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Advanced Surveillance Robot for Farm

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Abstract – The development & design of Advanced Surveillance Robot for Farm which is a smart, automated system specially designed for protection of crops from wild animals. It uses wireless technology, live video monitoring, and a sound-based deterrent to keep farms safe. The robot equipped with a high-resolution camera, GPS, and sensors can autonomously navigate and monitor the farm, detecting anomalies and alerting farmers in real-time. The robot's advanced computer vision algorithms enable it to identify and classify objects, including crops, livestock, and intruders. This project can contribute to the development of smart farming technologies, enhancing farm productivity, security, and sustainability.

***Key Words*:** Surveillance robot, Security, Navigation, Detection of Anomalies, Smart Farming.

1.INTRODUCTION

Agriculture is large sector that feeds the whole human being present on earth, almost 25% of words population does farming as their income- source occupation. But the farms face numerous challenges, including crop damage, livestock theft and intruder threats, resulting in significant economic losses. Traditional methods of surveillance and security such as manual patrols and fixed cameras, have limitations in terms of coverage and adaptability. So, to find solution on all this regarding is very important.

The advent of precision agriculture and use of smart farming technologies has changed the agricultural sector, making possible for farmers to optimize crop yields, reduce waste and improve resource allocation. Recent advancement in robotics, computer vision and artificial intelligence have enabled the development of autonomous surveillance robot. This robot includes features like real time monitoring, video recording, alarming systems, detecting anomalies which reduces efforts of farmers for real time patrolling and enhances security.

This research paper mainly focuses on the design, development and testing of advanced surveillance robot for farm, for farm security. The robot is equipped high-end system like cameras, GPS, sensors, etc. The paper notes the points like system design, components, working of robots, benefits and limitations and future scope of advancement. From this research we are focusing on the thought that robotic system and humans can work together for the development of the society.

2.LITERATURE REVIEW

Hrishikesh Deshpande et al [1] explained that development, design and implementation of surveillance robot using the ESP32-CAM can give us both the benefits of security and monitoring. They explained that the integration of robotics and surveillance technology has gained significant attention in recent years due increasing demands in industries. The ESP32-CAM is a low-cost development board that combines an ESP32 microcontroller with a camera module. It features Wi-Fi and Bluetooth capabilities, making it suitable for IoT applications. The paper generally makes an opinion about the ability of the robot to transmit video feed wirelessly is crucial in providing real time surveillance capabilities, and they developed a system that can be operated by remote server or mobile device.

Yash P. Chitale et al [2] proposed the model that introduces a sophisticated robot designed to seamlessly integrate into any home environment. They reviewed the variety of robots performing similar task before designing the actual one. It actually propagates the way of procuring existing features in surveillance robot based on IoT. The author emphasized that the use of IoT in surveillance robot can enhance security, reduce labor costs, and improve monitoring capabilities, making it a promising solution for various application, including home security, industrial surveillance, and public safety.

Shreyash Deshmukh et al [3] stated that security is a top priority for business, organizations, and many important localities. With increasing risk of calamities like fire-outbreaks, electrical short-circuit, criminal activities and many more. It is very important to invest in security-edge technologies.

Ansh Dudeja et al [4] developed an entire project based on wireless platform to minimalize the use of wire and help it to work smoothly in remote places. This paper aims to develop a multi-purpose surveillance robot to perform surveillance activities in industrial areas, militarized war zones or radioactive field areas with the objective of analyzing, governing and protecting the areas from unwanted threats.

CH. G. L. Pravallika et al [5] proposed that the development of multi-purpose robot can make big difference in monitoring and security-based operations. The authors highlighted the fact that robots are designed with the integration of multiple sensors and cameras to provide effective surveillance operations, and to increase potential benefits of robot, making it user-friendly and pocket-friendly.

