Smart Train-Elephant Collision Management System

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ABSTRACT

This paper presents a novel solution for the Train-elephant collision issue. It is a national-level issue, and a higher number of elephants die yearly. Approximately 47 elephants died from 2021 to 2024 due to a train-elephant collision. Therefore, we introduce a novel technical management system to avoid train-elephant collisions. The primary objective of this work is to explore the details of the issue and implement the system to repel the elephant using a real-time warning system. Simulation and hardware implementation were both carried out for the final outputs. In addition, introduce a communication system to make the train driver and the two nearby stations aware. The study demonstrates the potential real-time implementation system for the train-elephant national-level issue.

KEYWORDS: *Elephant detection system, Warning system, Elephant-Train collision, YOLOv8n.*

INTRODUCTION

At present, elephants are facing very crucial and saddest situations all over the world. Due to various human activities, human-elephant conflict increases day by day. According to the data of the Department of Wildlife Conservation, more than 170 people and nearly 500 elephants were killed due to human-elephant conflicts [1]. In addition, nearly 20 elephants were killed due to train-elephant collisions, and there is an annual number of elephant deaths in Sri Lanka. This is one of the main impacts on the wildlife system.

Figure 1 shows the total number of elephant deaths from 2012 to 2025 (up to 7 March 2025), including deaths due to train collisions. According to the statistics, nearly 47 elephants have died between 2021 and 2024. Compared to 2024 and 2025, there were a higher number of elephant deaths due to train collision incidents. Nowadays, train-elephant collisions are a national-level issue and are still unable to find a practical solution to this matter.

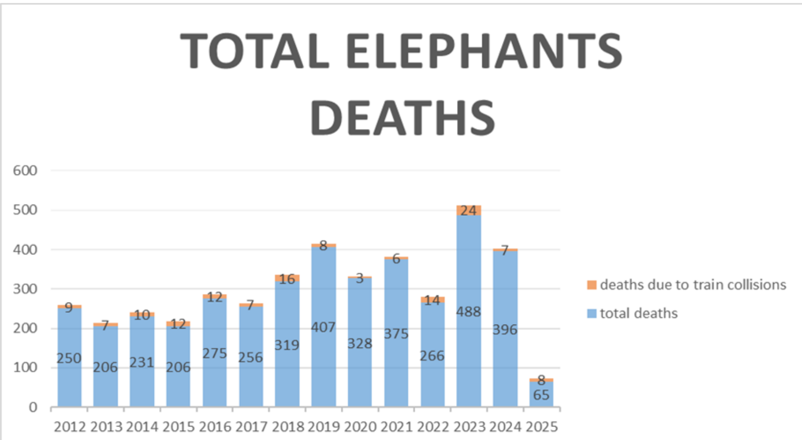

Figure 1. Total elephant deaths from 2012 to 2025 (up to date 7 March 2025), including deaths due train collisions.

Figure 2 shows the identified elephant-train collision that frequently occurred areas. However, the Department of Zoology and Environmental Sciences, University of Colombo, Sri Lanka, investigated elephant-train collision data from 2010 to 2023 and identified six critical collision hotspots. Those are 1.

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Galgamuwa to Maho 2. Kekirawa to Palugaswewa 3. Manampitiya to Welikanda 4. Aluth Oya to Kanthale 5. Gal Oya to Minneriya 6. Palugaswewa to Gal Oya [2].

Figure 2. Areas that are identified as elephant-train collisions frequently occur.

The main contributions of the paper are:

1. Identify the real-time implementation system through the survey.
2. Implement the elephant detection system and emergency warning system.
3. Conceptual design to implement the communication system under future works using the existing railway communication between two railway stations.

When we were researching train elephant collisions, we found a few similar research papers. The first paper describes a system that fixes an overhead camera in a railway crossing area where railway accidents happen, which can monitor the crossing. Using the SSD object detection algorithm will detect animals that cross the railway line, and an alert will be sent to the train stations. If the object is detected in 30 seconds. Here, the main issues were that if an elephant is detected, a message is sent to the nearest station. Also, if the camera detects an elephant when it passes the station, there is no way to notify the train driver. Also, the message goes to the station 30 seconds after the camera detects the elephant. In our project, we send the signal directly to the train driver, which increases its accuracy.
The second one is based on visual elephant detection by utilising the YOLO V3 CNN-based object detection framework. An Arduino board with a SIN800L GSM/GPRS module was interfaced with the Nvidia Jetson board of the detection unit. Utilising this module, the detection unit can send periodic SMS messages. The mobile app also updates the distance to the detection unit on a real-time map along with the detection status. However, no action is taken to remove the elephant from that location. In our project, a siren and a blinking light are used to remove the elephant, and a signal is sent to the train driver. Our unit turns on after the train arrives at the relevant station.

