Higher National Diploma in Engineering (HNDE)

Electrical and Electronics Engineering

Literature Review

Title of the Literature Review

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Human-elephant conflict (HEC) is a significant issue affecting both the socio-economic stability and environmental sustainability of countries where elephants live. Sri Lanka, in particular, has the highest annual elephant casualties and the second-highest human casualties in the world due to HEC, with India holding the top position. The primary drivers of HEC include changes in land usage, habitat destruction caused by growing human populations, and shifts in agricultural practices.

The major consequences of HEC include crop destruction, infrastructure damage, human casualties, and elephant deaths. A study of Sri Lankan mortalities from 1991 to 2021 shows a troubling trend, with elephant fatalities increasing by approximately 900% and human fatalities rising by around 200%. This stark rise highlights the urgency of addressing and mitigating HEC.

To prevent elephants from entering farmlands and other vulnerable areas, various deterrent systems have been implemented. Traditional methods include acoustic deterrents (such as firecrackers and drumbeats), trench excavations, lighting fires, beehive fences, electric fences, and seismic sensor-based systems. While these techniques are commonly used, they come with significant drawbacks, such as limited effectiveness, high maintenance, and potential harm to the elephants or the environment. [1]

The presence of elephants near railway tracks poses a significant risk to train safety, often resulting in accidents that can cause serious damage to both wildlife and passengers. Traditional methods of detecting elephants, such as manual patrols and the use of trained elephants, have been ineffective, time-consuming, and inefficient. These methods fail to provide real-time detection, leading to delays in response and increased accident risks.

The proposed solution to this problem is an automated elephant detection system using LoRa technology (Long Range). LoRa is a wireless communication technology that enables long-range, low-power communication, making it ideal for detecting elephants near railway tracks. The LoRa-based elephant detection system incorporates various components such as Node MCU, IoT devices, LCD screens, GPS modules, speakers, and image processing technology.

The system uses image processing to identify the presence of elephants, and LoRa technology to wirelessly transmit data over long distances. Additionally, the GPS module tracks the elephant's position and displays this information on an LCD screen. When an elephant is detected, the system alerts train drivers and railway authorities in real-time through loudspeakers, ensuring prompt action is taken.

The main problem addressed by this project is the frequent occurrence of accidents between trains and elephants near railway tracks. Due to their large size and quiet movement, elephants are often hard for train operators to detect in time, which can lead to collisions. The introduction of a LoRa-based detection system aims to significantly reduce these accidents, ensuring safer rail travel for both wildlife and passengers. [2]

The proposed project aims to enhance the existing classical electric fence system, which is widely used in areas prone to human-elephant conflicts. While traditional electric fences have been effective in some ways, issues like intrusions and breaches often occur, leading to collateral damage to both elephants and humans. To address these shortcomings, various research prototypes have been proposed.

For example, Fernando et al. (2020) introduced the Gaja-Mithuru system, a smart elephant monitoring and tracking approach. This system detects elephants, monitors their behavior, and predicts potential future

intrusions using seismic data and GPS data, alerting nearby villages in advance. Similarly, Theerthagiri and Thangavelu (2020) developed an elephant intrusion warning system using Internet of Things (IoT) technology and 6LoWPAN to provide early warnings.

Building on these ideas, the proposed prototype aims to improve upon the traditional electric fence by integrating motion sensors and an alarm system. This system can detect elephant breaches of the electric fence in real-time and send immediate alerts to local residents, allowing them to be more vigilant. Additionally, the information about the intrusion is automatically transmitted to relevant authorities for quick action, reducing the delay in addressing the issue compared to traditional fences, where information was only relayed after residents noticed a breach.

The proposed smart electric fence with IoT capabilities is expected to be a low-cost and effective solution to mitigate human-elephant conflicts, providing a more proactive and automated approach to preventing incidents. [3]

The rapid increase in the human population has resulted in large-scale deforestation, as forest lands are converted into human settlements. This has led to severe food and water shortages for wildlife, forcing animals to migrate into human habitats. Such interactions between humans and wildlife have caused significant loss of property and life. Reports from *The Times of India* indicate that over 1,300 people have lost their lives due to tiger and elephant attacks in India over the past three years. These conflicts pose a critical danger, and the recovery from such losses is often difficult and unpredictable.

Human-animal interactions have escalated into a major crisis, driven by various factors such as habitat destruction, climate changes, and resource scarcity. Additionally, forest fires, whether caused by natural occurrences or human activities, have been increasing at an alarming rate, leading to extensive damage to crops, wildlife, and human lives.

To address these challenges, we propose a network-based wireless sensor system designed for early detection and monitoring. This system utilizes GSM-based alert mechanisms and alarms to detect wildlife movement and forest fires. By monitoring forest humidity and environmental conditions, the approach aims to provide real-time alerts to communities living near forest borders, thereby preventing potential threats to human and animal lives.

