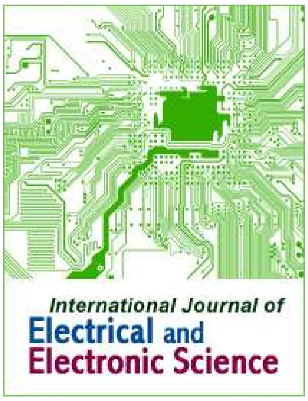
International Journal of Electrical and Electronic Science
2015; 2(2): 6-16
Published online August 10, 2015 (http://www.aascit.org/journal/ijees)
ISSN: 2375-2998

American Association for Science and Technology



Keywords
Ergonomics,
Computer Vision,
Infrared Camera,
Locomotive,
Train-Elephant Accident

Received: July 13, 2015
Revised: July 27, 2015
Accepted: July 28, 2015

Intelligent Vision Based Driver Assisted System for Trains – Elephants Accidents

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Citation
A. K. Kulatunga, J. Gowrynathan, R. Ekanayake, D. Athauda, C. Chandrakumar. Intelligent Vision Based Driver Assisted System for Trains – Elephants Accidents. *International Journal of Electrical and Electronic Science.* Vol. 2, No. 2, 2015, pp. 6-16.

Abstract
Elephant - train accidents significantly affect to increase mortality of elephants in Asian countries like Sri Lanka & India. In the year 2011, 10 elephants were by train accidents. In India Wild life organizations are doing researches and have found some preventive actions for this problem. By analyzing movement zones, crucial seasons, crucial paths, and crucial time periods & by training people emergency actions have been decided. Though there are preventive actions from outside of the locomotive cabs there are no any preventive actions from inside the locomotive cabs. But in Sri Lanka the awareness of this problem is not in considerable level. Though there are researches to prevent elephant train accidents by different ways until now there is no any research for improve vision based driving assisting system. In this research fleet of locomotives driver cabs were evaluated base on ergonomic guidelines and intelligent vision system is developed to overcome lack of visibility which is the main course for elephant accidents. The real-time long range images are captured and can be even process real-time to indicate drivers if it detect live elements on the tracks.

1. Introduction

Elephant - train accidents significantly affect to increase mortality of elephants in Asian countries like Sri Lanka & India. In the year 2011, 10 elephants were by train accidents (www.Lanka help magazine.lk). In India Wild life organizations are doing researches and have found some preventive actions for this problem. By analyzing movement zones, crucial seasons, crucial paths, and crucial time periods & by training people emergency actions have been decided. Though there are preventive actions from outside of the locomotive cabs there are no any preventive actions from inside the locomotive cabs. But in Sri Lanka the awareness of this problem is not in considerable level. Though there are many researches focusing on human elephant conflict many at the moment try to identify elephants movements using different racking mechanism. Li et al. have developed a partial information broadcasting scheme as a decentralized tracking strategy [1]. They propose two broadcasting policies by balancing the residual energy among sensors and reducing time delay. Gupta and Nathawat [2] have used GIS technology to systemize, standardize and manage enormous amounts of spatial data generated by the movement of elephant in the background of disturbance to the landscape.

The study is aimed on how elephants are distributed and their utilization patterns of different areas in different seasons. Environmental communication through an analysis of words and language used by journalists is tried by Nazareth et.al. [3] This research suggests that the technical knowledge and awareness of journalists should be improved in order to cover the elephant-men conflicts. Weerawansha et al. [4] tried to identify inherent problems related to elephant accidents and suggested a sustainable solution with the help of modern communication and scanning technology without vast investments. Using low frequency communication signals to repel elephants and implementing long range infra-red cameras are the two basic approaches proposed to prevent these disastrous accidents [5]. Though there are researches to prevent elephant train accidents by different ways until now no any research for improve vision based driving assisting system. This problem not only affects the wild elephant but also to the railways and the track needs to repair due to these accidents cost millions of rupees.