SYSTEM DESIGN

Here, we design the overall system model for the smart train elephant collision management system. Further, we focus on implementing the system at the elephant crossing point “Alimankada”. Figure 3 shows the block diagram of the overall system model. There are three main parts of this system: an elephant detection system, an emergency warning system, and a communication system.

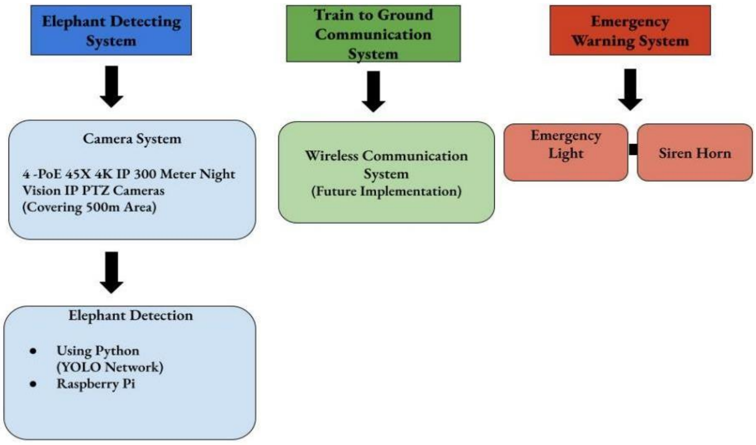

Figure 3. The block diagram of the overall system.

Figure 4 shows the overall system flow chart and how the system works step by step. Initially, we turn on our camera unit manually when a train comes to one of those two stations. After that, our system will continuously detect if an elephant is detected by our camera unit, immediately send a warning to the train indicating a red light on the train, and our emergency siren system will start automatically to drive away the elephant from the railway line. If there weren't an elephant, we would send a signal to the train to say that the railway line is safe by indicating a green light on the train. One of the special features of our unit is that when elephants try to cross the railway from left to right, we activate only our right-side emergency system to make sure that the elephant will return to the forest instead of crossing the railway line. Same as for the other side.

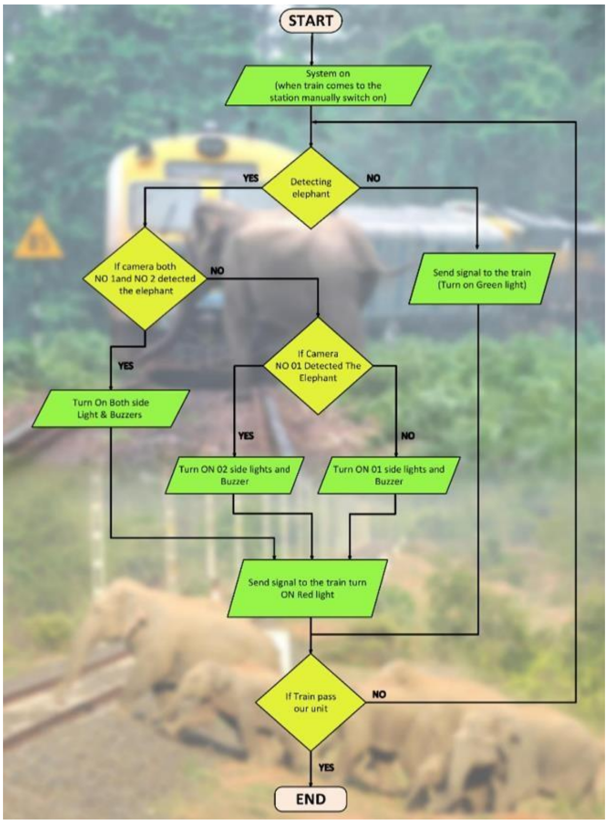

Figure 4. Overall system flow chart.

Elephant Detection System and Emergency Warning System

This system aims to identify the elephant at the elephant crossing point “Alimakada”. Figure 5 shows the exact idea of the system model, and it shows the way they place cameras and buzzers. Figure 6 shows the camera unit placement at the “Alimankada”. There are four cameras along with four emergency lights and two sirens' horns. All units are perpendicular to the railway line.

