

OBSTACLE DETECTION SYSTEM FOR RAILWAYS

Aloysius Lasantha Sanjay Sriwardene

(09/8718)



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Degree of Master of Science

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

July 2015

OBSTACLE DETECTION SYSTEM FOR RAILWAYS

Aloysius Lasantha Sanjay Sriwardene

(09/8718)



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Thesis submitted in partial fulfillment of the requirements for the degree Master of
Science

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

July 2015

DECLARATION BY THE CANDIDATE

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:  University of Moratuwa, Sri Lanka. Date:
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

The above candidate has carried out research for the Master's thesis under my supervision.

Signature of the supervisor:

Date

ABSTRACT

Trains are one of the oldest transportation systems used in the world. The first steam locomotive was built by Richard Trevithick and first commercial use was on the narrow gauge Middleton Railway in Leeds in 1812. There onwards with the development of railway transportation, locomotives improved in design from steam, diesel powered, electric and to hybrid during two centuries. With the development, more economical high speed locomotives have been introduced to the world.

Every transportation system consists of advantages and disadvantages to the public. The accidents are the most disadvantageous gain from the transportation systems. The railway transportation is one of the conventional system subjects to many accidents annually in most of the countries. High speed locomotives, insecure railway crossing, impatience vehicle drivers and animals are some factors to increase the railway accidents time to time. Comparatively to other transportation systems, accident preventive methods of locomotives are not in best use due to following reasons;

1. Noticing an obstacle on the railway at the correct time.
2. Identifying the braking distance for sufficient braking.
3. Limitation of braking due to derailing of locomotives from the railway.
4. Braking methods used are conventional types due to its complexity.

Therefore, there is a necessity for improving accident preventive methods in locomotives and image based obstacle detection system with driver assisting capabilities is proposed in this research. The objectives of this research are;

1. Design and development of a driver assisting interface with sensing mechanism to detect an obstacle and obtaining minimum distance to stop the locomotive.
2. Development of the overall system and validation.

The prototype comprises with two web cams, personal computer, arduino (UNO) hardware, and a servo motor.

One web camera (side camera) will be mounted to the side window of the locomotive cabin to capture images perpendicular to locomotive motion and the other camera (front camera) will be mounted on the front of the engine focusing the railway and will change its yaw angle by the servo motor connected through controller (arduino (UNO)) hardware to the personal computer.

Further, the front camera detects obstacles using a MATLAB program installed in the personal computer. The detection will be declared by beeping of an audible alarm where driver will be acknowledged the danger of hitting the obstacle instantly and by braking manually, the deceleration can be measured by another MATLAB program by processing the images taken by side camera and yaw of the front camera will be adjusted automatically. Increasing the braking gradually to move the obstacle from the danger zone to the safe zone shown in the front camera images and muting the audible alarm automatically, the locomotive can be stopped without hitting the obstacle.

The system was tested to a normal vehicle and to certain extent of trains since the limitations in testing the system in locomotives in Sri Lanka Railways and found to be satisfactory.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

ACKNOWLEDGEMENT

I wish to acknowledge my family especially my mother M.M.C.C. Sriwardene and my father E.A.U Sriwardene whom have advised me for higher studies in various occasions and all who have generously contributed their valuable time for this project assignment.

I would like to acknowledge the staff of the University of Moratuwa whom conducted the MSc course successfully have given me required knowledge and self confident to perform the research and especially Dr. Buddhika Jayasekera and Prof. Lanka Udawatta to encourage and advise me at the times of difficulties in performing the research work due to lack of information and tools. Further, I am grateful to Dr. Ranga Rodrigo of Electronic Department whom has guided me deeply into the theories to obtain best results and Prof. Nalin Wickramarachchi to advise me on various issues.

I am further grateful to AGM (M.D.&T.), Mr. Jaliya Seekkuge and Manager (Training), Mr. Parakrama Kulasiri of NWS&DB for arranging me a scholarship for the MSc studies from NWS&DB and to assist me to gather information from Sri Lanka Railways for my research work.