In remote and uncontrolled environments like forests and deserts, it is crucial to develop automated perception tools that replace manual field investigations. These tools enhance efficiency, accuracy, and predictability in monitoring wildlife and environmental conditions. Our project focuses on leveraging such intelligent systems to mitigate human-animal conflicts and forest-related hazards, ultimately contributing to ecological balance and public safety. [4]

Humans emerged from the forests, built civilizations, and achieved remarkable advancements. However, one of our greatest failures as a civilization has been the inability to preserve our forests, wildlife, and the environment. It is crucial for us to coexist harmoniously with wildlife, protect our forests, and promote sustainable scientific research to mitigate environmental degradation.

One of the most pressing human-wildlife conflicts involves elephants, as their habitats often overlap with human settlements. Understanding the causes of these conflicts is essential to developing effective solutions. Physical barriers, such as fences, have been used to prevent elephant intrusions. However, their high cost and the adaptability of elephants in overcoming such obstacles make them an ineffective long-term solution.

A more effective approach involves detecting elephants before they reach the Ecotone—the transition zone between forests and human settlements—and employing repellent methods to guide them back into their natural habitat. While visual-based detection systems, such as camera traps, are commonly used, they are often damaged by tree-dwelling animals or stolen by people. Previous studies have explored the use of vibration-based detection systems that rely on elephant footfalls. However, these systems are prone to false detections caused by environmental factors such as lightning and thunder.

In this research, we propose an improved algorithm-based detection system that differentiates elephants from other animals, minimizing false detections. The system has been tested under various conditions to enhance accuracy and reliability. Our work aims to contribute to a more effective and sustainable solution for mitigating human-elephant conflicts while ensuring the safety of both humans and wildlife. [5]

Wild elephants inhabit over 50 countries worldwide, primarily in Africa and 13 countries in Asia. Estimates suggest there are between 51,000 and 66,000 elephants in Asia, but only 35,000 to 50,000 remain in their natural habitats. Sri Lanka is home to approximately 10% of the total Asian elephant population, yet it accounts for only around 2% of their global range. The Sri Lankan elephant (Elephas maximus maximus) is one of three recognized subspecies of Asian elephants, alongside the Indian and Sumatran elephants.

Currently, elephants are found in five South Asian countries—Bangladesh, Bhutan, India, Nepal, and Sri Lanka. Of these, India has the largest elephant population, with an estimated 29,964 elephants, while Sri Lanka has approximately 5,787. However, the Sri Lankan elephant population has significantly declined from an estimated 12,000–14,000 in the 19th century due to habitat loss, poaching, and human-elephant conflict (HEC). Notably, less than 10% of Sri Lanka's elephants are tuskers, likely due to selective hunting for ivory.

HEC is a critical conservation, socio-economic, and environmental issue in elephant range countries, including Sri Lanka. Elephants frequently invade human settlements, damaging crops, property, and even causing human fatalities. The conflict arises from habitat fragmentation, resource competition, and changes in land use. Crop raiding is a major concern, leading to financial losses and negative perceptions of elephants among local communities. Many people view elephants as agricultural pests rather than protected wildlife, which further complicates conservation efforts.

Historically, efforts to mitigate HEC have included physical barriers such as electric fences, translocation of problem elephants, and the establishment of elephant holding grounds. However, these solutions have limitations, including high costs, maintenance challenges, and the adaptability of elephants in overcoming barriers. To develop more effective conservation strategies, it is essential to identify HEC risk zones accurately.

This study aims to address HEC by leveraging satellite data fusion and GIS modeling to map high-risk zones. Previous research has demonstrated the effectiveness of Normalized Difference Vegetation Index (NDVI) analysis for monitoring forest cover changes. By integrating satellite imagery with ecological and socio-economic data, this approach enables long-term monitoring of elephant movement patterns and habitat changes. Identifying high-risk zones will help in early-warning systems, strategic land-use planning, and improved conservation policies.

The proposed system will play a crucial role in mitigating HEC by offering data-driven insights into elephant behavior, habitat changes, and environmental patterns. By providing accurate information, it will empower researchers, conservationists, and policymakers to devise sustainable solutions that ensure the coexistence of humans and elephants while preserving Sri Lanka's biodiversity. [6]

The rapid population growth in Krishnagiri district has led to increased agricultural and industrial activities, causing forest land conversion into human settlements. This has resulted in food and water shortages for wild elephants, forcing them into human habitats and leading to frequent human-elephant conflicts (HEC). These conflicts cause damage to crops, property, and human lives, while elephants also suffer harm in retaliation.

To address this issue, the research proposes an IoT-based elephant intrusion detection and alert system. The system uses Internet-integrated sensors, ultrasonic sensors, and wireless sensor networks (WSN) to detect elephant movements near forest fences. Key components of the system include:

- Real-time surveillance and alert system: Internet-connected sensors detect and track elephants, instantly notifying forest officials and local residents.
- Ultrasonic sensors: Capable of sensing abnormalities within a 200-meter range, these sensors detect elephant movements and vocal signals.
- Wireless communication via IoT: Alerts are transmitted over the internet using Constrained Application Protocol (CoAP), ensuring effective and timely warnings.
- Automated response mechanisms: Authorities can take preventive action to guide elephants back to the forest, reducing conflict risks.

