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**Design of Automated Railway Level Crossing
System for Traffic-Railway Management**
Case study: AALRT

A Thesis in Traction and Train Control

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A Thesis

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ABSTRACT

Addis Ababa Light Rail Transit implemented Light Rail Transit system as an integrated form of public transport, with the rail running through city centers and linking main commercial centers, presents interference with other modes of transportation (road transport) in Addis Ababa (Ethiopia).

The main objective of this thesis work is to develop a model of automated railway level crossing system which should manage road-railway transport on level crossing. It is developed by modelling of interfaced automatic railway gate system and automatic object detection system. Simulations are done by using LabView, proteus, Arduino tools and Configure Virtual Serial Port Driver I used for interfacing the two system.

Simulation of the system demonstrated that automated level crossing system (interfaced railway automatic gate system and automatic object detection system) can detected an object at the position of $x = 340.49$, $y = 251.24$ with the score of 698.53 , 10 seconds for making decision for obstacle on crossing, which are good results according to AALRT level crossing background . Therefore, automated level crossing system be employed at AALRT level crossing where the chances of accidents should be avoided, the operation is automatic; error due to manual operation is prevented and it has reliable operation because time spend opening barrier manually is reduced.

Keywords: Arduino, IR sensor, level crossing, automatic gate, microcontroller, automatic object detection.

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TABLE OF CONTENTS

ABSTRACT.....	I
ACKNOWLEDGMENTS	II
TABLE OF CONTENTS	III
LIST OF FIGURES.....	VI
CHAPTER 1 INTRODUCTION	1
1.1 General background	1
1.2 Statement of the problem	3
1.3 Objectives.....	5
1.3.1 General Objective	5
1.3.2 Specific Objectives	5
1.4 Scope and Limitations of this Work	5
1.4.1 Scope of this study.....	5
1.5 Influences about this research work.....	5
1.6 Outline of thesis project	6
CHAPTER 2 : LITERATURE SURVEY.....	7
2.1.1 Localization of the Detected Object: Object Depth Estimation	10
2.2 Concluding Remarks of this chapter	17
CHAPTER 3 : AALRT LINE DESCRIPTION AND LEVEL CROSSING REQUIREMENTS	18
3.1 Background	18
3.2 History of railway level crossing	18
3.3 AALRT Railway Track Design	19
3.4 Accidents on AALRT Level Crossing.....	21
3.5 Types of level crossings in railway transport.....	22
3.5.1 Passive Crossings.....	23
3.5.2 Active Crossings	23
3.5.3 Manually Controlled Barrier monitored by Closed-Circuit Television.....	25
3.5.3.5 User Worked Crossing with Miniature Warning Lights (UWC-MWL)..	27

3.6	Safety of level crossing	28
3.7	Level crossing protection process	29
3.7.1	Rail Signal and Road Signal Co-ordination.....	29
3.7.2	Traffic Light Train Demand point (TLTDP)	30
3.7.3	Automatic Signals within the Train Approach Zone (TAZ)	30
3.7.4	Controlled Signals Within the Train Approach Zone.....	31
3.7.5	Interface Controls of level crossing	31
3.8	Sequence of Operation of Warning Devices (WDs).....	31
3.8.1	Timing Requirements for Sequence Operation	32
3.8.2	Protected railway level crossing	32
3.8.3	Level Crossing Interfaces to Road Traffic Lights	32
3.9	Factors contributing to collisions at level crossings	32
3.10	Requirements for Railway Gates	33
3.11	Level Crossing from Users Perceptive.....	33
3.12	Railway accident costs analysis	34
CHAPTER 4	METHODOLOGY	35
4.1	General Background	35
4.2	Designing of level crossing traffic automatic gate.....	36
4.2.2	Automatic level crossing system architecture modelling	41
4.3	Obstacle detection system on level crossing.....	42
4.3.1	Requirements	42
4.3.2	Video Imaging on Level Crossings	43
4.4	Software Simulation.....	44
4.4.1	LabVIEW.....	44
4.4.2	Proteus 8 Professional tool	45
CHAPTER 5	: SIMULATION RESULTS AND DISCUSSION	47
5.1	Automatic gate simulation Result (proteus simulation).....	47
5.1.1	Train arrival detections	49
5.2	LabVIEW simulation results (Obstacle Detection System).....	51
5.2.1	LabView design block diagram	53

5.2.2	Interfacing two systems	55
5.2.3	Discussion on the above result	58
5.2.4	Discussion on reliability of the models	59
CHAPTER 6	: CONCLUSIONS AND RECCOMENDATIONS.....	61
6.1	CONCLUSIONS.....	61
6.2	RECCOMENDATIONS	61
REFERENCES	62
APPENDIX A	68

LIST OF FIGURES

Figure 1-1: Typical railway level crossing[6]	3
Figure 2-1: Flowchart of obstacles detection system at level crossing[29].....	15
Figure 2-2: Block diagram of the above method[31]	16
Figure 3-1: Cross buck stop sign and line[12].....	19
Figure 3-2: Addis LRT system topological drawing[40]	20
Figure 3-3: Carlton level crossing (MCB-CCTV)[47]	25
Figure 3-4: Collingham level crossing (AHB)[20].....	26
Figure 3-5: Miniature warning lights showing it is safe to cross[51].....	27
Figure 3-6: User Worked Crossing with Miniature Warning Lights image[52]	28
Figure 4-1: Railway level crossing automatic gate protection system[50].....	37
Figure 4-2: Block diagram of power supply[20]	38
Figure 4-3: Circuit diagram of IR sensor module.....	38
Figure 4-4: If Q2 and Q3 are turned on	39
Figure 4-5 : Buzzer image[33].....	40
Figure 4-6: Image of DC motor for simulation purpose[64]	40
Figure 4-7: Simulation Model of automatic gate system.....	41
Figure 5-1: Flowchart of automatic gate working principle[25]	48
Figure 5-2: Automatic gate system when gate prepare for crossing mode.....	49
Figure 5-3: Automatic gate is closing.....	50
Figure 5-4: Automatic gate is opening	51
Figure 5-5: Checking presences of obstacles inside LX situation simulation by LabView tool	53
Figure 5-6: Block diagram of continuous checking object detection system.....	53
Figure 5-7: Block diagram of sample images, it runs once in a while	54
Figure 5-8: Block diagram for LabView interfacing	55
Figure 5-9: Image processing detecting an obstacle on crossing	56
Figure 5-10: If an obstacle moves again.....	57
Figure 5-11: Automated crossing when there is obstacle	58
Figure 6-1 : Configure Virtual Serial Port Driver for interfacing two systems.....	73

LIST OF TABLES

Table 5-1:Description of possible states of level crossing management system.....	59
Table 5-2: Situations of railway traffic movement near the level	60

GLOSSARY OF TERMS / LIST OF ABBREVIATIONS

AALRT: Addis Ababa Light Rail Transit

IR: Infra-red

PLC: programmable logic controller

CIP: Classification of Instructional Programs

LRT: Light Rail Transit

MCB-CCTV: Manually Controlled Barrier monitored by Closed-Circuit Television

AHB: Automatic half barrier

LED: Light emitting diode

RF: Radio frequency

GSM: Global system of Mobile

EW: East-West

NS: North-South

OC: Open Crossing

UWC/ UWC-T: User Worked Crossing

FP: Footpath Crossing

MCG: Manually Controlled Gate

ABCL: Automatic Barrier Locally Monitored

AOCL: Automatic Open Crossing Locally Monitored

FP-MWL: Footpath Crossing with Miniature Warning Lights

UWC-MWL: User Worked Crossing with Miniature Warning Lights

CP: Clearance Phase

TAZ: Automatic Signals within the Train Approach Zone

TLR: Traffic Light Response

MIMO: multiple inputs and multiple outputs

TPSs: train protection systems

ATP: automatic train protection system

MCC: Main control cabinet

PLC: Programmable logic circuit

LED: Light Emitting diode

RPM: Revolution per minute

LCD: Light crystal display

AFO: Audio frequency overlay

CHAPTER 1 INTRODUCTION

1.1 General background

Railway has become the important means of transportation today. Crossing locations of railways with roads (level crossings) are amongst the most eventful points on the transportation network around the world. At these points, due to the passing of the rail & road vehicles with two distinguished mechanism, the priority is given to the rail train able to its braking distance (depending on their weight and speed) is several hundred times longer than that of road vehicles[1]. In the new implementations of Railway systems like Addis Ababa Light Rail transit, a number of accidents are increasing because the system is manually operated by gate keepers. Since Addis Ababa Light Rail transit is the first light rail transit in Africa, automatic railway level crossing have to be incorporated for safety purpose in other to make people to believe in rail transport in Africa, automatic level crossing system needs more investigations, experienced researchers, modeling and analysis of all types of accidents which should happen on level crossing. Level crossing accidents not only dominate in terms of frequency, but also can be more severe in their consequences than other types of railway accidents, simply because they should involve not only injuries and fatalities for railway passengers but also death of people, as well as, to road vehicle occupants and other users of Level crossings like pedestrians. Increasing road construction and road vehicle population in Addis Ababa creates greater chance for Level crossing accidents to happen[2],[3].

In the past years, light rail transit (LRT) has established a significant contribution in many urban areas around the world cause is a comfortable and cheapest mode of transport which should be used to connect two cities and sub-cities. The ability of LRTs to operate in a broad range of environments, is charm to passengers of frequency of operation and its capacity have made the LRT an increasingly viable public transportation option for many urban areas. The LRT allows smooth, comfortable, environmentally friendly and quiet travel around town. It extends into the city downtown, enhances the character of downtown areas, is economical to use, can make sharp turns and is convenient to ride on. LRT level crossings are more prevalent in urban settings and it is imperative that these locations be carefully analyzed and designed such that this mode of transportation operates in synchronization with on-street automobile and pedestrian traffic[2].

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

Under all circumstances, the signaling systems must be reinforced by unconventional technology in such a way that risk will be minimized. Especially level or quad crossings have been identified as a particular target point in road and railway infrastructure, seriously affecting their safety. On road and railway infrastructure level crossing systems necessitates a high level of safety and experienced operators. Modern level crossings (or railroad crossings in American nomenclature) have come a long way from the early days of human railway employees waving red flags and shining lanterns to clear railroad tracks or vehicles and pedestrian traffic for oncoming trains. Road users must follow road rules and signs and pay attention to the road environment when approaching rail crossings. International police statistics show that up to 95 percent of crashes at railway crossings are caused by driver error and out of this 44 percent happened at crossings without an electronic warning system such as flashing lights and/or boom gates. This is largely attributable to inattention, driver distraction, risk taking, and disobeying and lack of knowledge of the road rules and sometimes suicide. In almost every case that the motorist failed to stop and give way to the train at the level crossing and that there was little the train driver could do to prevent the collision or minimize its effects[4].

For wide railway system, an effective management system is required to avoid train accidents at level crossing. Features inducing the probability of accident occurrence at LRT level crossings include [5]:

- ❖ Existence of physical obstructions restricting the visibility of the track, warning signs or signals to road users
- ❖ Absence of flashing lights and audible warning devices at level crossings;
- ❖ Poor alignment and elevation of the road crossing the track (the road may cross the track at an oblique angle or may approach the crossing on a steeply rising grade).
- ❖ Weather conditions and human errors
- ❖ Road traffic density i.e. maximum number of motor vehicles of all types passing the crossing within a 24 hour period
- ❖ Absence of full width barrier protection at level crossings;
- ❖ Reduced road surface condition at level crossings which leading to the grounding of low slung road vehicles
- ❖ Rail traffic density ;i.e. maximum number of trains passing the crossing within a 24 hour period

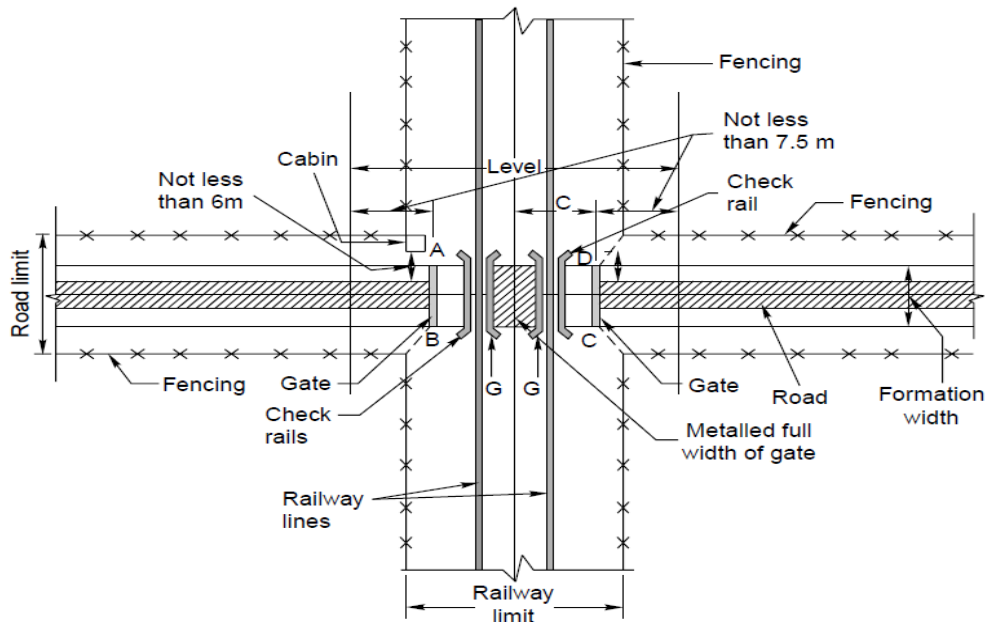


Figure 1-1: Typical railway level crossing[6]

In this study, automatic railway gate system operates after receiving a signal from the IR sensor. IR signal is used to trigger microcontroller to operate motor hence open or close the gate. Automatic object detection system developed by using camera-based system and computer processing unit, once a camera capture an object which is not moving, computer processing system will analyze the object and compare with images which are in the system, hence take a decision, hence take decision in 10 seconds by sending red light signal to tell a train driver to apply brake for collision avoidance[7].

1.2 Statement of the problem

Addis Ababa light rail transit has 13 level crossings manually operated by gate keepers, crossing operator has to be on duty all the time for gate operation to avoid train collision with road users.

In the current system, level crossings are designed to be manned. The lowering of the crossing barrier is achieved by manual control of the crossing operator who can adopt two modes for control, i.e. the indoor manual control and the on-site manual operation:

- ❖ Normally, when a train approaches the crossing, the operator should first make sure that the crossing area is cleared (without people and vehicle), and then press the lowering button of barrier for lowering control of the barrier;

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

- ❖ The crossing barrier can be lowered by on-site manual control in case of power failure or malfunction.

Accidents are eventually caused by manual management system, in case gate keeper lose communication with control center in addition with train driver doesn't have information about crossing status, collision occur between vehicle and train, or train with pedestrian hence delaying services. In addition to that, crossing barriers sometime experiences heavy wind, there are cases where crossing barriers hits contact wire when lifting up due to heavy wind, and that cause power failure and sometimes electric shocks on crossings. In case these problems happen; they delay services either train services or traffic user's services in general hence reduce operation efficiency.

Realizing above problems, this study proposes an automated level crossing system to avoid accidents from manually management system at AALRT crossings for an optimized traffic and railway intersection management. Automatic level crossing system is composed of interfaced automatic gate system and automatic object detection system. The incoming train is detected by IR sensor fixed in 50 m, IR LED sends radiation to train then photodiode receives the infrared reflection, IR becomes activated to send a triggering signal to microcontroller, to operate a DC motor hence close gate, LED signal displays red indication together buzzer sound for more restriction to road users, another IR sensor pair fixed in 50m (10 sec) from level crossing detect the departing train, hence transmit a triggering signal to microcontroller to open the gate hence displaying green indication with buzzer sound. If an obstacle get stuck on level crossing, object detection system (camera-based system) detects it and confirm by a flashing light to a train driver to apply brake for collision avoidance.

As it is explained in the introduction part, for prevention of fatal accidents, a system which can protect road users and detect an obstacle on level crossing and inform train driver whether there is an obstacle or not has to be introduced. The system of accident prevention using camera-based automatic gate system technology is going to be designed and analyzed. This model introduce the automatic railway gate operation. Human intervention shall be considered if there are problems occurred while this system was operated.

This is an idea to perform computer integration with electrical structure to simulate what the system can perform. Control systems with computer applications make the management become more effective.

1.3 Objectives

1.3.1 General Objective

The main objective of this research thesis is to develop an “automated railway level crossing system for road-railway management” replacing manual operated system on Addis Ababa Light Rail Transit (AALRT) to avoid accidents (collision) between traffic users and rail train in such a way that time delay and unreliability of services are minimized.

1.3.2 Specific Objectives

- To develop and simulate automatic gate system using proteus and Arduino
- To develop and simulate automatic image detection system using LabView tool
- To interface automatic gate system and automatic image detection system using Virtual Serial Port Driver
- To display red signal notification on level crossing using Arduino board through interface of both systems.

1.4 Scope and Limitations of this Work

1.4.1 Scope of this study

The performance analysis is based on simulation of the proposed techniques as prototype implementation is not feasible due to financial and time constraints. But as much as possible, an attempt has been made to drive developed model that will help to support the simulation.

1.5 Influences about this research work

In all the literatures and materials seen so far, safety at level crossings have been investigated at various levels. However, some of the differences in the previous work and the current work are underlined in the following points.

- 1) In this thesis, microcontroller and camera based detection system and the existing train (IR sensor detection) detection have been coordinated to automate and remove manual safety assurance at level crossing
- 2) Coordination algorithm has been developed, giving detection system signal indicator to inform train driver status about level crossing using flashing light.

- 3) Another interesting feature of this thesis is that, an optimization algorithm has been developed for minimizing both time delay, risk and maximizing track and road utilization.

1.6 Outline of thesis project

This research thesis consists of six chapters in total. The first chapter includes an introduction which provides clear information about the background of the thesis work, statement of the problem, objectives, scope and limitation of research, research method. Chapter 2 is outlining literature survey. It talks about previous papers and different models used to protect level crossing. Chapter 3 is composed of AALRT line description and level crossing requirements. This chapter consisted of the definitions, components, and general requirements used for developing level crossing. Chapter 4 and AALRT is about current level crossing and design architecture of new system. It is about review of the current working mechanism, this chapter explains previous different systems, steps to protect level crossing, level crossing safety in general and it finally reviews system development requirements where the working principles, system block diagram are discussed to allow the reader to get a clear understanding of the entire system. It will also give information for a proper and easy usage of the application. Chapter 5 concentrated on the result and discussion of this thesis project. What had been done was explained in diagrams and written programs. The expected results are also mentioned in this chapter. Chapter 6 is the final chapter in this report. The conclusions and recommendations are made in this chapter. Recommendations are made for any expansions or upgrades that might be done in the future are suggested.

CHAPTER 2 : LITERATURE SURVEY

This section reviews previously published research papers on railway level crossing automation and protection systems. Although a number of researches have been carried out on level crossing to avoid collision between train and road users avoidance, the importance of making level crossing automatic is more significant and is a new implemented system in AALRT level crossing management system.

Railway accidents are raising safety concerns in the society as well as in some other part of the world. Accidents can take place anywhere. Even the most advanced technology can't ensure accident free and 100% safe working conditions. But scientific investigation can be used just to make incremental improvements to a theory, process or the existing system. The occurrence of catastrophes could be reduced by making such investigations to find out the reasons and take necessary actions to avoid recurrence of such incidents. This has inspired many researchers to work on the improvement of the prevailing railway for the betterment of humanity[8].

The first warning means used at grade crossings consisted of conspicuous signs placed at the crossings, one sign generally sufficing for either a single or multiple track crossing. The legends on the signs conformed to the ideas of various railroad officials, state laws, and local authorities. It was also required that the engine whistle be sounded at varying distances from a crossing, one-fourth mile being most favored. The engine bell also was sounded until the train reached the crossing[9].

At some crossings where vehicular and train traffic was relatively heavy, crossing watchmen were used along with the signs. The watchmen usually flagged the traffic with a red flag during the day and a red lantern during periods of darkness. The warning given by the watch-men was frequently ignored by the drivers, a practice which not only increased the hazard of crossing the track, but also jeopardized the watchmen as well [10].

To alleviate this problem, manually operated gates which extended over the roadway were developed and used at some crossings beginning in 1870. These acted as a barrier to approaching vehicles and were first actuated by wire or pipe connections; later they were operated pneumatically, then by electric motors. Appropriate signs were continued in use to denote the existence of the crossing[11].

