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Early Warning System with High Frequency Sound to Prevent Elephant-Train Collisions

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***Abstract* - Elephant-train collisions are a serious problem as a result of the ongoing human-elephant conflict in Sri Lanka. Lack of enough response time as a result of things like poor driver sight at sharp corners, midnight train operations, and severe weather conditions is one of the main causes of these incidents. The majority of these mishaps routinely take place at predetermined spots along known elephant trails and corridors. We suggest creating a unique system using Convolutional Neural Networks (CNNs) for precise elephant recognition and the construction of an early warning system in response to this urgent situation. By utilizing powerful computer vision techniques, this system attempts to improve railway safety in conflict-prone locations. The suggested system will continually monitor its surroundings by installing strategically placed cameras along train tracks. The system will be trained to successfully recognize elephants in realtime video streams using CNNs. When elephants are detected near the tracks, the device activates an early warning mechanism, notifying train operators and allowing them to take preventive actions. By offering a novel way to reduce train-elephant accidents, this study tackles a crucial facet of human-elephant conflict. Modern technology and real-time monitoring combined with the suggested method have the ability to drastically minimize accidents and ensure the safety of both human populations and elephant herds. The adoption of focused mitigation methods may also be facilitated by the capacity to recognize collision prone regions. Through this project, we help to promote peaceful cohabitation between people and elephants while protecting these amazing animals for future generations.**

Keywords: Early Warning System, High Frequency, Sound, Prevention, Elephant-Train Collisions.

I. INTRODUCTION

Human Elephant Collision (HEC) is a problem that is quite common across many parts of the world.[1] One serious facet of the worsening Human-Elephant Conflict (HEC) in nations such as Sri Lanka involves elephant train collisions. Endangered Asian elephants are maimed or killed during such accidents, which also often results in orphaned or disabled elephants. Furthermore, railway services incur significant financial losses and disruptions to services annually due to such accidents. Most elephant-train collisions occur due to a lack of adequate reaction time due to poor driver visibility at sharp turns, nighttime operation, and poor weather conditions [9]. Railways and wildlife cohabitation is a big difficulty in many regions of the world, particularly when railway tracks cross [13] through animal habitats. The potential of train crashes with animals, particularly elephants is a major worry for both the railway sector and environmentalists. Every day, at least one elephant dies here, with the bulk of these deaths being attributable to the Human-Elephant Conflict (HEC). Sri Lanka had its highest-ever number of elephant fatalities - 433 in the previous year (2022). “Three elephants died after being knocked down by a speeding train on the 12th January in 2023 Batticaloa-Trinco-Colombo railway line near the Hatares Kotuwa area between Habarana and Gal-Oya stations, the Railway Department said.” So we can get this incident as a very near example of train- elephant collision. We are starting to build an Internet of Things-based solution to deal with a pressing problem. Our main goal, which draws inspiration from prior research articles, is to increase railway safety by putting in place a proactive warning system. To protect both elephant operations and railway operations, our method makes use of cutting-edge technologies.

Our method’s basis is built on the use of infrared cameras and the Convolutional Neural Network (CNN) algorithm. We will be able to precisely identify the presence of elephants on railway rails thanks to this potent combination. In the meanwhile, we’ll make use of GPS monitoring technologies to precisely track train movements in real-time. A sound notification designed to simulate the intensity of a bee’s buzz is vital to our system’s performance. This unusual sound has been shown to effectively dissuade elephants from approaching railway[3] tracks, hence averting possible train collisions. This novel feature will only be activated when a

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train approaches a certain region, ensuring that the system is responsive and focused.

We have strategically installed IoT-based hardware components at precisely selected sites to achieve these objectives. These components make it easier to capture live streaming video, allowing the system to identify motion and deviations from the current ambient conditions quickly. The extensive simulation exercises we are doing demonstrate our dedication to complete testing and validation. We are simultaneously creating a mobile application since we recognize the importance of real-time information transmission. This software will act as a crucial interface, sending train engine drivers and station staff timely alerts. Our commitment to a comprehensive safety solution is further demonstrated by the integration of this application into the current communication channels.

Our IoT-driven program, in conclusion, combines technical breakthroughs to protect both elephant populations and railway operations. We are creating a thorough safety net by utilizing cutting-edge camera systems, neural networks, GPS monitoring, and a special sound alarm mechanism. Our commitment to properly eliminating possible risks is further strengthened by our attention to thorough testing and the creation of a user friendly mobile application.

