Railway Accident Control by Digital Image Processing

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Abstract- **The government's biggest issue is accidents on the railroads, which can occur for a variety of causes. Railway networks passing through sensitive forests and other locations because of unforeseen animal arrivals, sand falls, large stones, or track faults that could result in fatalities and some degree of economic damage are a few of the causes. To stop all these issues Utilized is radar/photoelectric technology. The system is created using the available technology. The radar source on the locomotive closes the waves that cover an area of a few kilometers surrounding the train and detects any issues with the rail network. Based on this detection, the loco pilot reduces the locomotive speed. We are using digital signal processing technology to solve these issues. We use digital image processing technology for real-time implementation; when an obstruction is detected, the pilot of the locomotive is notified, and in electric trains, breaks are immediately applied. The way the digital image processing technology operates is that we first work with track data by keeping a database with several photographs taken depending on various scenarios of an obstacle's presence on a railway track. In front of the locomotive is this DIP technology product for controlling railway accidents.**

Keywords: **Raspberry Pi, IR Sensor, USB Web Camera and Servo motor.**

I. INTRODUCTION

Transportation safety regulations prohibiting railway level crossing accidents and suicides are in place. To increase safety measures, the government has been developing a variety of countermeasures for the rail industry. developing in-car devices that warn drivers of their surroundings while they are driving. Such systems prevent accidents by acting. The number of accidents has decreased as a result of these substantial activities. In this study, we presented a practical method that makes use of the Raspberry Pi. The system controls the system's engine in manual and automatic modes. Image processing Har Cascaded algorithms will be used to detect people or any other obstacles.

In India, train accidents happen frequently. Unfortunately, when these mishaps occur, people usually sustain severe injuries or even pass away. Train accidents usually involve both mechanical and human fault, and frequently they involve a combination of both. The overall goal of the project is to use this apparatus, which railway officials can use in real time, to detect any cracks or distortions in the railway track. By replacing the now practiced human investigation, the project setup would create the inspection and care of railway tracks gently and help them to monitor effectively. The vehicle's design and associated software are relatively straightforward and easily adoptable by the current system.

By fusing image processing methods with IoT technology, vision based IoT aims to make smart security systems for railways a reality. The authority uses vision IoT to monitor and manage railway activity. IoT devices that are new and improved, more responsive and intelligent than ever before, and thus more valuable to the user, have been made possible by the introduction of vision technology.

At a time when security is becoming increasingly important to people, it is urgent to find a novel, less expensive method of identifying the source of hostile activity in the railways and reporting it to the appropriate authorities. The goal of this project is to create a security system using IoT that detects motion in a railway environment, activates a PiCam to take pictures of the scene, and uses deep learning to identify the animal, person, or object causing the motion using Mobile Nets and Single shot detectors. On devices with limited resources, like smart phones and Raspberry Pi, these techniques can be combined and applied to identify objects in real time and very quickly. The system's accuracy, which is measured as the ratio of correctly detected objects to all objects that entered the farm within a given time frame, has produced satisfactory results in the experiments that have been conducted on it. The accuracy of the system is 92% regarding object detection and identification. The system's consistency, which is calculated as the ratio of user notifications to farm invasions, is found to be 100%.

II. PROBLEM STATEMENT

Securing obstructions and animals from the train is always a top priority in railway systems. So, the definition of the problem is the design and development of a digital image processing system to enable early identification of barriers or animals.

III. PROPOSED SYSTEM

The goal of the animal detection system is to identify any obstructions in front of the train and send an email to the following station. The hardware and software parts of the animal detection system will be fully described in this section.

a. OpenCV4

A free and open-source software library for computer vision and machine learning is called OpenCV. More than 2500 optimized algorithms are available in the collection, including a wide range of both traditional and cutting-edge computer vision and machine learning techniques. These techniques may be used to identify items, classify human behaviors in films, detect and recognize faces, track camera movements, track moving objects, extract three-dimensional representations of objects, and more. It supports Windows, Linux, Android, and Mac OS and provides interfaces for C++, Python, Java, and MATLAB.

