Evaluation of Fixation and Reaction Gaze Points near Speed Humps on Urban Roads

Satish Chandra[1], Ravi Sekhar Chalumuri[2]*, Kamini Gupta[3] and Neelima Chakrabarty[4]

[1] *Director, CSIR-Central Road Research Institute, Delhi-Mathura Road, New Delhi-110025*
[2,4] *Scientist, CSIR-Central Road Research Institute, Delhi-Mathura Road, New Delhi-110025*
[3] *Technical Officer, CSIR-Central Road Research Institute, Delhi-Mathura Road, New Delhi-110025*
*Corresponding Author: Ravi Sekhar Chalumuri, *chalumuri.ravisekhar@gmail.com*

Abstract

Isolated speed humps are extensively used as speed calming measures for the motorized vehicles on different categories of urban roads. Most of the urban roads in India are provided with either a trapezoidal or circular type of speed hump based on the category of the road. The height of these vertical calming measures influences the percent reduction of speed at the crown of the speed hump. It is observed that the passenger motorized vehicles are not reducing their speeds before the speed hump even when the speed hump is higher. The objective of this study is to evaluate the driver perception and reaction distance near the speed hump and thereby to study the sensitivity of these parameters with different age groups of drivers. For this, drivers of different ages (a total sample size of 5 subjects) are considered for experimentation for real time eye-tracking. The experimental results for image sequences of all subjects eye tracking are examined. The visit duration or dwell time for the area of interest (AOI) is estimated and compared among various ages of driver. The speed data is also collected using Velocity-Box (V-box) along with Eye-tracking data of each driver at the identified location. The collected eye tracking experiment data are being analyzed using statistical techniques. Regression analysis between vehicular speed (V) and fixation count (FC) was carried out and identified that the power model is the best fit for the collected data. These visualization data are considered to reveal characteristics of fixation and reaction gaze points near the identified speed humps. From the study results, it was observed that driver attention between 0-20m is double than the attention between 20-40m. The driver with the age group between 20 and 25 years had 48% AOI of visit duration and for age group 35-40 is 67%.

Keywords

Speed Hump, Eye Tracker, Gaze plots and Heat Maps, Regression Analysis

1. Introduction

There were about half a million road accidents occurred in India, which killed about 0.15 million people and injured about half million people. There were about 0.45 million road accidents that took place in India during the year 2019 (MoRTH 2019) This resulted in 0.15 million deaths and 0.45 million injuries on Indian Roads. Out of 40% on urban roads and 60% on interurban and rural roads. A 74.4% of road accidents in India are mainly caused due to driver's fault, this including over speeding, lane discipline and driving under the influence of alcohol or drugs. It was observed from the road accident statistics that the maximum number of fatalities were seen in the age group of 18 to 34 (50%). India, as a signatory to the Brasilia declaration, intends to reduce road accidents and traffic fatalities by 50% by 2022 (Mishra 2017).Therfore road safety should become an issue of national security. The severity of road accidents can be reduced by reducing the speed of vehicles (Zainuddin et.al, 2012). Traffic calming measures have played an important role in enhancing road safety by ensuring lowered driving speeds.

Traffic calming techniques have emerged primarily as a society requirement for the road safety. Proper implementation of traffic calming techniques definitely reduces the accidents, pollution and makes the neighborhood more livable. Isolated speed humps are extensively used as speed reduction techniques of the motorized vehicles on any type of urban road. In India, most of the urban roads are considering trapezoidal and circular speed humps based on category of road. The height of these vertical calming measures influences the percentage reduction of the desired speed at the crown of the speed humps. Passenger motorized vehicles are not reducing their speeds before the speed hump even when the speed hump is higher (Chandra et. al 2019).

Eye tracking studies are performed by recording the human visual activity during a specific activity (Kaminski et al, 2012), the main application of eye tracking in road traffic studies is to study the road rider behavior at various real world traffic situations. The eye trackers were successfully used to compare the driver behavior during a car driving simulator (laboratory study) and real-world driving conditions. The most significant eye tracking parameter in traffic studies is the eye fixation point. The fixation is not a movement, but an event in which the eye remains in a temporary immobility (Kaminski et al, 2012). The amount of fixation points shows that the focus of driver visual attention, this provides to understanding of behavior the driver in different driving scenarios. In the literature the indices

of eye movement are also commonly used as a metric of drivers' mental workload (Bie et al. 2012). The saccadic peak velocity is significantly associated with the drivers' mental workload in the dynamic and complex decision-making process, which can substitute pupil diameter index also.