I further thankful to Assistant General Manager, Mr. Nalaka Bandara, Chief Engineer, Mr. S. M. Abewickrama, Engineer, Mr. Samaradiwakara, Engineer, Mrs. Wathugala, Engineers (Motive Power (HLS)), Mr. Malinga, Mr. Asela & Mr. Buddhika Sampath, Manager (Operation's Department), Mr. Ratnayake & Officer, Mr. Rajantha of Sri Lanka Railways for assisting me to collect necessary data and measurements for the thesis.

Table of Contents

DECLARATION BY THE CANDIDATE.....	i
ABSTRACT.....	ii
ACKNOWLEDGEMENT	iv
LIST OF FIGURES	vii
LIST OF TABLES.....	x
LIST OF ABBREVIATIONS.....	xi
LIST OF APPENDICES.....	xiii
1.INTRODUCTION	1
1.1 Literature Review.....	1
1.2. Motivation and Specific Objectives of the Thesis	9
1.2.1 Motivation.....	9
1.2.2 Specific Objectives.....	9
1.3. Sri Lanka Railway.....	10
1.3.1 Statistics of Railway Accidents	10
1.3.2 Railway Types in Sri Lanaka	12
2.DESIGN OF OBSTACLE DETECTION SYSTEM FOR ASSISTING DRIVERS.....	14
2.1 Concept of the Design.....	14
2.2 System Overview and Major Components	15
2.2.1 Front Camera	16
2.2.2 Servo Motor	17
2.2.3 Controller: Arduino Hardware (UNO).....	19
2.2.4 Personal Computer.....	20
2.2.5 Side Camera	21
2.3 Algorithms of the System	22

2.3.1 Obstacle Detection	22
2.3.2 Locomotive Speed Detection, Minimum Distance for Braking & Minimum Angle of Front Camera during Braking	25
2.3.3 Deceleration, Minimum Distance Braking & Angle of the Front Camera	28
2.4 MATLAB Simulation	30
2.4.1 MATLAB Simulation 01	30
2.4.2 MATLAB Simulation 02	38
2.4.3 MATLAB Simulation 03	42
3.FIELD TESTS	43
3.1 Field Tests of MATLAB Simulation 01	43
3.2 Field Tests for MATLAB Simulation 02.....	51
3.3 Field Tests for MATLAB Simulation 03.....	53
3.4 Field Tests for Overall System	54
3.5 Tests for Motion Fields (Vector Fields) and Motion Segmentation	55
4.CONCLUSIONS & RECOMMENDATIONS.....	112
REFERENCE LIST	113



LIST OF FIGURES


		Page
Figure 1.1	Schematic diagram of the obstacle detection system at a railway crossing	01
Figure 1.2	Sensor Locations & LED Indicators of Train Obstacle Detection System in Indonesia	03
Figure 1.3	Rail Scout	04
Figure 1.4	Representation of locomotive's running on same track and in same direction	05
Figure 1.5	Camera moving towards the scene	06
Figure 1.6	<div style="display: flex; align-items: center;">  <div style="font-size: small;"> <p>Top: Two images from a video shot. Color based segmentation would not provide object regions. Center: Clustering of point trajectories indicates regions with similar motion. Bottom: Segmentation based on these clusters provides object regions.</p> </div> </div>	07
Figure 1.7	Broad Gauge Railway Curvatures	13
Figure 2.1	Detection of Obstacle at DANGER ZONE and alarming	14
Figure 2.2	Functional Flow of the Proposed System in Assisting Driver	15
Figure 2.3	Overall System Block Diagram	16
Figure 2.4	Builtup Model Assembled in Locomotive Engine No. 861 of Sri Lanka Railways	16
Figure 2.5	Front Camera	17

