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ABSTRACT

Internet of Things (IoT) technology has revolutionized various aspects of everyday life, and its impact on agriculture through Intelligent Smart Farming IoT devices is profound. The Smart Fence project introduces an innovative solution to protect agricultural assets from animal intrusion by integrating advanced sensor technology with responsive deterrent mechanisms. Motion detection sensors deployed along the farm boundary promptly detect animal movement, triggering a series of deterrent measures tailored to specific animal threats.

In this enhanced version, the system incorporates a customized frequency generator module capable of emitting frequencies specific to particular animal species. For instance, in regions like Saurashtra where blackbucks pose a significant threat to crops, the system emits frequencies targeted specifically to deter blackbucks. This targeted approach minimizes crop damage effectively.

The deterrent measures include LED strip lights for visual deterrence, a buzzer for sound generation, mist sensors for water atomization, and now, the customized frequency generator tailored to specific animal threats. These integrated components synergize to create a comprehensive deterrent system, safeguarding crops and reducing potential damage caused by wildlife intrusion.

The project's adaptability, scalability, and potential for further enhancements make it a promising solution for promoting sustainable agriculture practices and safeguarding farmers' livelihoods in diverse agricultural landscapes.

1. INTRODUCTION

1.1 Overview

The Smart Fence project harnesses IoT technology to combat agricultural asset vulnerability to animal intrusion. Through the integration of advanced sensors and responsive deterrent mechanisms, the system swiftly detects and addresses animal movement along farm perimeters. An innovative addition is the customized frequency generator module, which emits frequencies tailored to specific animal threats, enhancing targeted deterrence. Alongside visual, auditory, and mist-based deterrents, this comprehensive approach effectively safeguards crops, reduces wildlife-induced damage, and promises scalability and adaptability for sustainable agriculture practices, offering a robust defence for farmers' livelihoods across various agricultural contexts.

1.2 IoT TECHNOLOGY AND AGRICULTURE

1.2.1 IoT : CONCEPT AND DEFINITION

Internet of things IOT consists of two words Internet and Things .The term things in IOT refers to various IOT devices having unique identities and have capabilities to perform remote sensing , actuating and live monitoring of certain sort of data. IOT devices are also enable to have live exchange of data with other connected devices and application either directly or indirectly , or collected data from other devices and process the data and send the data to various servers. The other term internet is define as Global communication Network connecting Trillions of computers across the planets enabling sharing of information .Thus the IOT can be define as :"A dynamic Global Network Infrusture with self configuring capabilities based on standard and inter operable communication to protocol where physical and virtual things have identities, physical attributes ,and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network ,often communicate data associated with user and their environment." An ideal IoT device consists of various interfaces for making connectivity to other devices which can either be wired or wireless.

Any IoT based device consists of following components:

- I/O interface for Sensors.
- Interface for connecting to Internet.
- Interface for Memory and Storage.
- Interface for Audio/Video.

1.2.2 IoT ENABLING TECHNOLOGIES

Internet of Things has a strong backbone of various enabling technologies- Wireless Sensor Networks, Cloud Computing, Big Data, Embedded Systems, Security Protocols and Architectures, Protocols enabling communication, web services, Internet and Search Engines.

Wireless Sensor Network (WSN): It consists of various sensors/nodes which are integrated together to monitor various sorts of data.

Cloud Computing: Cloud Computing also known as on-demand computing is a type of Internet based computing which provides shared processing resources and data to computers and other devices on demand. It can be in various forms like IaaS, PaaS, SaaS, DaaS etc.

Big Data Analytics: Big data analytics is the process of examining large data sets containing various forms of data types—i.e. Big Data – to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful business information.

Communication Protocols: They form the backbone of IoT systems to enable connectivity and coupling to applications and these protocols facilitate exchange of data over the network as these protocols enable data exchange formats, data encoding and addressing.

Embedded Systems: It is a sort of computer system which consists of both hardware and software to perform specific tasks. It includes microprocessor/microcontroller, RAM/ROM, networking components, I/O units and storage devices.