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

In 1889, the first automatic control was used. This was an electrical switch placed under the rail so that the weight of a train would activate a bell at the crossing. The bell at that time was quite satisfactory, as it could be heard by pedestrians and horse drawn vehicles. The bell is still used as an adjunct to modern crossing warning systems and serves as a good warning for persons outside of automobiles and trucks[11].

The first application of an automatically controlled visual signal was introduced in 1914 in the form of a wigwag, which was a means of duplicating the watchman waving his lantern. There are a number of these wigwags still in use today, but they are being replaced with flashing light signals as crossings are upgraded.

In 1912, the wave light signal was first used, and here again the watchman waving his lantern idea was perpetuated without moving parts. Although improvements have been made in flashing light signals, their appearance has remained about the same and they are the standard we accept today.

Coincident with the changes in the indicating devices, the detection of trains was improved by incorporation of the DC track circuit in 1914. The track circuit is a positive means of detecting the presence of a train in the approach section to the crossing. In addition, should a failure occur in the track circuit because of a broken wire, poor connection, short-circuit, or broken rail, the crossing warning equipment would be activated.

In 1936, automatic gates were first used as an addition to the flashing light signals and bells. The gates were developed on the normally energized principle, in that they were held up electrically. When power was removed for any reason, they dropped by gravity. The arms were first referred to as “short arms” and were only long enough to block one approaching lane of traffic. Today, arms are provided up to 45 ft. in length and are made of wood, fiberglass, or aluminum.

About the same time those gates were first used, perhaps a little earlier, the steel cantilever structure came into being to relocate the flashing lights to a position over the highway where they could be seen more readily. The first cantilevers used arms of 6 to 8 ft. in length, which were extended to 12 ft. in the early 1940's. In the late 1950's the aluminum cantilever structure of the rotatable type was introduced. Today, both rotatable arms up to 26 ft. long and walkout structures up to 40 ft. long are available. Lane lights, back- to-back flashers, and crossbucks are used where needed on cantilever arms.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

By 1950, it had been shown that the DC track circuits used to detect trains on the approaches to grade crossings could be replaced by audio frequency overlay (AFO) track circuits. AFO track circuits did not require the use of insulated joints to define the limits of the circuit and did not interfere with DC track circuits used in railroad block signaling systems. Various AFO track circuits adjacent to each other were kept from interfering, one with another, by using different transmitting frequencies. The use of AFO track circuits for crossing warning systems has become widespread and now accounts for much of the grade crossing train detection equipment being installed today.

By 1960, it was recognized by the Southern Pacific Railroad that a train detection system was needed that was related to the speed, distance, and direction of trains. As a result, control equipment was developed that predicted the time of arrival of a train at a crossing and provided the same warning time for all trains regardless of their speed. This equipment is currently in use on all major railroads. Motion sensing devices are also used extensively. These activate the crossing warning equipment whenever a train is moving toward or actually occupies the crossing.

A comment should be offered concerning the design of electronic equipment used in crossing warning systems. This equipment follows the same safe development principles for operation and reliability as the original DC track circuit. To accomplish this, however, it has been said that 10% of the design effort is in making the equipment work and 90% in assuring proper operation and reliability. The railroad environment, both because of natural causes and vandalism, is acknowledged to be one of the most difficult in which to install equipment and provide the reliable operation required[11].

Out of the above systems, relevant research papers and document were conducted for reviewed in detail.

In the past, there were a quite number of automated level crossings with advanced technology that were invented to prevent accidents at intersection. To date, studies are still going on to improve safety at level crossing. There are many studies carried out and systems developed based on different technologies to promote the operation of railway industry without endangering the society.

The main objective of this research paper is to avoid the human intervention at level crossings completely, by automate the process of railway gate control. The principle of

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

operation behind the working of this project lies in the functioning of IR Sensor. Reflective type IR Sensor is used in this project. In Reflective Type IR Sensor, the IR transmitter and receiver are placed side by side. When there is no obstacle in front of the sensor, the IR rays transmitted by the IR Transmitter will travel undetected as there are no rays falling on the IR Receiver. If there is an obstacle in front of the IR Transmitter and Receiver pair, the IR Rays gets reflected off from the surface of the obstacle and are incident on the IR Receiver. This setup can be configured to detect an object like a Train and in turn can be used to switch ON or OFF the loads like motors with the help of microcontroller [12].

S. K. Dwarakanath and his coworkers focused on design an automatic railway gate control system by use of an Arduino Nano to control the whole circuit. Two Servo motors are used to open and close the railway gates. Four IR sensors are used for sensing the arrival or departure of train. The main objective is to close the railway gates when the train approaches it, so as to block vehicles from going across the track. As soon as the train moves further away from the railway crossing, the gates must automatically open to allow vehicles to cross. When a train arrives from any side, it first crosses sensor1 after that cross sensor2, in this way Arduino close the gate by sending the signal to servomotor. When train departure from any side it first cross the sensor2 after that cross the sensors, in this way Arduino open the gate [13].

2.1.1 Localization of the Detected Object: Object Depth Estimation

Stereo vision has become one of the most extensively researched topics in computer vision. However, the use of one camera for object detection process as partly solved some problems related to object detection and recognition in various types of scenes. The use of multi-camera systems provides additional information, such as the depth of objects in a given scene. Dense or sparse stereovision techniques can be used to match points. In dense stereovision, all points of an input image are taken into account for matching tasks. All pixels are used to prove the effectiveness of the proposed stereo matching algorithm compared with the state-of-art. This evaluation is done on the well-known dataset, D. Scharstein and his workmate [14] containing various pair of images with ground truth. The sparse stereovision is then adopted. Then, this proposed stereo detection algorithm is applied only on the moving zones detected automatically. Each disparity, determined for each point of the scene, represents the coordinate gap of the same point between the two left- and right-hand images representing the same scene from two different points of view.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

A depth map is obtained from the two images. Each value of this obtained map is an estimation of the distance between a real point in the 3-D space and the stereoscopic sensor and is given according to its intrinsic and extrinsic parameters, such as the focal length and the baseline. When a point is imaged from two different viewpoints, its image projection undergoes a displacement from its position in the first image to that in the second image. The amount of displacement, alternatively called disparity, is inversely proportional to distance and may therefore be used to compute 3D geometry. Given a correspondence between imaged points from two known viewpoints, it is possible to compute depth by triangulation. The problem of establishing correspondence is a fundamental difficulty and is the subject of a large body of literature on stereo vision. One prominent approach is to correlate pixels of similar intensities in two images, using an assumption that each scene point reflects the same intensity of light in the two views. The work carried out by Okutomi and his colleague [15] extends this correlation approach to two, three or more images and demonstrates that using several cameras at different camera separations, or baselines, yields a significant improvement in reconstruction accuracy. Most two-frame stereo matching approaches compute disparities and detect occlusions assuming that each pixel in the input image corresponds to a unique depth value. Until recently, computers were much too slow to even dream of having a real-time algorithm implementation of an algorithm based on color stereovision. But costs and processing time are decreasing at a steady pace, and it is becoming realistic to believe that such a thing will be commonplace soon. The stereo algorithm presented later, springs from relaxation and energy minimization fields. As a first step, disparity map volume is initialized applying a new local correlation function. After that, an assessment of quality of matching is addressed. A confidence measure is attributed to all the pairs of matched pixels, which are classified into three classes. Then, N. Fakhfakh et al. [16] the disparity value of all unclassified or badly matched pixels is updated based only on stable pixels classified as well-matched. The selected pixels are used as input into disparity re-estimation modules to update the remaining points.

N. H. K. V objective is to control the railway tracks by using anti-collision techniques. This model is implemented using sensor technique. Sensors are placed at a certain distance from the gate detects the approaching train and accordingly controls the operation of the gate. Also an indicator light has been provided to alert the motorists about the approaching train [17]. B. Farid and his colleagues proposed automatic railway gate control system

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

using IR sensor and Microcontroller for avoiding the accidents. However, this system suffers from a serious limitation that, IR sensor is not a good choice in high lighting conditions which results in low accuracy proposed pressure sensor based accident avoidance framework for an automatic railway crossing system[18].

The aim of this project paper is to presents an automatic rail gate control system at level crossing positions and accident prevention mechanism. Two vibration sensors are used to control the open and close state of the gate at level crossing position. An IR sensor is positioned to detect an unauthorized object on the track. Open and Close status of the gate and unauthorized object on the track will be communicated with the central control room using wireless communication protocol. The experimental results proved the proposed mechanism is a prudent approach to safeguard the human and to curtail the train accidents[19] while J. A. Enokela [20] and his colleague focused on railway gate control system and level crossing between railroad and highway for decreasing railroad-related accident and increasing safety. In addition, it also provides safety road users by reducing the accidents that usually. This system is designed using PIC 16F877A microcontroller to avoid railway accidents happening at railway gates where the level crossings. Microcontroller performs the complete operation i.e., sensing, gate closing and opening. As a train approaches the railway crossing from either side, the sensors placed at a certain distance from the gate detects the approaching train and controls the operation of the gate. This system was operated after signal received from the sensors. This signal is used to trigger the microcontroller for operating the gate motor, alarm system and light indicators. This system also can be used in parking gate controlling and sliding door system. The abstraction of this system is to provide the advanced control system available everywhere.

H. Bharathi[21] et al designed to control railway level-crossing gate through an Android application by the station master. This system uses Android application device for opening and closing the level-crossing gate, remotely. Remote operation can also be achieved by any smart phone or tablet with an Android-OS with a Graphical user interface, based on Touch Screen Operation. This system uses a microcontroller as the heart of the project, and is programmed in such a way that any control signal from the Android phone controls the motor for operating the gate.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

This paper [22] projected the automatic operation of railway gates using RF technology. The major issue of this technique was every train could be provided with RF technology. Thus it was economically feasible to implement. This study [23] proposed advanced railway accident prevention system using sensor networks. He used ZigBee RF module to communicate between base station and trains. But, ZigBee was a short distance communicating device. Therefore it is practically not possible to implement his technique.

This study [24] proposed automating the railway gates operation, in case there may be a chance that a vehicle may be locked between the crossing gates. That obstacle could be easily detected and intimated this information to the train unit with the help of Ultrasonic sensor and GSM. Thus, the possibility of accidents at the level crossings would be avoided into maximum extent. The obstacle detection unit has been employed in the proposed system to reduce the accidents at level crossings into maximum extent. Since the design is completely automated it can be used in remote areas where no station master or line man is present and it doesn't degrade than existing system. Thus this system finds its applications in many cases.

AKRITI and his colleague paper focused on automatically operable automotive vehicle gate apparatus provided with self-protection and automotive protection. The gate apparatus includes operational mechanism which moves a gate member within a gate way between a closed position and an open position. The gate apparatus also includes structure which permits the gate member to be moved to an open position when opening forces are applied there too, without operation of the operational mechanism. Thus, the gate apparatus is protected against damage. The gate apparatus also includes mechanism which permits the gate operation mechanism to move from an open position to a closed position while the gate member remains in an open position. Thus, if an automotive vehicle should be within the gateway when closing action of the gate operation mechanism occurs, the automotive vehicle is protected against damage but didn't introduced this technology on railway level crossings [25].

Traditionally, obstacle detection at level crossings is done by means of inductive sensors laid on the pavement detecting metallic structures. Another approach is to check if any object interrupts the transmission of a radio or light signal between an emitter and a receptor, strategically and accurately installed on the level crossing. Despite detecting a large set of obstacles to a train's passage, these solutions will disregard nonmetallic and small obstacles. A collision with such objects, although not necessarily damaging to the

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

train, may project them off the railway endangering people or goods present nearby. The aforementioned obstacle detection techniques also require time-consuming installation and calibration of the equipment. More importantly, even if the sensor detects the obstacle, it will not be able to provide sufficiently discriminatory data for a proper assessment of the alarm's severity. More details on the use of traditional obstacle detection techniques in level crossings can be found in[26].

The objective of this study is to present a system for obstacle detection in railway level crossings from 3D point clouds gained with curved 2D laser scanners. This recommended system was able to gain highly dense and correct point clouds, allowing the detection of small obstacles, like rocks laying near the rail. Throughout an offline training phase, this system learned a background model of the level crossing from a set of point clouds. Then the obstacle was compared online with the background model and identified as the occupied area. To diminish the requirement for manual on-site calibration, this system automatically forecasted the pose of the level crossing and railway according to the laser scanner[27].

Kim and Cohn [28] set up a camera in front of a locomotive to investigate the level crossing traffic accidents. After the ignition of the signal, it provided a computer vision system that automatically detects the possible after-accident scenes by detecting the effectiveness of the vehicles passing in front of the train. In addition, it provides a quick algorithm to detect moving objects recorded with a moving camera with minimum calculation. Their algorithm works in pseudo real-time and thinks that its algorithm can be applied to real-time applications such as collision warnings in the near future with the enhancement of hardware technology.

This study designed to develop an advanced system. This system was found to have moving obstacles on the railway crossing. The authors set up a gray scale CCD camera and developed a graphical user interface to manipulate the level crossing images. The software is programmed to perform various image processing techniques such as image subtraction, quadrature, morphological transformation and segmentation to track moving obstacles. Portions of the monitored image around the rails were labeled as alert and alarm zones where detected obstacles would trigger the sirens of this system. Under diverse lighting conditions for the model cars with different colors, experiments on the developed

Design of automated railway level crossing system for traffic-railway management Case study: AALRT

system indicated that the level of luminous was a significant factor affecting the average alert accuracy rate but the color of cars was not. Overall, the average warning accuracy rate reached 97.8%. The promising results of the disinfection capacity of the system may threaten the system deserves full scale development at railway transit sites to provide effective protection against unpredictable, preventable events. The flowchart of this system is presented as follow [29] :

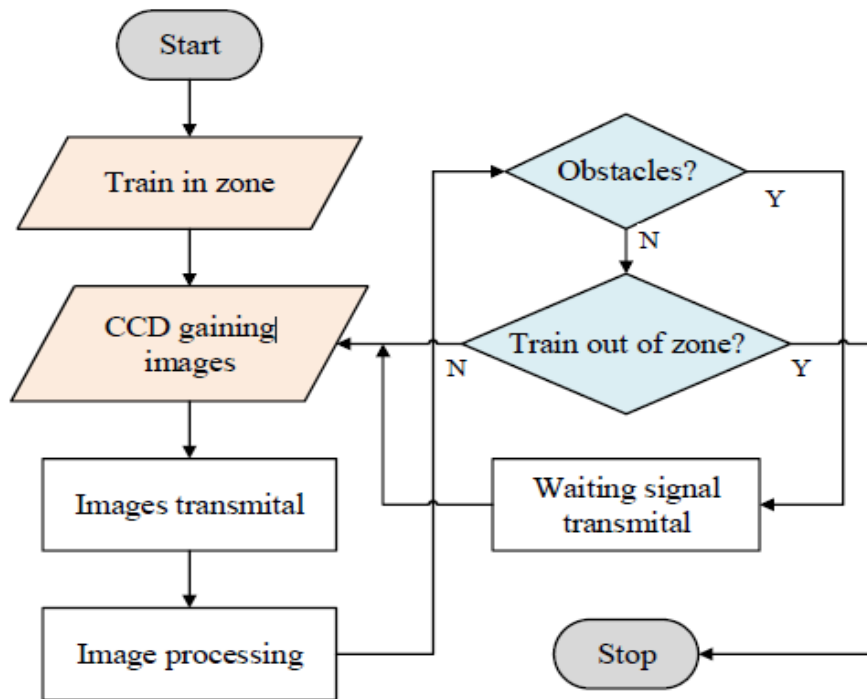


Figure 2-1: Flowchart of obstacles detection system at level crossing[29]

In this research, the obstacle has been detected at the railway crossing and the distance between the camera and the detected object has been calculated by contactless image processing techniques. It has been determined whether or not the object that may interfere with transportation or cause an accident. Pre-processing, feature extraction, though transformation, elimination of noisy pixels and some image processing techniques have been used during the detection of the level crossing. The railroad image must be clear of the noisy pixels of the scene so that the level crossing can be correctly detected. During the elimination of the noisy pixels, it should be taken into account to prevent the pixels which are important for the level crossing from being destroyed. Image processing filters have been applied to the image for this purpose. A single camera has been used in the proposed method to calculate the distance between the perceived foreign object and the camera. The number of pixels covered by the object in view is considered when calculating

Design of automated railway level crossing system for traffic-railway management Case study: AALRT

the distance between the object and the camera. The distances of objects from different distances from the camera are calculated in proportion to the number of pixels in the reference image[30].

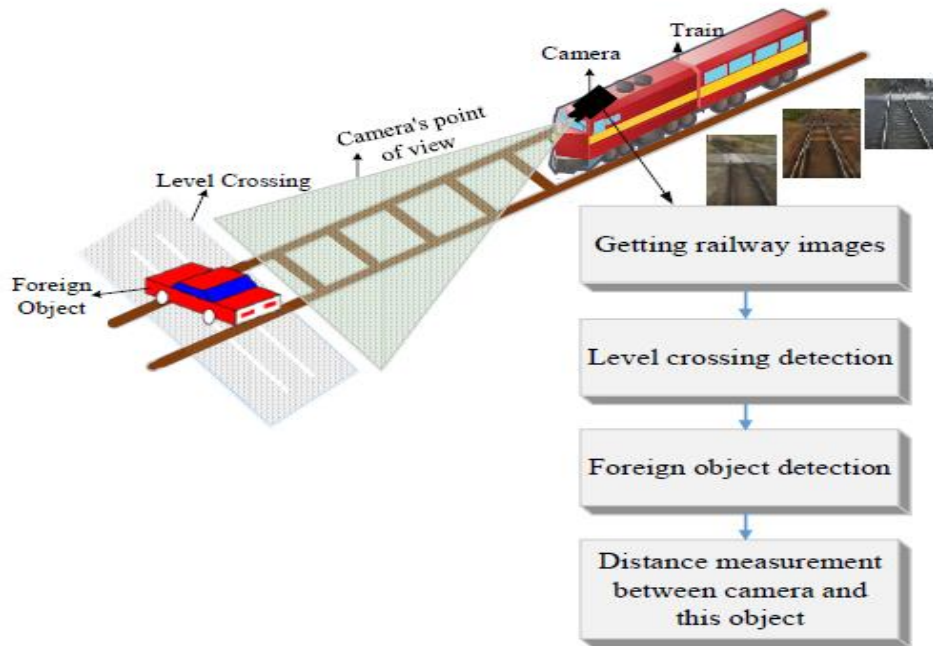


Figure 2-2: Block diagram of the above method[31]

The automatic railway gates operation has been projected using various methods. As proposed by Xishi Wang[32], the process of developing fault tolerance method has been applied for both the hardware and the software components. Magnetic sensors placed underground to detect the train are less affected by environmental changes and recognizes the direction of movement of vehicles.

This study gave a detailed introduction about the present railway technology and also discussed the disadvantages of manually activated railway signals and the railway warnings at the level cross. The train detectors act as the major component in the train automation system [33] .

This project anticipated an intelligent railway crossing control system for multiple tracks that features a controller which receives messages from incoming and outgoing trains by sensors. These messages contain detail information including the direction and identity of a train. Depending on those messages the controller device decides whenever the railroad

crossing gate will close or open. But this technique has the issue of high maintenance cost [34].

Banuchander J [35] developed a method to concentrate on anti-collision system to identify the collision points and to report these error cases to main control room, nearby station as well as grid control stations. Efficient Zig-Bee based Train Anti-Collision using Zig-Bee technology for railways is implemented.

2.2 Concluding Remarks of this chapter

As a summary of this chapter, the reliable approach for “Level crossing automation system” would use railway interfaced automatic gate system through the help of microcontroller arrangement and automatic obstacle (object) detection system through the use of camera-based system to avoid train collision with stuck object on crossing. The signal transmission between sensor and microcontroller is transferred using normal cables, Bluetooth or optic cables, and camera detection system uses cables to interconnect sub-system features. Further, using warning devices such as warning alarm, LED flashing lights, LCD display as the active warning devices to the road users. It is important to be noted that risks associated with the use of technology systems are becoming increasingly important in our society. Risk involves notions of failure and consequences of failure. Therefore, it requires an assessment of dependability; this might be expressed, for example, as probability of failure upon demand, rate of occurrence of failures, probability of mission failure, and so on

CHAPTER 3 : AALRT LINE DESCRIPTION AND LEVEL CROSSING REQUIREMENTS

3.1 Background

All road/rail intersections (grade or level crossings) are provided with either passive or active protection. Passive protection is the application of passive traffic control devices (signage) which provides an unchanging warning to the road user whether or not a train is approaching the crossing. Active protection is the application of warning devices to warn road users of the approach of a train when the train is a minimum time from entering the road-rail intersection. In some cases, it also blocks access to the crossing. This section addresses the terms and definitions relating to those locations where active level crossing warning or protection devices have been provided for the safety of road users, pedestrians, and rail traffic[36].