Figure 1. *Damages caused due to the accidents.*

Even though, there are no derailments always, there some instances where passengers stranded inside thick forest areas due to the derailments of night passenger trains (night mail). When statics of the train- elephant accidents investigated, it can be seen that, there are several locations where frequent accidents taken place. In addition, different time period of the night as well as different months of the year where frequent accidents are taken place. When locomotive drivers whom met with an elephant accidents are interviewed majority of them highlight the lack of visibility is the main cause for the accidents as when they recognize the elephants they could not apply train brakes on time due to short distance between elephants and the trains [7]. In addition, drivers always complain about the over grown thick vegetation by the side of the track. Even though some speed restrictions were imposed some elephant corridors sometime, they use to complain that it is impossible to control speeds of the locomotives due to sudden gradient variations of the track as well non availability of speedometers of locomotives due to poor maintenance. In addition, many use to complain that intensity of head lights also not adequate to sight the elephant at a reasonable distance to avoid accidents and sharp curves available in some sections. When visibility is concerned, it can happen due to two reasons: due to the outside aspects or inside aspects [8]. The outside aspects are considered the reasons for the lack visibility from the surrounding of the track such as vegetation besides tracks, sharp curves, (Shown in Figure 2), trapping of elephants between the earth cut and on embankments when train arrives, and the inside aspects are from locomotive itself such as locomotive cab arrangement, positioning of driver seat and most importantly the angle of visibility depend on the type of locomotive and intensity of head lights (shown in Figure 3). In addition to the site specific and cab specific problems there is another reason which attracts wild elephant closer to the railway tracks [9]. That is due to passenger's irresponsible behavior of throwing food garbage out of the windows by the sides of the tracks.

Earth cuts

Grown vegetation

Embankment

Sharp curves

Figure 2. *Site specific visibility problems.*

Figure 3. *Actual range of visibility at the driving seat of different locomotive cabs.*

Figure 4. *Passenger factors which attract wild elephants to the track.*

Though there are some preventive measured were taken from time to time such as removing of vegetation beside the track, imposing of speed restrictions, placing of some sign boards and provide some awareness sessions for the drivers by the wild life department has not impacted on mitigating this problem [10]. When explore the literature there are several attempts by our regional neighbor India since they too face similar problems especially in west Bengal region [2] and some issues in African continent as well. However, up to now, except for some low technical involvements, none of the researches tried to analyze this problem in an engineering point of view and to adapt latest technological developments to mitigate this problem. Therefore, this research aimed at detail investigation on visibility issues of the drivers and to assist them with intelligent vision based techniques to mitigate this problem. Rest of the paper is arranged as follows: The methodology of the research is presented in Section 2, analysis and results are in Section 3, followed by the Proposed Solution in the section 4 and conclusion in Section 5.

2. Methodology

The methodology proposed in this research consists of several stages. Initially accident related data collections and information gathering have been performed. This was done by collecting the primary records available with Sri Lanka railway's departments Anuradhapura Control room, sources from wild life department, interviewing the drivers whom met with elephant accidents and observing the respective sites by cab rides during the day time and night time as well.

In the second stage, data and information were analyzed to identify the main courses for the accidents. This was done based on the statistics available, referring geographical information maps, video recordings of the particular stretches of the tracks during the cab rides and facts shred by the drivers. Then main causes were identified and grouped them in to: locomotive related problems, site related problems and driver related problems. In the next stage, factors which affect each of these three main causes and possible further investigating tools and techniques were identified. Finally, possible technical solutions were suggested to mitigate the train-elephant accidents. The schematic representation of the methodology is presented in figure 5.