The objective of this study is to evaluate the Driver Perception and Reaction Distance near the speed hump and study the sensitivity of these parameters at speed hump and to assign the proper signage at proper distances to reduce speed and ultimately reduces the speed. Driver visual behavior at different distances from the speed breaker was also studied in terms of Gaze plots and Heat maps. This study also develops the relationship between the number of fixation points and the speed of the vehicles.

2. Literature Review

Xiaohua ZHAO et al. (2011) studied the effect of horizontal alignment on the drivers gaze pattern. The study results showed that drivers focused on the middle region during the driving process. As the radius of the curve increased, drivers' gazing points would move from the two sides of the road to the middle region. To evaluate the gaze behaviour pattern the straight and curved sections were used to evaluate the performance of drivers. Driver's gazing points tend to move to the centre line from two sides of the road with an increase of horizontal curves' radii increasing.Erhui Chen et al. (2011) studied the impact of traffic conditions on drivers' visual behaviour under light traffic, medium traffic and heavy traffic. A driving simulator and eye-tracker were used to test drivers' visual behaviour. The author concluded that with the increasing in traffic, the average fixations and standard deviation of horizontal search had an upward trend for the different traffic volume roads.The saccadic behaviour of the driver generally had small amplitude, low-saccadic behaviour was more than high-speed saccadic behaviour for three types of traffic volume on roads. For the three different traffic conditions, the fixations and the saccadic velocity were all significantly different. This shows that traffic volume affects the driver's visual search range.

Weiwei Qi et al. (2015) studied the evolution trend of driver's visual characteristics under traffic congestion and showed that increasing traffic congestion level makes the distribution of the drivers' fixation points become dispersed, with drivers' fixation points transferred to the central main viewing area (short distance) under the state of traffic congestion. This evolution trend can be interpreted as based on the change of road information amount. Zhuo-Fan Liu et al. (2016) studied the comparison between visual and cognitive distraction. They have considered three different distraction conditions this includes without distraction, with visual distraction and with cognitive distraction. The results revealed that the visual distraction leads to higher speed variance and resulted in higher workload. Cognitive distraction made steering less smooth, but improved lane maintenance. Visual distraction was associated with more off-road glances, while increased blink frequency was observed during cognitive distractions. Both distractions caused gaze concentration and slow saccades when drivers looked at the roadway.

Jiho Yeo et al. (2017) studied the effectiveness of speed humps and speed tables. This study shows the comparison of speed and acceleration at interrupted and non-interrupted humps. The differences of an average speed were statistically significant at all sections at speed humps. Drivers at both speed humps and tables had similar speed patterns before reaching the devices. After passing the devices, the magnitude of speed differences between the speed humps and tables increased up to 18% in 50m to 60m section. This study considered eye track experiment to observe eye movement and fixation on speed control devices. Yuan-yuan Ren et al. (2018) studied the driver attention allocation under different driving behaviour. Right and left turning behaviours, as well as right and left lane changes were designed on simulator test to investigate driver attention allocation under different driving behaviours. The distribution of fixation time on a driver's Area of Interest (AOI) and the searching range of visual information were used to express a driver's attention allocation. The author concludes that drivers paid considerable attention to information far ahead no matter what driving behaviour he was doing. Under free driving, when a vehicle is turning around on a curved section with large curvature, or doing a lane change, a driver's attention moves from the front area to the left side in left turning scenarios and it moves from the front area to the right side in the right turning scenario.

CSIR-CRRI (2018) studied the relationship between vision-related traits and their impacts on road safety and a critical review on the role of various aspects of visual function in driving on the basis of vision tests adminstered on the basis of vision testsadministered on 625 heavy commercial vehicle drivers in the four Indian metropolitan cities of India. This study highlighted that 22 percent of the subjects in the metropolitan cities were having unacceptable "Far Visual Acuity"; 25 percent of the subjects unacceptable "Stereopsis or Depth Perception" and 22 percent of the subjects unacceptable "Glare Recovery". Lijjarco et all (2020) assessed the visual health issues of various spanish

drivers and based on the study results they formulated guidelines to enhance road safety features. Similarly, Peregrina et al. (2020) studied the impact of age related vision change in drivers. They examined the relationship between simulated driving performance and the visual parameters tested. Paren et.al (2020) summarised various driver distraction methodologies include qualitative and quantitative measuring behaviour of the drivers. They suggested that an eye tracker is useful to capture eye position and pupil diameters.