3.2 History of railway level crossing

In the past, flagmen were used at level crossings to give signal on the approaching train. This was done by waving a red flag to direct commuters to off clear the rail tracks. Later, manual and electrical barriers were introduced as gates to obstruct commuters from entering the railway track. The gates are swung across the railway width to allow road users to enter the track at any time. In August 27th, 1867, J. Nason and J. F. Wilson were the first US researchers to be awarded a patent of crossing gates in Boston[37]. Sometimes later when motor vehicles appeared after, this type of barrier was barely used. Further, the need for livestock barrier also diminished dramatically later. In most countries, fully gated level crossings were replaced with weaker but more-visible barrier and relied upon road users by obeying to the warning signals as shown in figure 2. In Britain, the first automatic level crossing was introduced February 5, 1961. During the early days of Mania Railway, the right of way was given to the rail traffic simply because train cannot stop easily compare to road user[38].



Figure 3-1: Cross buck stop sign and line[12].

When it comes to warning systems at railway level crossings, signs are used as passive warnings or active automatic warning devices such as boom gates, flashing lights and alarms[39]. A level crossing with active warning systems has fewer accidents compared to the one with passive warning system[39].

3.3 AALRT Railway Track Design

The Addis Ababa Light Rail Transit (AA-LRT) project is composed of two routes called East-West Line which connects Hayat depot with the terminal point at Torhayloch (EW-22) and North-South line connects Kality depot with the terminal station (NS-27) at Minilik II Square near St George church. The trains are modern and they are 70% low floor trams. Primarily, ground lines are established, but in some sections, elevated or underground lines are employed. The project is a closed urban rail transit system. The LRT vehicles pass some intersections in the form of level crossing.

Design of automated railway level crossing system for traffic-railway management
Case study: AALRT

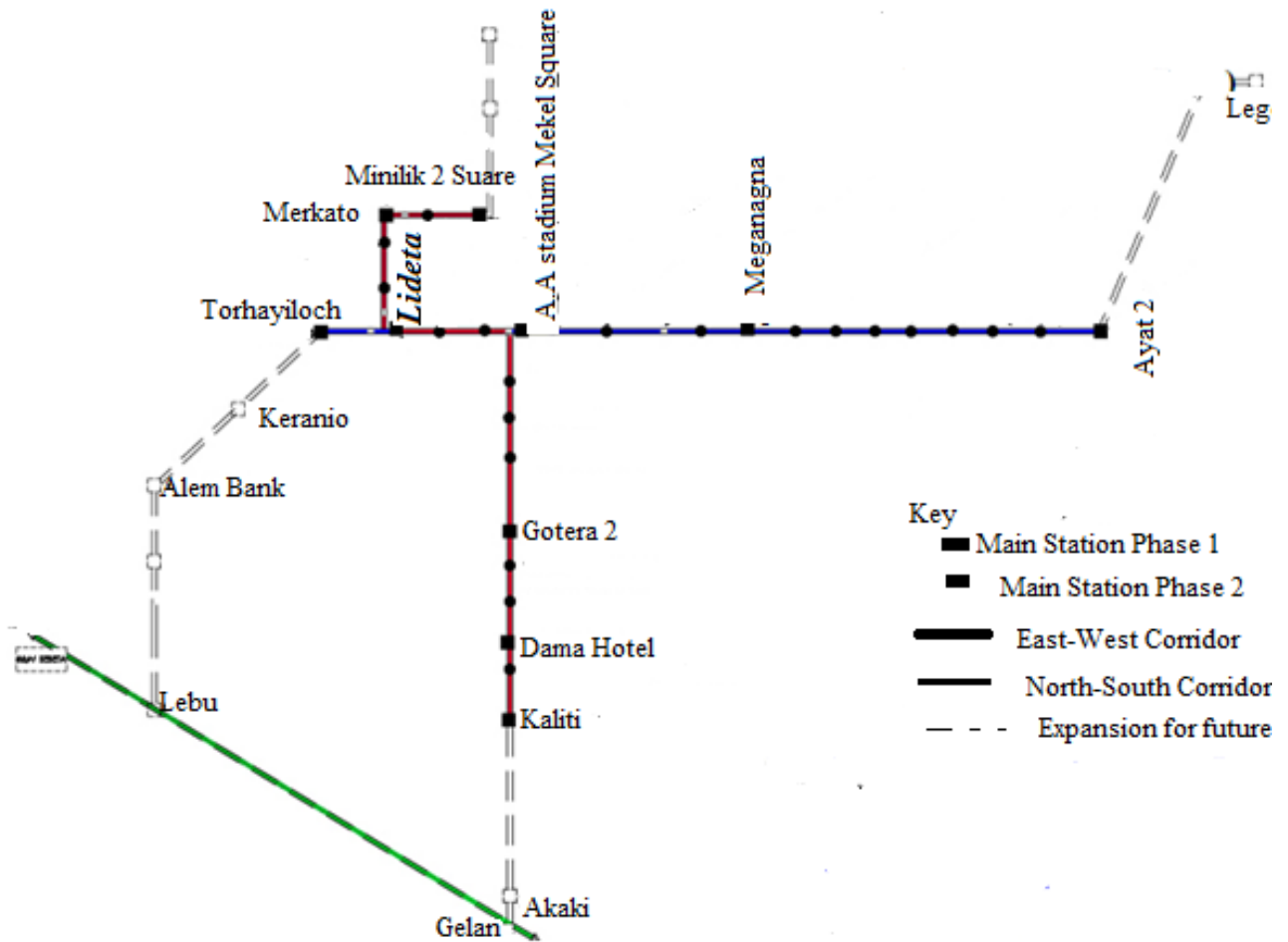


Figure 3-2: Addis LRT system topological drawing[40]

The signal system is designed on the Principle that the LRT vehicles shall pass intersections first. The planned lines are 75km in the overall length, and the lines in the E-W&N-S (Phase 1 Project to be executed currently is approximately 34.25km in length, including a common track section of 2.63km which extends from stadium to Lideta station.) Starting at the mileage of YCK5+046 and ending at the mileage YCK22+464, the main line of East-West line is nearly 17.410km long, while the main line of the North-South line is 16.561km long, with the starting mileage of YCK1+822 and the ending mileage of YCK18+381.

As we can see from the LRT topology, the project is divided into two phases. In the first phase, part of the route in East-West colored in blue and part of the route in the North-South colored in red will be completed whereas the remaining drawn in a broken line will be constructed in the second phase of the project. The first phase of the project Addis Ababa rail network coverage is

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

34.25km in two corridors that divides the city into four parts. The two corridors are called North- South line and East-West line. Their total length is 16.9km and 17.35km respectively and these routes share a common track of about 2.7km which starts from Addis Ababa Stadium ends at Lideta station as shown in the rough topology figure11. At the end of LRT 1st Project phase there will be a total of 39 stations of which five of them are located on the shared line (common track section). There is equal number of 17 stations on both EW line and NS line on the track sections other than the shared line. Both EW line and NS line have 13 level crossings on the track sections manually protected by boom barriers. For the EW line a parking lot is reserved near the starting point (Not build in current stage) and the Ayat depot is built near the ending point: for the North-South line, a parking lot is also reserved at the starting point (not build in current stage) and the Kality depot is built near the ending point. The parking lots reserved for the long term will not be constructed in short term[40].

Realizing the existing system involves manual operation by gate keepers which mainly depends upon the information received from control room. The human errors such as delay in informing the crossing operator about train arrival, delay in gate operation by gate keeper, a train driver hits an object on level crossing because he did not know crossing status before. All of these problems leads to accidents increasing rate and congestion at the level crossings once accident occurred. This research project developed automated railway level crossing operations i.e. automatic gate and automatic image detection systems to minimize accidents on crossings.

3.4 Accidents on AALRT Level Crossing

The evidence is that accidents at the intersections between road and rail contribute only a very small proportion of total road accidents in most countries of the region. However, it is a growing proportion as increasing road construction and road vehicle populations create greater opportunity for level crossing accidents to happen. Additionally, level crossing accidents tend to have casualties which are disproportionate with their number and frequency within the overall road safety picture. For example, where accidents involving collisions between two or more motor vehicles will usually generate limited casualties, collisions between road vehicles and trains at level crossings can, and often do, generate multiple casualties of both rail and road users, particularly when such collisions result in

train derailments. Therefore, too much is at stake to allow level crossing accidents to grow unchecked[40].

Of paramount importance in any program to improve level crossing safety is the need to have access to continuously updated information – to detailed level crossing inventories, to details of accident circumstances, causes and casualties as well as to details of the growth in the road and rail traffic passing level crossings. Such a program will depend upon regular hazard assessments being made of individual level crossing locations, in order to allow calculation of accident risks and probabilities and to be able to establish valid priorities for safety enhancement measures at level crossings. Essentially this will require the establishment of a comprehensive Safety Management System, of which a Safety Management Information System will be a vital component[41].

3.5 Types of level crossings in railway transport

Level crossings are provided on railway lines to allow road traffic and pedestrians to pass across the track. As the level of the passing road traffic is the same as that of the railway track, the crossing is referred to as a level crossing. Other types of crossings are road over bridge or road under bridge, where road traffic passes over or under the railway track. In both these cases, the necessary clearance between the road bed and the railway track is kept as prescribed in the schedule of dimensions. Collisions are the main cause of train accident at level crossing, because these places are very sensitive for accidents in railway transportation system. Level crossings differ depending on the type of protection they provided [42],[7].

- Passive crossings: the warning are provided with road signs and marking only. It's the road user's responsibility to make sure whether it is safe to cross the track or not[43],[8].
- Active crossings: where the road users or pedestrian are warned about the oncoming train by closing the mechanical barriers, activate flash lights and trigger the alarms. The active crossing operation can either be automatic (e.g. barriers raised and lowered automatically) or manual [43]and[29].

3.5.1 Passive Crossings

3.5.1.1 User Worked Crossing (UWC/ UWC-T)

This type of level crossing is usually a gate which either a vehicle user or pedestrian must operate in order to get through the level crossing. There are two types of user worked crossings; with and without a telephone. The telephones are usually in place where there is poor visibility and it is difficult for a user to determine whether or not it is safe to cross. There are also multiple signs in place giving the user instructions on how to operate the crossing. The telephones are connected to a signaller who must give permission for the user to cross and then the user must also let the signaller know when the track is clear on the other side. There is a speed restriction of 125mph for trains at these types of crossings in Britain[36].

3.5.1.2 Open Crossing (OC)

An open crossing only has signs to warn drivers to come to a stop before passing these level crossings because the area between the road and the rail is completely open. Open crossings are usually located on very quiet roads and in order for the vehicle users to pass safely, good visibility is a necessity for this crossing. Trains must slow down to a maximum speed of 10mph before crossing and some even stop completely before the level crossing to minimise the risk of a collision[44].

3.5.1.3 Footpath Crossing (FP)

These crossings are designed for the use of pedestrians and not vehicle users; they often have stiles or gates in place to reduce usage. There are no warning signals given to the crossing user with most of these crossings, however, in some cases where there is low sighting time, a “whistle” board may be put in place to make the train driver sound the horn to alert anyone wishing to cross that it isn’t safe to do so. It is solely the crossing user’s responsibility for ensuring that it is safe to cross before doing so. Similarly to user worked crossings, there are various signs in place to display to users the dangers and instructions of using the crossings. The maximum train line speed for a footpath crossing is 125mph[45].

3.5.2 Active Crossings

There are two different types of active crossings; manual and automatic. A manual crossing has a signaller and/or crossing keeper to operate the level crossing. An automatic

crossing is activated from an approaching train reaching a “strike-in” point and doesn’t rely on humans to operate them. A strike-in point is the distance back from a level crossing a train is which then initiates the closure sequence of the crossing[8].

3.5.2.1 Manually Controlled Gate (MCG)

These crossings have gates that are operated by a crossing keeper or manually by a signaller. At these crossings the usual position at which the gates are left is open to road traffic; this is usually done on busier roads though. On quieter roads it is often common practice for the gates to remain closed to the public and only opened by a crossing keeper after getting confirmation of no trains approaching the crossing. The maximum line speed at manually controlled gates is 125mph[8].

3.5.2.2 Manually Controlled Barrier (MCB)

These crossings are very similar to manually controlled gate crossings as they are controlled by a signaller or crossing keeper. They have full barriers that extend across the width of the road and warning lights and audible sounds are also incorporated within the design of the crossing to let pedestrians know of any approaching trains. After the activation sequence of the level crossing starts, there are amber warning lights and an audible warning for approximately 3 seconds. This is then followed by red flashing lights for 6 seconds, after which, the barriers close. Manually controlled barriers have either barriers that cover the width of the road on both sides of the crossing or 2 half barriers on both sides of the crossing. It takes 6-8 seconds for the barriers to reach the lowered position when the crossing has two full barriers, and takes an additional 6-8 seconds to close the exit barriers for the crossings with two half barriers [4]. The level crossing with two half barriers is designed so that vehicles and pedestrians have more time to leave the crossing if they are already on it. After the barriers are fully down the audible warning stops.

The maximum line speed for manually controlled barriers is 125mph. The average closure time of manually controlled barriers is 227 seconds[46]. However, if another train is approaching, the barriers will remain down as there would be difficulties raising and lowering the barriers quickly enough to let vehicles and pedestrians through safely.

3.5.3 Manually Controlled Barrier monitored by Closed-Circuit Television

These are very similar to the manually controlled barrier previously mentioned, except they are monitored with CCTV, which is viewed by a signaller to control the actions of the crossing. The maximum line speed of these crossings is 125mph.



Figure 3-3: Carlton level crossing (MCB-CCTV)[47]

3.5.3.1 Automatic Half Barrier Crossing (AHB)

An automatic half barrier crossing has barriers which only extend across the entrance of the road so that the exits are left clear. They are an automatic, active crossing meaning that warning lights and sounds are automatically activated by an approaching train before the closing sequence of the barriers. After the train has passed the level crossing the barriers automatically rise allowing vehicles to pass. The time taken between the activation of the closing sequence and the arrival of the train is a minimum of 27 seconds. This number varies though as only 50% of trains arrive within 50 seconds and 95% of trains arrive within 75 seconds[46]. The maximum line speed of an AHB crossing is 100mph (Rail Safety and Standards Board, 2016). The short arrival time of the train is to discourage vehicle users and pedestrians from “zigzagging”. Zigzagging is a term used to describe the action of a driver or pedestrian at an AHB crossing of driving or walking around the entrance barrier and then cutting back across to the correct side of the road to pass the level crossing[48].



Figure 3-4: Collingham level crossing (AHB)[20]

3.5.3.2 Automatic Barrier Locally Monitored (ABCL)

To pedestrians and road vehicle users this appears to be the same as an automatic half barrier crossing, however, the crossing is continuously monitored and the train driver must be sure that the crossing is clear before arriving. Trains must slow down to a maximum speed of 55mph before reaching the crossing[49].

3.5.3.3 Automatic Open Crossing Locally Monitored (AOCL)

This type of crossing has no barriers, but has audible warnings and flashing lights telling vehicle users it is unsafe to cross, which are automatically activated when a train is approaching. Road vehicle users and pedestrians should only cross when there are no warning signals being provided. The train driver must slow down to a maximum of 55mph to ensure that the crossing is clear before advancing. If more than one train is approaching the crossing then the lights and warning noise will continue until the second train passes[50].

3.5.3.4 Footpath Crossing with Miniature Warning Lights (FP-MWL)

This variation of the typical footpath crossing has similar features. However, the inclusion of red and green lights inform the pedestrian whether or not it is safe to cross. The light remains green until a train approaches the crossing, at which time the light will turn to red and will stay so until the train has passed. The red light could still be showing after a train has gone through which would indicate that another train is approaching and it is still unsafe to pass.



Figure 3-5: Miniature warning lights showing it is safe to cross[51]

3.5.3.5 User Worked Crossing with Miniature Warning Lights (UWC-MWL)

This level crossing has gates or barriers which extend across the whole road or path and the user must operate the crossing themselves before crossing. Similarly to a footpath crossing with miniature warning lights, there are red and green lights indicating to the user when it is safe to cross. There are also signs in place to tell the user how to safely pass the crossing. Figure 5 shows that the most common types of level crossings in Britain are footpath and user worked crossings. These are both types of passive crossing, so the user has to decide when it is safe to cross. There are also level crossings called station footpath or barrow crossings, which have the same features as a typical footpath crossing so these are included under that category[50].



Figure 3-6: User Worked Crossing with Miniature Warning Lights image[52]

Generally, automatic barrier and manual controlled crossings (including those monitored by CCTV cameras) are mostly used on public roads with high traffic volume. Automatic half-barrier crossings with fewer disturbances to road traffic for each train traverse are mostly used compared to manually controlled crossings, but they have a relatively high average risk. Automatic open crossings with flash lights and no barriers have a higher average risk of train colliding with road vehicles[53].

Classification methods of LC differ from one country to another. Other than that, there are main attributes depending on the functional of the road and railway crossing system such as Location of LC, owner of LC, volume of traffic, speed of traffic, the width of the road and equipment used at LC e.g. passive or active[54].

3.6 Safety of level crossing

Trains have a much larger mass relative to their braking capability, and thus a far longer braking distance than road vehicles. With rare exceptions, trains do not stop at level crossings and rely on vehicles and pedestrians to clear the tracks in advance.

Level crossings constitute a significant safety concern internationally. On average, each year around 400 people in the European Union and over 300 in the United States are killed in level crossing accidents. Collisions can occur with vehicles as well as pedestrians; pedestrian collisions are more likely to result in a fatality. Among pedestrians, young people (5–19 years), older people (60 years and over) and males are considered to be high risk users[36].

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

As far as warning systems for road users are concerned, level crossings either have "passive" protection, in the form of various types of warning signs, or "active" protection, using automatic warning devices such as flashing lights, warning sounds, and barriers or gates. In the 19th century and for much of the 20th, a written sign warning "Stop, look, and listen" (or similar wording) was the sole protection at most level crossings. Today, active protection is widely available, and fewer collisions take place at level crossings with active warning systems. Modern radar sensor systems can detect if level crossings are free of obstructions as trains approach. These improve safety by not lowering crossing barriers that may trap vehicles or pedestrians on the tracks, while signalling trains to brake until the obstruction clears (however, they cannot prevent a vehicle from moving out onto the track once it's far too late for the locomotive to slow even slightly)[35].

At railway stations, a pedestrian level crossing is sometimes provided to allow passengers to reach other platforms in the absence of an underpass or bridge, or for disabled access. Where third rail systems have level crossings, there is a gap in the third rail over the level crossing, but this does not interrupt the power supply to trains since they have current collectors on multiple cars.

3.7 Level crossing protection process

Level crossing mechanism can either be automatic or semi-automatic. The Automatic barrier is fully automated and is connected to the train detection system like sensors and so on. When the approaching train is detected, the barrier starts coming down; it is down well before the train reaches the crossing. Semi-automatic level crossing (using semi-automatic barriers) is installed in station areas so that they can be operated manually as well as automatically. The manual operation is usually done by the maintenance staff under the supervision of the station master[53].

3.7.1 Rail Signal and Road Signal Co-ordination

3.7.1.1 Requirement for railway signal and road signal coordination

The requirement is to co-ordinate railway level crossing operation with the operation of nearby traffic signals to ensure that the operation of one facility doesn't adversely impact on the safe operation of the other. In addition, the facilities and the interface between them need to be designed to minimize delays to both railway and road vehicles. In order that

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

the traffic lights can remove traffic conflicts with the level crossing operation, an advanced indication of train approach needs to be provided to the traffic lights controller. In this standard this is called the Train Call (TC). The road authorities in each state have their own descriptions for each co-ordination function and some of the functions operate differently. In response to the Train Demand (TD), the Road Authority will program the traffic lights cycles to[55]:

- Prevent through road traffic being directed onto the level crossing while it is operating
- Clear road traffic queued across the level crossing (Clearance Phase (CP)).