II. LITERATURE REVIEW

The elephant's native habitat has diminished over the last decade, putting more elephants in Sri Lanka at risk from high-speed trains. Wildlife specialists are concerned that the government of Sri Lanka is not doing enough to conserve these majestic species. Millions of tourists visit each year, and elephants are a significant draw. Elephants being hit by trains are a major issue that requires increased awareness and specific efforts to avoid injury. According to the Wildlife Protection Department, there are fewer elephant-train deaths. In 2018, 15 elephants were killed as a result of these crashes.

In the last several years, an average of 15 to 20 wild elephants has been killed by trains yearly. Yet, these incidents mainly result in the death of elephants, and they may also be catastrophic owing to the damage caused to the track, as well as inflict minor injuries to passengers due to quick stops. Many parts of the Northern and Eastern railway lines that pass through animal sanctuaries such as Somawathiya, Minneriya, Flood plains, and several elephant routes are affected. There are some parallels between these incidents. The majority of incidents involving groups of moms and calves occur at night during rainy and flooding seasons. Although these sorts of accidents have occurred over the previous decade, only ad hoc remedies have been implemented, and they are not entirely functioning owing to several obstacles.[2]-[7] We have developed an early warning system with high-frequency sound to prevent elephant-train collisions. This system will collect the data through GPS by calculating the time that the collision will occur, and it will update the data into a centralised database. Our goal is to prevent these kinds of accidents from happening. When it detects the distance through the ultrasonic sensor buzzer will start to produce the bee sound. This sound terrifies elephants and causes them to move away from the area where the collision is about to take place. It will also notify the driver of the impending collision through a mobile app warning.

When it comes to the literature survey, In the First research,[5]. This research mainly focuses on developing an early warning system for elephant train collisions. The mechanical, electrical, and communication components of the proposed approach are all integrated with the Internet of Things (IoT). The Jetson Xavier AGX development board gets by video footage and detects the elephant using the CNN algorithm. A reo-link security camera, and A Jetson Xavier AGX module, Solar Panel make up the electrical element, which offers a web/mobile interface as well as real-time video data collection of elephants. This system mainly uses mobile applications for display and warning to the driver. They were using a detecting module, which is located near the elephant's corridors. This detecting module has a 5MP camera, A jetson XAVIER AGX development board, a 100w solar panel, Dc to AC inverter and solar charger and 12v battery. This system gets powered by the solar system. This system is using Reolink RLC423 security camera. The camera consists of a CMOS sensor capable of daytime RGB and nighttime infrared video streams at a maximum resolution of 2560x1920 pixels. This is valuable for detecting an elephant in any condition (Day/Night). When the elephant is detecting the system, the system will automatically be informed of any elephant activity near the hotspot detection units using a mobile application.

In the second research, we mentioned [6], The mechanical, electrical, and communication components of the proposed system are all integrated with the Internet of Things (IoT). This research mainly focused on three parts. There are identifying the area of conflict, recognizing elephants in the video frame and Checking if the elephant is near the area of conflict. When they identified the are of the elephant and train collision, they have marked the GPS location first and using a CNN algorithm detected an elephant in the Video frame and generate a warning message and send it to the Authorities. They used two frameworks for detecting an elephants. The first framework is trained to recognize elephants. Whereas the second framework was trained for recognizing elephant faces. The major intuition behind using two separate frameworks is that, an elephant may occupy a large part of the video frame, therefore, the segmentation algorithm might not be able to

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capture the complete elephant. If the elephant is detected in a given area, then its position is tracked with respect to the area of conflict. A warning message is generated if the elephant is in the area of conflict. Otherwise, the movement of the elephant is continuously monitored.

In the third research I mentioned by [7]. This research mainly focuses on the innate fear of bees in the Elephants and the detection of the self-emanating natural alarm signal generated by an Elephant to warn other Elephants of potential danger, are utilized in this new technology. They mainly stored a subwoofer train engine near the front wheel. The driver can manually control the system. This system mainly doing mix the bee sound and wheel sound and transmit to large area. Further, the infrasound will be played only for some tens of seconds for every 4 to 5 kilometres, with this all possibility of any disorder to humans is practically nil.