The oculomotor abilities of the driver play a districtive role in improving the driving related abilities. The evaluation of drivers visual strategies and processes must determine their visual information management and predict their driving performance. Sampedro et.al (2021) examined 302 phycially fit drivers includes drivers and non drivers between 20 and 86 years age groupe.This study found that drivers performed better in adult development eye movement test (ADEM) than   non drivers drivers. This test consists of three sheets of numbers, two containing vertically aligned and one sheet containing horizontally alignned. This study also considered some of the important of oculomotor parameters such as day time difficulty, night time difficulty of driving.

The eye tracking approach was mainly used in the literature to study the driver distraction, driver gaze patterns while driving on horizontal curves. This method can be adopted in quantitative and qualitative measurement to measure the driver behaviour on field as well as in experimental study. In this study the eye tracker was used to study the driver behavior in real-world driving conditions.

3. Methodology and Data Collection

3.1 Methodology

The methodology adopted for this research consisted of identification of the study section, collection of primary data using video graphy, processing of video data and their analysis, and evaluation of eye tracking data near isolated speed hump. Different age groups of the drivers (between 20 to 40 years) were considered for experimentation of study. This study was limited to parabolic speed hump. A trap of 100 m length was considered in the approaching direction of the vehicle and it was divided in to five sections of 20 m each to observe the speed profile of approaching vehicles. Reference. Video data recorded in field were screened on a computer screen in the laboratory to extract the speed of the individual vehicle at different intervals before speed hump. The experimental results for image sequences of all subjects are examined using an eye tracker. The subject sat on the driver's seat and wear head mounted eye tracking device. This tracker has four camera sensors, with two sensors provided for each eye. These sensors help in getting the eye images during extreme gaze angles and create accurate data on pupil size. The eye glasses with sensors produce the eye gaze data, which are mapped to coordinate the system and video is recorded. The collected eye tracking data are used to identify the driver reaction and eye fixation near isolated speed humps. The relationship between the approaching speed of the vehicle and numbers of fixation points were devloped using regression analysis techniques.

In this study, Tobii Eye Tracker System was used to measure eye tracking. This system has three components namely Head Unit, Recording Unit and Analysis Software. The Head Unit is a wearable eye tracker (Figure 1) integrates the illumunatory and eye camera into the lens. The video data was captured related to the selected stretch with a sampling rate of 50Hz to 100Hz have been used. The tracking technique is based on corneal reflection, binocular and dark pupil tracking. The eye tracker with 4 eye cameras with a resolution of 1920 x 1080 pixels at 25 fps were considered in the data collection. The recorded unit collects the eye tracking data and allows the gaze data to be recorded. The recorded data can export into Tobil Pro Lab analytical software. This software assists for mapping tool for generating the map data from eye tracing videos to snap shots. The snapshots were used for generating visualizations, such as heat maps and gaze plots, and Areas of Interest. The automatic mapping was done with the help of Tobii Pro's new software.

Figure 1 Wearable Tobii Glass Eye Tracker

3.2 Data Collection

Five drivers of different age groups (age: 20-40 years) with an average of 12 years of driving experience were considered f

or real time eye-tracking. All the participants had a valid driver's license, good visual acuity. The experimental results for image sequences of all subjects eye tracking were examined. The experiment was performed between 3.00PM and 5.00PM. The location of the study section was considered on Maaulana Mohammad Ali Jauhar Marg in South Delhi (Four Lane Divided Carriageway).To observe the driving pattern near the speed hump, experimental studies were conducted. Participant drove a car equipped V-BOX apparatus a GPS logger and a wearable eye tracker. The information from the eye tracker and V- Box apparatus enable us to estimate eye fixation and speed profile. The eye tracker was calibrated before each test drive for each participant. Every participant completed three test drives for the selected route. During the task V-Box and eye tracker were simultaneously started for the selected trap length (i.e.100m upstream and downstream of the speed hump). The Figure2 shows the setup of vehicle and analysis in Eye tracker software with timeline data series.

Figure 2: Setup of V-Box and Eye tracker Software with timeline data series.