Raspberry Pi OpenCV 4 installation:
• Extend the Raspberry Pi's file system.
• Set up Open CV 4 prerequisites on the Raspberry Pi.
• Open CV 4 download for the Raspberry Pi.
• Set up the Open CV 4 virtual environment with Python 3.
• Open CV 4 C Build and Compilation for Raspberry Pi.
• Connecting the Python 3 virtual environment to OpenCV4.
• Examining the Open CV 4 installation on the Raspberry Pi

b. Deep Learning

Deep learning is a feature of artificial intelligence that replicates how the human brain processes information and develops patterns to aid in decision-making. In artificial intelligence (AI), deep learning is a subset of machine learning that enables networks to learn unsupervised from unstructured or unlabeled input. It is sometimes referred to as a deep neural network or deep neural learning.

In fields like computer vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation, bioinformatics, drug design, medical image analysis, material inspection, and board game programs, deep learning architectures like deep neural networks, deep belief networks, recurrent neural networks, and convolutional neural networks have produced results similar to and in some cases superior to traditional methods. The utilization of numerous network layers gives deep learning its "deep" term. Early research has shown that a network with a non-polynomial activation function and one hidden layer of unlimited breadth can, on the other hand, be a universal classifier. A more recent form, known as deep learning, focuses on an unbounded number of layers with bounded sizes, allowing for practical application and optimized implementation while maintaining theoretical universality under benign circumstances. For the purposes of efficiency, trainability, and understandability, deep learning layers are also allowed to be heterogeneous and to depart significantly from biologically informed connectionist models, hence the "structured" portion.

Overview:

Although they can also include propositional formulas or latent variables organized layer-wise in deep generative models like the nodes in deep belief networks and deep Boltzmann machines, most contemporary deep learning models are based on artificial neural networks, specifically Convolutional Neural Networks (CNNs).

Each degree of deep learning learns how to change the incoming data into a tad more abstract and composite representation. In an application for image recognition, the initial input could be a matrix of pixels; the first representational layer could abstract the pixels and encode edges; the second layer could compose and encode arrangements of edges; the third layer could encode a nose and eyes; and the fourth layer could recognize that the image contains a face. Crucially, a deep learning process can figure out on its own which features to best arrange at which level. A greedy layer-by-layer strategy can be used to build deep learning architectures. Deep learning aids in detaching these abstractions and identifying the elements that enhance performance.

Deep learning techniques avoid feature engineering for supervised learning tasks by converting the data into concise intermediate representations similar to primary components and resulting in layered structures that eliminate representational redundancy. Unsupervised learning tasks can be handled by deep learning algorithms. Since that unlabeled data are more prevalent than labeled data, this is a significant advantage. Neural history compressors and deep belief networks are two examples of deep structures that can be taught unsupervised.

Cognitive Networks:

1. Synthetic neural networks:

Computing systems inspired by the biological neural networks that make up animal brains are known as artificial neural networks (ANNs) or connectionist systems. These systems typically lack task-specific programming and instead learn to perform tasks by considering examples. For instance, in image recognition, they might study model photos that have been manually tagged as "cat" or "no cat," analyzes those images, and then use the analytic outcomes to recognize cats in other photographs. The applications that are challenging to explain with a conventional computer method have found the most usage for them.

Artificial neurons are a group of interconnected components that make up an ANN (analogous to biological neurons in a biological brain). A signal can be sent from one neuron to another through any connection (synapse) between neurons. The signal(s) can be processed by the receiving (postsynaptic) neuron, which can then signal downstream neurons linked to it. States may exist in neurons.

Neurons are typically arranged in layers. Various layers may modify their inputs in a variety of ways. Signals may pass through the layers more than once as they move from the first (input) to the last (output) layer. The original intent of the neural network strategy was to solve issues in a manner like that of the human brain. Over time, the emphasis shifted from general mental talents to matching mental abilities, resulting to biological abnormalities such back propagation, or transmitting information backwards and changing the network to reflect that knowledge. Computer vision, speech recognition, machine translation, social network

filtering, playing board and video games, and medical diagnosis are just a few of the applications where neural networks have been applied.