1.2.3 BENEFITS OF IOT IN AGRICULTURE

The following are the benefits of IoT in Agriculture:

1. IoT enables easy collection and management of tons of data collected from sensors and with integration of cloud computing services like Agriculture fields maps, cloud storage etc., data can be accessed live from anywhere and everywhere enabling live monitoring and end to end connectivity among all the parties concerned.

2. IoT is regarded as key component for Smart Farming as with accurate sensors and smart equipment's, farmers can increase the food production by 70% till year 2050 as depicted by experts.

3. With IoT productions costs can be reduced to a remarkable level which will in turn increase profitability and sustainability. 4. With IoT, efficiency level would be increased in terms of usage of Soil, Water, Fertilizers, Pesticides etc. 5. With IoT, various factors would also lead to the protection of environment.

2. OVERVIEW OF THE PROJECT

2.1 DEFINITION

The Smart Fence project is an IoT-based agricultural protection system that utilizes advanced sensor technology and responsive deterrent mechanisms to detect and deter animal intrusion along farm boundaries. A key innovation is the integration of a customized frequency generator module, emitting frequencies targeted to specific animal threats, enhancing the system's ability to mitigate damage. By combining visual, auditory, and mist-based deterrents, the project offers a comprehensive defence against wildlife intrusion, promoting sustainable agriculture practices and safeguarding farmers' livelihoods across diverse agricultural landscapes.

2.2 COMPONENT AND MODULES

2.2.1 ESP32-CAM

The ESP32-CAM is a small-size, low-power camera module based on ESP32. It comes with an OV2640 camera and provides an onboard TF card slot. This board has 4MB PSRAM which is used for buffering images from the camera into video streaming or other tasks and allows you to use higher quality in your pictures without crashing the ESP32. It also comes with an onboard LED for flash and several GPIOs to connect peripherals.

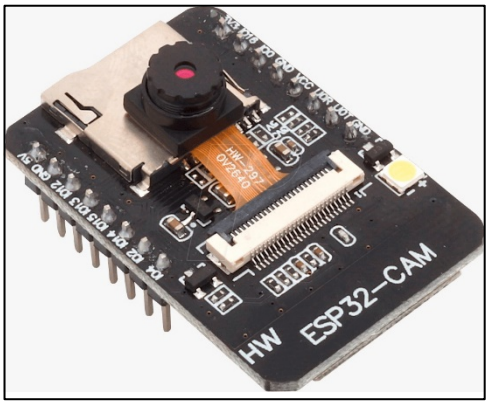

Figure 1 : ESP32-CAM Module

Description: A compact camera module based on the ESP32 microcontroller, capable of capturing images and video.
Specifications: Supports Wi-Fi connectivity, operates at 3.3V DC, and features an OV2640 camera sensor.
Application: Captures images of detected animal intrusions for monitoring and record-keeping purposes.

Features:

1. Onboard ESP32-S module, supports WiFi + Bluetooth
2. OV2640 camera with flash
3. Onboard TF card slot, supports up to 4G TF card for data storage

4. Supports WiFi video monitoring and WiFi image upload
5. Supports multi sleep modes, deep sleep current as low as 6mA
6. Control interface is accessible via pin-header, easy to be integrated and embedded into user products

2.2.2 SENSORS

2.2.2.1 PIR SENSOR

Figure 2 : PIR Sensor

Description: A motion detection sensor that detects infrared radiation emitted by moving objects, such as animals.
Specifications: Usually operates at a voltage range of 3.3V to 5V DC.
Application: Detects animal movement along the farm boundary and triggers the activation of deterrent mechanisms.

2.2.2.2 MIST SENSOR

Figure 3 : Mist Sensor

Description: A device that generates a fine mist or spray of water.
Specifications: Operates at various voltage levels, typically 5V DC, and features a water pump or atomizer mechanism.
Application: Releases a mist or spray to create a barrier or uncomfortable environment for animals, aiding in deterrence.

