of cultivating errands, overcoming the confinements related with human-dependent operations. This framework employments GPS signals to calculate the most brief way to the goal, guaranteeing that the tractor covers the complete field without any missed zones. This highlight not as it were progresses the productivity of cultivating operations but too diminishes the chance of mistakes and wastage, as the tractor can perform assignments precisely and reliably.

Moreover, the tractor consolidates intruder-scaring components to upgrade the security of crops. This highlight employments a high-voltage generator to actuate an electric burdening capability, sending a solid, non-lethal electric stun to any gatecrashers. This serves as an compelling obstacle, guaranteeing the security of crops and cultivate resources. This security highlight is especially vital for ranches found in inaccessible ranges, where they may be more helpless to robbery or harm.

The pesticide sprinkler framework contributes to viable bug control. This framework is controlled by a DC pump and a hand-off switch, guaranteeing that the pesticides are connected at the proper areas and volumes. This mechanization not as it were spares time but moreover decreases the workload on agriculturists, permitting them to center on other vital viewpoints of cultivating. The framework is planned to handle diverse sorts of pesticides, making it a flexible apparatus for different cultivating needs. The incorporation of sensors for temperature and stickiness estimation gives important information for educated decision-making. These sensors collect real-time information, which is at that point transmitted to a committed mobile app. This permits agriculturists to create educated choices based on the most recent natural conditions, contributing to more effective and maintainable cultivating hones.

The live spilling camera permits agriculturists to remotely screen their areas, empowering real-time evaluations of edit conditions. This real-time observation capability is pivotal for incite decision-making and for proactively reacting to changes or potential issues within the cultivate environment. By giving agriculturists with real-time get to to their areas, this framework empowers them to screen trim wellbeing, distinguish bugs or maladies, and confirm the tractor's position and advance. Bluetooth innovation encourages consistent communication between the mechanical tractor and an Android application, permitting ranchers to control and screen the gadget easily. This highlight gives ranchers the adaptability to oversee their ranches from anyplace, giving them with more noteworthy control over their operations.

Finally, the integration of a solar panel for charging ensures sustainable and eco-friendly energy sources, aligning with the growing emphasis on environmentally conscious farming practices. The solar panel, when exposed to sunlight, charges the tractor's batteries, ensuring that the tractor can operate continuously, even in remote or off-grid farming locations. This sustainable energy solution aligns with the global shift toward eco-friendly and energy-efficient agricultural practices.

Given that various states in India escalation depend on cultivation as the spine of their economies, the allotment of such autonomous advancements holds unimaginable ensure for growing trim yields and reducing the labour-intensive nature of routine developing. Precision cultivation, engaged by advanced device like autonomous tractors, not because it were addresses the challenges posed by the development of rural populaces but as well alters with the broader around the world float of leveraging advancement for doable and beneficial food era. As hypotheses in rustic device continue to rise, the utilization of quick agribusiness methods gets to be a significant step towards ensuring food security and flourishing in agrarian social orders.

2. LITERATURE SURVEY

The rural segment has been encountering a transformative move towards computerization and exactness cultivating strategies, driven by progressions in mechanical technology, sensor innovation, and counterfeit insights. Independent automated frameworks have risen as a promising arrangement to address the challenges confronted by agriculturists, such as work deficiencies, natural concerns, and the require for proficient asset administration. The integration of these cutting-edge innovations into rural hones has the potential to revolutionize conventional cultivating strategies, clearing the way for economical and data-driven horticulture.

Independent route could be a vital angle of automated cultivating frameworks, empowering exact and productive development inside areas. Numerous inquire about endeavors have centered on creating vigorous route calculations that use advances like Worldwide Situating Framework (GPS) and Inertial Estimation Units (IMUs) to decide the area and introduction of the mechanical stage. These calculations, coupled with modern path-planning methods, guarantee that rural assignments are executed precisely and reliably, minimizing the chance of blunders and moving forward in general proficiency.