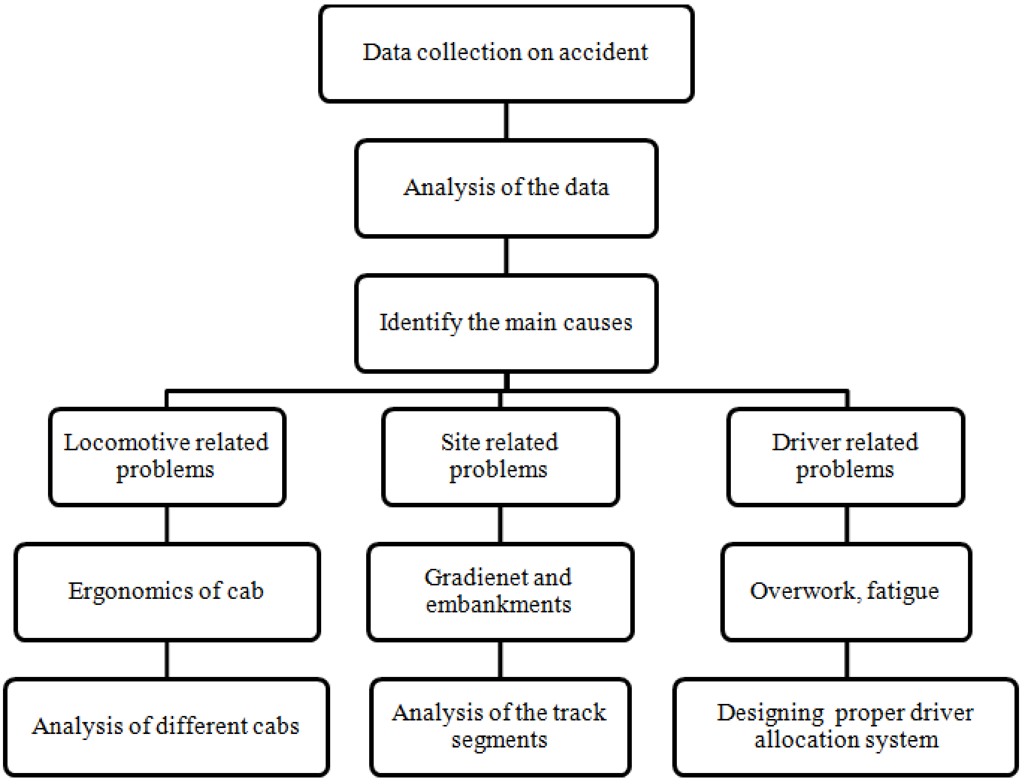


Figure 5. *Schematic representation of Methodology.*

Figure 6. *Map of the railway track segments.*

3. Analysis and Results

3.1. Analysis 1: Accidents

Mainly analysis was carried out in several directions. The first analysis was done about the accidents for the limited time period starting from august 2008 to April 2011; approximately 3 years. The locations where accident occurs and severity of the accidents etc. were investigated and summarized form of the results are given in Table 1 and Figure 5 and Figure 6. It can be seen that during this time period most of the accidents occurred in both branches (Trincomalee and Batticaloa) Eastern line. However, some segments of Northern and Mannar line was not relayed at that time. Even though we wanted to analyzed some information about the exact location, when (time) these type of accidents occur, what was the locomotive type which met with respective accidents, what was the weather condition when these accidents occurred, etc. were not recorded and available with SLR authorities.

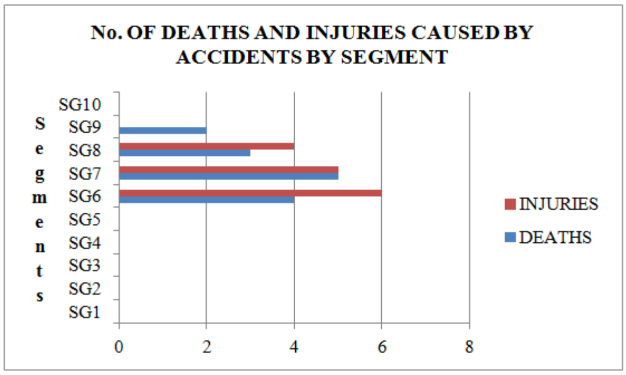


Figure 7. *Bar chart of deaths and injuries.*

Table 1. *Number of deaths and injuries by segments.*

Date	Type	Train	Place	Segment	deaths	Injuries
2008-08-18	M6	7081	PUW/GOA	SG6	1	1
2008-08-25	M4	6079	KRA/PUW	SG 6	1	1
2008-12-19	M4	6079	133,1/2HBN/HKT	SG 7	0	1
2008-12-23	M4	6079	GOA/HRG	SG 8	1	0
2009-01-05	M9	7084	GOA/HBN 135,1/2-3/4	SG 6	0	1
2009-03-26	M9	7084	105,1/2KLW/MLG	SG 6	0	3
2009-05-09	M2	7887	142 KNI/GOA	SG7	1	0
2009-09-26	M4	6084	WKD/MPD	SG 9	1	0
2009-11-23	M4	6079	MPT	SG 9	1	0
2009-12-17	M9	7083	GOA/KNI	SG 7	0	1
2010-01-02	M4	6084	HRG/GOA	SG 8	0	1
2010-01-02	M9	7083	GOA/ABR	SG 7	0	1
2010-05-07	M9	7084	APR/GOA	SG 7	0	1