2. Deep Neural Systems:

An artificial neural network (ANN) having more than two layers between the input and output layers is called a deep neural network (DNN). Whether there is a linear or nonlinear relationship between the input and the output, the DNN determines the best mathematical operation to convert the input into the output. The likelihood of each output is calculated as the network progresses through the layers. For instance, a DNN trained to identify dog breeds will examine the provided image and determine the likelihood that the dog in the image belongs to a particular breed. After reviewing the outcomes, the user can choose which probabilities the network should show (those that are higher than a given threshold, etc.) and return the suggested label. Each mathematical operation is regarded as a layer in and of itself, and complex DNN have several layers, thus the moniker "deep" networks.

Complex non-linear relationships can be modelled by DNNs. The compositional models produced by DNN architectures express the object as a layered composition of primitives.

The additional layers allow for the composition of characteristics from lower levels, perhaps allowing for the modelling of complex data with fewer units than a shallow network that performs similarly.

DNNs are typically feed-forward networks in which information moves straight from the input layer to the output layer. In the beginning, the DNN builds a map of virtual neurons and gives their connections random numerical weights. After multiplying the weights and inputs, an output in the range of 0 and 1 is produced. An algorithm would change the weights if the network had trouble correctly identifying a specific pattern.

In this manner, the algorithm can increase the weight of some factors while figuring out the best mathematical operation to fully analyze the data. Applications like language modelling use recurrent neural networks (RNNs), in which data can flow in any direction. For this usage, long short-term memory is especially useful. Computer vision employs convolutional deep neural networks (CNNs). Acoustic modelling for automatic speech recognition has also been used by CNNs (ASR).

c. SSD for Single Shot Object Detection a Mobile Network

The object detection technique Single Shot Multi Box Detector (SSD) is a version of the VGG16 architecture. At the time of its introduction at the end of November 2016, it achieved new benchmarks for speed and accuracy in object detection tasks, achieving over 74% MAP (mean average precision) at 59 frames per second on well-known datasets including Pascal VOC and COCO. Due to the need for two shots in R-CNN, SSD is quicker than R-CNN. While in SSD, it can be completed in a single step, one for generating region proposals and another for object detection. The COCO dataset was used to train the Mobile Net SSD technique, and PASCAL VOC reaching 72.7 percent map (mean average precision)was used to fine-tune it.

It consists of two sections: Convolutional filtering is used to extract feature maps and identify objects.

There are only two SSD variants available in particular:

• SSD300: The input size in this device is fixed to 300300. Although it has a higher processing speed and is less accurate than SSD512, it is utilized for photos with lesser resolution.

• SSD512: The input size in this device is fixed at 500500. It is more accurate than previous models and is utilized in photographs with higher quality.

Using Mobile Net as opposed to Reset, VGG, or Alex net has a benefit. This is because Reset, VGG, or Alex nets have vast networks and require more computation, whereas Mobile net has a straightforward architecture that consists of a 33-depth wise convolution and an additional 11 pointwise convolutions.

Algorithm for Single Shot Object Detection:

- The Open CVs dnn (deep neural network) module must first load a pre-trained object identification network.
- By doing so, we'll be able to send photos as inputs through the network and get the output bounding box (x, y) coordinates of each image object.

The code to print the name of the identified object and its confidence ratings is now being written.

•Next, we look at Mobile Net Single Shot Detector's output for the supplied photographs.

d. Raspberry Pi V4

The Raspberry Pi is a line of diminutive single-board computers created in the UK by the Raspberry Pi Foundation to support the instruction of fundamental computer science in classrooms and in underdeveloped nations. The initial model sold outside of its intended market for applications like robotics and was far more widely used than planned. There are no peripherals provided with the Raspberry Pi, including keyboards, mouse, or cases. Nonetheless, several accessories have been a part of numerous official and unofficial packages.

The performance of the So C can be increased while maintaining the board's lifespan by using one of five over clock (turbo) pre-sets available in more recent firmware versions. This is accomplished by keeping an eye on the chip's core temperature, the CPU load, and dynamically altering the core voltage and clock speeds. Performance is throttled when there is little demand on the CPU or when it is operating too hot, but if there is a lot of CPU activity and the chip temperature is acceptable, performance is momentarily increased with clock speeds of up to 1 GHz depending on the specific board and the selected turbo setting. The Raspberry-pin Pi's diagram is displayed in Figure 2.When the CPU is idle, its speed drops to 600 MHz, however in system information, it shows as 1200 MHz. The Raspberry Pi requires an operating system with ROS installed in order to function.

