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Railway Infrared Obstacle Detection and Response System

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Abstract: In today's era one of the greatest modes of transportation is railways. But when we come to see the risks, they too have their own capacity to bring catastrophe. But the risks and accidents that happen in railway tracks are also of great impact. So, our aim is to bring the rate of accidents and damages as low as we can. In this paper, we propose a security system with less effort, low costs but with efficient working using an Infrared vision camera and a small computer with some processing power. This setup when working in a synchronized manner can effectively bring down the rate of accidents that happen on railway tracks per year.

Keywords: Computer Vision, Image Processing, Infrared camera, Railways, security system.

1. INTRODUCTION

This system totally focuses on detection of the obstacles in front of the track. It makes use of the infrared camera and then the technique of computer vision is used to detect the obstacles in front of the track. . In last four years, 15 persons were killed on railway tracks across the country every day, according to a reply to an RTI query from the Railway Board. Between 2014 and the end of March 2018, a total of 23,013 passengers were killed while trespassing railway tracks, alighting from running trains or falling off trains while standing close to the door. The data was collected from Government Railway Police of various states. [1]

Thermal Infrared Camera: An IR Camera(also called an Infrared Camera or Thermal Camera or Thermal Imaging Camera or Infrared Thermography) is a device that forms a heat zone image using infrared radiation, similar to a common camera that forms an image using visible light[2]. Instead of the 400–700 nm range of the visible light camera, infrared cameras operate in wavelengths as long as 14,000 nm (14 µm). Their use is called thermography. Thermal imaging focuses and detects this radiation, then translates the temperature variations into a grayscale image, using brighter and darker shades of grey to represent hotter and cooler temperatures, which gives a visual representation to the heat profile of the scene. Many thermal imagers can also apply color profiles to these images, showing hotter objects as yellow and cooler objects as blue for example, to make it easier to compare temperatures in the image. [3]

Computer vision: Computer vision is a field of computer science that works on enabling computers to see, identify and process images in the same way that human vision does, and then provide appropriate output. It is like imparting human intelligence and instincts to a computer. But in reality, it is a difficult task to enable computers to recognize images of different objects. Computer vision is closely linked with artificial intelligence, as the computer must interpret what it sees, and then perform appropriate analysis or act accordingly. This provides great help in detecting obstacles etc. [4]

Canny Edge Detection Technique: Canny Edge Detection is a popular edge detection algorithm. It was developed by John F. Canny in 1986. It is a multi-stage algorithm and we will go through each stage.

Noise Reduction: Since edge detection is susceptible to noise in the image, first step is to remove the noise in the image with a 5x5 Gaussian filter.

Finding Intensity Gradient of the Image: Smoothened image is then filtered with a Sobel kernel in both horizontal and vertical direction to get first derivative in horizontal direction (G_x) and vertical direction (G_y).

$$Edge\_Gradient = \sqrt{G_x^2 + G_y^2} \quad \text{……… (1)}$$

$$Angle(\theta) = \tan^{-1}\left(\frac{G_y}{G_x}\right) \quad \text{…….. (2)}$$

Gradient direction is always perpendicular to edges. It is rounded to one of four angles representing vertical, horizontal and two diagonal directions.

Non-maximum Suppression: After getting gradient magnitude and direction, a full scan of image is done to remove any unwanted pixels which may not constitute the edge. For this, at every pixel, pixel is checked if it is a local maximum in its neighborhood in the direction of gradient. In short, the result you get is a binary image with "thin edges".

Hysteresis Thresholding: This stage decides which are all edges are really edges and which are not. For this, we need two threshold values, *minVal* and *maxVal*. Any edges with intensity gradient more than *maxVal* are sure to be edges and those below *minVal* are sure to be non-edges, so discarded. Those who lie between these two thresholds are classified edges or non-edges based on their connectivity. If they are connected to “sure-edge” pixels, they are considered to be part of edges. Otherwise, they are also discarded. This stage also removes small pixels noises on the assumption that edges are long lines. So what we finally get is strong edges in the image. [5]

In order to determine the distance from our camera to a known object or marker, we are going to utilize triangle similarity. [6]

The triangle similarity goes something like this: Let’s say we have a marker or object with a known width W. We then place this marker some distance D from our camera. We take a picture of our object using our camera and then measure the apparent width in pixels P. This allows us to derive the perceived focal length F of our camera:

$$F = (P * D) / W \ldots\ldots\ldots\ldots (3)$$

As I continue to move my camera both closer and farther away from the object/marker, I can apply the triangle similarity to determine the distance of the object to the camera:

$$D' = (W * F) / P \ldots\ldots\ldots (4)$$

Also, there are some lenses that return the distance of the object in sight to the camera.

