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Research Article

Real-time Animal Detection and Alert System using IoT and Deep Learning

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ABSTRACT

One pressing concern facing nations worldwide today is the incidence of fatalities and injuries resulting from road accidents. Human-animal collisions stand out as a prominent cause of many fatal accidents. Road accidents occur with alarming frequency every few seconds across the globe. The core objective of our project is to detect animals and issue warnings to vehicles, thereby mitigating highway accidents involving animals. Leveraging IoT technology, the implementation of a detection and alert system designed to significantly reduce animal-related accidents is proposed here. This alert system is engineered to transmit signals that promptly notify highway drivers when a detection event is triggered. IoT technology takes center stage in our solution, with the Raspberry Pi 3 Model B serving as the cornerstone for animal detection and vehicle alerting. Employing sensors, we identify obstacles that activate the Pi Camera, configured by the Raspberry Pi, to capture real-time images and video footage of animal movements using image detection techniques. Subsequently, individuals and vehicles navigating forested highways are issued alerts. Additionally, during nighttime hours, lights to mark specific distances are employed. Ultimately, the paper's primary objective is to safeguard animals from accidents and protect countless lives from potential danger. To achieve this, the YOLO (You Only Look Once) algorithm is implemented, which boasts the capability to process 45 frames per second and analyze the entire image to predict object presence.

Introduction

A pressing global challenge we confront today is the occurrence of fatalities and injuries resulting from road accidents. Human-animal collisions rank among the primary causes of these unfortunate incidents. Road accidents transpire every 15 minutes worldwide. Human-animal conflicts, often leading to crop damage, human fatalities, and the killing of animals by humans, represent a significant issue. Rare species of animals, in particular, face frequent mortality on forested highways. To mitigate animal-vehicle collisions, various warning signs have been deployed, but accidents persist. Factors such as driver negligence, failure to notice signs, or a lack of awareness contribute to these incidents. Applications built around animal detection are pivotal in addressing real-world problems. Most of these applications hinge on the identification of animals in images or videos. Thus, our initiative aims to protect animals, reduce global fatalities, and curtail wildlife deaths due to accidents. The central goal of animal detection is to minimize animal-vehicle collisions. We aim to develop a system installable along highways at specific intervals or within vehicles, effectively and accurately detecting animals to alert drivers to slow down.

INTERNET OF THINGS

The Internet of Things (IoT) signifies a network comprising interconnected computing devices, mechanical and digital machinery, objects, animals, or humans, each assigned unique identifications and equipped with the capacity to transmit data across a network without necessitating human-to-human or human-to-computer interaction. In the near future, IoT-based technology is poised to introduce advanced services and fundamentally reshape people's daily lives. Examples of its strong foothold encompass advancements in medicine, power, gene therapies, agriculture, smart cities, and intelligent homes. Presently, over 9 billion "Things" are connected to the Internet, with this number anticipated to soar to a staggering 20 billion.

IoT relies on four principal components:
Low-power embedded systems – These systems prioritize minimal battery consumption and high performance during electronic system design.
Cloud computing – IoT device-generated data, often voluminous, necessitates reliable storage servers. Cloud computing comes into play to process and analyze data, thereby revealing insights, including the identification of electrical faults or errors within the system.
Availability of big data – Given IoT's reliance on real-time sensors, a surge in big data is inevitable as these electronic devices proliferate across various fields.
Networking connection – Effective communication demands Internet connectivity, with each physical object associated with an IP address. However, the scarcity of available IP addresses under the current naming system, in light of the growing number of devices, necessitates researchers to explore alternative naming systems for representing physical objects.

Deep Learning

Deep learning represents a subset of machine learning within the realm of artificial intelligence. It encompasses networks capable of unsupervised learning from unstructured or unlabelled data. Also known as deep neural learning or deep neural networks, deep learning operates much like a human brain's structure. A defining characteristic of deep learning algorithms is their capacity to draw conclusions akin to human reasoning by continuously analyzing data structured with a logical framework. To realize this function, deep learning employs multi-layered algorithms, referred to as neural networks.