The system is designed in three modules:

1. Hardware development for sensor-based detection.
2. Algorithm development for intrusion detection using C/C++ programming.
3. Integration of hardware and software, validation, and real-time implementation. [7]

Human activity has significantly altered the natural environment, leading to resource depletion and endangering wildlife. The declining elephant population, mainly due to ivory poaching, is a major concern. The Great Elephant Census (GEC) revealed a 30% population decline between 2007 and 2014, highlighting the urgent need for improved conservation efforts.

Traditional elephant monitoring methods, such as aerial surveys, are costly and labor-intensive, relying on human observers. To overcome these challenges, researchers are exploring technological solutions like IoT-based monitoring systems, drones, and AI-powered detection algorithms. These innovations enable real-time tracking and early warning systems, helping prevent human-elephant conflicts and ensuring better wildlife protection.

Integrating IoT and sensor-based networks, particularly in areas like Krishnagiri district, India, offers an efficient and scalable approach to monitoring elephants and reducing conflicts. The adoption of smart technology can significantly enhance conservation strategies and contribute to long-term wildlife sustainability. [8]

Human-elephant conflict (HEC) is a significant problem in India, leading to casualties among both humans and elephants. Rapid human population growth has resulted in habitat encroachment, forcing elephants to venture into farmlands and human settlements in search of food and water. Traditional methods such as electrical fences, trenches, loud noises, and flashing lights have been used to deter elephants but have become less effective as elephants adapt to these deterrents.

Recent advancements in Internet of Things (IoT)-based smart solutions have been explored to mitigate HEC. Various studies have experimented with sensor-based systems, including seismic and piezoelectric

sensors, to detect elephant movement and provide early warnings. These technologies offer a real-time monitoring approach, helping both forest officials and local communities take preventive measures.

This literature review explores different IoT-based strategies proposed by researchers to enhance elephant tracking, improve conservation efforts, and reduce human-elephant conflicts effectively. [9]

Human-elephant conflict (HEC) is a major issue in Sri Lanka, leading to crop destruction, property damage, human casualties, and elephant deaths. The root cause of this conflict is rapid human population growth, which has resulted in habitat fragmentation and scarcity of food and water for elephants. As a result, elephants frequently venture into human settlements in search of resources.

Traditional deterrent methods, such as firecrackers, loud noises, electric fences, and high walls, have become ineffective over time, as elephants have adapted to these strategies. Furthermore, existing detection systems using seismic waves, image processing, and sensor-based tracking are often expensive, require high maintenance, and lack scalability for large-scale deployment.

The Department of Wildlife Conservation in Sri Lanka reports an elephant population of 3,500–4,000, with 225 elephants and 70 humans killed annually due to conflict. Several NGOs and government initiatives focus on community engagement, conservation efforts, and awareness programs to reduce HEC.

This explores advanced monitoring and detection techniques, including IoT-based tracking systems, to enhance early warning mechanisms, improve conservation efforts, and establish better communication between forest authorities and local communities. [10]

Human-elephant conflict (HEC) is a growing issue in Asia and Africa, leading to human and elephant deaths, crop destruction, and habitat loss. The main cause is human encroachment into elephant habitats due to population growth and deforestation.

Traditional methods like electric fences, firecrackers, and loud noises are often ineffective as elephants learn to bypass them. To improve conflict prevention, IoT-based smart detection systems are being explored to provide real-time monitoring and early warnings.

This examines existing HEC mitigation methods, their limitations, and the potential of IoT-based solutions to enhance conservation and human safety. [11]

Educational institutions face security challenges, including animal intrusions that pose risks to students and staff. Traditional methods such as human patrols and physical barriers are often ineffective.

To address this, an IoT-based Animal Detection System using ultrasonic sensors, ESP32 cameras, and machine learning (R-CNN) has been proposed. This system provides real-time monitoring, species classification, and instant alerts, achieving 97.6% accuracy in detection.

By integrating Arduino, GPS, and automation, this approach enhances campus security, improves animal behavior analysis, and supports ecological research, ensuring a safer coexistence between humans and wildlife in educational environments. [12]

The Human-Elephant Conflict (HEC) in Sri Lanka is worsening due to rapid human population growth (750 people added daily) and habitat encroachment. Despite 1.2 million hectares of protected land, more than 70% of elephants live outside these areas, leading to frequent elephant attacks on humans, especially at night.

Conventional GPS tracking collars, costing $3000–5000 per unit, have drawbacks such as high costs, frequent battery replacements, and the risks of immobilizing elephants for installation. Existing systems also require expensive satellite communication, making large-scale tracking unviable.

To address these issues, this study proposes a low-cost ($80) GPS tracking device that integrates energy harvesting (solar/kinetic) and remote configurability. This affordable, long-lasting system can provide real-time elephant tracking for better human-wildlife conflict management in Sri Lanka. [13]

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