A. Specifications:

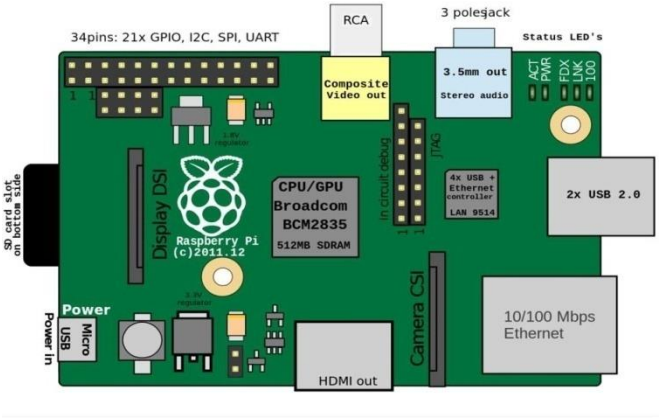

Fig. 1 Raspberry Pi 4 Model B

• 1GB, 2GB, or 4GB LPDDR4-3200 SDRAM from Broadcom BCM2711, a quad-core Cortex-A72 (ARM v8) 64-bit SoC running at 1.5GHz (depending on model)
• Bluetooth 5.0, BLE, and IEEE 802.11ac WiFi at 2.4 and 5.0 GHz
• Ethernet in Gigabit
There are 2 USB 3.0 ports and 2 USB 2.0 ports.
• 40-pin GPIO header standard for the Raspberry Pi (fully backwards compatible with previous boards)
• 2 ports for micro-HDMI (up to 4kp60 supported)
• 4-pole stereo audio and composite video port; 2-lane MIPI DSI display port; 2-lane MIPI CSI camera port; H.265 (4kp60 decoding), H264 (1080p60 decode, 1080p30 encode) 3.0 OpenGL graphics
• Micro-SD card slot for installing software and storing data
• Minimum 3A* at 5V DC through USB-C connector
• Minimum 3A* through the GPIO header at 5V DC
• Support for Power over Ethernet (PoE) (requires separate PoE HAT)
• Operational condition: 0 - 50 degrees C ambient.

B. Pin Description

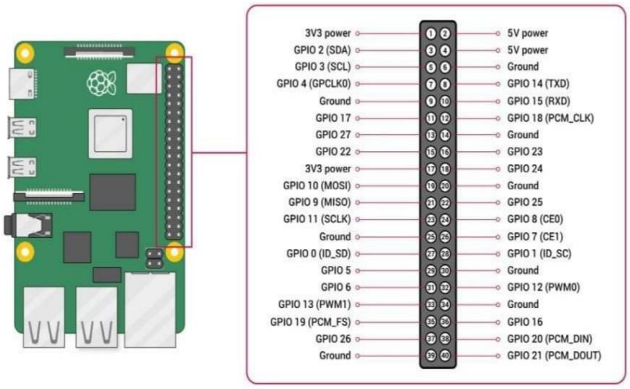

Fig. 2 Raspberry Pi 4 pin configuration

C. Raspbian OS installation
• Launch Etcher to copy software to the SD card of the Raspberry Pi. Install the Etcher software after downloading it.
• Download the Raspbian operating system for the Raspberry Pi after downloading and installing Etcher.
• By selecting Download ZIP, you can now download Raspbian Buster in ZIP file and store it on your desktop together with the required apps.
• Place a microSD card in the card reader. Put the card reader in the PC after that.
• Now launch Etcher and choose the Raspbian image by clicking select image. Choose Raspbian-buster-full-zip and then click Choose Target to choose the Micro-SD card as the target. Click Proceed after selecting Mass Storage Device Media. Finally, select Flash.
• Remove the SD card from your computer and put it in your Raspberry Pi.

e. ***USB Web Camera***

Fig. 3 USB Web Camera

Specifications:

