Advanced Railway Gate Control System using Webcam and MATLAB

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ABSTRACT

The Indian railway has thousands of kilometers railway tracks and there are thousands of railway crossings. Due to lack of manpower, the railway authorities are unable to monitor all the level crossings. Secondly the manually operated railway gate crossings are prone to mechanical faults and human errors. This leads to accidents at the crossings, intern results in casualties, losses of lives and losses of public property. Several optoelectronic sensor and microcontroller based techniques are being implemented and newer techniques have been suggested to overcome this problem. This paper presents an advanced automatic railway gate control system model. The model incorporates webcams, gate driving and alert mechanism interfaced using MATLAB based software module. The system has been designed, developed and tested. The webcams installed across railway gate crossing identifies the arrival and departure of railway and the software control enables appropriate opening and closing of the gate arm accordingly and automatically. The quick response technique implemented in the system reduces the gate operation time and also the waiting time. Superior image based detection and control, quick response, database support, human attention and intervention free etc. are the merits of the system.

Keywords

Webcam, stepper motor, level crossing, advance railway gate control system.

1. INTRODUCTION

The Indian railway has established railway tracks of 108,706 kilometer length and has 11,000 goods and passenger trains running every day [1]. The railway authorities are taking continuous steps and putting efforts towards safety and security of passengers and concerned people through innovative use of technology. Thereafter out of the total 131 train accidents that occurred on Indian railway during 2011-12, 119 (90.84%) were due to human failure, including 57(43.51%) due to the failure of railway staff and 62(47.33%) due to the failure of other than railway staff. Most of the accidents due to failure of other than railway staff have occurred at unmanned level crossings where the liability is primarily that of road users. 3 (2.29%) accidents were caused due to 'equipment failure', 6 (4.58%) were due to sabotage, 2 (1.53%) on account of incidental factors and 1 (0.76%) accident was caused due to the combination of factors [2]. The statistics shows that majority of the accidents occurred at unmanned level crossings and are due to failure of other than railway staff. The effects of the railway accidents are extensive and expensive too. This causes casualties, lifelong injuries, unaccountable losses of lives and national property in thousands of crores of rupees and also there is an interruption through railway communication.

Due to the increased frequency of trains on the railway tracks and also vehicles on the roads at the crossings, the operations at the railway gates are not so reliable nowadays.

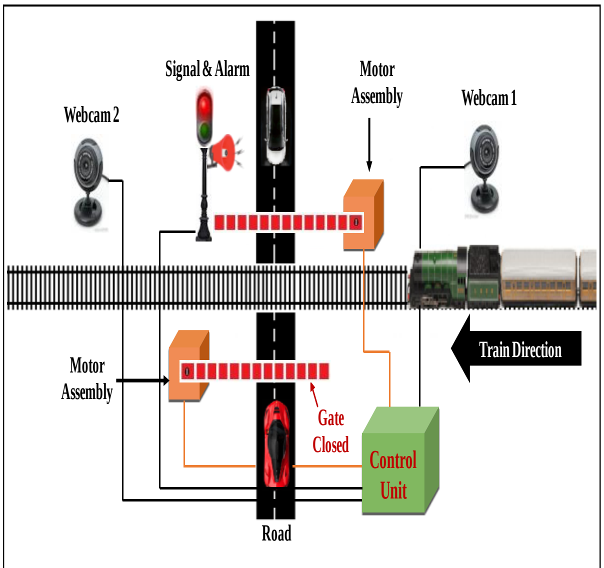

Figure 1: Train arrival gate operations

Primarily the road users have to wait for a long time before the arrival and also after departure of the train. In addition to this, the carelessness of the road users and the errors made by the gatekeepers are also responsible for the waiting and accidents. The accident data analysis shows that most of the unmanned level crossing accidents are caused due to negligence of road vehicle users. This paper deals with a topic of much contemporary relevance. It proposes a distinctive and reasonable solution that eliminates human intervention, improves safety, and provides quick operations and database for future use. The published articles show that the automatic railway gate crossing control systems developed so far are optoelectronic sensor and microcontroller based, which could sense the arrival and departure of train only, but could not record the other details[3-8]. Here comes the importance of the developed 'Advance Railway Gate Control System'.

2. OURWORK

The block diagram of the developed Advance Railway Gate Control System' model is as shown in figure 1.