2.2.2.3 IC555 FREQUENCY GENERATOR

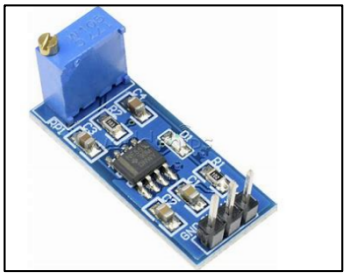

Figure 4 : IC555 Frequency Generator

Description: An integrated circuit (IC) timer chip capable of generating precise and stable square wave signals.
Specifications: Operates at various voltage levels, typically 5V DC, and produces square wave output signals at adjustable frequencies.
Application: Generates unpleasant tones or frequencies to deter animals from entering the protected area.

2.2.3 COMPONENTS

2.2.3.1 2-CHANNEL RELAY

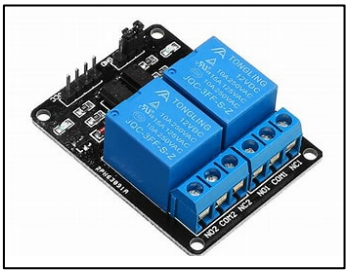

Figure 5 : 2-Channel Relay

Description: A relay module with two channels, allowing control of two independent circuits.
Specifications: Typically operates at 5V DC and can switch high-voltage or high-current loads.
Application: Controls the activation of deterrent mechanisms such as LED strip lights, mist generators, and sound generators.

2.2.3.2 BUZZER

Figure 6 : Buzzer

Description: An electronic sound-producing device that emits audible tones or alarms.
Specifications: Typically operates at 5V DC and produces sound output at adjustable frequencies.
Application: Emits loud sounds to startle and deter animals from entering the protected area.

2.2.3.3 LED STRIP LIGHT

Figure 7 : LED Strip

Description: A flexible strip of LEDs that provides illumination.
Specifications: Typically operates at 12V DC and comes in various lengths and colors.
Application: Illuminates the area to visually deter animals and enhance surveillance during low-light conditions.

2.2.4 POWER SUPPLY

2.2.4.1 9V BATTERY

Figure 8 : 9V Battery

The backbone of the Smart Fence system, the 9-volt battery, offers a portable and independent power source, ensuring continuous operation without reliance on external power grids. Its compact size and reliable performance make it an ideal choice for powering the surveillance and deterrent mechanisms.

2.2.4.2 RECHARGEABLE BATTERY

Figure 9 : Rechargeable Battery

The sealed lead-acid (SLA) 12V, 9Ah rechargeable battery is rated at a 5-hour (0.2) and 20-hour (0.05C) discharge. Longer discharge times produce higher capacity readings because of lower losses.
The lead-acid performs well on high load currents. This battery act as an internal power supply for the whole circuit.

2.3 ULTRASONIC FREQUENCY RANGE

Animal	Frequency Range (Hz)
Blackbucks	20,000 - 25,000
Nilgai (Blue Bull)	15,000 - 18,000
Wild Boars	10,000 - 15,000
Monkeys	10,000 - 20,000
Birds (Sparrows, Pigeons, etc.)	5,000 - 10,000
Rodents (Rats, Mice, etc.)	20,000 - 30,000

Table 1 : List of Frequency Range

1. Blackbucks:
    - These antelopes are known for damaging crops by trampling and feeding on agricultural produce.
    - Frequency Range: 20,000 - 25,000 Hz
    - Effective deterrent frequencies within this range can help discourage blackbucks from entering crop fields.
2. Nilgai (Blue Bull):
    - Nilgai, or the blue bull, is the largest antelope species native to India and is notorious for crop depredation.
    - Frequency Range: 15,000 - 18,000 Hz
    - Emitting frequencies within this range can effectively deter Nilgai from damaging crops.
3. Wild Boars:
    - Wild boars are omnivorous animals that cause significant damage to crops by rooting and foraging.
    - Frequency Range: 10,000 - 15,000 Hz
    - Utilizing deterrent frequencies within this range can help deter wild boars and reduce crop destruction.