This paper is divided into six sections. Literature survey is discussed in section 2. In section 3 the proposed model is discussed. Section 4 contains the limitations of the proposed model. The other application of the proposed model is discussed in section 5. Section 6 finally states the conclusion.

2. STATE OF ART

A thermal imaging camera (infrared camera) is a type of camera used in firefighting. By rendering infrared radiation as visible light, such cameras allow firefighters to see areas of heat through smoke, darkness, or heat-permeable barriers. In addition to the ability to see through dense smoke, thermal imaging cameras also can see materials involved in spontaneous, low level combustion. In one documented instance, a TIC was used to isolate a smoldering hot spot in a grain storage facility; by isolating and removing only the affected grain, 75% of the stored crop was saved. [7]

Thermal imaging can be used to gather quantitative data for students' exploration of physical phenomena, such as thermal diffusion from a point source, cooling of roller-coaster brakes, or in the development of an analogy between thermal and electrical conduction. As an easy-to-use, yet powerful technology, thermal imaging is particularly well suited for inquiry-based laboratory activities in physics and chemistry education. In a separate study, groups of upper-secondary students carried out IR experiments to study heat conduction, friction and inelastic collisions. It was found that higher-level students tended to invoke microscopic models in their explanations of the phenomena. Thermal imaging has been used in informal settings, such as science museum exhibits.

Thermal imaging has been used in informal settings, such as science museum exhibits. In comparison with being asked to follow detailed instructions, visitors have been found to engage more creatively with the technology through minimal guidance, such as observing melting snow brought in from outside or visualizing temperature increase from rubbing their hands together. As the price has dropped significantly in recent years, IR cameras have become an attractive educational technology for science education, which complements traditional thermometer measurements. [8]

Computer vision is an AI technology that allows computers to understand and label images, is now used in convenience stores, driverless car testing, daily medical diagnostics, and in monitoring the health of crops and livestock. From our research, we have seen that computers are proficient at recognizing images. Today, top technology companies such as Amazon, Google, Microsoft, and Facebook are investing billions of dollars in computer vision research and product development. With this in mind, we decided to find out how the top global tech firms are making use of computer vision and explore what kind of new technology and media could appear over the next few years. From our research, we’ve found that many of the use cases of computer vision fall into the following clusters:

- Retail and Retail Security
- Automotive sector
- Healthcare sector
- Agriculture sector
- Banking sector
- Industrial sector [9]

The above mentioned technologies have been used before in some other research works such as detecting cracks in railway tracks. Also there have been many surveys on thermal imaging systems and their real time applications.

3. PROPOSED MODEL

This model is all about building a security system with the help of a computer, an infrared camera and the other hardware parts (brakes, etc.) to avoid collision and prevent damage. The software is developed with the help of computer vision (image processing) which detects obstacles that are on the track of a moving train and alerts the driver regarding the same. The driver can then take a decision as to stop the train or ignore the alert (in case of a threat or security breach).

The steps involved in this proposed system are as follows:

Step 1: As shown in fig 1. A train is running at a speed of x units on a railway track and an IR camera is mounted on the front part of the engine. This camera has a visibility range of up to 5 Km and has a rate of image generation of 1 image per second.

Fig 1: Train is running with a speed of X units.

Step 2: As shown in fig 2. An obstacle (a human being, animal, vehicle, etc) appears in front of the track the IR Camera will now take thermal image of the obstacle and send it to the computer placed in driver's cabin.

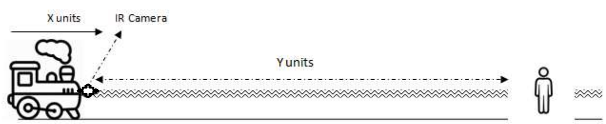

Fig 2: Obstacle detection.

