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IoT based Elephant Detection System using Vibration Sensors

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***Abstract*—This research proposed the development of IoT based detection system using vibration sensors to detect elephants. A method based on the detection of vibration caused by footfalls of elephants. The purpose of this method is to detect elephant intrusion with minimum or zero false detection. This system consists of two client detection units and a server unit. The client detection units were embedded underground at a certain distance apart depending upon geographical factors. These client detection units will pick up the vibration and send the data to a cloud, from which the server unit gather and analyses the data to provide whether it is real detection or not.**

***Index Terms*— Human-Elephant conflict, Vibration sensor, Thing speak cloud, Ecotone, IoT.**

I. INTRODUCTION

Humans came out of the forest, build civilization, excelled in all our adventures, and reached a remarkable development. But one of the things we as a civilization failed is in preserving our forests, wildlife, and our environment. So, it is of great importance for us to live in harmony with wildlife and to preserve our forests and promote more sustainable scientific research for the same. People and elephants often have overlapping interests which cause conflicts between them. Understanding these two can help eliminate the causes of conflicts [1]. The causes of conflict or confrontation are often complex and difficult to resolve. Thus, physical barriers are designed to keep elephants out by making it as difficult as possible for them to enter an area [2]. But the high cost of implementing physical barrier and adaptiveness of the elephant to overcome such obstacles, makes them an ineffective solution. The best method will be to detect the elephants before reaching the Ecotone (a geographical area separating forest and human environment) and to use repulsive methods to ward off the elephants back to the forest. Commonly used detection system is visual based, although they are effective, the cameras placed in tress are damaged by tree-dwellers and are even stolen by people. Earlier, Studies are conducted to utilise the vibration caused by the footfall of the elephants to detect them. But one of the disadvantages is the false detections, Weather conditions like lightning and thunder can cause false detections. So, in this work we tried to eliminate false detection by coming up with an algorithm to differentiate Elephants from other animals. And tested the system under different circumstances.

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II. Related Works

A. S. J. Sugumar and R. Jayaparvathy., "An early warning system for elephant intrusion along the forest border areas",[3].

This paper put forth the idea to use a seismic geophone to detect the movements of elephants in forest border areas. Elephants on foot withinside the sensing variety of the geophones produce a vibration that is transformed to an electrical signal, processed in an embedded controller and an SMS is dispatched to the local area officers for important action. This technique can guarantee minimal disturbance from tree-dwellers since it is buried underground. But the drawback is that a large-scale implementation is not possible due to high cost.

B. S. J. Sugumar, R. Jayaparvathy, "An Improved Real Time Image Detection System for Elephant Intrusion along the Forest Border Areas",[4]

In this paper, a visual-based detection is proposed. The elephant's picture is captured withinside the forest border region and is sent to a base station through an RF network. The acquired picture is decomposed using Haar wavelet to attain multilevel wavelet coefficients, with which we carry out picture characteristic extraction and similarity in shape among the elephant query image and the database picture the use of image vision algorithms. The predominant drawback is that the cameras are only mounted on towers or bushes in positive pockets. It is a costly solution for huge scale monitoring.

C. Saxena A., Gupta D.K., Singh S. "An Animal Detection and Collision Avoidance System Using Deep Learning." [5]

In this paper, the authors have proposed an Animal detection and Collision Avoidance System to detect animals near or approaching the car to avoid collisions and their consequent fatality. The system has a forward-facing camera mounted on the vehicle. On animal detection, the system sends notifications to the driver to avoid the collision. The key insight inferred from the proposed system is that even though Faster RCNN is more accurate, the use of the region proposal method in detecting ROI in Faster RCNN makes it slower than SSD, while SSD is fast in processing but less accurate compared to Faster RCNN. So, this system can be implemented in vehicles that travel through forest areas. but a large-scale implementation on forest areas is not possible because cameras and gadgets placed inside the forest are always a curiosity to tree-dwellers like monkeys and they will eventually destroy these cameras.