Date	Type	Train	Place	Segment	deaths	Injuries
2010-07-24	M2	Oil RR Boc	GOA/HRG	SG 8	2	0
2010-10-03	M9	7084	KWI/GOA	SG 6	2	2
2010-10-21	M4	6083	GOA/HRG146.40	SG 8	0	2
2010-10-28	M9	7083	HBN/GOA-131.25	SG 6	0	1
2010-12-14	M9	7083	GOA/KNI-142.75	SG 7	0	1
2011-01-11	M6	RB	GOA	SG 8	0	1
2011-03-11	M2	7883	GBY/KNI	SG 7	2	0
2011-03-26	M2		KNI/GOA	SG 7	hit & run	0
2011-04-13	M6	7081	GOA/KNI	SG 7	2	0

3.2. Analysis 02: Visibility Analysis for Locomotive Cabs Driving Seat

Since the locomotive drivers pointed out that lack of visibility is the main problem, visibility related to ergonomics analysis was carried out in different types of locomotives. Amount of angle (visibility) the driver can see through windscreen is the main factor to cause accidents during day and night, since the driver has no other assisted way to identify the object such as cameras inside the cab. Hence, it is very important to calculate the visibility angle that driver can see through for different types of locomotives. The visibility from the driving seat is measured while operation of locomotive was tested. Since we could not find any previously used approach for similar type of analysis, we defined visibility angle and relative visibility percentage as shown below;

Visibility to the driver from different cabs

Θ = Visibility angle

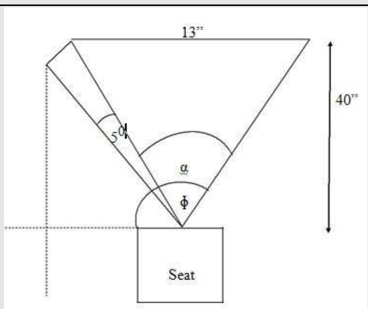
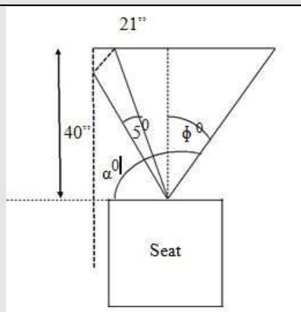
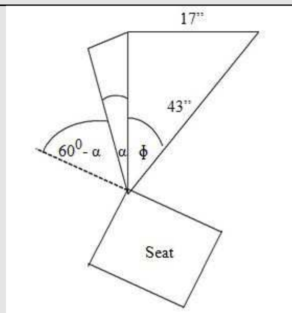
If the $\Theta^{0} = 180^{0}$, visibility = 100%.

If the $\Theta^{0} = 0^{0}$, visibility = 0%.

Visibility= (Θ x 100%) / 180

Based on this principle we calculated angle of visibility of several type of locomotives which has the possibility of operating in these stretches and results are presented in Table 2.

Table 2. *Percentage of Visibility calculations of different types of locomotives.*

Locomotive type	M5 & W3	M7	M2 & M6
Figure			
Calculation	$\tan(\alpha/2) = a/2b$ $\tan(\alpha/2) = 0.1625$ $\phi = 90 + (\alpha/2)$ $\Theta = 90 + (\alpha/2) - 5$	$\tan\phi = 21/(2x40)$ $\phi = 15$ $\alpha = 90 + 15 = 105$ $\Theta = 105 - 5$	$\tan\phi = 17/43$ $\phi = 22$ $\alpha = 5$ $\Theta = \phi + 60^{0} - \alpha$
Angle of visibility (Θ)	95^{0}	100^{0}	77^{0}
Percentage of visibility (%)	52.77	55.55	42.77