Gaja Ashok et al [6] stated that the surveillance mechanism includes a net camera mounted over it, through that we'll get live video feed, and therefore, the fascinating half is that we are able to management and move this mechanism from an online browser over the web. Because it is often controlled victimization web page in Mobile. We tend to engineer a web

page in markup language that has Left, Right, Forward, Backward links, clicking on that we are able to move the mechanism in any direction. It additionally includes a DHT11 detector and Gas detector to apprise through IFTTT. Once the temperature is high and any harmful gas is detected severally.

K. Rajkumar et al [7] in their project, the robot is designed to move by our command and also by its own according to the command given by the program. The video is monitored at the control unit. In this prototype project, the robot is designed in such a way that it can be moved anywhere and it can get the information of particular place. It is easy to detect any fault in that specified area. It leads easy process without interaction of humans. This project is very much useful in the places where a human cannot go into the places like canals, smoke-oriented caves and it will be very much useful in such situations.

G. Anandravisekar et al [8] in this paper, the framework for making a robot for surveillance purpose is propose. It overcome the problem of limited range surveillance by using the concept of IoT. We can control the robot with the help of laptop/mobile manually. Automatic monitoring can also be done. Our proposed robot is small in size thus maneuvering into area where human access is impossible. Wireless technology is one of the most integral technologies in the electronics field. This technology is used to serve our project as a supreme part of surveillance act. This provides highly efficient and a cost-effective robot that replaces human work and reduces human labor and performing monitoring works in a well effective manner.

3 SYSTEM DESIGN

Designing a complicated system like a surveillance robot involves multiple components and consideration, including hardware, software, communications devices, and user interfaces. The surveillance robot is designed to monitor specific areas, capture mobilities, audios, detect intrusions or anomalies, and communicate with a central control system or operator.

Table -1: Components of Advanced Surveillance Robot for Farm

Sr. No.	Components	Function
1.	Arduino-Uno	Main microcontroller, processes commands & controls all components.
2.	12V DC Motors	Drives the robot for movement.
3.	30 RPM Motor	Used for gimble control (cannon positioning).
4.	L298 Motor Driver	Controls the gimble motors for two-axis movement.
5.	HC-05 Bluetooth Module	Wireless communication with a mobile app or remote control.
6.	ESP-32 CAM Module	Captures and transmits live video footage.
7.	Air Valve	Injects acetylene gas into the firing chamber.
8.	High-Voltage Pulse Generator	Creates a spark to ignite the cannon fuel.
9.	Relay Module (4 relays)	Controls the main motors for robot movement.
10.	12V 4A Battery	Powers the entire system.
11.	Buck Converter	Converts 12V to 5V for Arduino and low-power components.

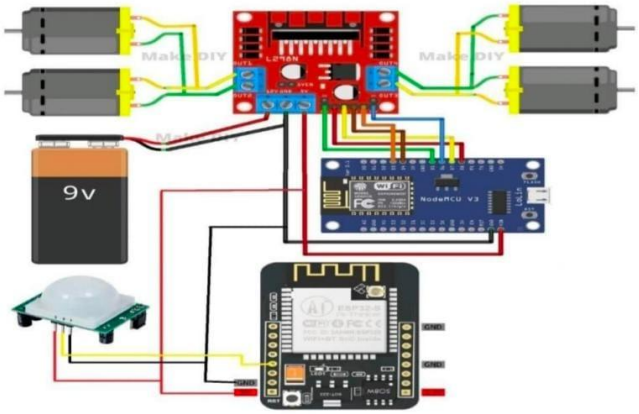


Fig 1. Architecture of Advanced Surveillance Robot for Farm

3.1 Arduino Uno (Microcontroller):

- **Function**: Acts as the central control unit of the robot.
- **Role in the Project**:
  - Controls all components, including motors, relays, gimbal movement, Bluetooth communication, and ignition system.
  - Receives commands via the HC-05 Bluetooth module and processes inputs to operate the robot's movement and firing system.
  - Controls the ESP32-CAM module for real-time video monitoring.
- **Specifications:**
  - 8-bit ATmega328P microcontroller
  - 14 digital I/O pins (6 PWM outputs)
  - 6 analog input pins
  - Operates on 5V, powered via a buck converter.