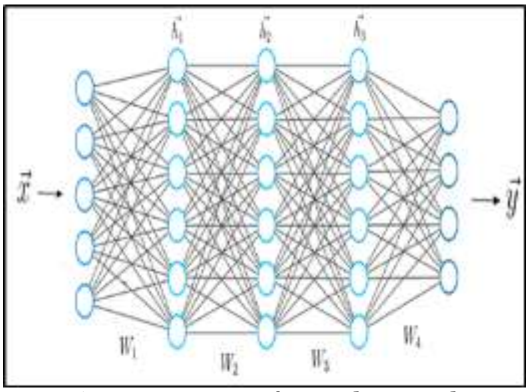

Fig 1. Structure of neural network

Figure 1 illustrates the fundamental structure of a neural network, comprising an input layer and an output layer. Each input layer possesses a single input and a corresponding output.
Neurons serve as the basic units of neural networks. These networks consist of input neurons corresponding to the input layer, output neurons corresponding to the output layer, and hidden neurons within the hidden layer. Hidden neurons apply weights to the input, directing them through an activation function to produce output. They execute non-linear transformations of inputs and channel them accordingly.

Methodology

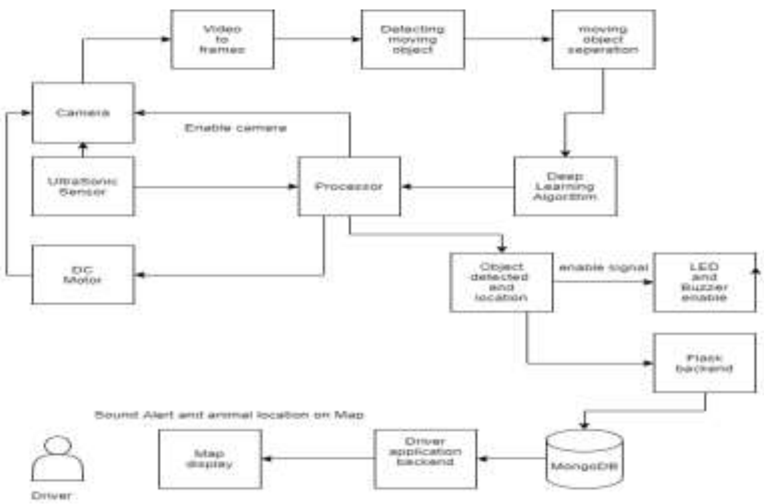

Fig 2. Block diagram

The accuracy of our system hinges significantly on the ultrasonic sensors' ability to precisely detect objects in the environment. When the sensor detects an animal, it triggers the camera to capture video footage. The recorded video is then converted into frames and fed into the model, which has been trained on an animal dataset using the highly efficient and accurate YOLO algorithm for image detection as shown in figure 2. Upon detecting an animal in the images, the model performs classification and outputs the animal's class, along with its location, which is stored in the database via the Flask backend. Simultaneously, a signal is sent to activate the LED lights and buzzer as an alert system. The backend of the driver alert application queries the database in real-time for any new entries and forwards this information to the frontend, which displays it on a map. Audible alerts notify the driver and show the animal's location on the map, prompting the driver to slow down to avoid potential collisions with wildlife. This system demonstrates its potential to significantly reduce the occurrence of human-animal collisions and thereby mitigate road accidents resulting from encounters with wild animals.

Working and Results.

In this study, we employ a Raspberry Pi device along with Pi camera and ultrasonic sensors to detect animals. The primary objective is to identify animals and issue warnings to approaching vehicles, thereby reducing the incidence of wildlife-related accidents on forest roads. The core components responsible for issuing warnings to vehicles include a sound buzzer, LED lights, and the Driver Alert application. Additionally, a DC motor is utilized for specific rotational functions. The entire system is strategically placed along forest roadways at designated locations. When an animal approaches the road, the ultrasonic sensor detects its presence and triggers the Pi camera to activate. Subsequently, the camera captures live images of the animals and forwards them to a deep-learning model for animal classification. To alert nearby vehicles, both the sound buzzer and LED lights are activated as soon as the sensor provides the alert signal. The animal's classification and location data are stored in a database. This information is continuously monitored by the driver alert application, which checks for new entries at one-second intervals. When a new entry is detected, the map display generates an audible notification, and the animal's location is marked on the map. This system encourages vehicles to reduce their speed to allow animals to safely cross or move alongside the road, ultimately leading to fewer accidents and reduced harm to both wildlife and vehicles on forest highways.