The worst case time for the traffic signals to reach Clearance Phase (CP) and the minimum duration of the Clearance Phase (CP) are determined by the road authority for each intersection. When traffic lights are provided on both sides of the railway, the road authority will arrange the traffic light phasing so as to prevent a queue from forming, as far as practical. This may reduce the criticality of the clearance phase. Where a traffic light is located prior to the level crossing or at the level crossing, it will be coordinated by the Road Authority to display 'stop' whenever the lights are operating[47].

3.7.2 Traffic Light Train Demand point (TLTDP)

Where possible the Train demand initiation point should be aligned with the start of the holding section for the crossing. If necessary the train demand initiation point shall be extended to accommodate this. In this case where the holding section is longer than the train demand time required by the Road Authority (RA) it shall be delayed by the time difference[36].

3.7.3 Automatic Signals within the Train Approach Zone (TAZ)

In this situation the signal is not interlocked with the traffic lights. A Train Demand input will be provided to the road authority when the train approaches. This input is to be timed off and if a traffic light response is not received by the time the traffic lights demand time has expired a force shall be applied to the traffic lights controller. The traffic lights will cycle through to Clearance Phase before activation of the level crossing. Activation of the crossing will occur when the train reaches the level crossing approach track section[48].

3.7.4 Controlled Signals Within the Train Approach Zone.

In this situation, the road authority will provide a Traffic Light Response (TLR) function to the level crossing. When a rail movement is to be made, the Train Demand indication is provided to the traffic lights controller when the train approaches (with the signal clear) or the signal route is set (if a train is closely approaching). If the traffic lights cycle to the clearance phase earlier than the train demand time, an indication (Traffic Light Response) is provided to the rail signal system. If a train is within the zone covered by the traffic light demand time, signal clearing must be delayed until the traffic lights are in the clearance phase or until the traffic lights demand time has expired. The TLR enables the Rail Signal clearing to progress without waiting for the termination of the full Train Demand Response Time (DRT)[52]. The level crossing activation is governed by the train being within the approach section. If the train is within the approach section when the signal is cleared the receipt of the TLR allows the activation of the crossing to commence directly and this activation allows the interlocks between the signal and the level crossing to be fulfilled, thus allowing the signal to clear earlier than if the full train demand time was satisfied. The TLR will be sent from the traffic lights controller at a given time after the start of the clearance phase (the time delay is usually queue clearance time minus the gate delay). Should the Traffic Light Response not be received a force must be sent to the traffic lights controller and the activation of the level crossing must be initiated at the expiry of the Train Demand Response Time (DRT)[48].

3.7.5 Interface Controls of level crossing

Interface controls should be arranged to accord to the agreed rail – road co-ordination scheme for the State concerned. The interface between the rail and road signals shall constitute functions which are transmitted as voltage-free contacts for electrical isolation.

3.8 Sequence of Operation of Warning Devices (WDs)

If no train is approaching the level crossing then all warning lights shall be extinguished, any barriers shall be in the fully open position and the audible warning devices shall be silent. If a train is approaching the level crossing then the Advanced Warning Lights (AWL) shall operate before the lights are activated. This is to allow vehicles travelling at the road speed limit after passing the AWL while extinguished to be able to pass through the crossing without the crossing commencing to operate before they arrive at it. The

lights will then activate and the level crossing will follow its prescribed sequence of operation as required by the particular equipment arrangement. The AWL shall extinguish when the lights extinguish[50].

3.8.1 Timing Requirements for Sequence Operation

The timing for starting advance warning lights before the level crossing warning is in the range of 5 to 17 seconds before level crossing start. All timing calculations should be agreed with the Road Authority (RA). The approach section for the level crossing shall be extended to become the sum of the time required for the level crossing approach and the advance warning lights pre start time by the addition of an extra track circuit. If the crossing has a holding section the warning lights start can be generated by delaying this section of track[56].

3.8.2 Protected railway level crossing

A Protected Level Crossing is defined to be a road-rail intersection at which a risk assessment has determined that the hazard is such that provision of active warning and/or protection devices is required in the interests of the safety of the road traffic, pedestrians and rail traffic. Active warning devices are provide for the protection of crossing users and there are no passive traffic control devices such as “GIVE WAY” or “STOP” signs because these warning signs are provided to passive crossings which mainly used in rural areas[57].

3.8.3 Level Crossing Interfaces to Road Traffic Lights

Where a level crossing is located next to a set of traffic lights, the potential exists for motor vehicles to stop at the traffic lights and queue back across the railway or for a queue at a level crossing to obstruct the intersection behind. Where this occurs, interconnection between level crossing controls and the traffic lights are usually provided to assist in minimizing this problem[58].

3.9 Factors contributing to collisions at level crossings

There is no single reason for level crossing collisions and near misses occurring. Contributing factors can include [53]:

1. People, especially road users and the extent to which they obey the law and respond appropriately to the circumstances of the moment
2. Vehicles and infrastructure, including speed limits, the design of vehicles, and the design and condition of level crossings and level crossing environments
3. The overall management of road-rail interfaces, including coordination between service providers, the allocation of resources, and the ways in which knowledge is applied to enhance safety.

3.10 Requirements for Railway Gates

When an interface with traffic lights is to be provided on a crossing without boom gates, it will be necessary to install boom gates where the boom operation is an essential part of preventing a queue reforming over the crossing when the clearance phase on the traffic lights ahead is terminating. When separate traffic light installations exist on either side of a crossing without booms, it may not be necessary to provide the booms where the traffic light interfacing ensures that vehicles will not come to a stand across the road – rail intersection. Individual sites should be risk assessed to ensure traffic queuing is prevented[49].

3.11 Level Crossing from Users Perceptive

Decision making based on human behaviors also contribute to accidents at level crossing. House of Commons Transport Committee, Eleventh Report of Session [59] studied that road users are intolerance to long closure duration of the gate. Further found out that almost 30% of the road users make delay decision which results in accident. Study[60] proposed a trial based on vehicle drivers on speed reduction prior the level crossing. The trial involve speed reduction from 110 km/h to 80 km/h over the distance of 600 m. demonstration of speed data analysis shows relatively mean speed differences between the set points. Mike Laycock [61] and Study [59]found out that media and society pressure are the major factors that determine the choice of selecting the best safety system at level crossing. Hence they use fuzzy logic as an essential criterion for relevant decision making. Study [62]used fuzzy logic control for decision making during the arrival and departure of the train. Output signals are generated to warning devices. They system use three vital

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

parameter namely; visual, acoustic, and vibration as the inputs for decision making. The model use MIMO (multiple inputs and multiple outputs) as parameters.

Study[9] found out those different types of signs at railway level crossing makes the drivers more vigilant compared to single signs. The results showed that driver's response to active crossings is higher than the passive crossings. While study[47] found out those drivers prefer flashing lights than traffic lights. Study [36]found out that the behavior of road users at the LC is insufficient. Most of the road users do not adhere to the rules and regulations of the road. Standard should be applied at LC and also develop new technological innovation to increase safety at LC. Education and safety campaign awareness should be carried out regularly to inform road users about the danger of misbehaving and ignoring road rules.

3.12 Railway accident costs analysis

The cost of Accident with regards to serious injuries and fatalities, delay costs, infrastructure or material damage costs and environmental economically affect the railway industry. The cost of fatalities has the most significant economic impact to the Europeans member's economy. In 2014, it's further estimated that value of 1.4 billion Euros was used in prevention of casualties. However, the total costs of material damage and delay were 103 million Euro and 71 million EURO respectively[63].

CHAPTER 4 METHODOLOGY

4.1 General Background

In the existing system, each of the 13 level crossings for LRT line and highway provide with one set of independent crossings equipment.

AALRT level crossing control system is mainly composed of the following equipment:

- ❖ Control and Indication panel CIP (in the control cabinet);
- ❖ Barrier Control Box
- ❖ Barrier and Road signal;
- ❖ Audible alarm device
- ❖ Main control cabinet MCC;

Main control cabinet consists of main control unit, outdoor equipment interface board and power module. The main control unit adopts PLC technology; except the interlocking system interface, AALRT level crossing subsystem adopts all-electronic mode for crossing equipment control, with the dimension of 1200*710*300mm (H*W*D) and wall mounting type.

Control and indication panel CIP is integrated on the faceplate of the control cabinet. The level crossing subsystem will, according to the information of train approaching, automatically send the indoor and outdoor train approaching alarm notices[40].

- ❖ Buzzer alarm adopted for indoor train approaching alarm notice;
- ❖ Audible and visual alarm and indication of signal are adopted for informing the pedestrians and the vehicle on the road of train approaching and status of level crossing. The outdoor audible alarm device is installed at the top of the road signal post and horn loudspeaker is adopted, with the sound level of 60~100dB and volume adjustment device. Voice alarm is adopted for audio alarm of the approaching notice.

If there is train approaching level crossing in both up and down direction, the level crossing subsystem is able to send the train approaching alarm notice continuously or send such alarm once again. The guard can cancel the indoor train approaching alarm notice by pressing the Acknowledge button on the control and indication panel.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

The interlocking system sends the high-level of train approaching and notice level crossing LRT train leave the crossing and level crossing subsystem that will automatically stop the outdoor train approaching alarm and lift the barrier. If the conditions for lifting are not satisfied, the barrier will remain in the status of lowering and the control circuit will cut off the operation of lifting. Both manual and automatic lifting of barriers is not allowed.

The crossing operator will control lowering of the barrier manually. When the train approaches the crossing, the crossing operator will, according to the information of train approaching alarm notice, press the lowering button for manual control of lowering of the barrier after confirming that pedestrians and vehicles within the area of crossing road surface are cleared[40].

In the current system, the level crossing is designed to be manned. The lowering of the crossing barrier will be achieved by manual control of the Crossing operator who can adopt two modes for control, i.e. the indoor manual control and the on-site manual operation:

- ❖ Normally, when a train approaches the crossing, the operator should first make sure that the crossing area is cleared (without people and vehicle), and then press the lowering button of barrier for lowering control of the barrier;
- ❖ The crossing barrier can be lowered by on-site manual control in case of power failure or malfunction[40].

4.2 Designing of level crossing traffic automatic gate

AALRT level crossing system is not safe, safety-critical in nature and designing such a system is a very widespread research activity. The level crossing system consists of the level crossing physical component managed by the level crossing control Unit. Level crossing barriers, level crossing road signal and level crossing rail signal are the three major physical components of the level crossing system.

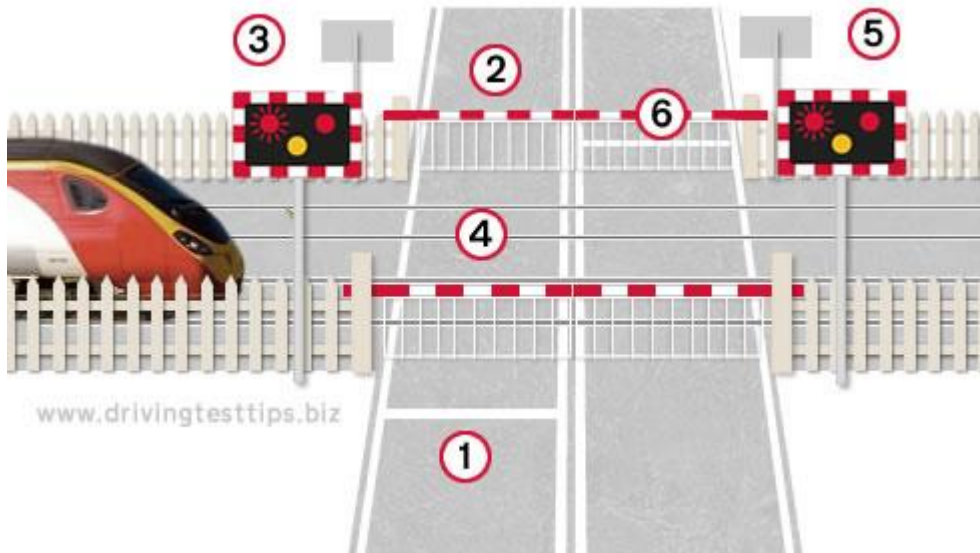


Figure 4-1: Railway level crossing automatic gate protection system[50]

Figure 4-1 shows over all block diagrams for level crossing automatic gate control system by using microcontroller. So, automatic gate system controller operate the following function of the railway gate control system:

- ❖ To sense the arrival and departure of the train by using IR sensor
- ❖ To open and close the railway gate automatically by using two dc motor
- ❖ Buzzer and light signal for warning the road users
- ❖ Traffic light indications

This prototype of this thesis demonstrate the Automatic Railway Gate Control by using microcontroller. This thesis utilizes six IR sensor pairs. Two Pairs are placed at either side of the level crossing with 1 Km to sense the train arrival and departure. An automatic image detection system (camera detection) is placed near the level crossing facing level crossing, controlling the movement of road users (vehicles, pedestrians) users on level crossing, to detect obstacles on level crossing i.e. an object get locked on crossing. A flashing light indication is used to flash once a detection system get an object stayed on crossing 2 minutes, two DC motors are used in this system which are used to open or close the gate at both side of the track. Green and Red LEDs are used as traffic signal light, and Buzzer is used as an alarm for more restrictions[18].

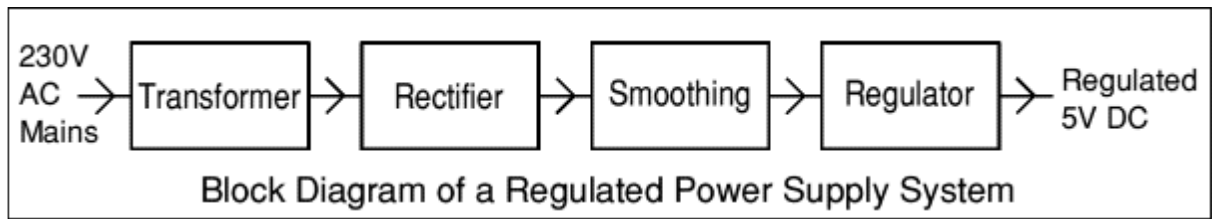


Figure 4-2: Block diagram of power supply[20]

4.2.1.1 IR Module

An infrared sensor is an electronic device that emits in order to sense some aspects of the surroundings.

An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor Usually in the infrared spectrum, all the objects radiate some form of thermal radiations[19].

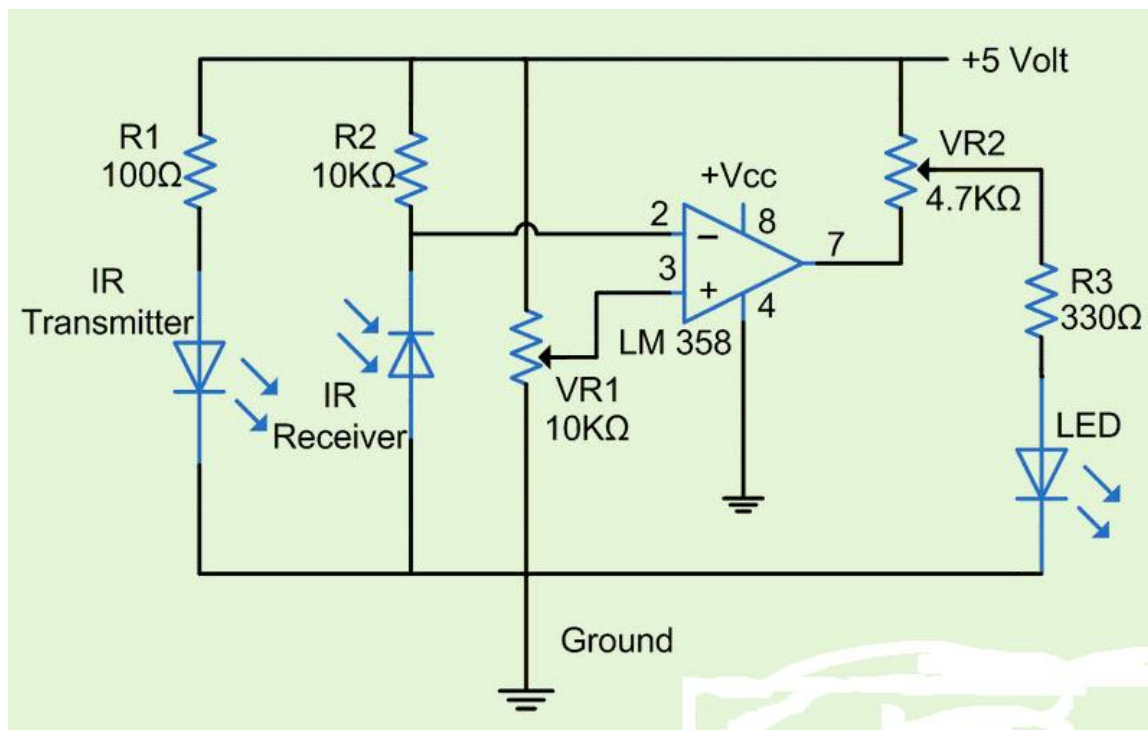


Figure 4-3: Circuit diagram of IR sensor module

These types of radiations are invisible to our eyes can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR

LED. When IR light falls on the photodiode, the resistances and these output voltages, change in proportion to the magnitude of the IR light received[19].

4.2.1.2 H-Bridge Circuit

The basic operating mode of an H-bridge is fairly simple if Q1 and Q4 are turned on the left lead of the motor will be connected to the power supply, while the right lead is connected to ground Current starts blowing through the motor which energizes the motor in (let's say) the forward direction and the motor shaft starts spinning[25].

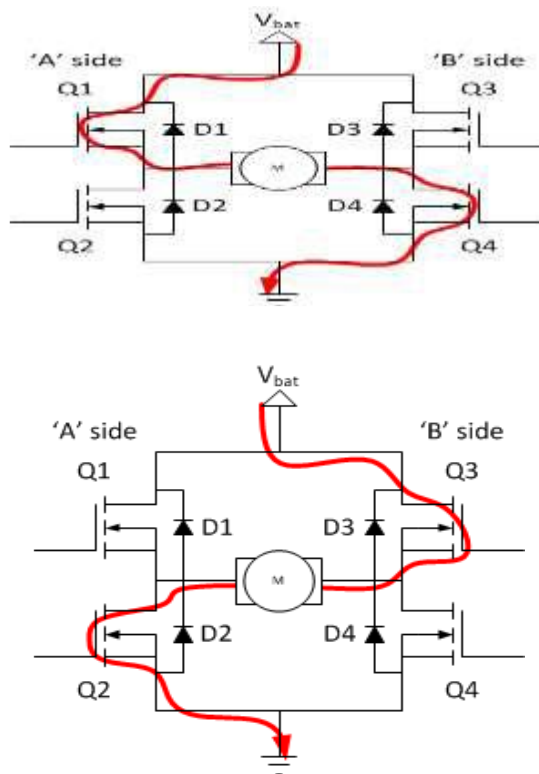


Figure 4-4: If Q2 and Q3 are turned on

If Q2 and Q3 are turned on, the reverse will happen, the motor gets energized in the reverse direction, and the shaft will start spinning backwards.

4.2.1.3 Buzzer for sound

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke[33].



Figure 4-5 : Buzzer image[33]

4.2.1.4 DC Motor for gate operation

Geared DC Motors can be defined as an extension of DC motor which already had its insight details demystified here. A geared DC Motor-30RPM, 12Volts geared are generally a simple DC Motor with a gearbox attached to it. The speed of the motor is counted in terms of rotations of the shaft per minute and is termed as RPM. The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This insight will explore all the minor and major details that make the gear and hence the working of geared DC motor. At the first sight, the external structure of a DC geared motor looks as a straight expansion over the simple DC ones[33]..