The system incorporates five blocks as given below:

- Two webcams
- Train identification
- A gate control mechanism

- Signaling unit and
- A Control unit

The block diagram also describes the alignment of various blocks of the system. As shown in the figure 1, two webcams are installed across the railway gate crossing. Webcam numbered one is facing towards arrival direction and webcam 2 is installed at opposite side sensing departure of the train. As soon as the webcam1 senses arrival of the train, the software control enables the gate control mechanism to close the gate by actuating the stepper motor to rotate the gate arm. This action is also accompanied with signaling sound and light alert for the public at the crossing. When the train leaves the gate, webcam2 senses its departure. Immediately the software control enables the gate control mechanism to open the gate again with signaling sound and light alert as shown in figure 2.

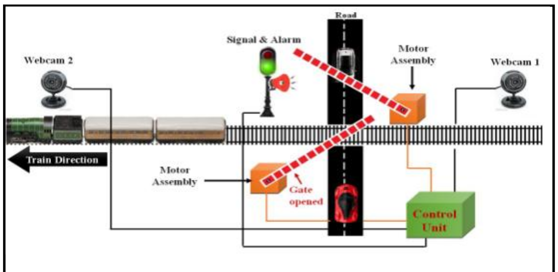

Figure 2: Train departure gate operations

Appropriate and quick opening and closing of the gate enables to keep the gate closed only during passing of the train at the crossing. This keeps the gate closed for minimum time and thus minimizes the waiting time of the road users at the crossing. The audible and visible signaling provides alerts to the road users that guides them for appropriate use of the crossing and provides safety to them.

2.1 The gate control unit

The gate control mechanism is shown in fig 3. The gate arm is bolted to the axel of stepper motor (Figure 2). The stepper motor is interfaced to the control unit through motor driver circuitry. The opening and closing of the gate is appropriately done by means of switching the stepper motor in clockwise or in anticlockwise directions.

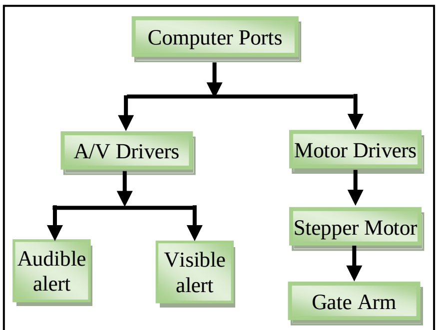

Figure 3: The gate control mechanism

As name suggests the stepper motor rotates in steps with pulsed inputs. Each step is a fraction of a full circle that depends on the mechanical assembly of the motor and the driving method.

2.2 Gate control operations

Figure 4 shows the photograph of the model showing the gate closing event.

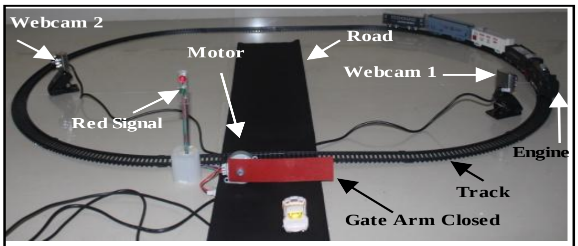

Figure 4: Gate closing event photograph

It shows an arriving train, which is detected by the webcam 1. The software control enables the gate control mechanism to close the gate by rotating the stepper motor in clockwise direction. This makes the movements of gate arm in downward direction across the road and the road is closed for the road traffic.

Figure 5 shows the photograph of gate opening event. The train crosses the gate and the webcam 2 senses its departure from the gate. The software control enables the control mechanism to open the gate by actuating stepper motor to rotate in anticlockwise direction. This makes the movements of gate arm in upward direction vertical to the road and the gate is opened for the road traffic.

2.3 Identification mechanism

The fault free and secured operations at the railway gate crossings entirely rely on the accurate identification of the train during arrival. Hence the train arrival detection mechanisms are of prime importance in such systems. Present system suggests an alternative to the traditional sensor based techniques. The system incorporates an advanced train identification technique based on image processing principles using database information. The database of the trains on the route is initially developed. It includes the train information and special tags for train identification.