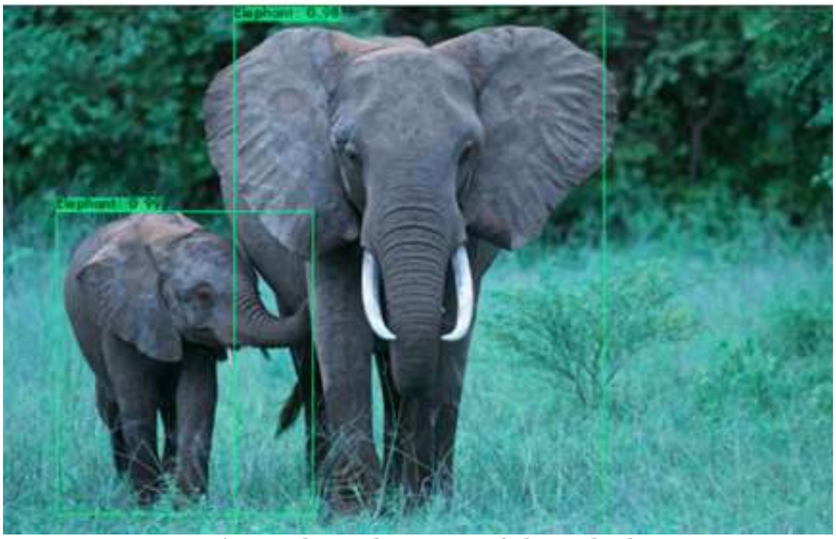

Fig 3. Object detection of class Elephant

Fig 4. Object detection of class Tiger

Figure 3 and 4 shows the object detection of Elephants and Tigers. Figure 5 shows the Driver Alert Application Map.

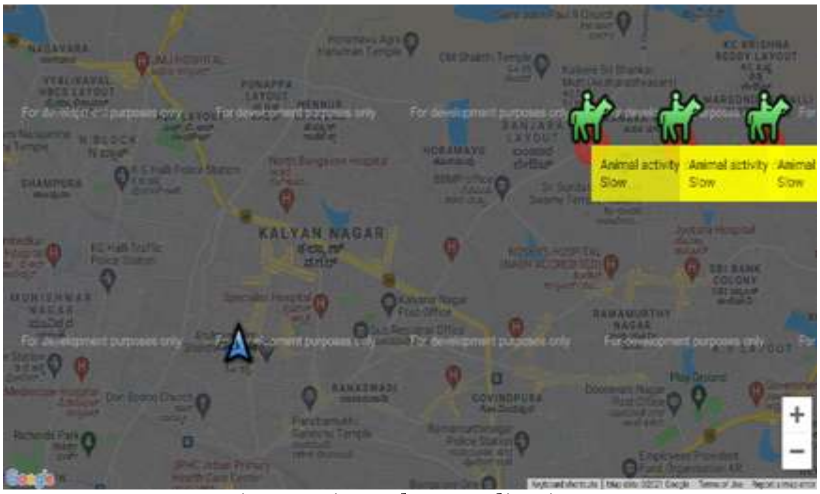

Fig 5. Driver Alert Application Map

Conclusion

In today's technologically driven world, machine learning techniques, particularly deep learning, have become integral to various aspects of our lives. These methods are harnessed across a multitude of applications and algorithms. This research introduces an innovative approach to wildlife detection using a combination of IoT and deep learning. The central aim is to identify animals and provide timely warnings to vehicles traveling on forest roads. It is widely acknowledged that forest highway accidents often result in harm to animals, leading to fatalities and adverse effects on endangered species. This paper employs the Raspberry Pi 3 Model B to detect animals and alert oncoming vehicles. To achieve this, we utilize an ultrasonic sensor to detect obstacles. Once an obstacle is identified, the Pi camera activates, capturing real-time images of the animals. These images are then subjected to analysis using deep learning algorithms stored in a database. Subsequently, vehicles on forest highways are alerted to potential hazards. Future possibilities include integrating this system into vehicles, extending its detection range, and enabling autonomous speed reduction to prevent collisions. We anticipate that our research will contribute to wildlife preservation and accident prevention.

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