- Image Sensor: Color CMOS image sensor
- Video Format: 24-bit RGB
- Interface: USB
- S/N ratio: 48 dB
- Dynamic range: 3 cm to infinity
- Built in image compassion
- Automatic white balance
- Automatic color compensation
- Dynamic image e-mail
- Manual focus
- Shutter key

f. Servo Motor SG90

Fig. 4 Servo Motor SG90

A servo motor is an electrical device that can precisely push or spin an item. A servo motor can be used to rotate an object at predetermined angles or distances. It is composed of a straightforward motor that utilizes a servo mechanism.

g. IR Sensor

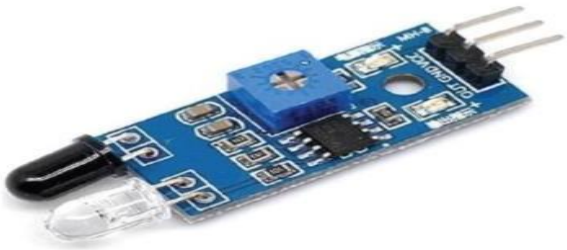

Fig . 5 IR Sensor

An electrical device that senses certain aspects of its environment is called an infrared sensor. It accomplishes this by either producing infrared radiation or sensing it. Besides sensing motion, infrared sensors can also measure the heat that an item emits.

h. Python

Python is a general-purpose, interpreted programming language. Python uses garbage collection and has dynamic typing. It supports a variety of programming paradigms, including procedural, object-oriented, and functional programming as well as structured programming (especially). Due to its extensive standard library, Python is frequently referred to as a "batteries included" language.

A multi-paradigm programming language is Python. Many of its features also allow functional programming and aspect-oriented programming, and both object-oriented programming and structured programming are fully supported. Extensions are available for many additional paradigms, such as design by contract and logic programming. Python's memory management system combines reference counting and a cycle-detecting garbage collector with dynamic typing. Moreover, it has a dynamic name resolution (late binding) capability that binds variable and method names as the Programme is being run.

The extensive standard library of Python, frequently considered as one of its greatest features, offers tools appropriate for a variety of jobs. Several common formats and protocols, including MIME and HTTP, are supported for programs that interact with the internet. It has modules for building graphical user interfaces, establishing connections to relational databases, generating pseudorandom numbers, performing arithmetic with arbitrary precision decimals, working with regular expressions, and performing unit tests. Specifications cover a few components of the standard library, but not most of its modules. They are described through their internal documentation, test suites, and source code. Just a few modules must be changed or completely rewritten for alternative implementations, though, as most of the standard library is written in cross-platform Python.

IV. DESIGN AND IMPLEMENTATION

The suggested solution uses a Raspberry Pi board to look for suspicious activity or movement in the farmland and then activates a USB Web Camera to snap pictures of the scene. The image processing module placed on the Raspberry Pi board uses Single Shot detectors and Mobile networks approach of Deep Learning to identify the object in the image. The farmer receives an email notification of this communication.

A. System Design

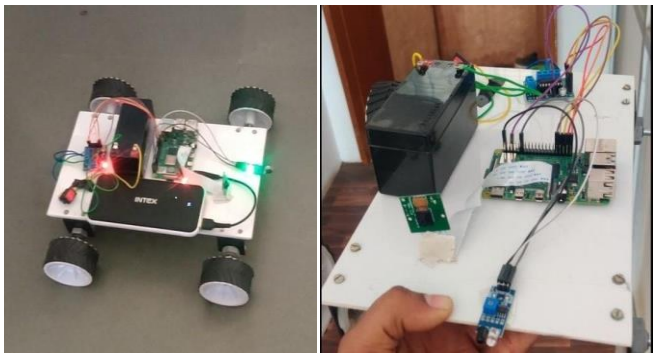

Fig. 6 System Design

The Animal detecting system's initial prototype can be shown in Figure 7. The project uses a USB web camera to take pictures and record videos when motion is detected by three IR sensors linked to a Raspberry Pi. The Raspberry Pi is connected to a servo motor, and a USB web camera is mounted on top of the servomotor to rotate the camera in the appropriate direction. As a result, the Camera will swivel in that direction to take the picture and record the video when an intruder is picked up by one of the IR sensors. Also, the Raspberry Pi is connected to a Piezo buzzer, which makes a sound when it detects motion for alerting purposes.