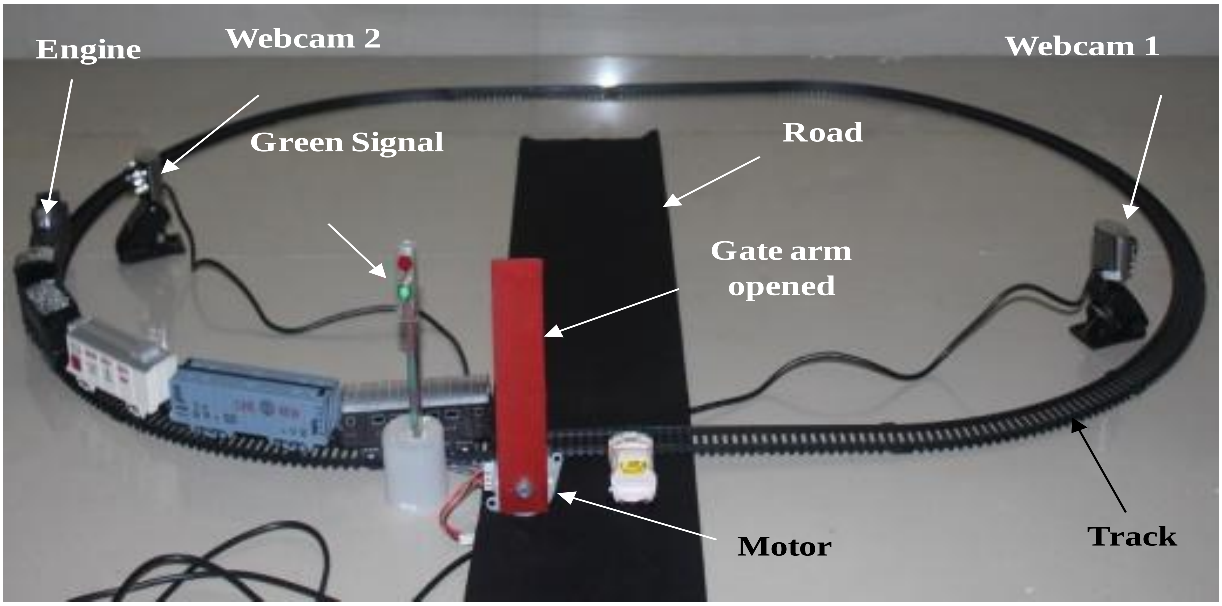

Figure 5: Gate opening event photograph

The train can be identified by a special tag. The tag may be the specific color, number, certain code or some optoelectronic or electromagnetic means. Here in this project we have implemented engine images as the tags. The monitoring program enables webcam 1 to continuously observe the train arrival by taking snapshots. Every image is compared with the database images. When the train arrival is pictured, the train image is compared with the database images. When match is found the arrival of train is registered and train is identified. Immediately the monitor program initiates the gate control mechanism to close the gate and generates audio visual warnings to alert the road users. Further the departure of train is pictured by webcam 2, the program control quickly opens the gate and generates audio visual warnings again as an alert. This technique has further attractive features. The database information such as gate number, location of the train, train name or number, day, date, time of arrival at the gate, delay time if any etc. may be send to a specific mobile number/s of railway authorities. It can also be transmitted on to the specific website and can be made available to all concerned (passengers onboard, passengers waiting on further stations and concerned people so as to plan their further journey).The railway authorities can utilize this information to monitor further journey of the train and also for informing the stations ahead and concerned people.

2.4 The software developments

MATLAB is the best image processing tool because; it has a very strong image processing tool box which supports a diverse set of image types, a very large (and growing) database of built-in algorithms for image processing and computer vision applications, the ability to process both still images and videos etc. [9]. Looking to these attractive features MATLAB based software tool has been incorporated in present developments. The block diagram (figure 6) of gate control software module includes image data acquisition, processing and gate monitoring. The control process flow chart is given in figure 7.

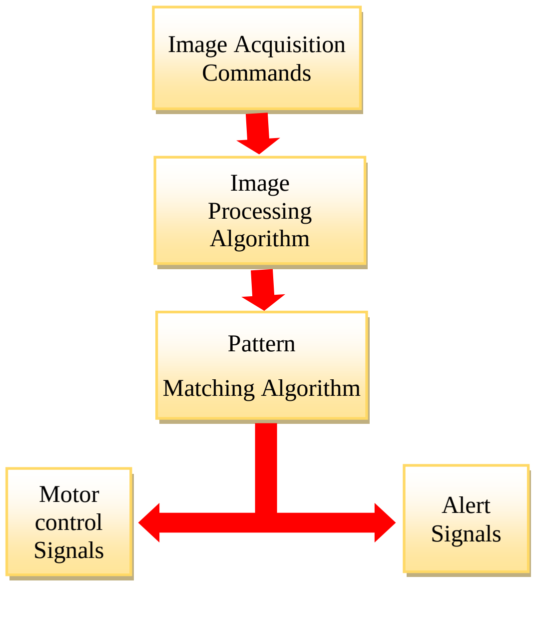

Figure 6: Hardware software interfacing of the railway gate control system

The gate arm is driven by the stepper motor which is interfaced to a PC port through the driver circuitry and the port is configured in output mode through software. Similarly the webcams are interfaced to other PC ports and the ports are configured in input mode through software. The software program repeatedly enables webcam 1 to take snapshots till arrival of a train. The MATLAB code compares different extracted parameters of currently grabbed images with the preserved reference images using pattern matching technique. When image of detected object (railway) is matched with reference image, the MATLAB code initiates rotation of the stepper motor in clockwise direction by sending pulses to motor so as to make rotation of the motor axel through angle 90°.