The collected eye tracking data were considered to identify the driver reaction and eye fixation near isolated speed hump. The V-Box data and eye tracker data were analysed through the analysis software (Table 1). From the V-Box data speed profile of different participants were plotted for the distance 100m upstream. The sections were divided into five i.e. 0-20m, 20m-40m, 40-60m, 60m-80m, and 80m-100m. The speed profiles of each subject at different intervals were developed. From the eye tracker data, gaze plots and heat maps were developed for the Area of Interest (AOI). The video run from the V-Box data and eye tracker was simultaneously analysed for the calibration purpose. After running both the video data, the time for each 20m section is calculated form the speed data with distance and time extracted from the V-Box data analysis software. Then, from the eye tracker analysis software 20m section up to 100m

distance from speed hump were analyzed and developed, Gaze plots and heat maps. The main parameters were extracted from eye-tracker data include fixation time, fixation counts, total time of interest duration, AOI duration and AOI count. In this study the Area of Interest (AOI) is selected as a speed hump for data analysis, as shown in Figure 1. The eye track metrics considered in this study are briefly described in Table 2.

Table 1 Characteristics of Subjects considered for real time eye tracker data

Subject Number	Age (Years)	Type of Driver	Driving Experience (Years)
Subject 1	37	Private	14
Subject 2	40	Commercial	20
Subject 3	29	Private	10
Subject 4	30	Private	11
Subject 5	23	Private	5

Table 2 Eye Track measures considered for this study

Sl. No	Name of the measure	Description
1	Fixation Count	The number of times the eye fixes in a particular region of interest.
2	Time of Interest	The degree of analytical flexibility organizing the data according to intervals of time.
3	Area of Interest (AOI)	Selected region of a displayed stimulus
4	AOI Total Fixation Duration	How long the fixation lasted
5	AOI Total Fixation Count	The total no of times the eye fixed in a particular AOI.
6	AOI Visiting Count	The number of visits with in AOI
7	AOI Visiting Duration	The total amount of time that spends looking at a particular AOI

3.3 Ethics and Data processing

Ethical principles and data treatmentment details were adopted for the video processing data, the speed distribution of vehicle data collected by V-box. Personnel and confidential data were not used and the voluntary subject participantion were anonymous. Data processing was carriedout using descriptive statistical methods includes central tendency of the data (mean). Statistical regression techniques were adopted to devlop the relation between speed and fixation counts. This model was developed by considering the 5 % level of significance ($p<0.05$) and for devloping the statistical models SPSS (SPSS version 24) software was considered. The goodness fit measurement of the model includes the coefficient of determination, sum squared error androot mean squared error was considered in validating the models.

4. Analysis and Results

4.1 Speed of Vehicles Approaching Speed Hump

The logged data obtained from the probe vehicle was considered for the development of the speed profile of various subjects. Figure1 shows the speed profile of the vehicle driven by a typical subject obtained from the V-box at a speed hump. The figure1 shows the speed profile with the time and distance on the selected route i.e.100m upstream and

100m downstream from the speed hump. From Figure 3, it can be observed that the significant speed reduction of speed was observed between 0-20m before the speed hump. After the speed hump, the driver retained the speed back to 30km/h within 30m of the speed hump. At the crown of the speed hump, the speed of the vehicle was reduced to 10 km/h. The speed variation of the five subjects is also presented in figure 4. From this figure, it can be observed that all the drivers tend to follow the normal speed up to 20m before the speed hump, after that they are forced to reduce the speed. Figure 4 shows the speed profiles of the various drives at identified speed hump.
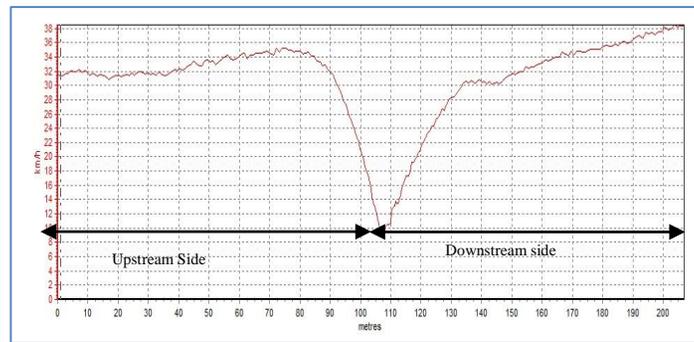

