Animal And Fire Detection And Crop Protection Using Acoustic Waves

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Abstract- *Crop damage from wild animals and accidental fires presents a major challenge for farmers, causing significant economic losses. To address this issue, the Animal and Fire Detection and Crop Protection System Using Acoustic Waves has been developed to offer an effective, automated solution for safeguarding crops. The system employs a NODE MCU Microcontroller, which serves as the central processing unit, along with a flame sensor, ultrasonic sensor, and Passive Infrared (PIR) sensor to detect both animal intrusions and fire incidents in agricultural fields. The sensors work together to monitor and protect crops efficiently. The PIR sensor detects the presence of animals by identifying movement in the vicinity of the crops, while the ultrasonic sensor measures the distance between the animals and the crops. When an animal is detected within a predefined proximity, the system activates an acoustic wave generator to emit high-frequency sounds that deter the animals from approaching, effectively protecting the crops without causing harm. At the same time, the flame sensor continuously monitors the environment for signs of fire. It can detect the presence of flames early, enabling the system to alert farmers and trigger automatic firefighting mechanisms if necessary, helping to minimize potential crop damage. The NODE MCU Microcontroller processes data from all the sensors in real-time, ensuring a rapid response to any threat detected by the system. The system is cost-effective, simple to deploy, and requires minimal human intervention. It is an ideal solution for enhancing crop security, particularly in rural and remote areas where the risk of animal damage and accidental fires is high. The Animal and Fire Detection and Crop Protection System provide a sustainable and reliable approach to protecting crops from these two significant threats. Technological improvements in the areas such as Internet of Things (IoT), Artificial Intelligence, applications have become smarter and connected devices give rise to their exploitation if environment throughout the world. Increase in generation of data by these systems, Machine Learning techniques can be applied to further enhance the intelligence andthe capabilities. The field of sustainable environment and renewable energy has attracted many researchers and we have come up with a new approach in saving energy as well as predicting wild fires with this approach that uses IoT in getting data and handling data, further prediction using Machine Learning. In this review, Forest fires is considered to be an umbrella term that covers prediction of happening, real-time monitoring and prevention/detection of forest fires. These are rare but very significant events. This paper describes the development of Machine Learning and IOT system that enables real-time data visualization of the factors that help in increase in risk of forest fire that is generated by the forests.*

I. INTRODUCTION

Wildfires are of the major causes of degradation of India's forests and wildlife. According to a paper written by NRSA, it is estimated that the proportion of forest areas prone to forest fires annually ranges from 33% in some states to over a staggering 90% in others. Forest fires in India are not only caused due to natural processes or natural forces but also as a result of human error. India has recently witnessed a 125% spike (from 15,937 to 35,888) in fires that are associated with human error in just two years (2015-2017). These cases rather than prediction of fires, need quick ways to suppress it or stop it from spreading. Vast areas have been torched due to improper maintenance of forests. There are no traditional methods other than remote sensing followed to prevent or to manage forest fires in India and in many parts of the world. Most of the detection methods include satellite imagery and estimation of forest fire through it. But there are significantly certain limitations with it.

1. They focus more estimation after wild fire occurrence.
2. No smarter way to prevent as quick as possible.
3. Ariel sensitivity is very less.
4. Need heavy resource for real-time monitoring.

II. OBJECTIVE

Crop damage from wild animals and accidental fires is a major challenge for farmers, leading to significant economic losses. The Animal and Fire Detection and Crop Protection System Using Acoustic Waves is designed to provide an effective, automated solution for safeguarding crops.This system leverages an ESP32 microcontroller, a flame sensor, an ultrasonic sensor, and a Passive Infrared (PIR) sensor to detect intrusions and fires in agricultural fields.