4. Monkeys:
    - Monkeys, particularly Rhesus macaques and langurs, are notorious for raiding agricultural fields and orchards.
    - Frequency Range: 10,000 - 20,000 Hz
    - Emitting frequencies within this range can discourage monkeys from entering crop areas and causing damage.
5. Birds (Sparrows, Pigeons, etc.):
    - Various bird species, including sparrows and pigeons, often feed on seeds, fruits, and grains, leading to crop losses.
    - Frequency Range: 5,000 - 10,000 Hz
    - Emitting frequencies within this range can deter birds from foraging in crop fields and orchards.
6. Rodents (Rats, Mice, etc.):
    - Rodents such as rats and mice are notorious for feeding on crops, stored grains, and seeds, causing significant economic losses.
    - Frequency Range: 20,000 - 30,000 Hz
    - Using deterrent frequencies within this range can help repel rodents and mitigate crop damage.

3. BLOCK-DIAGRAM

Initiating with the detection of animal movement by PIR sensors along the farm perimeter, signals are processed by the microcontroller, such as ESP32-CAM, to activate responsive mechanisms via the 2-channel relay. This relay controls the operation of various deterrent mechanisms, including LED strip lights for visual deterrence, a buzzer for emitting loud sounds, and the customized frequency generator emitting frequencies tailored to specific animal threats. Simultaneously, the ESP32-CAM module captures images or video footage of the intrusion for real-time monitoring and sends the captured data based on detection. This includes frequencies designed to deter specific animals like blackbucks, which are imperceptible to humans but effective against the target species, ensuring comprehensive protection of agricultural assets. Below figure 10 shows the block diagram of the system

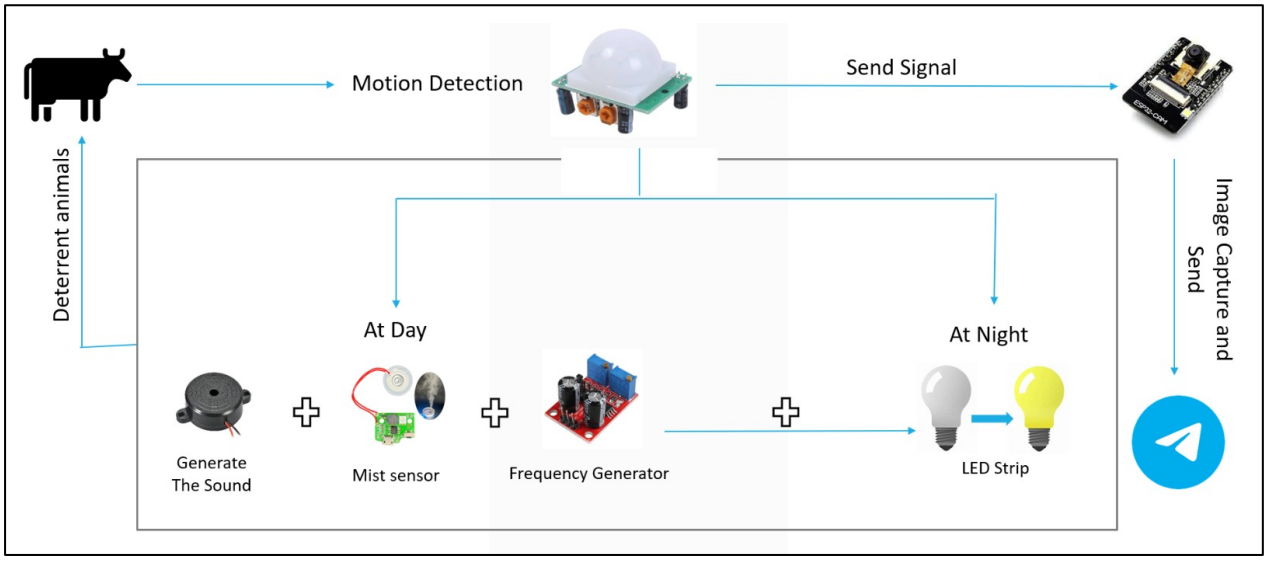

Figure 10 : Block Diagram

Implementation :

At its core, the system operates on the principles of real-time monitoring and proactive response. Surveillance cameras strategically positioned across the farm continuously monitor the premises, capturing any movement or activity. Integrated motion sensors detect the presence of animals, triggering immediate alerts to notify farmers of potential threats.