Figure 3: Speed profile of the vehicles driven by subject at speed hump
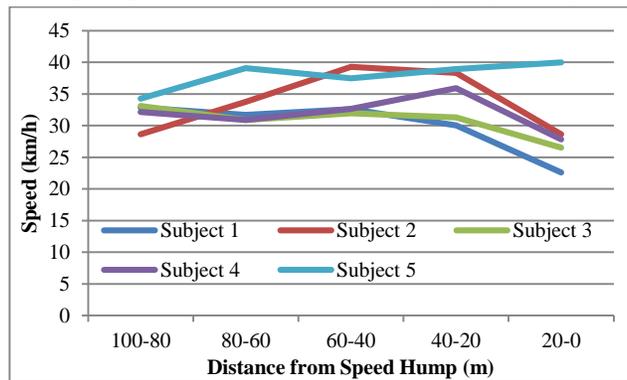

Figure 4 Speed Profiles of different drivers at Identified speed hump.

4. 2 Eye Tracking Behavior of Drivers Approaching a Speed Hump

The eye tracking behavior of five identified subjects approaching a speed hump is measured in terms of fixation count, total time of interest duration, Area of Interest (AOI) of total fixation duration, AOI total fixation count, AOI visit count and AOI visit duration is extracted from the eye tracker. The gaze plots and heat map of the typical driver behavior approaching a speed hump is given in Figure 5. The gaze point shows where the eyes of the driver are looking at the /static or moving object or subject. If a series of gaze points is very close, the gaze cluster constitutes a fixation denoting period where the eyes are locked toward an object, this measures the visual attention of the driver approaching the speed hump. The heat map visualizes the viewed area data in the range of colors. This study considered three range of colors, namely green, yellow and red for heat map. Green shows that those areas where the objects is spending less time and red indicates that the most viewed areas. From the figure 4 it was observed that, the gaze points are saccadic movements before the 100m from the speed hump, whereas no saccadic movement was observed from 40m of the

crown of the speed hump. It was also observed that focused fixed points were from 40 m before the speed hump and beyond this, scattered fixation points were observed(figure 5).

Similarly, heat maps presented in Figure 5, show the general distribution of gaze points and effectively reveal the focus of visual attention.They are typically displayed as a colour gradient overlay on the presented image or stimulus. The red, yellow and green represent in descending order the number of gaze points that were directed towards parts of the image. Heatmaps can be helpful in understanding how different groups might view a stimulus in alternative way. The reduced and more broadly distributed heat over the image suggests reduced cognitive load, increased understandability, and deeper penetration. During a recording an eye tracker collects raw eye movement data points according to its sampling rate. To,visualize and interpret the data, these raw data points are further processed into attentional eye movements, such as fixations, and overlaid on the stimuli used in the test.

In this study, the speed hump is selected as an Area of Interest (AOI) means our study area and estimated other important metrics such as total fixation duration and fixation count. It was observed from the data that the average fixation duration before 20m speed hump is 1.1 sec and between 20-40m is 0.5s. The average fixation count before 20m of speed hump is 4 nos and between 20-40m is 2 nos. This indicates that, the driver attention between 0-20m is double than the attention between 20-40m. Beyond the 40m the AOI fixation duration and AOI fixation count arezero. This emphaises that the drivers reacts to reduce the speed from 40m of the crown of the speed hump. The figure shows that as participants drove towards the speed hump with low traffic, fixation became approximately equal or no distraction being was shown, as we conclude from the gaze plot map. When the traffic volume increases, the driver becomes distracted and the fall on both sides of the fixation locations also increases. The driver only starts fixating when reaching up to the distance of 40m from the speed hump.
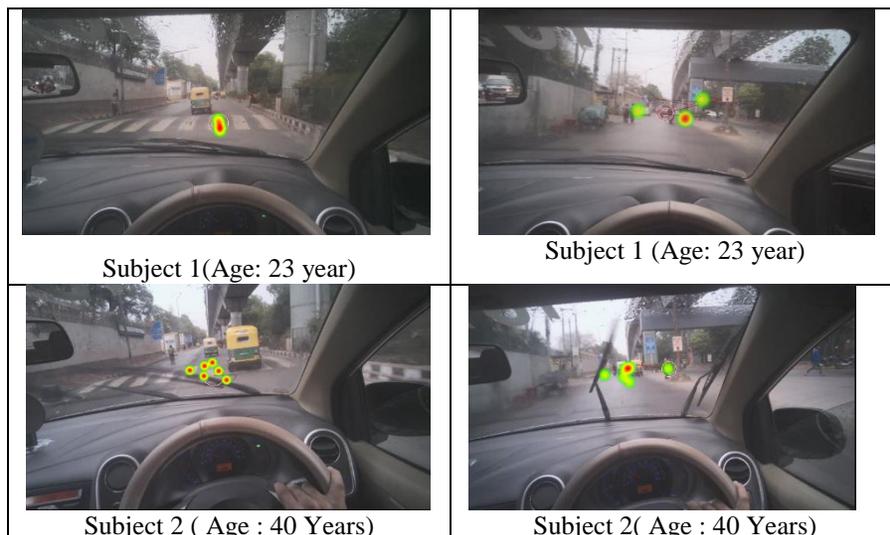

