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# Smart Fence With Reduced Power Consumption For Elephant Proximity Detection, Access Prevention, And Repulsion

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***Abstract*—Sri Lanka grapples with the long-standing issue of Human-Elephant Conflict (HEC), impacting rural communities. Both governmental bodies and local populations have employed traditional methodologies. Current solutions primarily involve electric fences. This consumes an unnecessary amount of funds, power, and time. Some research has explored the effectiveness of using bees and beehive fences to deter elephants. However, there is limited research on artificial bee sounds and lighting as deterrents. This project aims to assess these unconventional techniques and create a low-power smart-fence system activated by a doppler radar sensor kept at tested heights. By optimizing resource usage, this initiative seeks to provide a comprehensive solution to HEC, benefiting both local communities and wildlife conservation efforts.**

***Keywords—Human-elephant conflict, Doppler radar, elephant proximity detection, smart electric fence***

## I. INTRODUCTION

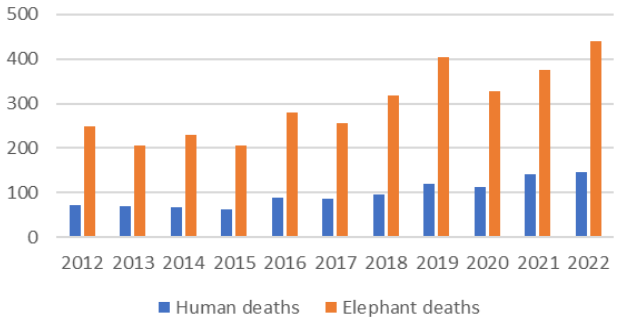


Fig. 1. HEC casualties [11]

Sri Lanka is a country with Human-elephant conflict (HEC) for a long time. Both human as well as elephant casualties are at a high rate including deaths. The economy of the farmers as well as the country are affected due to HEC. Figure 1 shows the situation is worsening by day. The government and the people use a few tactics to reduce this situation. The most common solution is electric fences. Research has been done to determine the effectiveness of using bees and beehive fences to scare off Elephants. This has proven to be somewhat effective.

A typical farmer residing in elephant-affected regions of Sri Lanka experiences an estimated annual loss of more than USD 200 due to crop damage [1]. The Department of Wildlife Conservation (DWC) allocates annual funds for various Human-Elephant Conflict (HEC) mitigation activities, including those related to elephant deterrence, compensation for damages, elephant capture and translocation, and organized elephant drives [2, 3]. In the years 2019 and 2020, Sri Lanka invested USD 2.74 million in the construction of electric fences, resulting in the electrification of approximately 4,756 kilometers of fencing [4]. Over the period from 2011 to 2018, records indicate that USD 0.76 million was disbursed as compensation for human fatalities and USD 1.7 million for property damage within the context of Human-Elephant Conflict. Furthermore, USD 0.05 million was earmarked for addressing injuries in 2017 and 2018 [5].

Elephant is said to fear light (flashing lights, fire), heavy noise (Beating drums, bee sound) and tiger's roar [6]. The likelihood of an elephant incursion into a crop field had significantly reduced in the presence of a solar-powered strobe light barrier [7]. By emitting recorded bee sound, elephant deterrence was accomplished [8]. Elephants responded by moving significantly further away from their resting site in bee playback trials compared to controls [9]. The effectiveness of using a Doppler radar to detect large mammals when they approach the highway was 58.1-85% [10]. The integrated design shown in Figure 2 is a combination of the following systems.

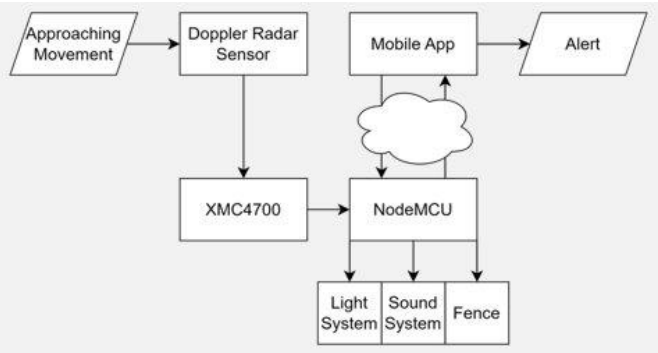


Fig. 2. Working mechanism

## II. Materials and Methods

### A. Tracking System

The doppler radar is kept at a height which an elephant would be comprehensible. The sensor can be programmed to detect reading only between a predefined speed level of an Elephant. An output is triggered when predefined movement is detected. This output can be used to turn on the deterrent mechanisms. The sensor is powered separately from the fence using a solar panel. 24GHz BGT24LTR11 radar transceiver is used as the doppler radar and XMC4700 is used as the microcontroller. The deterrent system is turned on and the community is alerted by SMS sent via the app.

### B. Deterrent System

The deterrent system consists of 3 components. The bee sound was highly effective, and the elephants ran with the sound increasing. Farmers who have flashlights installed to their fences said they use it because it is somewhat effective. They have electric fences as a precautionary mechanism. Both these deterrents have been used and researched in above mentioned literature as well. The fence is electrified only when elephants are detected. The power for the fence is acquired using any available method in the area.