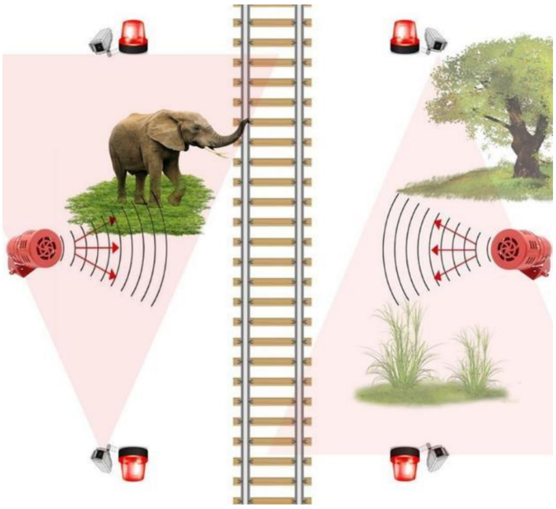

Figure 5. Overall view of the elephant detection system.

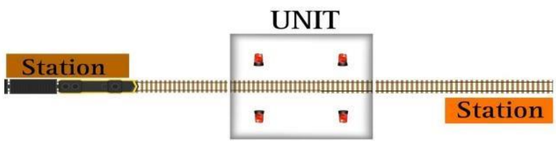

Figure 6. The camera unit placement at the “Alimankada”.

When the train comes to one of the railway stations, we will switch on our camera unit. After that, our camera unit will detect elephants using YOLOv8n. YOLO is a single-shot detector that uses a fully Convolutional Neural Network (CNN) to perform object detection in static images by classifying objects, localising their positions using bounding boxes (a visual representation of coordinates on an image defined by a rectangular or square region), and recognising the objects based on their predicted class labels and probabilities. If the image of the camera is detected as an elephant, we send three output signals (12V) by using our Raspberry Pi board to the train, emergency light, and siren horn through a relay module. The relay module is controlled by manual switches on each station.
When the train comes to the station switch turns on our relay module, and it stays on until the train comes to the other station. After the train comes to the other station, the manual switch turns off at that station. Our cameras detect elephants and send a signal to the train by indicating green (no elephant detected) and red (Elephant detected) lights in the train continuously when trains are between our two stations. With that information, the engine driver can make decisions about whether to go, stop, or slow down. When an elephant detects and sends the signal to the train, at the same time, our emergency warning unit will activate. The siren horn will trigger the repellent sound with a 1450Hz [3] frequency to drive away elephants back into the forest, and the emergency light will make a huge impact at night. All these “Alimankada” areas are close to national parks and forests; therefore, we use solar power to power up the system.

1.1.1 Camera Unit

We use Hikvision TandemVu PTZ cameras to detect elephants. The TandemVu PTZ cameras feature Hikvision’s next-generation camera design, integrating multiple lenses in one security camera to provide a big picture and small details in tandem. It has two main views first one super wide view: Panoramic channel supports a 180° ultra-wide view. Second one, smart linkage: Automatic target detection via the panoramic channel with instant target tracking via the PTZ channel. It has a ColorVu feature that provides colour images overnight with a fixed, F1.0 lens that lets in as much light as possible. Also, it has DarkFighter: Pan, tilt, and zoom for vivid details even in low light. It provides high-quality imaging with 6 MP resolution for the bullet channel and 8MP for the PTZ channel. Maximum resolution in the bullet channel is 3680 × 1656, and in the PTZ channel is 3840 × 2160. Figures 7 and 8 show the performance of our PTZ camera in day and night.

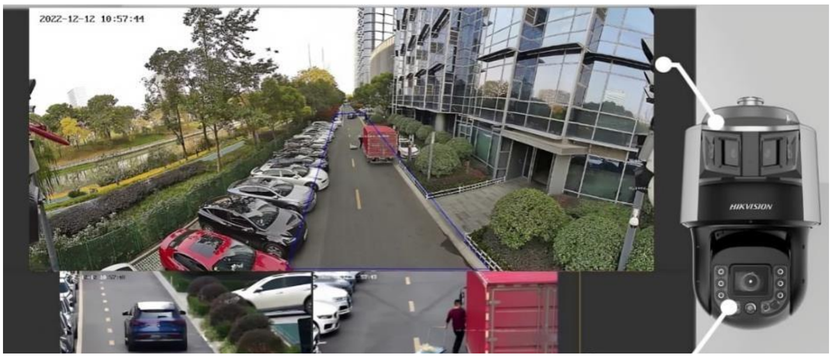

Figure 8. Night light camera performance.