B. Block diagram

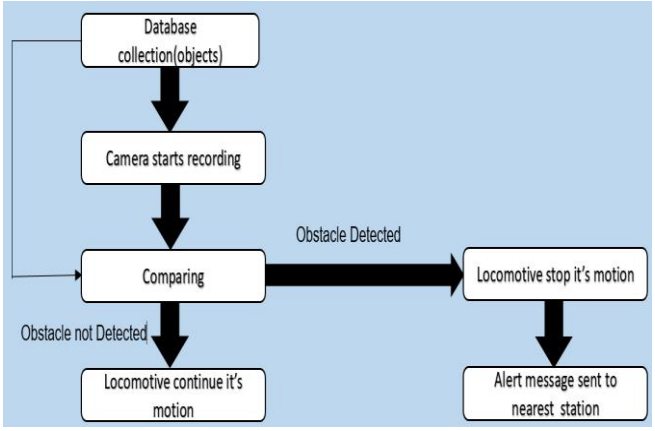

Fig. 7 Block diagrams

The block diagram of the suggested methodology is shown in figure 4.3. The Raspberry Pi, IR sensors, USB web camera, and servo motor are all shown in the block diagram. The outputs come from the buzzer, servomotor, and image processing unit that makes

use of OpenCV. The input comes from the IR sensors and camera. This section describes the proposed system that uses a Raspberry Pi and OpenCV to detect motion inside a farm, take a picture of the scene after motion is detected, process the picture using OpenCV on the Raspberry Pi, identify the object—an animal, a person, or anything else—that is causing the intrusion, and send an alert to the farmer.

The processing module is made up of a Raspberry Pi board and an image processing component that leverages OpenCV to provide quick image processing. When an IR sensor detects motion, the Raspberry Pi will command the USB Web Camera to capture a photo of the surrounding area. The USB Web Cam records the image and video, and the Raspberry Pi then creates a local duplicate of the image. The system is implemented using a camera, three Infrared sensors, and other components. At this point, deep learning is used with Single Shot Detectors (SSD) and Mobile Nets to identify objects in the collected scene image.

The SSD object detections are divided into two sections:
1) Extract feature maps.
2) Making use of convolutional filters to find items.

SSD recognizes numerous things in a picture with a single scan. In contrast, Mobile nets with streamlined architecture construct light deep neural networks using depth-wise distinct convolutions. The two methods discussed above are combined to produce a super-fast, real-time object identification technique that operates on devices with limited resources, such smart phones and Raspberry Pi. An object detection network that has already been trained is loaded using OpenCV's deep neural network (DNN) module. Bounding box (x, y)-coordinates for each object in an image can be retrieved by passing input images through the network. The Raspberry Pi's OpenCV module, which is installed, performs object identification, provides information about the object that has moved or engaged in any malicious action, and then passes that information to the Email notification module. The SMTP protocol is used by the email notification module, which will also have the user's email address.

C. Circuit Diagram

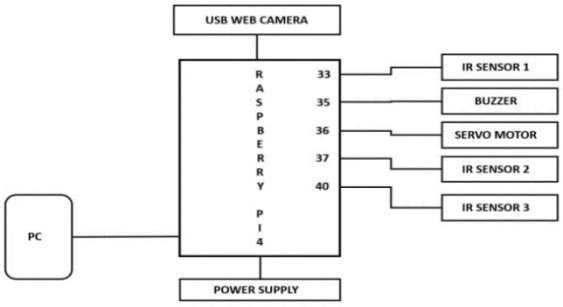

Fig. 8 Circuit Diagram

The circuit design for the suggested methodology is shown in figure 9. Using flat ribbon wire, the camera is connected to the Raspberry Pi's Camera Serial Interface (CSI) port. The Raspberry Pi and PC are connected via Ethernet to create a virtual screen for the Raspberry Pi. All three IR sensors and the servo motor's Vcc and ground pins are linked to the Vcc and ground pins of the Raspberry Pi, respectively. The Raspberry Pi's 37, 33, and 40 pins are connected to the output pins of the IR sensor 1, 2, and 3, accordingly. The Raspberry Pi's 35 and 39 pins are connected to the buzzer's positive and negative pins, respectively.