Step 3: As shown in fig 3. The computer processes the image of the obstacle to check whether the obstacle is in between the tracks or not and also calculates the distance between the camera/engine and the obstacle(y units) using the equations (1), (2), (3) and (4). This information pops up on the screen in front of the driver with an alert message and asks him either to engage the brakes or to ignore the situation. Until the driver decides, the speed of the train is decreased to the half of its initial speed(x/2 units) by applying breaks up to a small extent. Now there will be two cases i.e. Step 4 or Step 5.

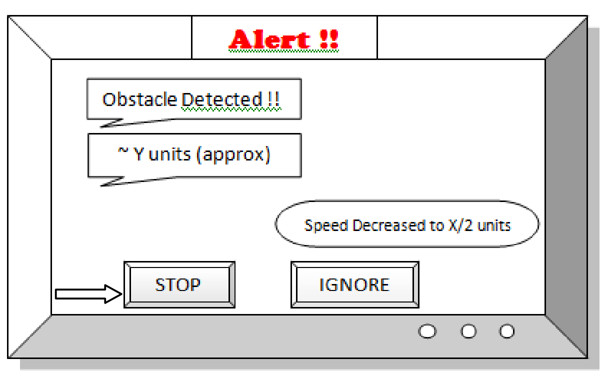

Fig 3: Computer screen showing alert.

Step 4: As shown in fig 4. The driver responds to the situation in step 3 and asks to engage the brakes. As soon as the driver does so, the train comes to a halt by applying brakes to their full capacity.

Fig 4: Speed reduction and brakes applied.

Step 5: As shown in fig 5 and fig 6. The driver decides to ignore the message (due to a potential threat detection ,security breach or he believes that the obstacle is too small or can be warned to clear the track) that shows up in Step 3, the system shuts down the alert and disengages the brakes so that the train may return to its initial speed(x units).

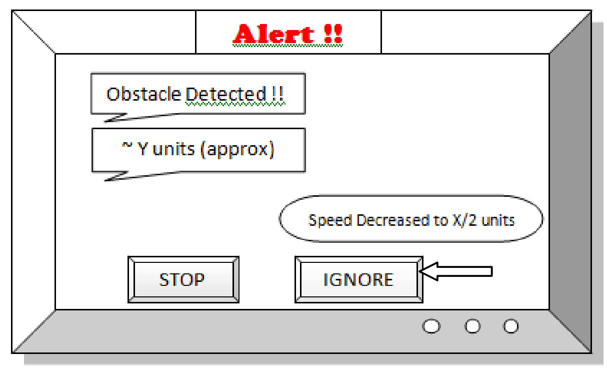

Fig 5: Computer screen showing alert.

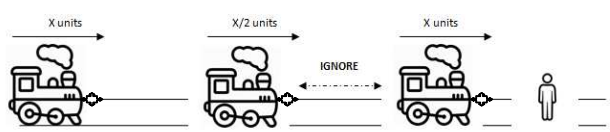

Fig 6: Alert ignored by the driver.

4. LIMITATIONS

There are a few limitations to the above proposed model as well. The first limitation is that the weather can sometimes be an obstruction in catching the front view using the camera. The infrared camera faces trouble in taking a thermal image during dense fog or very heavy rain.
Another limitation can be the geographic location of the area through which the train is going. If the train is passing through a dense forest and the track is curved and covered with trees or bushes on both sides, this might create a problem for the camera to detect obstacles in front of the train in proper time.

5. OTHER APPLICATIONS

The above proposed model can also be effectively used in cars and motorbikes as well where the accident rates due to collision is much higher than that in railways. This system can also aid to the development of self driving vehicles.

It can also help tracing out a human being in lost in a dense forest by tracing the heat figure of different creatures.

Thus it also has the capacity to help the army and other forces to keep a better control on the border activities and keep a check on the intruders that make an unauthorized access in the country by taking the help of those dense forests or mountains.

It can also be used during natural disasters such as earthquakes, floods, etc to find people stuck in the affected areas and to distinguish between living and dead.

6. CONCLUSION

The most precious thing in the world is life and technology helps to make life easy faster and comfortable at lowest price. Our proposed model works on the same line. By utilizing the features IR camera we proposed a very low cost railway security system through which the chances of accidents on railway tracks can be minimized. Presently it is a model and in future we will simulate it. Also we are looking to incorporate this model in other security systems.

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