Figure 4-6: Image of DC motor for simulation purpose[64]

4.2.2 Automatic level crossing system architecture modelling

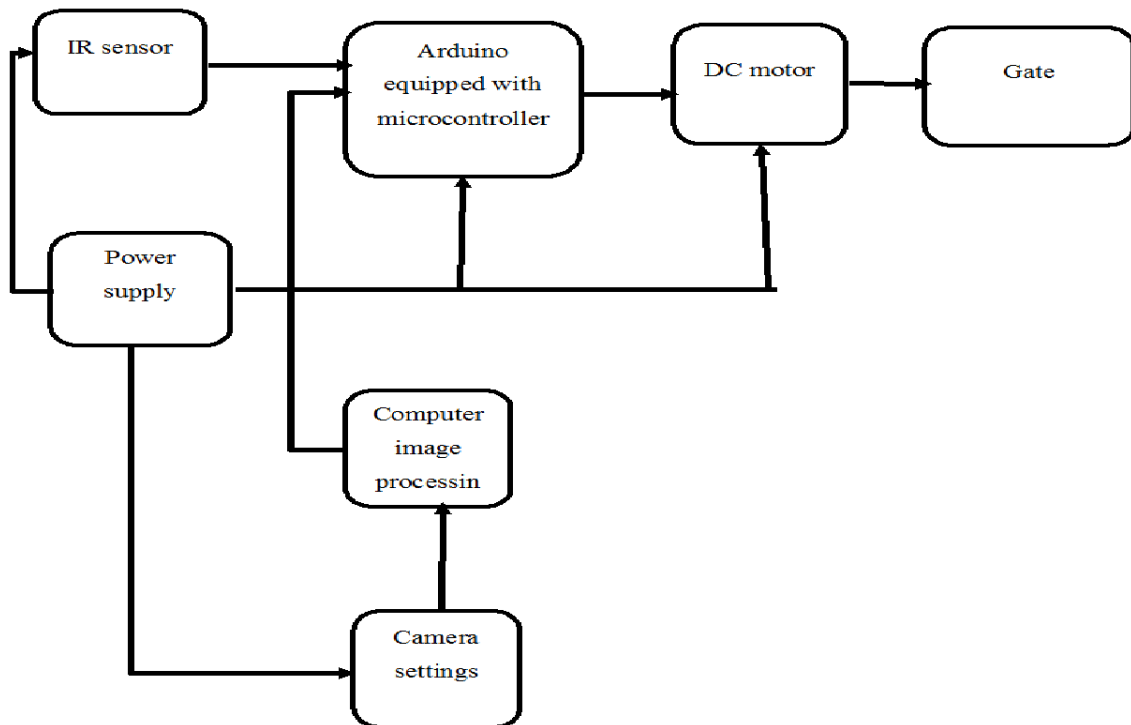


Figure 4-7: Simulation Model of automatic gate system

Automated railway level crossing is composed with automatic gate system and automatic image detection system. Automatic gate system is build up with IR sensor, Arduino composed with microcontroller, DC motor and gate. Then automatic image detection system is composed with camera and image processing unit. The output of image detection system for obstacle detection is interfaced to Arduino for notification indication to a driver if there is a danger on level crossing as shown on figure4-9.

4.2.2.1 Opening of Railway Gates

In real time, the IR sensors are placed behind the track at a distance of 3 Km on both sides of the level crossing. If IR1 detects the arrival of the train, it sends the signal to the microcontroller. Then the microcontroller activates the buzzer for warning the level crossing users that the railway gates are yet to be closed and the arrival of the train within a stipulated time. The controller then activates the pair of DC motors which acts as the railway gates. The DC motor rotates in forward direction for 5 seconds in order to close the railway gates perfectly. A 16X2 LCD has been employed to display the status of the operation. When the IR1 detects the train, “TRAIN ARRIVED” has been displayed and

when the gates are closed, “GATES CLOSED” has been displayed by the LCD for the level crossing exploiters.

4.2.2.2 Closing of Railway Gates

After the train crossed the level crossing, when IR2 detects the departure of the train, it sends the signal to the controller. Then the microcontroller again activates the buzzer to notify that the railway gates are yet to be closed. Then the controller again activates the pair of DC motor in backward direction for 5 seconds to open the railway gates perfectly. The current status of the operation has been displayed through the LCD, i.e. when the IR2 detects the train, “TRAIN DEPARTURED” has been displayed and when the gates are opened, “GATES OPENED” has been displayed by the LCD.

4.2.2.3 Obstacle Detection between the Railway Gates

In the proposed system, while automating the railway gates operation, there may be a chance that a vehicle or another object may be locked between the crossing gates. Thus, in order to avoid its collision and train, the system has been taken some fruitful steps. A camera detection system has been placed at the level crossings in cross manner in one side. This camera is controlling level crossing area. A camera has inbuilt transmitter and receiver (capture) object from level crossing to computer processing unit. The transmitter continuously transmits the templates images and this could be reflected by the constant obstacle. This distance could be programmed into the controller as the threshold distance.

4.3 Obstacle detection system on level crossing

4.3.1 Requirements

The most reliable solution to decrease the risk and accident rate at level crossings is to eliminate unsafe railroad crossings. This avoids any collisions between trains and road users. Unfortunately, this is impossible in most cases, due to location feasibility and cost that would be incurred. For instance, almost 10 million Euros per year are earmarked for the removal of the most dangerous level crossings in France. To overcome these limits, the development of an obstacle detection system was required. Possible solutions using advanced technologies to improve level crossing safety. The proposed system is intended to replace the present equipment installed on each level crossing. The purpose of such a system is to provide enforced information to the train driver, it can be considered as new system operations. This concerns the detection and tracking of any kind of objects, such

as pedestrians, people on two-wheeled vehicle, wheelchairs and car drivers. Presently, sensors are evaluated relying on their false object detection alert among other. This may increase the risk related to level crossing users. It is important to be noted that risks associated with the use of technology systems are becoming increasingly important in our society. Risk involves notions of failure and consequences of failure. Therefore, it requires an assessment of dependability; this might be expressed, for example, as probability of failure upon demand, rate of occurrence of failures, probability of mission failure, and so on. Each level crossing is equipped with various sensors for tracking and timely detection of potentially hazardous situations. To be reliable, the related information must be shared and transmitted to the train dispatching center, stations, train drivers and road users. A brief summary of the technical characteristics of most devices provides the necessary understanding to design effective obstacle detection system. Generally, most level crossings are fitted with standard equipments such as lights, automatic full or half barriers, notices. This equipment warns and prevents all users of the level crossing if a train is approaching the dangerous area[16].

4.3.2 Video Imaging on Level Crossings

One of the main operational purposes for the introduction of stereo camera at level crossing is the automatic detection of specific events. Actually, no conventional vision-based system is installed at level crossings today, but a few level crossings are equipped by a camera-based system. The purpose is not to visually analyze such crossing zone when there is stereo camera. An automatic process must be established in order to only transmit relevant information to the control room and train driver like the presence of an obstacle in the crossing zone at a critical time. A typical example of a hazardous scenario consists of detecting a car stationary in the crossing zone for a few minutes, this before the lowering of barriers and without a priori about the position of train. The decision that must be taken for a given situation depends on several factors such as its speed when the brakes are applied [65], the geography of the track, in particular the track slope the train travels over from when the brakes are applied to where the front of the train stops, the mass distribution of the train and the proximity of the nearest train to the level crossing. The automatic video system can have a priori about the position of the nearest train; this accurate information can be given permanently by the control room. Otherwise, another way is to rely on vision by detecting the movement of gate. It is envisaged that the new technologies will increase

the number of monitored camera images, give the staff earlier warnings to be able to produce more timely responses, and support the recording and collection of evidence of detected events. The level crossing obstacle detection system that uses cameras detects any kind of objects, such as pedestrians and wheelchairs, that cannot be detected by the conventional systems of the photoelectric (i.e. optical beam), ultrasonic, and loop coil types. These particular objects that can be detected using passive vision may be tracked close together in space and time. This allows us to model spatiotemporal behavior from image sequence. Nowadays, most of the conventional object detection systems described above supervises only dangerous crossing areas. According to the technology used, the detected object is tracked when it appears in the critical zone. For this purpose, using artificial vision can provide more relevant information and with such a system, dangerous scenarios can be recognized at the right time. Fig. (5) presents a reference scenario of hazardous situations detected from a stereo camera. Interpreting this scenario allows us to deduce the importance of the level crossings environment, which gives significant information such as road traffic and the status of the red-light. This additional information can be provided as input to the computational system related to the cameras.

4.4 Software Simulation

4.4.1 LabVIEW

In the past, LabVIEW was just a graphical programming language that was developed to make it easier to collect data from laboratory instruments using data acquisition systems. LabVIEW was always easy to use once you got used to wiring connectors to write your computer programs, and it definitely makes data acquisition an easier task than without LabVIEW, but LabVIEW is not just for data acquisition any more.

LabVIEW can be used to perform the following:

- A. acquire data from instruments
- B. process data (e.g., filtering, transforms)
- C. analyze data
- D. control instruments and equipment

For engineers and researchers, LabVIEW makes it possible to bring information from the outside world into a computer, make decisions based on the acquired data, and send computed results back into the world to control the way a piece of equipment operates.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

LabVIEW produced by National Instruments is visual programming language that allows creating program with graphics instead of text based code. LabVIEW code/ programs is called Virtual Instrument or VI and it can have copy of real world instruments e.g. switches and LED on its virtual workbench

On creation of new VI, two major windows are opened:

- A. Block diagram where graphical code is built
- B. Front panel where the virtual instrument (e.g. Waveform, switches) are created and displayed for user interaction.

LabVIEW codes are built by wiring the nodes of functional graphical blocks together. The node of functional graphical blocks only executes its function only after it has received data from previous node. In my simulation LabVIEW is used to simulate image detection system[66].

4.4.2 Proteus 8 Professional tool

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards. It was developed in Yorkshire, England by Labcenter Electronics Ltd and is available in English, French, Spanish and Chinese languages.

Proteus 8 Professional provides the means to enter the design in the first place, the architecture for real time interactive simulation and a system for managing the source and object code associated with each project. In addition, a number of graph objects can be placed on the schematic to enable conventional time, frequency and swept variable simulation to be performed.

Major features of PROTEUS VSM include:

- ❖ True Mixed Mode simulation based on Berkeley SPICE3F5 with extensions for digital simulation and true mixed mode operation
- ❖ Support for both interactive and graph based simulation
- ❖ CPU Models available for popular microcontrollers such as the PIC and 8051 series.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

- ❖ Interactive peripheral models include LED and LCD displays, a universal matrix keypad, an RS232 terminal and a whole library of switches, pots, lamps, LEDs etc.
- ❖ Virtual Instruments include voltmeters, ammeters, a dual beam oscilloscope and a 24channel logic analyzer.
- ❖ On-screen graphing - the graphs are placed directly on the schematic just like any other object. Graphs can be maximized to a full screen mode for cursor based measurement and so forth.
- ❖ Graph Based Analysis types include transient, frequency, noise, distortion, AC and DC sweeps and Fourier transform. An Audio graph allows playback of simulated waveforms.
- ❖ Direct support for analogue component models in SPICE format.
- ❖ Open architecture for 'plug in' component models coded in C++ or other languages. These can be electrical, graphical or a combination of the two.
- ❖ Digital simulator includes a BASIC-like programming language for modelling and test vector generation.
- ❖ A design created for simulation can also be used to generate a net list for creating a PCB- there is no need to enter the design a second time[64]

CHAPTER 5 : SIMULATION RESULTS AND DISCUSSION

Automatic gate simulation is very important in automation of level crossing for traffic-railway management to create the interface of railway transport and road transport to avoid collision (accidents) between vehicle and pedestrian. Automatic gate simulation is composed by: Arduino Uno equipped with ATMEGA. Microcontroller, LED lights (Red and Green), L293D motor driver, DC motor, IR sensors. In this thesis project. To simulate automatic gate proteus 8 professional is used for circuit design, and Arduino is used for source code generation. Automatic object detection is simulated by using stereo camera and computer processing unit, means a camera is fixed to level crossing, detecting each and every object moving on level crossing, a detecting system has to differentiate a moving object and static object. If a camera detected a static object in 2 min, it will send display a flashing light, through Arduino Uno. The output of automatic gate and automatic object detection system are interfaced to get one automatic system for level crossing management. Once an object is locked on level crossing, it is difficult to a driver to know if the object is locked on crossing. Automatic object detection output is interfaced by railway automatic gate. Red light is used here to indicate danger, once an object get locked on crossing, automatic object system detects and confirm by display Red indications, once a driver see that Red indication, has to apply appropriate action (Brake). Once the object gate remove, a driver has to acknowledge the notification by a button, otherwise notification shall continue to display danger indication.

5.1 Automatic gate simulation Result (proteus simulation)

This prototype demonstrated the automatic railway gate control by using Arduino Uno equipped with ATMEGA. Microcontroller .The IR sensors are fixed at certain distance on both sides of the gate, that is before the train arrive and after the train departure. The sensed signal is send to the Arduino Uno equipped with ATMEGA. Microcontroller to operate motor, hence open or close the gate. At the same time, alarm and indication light signal are provided to the road users. In sequences, the gate motor will move forward direction to move the gate downwards direction. It will stay closed at certain time until the train has crossed the gate and reached the second sensor activate the motor in backward direction to open the gate by moving it in upward direction.

The system of automatic gate is designed by using proteus 8 professional. Here Arduino Uno equipped with ATMEGA. Microcontroller for the control according to the data pattern produced at the input port of the micro controller, the appropriate selected action will be taken.

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The logic is produced by the program written in Arduino tool. The software program is written, by using the Arduino tool. The program written is then converted in HEX code after simulation and uploaded to Arduino device, through proteus 8 professional tool.

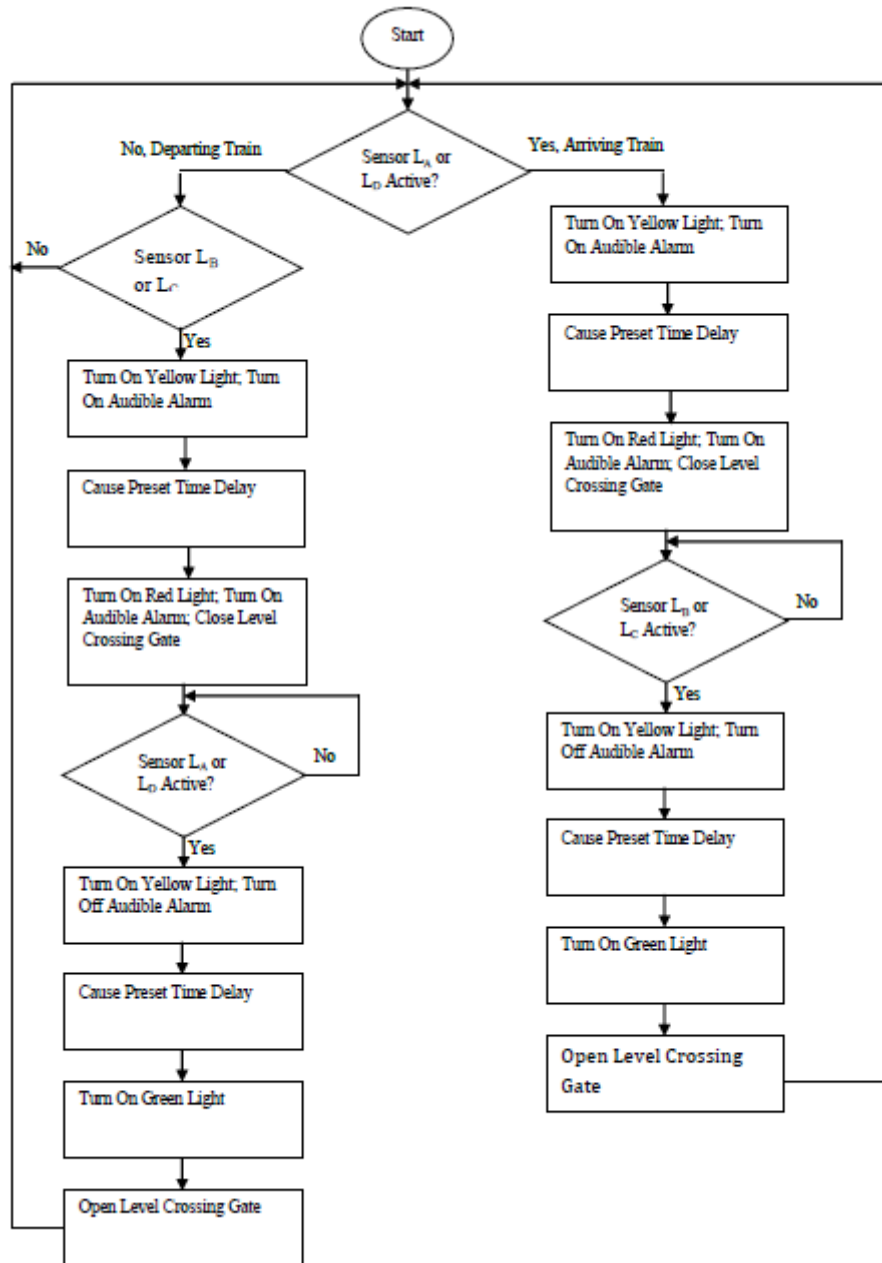


Figure 5-1: Flowchart of automatic gate working principle[25]

This prototype is designed using microcontroller to avoid railway accidents happening at unattended railway gates, if implemented in spirit. This project utilizes two powerful IR transmitters and two receivers; one pair of transmitter and receiver is fixed at upside (from where the train comes) at a level higher than a human being in exact alignment and similarly the other pair is fixed at down side of the train direction. Sensor activation time

Design of automated railway level crossing system for traffic-railway management Case study: AALRT

is so adjusted by calculating the time taken at a certain speed to cross at least one compartment of standard minimum size of the AALRT railway. As shown in figure 5-2, means that a sensor has sensed an incoming train, and sent a trigger signal, and as seeing, yellow light indication is displayed to road user to be careful.

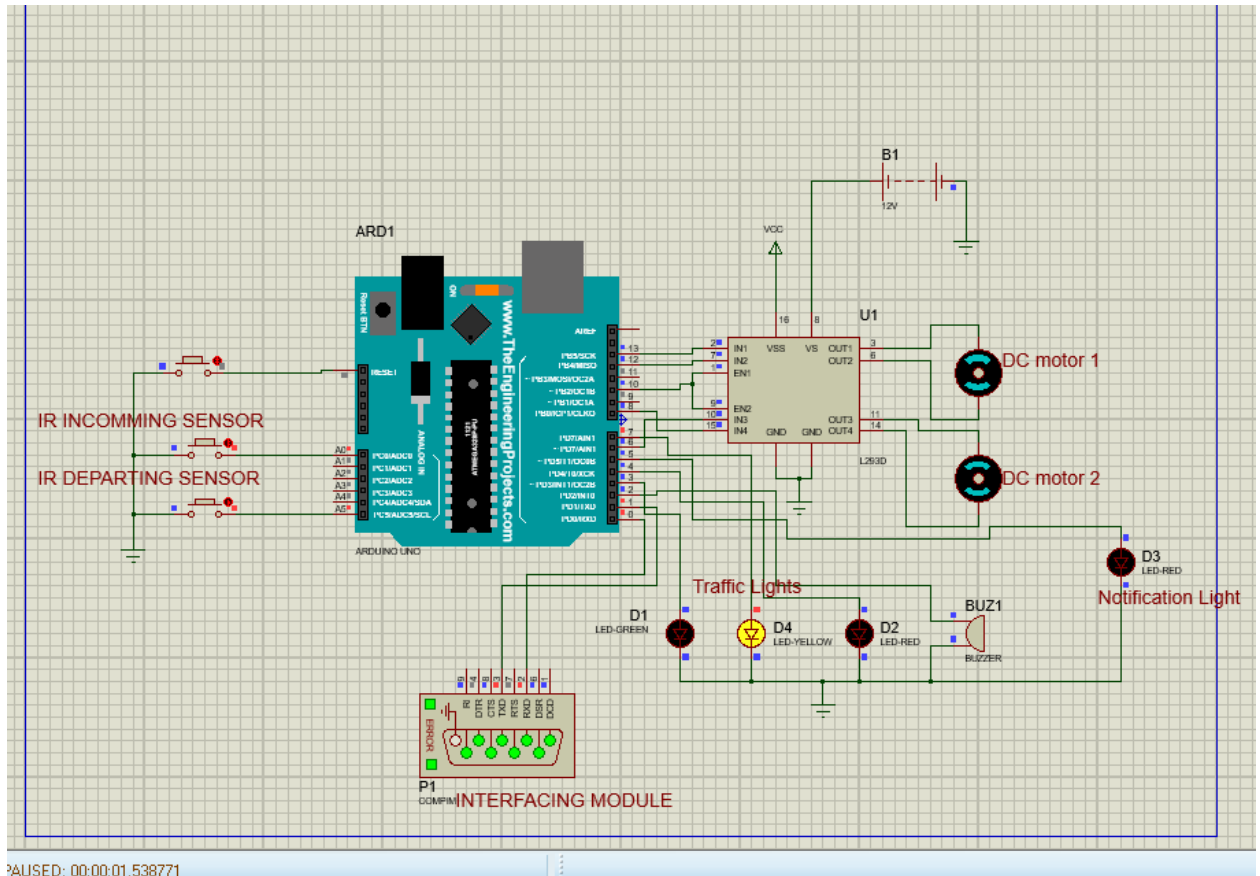


Figure 5-2: Automatic gate system when gate prepare for crossing mode

5.1.1 Train arrival detections

When foreside receiver gets activated, the gate motor is turned on in one direction, motor has to run in controlled motion, means it has to start slowly and speed increases by time and the gate is closed and stays closed until the train crosses the gate and reaches aft side sensors. Red indication is displayed as shown in figure 5-3 for restrictions and ,Buzzer will immediately sound at the fore side receiver activation and gate will close after 5 seconds, so giving time to drivers to clear gate area in order to avoid trapping between the gates and stop sound after the train has crossed.