III. METHODOLOGY

Image processing algorithms and IoT were mostly employed in early warning systems with high-frequency sound to prevent elephant-train accidents. The harm caused by the significant number of elephant crashes in the train in terms of life and economics is enormous, thus we developed this technology as a solution. The technology is deployed in elephant paths that have already been discovered. As a result, we literally develop an Image processing and IoT-based Early warning system with high-frequency sound to prevent elephant-train crashes system with four key components, which are as follows:

- Providing a warnings to the engine driver and elephants
- Detect elephants crossing railway line using image processing
- Real-time accident alert system
- Automatic early warning system using geofencing technology

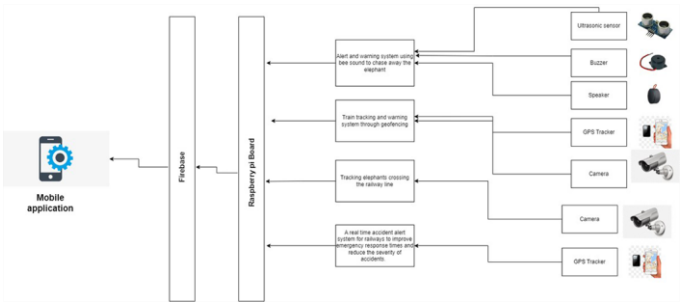

Figure 1: Collision location detection and report a collision

That can for all intents and purposes be controlled and monitored through a mobile application. We also for all intents and purposes suggested using a sort of Raspberry Pi as the sort of central unit. The Raspberry Pi is ideal for adaptive technology since it can show visuals or play media in high definition resolution, which is ideal for prototyping embedded systems.You can build complex, useful buildings with this tool at a cheaper cost. Finally, all four elements will be subtly connected to a single mobile app with an intuitive user experience. In this system mainly can access the wildlife department authorities and railway department. The railway drivers can register and use this system too.

• Processing Unit

Except for the real-time accident alert system and other three sub systems are run on the Raspberry Pi 4 board. This product's key features include a high-performance Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz processor. Hardware video decodes at up to 4Kp60, up to 8GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability (via a separate PoE HAT add-on). This board needs only 5V DC power and it operates the 0–50ºC temperature. Infrared security Camera also connects to this board and SSD object detection framework is run on there. These factors, especially the availability of a reasonably powerful onboard GPU suitable for deep learning based applications highlights its suitability for the proposed elephant detection. Bee sound with a warning system also handles this processing unit and speakers also interconnect with the board.

• Power system

As an attempt to design the power system for the modules we are mainly focused on the situation about the places. We can't get electricity power because these areas are remote and forest areas so we planned to get a solar system. We use 100w solar panel, solar MPPT charger, 12v 40Ah rechargeable battery and 300W inverter to get 220v current.

A) Providing a warnings to the engine driver and elephants

Delving into the core of our warning system, we unveil its intricate components strategy to ensure the safety of both elephants and trains. At its core, this technology is engineered to accurately detect elephants and gauge their proximity to oncoming trains. When a train is detected, this elaborate process becomes the bedrock for initiating a series of precautionary measures.

Audible alerts through a powerful 115dB 12V 40W Alarm Loudspeaker, visual cues, and direct communication (sending Warning message using a mobile app) with train operators form a cohesive unit. These mechanisms collaborate harmoniously, aiming to avert potential collisions that could imperil both the majestic elephants and the operational

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efficiency of the railway network. A impactful facet of our warning system lies in the strategic use of a buzzing sound reminiscent of bees. This auditory signal is meticulously chosen, capitalizing on elephants' innate fear of bees, prompting them to swiftly vacate the railway track area. This sound acts as a potent deterrent, compelling these revered creatures to steer clear of the imminent train danger.

Complementing these aspects, our groundbreaking approach also introduces advanced mobile applications that directly notify train drivers. These apps relay crucial details about elephant presence and proximity to train personnel. Armed with this preemptive alert, informed decisions and preventive actions, such as slowing or stopping the train, become viable, significantly reducing the risk of severe accidents.

Our solution harnesses cloud-based databases to meticulously log alarm activation and deactivation times, train passages, and real-time applications. Authorized personnel can access this data through a mobile app on a weekly or monthly basis, fostering accountability and facilitating data driven decision-making.