Fig 2. Arduino Uno (Microcontroller)

3.2 12V DC Motors (For Robot Movement):

- **Function:** Provides mobility to the robot to move across the farm field.
- **Role in the Project:**

- Two 12V high-torque DC motors drive the wheels of the robot.
- Controlled via relays, allowing the robot to move forward, backward, left, and right.
- Ensures smooth navigation over uneven and rough terrains.

- **Specifications:**
  - Operates on 12V DC
  - High torque to handle outdoor conditions
  - Speed: 30-100 RPM (based on gear ratio selection)

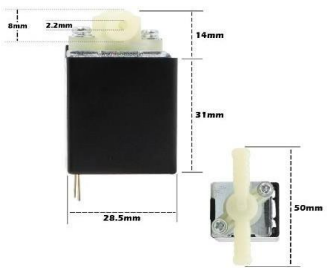
Fig 3. V DC Motors (For Robot Movement)

3.3 30 RPM Motor (For Gimbal Movement):

- **Function**: Controls the two-axis gimbal that aims the calcium carbide cannon.
- **Role in the Project:**
  - Enables precise horizontal and vertical positioning of the cannon.
  - Ensures accurate targeting for optimal deterrence of wild animals.
  - Driven by the L298 motor driver for smooth and stable control.
- **Specifications:**
  - Operates on 12V DC
  - Speed: 30 RPM
  - High torque for steady movement and positioning

Fig 4. RPM Motor (For Gimbal Movement)

3.4 L298 Motor Driver (For Two-Axis Gimbal Control):



- **Function:** Controls the gimbal motors responsible for aiming the cannon.
- **Role in the Project:**
  - Drives the 30 RPM motors in both horizontal (pan) and vertical (tilt) directions.
  - Allows bidirectional motor control with PWM speed adjustment.
  - Connected to Arduino Uno, receiving commands for precise aiming.
- **Specifications:**
  - Dual H-Bridge motor driver
  - Supports up to 2A per channel
  - Operates on 5V logic (compatible with Arduino)

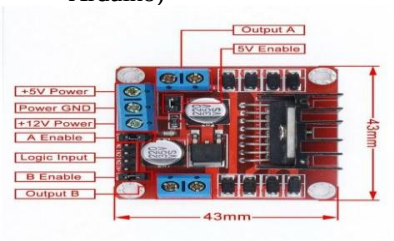


Fig 5. L298 Motor Driver (For Two-Axis Gimbal Control)

3.5 HC-05 Bluetooth Module (For Wireless Operation):

- **Function:** Enables wireless communication between the robot and a mobile app or remote controller.
- **Role in the Project:**
  - Allows farmers to remotely control the robot without physical contact.
  - Sends commands to move the robot, aim the gimbal, and fire the cannon.
  - Communicates with Arduino Uno via serial interface (TX/RX pins).
- **Specifications:**
  - Operates on 3.3V to 5V
  - Supports UART communication
  - Wireless range: 10–15 meters

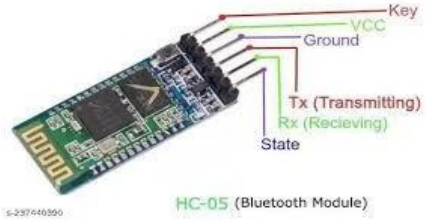


Fig 6. HC-05 Bluetooth Module (For Wireless Operation)

3.6 Air Valve (For Fuel Gas Injection into the Firing Chamber):

- **Function:** Controls the flow of acetylene gas (produced by the reaction of calcium carbide and water) into the firing chamber.
- **Role in the Project**:
  - Ensures precise control of fuel supply to prevent excessive gas accumulation.
  - Helps maintain a consistent ignition process for reliable cannon operation.
- **Specifications:**
  - Operates on 12V DC
  - Electromagnetic valve type

Fig 7. Air Valve (For Fuel Gas Injection into the Firing Chamber)