3.3. Analysis 03: Anthropometric Data Analysis

Even though the visibility problem is overcome, reacting speed to an emergency situation is crucial. Therefore, further ergonomical analysis was performed on local anthropometric measurements, whether different types of locomotives have any difficulty for operating and availability, visibility of important gauges (speedometer and vacuum pressure etc.) and devices (focus of Headlights, horns, vipers etc.). This is very important requirement as most of the locomotives were about 40 to 60 years old and most probably many of the were not designed considering ergonomic principles or at least based on Anthropometric data of our region. Since speed is a most important factor to cause train accidents. Major problem in this case is the train cannot be stopped in an emergency case [11]. The driver needs considerable time to stop the train. Response time in an emergency stop has divided to three categories: Capture time, Reaction time and Breaking time. If the speed is high the ability to capture unexpected disturbances will reduce. Also the breaking time is much higher. Following section presents Anthropometric data comparisons with reachability to different levers etc. during the operating the locomotive by the drivers[12]. This comparison was done based on maximum allowable extension of arms in seating posture for ordinary men of south Asian region. Table 3 shows the actual reachability distances in inches of 5 different engine models of aging from 35 to 60 years old. Based on the measurements it can be conclude that though these locomotives are fairly old designs still there is no significant reachability problems for essential operating levers.

Table 3. Anthropometric data comparisons for reachability of operating levers.

Lever/ Equipment	Approved maximum distance (For male in inches) / Actual distances (in inches)	Engine type				
		M2	M5	M6	W3	M7
		Engine number				
		626	767	796	683	807
Dynamic brake	33.8	13	26	21	26	31
Throttle	33.8	27	24	19	26	26
Horn	33.8	23	22	23	19	23
Reverser	33.8	22	**	**	31	**
Vacuum brake	33.8	10	24	27	**	32
Emergency brake	33.8	23	23	22	24	**

** Not available for particular type

3.4. Analysis 04: Locomotive Operating Condition Survey

Table 4. Point scale of the condition of operating of each device.

Weightage	Description
5	Operations cannot be done or high risk for accidents without this
4	High risk for accidents
3	If this is available possible faults can be avoided including emergency situations
2	Easy to identify possible faults and mistakes
1	Reduce difficulties of driver while driving
0	Equipment/ gauges are not working

As previously mentioned, operating condition of the locomotive also plays a significant role towards accidents. Therefore, a survey was carried out to investigate whether basic gauges and devices which are important for safety and smooth operation of the locomotive. A point rating scale was use to evaluate level of operation of each of the devices we considered and it is given in Table 4.

Based on the survey carried out, percentage risk factor was calculated as follows;

$$Percentage\ risk\ avoidance = \frac{Earned\ points\ X\ 100\%}{Maximum\ possible\ points} \quad (1)$$

The maximum permissible points will vary from one locomotive type to another depend on the originally available devices and gauges. There are several devices also play an important role in visibility related aspects for example: head lights, Vipers etc. Therefore, further analysis was done to calculate cumulative visibility aspects with the assistance of points earned by each locomotive during the survey and relevant results are summarized in the Table 08.

Table 5. Points earned of different locomotive cab types (maximum value is 2 points).

Earned points	Engine type				
	M2	M5	M6	W3	M7
	Engine number				
Equipment/ Gauge	626	767	796	683	807
Dynamic brake	5	5	5	5	**
Throttle	5	5	5	5	5
Vacuum brake	**	**	5	**	5
Horn	5	5	5	5	5
Air brake	**	**	5	**	5
Air pressure meter	2	2	2	2	2
Vacuum pressure meter	2	3	2	2	2
Break pressure meter	2	2	2	2	2
Reverser	0	**	2	**	**
Fuel level meter	0	0	0	0	0
Water temperature meter	0	0	0	0	0
Speedometer	0	0	0	0	5
Viper- Front left	0	1	0	1	0
Viper- Back left	0	1	1	0	0
Viper- Front right	0	1	1	0	0
Viper- Back right	0	1	1	1	0
Head lights	4	2	2	2	2
Spot lights	0	0	0	1	0
Battery- Voltmeter & Ammeter	1	0	1	1	1
Fire extinguishers	5	5	5	5	5
Emergency brake	5	5	5	5	0
Emergency tool kit	2	1	2	2	2
Notches for wheels	0	2	2	2	0
Emergency engine stop	0	0	4	4	0