This closes the gate arm and restricts the road traffic. Similarly reverse action is initiated when the train departs from the crossing, so that the gate arm is opened for road traffic to pass through.

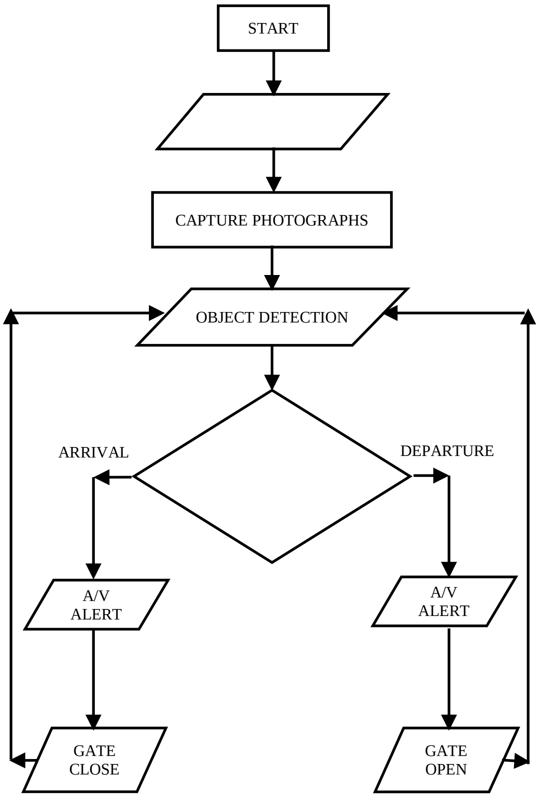

Figure 7: Gate control process flow-chart

3. RESULT (Experimental data)

Figure 8 shows screenshot of arrival of train detected by webcam 1 using MATLAB. On the command window, date and time of train detection is displayed and stopwatch is started at the same time to note the operation delay.Figure 9 shows screenshot of departure of train detected by webcam 2 using MATLAB. Then after confirming the train departure stopwatch is stopped. On the command window, date and time of train detection by webcam 2 with elapsed delay is displayed.

Figure 8: Arrival of train detected by webcam 1 using MATLAB

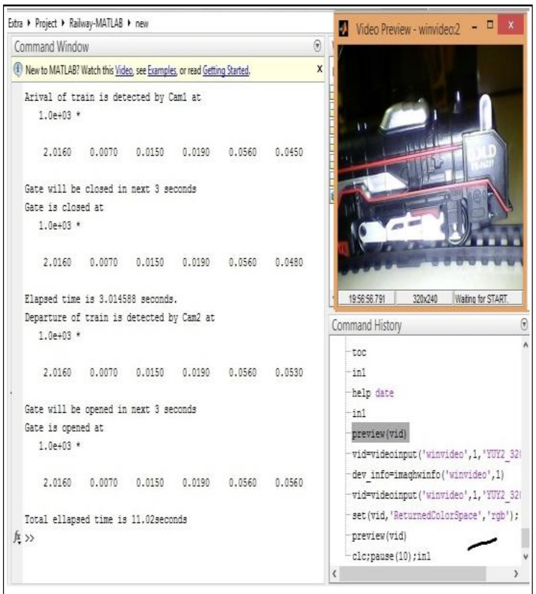

Figure 9: Departure of train detected by webcam 2 using MATLAB

4. ADVANTAGES

- ✓ Improved detection technique
- ✓ Automated
- ✓ Provides Safety
- ✓ High speed operations
- ✓ Accident avoidance

5. CONCLUSION

The advance railway gate control and security system has been designed and developed. The associated software module has also been developed using MATLAB. Further the developed tool was tested in several runs. It has been observed that the model works as per the design and program control. It was also tested for objects other than the railway engine model. The results showed that the system successfully differentiates between other objects and railway engine model. Thus it proves the importance of camera based sensors and the image processing technique in perfect identification of the object.

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