### C. Mobile App

The mobile app is monitored by an administrator and can react accordingly. The app shows Current Status from the sensor (No Motion/ Approaching/ Departing). Also, it is used to view and control Fence Power, Bee sound, and Flashlight. Alerts are sent to civilians and the Kill Switch can Turn ON/ OFF the Automatic fence functions. 'Current Area' shows Not detected/ Alert/ Critical status, and the 'Last Synced time' reads the last online time of the fence.

### D. Cloud Database

Firebase is used as the cloud database. It records all the reading from the sensor and communicates commands from the app to the Smart Fence. NodeMCU with ESP8266 connects the Smart Fence with the cloud.

## III. Results and Discussion

### A. Experiments

i). Effectiveness of recorded bee sound was tested on a domestic elephant as well as on wild elephants in Udawalawa.

ii). To determine the Effectiveness of Visual Stimuli, a domestic elephant was exposed to different colours of light. Effectiveness on the Elephants at Udawalawa were evaluated by Expert interviews carried out with people who had installed flashlights on their fences to keep elephants away.

iii). A doppler radar sensor was used to track movements of approaching and fleeing elephants. Elephants' speeds were recorded.

iv). The heights of the elephants were measured relative to a landmark near where they were standing.

v). The device outputs an attribute as Level which corresponds with the distance. Hence the respective Levels were marked for different distances.

### B. Results

Table 1: Auditory Stimuli

| Sound | Frequency (Hz) | Playback Method | Remark |
|---|---|---|---|
| Bee sound | 25 – 15,000 | Balanced | Elephant on alert |
| | | Increasing | Elephant retreat |

The domestic elephant was on alert the whole time we played the bee sound. It was chained hence couldn't move. The caretaker was cartain that if the elephant wasn't chained, it would have run. At Udawalawa, initially a balanced bee sound was played, and the elephants were on alert, but no response was shown. But when the sound was increased to imitate a scenario in which bees were nearing, the elephants fled.

Table 2: Visual Stimuli

| Farmer/ Landowner | Availability of Flashlights | Colours used | Rating given for effectiveness (Out of 5) |
|---|---|---|---|
| 1 | Yes | Blue/ Red | 4 |
| 2 | Yes | White/ Blue | 4 |
| 3 | Yes | White/ Yellow | 3 |
| 4 | Yes | Blue/ White | 4 |

The domestic elephant did not show any response to the lights as it had experience in going in colourful Peraharas. We interviewed a few property owners in the Udawalawa area who had flashlights installed around their property to keep Elephants away. They commented that the light system was effective in keeping the elephants away.

Table 3: Elephant Movement Speeds

| Elephant | Top speed (m/s) | Normal speed (m/s) |
|---|---|---|
| 1 | 6.70 | 4.91 |
| 2 | 6.53 | 5.09 |
| 3 | 6.68 | 4.95 |
| 4 | 6.51 | 5.02 |
| 5 | 6.64 | 4.98 |

The device recorded speeds of the elephants we observed while they were nearing and fleeing the area. These speeds are separately tabulated to determine the best speed range of an elephant. The device can be configured to only detect movements within that specific speed range.

Table 4: Elephant Heights

| Elephant | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Height (m) | 2.75 | 2.34 | 3.12 | 2.00 | 2.68 |

The elephant heights were recorded to find an average height of an Elephant. By doing so the device could be placed at a height which would be suitable to detect an Elephant and not detect other animals.

Table 5: Level Configuration

| Distance (m) | Level Value (Hz) | Distance (m) | Level Value (Hz) |
|---|---|---|---|
| 7 | 25 | 3 | 108 |
| 6.5 | 48 | 2.5 | 128 |
| 6 | 54 | 2 | 195 |
| 5.5 | 58 | 1.5 | 338 |
| 5 | 65 | 1 | 552 |
| 4.5 | 78 | 0.5 | 894 |
| 4 | 92 | 0 | 1001 |
| 3.5 | 98 | | |

The detection system is proposed to have two areas namely Safe Area and Critical Area. These are placed at two predefined distances. Since the device only has an attribute as Level, these corresponding measurements have been used to determine the Levels for the required distances.

## IV. Conclusion

The Human-Elephant Conflict (HEC) issue in Sri Lanka has persistently disrupted the lives of rural communities. Traditional methods, such as electric fences, have been employed to address this challenge, but its maintenance and operational costs are high. This research has addressed the gap of limited research exploring the effectiveness of bee-related deterrents and lighting conditions in mitigating HEC. We have concluded from our findings that when an Elephant is approaching the bee sound should increase with time for it to be effective. Furthermore, blue and white colour bright lights have proven more effective in keeping Elephants at bay. Average speed of an Elephant has ranged from 5 m/s to 6.6 m/s. Our project has integrated these methods with the electric fence to mitigate its costs and increase its efficiency and effectiveness. One of the main benefits would be the power saved from not having to keep the fence electrified for more than 14 hours per day. Furthermore, this project represents a significant step forward in addressing HEC by proposing a smart-fence system. As we move forward, it is imperative to continue exploring innovative approaches to resolve HEC comprehensively. By bridging the gap between technology and conservation, we can create a sustainable coexistence between humans and elephants, benefiting both local communities and wildlife conservation efforts in Sri Lanka.

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