Earned points	Engine type				
	M2	M5	M6	W3	M7
	Engine number				
Fault indication lights	0	0	0	0	0
Fire	0	0	0	0	0
General warning	0	0	0	0	0
Pneumatic	0	0	0	0	0
Dynamic brake on/ warning	0	0	0	0	0
Temperature	0	0	0	0	0
Power fault	0	0	0	0	0
Blower fault	0	0	0	0	0
Hot engine	0	0	0	0	0
Engine fault	0	0	0	0	0
Ground fault	0	0	0	0	0
Compressor oil pressure	0	0	0	2	0
Engine oil pressure	0	0	0	2	0
Wheel slip/ slide	0	0	0	2	0
Cooling water level	0	0	0	2	0
Engine over speed	0	0	0	2	0
Air flap closed	0	0	0	2	0

** No need for this type

Table 6. *Earned points for factors of visibility.*

Parameter	Earned point	Engine type				
		M2	M5	M6	W3	M7
	Maximum point	Engine number				
		626	**767**	**796**	**683**	**807**
Visibility angle	50	21	26	21	26	28
Ability to observe both sides	5	0	5	0	5	5
Front right viper	5	0	5	5	5	0
Front left viper	5	0	5	0	5	0
Back right viper	5	0	5	5	0	0
Back left viper	5	0	5	5	0	0
Head light	30	25	15	15	15	15

An example calculation is shown below for M2 locomotives which operate in these lines more frequently.

Cumulative Visibility = (Total earned points x 100%)/100= 38 x100%/96 = 39.58%

Results set 03

Table 7. *Percentage risk avoidance of different types of locomotive cabs.*

Lever/ Equipment	Engine type				
	M2	M5	M6	W3	M7
	Engine number				
	626	**767**	**796**	**683**	**807**
Earned Points	38	41	57	57	41
Maximum possible points	96	94	106	99	99
Percentage risk avoidance (%)	39.58	43.62	53.77	57.57	41.41

Therefore, it can be concluded that least visible locomotive type with least percentage risk avoidance shown in locomotive type M2 followed by M7 with present conditions. The highest percentage risk avoidance is shown in M6 type locomotives.

4. Proposed Solution to Enhance the Driver Visibility

Since lack of visibility during the night is the main problem for the train elephant accidents we come up with novel approach which has not been used in anywhere for railways or similar applications to enhance the visibility aspects. Here we selected a long range night vision camera which can be operated in outdoor environment and it was mounted on the short hood side of the locomotive (As shown in Figure 8). Though this solution needs considerable investment (SLR 1 Million approx), when visibility was concerned, even if we use locomotives which has dual cab with flat nose, will have a problem with lack of visibility during the nights. Some of the specifications of the camera we have selected are given in Table 05.

Table 8. *Night vision camera specifications.*

Parameter	Specification
Field of view	24° (H) x 18°(V) with 19 mm lens
Field of view with 2X extender	12° (H) x 9°(V) with 19 mm lens
Focus	Fixed
Camera weight (Lens + Batteries)	660 grams
Spectral range	7.5 to 13.5 µm
Thermal sensitivity	<50 mK at f/1.0 at +25^{0}C
Image frequency	8.3 Hz Pal / 7.5 Hz NTSC
Electronic zoom	2X
Image processing	Digital Detail Enhancement (DDE)
Operating temperature range	-20°C to +60°C
Humidity non condensing	5% to 95%

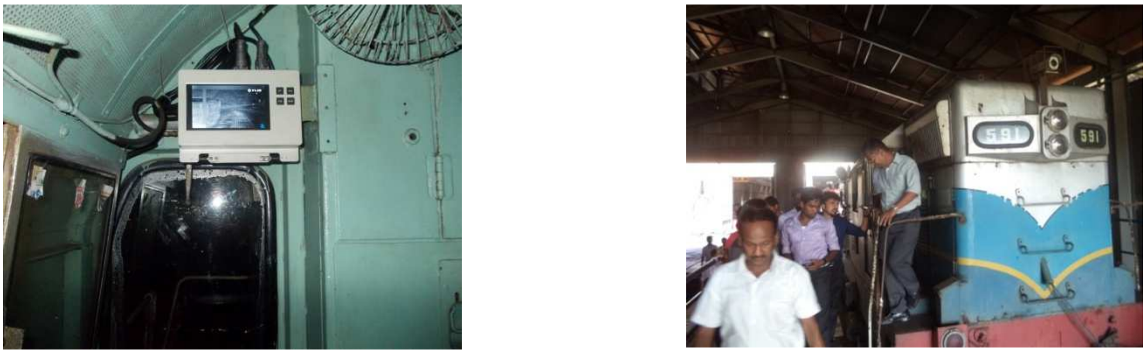


Figure 8. *Camera and display position.*

Table 9. *Visibility comparison.*

Situation	Visibility range /(m)
Day time (day light conditions)	0 - 800
Night (with Head lights only)	0 – 40
Night (with night vision camera)	0 – 600