B) Detect elephants crossing railway line using image processing

Our system's main functionality relies on the detection of elephants, which acts as the foundation for all the related subsystems. The success of our system is dependent on this critical process, which serves as the basis for the whole structure. To promote harmony and reduce conflict, our system is strategically placed along pre-established elephant pathways that cross railway lines.

Our system's efficiency depends heavily on the use of cutting-edge camera technology. The device can reliably and correctly detect the presence of elephants within its operational region thanks to this innovative method. The video system serves as a vigilant sentinel, ready to notify pertinent parties of the presence of elephants quickly. It's significant that the technology goes beyond simple detection to count and keep track of the number of elephants seen.

Our solution works by automatically and seamlessly recording and preserving critical data about elephant interactions. This comprehensive dataset includes critical factors such as the geographical location of the contacts, the exact times at which they occur, the lengths of these interactions, and the number of elephants present. This abundance of data is conveniently kept in a sophisticated cloud-based database, offering a solid platform for in-depth research. This data collecting procedure is important for two reasons. For starters, it provides a foundation for in-depth investigation, allowing us to obtain significant insights into elephant behavior and movement patterns.[8] We may strategically enhance our system for increased efficacy by interpreting these patterns. Second, the utility of this stored data extends beyond the internal operations of our system. It provides significant benefits to relevant stakeholders such as the railway and wildlife agencies. A user-friendly smartphone application has been created to aid with data interpretation. This tool gives these departments quick access to summary reports, efficiently condensing large amounts of data into useful insights.

• Infrared Security Camera

The primary sensor of the detection unit is a Hikvision security camera. The camera consists of a CMOS sensor capable of daytime RGB and nighttime infrared video streams at a maximum resolution of 2560 x 1944 pixels. This near field IR camera is aided by powerful IR illuminators that automatically switch on in low-light conditions. This camera has 5 megapixel and 3.6mm wide angle camera capture quality and wide view video so this is very useful to detect the elephant and count of the elephant. It has EXIR 2.0 smart IR up to 80m IR distance night vision system at night. This camera is also IP67 so this is very reliable for the system.

• CNN (convolution neural network)

CNN is a strong image processing technique [no]. These methods are presently the best we have for image processing that is automated. In there we used the SSD (single shot detection) algorithm to detect the elephants and count the elephants. This is also related to CNN but it is very easy to use our system.

C) Real-time accident alert system

The suggested real-time alerting system for monitoring elephant crashes on trains is a painstakingly developed framework that blends cutting-edge technology, data analysis, and conservation principles. This methodical approach guarantees that the system is successful in both preventing collisions and responding quickly in the case of a collision. In recent years, incidents between elephants and railways have been a source of worry. While these incidents frequently result in elephant injuries, the good element is that fatalities are uncommon. The absence of early knowledge and efficient communication between wildlife authorities and the location of these fatal crashes is a critical aspect contributing to this perilous scenario.

The difficulty of the situation derives from the fact that these mishaps frequently take place in isolated, heavily forested places, making it difficult for officials to react quickly

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and help the hurt elephants. These endangered species' existence depends on closing this communication gap and putting quick reaction systems in place. The use of a smartphone app to immediately alert the wildlife department after an incident involving elephants and trains is one creative approach that has attracted notice. This program would be crucial in reducing the time it takes between an accident happening and the start of relief activities. The information of the collision, such as time and location, might be quickly reported to the appropriate authorities by using this smartphone app. This would allow them to quickly assemble rescue teams, veterinary doctors, and other equipment. Such fast action would not only improve the odds of life for the injured elephants, but would also allow for more efficient treatment and care. The value of this technique resides not only in its ability to save individual lives, but also in its contribution to overall species conservation. High-risk zones can be identified by producing thorough reports after gathering and examining collision data. It is now possible to take preventative action thanks to this essential knowledge. For example, these regions might be identified as prospective danger zones, triggering the installation of warning devices or barriers to avert collisions in the future.