The inclusion of ultrasonic sound generators adds an extra layer of deterrence, emitting high-frequency sounds that are unpleasant to animals, effectively discouraging them from entering the farm premises. Additionally, access control mechanisms, such as remote-controlled gates or barriers, further enhance security by restricting unauthorized entry.

Crucially, the system leverages IoT technology to enable remote monitoring and management. Farmers can access the system through a user-friendly interface, allowing them to view live camera feeds, receive real-time alerts, and remotely control security measures from anywhere, at any time.

By providing actionable insights and timely alerts, the IoT-Based Farm Surveillance System empowers farmers to take swift preventive action, minimizing the risk of crop damage and ensuring the continued productivity and profitability of their farms. It represents a vital tool in modern agriculture, offering comprehensive security coverage and peace of mind to farmers facing the persistent challenge of protecting their hard-earned harvests.

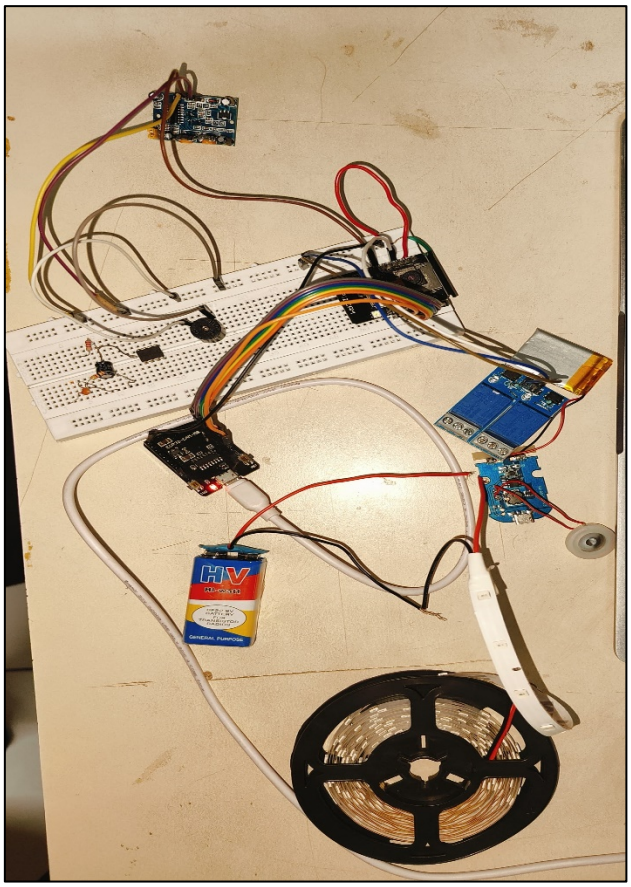

Figure 11 : Impplementation

4. CONCLUSION & FUTURE SCOPE

4.1 CONCLUSION

1. The IoT-Based Farm Surveillance System represents a pioneering solution at the intersection of agriculture and technology, offering farmers a powerful tool to safeguard their livelihoods and assets.
2. Through the integration of cutting-edge technologies such as IoT, image processing, and remote monitoring, the system empowers farmers with real-time insights and proactive security measures.
3. As we continue to innovate and expand the capabilities of the ESP32-CAM Farm Surveillance System, we envision a future where smart farming technologies play a central role in sustainable agriculture practices.

4.2 FUTURE SCOPE

Automation and control systems revolutionize agricultural practices through automated irrigation systems, which optimize water usage, remote-controlled gates or barriers that enhance access control and security, and robotic pest control devices that efficiently manage pest populations while reducing reliance on harmful chemicals. Biometric identification technologies such as facial recognition and animal tracking offer advanced security measures by accurately identifying individuals or animals, enhancing monitoring and control capabilities. Furthermore, intrusion detection systems play a vital role in home surveillance by promptly identifying and alerting homeowners to potential security breaches, ensuring peace of mind and safeguarding property and loved ones.

5. REFERENCE

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