Gaze plots 0m - 20m from the speed hump	Heat map 0m - 20m from the speed hump
Gaze plots 20m-40m from the speed hump	Heat map 20m - 40m from speed hump
Gaze plots 40m-60m from the speed hump	Heatmap 40m - 60m from the speed hump
Gaze plots 60m-80m from speed hump	Heat map 60m - 80m from the speed hump

Gaze plots 80m-100m from the speed hump

Heat map 80m - 100m from speed hump

Figure 5: Gaze plots and Heatmap of Driver approaching Speed Hump

The heat map for different ages of drivers approaching to speed hump i.e from 0m-20m from speed hump and from 80m-100m from speed hump is developed and presented in Figure 6. The visit duration or dwell time for Area of Interest (AOI) is estimated. AOI of total visit duration is the total time spent by each participant on the area of interest. This metric deal with the information when examining participant interest or ease of understanding. From the results, it was inferred that the driver with the age group between 20-25years the average total AOI visit duration is 48% and for the age group between 35 and 40 years age group is 67%. This shows that with the increase of age, participant interest or visual understanding increases while approaching to the speed hump. It was also observed from the figure that if age is 23 years the fixation points are focused (20m before speed hump) where as increases in ages more cluster of fixed points were observed before the speed hump.

Individual fixation have interpretable functional roles. The driver never focused or fixate at any particular location or object for any extended time and on straight path drivers have more time available in the exploration of more environment detail as shown in Figure 5. compared to curves. Driver's near and far path fixation difference due to the cognitive load. Due to cognitive load time to response to other stimuli present on the varies. In Fig. 5 for the same stretch the driver had different representations of stimuli in front of them. The mapping of the fixations in the form of heatmap shows that the driver respond significantly different. The various study conducted related to cognitive load for the driver performance show these variations (Van Gervan et al. 2002 and Johan Engostorm et al. 2017). Driver's lateral and longitudinal control efficiency also helpful in interpreting the driver visual search (Salvucci & and Grey, (2004) and Wann & Wilkie 2004). The movement of the eye has important significance in visual search as suggest by Wilkie & Waan (2003).The cognitive load led to shorter look-ahead lead distances. Also, look-ahead lead time was smaller, which means that drivers did not essentially compensate for the cognitive load by reducing their speed slightly under cognitive load. This effect is consistent with the gaze concentration effect of cognitive load (e.g. Recarte and Nunes 2003, Victor et al.2005).
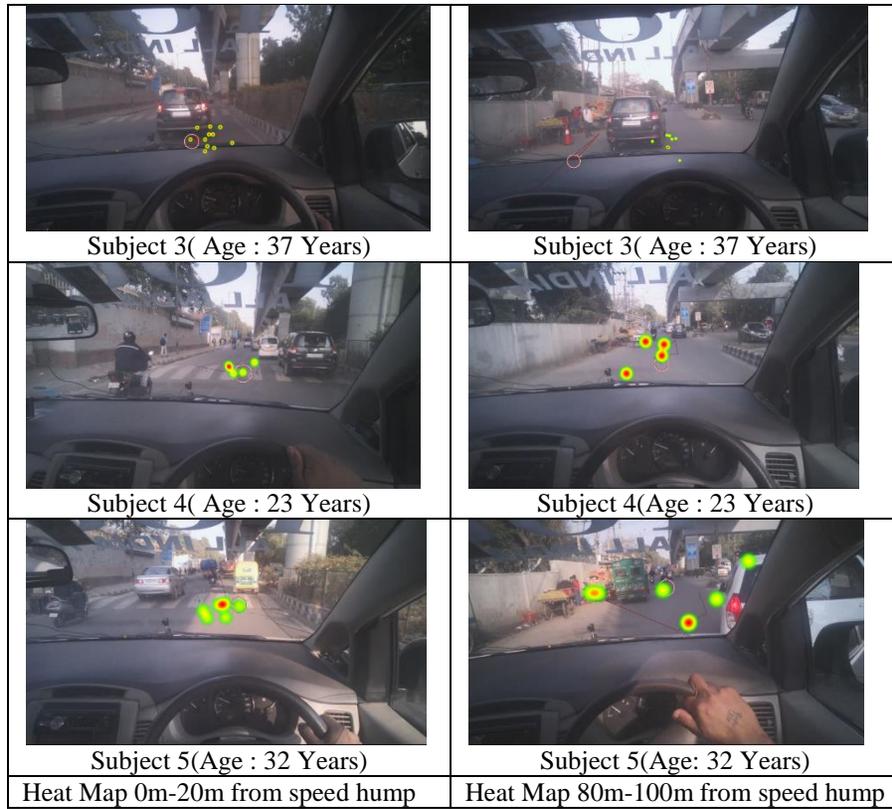