III. PROPOSED SYSTEM

The ESP32 microcontroller is the central processing unit of the system. It collects data from various sensors, processes it, and triggers the appropriate response. The PIR sensor detects infrared radiation emitted by warm-blooded animals. The flame sensor continuously monitors for the presence of fire in the vicinity of the crops.Ultrasonic sensor uses an acoustic wave generator to used to measure crop heights and can be used to monitor water and liquid levels.

A buzzer sound is produced, a light electric current is passed to the fence, and a message alerting the farmer to the animal's entry into the farmland is transmitted.

IV. LITERATURE SURVEY

A Decision Support Framework for National Crop Production Planning. 2021

[Nida Rasheed , Shoab Ahmed Khan, Ali Hassan, And Saria Safdar]

Current systems often rely on manual data collection from agricultural agencies, government bodies, and local farmers. This data includes crop yields, soil health, weather patterns, and market conditions. However, manual data entry and analysis can lead to delays, inaccuracies, and inefficient decision-making. Planning is usually based on past agricultural data and trends, which do not account for dynamic, real-time factors like climate change, shifting market demands, and other modern-day challenges that can influence crop yields. Decisions are often based on the judgment of agricultural experts or policymakers, which, while valuable, may not always reflect the complexities of local conditions or be sufficiently data-driven crop planning is often conducted centrally by government bodies, without considering the diverse and unique conditions of different regions.

Energy Reduction Methods For Wild Animal Detection Devices.2022

[Reon Sato , Hiroshi Saito, Yoichi Tomioka, And Yukihide Kohira]

System related to energy reduction methods for wild animal detection devices is LoRa-based wildlife monitoring systems, which use low-power, long-range communication to track animal movements efficiently. Additionally, passive infrared (PIR) sensor-based camera traps are widely used for detecting wildlife while conserving energy by only activating when movement is detected. Some systems integrate edge AI processing, where lightweight machine learning models analyze data locally to reduce the need for continuous wireless transmission, further saving energy. These technologies align with the goal of minimizing power consumption in wildlife detection while ensuring reliable monitoring in remote environments.The detection device starts the processing when the motion sensor senses something. The light sensor measures the brightness in front of the detection device.

V. HARDWARE

The device uses the Server-client architecture. The hardware used in this prototype consists of few modules namely -- a Wifi module (ESP8266) in every node that acts as a client, additionally every node has a DHT11 sensor which acts as Temperature and Humidity data extractor that is essential for calculating the Haines Index, IR fire sensor which acts as a flame detector, A anemometer which gets the data of the wind pattern. Looking at the server side, we have a Raspberry pi which acts as a local machine learning inference machine and also as a local data storage device.

The whole prototype is extremely affordable and cost efficient in contrast to its epic features. This makes it possible to scale high and also upgrading or maintaining it. This on situation also helps in incorporating the additional sensors when needed or to fight extreme situations. These devices also help in assisting firefighting with developed strategy. The reason for the proposed system to use IoT infrastructure is that there is no need of human interaction, they are completely automated and can be debugged not only onsite but also from base station or even from home.

They are interrelated computing devices having ability to transfer data over network without human-machine interaction. Section IV explains the overview of the proposed system.

Going on the detailed description of the devices:

1. NODE MCU
2. PIR SENSOR
3. FLAME DETECTOR,
4. ULTRASONIC SENSOR,
5. BUZZER.

1. NODE MCU

Node MCU consists of ESP8266 chip that has capability of Wi-Fi and have TCP/IP protocol enabled. It has microcontroller Tensilica Xtensa 32-bit LX106 RISC microprocessor which operates at 80 to 160 MHz adjustable clock frequency and supports RTOS. NodeMCU operates at 3V to 3.6V and has a building voltage regulator. Node MCU also has a built in ADC channel which is limited to 10bit.

NodeMCU has SPI and I2C interface to enable the sensor communication and connection with it.

2. PIR SENSOR

A Passive Infrared sensor(PIR sensor) is an electronic device that measures infrared (IR) light radiating from objects in its field of view. PIR sensors are often used in the construction of PIR- based motion detectors. Apparent motion is detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a wall.