D) Automatic early warning system using geofencing technology

In this part, the first system gets Train location and GPS coordination using an Arduino board with a SIM800L GSM/GPRS module this module can send a sms also after that when the train is near the marked high-risk area system can check the data and generate the warning alert to the driver. We are using Geofencing Technology [4] to mark the high risk areas. In this case we have to identify what are the high risk areas through the data sets. All the processing is done by the Raspberry – Pi board. When the alert passes through firebase to mobile Application. Users can watch what the alerts are using Mobile Application. We are planning to mount the SIM800L GSM/GPRS module in the train engine and it always tracks the location. The second type of warning system is used when an elephant detects the system then we are planning to generate warning messages to drivers it will Generate by the system and it is also showing in the Mobile Application. So in this warning system drivers can manage the time and they can give high priority to the railway line and they can adhere to rules. As another feature of this system get a record of what are the train passing through high-risk areas time slots and what are the times of elephants were detected time frames. System generates the report and authorities can refer this data using mobile application, and they can get decision about changing the train timetable. This system is very important to the wildlife department and railway department.

IV. RESULTS AND DISCUSSION

• Install the system in high-risk areas

The thorough study sought to analyze the effects of modifications to Sri Lanka's rail network on animal movement and corridor areas, focusing on the Asian elephant population. The study includes analyzing train-elephant collision data to understand better collision patterns, mortality, and the ramifications for elephant numbers and ecosystems. The study covered three independent time periods: 2008-2013, 2014-2020, and more recent data up to 2023. [10]

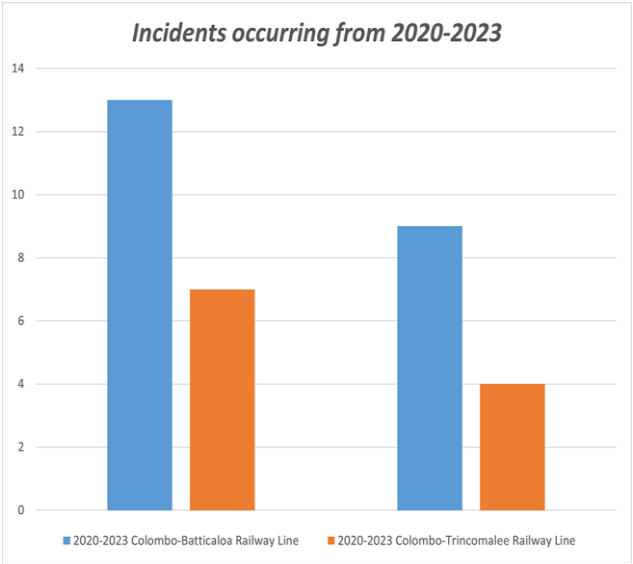

Figure 2: Comparisons of Colombo-Batticaloa Railway Line - Colombo-Trincomalee Railway Line

The collected data provides valuable information about where collisions are more likely to occur, and which parts are particularly vulnerable. The findings are critical for developing targeted interventions such as wildlife crossings, habitat protection, and innovative early warning systems.

According to this analysis, the system can install with the permission of authorities in High-risk areas.

• Detecting Elephants through image processing

Once the Elephant come close to the system, which installs close to the railway track detects the elephants. After detecting the elephant system will be directed into image processing. Using CNN (convolutional neural networks) algorithm and data analyst techniques, the output will be directed to an XML Sheet. The final output will be, • Elephant count • Measured distance • location • Date and Time These Data sets will be uploaded to the cloud through Firebase and can access any authorized person via the mobile app.

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• Alerting system and chasing away the elephants using

The primary objective was to determine the effectiveness of bee sounds in discouraging elephants from high-risk regions near train tracks. The study includes the design and installation of a system that combines image processing technologies, mobile applications, and audio stimulation to improve the safety of both train operations and the elephants' well-being. Our findings give concrete proof that elephants are deterred from approaching train tracks by bee noises. The deployment of our designed system revealed that when the system detected a train coming from a high-risk area, a message was instantly delivered to the train driver. This enabled the driver to be attentive and prepared for potential elephant encounters. When elephants were detected near the railroad lines, the system let train drivers and station managers use a mobile application integrated with image processing capabilities to trigger the emission of bee noises. The elephants moved away from the tracks as a result of the bee sounds that were emitted. This finding implies that bee sounds can be used to reduce train elephant collisions in a non-harmful and humane manner.