Subject 1(Age: 23 year)

Subject 1 (Age: 23 year)

Subject 2 (Age : 40 Years)

Subject 2(Age : 40 Years)

Subject 3(Age : 37 Years)	Subject 3(Age : 37 Years)
Subject 4(Age : 23 Years)	Subject 4(Age : 23 Years)
Subject 5(Age : 32 Years)	Subject 5(Age: 32 Years)
Heat Map 0m-20m from speed hump	Heat Map 80m-100m from speed hump

Figure 6 Heat Map of different age of drivers approaching to speed hump

5. Relationship between the Speed and Fixation Counts

This study considered linear and non linera regression analysis were carried out to describe the relation between speed and fixation counts. Statistical validation of the devloped model were performed through root mean square error (RMSE). The regression model was fitted using SPSS software (SPSS version 24.0). The regression analysis between vehicular speed (V) and fixation count (FC) was carried out by considering all the five subjects data to know the functional relationship between these two variables. For this, four different models such as linear , quadratic, exponential, and Power are considered to investigate the appropriate relationship between the dependent parameter (FC) and independent parameter (Speed). Table 3 presents a summary of the model coefficients and goodness of fit values for eye track data collected before the speed hump. Three goodness of fit parameters such as coefficient of determination (R^2) , standard error of estimate (SEE) and root mean squared error (RMSE) was considered to identify the best fit model for the data. It is observed that R^2 values are comparatively higher in the case of exponential and power model. The SEE and RMSE values suggest that the exponential and power models are better than other models. Here the exponential and power models are finally accepted and are presented at Figure 7.

Table 3: Summary of Model coefficients and goodness of fit values

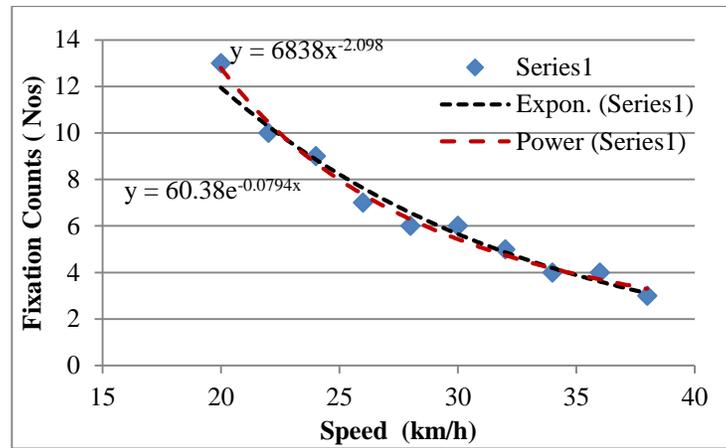| Model	Equation	Goodness of fit		
		Coefficient of Regression (R^2)	Std. Error (SSE)	RMSE
Linear	F.C. = -0.493*V=21.02	0.914	7.58	0.9739
Quadratic	F.C. = -0.255*V^2-1.97*V=41.68	0.977	2.065	0.5432
Exponential	$FC = 60.38e^{-0.0794V}$	0.978	1.973	0.4966
Power	FC = 6838*V$^{-2.098}$	0.987	1.141	0.3777

9

Figure 7: Relation between Speed Vs Fixation Count

From Figure 6, it can be observed that with the increase in speed, the fixation count reduces. Similarly, the duration of the fixation also decreases and the driver is more focused. But as the speed decreases the drivers information needs should have significant effect on isula search strategy when people who are uncertain about the surrounding environment will be more actively searchfor information. The relation is suggested when the driver is at higher speed and reduces the uncertainty of the visual search during the run . This implies that for greater speed driver pay less attention to the surrounding objects during the driving task.