D. Pisit Phokharatkul, Danai Liswadiratanakul, 'Using the Vibration Sensors to Detect ElephanTS'. [6]

In this research, they focused development of vibration sensors to detect elephants replacing more costlier seismic geophones. This method focused on the detection of vibration caused by footfalls. The vibration sensor at the inner side of the circular plate detects the footfall and sends an electrical signal when elephants enter the sensor areas, an early warning through SMS/social media is sent to the nearby forest officials and to the owner of the crop field. It is an affordable low and practical solution. The studies were primarily concentrated on the selection of circular plates and testing the footfall of the elephants. More research is required on this to examine its application in large scale detection.

III. System Description

Started with the design and building of the detection system. The detection system consists of a circular plate that will vibrate when it receives the pressure forces from the footfall of elephants.

The vibration waves from the footfall of elephants have a natural frequency in the ranges 4.5 – 80 Hz [7]. The circular plate is made of stainless steel and has a radius of 27.4 cm., and 1.2 mm. thickness which is ideal to detect a peak of frequency 20 Hz [6]. The vibration measurement module consists of an 801S vibration sensor installed at the inner circular plate. The 801s vibration sensor is used because it has a very small size and easy availability. The microcontroller used is ESP, because it is reliable and has ultra-low power consumption. The battery used is Li-ion and a casing is 3D printed to protect all the components. The server unit of the detection system consists of an ESP, which is connected to a PC/ laptop, and it analyses the data gathered from the two client detection units and determines whether the detection was real or not. The server unit analysis is determined on different parameters. The Geographical Location considered in this prototype work is in Ettimadai, Coimbatore. Due to the current pandemic situation, a study of geographical location was not possible. So, some of the parameters considered are based on online data and assumptions.

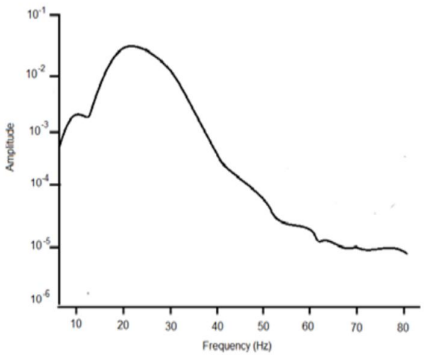

Fig. 1. Power spectrum plot [6]

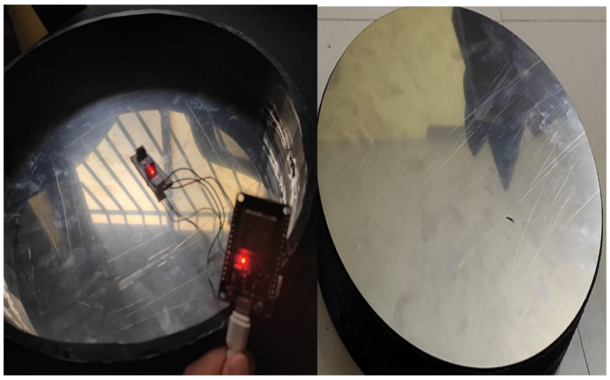

Fig.2. Components and Top view of the client detection units

One of the parameters is the speed of the elephant through the area, which we took as 7 km/h(online). Another factor is the number of openings (traditional pockets) in this area which elephants utilize to reach the ecotone and the distance between them, which are assumed in the case of this work.

A. Circuit Diagram

The client detection unit consists of two detection modules which is depicted in the above Fig. 2. Each Detection module consists of vibration sensors connected with ESP and it sends the vibration data as a message to the Cloud.

If the Unit was to detect a vibrational signal, it compares it with the programmed threshold value and if the detected signal is bigger than the threshold value. Thing speak cloud acts as the main communication medium between the client esps/ detection units and the Server esp which is connected to the computer. Server esp is coded in such a way that when the cloud is uploaded with a fresh set of data. Server esp will be able to access new data and the proposed network connection diagram is shown below in Fig. 3.