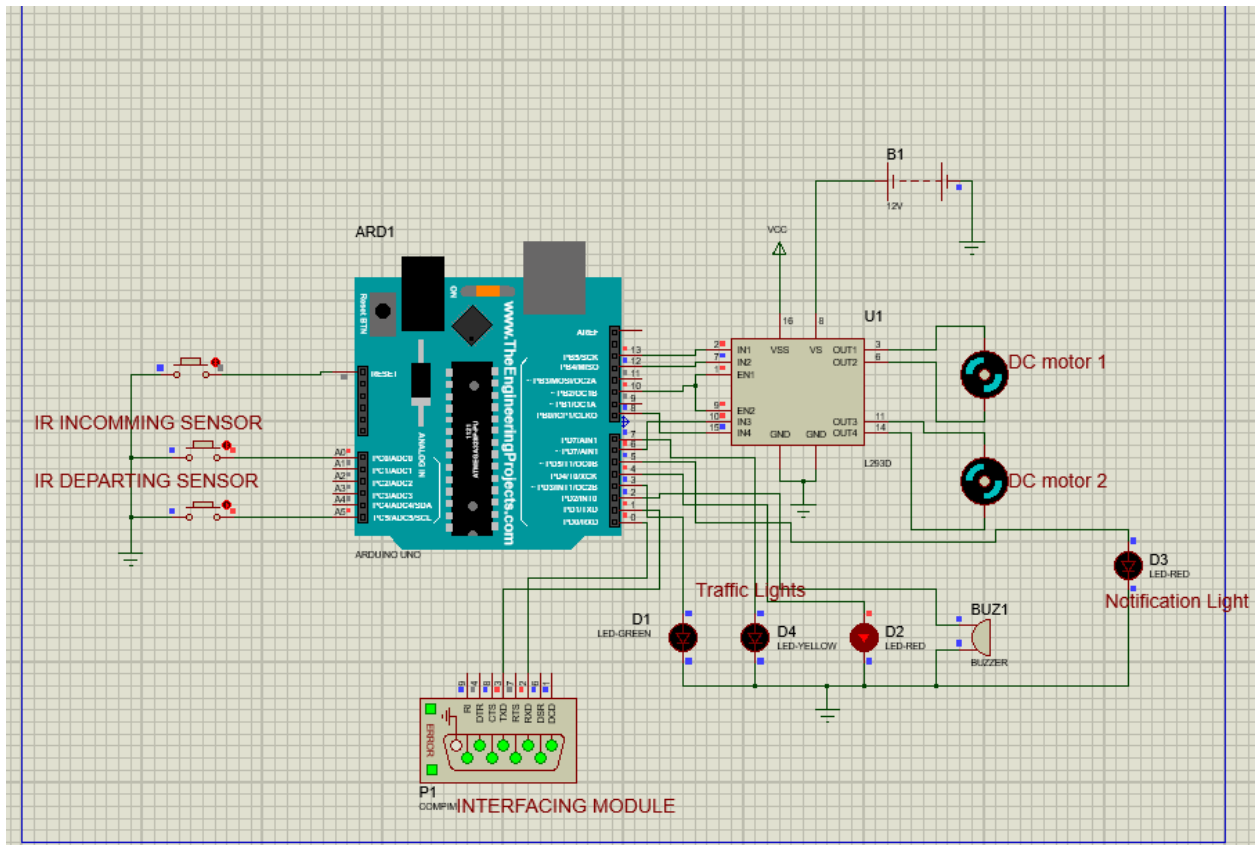


Figure 5-3: Automatic gate is closing

5.1.1.1 Gate closing operation

When a train departed, IR sensor automatically produces the signal to operate the motor through microcontroller and hence open the gate for the passage of road vehicle (traffic users). When any presence of obstacle is sensed, automatic detection system controller gives signal for obstacle to a train driver to apply brake before hitting the obstacle, motor is operated to close the gate.

5.1.1.1.1 Signal for train

When the path is clear inside the gate, GREEN signal is produced as shown in figure 5-4 for the train when there is any obstacle; signal is made RED for the train in order to slow down its speed after 1 Km (20 sec) from the gate. Another signal placed at 0.5 km (10 sec) before the gate, when it is still RED when train approaches if then provisions if then provisions should be stopping the train.

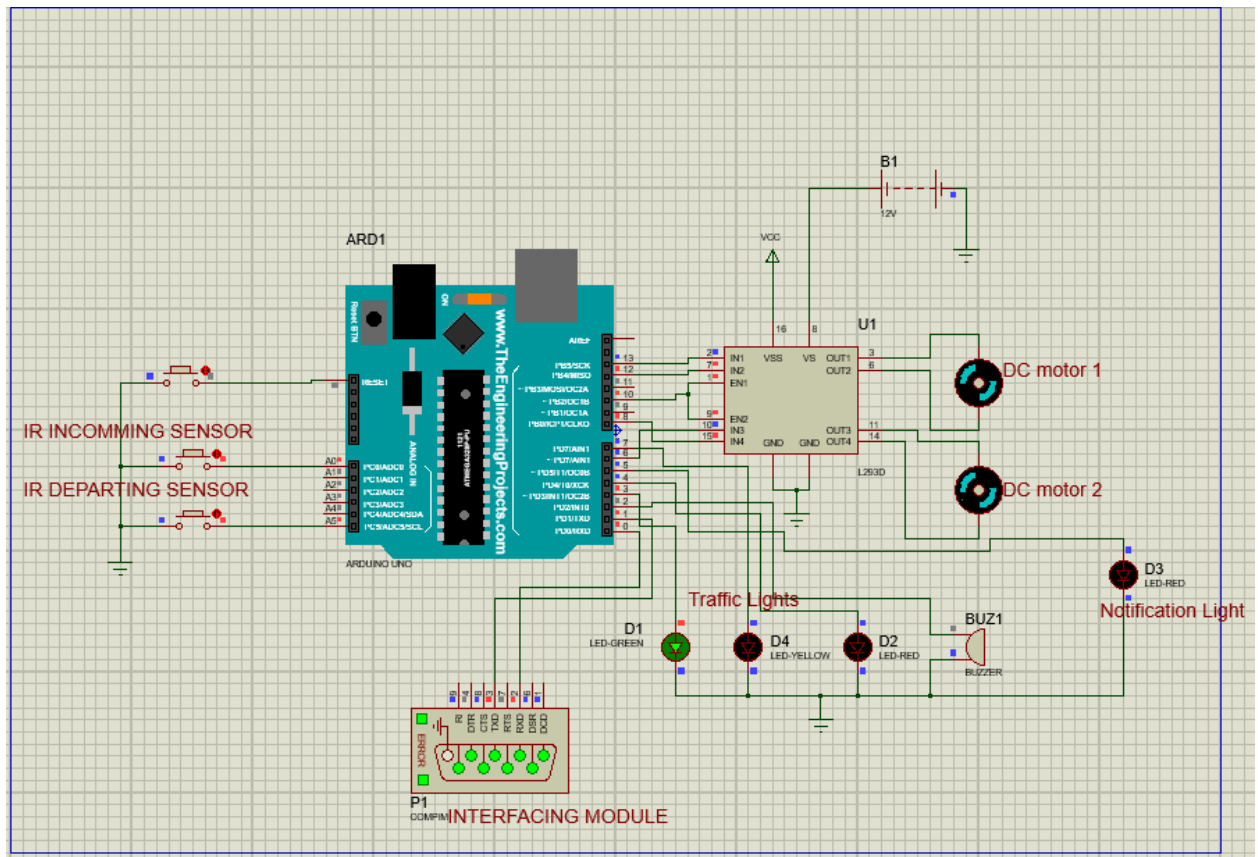


Figure 5-4: Automatic gate is opening

5.1.1.2 Train Departure Detection

Detection of train departure is also done using IR departure sensor and microcontroller as explained under the head of train arrival detection. Train departure sensing is done by sensors IR departure sensors respectively considering the directions of train approach.

5.1.1.2.1 Gate operating

When the train departure is sensed by the sensors, signal is given to the Microcontroller which operates the motor in reverse direction and the gates are opened. Once the gate is opened signal for road users are made GREEN so that the vehicles can pass on crossing safely.

5.2 LabVIEW simulation results (Obstacle Detection System)

This study designs an advanced safety system for obstacle detection by machine vision railway crossings. A stereo camera installed at a crossing continuously captures images of objects over crossing. A LabView programming is used for designing and simulating image detection system

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

Actually LabView VIEW programming contains two display panels. The front panel is for the user interface and the other is the block diagram that contains the graphical source code that defines the functionality of the VI. The front panel for the current work is shown in the figure5-5, there are eight states. Obstacle detection system contains different parts; it has image out window, which is a level crossing ground, where all road users are passing during road user's movement. The second panel is for object template, once an object locked on crossing without moving during time equivalent to 1 min called target time, camera snap a frame and then run it to compare it with template we have in detection system. The third panel is called template panel, where snapped object (image) is compared with template to identify the object locked on crossing. All that image processing is done in one minute, after identifying the object, detection will send a notification in this case is Red flashing light, telling a train driver to be careful before colliding with the locked object. When one sensor is activated, their corresponding warning signals will start to respond. Millisecond timer will start counting until it reaches its specified timeout (10 second in this case). The eight different cases, where the states are triggered, are represented in the following different block diagrams. This detection system also is showing, object size, the position of the object, inclination angle, and the score. Actually the score is the detection capacity, as this score increase, detection level reduced, and as it becomes small sensitivity raised.

Image subtraction: Each pixel of the acquired grayscale image has 8-bit intensity. A railway crossing image clear of any obstacles is initially saved as a reference image. In order to detect moving targets, the software performs the image subtraction of the reference image from each of the monitored images. Those pixels that passes higher values are the candidates of the targets. These clustered pixels might belong to the model vehicles, pedestrians which are indeed the obstacles of interests, or other smaller and important objects that not impede safety. Some other pixels in the image and can be categorized into noises. There are inevitably pixels with smaller values, which actually belong to the moving targets. It is because the grayscale of these pixels is similar to the backgrounds. They will be recovered by morphology.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

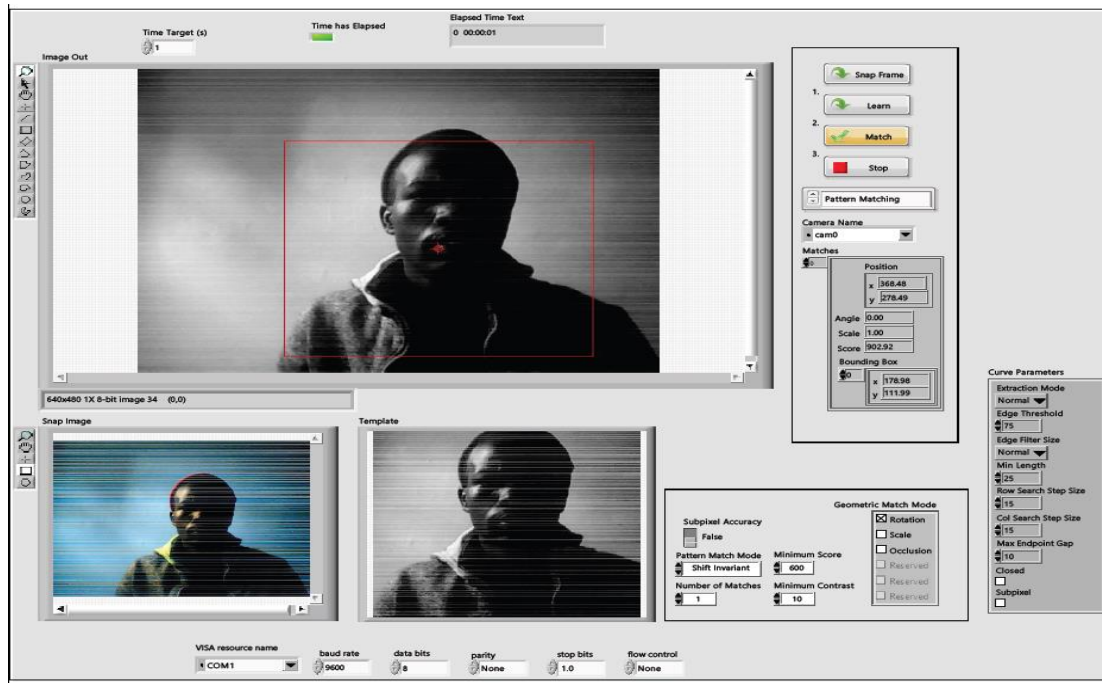


Figure 5-5: Checking presences of obstacles inside LX situation simulation by LabView tool

5.2.1 LabView design block diagram

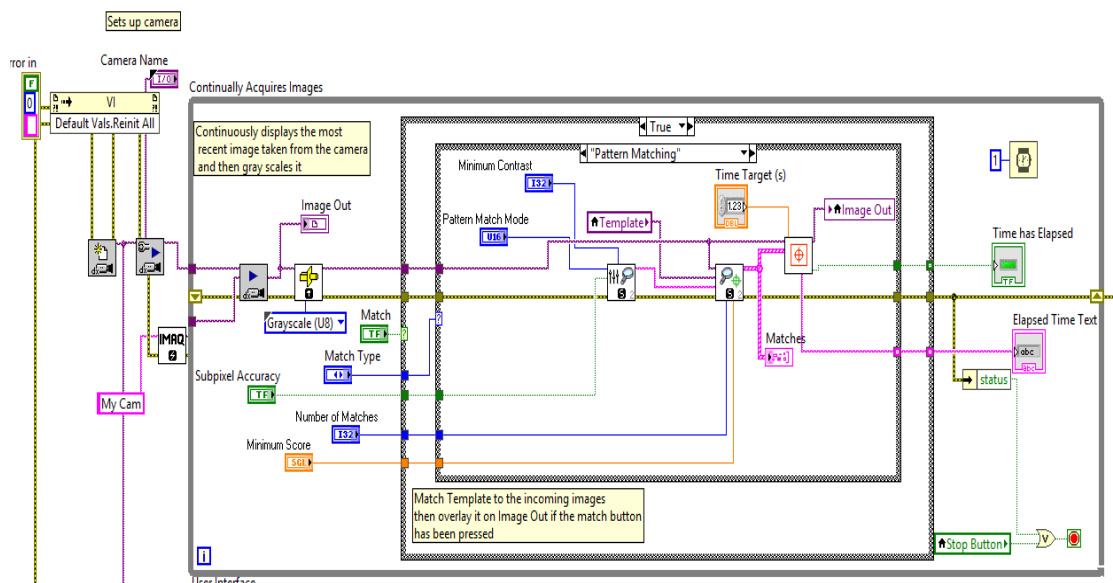


Figure 5-6: Block diagram of continuous checking object detection system

This prototype of automatic object detection system is designed by using a tool called LabView VIEW programming. This is block diagram; this block has two parts, one part is

Design of automated railway level crossing system for traffic-railway management Case study: AALRT

for continuous object detection as shown in figure 5-7, and it continuously acquire images i.e. it continuously displays the most recent images taken from a camera and then gray scale them for better detection. Therefore, after learning the image captured, if the image is true, it is passed to the pattern matching block to match the template to the incoming images then overlay it on image out if the match button has been pressed.

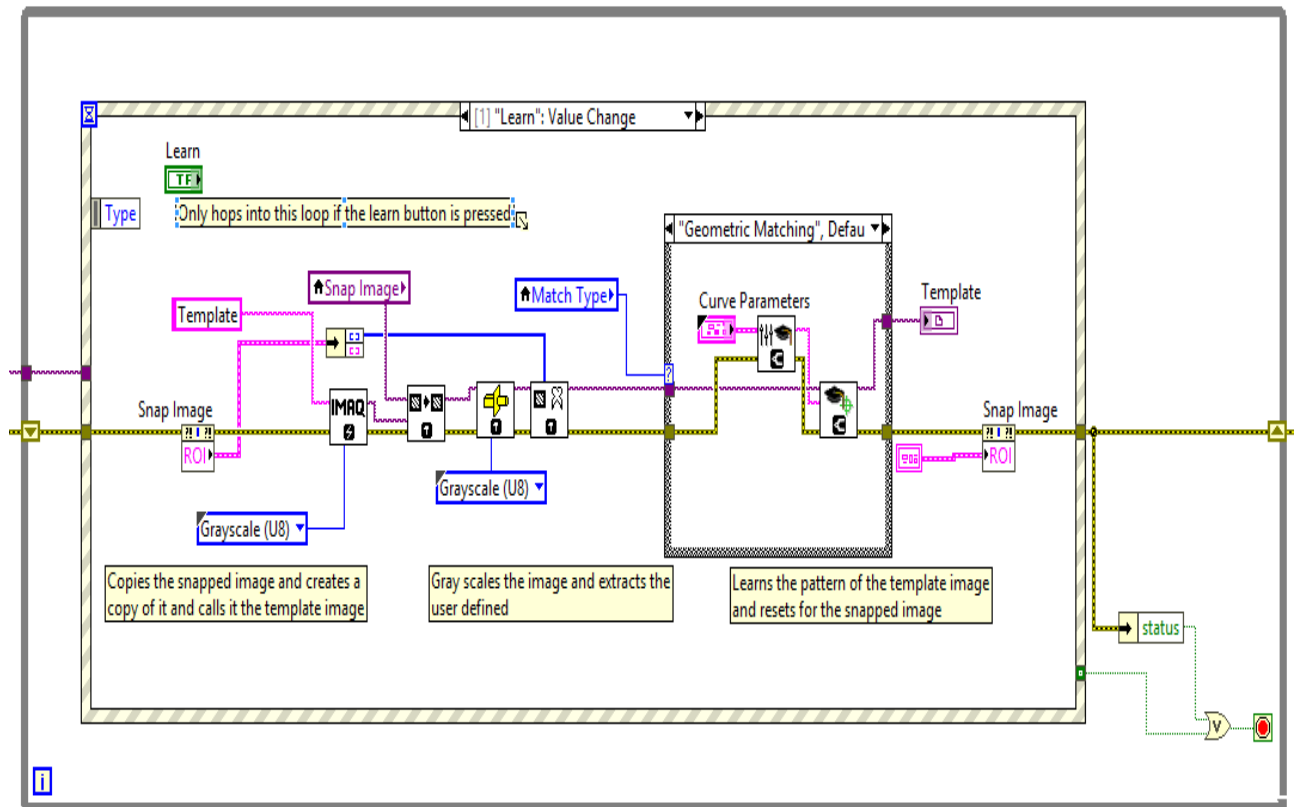


Figure 5-7: Block diagram of sample images, it runs once in a while

This block diagram is a diagram of image samples, it runs once in a while. After getting copies of the template images, images are gray scaled and extracts the user defined. Then learns the template images and resets for the snapped image. In this sections, system will provide to image all properties, including size, curve parameters, scale etc. Inside of this block they are other sub-blocks which helps the whole block to run, including stop button for changing values, snap button as well as learn, but these button runs once to have templates.

Design of automated railway level crossing system for traffic-railway management Case study: AALRT

5.2.2 Interfacing two systems

In order to make two system working as one system, they have to be interfaced. Configure Virtual Serial Port Driver is used for interfacing automatic object detection system and railway automatic gate, to have one system. Configure Virtual Serial Port Driver used for exchanging data, actually Configure Virtual Serial Port Driver has ports called COMs which used for data exchange, means a COM can send as well as receive data. Automatic image detection system has to differentiate moving object and stopped objects on level crossing, once it get a stopped object, it has to display a notification to a driver to apply brake to avoid collision between train and a locked object. Red indication is used to display notification, this notification will be displayed on Arduino used for automatic gate in proteus 8 professional. The output of LabVIEW is connected to COM1 of Virtual Serial Port Driver, and Proteus results (automatic gate) is connected to COM2, therefore, LabVIEW will exchange data with proteus using Virtual Serial Port Driver. As shown in figure 5-8, this is front panel of LabView for interfacing diagram.