Environmental monitoring and data collection have also gained significant importance in precision agriculture. By integrating sensor systems capable of measuring factors such as temperature, humidity, soil moisture, and sunlight intensity, robotic farming systems can gather valuable insights into field conditions. This real-time data enables informed decision-making, allowing farmers to optimize resource utilization, implement targeted interventions, and potentially increase crop yields. The development of wireless communication technologies has further facilitated the seamless transmission of sensor data to central monitoring stations or mobile applications, enhancing the overall management and control of farming operations. In addition to navigation and environmental monitoring, researchers have explored various applications of robotics in agriculture, such as autonomous planting, precision spraying of pesticides and fertilizers, and automated harvesting. These applications not only reduce the physical labour required but also promote sustainable practices by minimizing the overuse of resources and reducing the environmental impact of traditional farming methods.

The literature in this field spans a wide range of studies, encompassing theoretical frameworks, simulation models, prototype developments, and real-world implementations. The following sections provide an in-depth review of notable works and contributions, highlighting the advancements, challenges, and future directions in the realm of autonomous robotic systems for agriculture.

(i) A Development of an autonomous Unmanned Aerial Vehicle (UAV) that can locate and map people in flooded areas using image processing and GPS technology,
This study aims to equip an unmanned aerial vehicle (UAV), also called a drone, with an onboard. a microcomputer that can perform autonomous surveying with image processing for human detection and quantification, Global Positioning System (GPS) technology for location tagging of detected people, as well as LiDAR sensors for obstacle detection to be used for obstacle avoidance to achieve an enhanced autonomous flight. A user interface for the system will also be developed to display the data being gathered by the drone, namely the detected people and their location, as well as monitor what the drone sees when in flight. This will be used to aid search and rescue operations in flooded areas and aims to speed up the victim search process. The study includes the development of the drone, the human detection and quantification model, the obstacle detection and avoidance algorithm, and the data display on a ground station's Graphical User Interface (GUI).

(ii) Sensor fusion module for autonomous vehicles using IMU and GPS sensors,
Autonomous vehicles use various sensors and algorithms to analyze sensor data streams and accurately interpret their surroundings. The research presented in this paper consists of designing a sensor integration algorithm that predicts the position and direction of a specific vehicle based on the fusion of IMU and GPS data. This is important to achieve the highest standards of safety and security by improving operations that enable consistency, accuracy and reliability. Historically, navigation has used dedicated GPS solutions that are not capable of scanning the surrounding environment. This overcomes the limitations of GPS-based navigation systems by combining and correlating data from inertial measurement units (IMUs) and GPS sensors.

(iii) GPS-Aided Auto Route Framework for Independent Vehicles,
Autonomous Vehicles (AV) are the future of the smart digital world. Auto Navigation is the heart of AVs. However, researchers have been working on precise auto navigation control of AVs for many years. Hence, In this paper, a GPS-aided auto navigation system is proposed with position control and heading control of AV. Further, to test the proposed algorithm an AV is designed and developed with low-cost sensors and actuators. The real-time testing of the proposed adaptive control auto navigation mechanism has been performed with three test cases such as straight line, L-shaped and Semi-circular. The results shown in this paper are the deviation between the travelled path and the defined path of the vehicle in different trajectories by assuming no obstacles in the path. The deviation of the path travelled by AV concerning the defined path using the proposed algorithm is less than 0.5m. Finally, the telemetry of AV has been monitored by the developed Graphical User Interface (GUI). This work is very useful in the auto navigation of vehicles where humans can not be sustained.

(iv) Smart Automated Pesticide Spraying Bot
These days agriculturists are playing a significant part by working difficult within the rural lands and planting the crops for the social orders living completely different locales for gaining their least needs. In India, pesticide utilization is higher than 70% while around the world pesticide utilization is 44% only. Discuss is getting contaminated by utilizing these pesticides. This is often a major issue in agribusiness. For this, a robot is created to splash the pesticides on its possess and it is less destructive to the environment. The extend is beneath a remote sensor arrange. The application of remote sensor systems in rural, Bio-medical, Natural etc. This bot will offer assistance the ranchers exceptionally viably. This bot will splash the pesticides over whole the trim with the assistance of portable phones. This bot can be effortlessly controllable. The bot sprinkles the pesticides covering all plants on the cultivate. This will be utilized in bug control and infection avoidance application shapes. By utilizing this bot, the time and work of the agriculturist will be decreased.