The Raspberry Pi's pin number 36 is connected to the servo motor's signal pin. The processing of the images is done with OpenCV. Programming is done using the Python language.

D. Implementation

- **Image capturing**

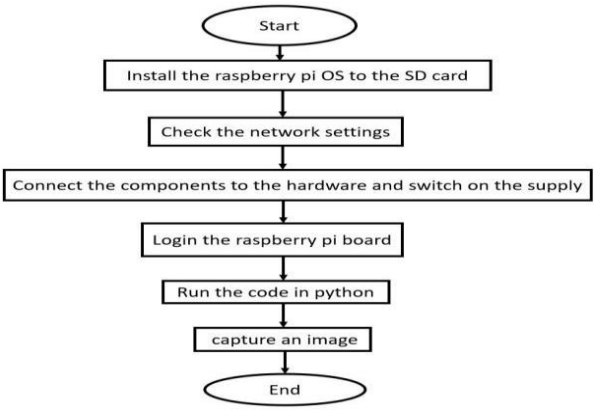

Fig. 9 Image capturing flow chart

Figure 10 depicts the picture capture flow chart. Here is a discussion of the algorithm.

Step 1: use the balena Etcher Programme to install the Raspbian operating system on the Raspberry Pi.
Step 2: Verify internet accessibility. Connect the camera to the Pi board, then turn on the power.
Step 3: Enter the Raspberry Pi's login and password, which are pi and raspberry.
Step 4: In order to access the USB camera, type sudo apt-get install fs webcam.
Step 5: To execute the code, type python prg name.py.
Step 6: The image is taken in and will be in the jpeg format.

- Video capturing

The following is the algorithm for recording video using the OpenCV package.
Step 1: To import the OpenCV library for video capture, type import cv2.
Step 2: To obtain a video capture object for the camera, use cv2.VideoCapture().
Step 3: Use the read () method to read the video frame-by-frame using the ret, frame = cap syntax and an unlimited while loop ().
Step 4: Employ the cv2.imshow() method to display the video's frames.
Step 5: When the user presses a particular key, the loop ends (Q).

- Email Sending

One of the most useful services on the internet nowadays is emerging as email. SMTP is a means for sending mail from one user to another that is used by the majority of internet-based services. POP (post office protocol) or IMAP (internet message access protocol), both of which are pull protocols, are used to retrieve mail at the recipient's end whereas SMTP (a push protocol) is used to send mail. SMTP Foundations:

The application layer protocol is SMTP. A TCP connection is established between the client and the SMTP server before the mail is sent via the connection. The SMTP server is constantly set to listen. The SMTP process starts a connection on that port as soon as it starts to listen for a TCP connection from any client (25). Once the TCP connection has been established properly, the client process immediately sends the email. Protocol SMTP:

- Receiving Email

At predetermined intervals, the user agent on the server side checks the mailboxes. It alerts the user to any information received if any. When a user attempts to read a message, a list of messages with a brief summary of each message in the inbox is displayed. The user can view the contents of any selected mail message on the terminal.

V. RESULTS AND DISCUSSIONS

The accuracy of object detection using Mobile Nets and Single Shot Object Detectors (SSD) through deep learning has been examined in this section. In order to perform the assigned duty, the system is designed to direct the train by sending an email to the following station when the object is detected. Finally, following pre-processing of the captured image and object detection using Mobile Nets and Single Shot object Detectors (SSD) through deep learning, the captured image and videos are transmitted to the landowner via mail by utilizing the SMTP protocol.

- Working principle

Fig. 10 Working prototype of the animal detection system

A functioning prototype of the suggested animal detection system is shown in Figure 11.
The framework created can be utilized in Smart Agriculture applications, such as spotting criminal activity on farmland and stopping animal encroachment.

Following image pre-processing, object detection is carried out via Mobile Nets and Single Shot object Detectors (SSD) through deep learning. Figure 11 displays the outcomes for the detection of several species, including cows, horses, sheep, and tigers.