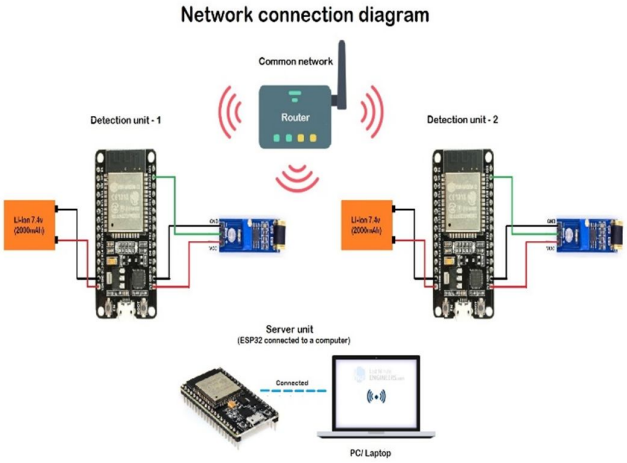

Fig.3. Network connection Diagram

B. Flow Chart

The flow chart explains certain circumstances that may arise in the natural environment and distinguish between the original detection and false alarms. There are multiple possibilities of false alarms. One of the causes may be due to natural phenomena like thunder or earthquake. In that case, sensors from tier 1 and tier 2 vibrate at the same time so we can deem it as a false alarm. Another possibility of false detection is based on the standby time, which is the time taken by the elephants to travel between tier 1 (first opening) and tier 2 (second opening). There are unpredictable conditions like heavy rain, in which the condition of soil may worsen failing to detect vibration or if tier 2 is breached without any detection at the first. So, in such scenarios, a visual inspection may be required.

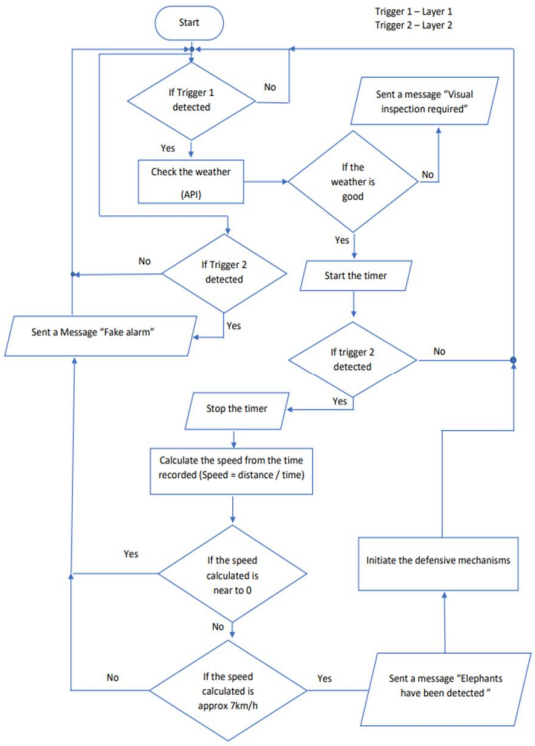

Fig.4. Flow chart for detection

IV. Implementation and Results

A. Working

The collective working of program and hardware in the client detection units and the server makes up the whole algorithm. Working is given as steps for the purpose of better understanding.

The esps / the detection unit waits for a vibrational signal. If the Unit was to detect a vibrational signal, it compares it with the programmed threshold value and if the detected signal is bigger than the threshold value, it initiates a weather check using the API provided by the online website: https://openweathermap.org/. This website is used because it provides a more accurate weather forecast for a given location and is free.

If the website returns the conditions for thunderstorms and heavy rainfall, the esps are programmed to transmit a message to the Cloud (Thing speak) as status, which says "visual inspection required". Thing speak cloud acts as the main communication medium between the client esps/ detection units and the Server esp which is connected to the computer.

If the website returns any other weather condition, the esps sent a specific message to the field allocated to them. For example, Detection Unit 1 is assigned with field 1 and Detection unit 2 is assigned to field 2 in the private channel created on Thing speak website. Therefore, if a vibrational signal which is greater than the threshold is picked up by the sensor, esp of that detection unit will upload a set of data into the field that is allocated to it in the cloud. Here 1 and 0 is passed to represent if the trigger has been detected are not, respectively.