3. PROPOSED WORK

The proposed work in this research paper presents a comprehensive autonomous robotic tractor system designed to revolutionize traditional farming practices. Leveraging cutting-edge technologies, this system aims to address various challenges faced by farmers, such as labour shortages, precision agriculture requirements, and environmental sustainability concerns. At the core of this system lies an autonomous GPS-guided navigation mechanism that enables the tractor to traverse fields with high accuracy, executing essential tasks like ploughing, seeding, and crop maintenance. Complementing this navigation capability is a suite of environmental sensors that monitor critical parameters like temperature, humidity, sunlight intensity, and soil moisture content, providing real-time data for informed decision-making and optimized resource utilization. Additionally, the system incorporates advanced features such as a live video streaming camera for remote field monitoring, an IoT-controlled pesticide spraying system for precise and automated pest management, and a solar-powered charging system for sustainable energy usage. Furthermore, the proposed work includes an innovative security system that leverages wireless sensors and a high-voltage generator to deter potential intruders, safeguarding crops and farm assets. Through the seamless integration of these cutting-edge technologies, the proposed autonomous robotic tractor system aims to enhance farming efficiency, promote sustainable practices, and empower farmers with the tools necessary to meet the growing demands of the agricultural sector.

3.1 Materials Used

Hardware Requirements

ATMEGA328P Microcontroller.

Gps Module

Temperature-Humidity Sensor

Moisture Sensor

Li-Ion Battery

Solar Panel

Solar Charge Controller

DC Pump

Relay

AI Camera

High Voltage Generator

Motor Driver

Ultrasonic Sonar Sensor

Software Requirements:

Programming Language: C++

Development Environment: Arduino IDE.

Operating System: Windows 10

ARDUINO UNO:

The Arduino UNO is an Atmega328-based microcontroller board. There are 14 advanced pins and 6 simple pins on this board. A 16 MHz resonator, a USB association, a control jack, an in-circuit framework programming (ICSP) header and a reset button are displayed. It is an open-source hardware stage which is easy-to utilize for fledglings. It comprises of both a physical programmable circuit board and a chunk of computer program, or IDE which is Coordinates Improvement Environment that runs on the computer. This is often utilized to compose and transfer coding systems to the physical board.

GPS Guidance System

The GPS direction framework is indispensably to the independent operation of the automated tractor. It incorporates a NEO-6M GPS module that gets signals from satellites to decide the tractor's exact area inside the cultivate. The framework is complemented by a advanced calculation modified into the ATmega328p microcontroller, which forms the GPS information to explore the tractor along foreordained waypoints. This guarantees that the tractor can independently navigate the field with tall precision, dodging deterrents and guaranteeing that agrarian errands such as seeding and splashing are performed with exactness. By computerizing route, the framework diminishes the require for manual mediation and permits for operations to be carried out with consistency and productivity.

ESP32 AI Cam:

The ESP32 AI Cam is a powerful board that combines an ESP32 microcontroller with a camera module, enabling the robotic tractor to capture and stream live video footage. This feature provides farmers with the ability to visually monitor their fields in real-time through the IoT application. The camera can be used for various purposes, such as monitoring crop growth, detecting pests or diseases, and verifying the tractor's position and progress

Pesticide Spraying System:

The pesticide showering framework may be a basic highlight pointed at mechanizing the method of applying chemicals to crops. It comprises of a DC pump that apportions pesticides, which is controlled by the microcontroller through a 5V transfer switch. The framework permits for exact control over the sum and timing of pesticide application, guaranteeing that the chemicals are disseminated equally and as it were where required.

IoT-Based Security System:

The security system of the robotic tractor utilizes a network of wireless sensors to detect the presence of intruders or wild animals. Upon detection, the system triggers a high-voltage generator capable of producing a non-lethal electric shock as a deterrent. This feature is particularly important for protecting crops and farm equipment from damage or theft. The security system is designed to be selective, ensuring that it targets only genuine threats while avoiding false activations. It also enhances the safety of the farm by providing a layer of protection that operates independently of the farmer's presence.

Environmental Sensors:

A suite of natural sensors is coordinates into the automated tractor to degree basic parameters such as temperature, mugginess, daylight concentrated, and soil dampness. These sensors give the microcontroller with real-time information, which is at that point transmitted to the IoT application. Ranchers can utilize this information to form educated choices approximately water system, fertilization, and gathering times. The capacity to persistently screen natural conditions permits for versatile cultivating methodologies that can lead to made strides edit wellbeing, optimized asset utilize, and possibly higher yields.