Based on the initial trials it can easily recognize any live object within the range of 0-400 m and with more focus attention up to 600m. Further, this camera will assist driver to easily recognize life animals on the track with red spot. However, this method also has some limitations; socially in the bends the visibility range will be shorter. Further, if a driver attention is not goes into the display panel, there is a possibility that train will reach closer to the elephants without noticing. Therefore, there are two proposals have been experimenting at the lab level currently to overcome them.

View Straight stretch Curve

Day time

Night view with headlight

Night view with night vision camera

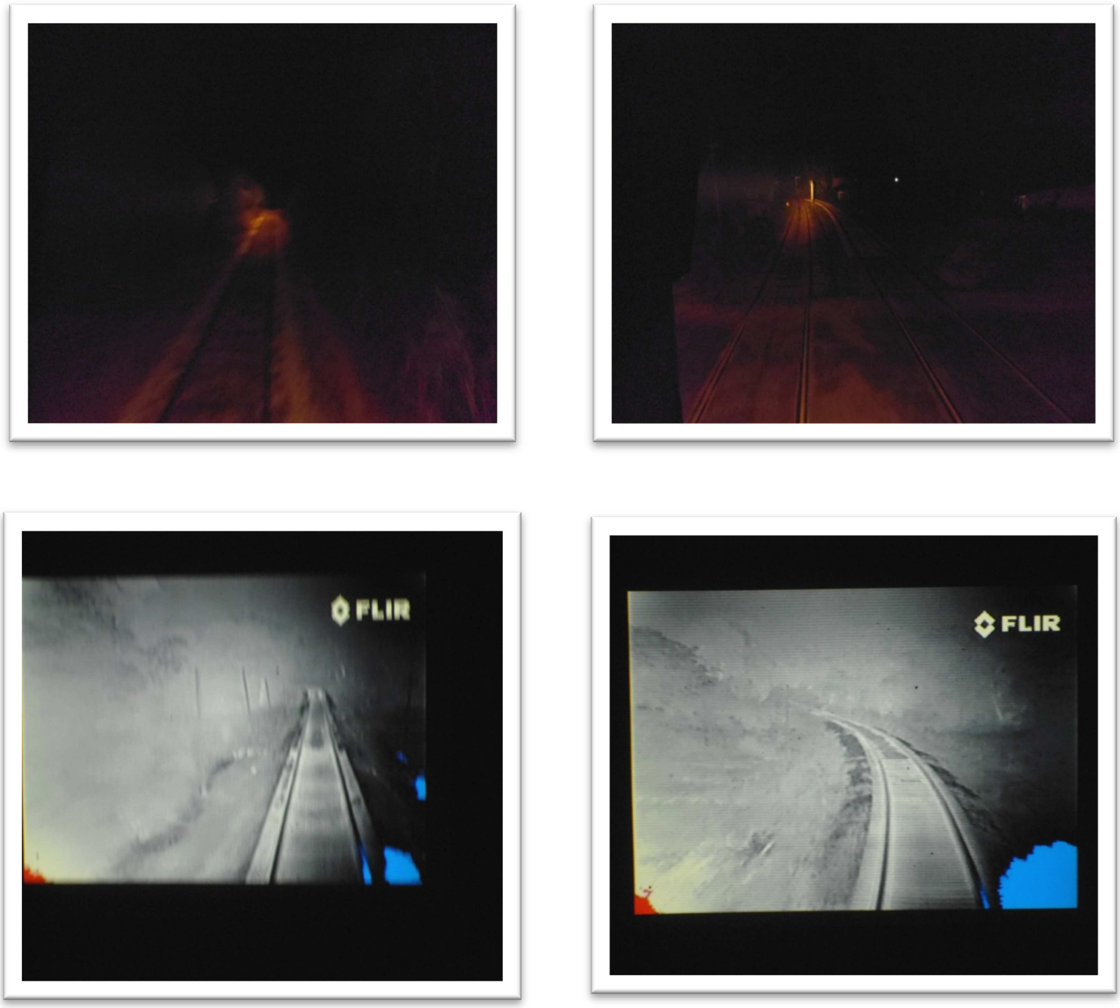


Figure 9. *Visibility difference during the day, night with headlights and night vision camera.*