3. FLAME DETECTOR

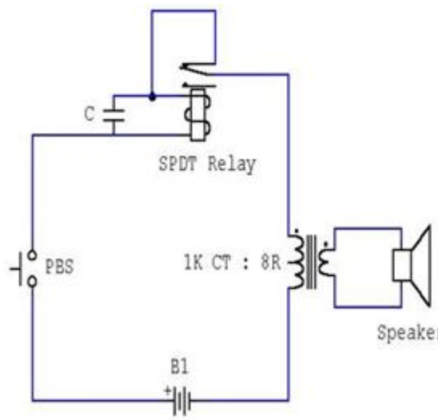
This sensor can detect the presence of flame or fire at an wavelength of 760nm to 1100 nm range of light source. This works on 3.3V input and has a built in voltage comparator. This sensor is also having adjustable trigger level for precise detection.

4. **ULTRASONIC SENSOR**

Ultrasonic sensor uses an acoustic wave generator to used to measure crop heights and can be used to monitor water and liquid levels.

5. BUZZER

A buzzer or beeper is a signalling device, The word "buzzer" comes from the rasping noise that buzzers made when they were electromagnetical devices, operated from stepped-down AC line voltage at 50 or 60 cycles.



VI. SYSTEM WORKING

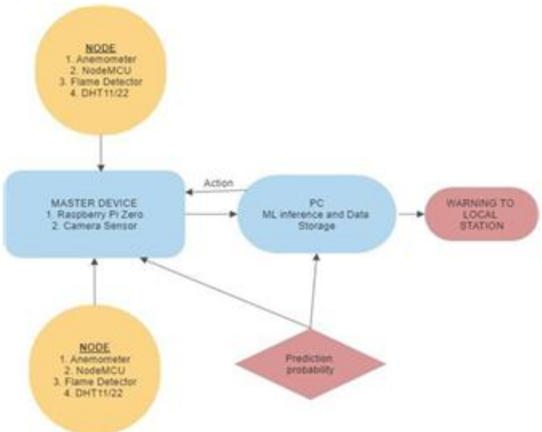
Here, the below figure shows the block diagram of the system and the hardware architecture and explains the flow of data and the predictions. Theoretical working of the device would be in a way where every segment of the working is decentralized and distributed. The whole model of data is distributed in 2 separate segments.

One segment does the prediction by using Haines Index and the other is with the help of neural networks.

$$\sigma(\mathbf{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}} \text{ for } i = 1, \ldots, K \text{ and } \mathbf{z} = (z_1, \ldots, z_K) \in \mathbb{R}^K$$

In the master computer, continuous inference on the incoming data is taking place where all of data from the sensors are preprocessed and dimensionally reduced and given as input. The output is having a SoftMax activation function for estimating the probability distribution of having the occurrence of forest fire.

This function omits the estimated probablity of the results



Based on the threshold setting we can use it for locational update of the master node which is a raspberry pi consisting of a camera. This update consists of image classification which is looking for biomass. Once it is locally classified, an alert will be made according to the situation. Below are the tested graphical results on a small local area. In the second case, forest fire conditions are being simulated and the accuracy of the device is being tested. The same architecture when trained with images of animals being poached will work as a animal poaching detection system.

VII. RESULTS AND CONCLUSION

In this project we have built a software and hardware where you can deploy in forests which can be used to detect and predict the occurrence of forest fire as well a animal poaching detection system. The current hardware setup has a low range, this can be reinforced with new technologies like LoRa. Threshold function is updated on the future work of the project where the prediction function is automated. Here is the generated graph from the data taken from 3 nodes to a master device.

All of the sensor data is preprocessed into a single channel and the graph shows that data. When fames are simulated are in the environmnet at few particular instants, the(yellow) levels hike. At the same particular point there is huge change observed in the tempereture as well as in the humidity level in the environment.

These are prediction probablity instants for the same data shown in the above picture.

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