Server esp is coded in such a way that when the cloud is uploaded with a fresh set of data. Server esp will be able to access the newest data. There are basically 3 possibilities

(1) Trigger 1 – 1, Trigger 2 – 0
(2) Trigger 1 – 0, Trigger 2 – 1
(3) Trigger 1 – 1, Trigger 2 – 1

In case of (1,0), a timer will be actuated and waits for trigger 2 to be detected until the timer reaches a timeout value, then the timer, as well as the data, will be replaced with zeros and a message will be displayed "FAKE alarm" in the serial port

In the case of (0,1), a message will be displayed: “Fake alarm” in the serial port.
In the case of (1,1), the timer stops, and the speed is calculated with the known distance and measured time. If the speed is within the speed range programmed into the esp, it will display a warning message in the serial port “Elephants have been detected and initiate the defence mechanisms” or if the speed calculated is not within the programmed speed range it will be displayed the message “Fake Alarm”.

B. Testing

The Detection system was modelled using SolidWorks and the circular plates are fabricated using stainless steel. The casing/ sensor mount is 3D printed using ABS. The prototype was tested with the 20 Hz (peak frequency produced by the elephant’s footfall) which was mimicked. The Geographical Location considered in this work is Ettimadai, Coimbatore. Although, this detection system is designed for a particular area. The detection system is highly flexible and can be reprogramed to any location if data about the location is available. Testing was done for different circumstances and the results obtained are satisfactory.

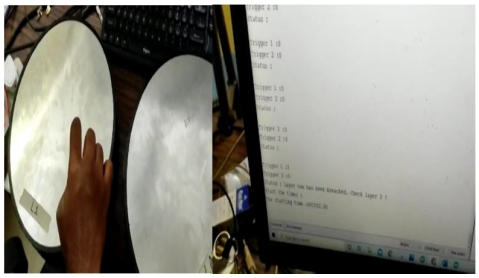

Fig. 5. Images from prototype testing

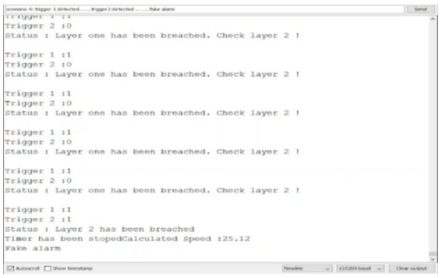

Fig. 6. Layer 2 breached initially (false alarm)

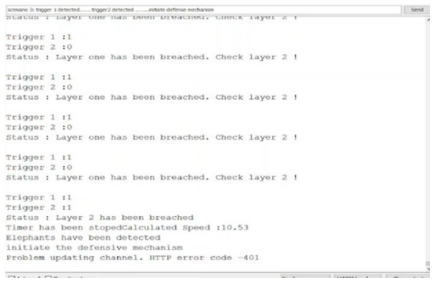

Fig. 7. Trigger 1 and Trigger 2 detected (Elephant Detected)

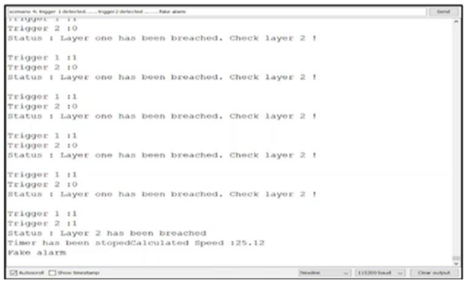

Fig. 8. Trigger 1 and Trigger 2 detected (false detction)

V. Conclusion

Vibration based detection is more affordable and can be implemented on a large scale. This work enables in detecting the elephants before they reach the ecotone region. Thus, reducing Human-Elephant conflicts.
The existing detection and repellent systems in the farms or villages are somewhat but are vulnerable to tree-dwellers and vandalism. The best method would be detecting the elephants before they reach the edges of the forest using technologies that can camouflage. The Geographical Location considered in this work is Ettimadai, Coimbatore. Unfortunately, a survey of the region was not possible during this work so, online data and some assumptions are made for the completion of the work. The future work would involve the design, build and testing of a drone that can be used to ward off elephants (biomimicking the bees).

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