5. Conclusion

The train elephant accident mitigation problem was investigated in this paper. The main causes for the accidents were investigated and categorized and relevant data related to accidents were analyzed with location wise and severity wise as well. Since many complain come from locomotive operators about visibility, we carried out ergonomical study of the different locomotive cab as well. Based on these findings we proposed intelligent mechanism which has enhance night visibility easily. Though the proposed solution is considerable investment, due to its smartness it can be use for similar situations. Currently, one pilot study was carried out with the proposed solution and it provides visibility to break in adequate distance of 600m with approximately 50 kmph. There are some constraint at the moment specially to get more visibility range in the curves and to get driver s attention, in case driver is not watching the display frequently and some discomfort for the drivers to view the display panel due to high intensity of the scan with low cab lights during the night. Though these problems also addressed by the researches in lab level, these knowhow has not been transferred to the railway authorities due to their unprofessionalism to get technology transferred properly with right terms and conditions. However, in future more elaborated publication of these techniques will be published.

Acknowledgements

Mr. Primal Madushanka, Mr. S. Wickramaratne, Mr. MangalaPerera and Mr. A. Perera of Railways Heritage Trust of Sri Lanka and officials of Sociology Division of Wild Life Department of Sri Lanka.

References

[1] Jianghai Li, Qing-Shan Jia, Xiaohong Guan, and Xi Chen, “Tracking moving object via a sensor network with a partial information broadcasting scheme”, Proceedings of the 48th IEEE Conference on Decision and Control, Vol.181, pp. 4733-4753, 2011.

[2] H.S. Gupta, and M.S. Nathawat, “Elephant Movement in Kara C.D. Block – A Spatio-Temporal Analysis, Journal of the IUCN/SSC Asian Elephant Specialist Group, pp. 21-24, 2009.

[3] Marianne de Nazareth, and S. Nagarathinam, “Human Elephant Conflict and the Role of Print Media”, Journal of the IUCN/SSC Asian Elephant Specialist Group, pp. 38-41, 2012.

[4] G. Weerawansha, A.K. Kulatunga, and S. Samaraweera, “Early Detection of Wild Elephants to Prevent Train-Elephant Accidents”, International conference on Building resilience 2011, Kandalama, Sri Lanka

[5] B. M. A. Oswin Perera, “The Human-Elephant Conflict: A Review of Current Status and Mitigation Methods”, Gajaha 30, pp.41-52, 2009.

[6] H. S. Gupta and M. S. Nathawat, “Elephant Movement in Karra C.D. Block – A Spatio-Temporal Analysis”, Gajah 31, pp.21-24, 2009.

[7] Anil Kumar Singh, Ashok Kumar, Aniruddha Mookerjee and Vivek Menon, “A scientific approach to understanding and mitigating elephant mortality due to train accidents in rajaji national park”, Wildlife trust of India and the international fund for animal welfare of a rapid action project on understanding and mitigating the problem of elephant mortality due to train hits, September 2001.

[8] G.J. Steina, P. Muckaa, T.P. Gunstonb and S. Badurac, “Modelling and simulation of locomotive driver’s seat vertical suspension vibration isolation system”, International Journal of Industrial Ergonomics 38, pp.384–395, 2008.

[9] Parviz Palangpour, Ganesh K. Venayagamoorthy and Kevin Duffy, “Time-delay neural network based predictions of elephant distribution in a South African game reserve”, Swarm Intelligence Symposium, 2006.

[10] Pieter J.Venter and Johan J.Hanekom, “Automatic detection of African elephant (Loxodonta africana) infrasonic vocalizations from recordings”, bio systems engineering 106, pp.286-294, 2010.

[11] John R. Wilson and Beverley J. Norris, “Rail human factors: Past, present and future”, Applied Ergonomics 36, pp.649–660, 2005.

[12] M.G. Stevenson, N. Coleman, A.F. Long and A.M. Williamson, “Assessment, re-design and evaluation of changes to the driver's cab in a suburban electric train”, Applied Ergonomics 31, pp.499-506, 2000.