Solar Panel and Lithium-Ion Batteries:

The robotic tractor is equipped with a solar panel and lithium-ion batteries to form a self- sustaining energy system. The solar panel, rated at 9V 4.5W, harnesses solar energy to charge the 8.4V lithium-ion batteries, providing a green and cost-effective power solution. This system ensures that the tractor can continue to operate even in remote areas without access to traditional power sources. The inclusion of a solar charge controller prevents overcharging and extends the life of the batteries, making the system both durable and environmentally friendly.

RFID Technology:

The IoT application serves as the user interface for the entire system, enabling farmers to interact with the robotic tractor through a mobile app. This app allows for the control of the tractor's movements, activation of the pesticide spraying system, and the use of the security features. It also displays the real-time data collected from the environmental sensors, providing insights into the current conditions of the farm. The app is designed with simplicity in mind, ensuring that farmers of all technical backgrounds can easily navigate its features and use it to manage their agricultural operations effectively.

3.2 Methodology used

In our venture, we utilize a multi-faceted strategy, including different modules custom-made to the particular prerequisites of a mechanical pharmaceutical allocator for elderly care. In our work we utilize a few modules, these modules/methodologies are recorded underneath.

Autonomous Navigation System

Develop and implement an autonomous GPS-guided navigation system utilizing the NEO-6M GPS module and sophisticated algorithms programmed into the ATmega328p microcontroller. Integrate proximity sensors for obstacle detection, ensuring safe and precise navigation within the farm environment.

Configure motor controls to enable autonomous movement towards targeted locations based on GPS coordinates.

Live Video Streaming Module

Integrate the ESP32 AI Cam board for live video streaming capabilities, allowing farmers to remotely monitor field conditions. Implement image processing algorithms for advanced applications like crop health analysis and yield prediction. Establish a secure and low-latency communication protocol for seamless video transmission to the IoT application.

Pesticide Spraying Mechanism

Construct an automated pesticide spraying system comprising a DC pump and relay switch controlled by the microcontroller.

Develop a precise liquid dispensing mechanism with adjustable spray patterns and volumes.

Implement real-time control and scheduling of spraying operations through the IoT application interface.

IoT and Mobile Integration

Design and develop a user-friendly IoT application for smartphones, serving as the primary interface for farmers.

Implement secure communication protocols for data exchange between the tractor and the application.

Incorporate features like real-time environmental data display, remote control of tractor functions, and live video streaming.

Environmental Sensing

Interface a suite of sensors, including the DHT11 for temperature and humidity, with the microcontroller for accurate environmental data collection.

Implement data processing algorithms to extract meaningful insights from sensor readings.

Integrate sensor data into the IoT application for informed decision-making by farmers.

Security System Integration

Develop an IoT-based security system by incorporating wireless sensors for intruder detection.
Program the high-voltage generator to activate the electric tazing capability as a non-lethal deterrent upon detection.
Establish secure communication protocols between the security system and the IoT application for remote monitoring and control.

Solar Power Management

Integrate a solar panel and charge controller for sustainable energy harvesting and battery charging.
Implement power management algorithms to optimize energy usage and ensure uninterrupted operation.
Conduct testing and calibration to ensure efficient solar energy conversion and storage.

System Integration and Testing

Integrate all developed modules into a cohesive robotic tractor system, ensuring seamless communication and functionality.
Conduct comprehensive testing, including functionality, usability, and reliability assessments.
Refine and optimize the system based on testing results to ensure its effectiveness in real-world agricultural scenarios.

Voice Alert System

Purpose: Provides audible notifications and reminders to farmers.
Role in Agricultural Operations: Enhances farm management by alerting farmers about scheduled tasks, environmental conditions, or potential issues through voice alerts.

Integrate a voice alert system to provide audible signals for pesticide schedules and important information.
Implement natural language processing algorithms for clear and effective communication.
Ensure seamless integration with the overall scheduling and alert system.