3.7 High-Voltage Pulse Generator (For Cannon Ignition):

- **Function**: Generates a high-voltage spark to ignite the acetylene gas inside the firing chamber.
- **Role in the Project:**
  - Triggers controlled explosions to produce loud sound bursts.
  - Works in synchronization with the air valve and fuel injection system
  - Ensures effective deterrence against wild animals.
- **Specifications:**
  - Output voltage: 5kV – 15kV
  - Low-power trigger mechanism

Fig 8. High-Voltage Pulse Generator (For Cannon Ignition)

3.8 Combination of 4 Relays (For Main Motor Control):

- **Function:** Controls the 12V DC motors responsible for the robot's movement.
- **Role in the Project:**
  - Provides switching control to allow forward, backward, left, and right movement.
  - Helps in directional control by switching motor polarity.
- **Specifications:**
  - Operates on 12V DC
  - 4-channel relay module
  - Supports high-power loads

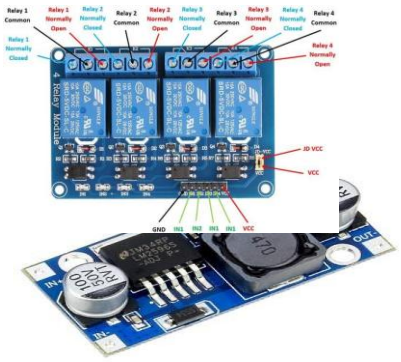


Fig 9. Combination of 4 Relays (For Main Motor Control

3.9 ESP32-CAM Module (For Real-Time Video Streaming):

- **Function:** Captures live video footage and streams it over Wi-Fi for remote monitoring.
- **Role in the Project:**
  - Helps farmers monitor their fields from a smartphone or computer.
  - Provides visual confirmation of intrusions.
  - Allows manual control of the robot based on real-time threats.
- **Specifications:**
  - Built-in Wi-Fi connectivity
  - Supports JPEG image capture and video streaming
  - Operates on 3.3V – 5V

Fig 10. ESP32-CAM Module (For Real-Time Video Streaming)

3.10 12V 4A Battery (Main Power Supply for the Robot):

- **Function:** Provides power to the entire system.
- **Role in the Project:**
  - Powers the motors, relays, air valve, ignition system, and Arduino Uno.
  - Ensures long operational time in outdoor environments.
  - Capable of handling high-current loads for stable performance.
- **Specifications:**
  - Output voltage: 12V DC
  - Capacity: 4A (sufficient for continuous operation)

3.11 Buck Converter (Voltage Regulator for Arduino and Relays):

- **Function:** Converts 12V DC to 5V DC for low-power components.
- **Role in the Project:**
  - Supplies stable 5V power to Arduino Uno, ESP32-CAM, and relay modules.
  - Prevents voltage fluctuations and protects sensitive components.
  - Ensures efficient power distribution to all electronic parts.
- **Specifications:**
  - Input voltage: 12V DC
  - Output voltage: 5V DC (adjustable)
  - High-efficiency conversion

Fig 11. Buck Converter (Voltage Regulator for Arduino and Relays)

4. WORKING

The working of Autonomous Surveillance Robot involves a simulation of hardware and software components that enables it to remotely monitor an area, gather data. The robot is powered on, initializing its systems, including sensors, cameras and communication modules. Then by using pre-defined routes or algorithms, the robot determines the best path to navigate through the location which is need to be inspected. The robot uses sensors to detect obstacles, inappropriate activities, animals, etc. When anything is detected, it records and send signals to the operator. The motors control the movement of the robot, allowing it to move forward, backward, turn and adjust its speed. The robot's camera captures real-time video footage

of its surrounding. It may include features like panning, tilting and zooming to adjust the camera's orientation and focus on specific areas of interest.

The block diagram given below shows the rough sketch of Autonomous agriculture surveillance robot and positioning of the components mentioned above in table-1.