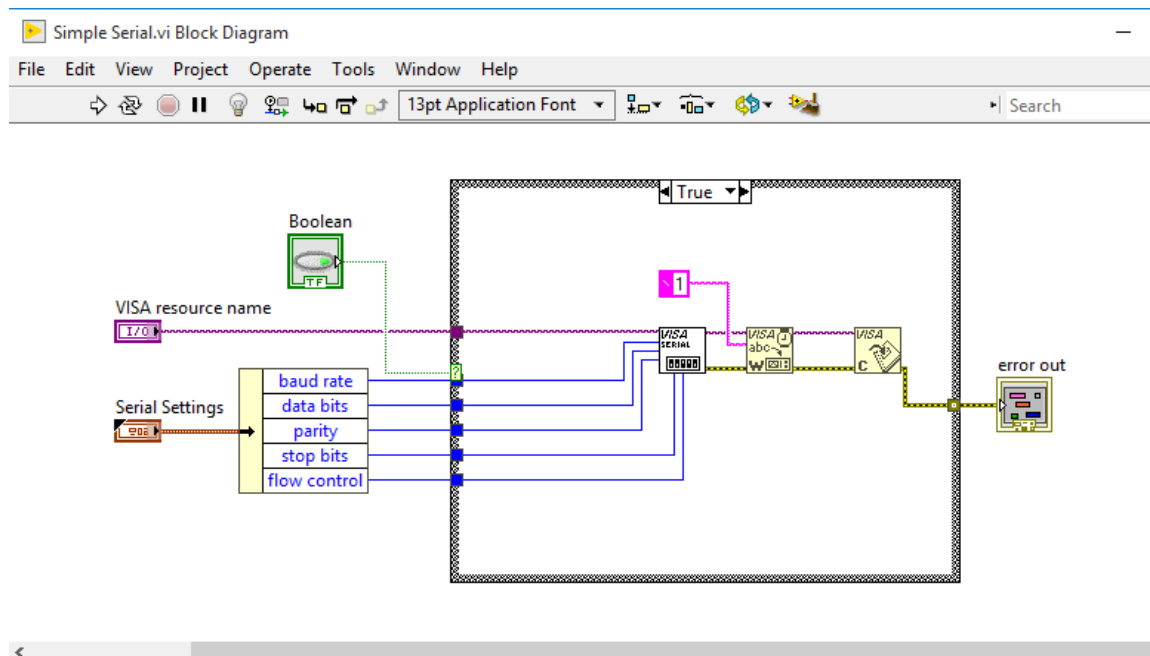


Figure 5-8: Block diagram for LabView interfacing

Interfacing system on LabVIEW side has a block diagram, this diagram works by elapsed time, if the signal is true i.e. an image detection system get a locked object for 30 seconds, Elapsed time start to count, if elapsed time finished, LabVIEW send data to Arduino to display notification. If data sent by LabView are received by Arduino (Proteus), a Red display indication notification as shown in figure 5-10 is displayed. If the signal is false

Design of automated railway level crossing system for traffic-railway management Case study: AALRT

which means automatic image detection system doesn't get a stopped object for 30 second, LabView cannot send data.

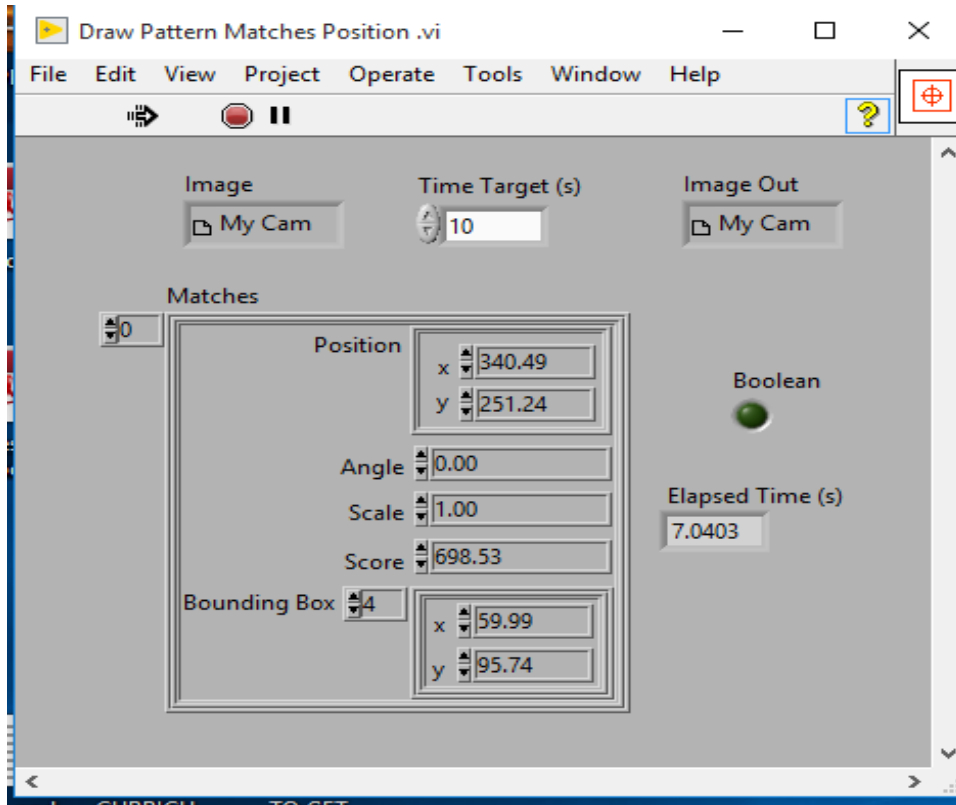


Figure 5-9: Image processing detecting an obstacle on crossing

The image processing system checked (by tracking) that on level crossing there is an object which is not moving, it will send a red indication notification to driver to apply brake for collision avoidance, after rescue of that object, station attendant will press reset button to reset the system. Here gates will remain opened but traffic rights displays danger. Elapsed time equivalent to 10 seconds is set in the system, when an object stopped, this elapsed

Design of automated railway level crossing system for traffic-railway management Case study: AALRT

time in image processing start counting down, if it moves again, elapsed time comes back to 10 seconds. As shown in this figure

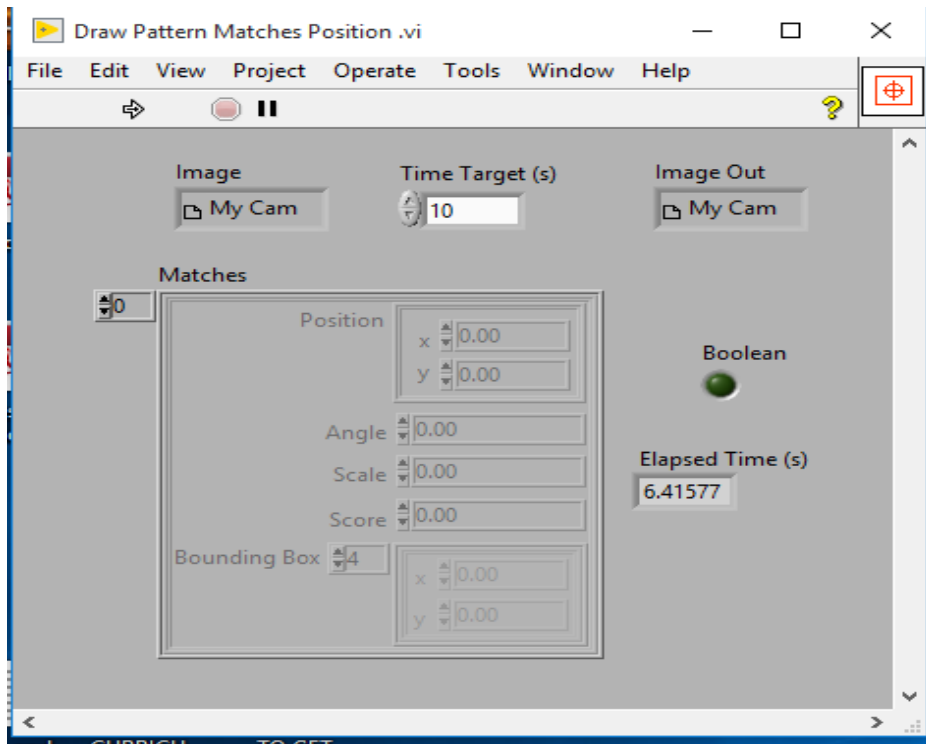


Figure 5-10: If an obstacle moves again

The object on level crossing continuously are being checked by image processing system, when an object stopped some time on crossing the matches option as an object changes its position, angle, scale and score on crossing surface. Elapsed time is keep counting and changing as an object is not moving, if an object moves from that position, matches parameters changes and elapsed time stopped counting and start by zero again. Boolean will flash in case elapsed time reaches time target hence displaying red indication for danger on crossing.

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

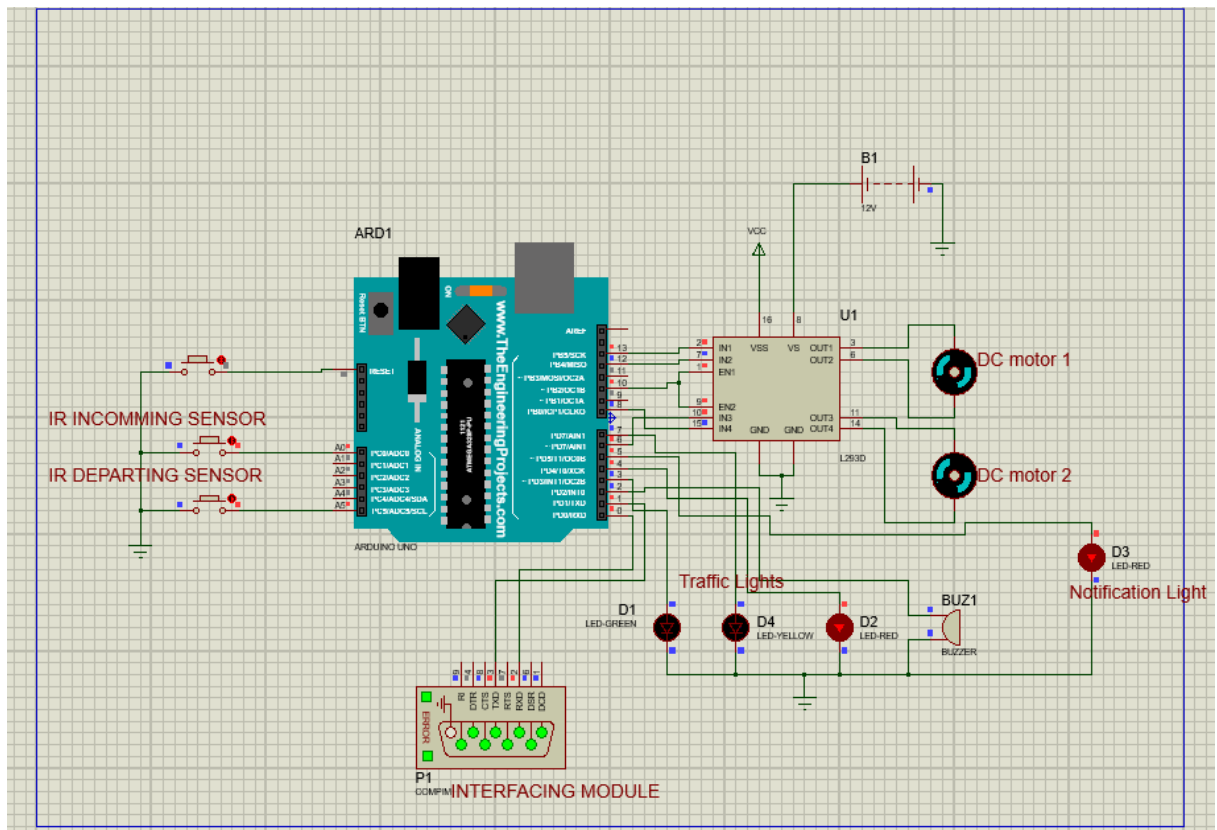


Figure 5-11: Automated crossing when there is obstacle

As said above, automatic object detection system was created such that it differentiate moving objects and static objects on crossing. In case image processing unit captured a static object on crossing, it start counting, in the system we have 10 sec; if an object get locked on crossing image processing unit starts counting down, if 10 sec finished it will directly send a Red notification to a driver to apply brake as seen in figure5-10. As illustrated in this figure, when an object get locked on crossing, road users would stop passing on crossing until the object is cleared or removed on crossing. Red notification will stay ON, until when object is removed and train is cleared on crossing.

5.2.3 Discussion on the above result

The road and rail traffic movement near the railway level crossings has to follow strict traffic lights. Table 5-1 summarizes different situations in railway-traffic movement near level crossings. Simulation of the system demonstrated that automated level crossing

Design of automated railway level crossing system for traffic-railway management
Case study: AALRT

system (interfaced railway automatic gate system and automatic object detection system) can detect an object at the position of $x = 340.49$, $y = 251.24$ with the score of 698.53, 10 seconds for making decision for obstacle on crossing, which are good results according to AALRT level crossing background

Table 5-1: Description of possible states of level crossing management system

Serial No.	current state	Next state	Actions
1	Initial set	IR Waiting mode	<ul style="list-style-type: none"> ➤ Road signal flashing GREEN ➤ Gate is open ➤ Buzzer is OFF
2	IR sensor detecting an incoming train	detection system Checking presences of obstacles inside level crossing	<ul style="list-style-type: none"> ➤ Road signal flashing Yellow ➤ Motor is ready to close the gate ➤ Buzzer On
3	IR sensor send a signal to trigger microcontroller	detection system Checking presences of obstacles inside level crossing	<ul style="list-style-type: none"> ➤ Road signal flashing RED ➤ Gate is completely closed ➤ Buzzer is OFF
4	IR sensor Checking departure of train	detection system Checking presences of obstacles inside level crossing	<ul style="list-style-type: none"> ➤ Road signal flashing Yellow ➤ Gate get ready to open ➤ Buzzer is ON
5	IR sensor send a signal to trigger microcontroller	Checking presences of obstacles inside level crossing	<ul style="list-style-type: none"> ➤ Road signal flashing RED ➤ Motor is ready to close the gate ➤ Buzzer is Off
6	Checking for faulty situations	Informing disaster management force	<ul style="list-style-type: none"> ➤ Road signal flashing RED ➤ Gate is completely open ➤ Buzzer is OFF
7	Informing disaster management force	Initial setting	<ul style="list-style-type: none"> ➤ Road signal flashing GREEN ➤ Gate is completely open ➤ Buzzer is Off

5.2.4 Discussion on reliability of the models

At present the existing system is manually and road users controlled system once the train arrived and leaves the level crossing. The crossing master informs the crossing operator about the arrival of the train through the telephone. Once the crossing operator receives the information then he closes the gate depending on the timing at which the train arrives

Design of automated railway level crossing system for traffic-railway management
Case study: AALRT

on the crossing, and on AALRT are using barriers. Hence if the crossing operator loses communication with station master due to certain reasons, automatically collision shall happen between train and road users. There is no centralized system is available presently signals are control by mean of interlocking and wrong signals and signal device which is totally semiautomatic system. The automatic railway level crossing including automatic controlled gate and automatic obstacle (image) detection system at AALRT level crossing will minimize problems caused by existing crossings. The time for which it is closed is less compared to the manually operated gates and also reduces the human labor, hence to reduce accidents on level crossing. This type of automated level crossings can be employed in an unmanned level crossing where the chances of accidents are higher and reliable operation is required. Since the operation is automatic error due to manual operation is prevented. And implementing the work railway system can be centralized which can control the train collision accidents.

Table 5-2: Situations of railway traffic movement near the level

Situation of the Road users						
Aspects of roads lights	Not Entered in the Influence Area	Just Entered in the Influence Area	After (t_1+t_2) s in the Influence Area	Entered in the Approaching Area	On the Track (Level crossing) Crossed the Level crossing	Crossed the Level crossing
Before the Arriving Crossing gate	Permitted	Permitted	Permitted	Permitted	Permitted	Permitted
Just Under the Arriving crossing gate	Permitted	Permitted	Not permitted	Not permitted	Not permitted	Permitted
Within the Road	Permitted	Permitted	Permitted	Not permitted	Not permitted	Permitted
Left the Leaving Crossing	Permitted	Permitted	Permitted	Permitted	Permitted	Permitted

CHAPTER 6 : CONCLUSIONS AND RECCOMENDATIONS

6.1 CONCLUSIONS

From the above discussion and information of this system, it is clear that the system is highly reliable, effective and economical at traffic area, suburban area and the route where frequency of trains is high. As the system is automated, it avoids manual errors and thus provides ultimate safety to road users. By this mechanism, presence of a gatekeeper is not necessary and automatic operation of the gate through the motor action is achieved. If there is any difficulty then train will stop at train approach distances from the level crossing when train driver get a red light notification.

I hope that, simulated automatic gate control can make a positive contribution at AALRT. So doing this I recommend Ethiopian Railway Corporation (ERC) to implement automatic Level crossing system in the railway sector to minimize the chance of accident and to ensure safety to the peoples.

6.2 RECCOMENDATIONS

This paper has satisfactorily fulfilled the basic things such as prevention of accidents inside the level crossing and the wastage of a man-power. Since this arrangement can be used in remote areas where the power supply cannot be expected for the motor operation, sensors, buzzer and signal lights, solar power can be the solution there.

The last but not least recommendation goes towards the African Railway Center of Excellence (ARCE), requesting them to assist students doing their researches in Railway engineering to get access to licensed software in order for results obtained to be of high credibility as almost everyone uses non licensed cracked versions of software.

REFERENCES

- [1] W. W. Hay, “Railway Engineering,” Encyclopedia of Physical Science and Technology, 2004.
- [2] R. C. Agreements, “China railway group limited,” Certificate of Engineering Design, 2013, pp. 1–12.
- [3] A. Shiferaw, “Productive Capacity and Economic Growth in Ethiopia,” *Dep. Econ. Soc. Aff.*, no. 34, 2017.
- [4] Mikial B., “Road Safety and Rail Crossings/ Level Crossings,” <http://www.Road safety and/Road-Safety-and-RailCrossings-Level-Crossings.htm>, 12/3/2019.
- [5] S. Khoudor L. Et al, “Level Crossing Technology,” Safer Eur. Lev. Crossing Apprais. Technol. ISBN 978-2-85782-663, pp. 67–77, 2008.
- [6] S. Chandra and M. M. Agarwal, *Railway engineering*, vol. 1, no. 2. 2007.
- [7] N. R. Sankaraiah S., Mirza S. A. B., “Automatic Railway Gate Control System using IR and Pressure Sensors with Voice Announcement,” *Int. J. Innov. Technol.*, vol. 3, no. 3, pp. 0355–0357, 2016.
- [8] S. Laapotti, “Comparison of fatal motor vehicle accidents at passive and active railway level crossings in Finland,” *IATSS Res.*, vol. 40, no. 1, pp. 1–6, 2016.
- [9] N. Rudin-Brown, Lenné, Michael Christina, Navarro, Jordan, Edquist, Jessica, Trotter, Margaret, Tomasevic, Driver behaviour at rail level crossings: Responses to flashing lights, traffic signals and stop signs in simulated rural driving. .
- [10] A. Kumar, “Human Behavioral Aspects of Level Crossing Safety with Special,” *Jordan J. Mech. Ind. Eng.*, vol. 6, no. 1, pp. 37–43, 2012.
- [11] G. Railway and S. Company, “railway-highway grade crossing warning systems and the genesis of standard,” pp. 133–138.
- [12] S. Kader, Et al, “Design and Construction of an Automatic Railway Gate System,” *Dep. Mech. Eng. Khulna Univ. Eng. Technol. Khulna-9203*, vol. 3, no. 4, 2016.