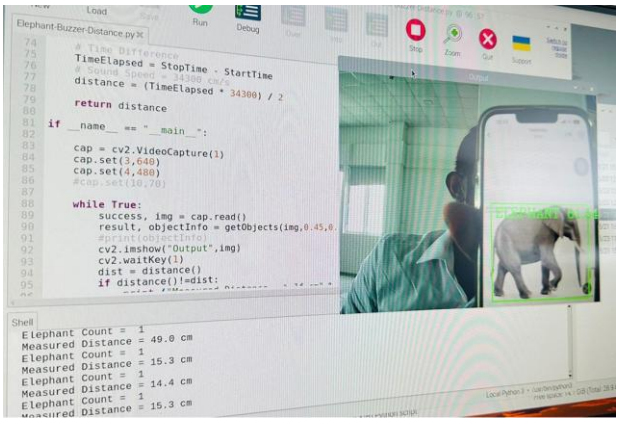

Figure 3: Detecting Elephants from a sample photo

• Notify Authorities ASAP after a collision

Real-time Notification: When a collision is detected, the mobile app immediately initiates a real-time notification process. The notification method guaranteed that appropriate authorities, such as wildlife conservation organizations, train operators, and local law enforcement agencies, were notified of the occurrence as soon as possible. The warnings were sent out within seconds of the collision being detected, dramatically shortening reaction times compared to traditional techniques.

Data Transmission: The mobile app communicated critical incident information to the appropriate authorities. These parameters included the collision's specific GPS position, a timestamp, and the number of elephants involved. The GPS location was accurate within a few meters, allowing reaction teams to arrive at the event scene quickly.

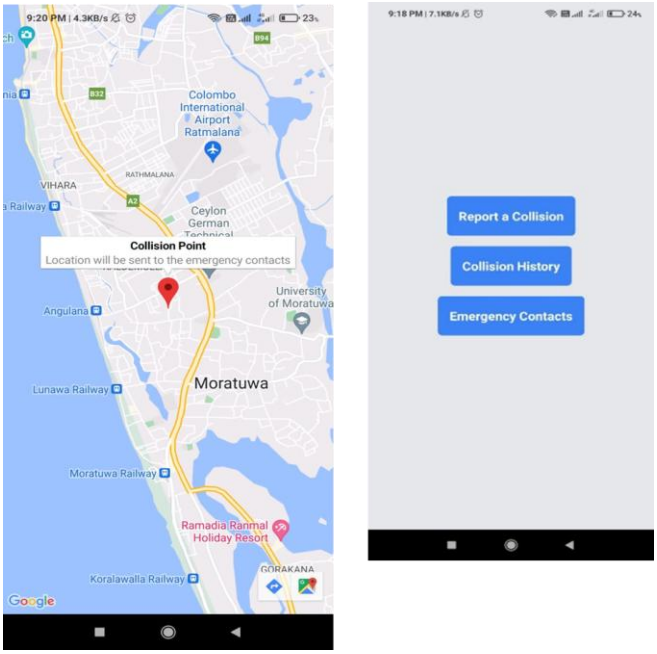

Figure 4: Collision location detection and report a collision

V. CONCLUSION

In conclusion, there is great potential for reducing a serious environmental and safety risk through the invention and application of an early warning system that uses high-frequency sound to prevent elephant-train collisions. To overcome the special difficulties presented by elephants' interaction with trains in shared habitats, this creative method makes use of elephants' sensitive hearing abilities and their capacity to recognize higher frequency sounds. This system can detect train movements well in advance and generate high-frequency sound signals that are undetectable to humans but successfully warn elephants of an oncoming train's presence with the use of modern sensor technology and prediction algorithms. The effectiveness of this strategy depends on an in-depth knowledge of elephant behavior, hearing ability, and their reaction to these aural signals. Improved safety for both elephants and train passengers, a decrease in elephant fatalities, and the preservation of vital wildlife corridors are all advantages of the planned early warning system. Additionally, the system's noninvasive design guarantees that local ecosystems and human activities won't be significantly impacted. In summary, the integration of a high-frequency sound-based early warning system has the potential to significantly reduce elephant train collisions, promoting coexistence between humans and wildlife. This innovative solution stands as a testament to the power of interdisciplinary collaboration and technological innovation in tackling complex challenges at the intersection of conservation and

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human development. As we move forward, it is imperative to continue refining and adapting this system to different environments, fostering harmony between our transportation networks and the diverse ecosystems we share with these magnificent creatures.

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