6. Discussion

This study made an attempt to develop the relationship between the speed of vehicles approaching to speed hump and fixation counts. This study made an ivestigation by considering five subjects and their eye track movements appraching to the speed hump. From the results it was observed that the speed of the vehicle drastically reduces from more than 40 km/h to less than 20 km/h when the vehicle approaches a speed hump. Where as the fixation counts increased from 3 to 13 while the vehcular speed decresing from 40 km/h to 20 km/h. Li et.al (2018) studied the inflence of vehicle speed on the characteristics of drivers eye movement at highway tunnel entrance. This study evaluated that the average number of fixations has negative correlations with the vehicle speed. The study results indicate that drivers were more concerned before reaching speed hump. The limitation of this study is the sample size, this study considers the five subjects whose age group is between 23 and 40 years.

A preventive measure to reduce the risk at speed hump is to introduce effective traffic calming measures driving related factors such as key issues related to driver oculomotor abilities societal and transport environment should be considered. The use of intelligent tarnsporattion system (ITS) and artificial intelligent applications in traffic information, public transporation and passenger transportation information will help improve the mobility traffic on urban roads (Alonso et.al, 2021)..Driving related cues such as road signs, markings should be very accessive for road users to reduce the risk of accidents at speed hump

7. Policy Implications

This study evaluated the driver's attention in relation to the distance of the speed hump and related speed of the vehicle, and driver's fixation distribution. The findings of this study demonstrated that driver behavior would be changed with the deployment of speed humps. The outcome of this study is useful for recommending the appropriate location of visual warnings or pre warning to ensure that the drivers became aware of the subsequent speed reducers. Indian roads congress published guidelines on traffic calming measures in urban and rural areas where visual warnings are discussed (IRC 99). This study demonstrates the application of an eye tracker as quantitative measure and recommended to examine sutaible position for placing traffic signs and other traffic control devices approaching vehicle to traffic

calming measures. The results of this study will also be useful to derive recommendations for distracted drivers at speed humps, which ultimately add to road safety, which will be helpful to the planner and implementation authorities.

8. Conclusions

This paper investigated the general characteristic of fixation counts through the statistics of visual parameter using eye tracking device. The higher the sampling frequency, the better is ability to estimate the true path of the eye when it moves. From the driver observation and study results, it was concluded that the driver behiour approaching to speed hump under different traffic condition the fixation pattern of the driver changes. The following significant findings were drawn from this study.

- The horizontal search span of the driver was wider and the fixation area was scattered as shown in the gaze plots for 100m-80m from the speed hump where the gaze plots were not so much scattered where vehicle approaching near ther speed hump (0m-20m). From the speed profile data, it was observed that the driver changes their speed instantly reaching to the speed breaker. The average AOI of the fixation duration before 20m speed hump is 1.1 sec and between 20-40m is 0.5s. This indicates that, the driver attention between 0-20m is double than the attention between 20-40m.
- From the relationship between speed and fixation count, it was observed that the average fixation counts decrease with the increase in vehicle speed. The distribution of driver fixating points in the area of interest is more concentrated under the state of smooth traffic and under the state of high volume traffic the drivers' fixation points is more divergent. From the results, it can also conclude that the driving load increases, the difficulty of processing information increases the driver with the age group between 20-25years the average total AOI of visit duration is 48% and for the age group between 35 and 40 years age group is 67%. This shows that with the increase of age, participant interest or visual understanding increases while approaching to the speed hump.
- The speed and fixation count relation suggest that the drivers stationary fixation glance indicated that all divers are more likely to have more focus of fixation with a speed of 25kmph-30kmph at a distance of 40m-50m from the speed hump.

Due to the restriction of the experimental condition, only the index of driver fixation counts, fixation duration, AOI of fixation counts, AOI of fixation duration and AOI of visit count were selected. Further studies are required to investigate variation of drivers' parameters under the state of different traffic conditions, different age groups and behaviour at different shapes of speed humps.

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