Design of automated railway level crossing system for traffic-railway management
Case study: AALRT

- [13] S. K. Dwarakanath, Et al, “Arduino Based Automatic Railway Gate Control and Obstacle Detection System,” *Int. J. Adv. Res. Electr. Electron. Instrum. Eng.*, vol. 5, no. 5, pp. 4335–4341, 2016.
- [14] R. S. D. Scharstein, “Middlebury stereo vision research page,” <http://vision.middlebury.edu/stereo/.31/04/2019> .
- [15] T. K. M. Okutomiand, “A multiple-baseline stereo,” *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 15, no. 4, pp. 353–363, 1993.
- [16] N. Fakhfakh, Et al, “A Video-Based Object Detection System for Improving Safety at Level Crossings,” pp. 45–59, 2011.
- [17] N. H. K. V, “Train Collision Avoidance by Using Sensors,” vol. 6, no. 6, pp. 681–687, 2016.
- [18] S. Searches, “Automatic Railway Gate Control Using Arduino & IR Sensor <http://www.circuitstoday.com/automatic-railway-gate-control-using-ardu...>,” pp. 1–16, 2019.
- [19] S. To, H. Abid, and B. Farid, “Project Report On Automatic Railway Gate Control System Using IR,” 2015.
- [20] J. A. Enokela & K. L. Oladejo, “an Automated Railway Station Traffic Control System,” vol. 36, no. 1, pp. 138–147, 2017.
- [21] H. Bharathi and T. Vijetha, “Railway Level Crossing Gate Control through GSM by SMS with User Programmable Number Features by the Station Master or the Driver,” vol. 1, no. 3, pp. 68–69, 2016.
- [22] Kawshik Shikder, “Intelligent System for Train Engine with Automatic Gate Controlling using Wireless Technology in Bangladesh,” *Int. J. Sci. Res.*, vol. 3, no. 3.
- [23] S. K. Et al , “Advanced Railway Accident Prevention System Using Sensor Networks,” *Int. J. Adv. Res. Comput. Commun. Eng.*, vol. 3, no. 5.
- [24] A. Satish and D. Palanisamy, “intelligent system for automatic railway gate,” no.

August, 2017.

- [25] Akriti & Upendra Prasad, “Automatic Railway Crossing System,” *Int. J. Electr. Electron. Eng.*, vol. 3, no. 4, pp. 17–22, 2014.
- [26] “Development of Advanced Obstacle-Detecting Methods for Level Crossings Hiroto Takeuchi, Tetsuyoshi Shozawa Central Japan Railway Company, Aichi, Japan,” pp. 1–6.
- [27] C. Tastimur, Et al, “Image processing based level crossing detection and foreign objects recognition approach in railways,” *Int. J. Appl. Math. Electron. Comput.*, no. Special Issue, pp. 19–23, 2017.
- [28] Z.W. Kim and T. E. Cohn, “Pseudoreal-Time Activity Detection for Railroad Grade-Crossing Safety,” *EEE Trans. Intell. Transp. Syst.*, vol. 5, no. 4.
- [29] S. Sharad, P. Et al, “An Automated System to Mitigate Loss of Life at Unmanned Level Crossings,” *Procedia Comput. Sci.*, vol. 92, no. Ananthanarayanan V, pp. 404–409, 2016.
- [30] T. York and R. Jain, “Fundamentals of Image Sensor Performance,” pp. 1–8, 2011.
- [31] N. Fakhfakh, “A Video-Based Object Detection System for Improving Safety at Level Crossings,” *Open Transp. J.*, vol. 5, no. 1, pp. 45–59, 2011.
- [32] C. Xishi Wang, Et al, “A new microprocessor based approach to an automatic control system,” *Int. Symp. Ind. Electron.*, pp. 842–843, 1992.
- [33] M. G. Atul Kumar Dewangan and P. Patel, “Automation of Railway Gate Control Using Microcontroller,” *Int. J. Eng. Res. Technol.*, pp. 1–8, 2012.
- [34] Greene, Et al, “Rail Crack Detection: An Infrared Approach to In-service Track Monitoring,” *SEM Annu. Conf. Expo. Exp. Appl. Mech.*, 2006.
- [35] P. B. J. Banuchandar, Et al, “automated unmanned railway level crossing system,” *Int. J. Mod. Eng. Res.*, vol. 2, no. 1, pp. 458–463.
- [36] S. Kasalica, R. Vukadinović, and V. Lučanin, “Study of Drivers’ Behaviour at a Passive Railway Crossing,” *PROMET - Traffic & Transportation*, vol. 24, no. 3, pp.

193–201, 2012.

- [37] Rivanna Chapter, “This Month in Railroad History: August”. 2005,” Natl. Railw. Hist. Soc.
- [38] Dave Harris, “Britain first Automatic level crossing,” *Spat. Lev. Crossing*, vol. 2, no. 5, p. 2, 2009.
- [39] D. Ćirović, G., & Pamučar, “Decision support model for prioritizing railway level crossings for safety improvements: Application of the adaptive neuro-fuzzy system,” *Expert Syst. Appl.*, vol. 6, no. 40, pp. 2208-2223., 2013.
- [40] Y. Jemere, “Addis Ababa Light Rail Transit Project,” 2012.
- [41] Y. K. Kumar, S., & Jain, “Review of Measurement Techniques for Level Crossings,” *Int. J. Res. Sci. Adv. Technol.*, vol. 2, no. 4, pp. 161–165, 2013.
- [42] D. Seo, D. C. Hernández, and K. H. Jo, Comparison of edge operators for detection of vanishing points, vol. 9329. 2015.
- [43] V. Singhal, S. S. Jain, M. Parida, S. Kushwaha, and K. Malik, “ICT Enabled Railway Level Crossing Prevention Techniques,” no. November, 2017.
- [44] S. Yadav, “Oriental Journal Of Automatic Railway Gate Control Using Microcontroller,” 2013.
- [45] P. Source, D. Status, and A. Record, “Level Crossing Design,” 2009.
- [46] O. of R. and Road, “http://orr.gov.uk/_data/assets/pdf_file/0007/22876/rail-safety-statistics-2015-16.pdf,” *Annual Statistical Release - Rail Safety Statistics*. .
- [47] D. A. Noyce and D. B. Fambro, “Enhanced Traffic Control Devices at Passive Highway-Railroad Grade Crossings,” *Transp. Res. Rec. J. Transp. Res. Board*, vol. 1648, no. 1, pp. 19–27, 2007.
- [48] A. Z. Arismani, Et al “ATC railway intelligent network system,” *Eur. J. Acad. Essays ISSN*, vol. 2, no. 7online, pp. 1–4, 2015.
- [49] R. I. Standard, “Level Crossing Operational Interfaces with Trains Level Crossing

Design of automated railway level crossing system for traffic-railway management
Case study: AALRT

Operational Interfaces with Trains,” 2016.

- [50] S. H. Richards and K. W. Heathington, “Assessment of Warning Time Needs at Railroad-Highway Grade Crossing with Active Traffic Control,” *Transp. Res. Rec.*, vol. 1254, pp. 72–84, 1990.
- [51] Road and Traffic Authority, “Traffic signal Design – Appendix G level Crossing Interface Traffic Signal Design Guidance,” 978-1-921242-95–3, 2010.
- [52] J. Pochet, Et al, “Automatic Train Supervision for a CBTC Suburban Railway Line Using Multiobjective Optimization,” 2017.
- [53] I. Jain, S. Malik, and S. Agrawal, “Automatic Railway Barrier System, Railway Tracking and Collision Avoidance using IOT,” *Int. J. Comput. Appl.*, vol. 175, no. 8, pp. 13–16, 2017.
- [54] J. Zaker and A. Sadeghi, “Evaluation of Safety Improvement in Iranian Railway Level Crossings,” vol. 1, no. 1, pp. 1–6, 2012.
- [55] H. A. Iordanopoulos P. Et al, “Requirements for Interoperable Intelligent Transport System deployment in South East Europe,” in *International Symposium on Electronics in Transport*, 2014.
- [56] W. Shackelford et al., *Australia transportation research board executive committee 1999 officer*
- [57] M. M. J. Et al, “A Review Paper on the Evaluating cost-effective Railway Level Crossing Protection System,” no. 9, pp. 226–228, 2017.
- [58] E. Delmonte and S. Tong, “Investigation into traffic delays at level crossings.”
- [59] H. of C. Report, “Transport Committee Safety at level crossings,” no. February, 2014.
- [60] T. Ye, B. Wang, Et al, “Automatic railway traffic object detection system using feature fusion refine neural network under shunting mode,” *Sensors (Switzerland)*, vol. 18, no. 6, 2018.
- [61] Mike Laycock, “Network Rail apologises after wrongly saying Selby level crossing

Design of automated railway level crossing system for traffic-railway management
Case study: AALRT

to shut next week,” <https://www.yorkpress.co.uk/news/17453216.network-rail-apologises-after-wrongly-saying-selby-level-crossing-to-shut-next-week/>, p. 1.

- [62] Ta-Chung Chu, “Fuzzy logic control in decision-making,” in Proceedings IEEE Conference on Industrial Automation and Control Emerging Technology Applications, 1995, pp. 444–451.
- [63] I. S. Hristoski and P. J. Mitrevski, “Evaluating e-Customers ’ Satisfaction in B2C e-Commerce: the Case of Macedonian Students Evaluating e- Customers ’ Satisfaction in B2C e -Commerce: the Case of Macedonian Students The introduction and worldwide propagation of the e-Commerce paradigm hav,” no. June, pp. 321–332, 2016.
- [64] J. A. Enokela and K. L. Oladejo, “an automated railway station traffic control system.”
- [65] G. N. D. Barney, D. Haley, “Calculating train braking distance,” in Conference in Research and Practice in Information Technology Series, 2001, pp. 23–29.
- [66] S. Folea, practical applications and solutions using labview [™] software Edited by Silviu Folea, no. May. 2014.

APPENDIX A

A. 1. Arduino codes for automatic gate Program

```
int enablePin = 10;
```

```
int in1Pin = 13;
```

```
int in2Pin = 12;
```

```
int in3Pin = 6;
```

```
int in4Pin = 8;
```

```
int GreenLed = 3;
```

```
int YellowLed = 7;
```

```
int RedLed = 4;
```

```
int Buzzer = 2;
```

```
int TrainArrival = A0;
```

```
int TrainDepart = A5;
```

```
int Notification = 5;
```

```
void setup()
```

```
{
```

```
  pinMode(in1Pin, OUTPUT);
```

```
  pinMode(in2Pin, OUTPUT);
```

```
  pinMode(in3Pin, OUTPUT);
```

```
  pinMode(in4Pin, OUTPUT);
```

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

```
pinMode(GreenLed, OUTPUT);

pinMode(RedLed, OUTPUT);

pinMode(YellowLed, OUTPUT);

pinMode(Buzzer, OUTPUT);

pinMode(Notification, OUTPUT);

pinMode(enablePin, OUTPUT);

pinMode(TrainArrival, INPUT_PULLUP);

pinMode(TrainDepart, INPUT_PULLUP);

}

void loop()

{

  Serial.begin(9600);

  if(Serial.available(>0){

    String val=Serial.readString();

    if(val=="1"){

      digitalWrite(Notification,HIGH);

    }

  }

}

int stop=0;
```

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

```
int speed = 255;

boolean forward = digitalRead(TrainArrival);

while(!forward){

    digitalWrite(GreenLed,LOW);

    digitalWrite(YellowLed,HIGH);

    digitalWrite(Buzzer,LOW);

    delay(3000);

    digitalWrite(RedLed,HIGH);

    digitalWrite(YellowLed,LOW);

    setMotorForward(speed, forward);

    delay(3000);

    setMotorForward(stop, forward);

    forward= !forward;

}

boolean reverse = digitalRead(TrainDepart);

while(!reverse){

    digitalWrite(YellowLed,HIGH);

    digitalWrite(RedLed,LOW);

    digitalWrite(Buzzer,HIGH);

    delay(3000);
```

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

```
digitalWrite(GreenLed,HIGH);

digitalWrite(YellowLed,LOW);

setMotorReverse(speed, reverse);

delay(3000);

setMotorReverse(stop, reverse);

reverse= !reverse;

}

}

void setMotorReverse(int speed, boolean reverse)

{

analogWrite(enablePin, speed);

digitalWrite(in1Pin, reverse);

digitalWrite(in2Pin, !reverse);

digitalWrite(in3Pin, reverse);

digitalWrite(in4Pin, !reverse);

}

void setMotorForward(int speed, boolean forward)

{

analogWrite(enablePin, speed);

digitalWrite(in1Pin, ! forward);
```

Design of automated railway level crossing system for traffic-railway management

Case study: AALRT

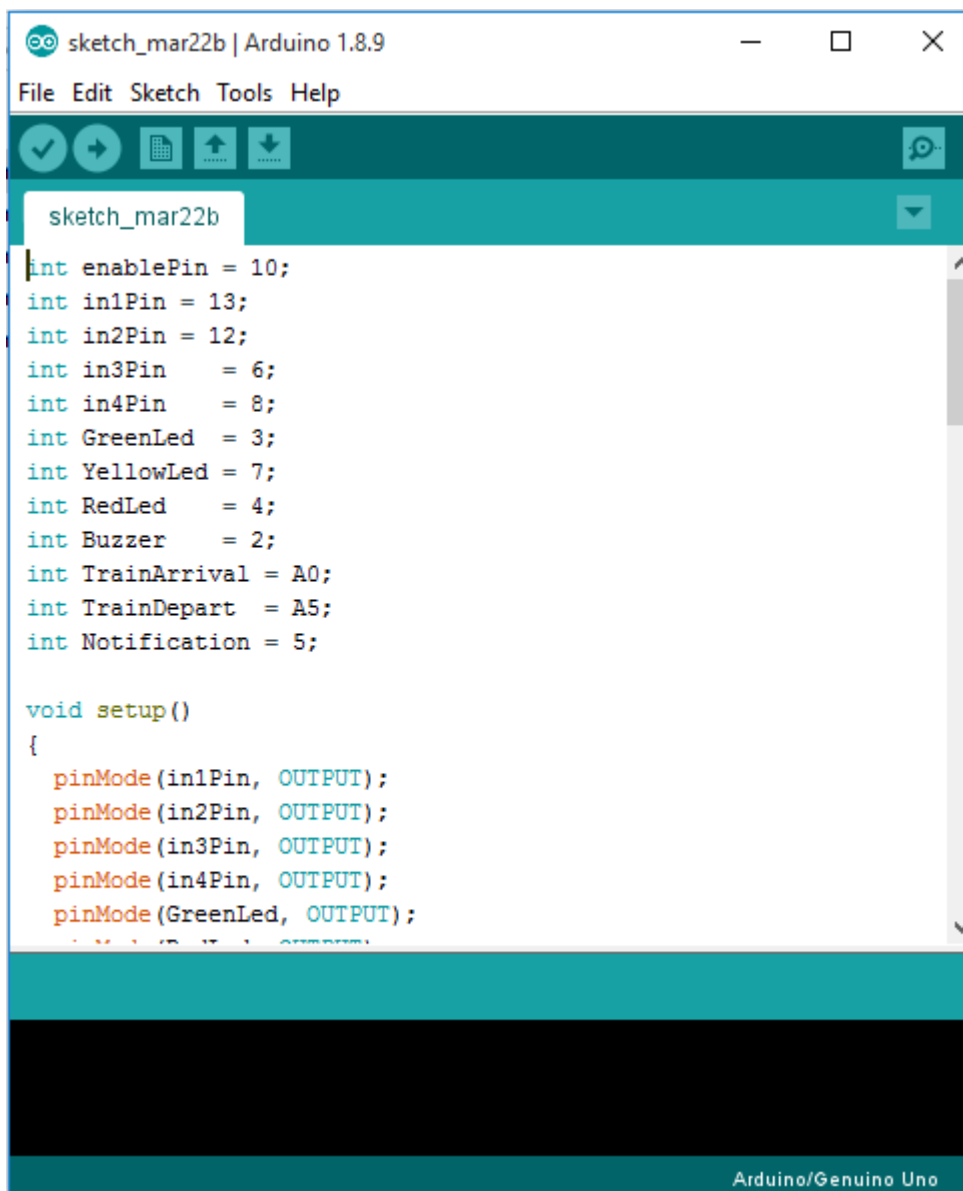
```
digitalWrite(in2Pin, forward);

digitalWrite(in3Pin, ! forward);

digitalWrite(in4Pin, forward);

}
```

B. IMAGE OF ARDUINO PROGRAMMING



```
sketch_mar22b | Arduino 1.8.9
File Edit Sketch Tools Help
sketch_mar22b
int enablePin = 10;
int in1Pin = 13;
int in2Pin = 12;
int in3Pin = 6;
int in4Pin = 8;
int GreenLed = 3;
int YellowLed = 7;
int RedLed = 4;
int Buzzer = 2;
int TrainArrival = A0;
int TrainDepart = A5;
int Notification = 5;

void setup()
{
  pinMode(in1Pin, OUTPUT);
  pinMode(in2Pin, OUTPUT);
  pinMode(in3Pin, OUTPUT);
  pinMode(in4Pin, OUTPUT);
  pinMode(GreenLed, OUTPUT);
  pinMode(YellowLed, OUTPUT);
  pinMode(RedLed, OUTPUT);
  pinMode(Buzzer, OUTPUT);
  pinMode(TrainArrival, INPUT);
  pinMode(TrainDepart, INPUT);
  pinMode(Notification, INPUT);
}
```

Arduino/Genuino Uno

Design of automated railway level crossing system for traffic-railway management
Case study: AALRT

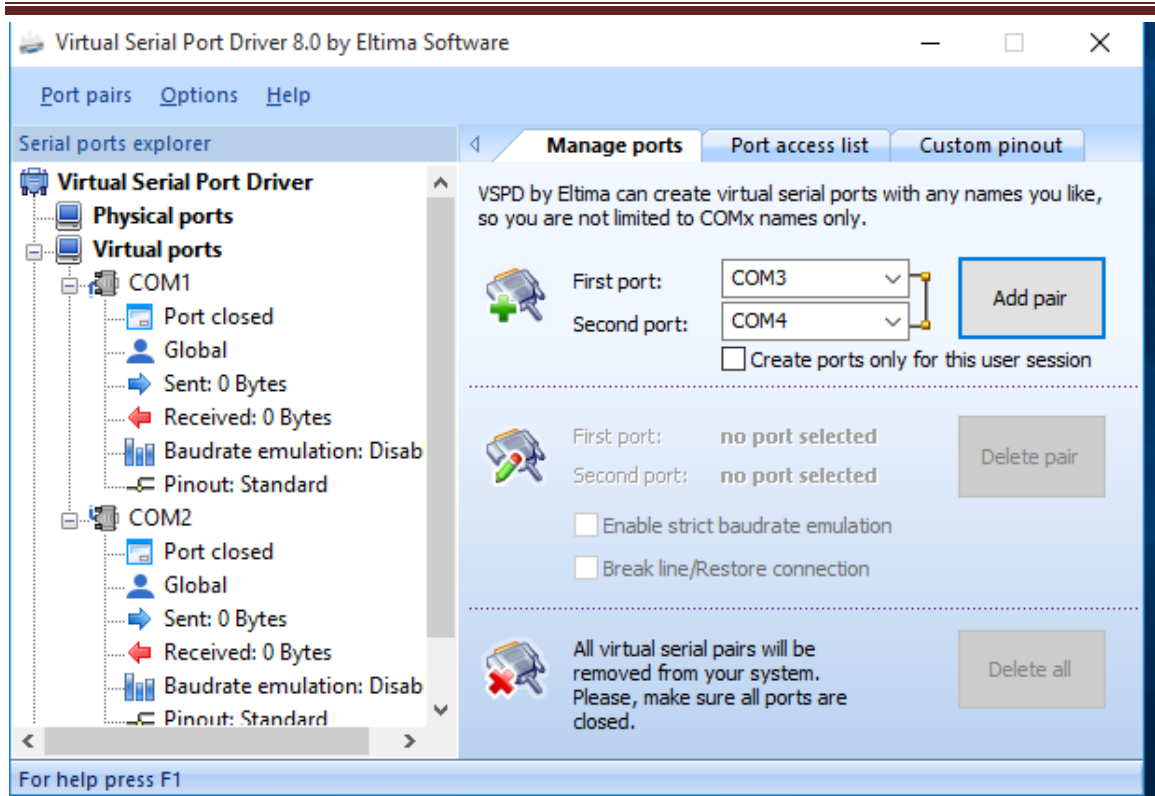


Figure 6-1 : Configure Virtual Serial Port Driver for interfacing two systems