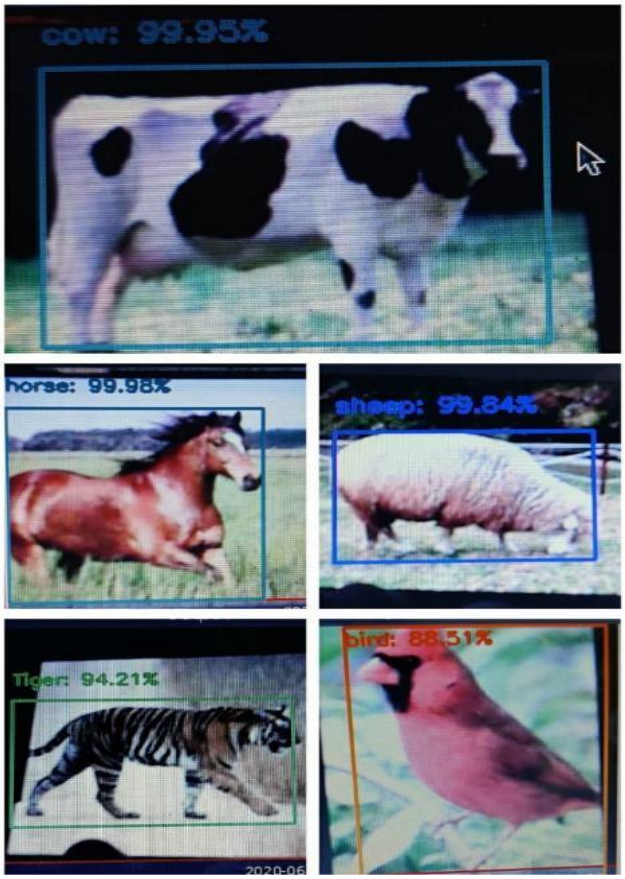

Fig. 11 Results obtained for animal detection

Sl.no	Name of the animal	Percentage of accuracy
1	Cow	99.95
2	Horse	99.95
3	Sheep	99.84
4	Tiger	94.21

Table. 1 Percentage of obstacles detection accuracy

Mail received by the locomotive:
Following image and video capture, the owner of the land is contacted via mail with the images and films that were acquired using the SMTP protocol.
Figure 13 displays the emails that included the photograph. locomotive acquired and brought to the main station.

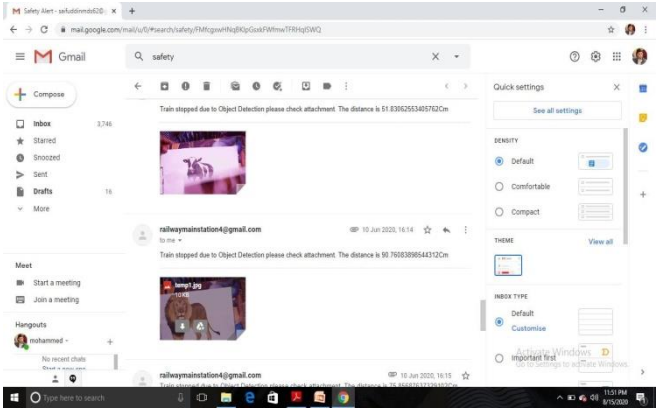

Fig. 12 Mail received by the locomotive to main station

VI. CONCLUSION

• The locomotive's frontal impediments will be detected by the designed prototype and by doing this, railway accidents can be decreased.
• It is simple to implement this system and this effort aids in the preservation of numerous animal lives in forested areas.
This project's primary goals are the protection of animals and the avoidance of train accidents. An image is taken, and a notification is sent via email to the closest railway station when the IR sensor detects any movement. Consequently, it can be said that the method is very beneficial to farmers and reasonably priced. Also, the method protects the obstacles while being safe for both humans and animals to use.

VII. FUTURE SCOPE

• This study can be expanded to wider agricultural areas with more animal datasets in future studies, with the main use being to detect the item with better qualities in the external environment.
•Thermal imaging can be employed for night vision to operate the system in farmland at night.

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