4. OUTCOME

Sensor Data Measurement:

The ATmega328p microcontroller is central to the project's capacity to accumulate natural information, which is vital for exactness cultivating. With its capacity to interface with the DHT11 sensor, the microcontroller can precisely degree temperature and stickiness levels within the field. These estimations are fundamental for understanding the microclimate around crops, which in turn impacts choices on watering plans, malady avoidance, and trim revolution. Such data-driven cultivating can lead to higher trim yields and more proficient utilize of resources by permitting ranchers to reply to the particular needs of their crops in real-time.

Mobile App Interface:

The Bluetooth module's role is to provide a wireless communication channel between the microcontroller and the mobile app. By facilitating this connection, farmers can receive sensor data directly on their smartphones, enabling them to monitor environmental conditions without being physically present in the field. This not only saves time but also allows for immediate intervention when the data indicates that certain thresholds have been crossed. The app can be designed to offer a user-friendly interface, alert systems, and even control mechanisms for various tractor functions, making it a powerful tool for farm management.

Real-time Farm Information:
Get to to real-time cultivate data could be a game-changer for agriculturists. By leveraging the information collected from different sensors, ranchers can make educated choices almost water system, fertilization, and collecting. This level of detail makes a difference to optimize cultivating hones, coming about in superior asset administration and potentially higher yields. For illustration, knowing the precise dampness substance of the soil can avoid over-irrigation, which not as it were moderates water but moreover decreases the chance of root decay and other moisture-related infections.

Reduction in Health Hazards:
The independent mechanical tractor's pesticide showering capabilities are planned to play down human presentation to destructive chemicals. By taking care of this errand independently, the tractor kills the require for ranchers to come into coordinate contact with pesticides, which can lead to genuine wellbeing issues over time. This include not as it were shields the wellbeing of the ranchers but moreover guarantees reliable and exact application of pesticides, which can move forward bother control and decrease the sum of chemicals required, in this manner profiting the environment.

Independence from Tractor Drivers:
This technology frees farmers from the unpredictability of human tractor drivers. Autonomous tractors can be programmed to perform tasks at specific times, ensuring that farming activities such as plowing, seeding, and harvesting are carried out exactly when needed. This precision prevents delays and improves the overall efficiency of farm operations. As a result, farmers can focus on other important aspects of farm management, knowing that the autonomous tractor is reliably executing its tasks.

Enhanced Security:
The consideration of security components within the automated tractor gives an extra layer of security for the crops. By identifying and frightening absent gatecrashers or wild creatures, the tractor makes a difference to avoid potential damage to the areas. Typically especially critical for crops that are delicate or have tall esteem, such as Shri-Gandha, where any unsettling influence or harm can lead to noteworthy monetary misfortunes. The tractor can hence act as a gatekeeper for the areas, guaranteeing that crops are ensured around the clock.

REFRENCES

[1] .V Gowrishankar, K Venkatachalam, “Survey on Performance Analysis of Data Converters for Sensor Network Applications”, Vol. 6, Issue 8, 2016, page.2275- 2284.

[2].S Mahendra Kumar and T Guna Sekar, (2016) “Cross-Layer Design for Energy Efficient Multicast Video Transmission over Mobile Ad HocNetworks”, Asian Journal of Research in Social Sciences and Humanities, Volume 6, Issue 9, Pages 719-734.

[3].Ashish Lalwani, mrunmai Bhide, S. K. Shah, A Review: Autonomous Agribot for Smart Farming, 46th IRF International Conference, 2015.

[4]Gulam Amer, S.M.M. Mudassir, M.A. Malik, “Design and operation of Wi-Fi Agribot Integrated system”, International Conference on Industrial Instrumentation and control (ICIC), IEEE,2015.

[5]Akhila Gollakota, M.B. Srinivas, Agribot-A multipurpose agricultural robot, India Conference (INDICON), IEEE,2011.

[6]V Gowrishankar, K Venkatachalam, “Efficient FIR Filter Design Using Modified Carry Select Adder & Wallace Tree Multiplier”, Vol. 2, Issue 3, 2013, page.703-711.

[7]Amritanshu Srivastava, Shubham Vijay, Alka Negi, Akash Singh, “DTMF Based Intelligent Farming Robotic Vehicle,” International Conferenceon Embedded Systems (ICES), IEEE2014.

[8]Development of a Wireless Surveillance Robot for Controlling from Long Distance.

[9]Design and Implementation of Remote Operated Spy Robot Control System.

[10]War Field Spying Robot with Wireless Camera and Firing System.