1.1.2 Power Unit

In the system, most power is consumed by the 4 cameras and the unit (elephant detection process unit). When considering other components, such as siren horns and blinking lights in the warning system, those components are not working all the time. It will trigger only if an elephant is detected while the train is between the relevant two stations. Because of that, we can neglect siren horns and emergency lights. Table 1 shows the power consumption of our system for two days.

Table 1. Table of power consumption of the system.

component	power consumption (W)	amount	Power consumption for two days (Wh)
camera	24	4	4608
unit	20	1	960
Total			5568

We use a 314Ah Prismatic Lithium-Ion Cell Battery. Each battery has 3.2V, and we can create a 12V battery pack using four cell batteries. Using two battery packs, we can get a total of 7536Wh. There will be a 20% loss due to heat. However, that can give power to the system for two complete days without a solar power unit. The system powers up solar panels and uses the battery to store the energy.

2 RESULTS AND DISCUSSION

Figure 9 shows the elephant that correctly identified the system. Using the YOLOv8n algorithm enhanced the accuracy of detecting only elephants, and our basic requirement was satisfied. There are four cameras installed in the total system, and each camera can identify the elephant correctly within a range of 300 m. Figure 10 shows the implemented prototype overall system. It shows the emergency warning system and activates the siren and emergency light to repel the elephant. In addition, send the signal to the train to make it aware of the situation.

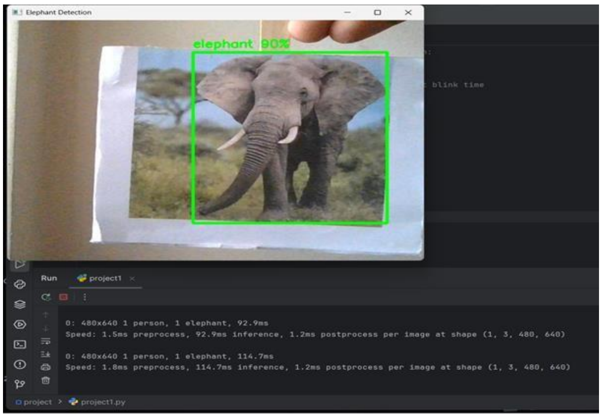

Figure 9. The system identified the elephant using YOLOv8n.

Figure 10. The prototype implemented an elephant detection system and an emergency warning system.

3 CONCLUSIONS

This paper investigates a novel solution for the Train-elephant collision issue. In conclusion, the hardware-implemented prototype system successfully met the objectives. The prototype system has undergone various tests and finally achieved the expected outcomes. This paper mentioned all technical details and component details briefly. This paper provides a strong foundation for future work in communication systems. Before implementing this in real real-time system needs to be tested by choosing a frequent hotspot such as Palugaswewa–Gal Oya Junction. At most 3 months should be spent studying in the camera unit before implementing this in other hotspots. In the future system will develop to detect other animals as well as people. This system is the solution to the burning issue of saving wildlife as well as the people in Sri Lanka.

4 FUTURE WORKS

Future work could involve a communication system in this project. This future work could explore communication between Alimankada and the train driver, and between Alimankada and to railway station to be aware of the situation at Alimankada. Figure 11 shows the conceptual design for future implementation.
We are using fibre optics to communicate between Alimankada and the stations. There are a few reasons why we are using fibre optics, such as High Bandwidth, which supports long-distance data transmission with minimal signal loss.
Communicating between Alimankada and the train driver, we are using 3 ESP32 boards. Using Wi-Fi can create a simple client or peer-to-peer network between ESP32 boards. It is relatively straightforward to implement, has potentially higher data transfer rates, and can be extended to larger networks.

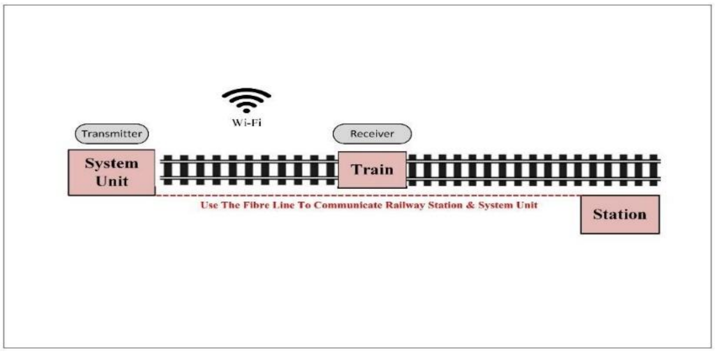

Figure 11. Conceptual design for the communication system.

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