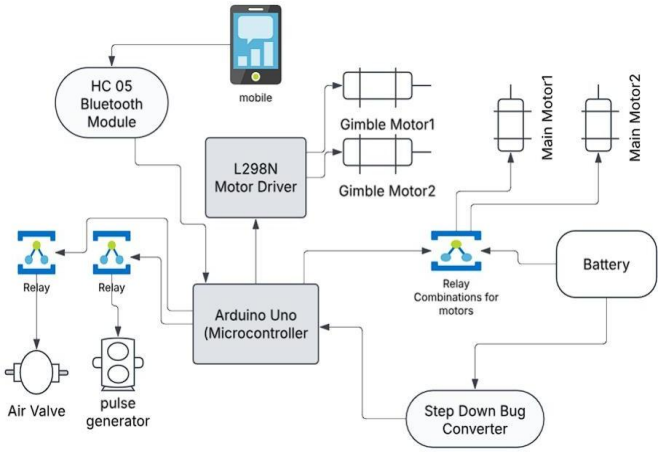


Fig 12. Schematic representation of components used in designing of robot.

5. BENEFITS AND LIMITATIONS

5.1 BENEFITS

1. **Increased Efficiency-** Robot can cover large area of farmland quickly and consistently, allowing for more efficient monitoring of crops and livestock compared to manual inspection.
2. **Real Time Data Collection-** The surveillance robots are equipped with sensors and cameras that provide real-time data on crop health, soil condition, and pest infestations.
3. **Enhanced Security-** Surveillance robots can patrol areas more effectively than static cameras, providing real time monitoring and immediate alerts for any unusual activity.
4. **Cost Saving-** While initial investment can be high but surveillance robots can save long-term labor costs by minimizing the need for human security personnel.
5. **24/7 Monitoring-** These robots can operate continuously without any fatigue, ensuring constant surveillance and reducing the risk of human error or oversight.
6. **Versatility-** Surveillance robots can be used in a variety of settings, including warehouses, retail spaces, public areas and agriculture fields, making them adaptable everywhere.
7. **Environmental Monitoring-** In addition to security, surveillance robots can monitor environmental conditions. For example, air quality, temperature in various settings, contributing to better safety and compliance.

5.2 LIMITATIONS

1. **Limited Range of Connectivity –** The HC-05 Bluetooth module has a short-range (10–20 meters), restricting control distance. While Wi-Fi connectivity (ESP32-CAM) extends monitoring range, it depends on network availability.
2. **Dependence on Stable Network –** The ESP32-CAM requires a stable Wi-Fi connection for real-time video streaming. In remote areas with poor network coverage, monitoring efficiency is reduced.
3. **Weather Sensitivity** – Harsh weather conditions like heavy rain, extreme heat, or strong winds can affect the performance of electronic components and may cause damage to the robot's mobility and surveillance system.
4. **Calcium Carbide Cannon Limitations –** The sound deterrence system relies on calcium carbide combustion, which may require frequent refueling and could pose safety risks if not handled properly.
5. **Obstruction and Terrain Challenges –** Uneven farmland, muddy areas, or dense vegetation may obstruct the robot's movement, making it difficult to navigate across large or rugged farm areas.
6. **Limited Sound-Based Deterrence –** Some animals may adapt to the sound bursts over time, reducing the effectiveness of the deterrent system.

6. CONCLUSIONS

The Advanced Surveillance Robot for Farm is a smart, automated system designed to protect crops from wild animals. It uses wireless technology, live video monitoring, and a sound-based deterrent to keep farms safe. This project shows how surveillance technology is evolving by combining robotics, IoT (Internet of Things), and advanced sensors. These tools allow for remote monitoring, real-time analysis, and better safety measures. Innovations like flexible robots, IoT-based solutions, and smart systems for managing disasters demonstrate accuracy, adaptability, and proactive security. These advancements are changing how humans and robots work together, making things safer and more efficient in many areas.

7. FUTURE SCOPE

- Implement machine learning algorithms to differentiate between harmless animals (e.g., birds) and potential threats (e.g., wild boars).
- Add obstacle detection and avoidance using ultrasonic sensors or LIDAR to ensure safe navigation in uneven terrains.
- Integrate solar panels to provide continuous power supply, especially in remote farm areas.
- Implement IoT integration to allow farmers to monitor and control the robot via the internet from anywhere in the world.

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