Figure 2.6	Servo Motor- TowerPro (SG-5010)	18
Figure 2.7	Servo Motor Angles and Corresponding Durations	19
Figure 2.8	Lakduino UNO Rev4 Hardware	20
Figure 2.9	Personal Computer	21
Figure 2.10	Side Camera	22
Figure 2.11	Flow Chart and Link Equations of Section 2.3.1	22
Figure 2.12	Flow Chart and Link Equations of Section 2.3.2.1	25
Figure 2.13	Front Camera Geometry	29
Figure 2.14	MATLAB Simulation 01	31
Figure 2.15	Thresholding and Region Filtering of	
	MATLAB Simulation 01	34
Figure 2.16	Display Bounding Boxes and Number of Obstacles of	
	MATLAB Simulation 01	37
Figure 2.17	MATLAB Simulation 02	41
Figure 2.18	MATLAB Simulation 03	42
Figure 3.1	Overall Arrangement of Finger Tip Test	43
Figure 3.2	Verification Test of MATLAB Simulation 01	44
Figure 3.3	Locomotive Travels at Constant Speed	46
Figure 3.4	Collision of Two Locomotive Engines	48
Figure 3.5	Built up Model Assembled in Locomotive Engine	
	Class Y 689 Load R for Testing	49
Figure 3.6	Selected Obstacle, Locomotive Engine	

	Class S1 1SD 16308	50
Figure 3.7	Display of MATLAB Simulation 02 for 2 nd Set of Data	52
Figure 3.8	Changing Angle from 40deg to 20deg	53
Figure 3.9	Improvement of SAFETY ZONE Margins by Modifying MATLAB Simulation 01	55
Figure 3.10	Identifying the Focus of Expansion from Motion Vector Fields	56
Figure 3.11	Adapting Video to Workspace, Simulink Block for analyzing Final 10 Nos. of Frames	57
Figure 3.12	Measuring Actual Heights of Objects captured from Web Camera	80
Figure 3.13	Image of Square Hard Board (100mm x 100mm) at 1100mm Distance	81
Figure 3.14	Locomotive engine travels in a constant speed	82
Figure 3.15	Pixel values of the cursor point	83
Figure 3.16	Collision of Locomotives	88
Figure 3.17	Locomotive engine collision with road vehicles	97
Figure 3.18	Dog was hit by a locomotive	100



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF TABLES

		Page
Table 1.1	Statistics of Annual Railway Accidents from Year 2000	11
Table 1.2	Sri Lanka Railway Administrative Report 2011	12
Table 3.1	Obstacle Detection Distance	50
Table 3.2	Trial of Varying Speed of Locomotive Engine, Class Y 689 Load R	52
Table D	Financial Expenditure for preparing Prototype Model	118



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF ABBREVIATIONS

Abbreviation	Description
A.H.V.D	Horizontally- Vertically Different Powered
a	Acceleration (m/s^2)
B.G.	Broad Gauge
CCTV	Closed- Circuit TeleVision
COM	Communication Port
CPU	Central Processing Unit
C1	Factor to convert kmph to m/s (C1= 0.277777777777778)
E	Global Energy Functional
F	Focal Length
FOE	Focus of Expansion
GND	Ground
GPRS	General Packet Radio Service
HDTV	High Definition TeleVision
h	Hieght of the front camera center to ground level
ICSP	In- Circuit Serial Bus
I_t	Derivative of the image intensity along time
I_x	Derivative of the image intensity along x axis
I_y	Derivative of the image intensity along y axis
K	To convert radian angle to degree angle (K = 57.29577951)
LPT	Line Print Terminal



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF ABBREVIATIONS

Abbreviation	Description
l	Length from Front Camera Center to considered Sleeper
N	N th frame
n	n th frame
P	Principle Point
PWM	Pulse With Modulation
RAM	Random Access Memory
R'G'B'	Additive color module, Red, Green & Blue
s	s th distance where V=0
U	Velocity of an object at the starting of s th distance
USB	Universal Serial Bus
u	Horizontal optical flow
V	Velocity of an object at s th distance
v	Vertical optical flow
w	Speed of the Locomotive
YUY2	FOURCC Code for identifying a digital, color- difference component video picture format
Y'	Component of Gamma corrected R'G'B'



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF APPENDICES

Appendix	Description	Page
Appendix- A	Letter of Request	115
Appendix- B	Letter of Obtaining Statistics from Railway	116
Appendix- C	Letter of Requesting to Test Prototype	117
Appendix- D	Financial Expenditure for preparing Prototype	
	Model	118



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk