

DYNAMIC CURVE WARNING SYSTEM FOR HETEROGENEOUS MIXED TRAFFIC CONDITION

PROJECT REPORT

Submitted by

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of

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TRANSPORTATION ENGINEERING



DEPARTMENT OF CIVIL ENGINEERING

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DECLARATION

I undersigned hereby declare that the project report “Dynamic Curve Warning System for Heterogeneous Mixed Traffic Condition”, submitted for partial fulfillment of the requirements for the award of degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Dr. Kavitha Madhu. This submission represents my idea in my own words and where ideas or words of others have been included; I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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CERTIFICATE

Certified that this report entitled “**DYNAMIC CURVE WARNING SYSTEM FOR HETEROGENEOUS MIXED TRAFFIC CONDITION**” is the report of the project presented by **ATHIRA P R, TKM21CETE03** during **2022-2023** in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Transportation Engineering of the A P J Abdul Kalam Technological University.

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ABSTRACT

Sharp curves are hazardous because of narrow, poorly maintained, and limited visibility roads. Drivers in heterogeneous traffic may engage in dangerous driving behaviors such as overtaking on sharp curves or driving at high speeds. As per the Ministry of Road Transport and Highway (MoRTH 2016), 21% of traffic accidents occur due to the overtaking of vehicles. The main reason for accidents on curve roads is due to the high speed of the driver or unawareness of the oncoming vehicle to the curve. Lack of communication between the ends of the curve and visibility problems around the curve make hazardous situations. Existing methodologies like convex mirrors, sensor-based collision avoidance systems, headlights, and horns are used to reduce collisions. In modern transportation systems, in-vehicle and in-road technology are important for collision avoidance. User perception studied through a questionnaire survey is first conducted to analyze how the users perceive the new concept of the driving assistance system instead of the conventional system (eg: convex mirror) that are commonly provided. For the detection process, vehicle detection algorithms (YOLOv5l) are used. Vehicle detection involves analyzing an image or video to identify the presence of vehicles by detecting patterns, shapes, and colors that correspond to vehicles, and then distinguishing them from the background. The annotation and augmentation process helps to improve the accuracy of the model. Curve collision warning systems use cameras and signal boards, to detect when a vehicle is approaching a curve too quickly, and then issue a visual warning to the driver to slow down or take other corrective action to avoid a potential collision. The accuracy and precision obtained for the curve collision warning are analyzed and both results are above the acceptable limit. So, this collision avoidance system is essential in preventing accidents and saving lives by detecting and responding to the potential collision in real-time.

Keywords: *collision avoidance, user perception study, annotation, augmentation, decision sight distance, curve warning system*

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CHAPTER 1 INTRODUCTION

1.1 GENERAL

Curve warning system increases driver alertness and guides the driver through curves safely. Despite commitments and effort, road accidents remain one of the leading causes of death, disability, and hospitalization in the country. Road features such as straight roads, curved roads, sharp turns, and potholes are prone to accidents as skill, exceptional care, and attention are required to overcome these road features. Wide variances in the static and dynamic properties of vehicles are present in the traffic on Indian roadways, which is highly heterogeneous in nature. They occupy any lateral place on the road that is open to them and do not maintain proper lane discipline. Usage of an opposing lane to overtake slower-moving vehicles while oncoming traffic is coming from the opposite direction is one of the most difficult and crucial manoeuvres on undivided roads. They cannot be avoided, especially in mixed traffic situations where there is a constant speed differential between fast and slow-moving vehicles. Figure 1.1 is a graph showing the percentage of accidents, the person killed in the accident, and injuries that happened during accidents of different road features as per the road accident publication in 2021 by the Ministry of Road Transport and Highway.

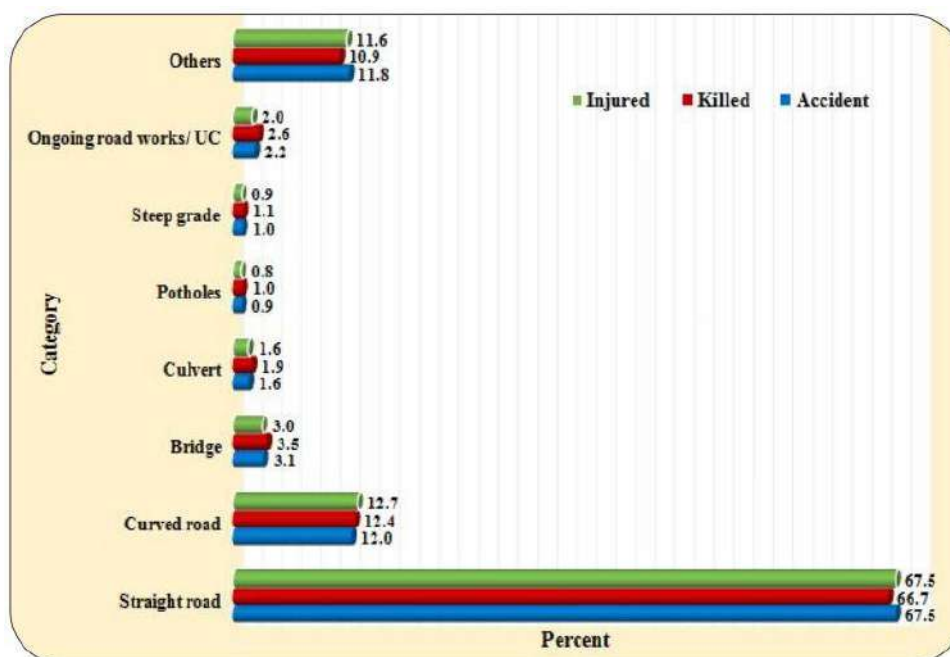


Figure 1.1 Accidents, Persons Killed, and Injuries by Road Feature in 2021
(Source: Ministry of Road Transport and Highway, Road Accident Report,2021)

It shows that the most significant percentage of accidents happened on straight roads, and the second is on curved roads. The process of overtaking entails lane-changing maneuvers, acceleration, and deceleration movements, estimation of the relative speeds of the overtaking and overtaken vehicles, as well as the estimation of the speed and distance of the oncoming vehicle (Mocsari, 2009).

1.2 PROBLEM STATEMENT

The driver's negligence is the primary cause of traffic accidents. Due to a lack of communication and visibility on these curves, vehicles passing through hairpin curves are highly accident-prone areas. Drivers should therefore take extreme caution when driving around sharp curves. Another major drawback of driving on a curved road is creating traffic congestion. This is a result of the unorganized movement of the vehicle. To reduce collisions on curved roads due to the overtaking maneuver of drivers, it is important to study the vehicles that pass through the curves. Through proper analysis, a suitable curve warning system is proposed to assist the drivers who negotiate the curve to stop their existing tendency of overtaking.

1.3 OBJECTIVES OF THE WORK

The study aims to reduce the traffic accidents that happen on curved roads during overtaking maneuvers by providing a suitable curve warning system. And to analyze the perception of people about the new idea of introducing curve warning assistance through a user perception study.

The objective of this study is,

- To analyze the perception of users towards the implementation of a curve warning system using a user perception study.
- To detect and classify the vehicles through the curve using an image processing technique.
- To provide curve warning indication to the drivers.

1.4 SCOPE OF THE WORK

The work is carried out in a two-lane NH flexible pavement road curve. The type of data collected is traffic video (through hand cameras) and data collection using a questionnaire survey.

1.5 ORGANIZATION OF REPORT

The work is organized into ten chapters. Chapter 1 is the introduction which comprises the problem statement, objectives, and the scope of the study. Chapter 2 comprises a detailed literature review as a part of the study. The various types of methods of implementing warning systems are discussed in this chapter. Chapter 3 explains the detailed methodology adopted in the study. It gives a clear idea about the various stages of work. Chapter 4 deals with the study area and data collection. Chapter 5 is about the user perception study, which discusses the questions selected for conducting the survey. Chapter 6 deals with the vehicle detection process and the methods used for the detection process to improve accuracy are included in this chapter. A curve collision warning is included in Chapter 7. Chapter 8 deals with the results and discussions. Chapter 9 discusses the conclusions drawn from the work and the future scope of the work.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

High speeds and careless driving are mainly responsible for numerous accidents. In hilly terrain, the situation is even more dangerous because the vehicles on the hairpin curve have no visibility. One of the most significant contributing factors to lane departure crashes has been identified as horizontal curves. According to the Federal Highway Administration (FHWA), about 25% of fatal collisions involved horizontal curves, especially on two-lane rural roads. Running off the road or moving into the opposite lane are two common crash scenarios on horizontal curves (Persaud et al., 2000). For instance, a vehicle may not have enough centripetal force to stay in the lane if it is approaching a right-turn horizontal curve at a speed greater than the design speed. Due to this, the car may drift to the right and leave the lane, which could result in a head-on collision with a car moving the other way. Human error is the leading cause of curve-related crashes. Much research has been developed to assist drivers who pass curves to avoid collisions during overtaking in the form of in-vehicle and on-road technologies

2.2 TYPES OF SENSORS USED FOR ASSISTANCE

Sensor technology has become ubiquitous and has received a lot of attention. Sensors are used in many fields, such as healthcare, agriculture, forestry, vehicles, and ship surveillance. In transportation, sensor technology supports the design and development of a wide range of traffic control, safety, and entertainment applications. Over the past years, sensors and actuators such as tire pressure sensors and rear vision systems have been mandated in the manufacture of vehicles and the implementation of intelligent transportation systems. Provide services that improve driver and passenger satisfaction, improve road safety, and reduce traffic congestion. Other sensors are optionally installed by the manufacturer to monitor vehicle performance and health, improve the vehicle's efficiency, and assist the driver. Table 2.1 shows the classification of different types of sensors used in vehicles (Abdelhamid et al., 2015).

Table 2.1 Different types of sensors used in a vehicle

Type of sensor	Description	Example
Safety	It forms the basis of safety systems and focus on detecting accident hazards and events in near real-time.	<ul style="list-style-type: none"> • Speed sensors • Cameras • Radars and laser beams • Inertial sensors • Ultrasonic sensors • Proximity sensors • Night vision sensors
Traffic	To monitor specific zones' traffic condition, for collecting data to improve traffic management	<ul style="list-style-type: none"> • Proximity sensors • Cameras • Ultrasonic Sensors • Radar
Assistance	To collect data which provides support for convenience and comfort applications.	<ul style="list-style-type: none"> • Rain sensors • Temperature sensors • Image sensors • Position sensors • Distance sensors
Environment	To analyze the environmental conditions, to alert the passengers and drivers and act as a warning service that is used to enhance their journey.	<ul style="list-style-type: none"> • Pressure sensors • Cameras • Temperature sensors • Distance sensors • Weather conditions

2.2.1 In-Vehicle Sensors

The sensors are an unavoidable part of vehicles, which helps in detecting traffic congestion, helps in parking maneuvers, detecting a higher level of CO₂ emissions, and provide a proper warning to drivers (Guerrero et al., 2018). Figure 2.1 depicts the sensors that are most widely used in vehicles nowadays. Among the different sensors, the Light Detection and Ranging (LIDAR) sensor is mainly used in automated vehicles,

it is a new technology to measure the distances to stationary as well as moving objects, volume, and speed (Zamfir., 2020).

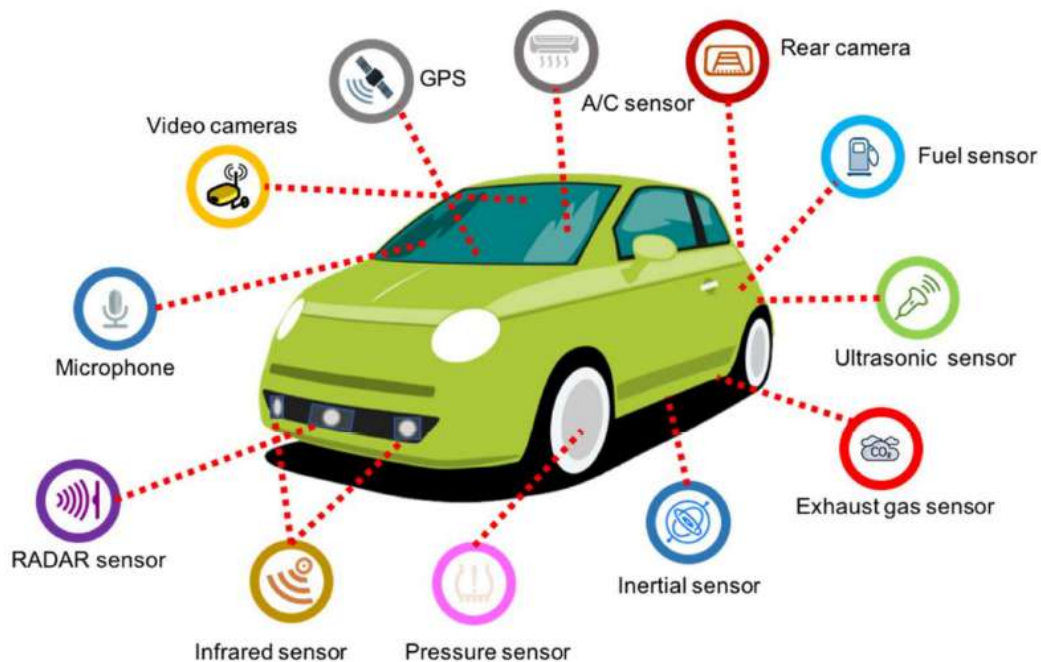


Figure 2.1 Sensors Used in Vehicles

(Source: Guerrero et al., 2018)

2.2.2 In-Road Sensors

The sensors are placed on the road to assist the drivers. Sensors are divided into two categories based on their placement: intrusive sensors and non-intrusive sensors. Intrusive sensors are placed on the surface of the pavement, and they show great accuracy. But the installation and maintenance costs are too high. Non-intrusive sensors can detect vehicle speed and are placed in locations other than road surfaces.

2.3 EXISTING METHODOLOGIES ADOPTED IN CURVES

To avoid head-on collisions on curves, some methodologies were adopted. The existing methodologies adopted in a curve to avoid collision are by using sensors, reflecting mirrors, headlights, and horns (Prajwal et al., 2019)

2.3.1 Sensor-based collision avoidance system

Anand et al. (2019) mentioned the usage of ultrasonic sensors for the detection of vehicles. For that, they use two ultrasonic sensors at the curve, and speed is calculated

by knowing the distance between these two sensors and the time required to cross these points.

2.3.2 Convex mirror

On roadways, driveways, and in alleyways where there is a blind spot or when the driver has restricted sight, the convex mirror is also utilized to protect drivers. It is a mirror with a bulged reflecting surface where the light incident on it gets reflected in different angles. This type of methodology is mainly used in hilly areas; this shows the view of the opposing vehicle approaching the curve. The main drawback of this type of system is that the surface gets faded with time, and is not suitable for use at night times, in foggy environments, and in rainy seasons.

2.3.3 Headlights and horns

While driving around hairpin corners, both headlights and horns are frequently utilized. Headlights can only be used at night by flashing on high beams, and may not be an effective strategy during the day. Horn volume and interference with the environment can change, making it difficult to hear while driving.

2.4 IN-VEHICLE TECHNOLOGY

The development of existing curve speed warning systems involves issuing a single speed warning or employing traffic control devices to warn approaching drivers. The advanced driving assistance system (ADAS) was developed to assist drivers who drive cars. A series of electronic technologies known as advanced driving assistance systems help drivers with driving and parking tasks. ADAS improves vehicle and road safety by providing a secure human-machine interface. To identify surrounding obstacles or driving errors and take appropriate action, ADAS uses automated technologies, including sensors and cameras. Depending on the elements that are installed in the vehicle, ADAS can enable a varying degree of autonomous driving. Lane departure warning systems (LDW), over-speed warnings, and blind spot warnings are some examples (R. Gouribhatla and S.S. Pulugurtha, 2022).

Hazoor et al. (2022) compared the available sight distance (ASD) and stopping sight distance (SSD) and developed an intelligent speed adaptation (ISA) system to assist the driver in choosing an appropriate speed on portions of the road with restricted visibility.

This system detects ASD and can provide speed advice to drivers (Habib et al., 2022). The system operates in two ways by alerting the driver with a visual warning, and an audio warning. Figure 2.2 shows the display information provided to the drivers and their graphical representation. Figure 2.3 is the auditory alert provided to the drivers and their graphical representation of its working.

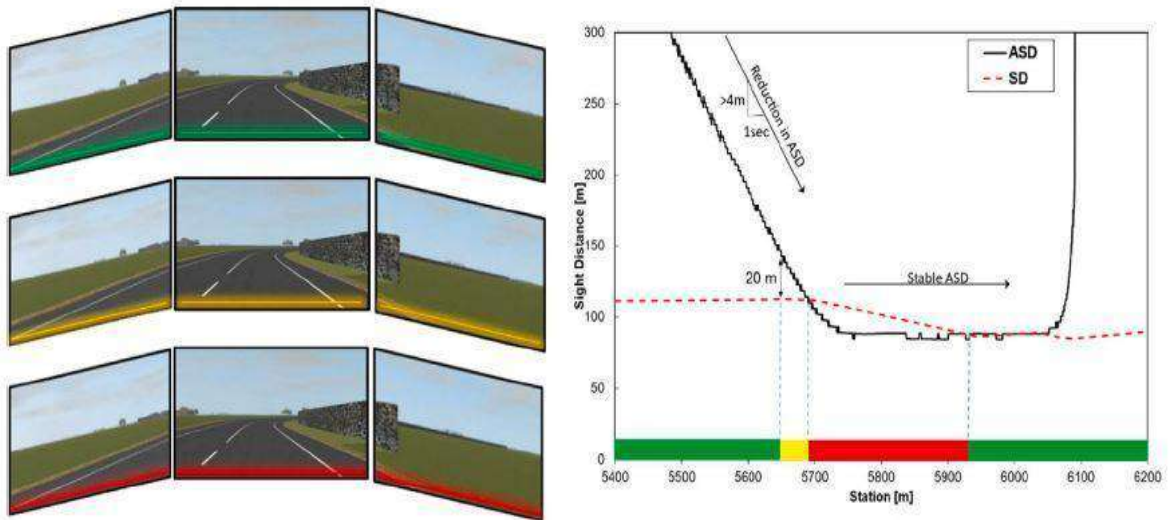


Figure 2.2 LED Information on Screen of Driving Simulator.
(Source: Hazoot et al., 2022)

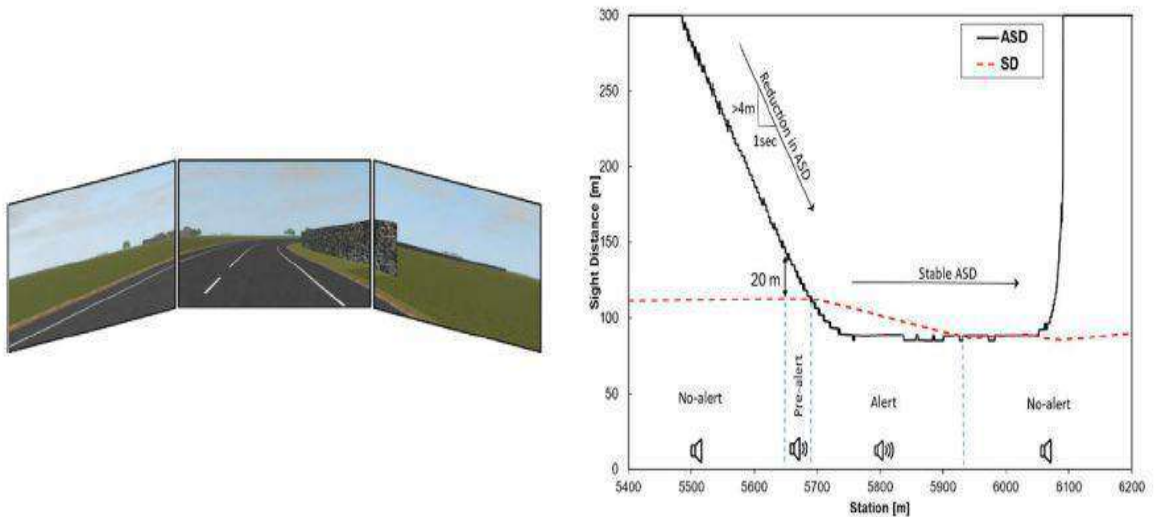


Figure 2.3 Auditory Alert Provided to Drivers
(Source: Hazoor et al., 2022)

ASD can be calculated in two ways; in a virtual scenario, it is estimated in real-time by using LiDAR technology coupled with MATLAB algorithms (Ma et al., 2019). But in the case of the virtual scenario, ASD is calculated by creating a 3D road model by

setting virtual sensors on ego vehicles (Hazoor et al., 2021). The virtual scenario setup was shown in Figure 2.4. The equation for finding the exact real-time stopping distance and Real-time safe speed limit is mentioned in Equations 2.1 and 2.2, respectively.

Exact real-time stopping distance (SD),

$$SD = v \cdot \tau + \frac{v^2}{2g \cdot (f \pm i)} \quad (2.1)$$

Real-time safe speed limit (v_L),

$$v_L = -g(f + i) \cdot \left[\tau - \sqrt{\frac{2 \cdot ASD}{g(f+i)} + \tau^2} \right] \quad (2.2)$$

Where, v is the real-time speed of the vehicle, τ is the reaction time in seconds, f is the tire-road friction coefficient, g is the gravitational acceleration, and i is the local longitudinal grade of the road. Equations 2.1 and 2.2 are used in the MATLAB algorithms to detect the exact real-time stopping distance and real-time safe speed limit



Figure 2.4 The Virtual Scenario Setup for the Experiment
(Source: Hazoor et al., 2022)

Bassani et al. (2019) compare ASD and SSD to analyze actual visibility conditions. It was shown that the majority of drivers used tactics that produced stopping distances that

were lower than the available sight distance, keeping safe driving conditions. Some drivers slowed down, some widened their lateral distance from any sight obstructions along the side of the road, some did both, and some did neither. According to preliminary research, the safety advantages of a vehicle speed reduction strategy far outweigh those of a lateral lane move.

2.5 IN-ROAD TECHNOLOGIES

These types of technologies are used outside the vehicle and this technique is common to all the people using the road. Compared to in-vehicle technology it is more economical. Asaithambi et al. (2017) use two types of methods for data collection; one is the moving car method, which helps with the collection of data on overtaking vehicles. The second method used is the register plate method, used for the collection of the flow of traffic, traffic composition, and the number of overtaking and overtaken vehicles. Vehicle detection algorithms are used for the detection and classification of vehicles (Song et al., 2019).

2.5.1 Comparison of Object Detection Algorithms

The important part of object detection is image classification and detection. One such extensively used image classification domain is Microsoft COCO (Common Object in Context). It is an object detection benchmark dataset. It presents a large-scale dataset that may be used for image recognition and classification. Srivastava et al. (2021) did a comparison between You Only Look Once (YOLO), a faster Region-based Convolutional Neural Network (Faster R-CNN), and Single Shot Detector (SSD). The performance of these three algorithms is compared in this comparative analysis using the Microsoft COCO dataset, and their advantages and disadvantages are examined using metrics including accuracy, precision, and F1 score. The analysis's findings suggest that the use cases in which each algorithm is put to use greatly influence which algorithm is best suited among the three. YOLO-v3 performs better than SSD and Faster R-CNN in the same testing scenario, making it the best algorithm among the three.

2.5.2 Method of Providing Road Technology

Suthan et al. (2022) use cameras and sensors on the roadside to detect vehicles. The suggested method helps the vehicle approaching from the opposite direction by

detecting the vehicles on one side of the curve. Figure 2.5 shown above is the layout of fixing the camera and display board on the road.

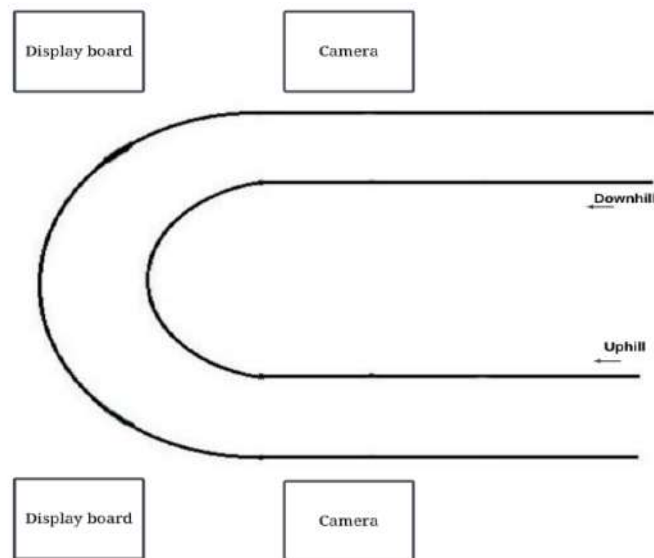


Figure 2.5 Proposed Collision Avoidance System

(Source: Suthan et al., 2022)

The suggested system's objective is to categorize various vehicles traveling through one direction of the curve road and alert vehicles traveling in the other way of the hairpin via a display board. The information on this display board includes the type of vehicle, how long it takes to pass a vehicle at a curve, and how many vehicles are on the curve.

Ramachandran et al. (2019) propose a work to decrease the danger associated with operating a vehicle in terrain with steep curves and hairpin turns. The deployed controller with an ultrasonic sensor detects the vehicle approaching the bend and warns it to the opposite side of the bend or curve; it gives the driver approaching the hairpin bend or curve from the opposite side three levels of LED warnings. Additionally, it measures the vehicle's speed; if the speed is too high, a buzzer will alert the driver. Drivers will take this to mean that they should slow down their cars as a result of these messages. The main objective of the intended system is to lower the number of fatalities in mountainous areas by avoiding accidents for both drivers and passengers. This technology makes it possible to analyze the number of uphill and downhill autos in hill stations by storing data in the cloud. The analyzed data is seen online using a web application. The web tool can be used as a traffic pattern analyst by people who desire to go that way. Figure 2.6 is the layout of the methodology proposed for this work.

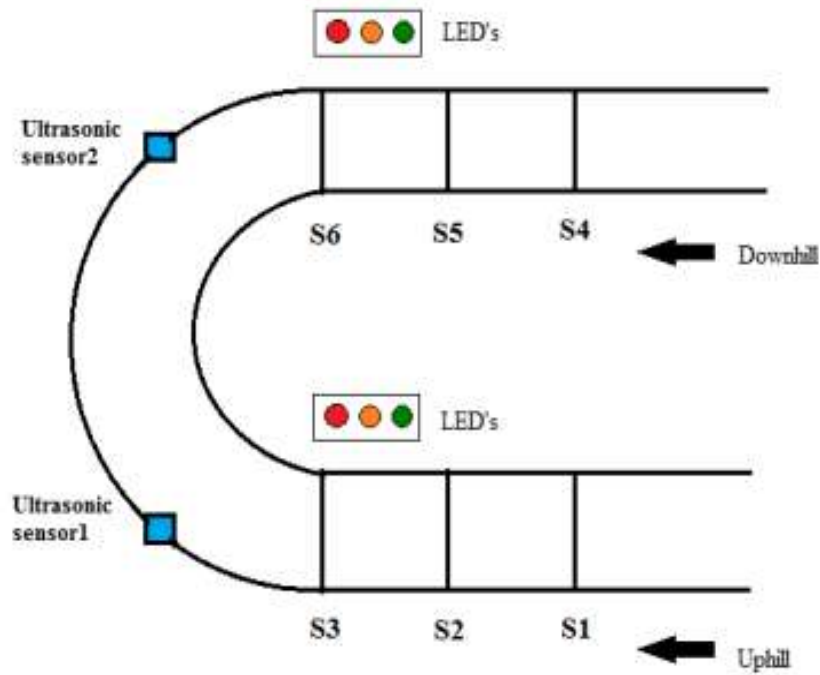


Figure 2.6 Layout of the proposed methodology
 (Source: Ramachandran et al., 2019)

User perception studies are conducted in two ways: face-to-face interviews and through google forms. Face-to-face interviews were done, which had a number of benefits, including the ability to explore complicated subjects since the interviewer could explain his or her questions in greater detail and the ability to inspire respondents to provide accurate responses to the survey questions (Schroder, 2016).

2.6 GAPS IDENTIFIED

The gap identified from this literature is the use of real-time curve warning systems by using artificial intelligence is not implemented in real scenarios. Normally sensors are used for the vehicle detection process. If a vehicle's position, speed, and trajectory are not accurately detected by its sensors, the warning system may get inaccurate or incomplete data. And the accuracy of the sensors can be lowered by unfavorable weather such as snow, rain, or fog. Things like fallen trees, garbage, or animals on the road might obstruct the sensors and reduce the warning system's accuracy. So to avoid the defects by sensors, real-time cameras are introduced. By using the camera's accuracy of detection can be improved and obtain more reliable results. This method helps to alert the driver by proving a proper warning of vehicles that enter into the curves through a red light.

2.7 SUMMARY

In this section various kinds of literature related to the selected topic are discussed. Each and every highway must include curves because they allow for progressive direction changes. However, because of the lack of curve warning signs and vehicle handling procedures, safety hazards for road users are more likely to occur on curves. For in-vehicle technologies, ADAS is used to assist and guide the drivers for smooth driving, whereas in in-road technologies cameras and LED display boards are used for assisting the drivers.

CHAPTER 3

METHODOLOGY OF WORK

3.1 GENERAL

Sharp curve roads are hazardous in India because of narrow, poorly maintained, and limited visibility roads. Negotiation of obeying traffic rules engages in dangerous driving behaviors such as overtaking on sharp curves or driving at high speeds cause accidents. Impatience, lack of awareness, overconfidence, peer pressure, etc., are all these factors that influence the overtaking tendency. Approximately 25% to 30% of fatal accidents occurred on curved sections, making accident severity more severe compared to straight sections (Yuan-yuan et al., 2011). In a foreign country, the rules and regulations are very strict, if anyone violates the rule he or she knows very well about the after consequences.

Overtaking on a curve, especially on a sharp curve is not allowed, but people always have a tendency to overtake a slow-moving vehicle. Also while negotiating a curve heavy vehicles occupy more space for turning for that they use the space provided by the opposite lane which also causes a chance of head-on collisions on the curve. So if indicating the presence of a vehicle entering a curve can help to alert the driver and helps to stop their tendency in overtaking vehicles. Figure 3.1 shows the usage of the opposite lane by heavy vehicles while negotiating the hairpin curve.



Figure 3.1 Usage of opposite lanes by heavy vehicles

Another noticed incident is the tendency of drivers to overtake the slow-moving vehicle while entering into the curves. The sudden lane change without knowing the presence of

an oncoming vehicle from the opposite road causes crashes. Some noticed accident causing overtaking behaviors of drivers are shown in Figure 3.2.



Figure 3.2 Tendency of Overtaking Slow-Moving Vehicles

3.2 DETAILED METHODOLOGY

The methodology adopted for the work to achieve the mentioned objectives is discussed here. The first is to identify a problem, then conduct studies on various literature to find out more details about the selected topic for the progress of work. After the selection of a topic, the selection of a suitable location is the next important step. Next is data collection, here the data collection is conducted in two ways through video collection and by conducting user perception analysis. Traffic data collected through the videos are used as the input to the vehicle detection process and YOLOv5l is used for this process of detection. The curve collision warning process is done by using the results obtained from the vehicle detection process and applying some logic in Python.

Figure 3.3 is the flowchart of the methodology adopted for the study. The details of each step are also included in this chapter.

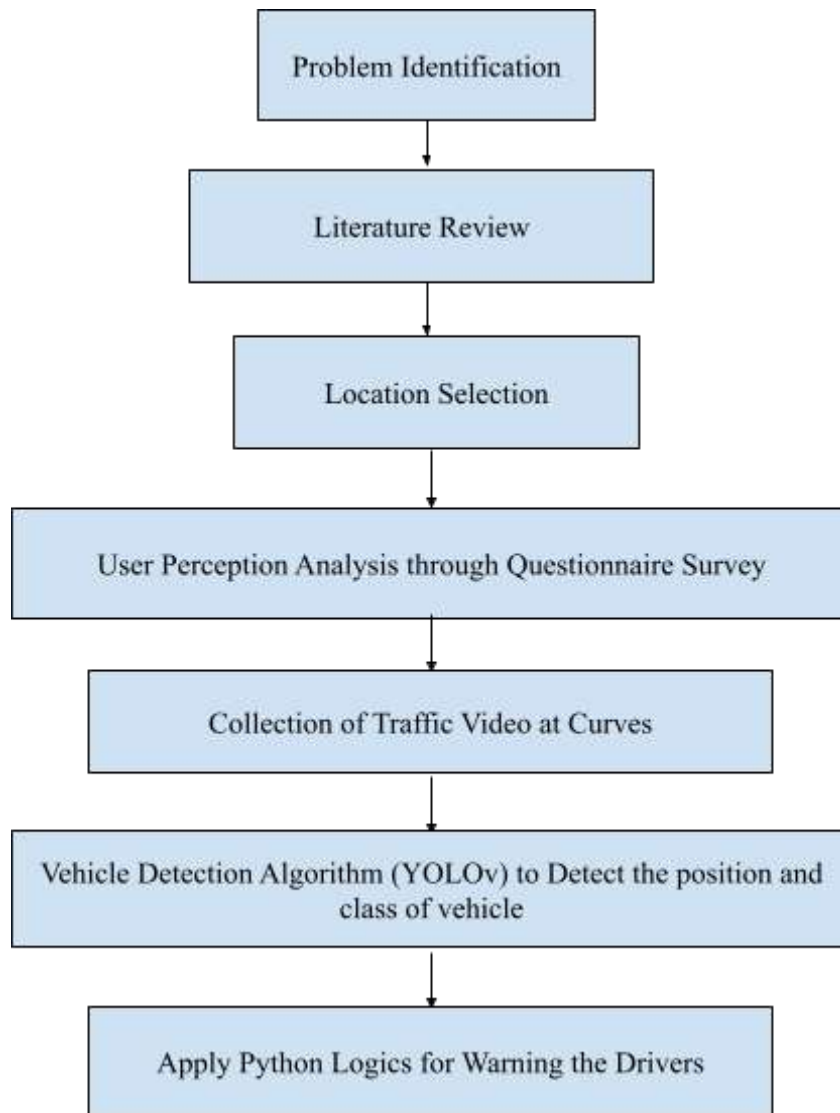


Figure 3.3 Flowchart Diagram of Detailed Methodology

3.2.1 Identification of Study Stretch

Identifying a suitable study location is one of the significant tasks in the progress of the project. Here overtaking tendency of the drivers on curves is considered for the work. Overtaking on curves is prohibited but still, drivers tend to overtake the slow-moving vehicle. So through providing the curve collision warning system, the tendency of overtaking drivers can be stopped.

3.2.2 Literature Studies

The literature survey helped to identify various methods and techniques used in advanced driving assistance systems and a user perception survey.

3.2.3 Selection of Study Location

Selecting a suitable location for the successful completion of a project is very important. So sharp curves are identified in the Kottayam district and selected a suitable location based on the accessibility, easiness of taking videographs, and whether an elevated location is available for capturing the top view to reduce the overlapping effect. Two hairpin road locations were selected first one is Vazhoor Road in Kottayam and the next is Ponkunnam Road in Kottayam, both included in NH 186. Due to the difficulty in placing cameras in a top position the first sight is canceled and go for the second site. More details of the study location are discussed in Chapter 4.

3.2.4 Questionnaire Preparation for User Perception

To find out how the users perceive the idea of introducing a new advanced driving assistance signal system, the perception survey is conducted. This includes questions about the basic details of the users, their comfort through the existing roads, and statement questions about the conventional driving assistance system (convex mirror) and newly designed advanced driving assistance system. Statement questions are framed on a Likert scale, rating from 1 to 5 scale. One for strongly disagreed statements and 5 for strongly agreed statements. The questions included in each section are discussed in Chapter 5.

3.2.5 Pilot Study

To evaluate the feasibility and potential of a project pilot study is conducted. Before carrying out a larger study, a pilot study is used to test and make adjustments to the research techniques, methods, and tools. The accuracy, effectiveness, and validity of the research project can be increased by using the findings of a pilot study to modify the research design, methods, or tools. In this approach, a pilot study can assist researchers in reducing errors, saving time and money, and improving the quality of their research.

In the case of fixing a suitable location, the pilot study helps to finalize the study location, the elevation of the fixing camera, and minimum overlapping position, etc. Figure 3.4 shows the first selected location of NH-183 at Vazhoor, Kottayam district.



Figure 3.4 Location at Vazhoor Kottayam District

The preliminary study conducted at the Vazhoor Road curve shows that the position and angle of the fixing camera are not good to detect the vehicle properly, because of the high rate of overlapping. Overlapping means if a small vehicle passes through in the opposite lane due to the presence of a heavy vehicle in the present lane the effect of the small vehicle is not captured in the camera. So the difficulty in placing the camera on an elevated position changed the location at Vazhoor Road to Ponkunnam Road, which also comes under NH 186. Figure 3.5 shows the location at Ponkunnam Road, Kottayam district. Where the overlapping effect is reduced to a far extent due to the top view of the video. So it will give a good result during the detection process.



Figure 3.5 Location at Ponkunnam Road, Kottayam District

3.3 DATA COLLECTION

Data like traffic videos of vehicles entering and leaving from the two approaching legs of the curve and perception data from the questionnaire survey are needed for this work. The videos collected should be at a top elevated level to avoid the overlapping of vehicles. Peak and off-peak hours of a total of 6 hours of data are collected for vehicle detection purposes. User perception data of 385 data is collected to find out the overall perception of users. The data collection procedure is discussed and detailed in Chapter 4.

3.4 VEHICLE DETECTION BY YOLOV5L

Vehicle detection is the process of detecting the vehicle presence on the frames, identifying the type of vehicle, and its coordinate. YOLOv5l is used for detection purposes. More about the detection process is discussed in Chapter 5.

3.5 CURVE COLLISION WARNING PROCESS

This procedure is done by using the model weight files obtained from the vehicle detection process. The concept of the slope of a line is used to identify the vehicle crossing the threshold line. Chapter 6 discusses the curve warning process.

3.6 SUMMARY

This section discussed the methodology followed for the study. The details regarding data collection and extraction are also discussed. Data collection, selection of location, vehicle detection, and curve collision warning process are elaborated on in the coming section of this report.

CHAPTER 4

STUDY AREA AND DATA COLLECTION

4.1 GENERAL

Selection of a suitable study location is very important for the smooth progress of the work. The importance of selecting a location mainly depends upon the nature of the project, availability of data sources, accessibility, etc. Data collection is another important factor to be considered for a project. It is the process of collecting the details needed for the work, and systematically measuring the obtained result, so it helps one to answer the questions easily. There are many methods to collect data like conducting surveys, interviews, observations, experiments, from secondary data sources, etc., and it's also important to select the most suitable method.

4.2 STUDY AREA

The study location selected for the work is Ponkunnam Road as part of NH 183 in the Kottayam district. The location map of the selected study location is shown in Figure 4.1. The study stretch is a sharp curve having two-lane undivided carriageways with less sight distance. The photograph of the curved road study section is shown in Figure 4.2.



Figure 4.1 Location Selected for the Study
(Source: Google Earth Pro)



Figure 4.2 Snapshot of Study Area

4.3 DATA COLLECTION

Data collection is done in two phases. The first phase is to collect the videograph of the traffic from the selected sharp curve. The second phase is to collect the response of the users through a user perception questionnaire survey. For that, ask questions to the users on the selected study location and send a Google form to the people. The questionnaire was simple in format. Anyone experienced in moving through the hairpin can easily understand the questions.

4.3.1 Traffic Video Collection

Videographs of the traffic are needed for this study. The videos are collected by placing two cameras on two legs of the curve. Figure 4.3 shows the position of the camera fixed, and also the camera is focusing towards the legs of the road, so there by the videograph of oncoming vehicles is captured.



Figure 4.3 Camera location for taking videographs
(Source: Google Earth Pro)

In Figure, 4.3 one and two markings on red circles indicate the position selected for taking the video collection. Figure 4.4 shows the video frame taken from the two cameras on the left and right sides of the curve focusing on the legs.



Figure 4.4 Visuals obtained through left and right side cameras

The cameras are placed parallel to the movement of the traffic at a high elevated position. The position of placing the camera is very important for the vehicle detection process. Overlapping of the vehicle should be very less as possible because overlapping cause missing the small vehicles in the detection process if a large vehicle is in front of the small one. If the camera is placed at a high elevation it helps to reduce the chance of overlapping vehicles compared to placing it on the ground level. Once the location for fixing the camera is chosen it should not be changed, throughout the data collection, it should be kept in the same position also.

Traffic videos of a total of seven hours were taken, including peak and off-peak traffic. From morning 8.00 am to 10.30 am, noon 12.00 pm to 2.00 pm, and evening 4.00 pm to 6.30 pm was collected. For capturing the videos two hand cameras, and two tripods are used. The weather condition is sunny and warm during the survey time.

4.3.2 User Perception Survey

User perception studies are useful for getting user input based on their experiences with questions asked of them. These surveys can offer insightful information about how customers view the quality, usefulness, and level of satisfaction of service. Users are often questioned about their opinions and experiences in a survey, and the responses are then examined for patterns and trends.

In this work, a user perception survey is done by preparing a four-sectioned questionnaire. The first section consists of asking the basic questions including gender, age, driving experience, occupation, the purpose of the trip, and frequency of travel through the hairpin roads. The second section deals with questions about their comfort through the existing hairpin road sections. The third section deals with asking them about the conventional assistance systems (eg: convex mirrors) whereas the fourth section deals with questions related to the proposed new advanced assistance system. Questions related to the new proposed system are asked by showing a proposed working of the system through a cad drawing. The detailed description of the user perception study is discussed in Chapter 5, and the Google form prepared for asking questions to the drivers is also mentioned in Appendix A.

4.4 SUMMARY

Data collection and study area related to this work are discussed in this chapter. Data collection involves collecting the video of traffic at peak and off-peak hours for the vehicle detection process. A user perception study conducted to analyze the perception of users towards the current and new idea of advanced driving assistance systems is also discussed in this chapter.

CHAPTER 5

USER PERCEPTION STUDY

5.1 GENERAL

User perception study is mainly conducted to analyze the perception of the users towards the questions asked to them (Pattnaik and Ramesh kumar, 1996). The final result is obtained by analyzing the whole opinion obtained by the user. The time and cooperation of the users while asking them questions are important for the smooth progress of data collection. The main aim of conducting this study is to find out the need of proposing a new assistance system based on the user's perception.

5.2 QUESTIONNAIRE SURVEY

For conducting the study, four sections of questionnaires are prepared in Google form. The details of the questions included in each section are mentioned below. The purpose of a user perception study on curved roads is to understand how drivers perceive and interact with the signals and features provided on a road curve, and how these factors influence their driving behavior and safety.

5.2.1 Basic Information

In this section, the basic details of the users are asked, which include their socio-economic details, trip purpose, and frequency of usage.

- Gender
- Age
- Driving Experience
- Occupation
- Purpose of the trip
- Frequency of travel

5.2.2 Perception Towards Existing Roads

- Feel safe or not while traveling through curves
- Effectiveness of the current driving assistance technology (convex mirror)
- Overall degree of satisfaction when you navigate through a hairpin curve compared to normal curve

- Rating 5 factors based on your experience of traveling through hairpin curves.
 1. Road surface quality (eg: potholes) affects the movement through curves
 2. Pavement marking influences the guidance of vehicles along curve
 3. The presence of a signboard alerts the driver at the entrance and exit points of curve
 4. Landscaping and advertisement boards distract the concentration of driver
 5. The presence of heavy vehicles (bus/truck) against us causes distractions

5.2.2.1 Relative Important Index

In rating scale surveys, the relative important index (RII) is a statistical tool used to find out the relative importance of factors considered for the study (Ko et al., 2009). Pecheux et al. (2004) consider the presence of signals and the presence of heavy vehicles for their study. The RII is finding out by asking respondents to rate the importance of each factor on a scale, typically from 1 to 5 scale, with 1 for strongly disagree and 5 for strongly agree, the RII is calculated by using Equation 5.1 mentioned below,

$$RII = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{A * N} \quad (5.1)$$

Where, n_5 = no. of respondents for strongly agree

n_4 = no. of respondents for agree

n_3 = no. of respondents for neither agree nor disagree

n_2 = no. of respondents for disagree

n_1 = no. of respondents for strongly disagree

A = Highest weight (here $A = 5$)

N = Total Number of responses

5.2.3 Perception Towards Conventional Driving Assistance System

In this section, some statements related to the usage of convex mirrors are asked of the drivers or users and ask them to rate each statement on a 5 scale rating based on their experience.

Prerequisite: These two questions below are asked to all the users to know if they are aware of this or not because as we all know poorly maintained mirrors or sign boards are not properly visible due to fading of mirrors, growth of plants in front of these, damaged due to hitting of vehicles, etc. The second question is asked to give them aware that images on the mirror are only visible while reaching near the mirror, this question helps to compare the attention of the driver towards the convex mirror and the new assistance system.

- Do you know this type of system on curved roads?



Figure 5.1 Convex Mirror

- From where do you see the vehicle opposite to us on this convex mirror?

Statement questions: Here three statement questions about the convex mirror usage are asked to the users to know their opinion about this. Also, ask them to rate it on a 1 to 5 scale.

- The convex mirror gives a distorted size and shape to the vehicle. How do you rate the statement?
- In a curve using a convex mirror it's difficult to judge the opposite vehicle's distance from our vehicle. How do you rate the statement?

- During the rainy season, a convex mirror is complex to judge the opposite vehicles, which causes stress and decreased safety. How do you rate the statement?

5.2.4 Perception Towards the Concept of New Driving Assistance System

This section deals with the statements related to the usage of the new assistance system. For that, a CAD drawing is created showing the working of the system. During the survey the concept of the CAD drawing is explain to the users and after that ask them to rate the statements provided. Figure 3.4 shows the CAD drawing of the proposed model.

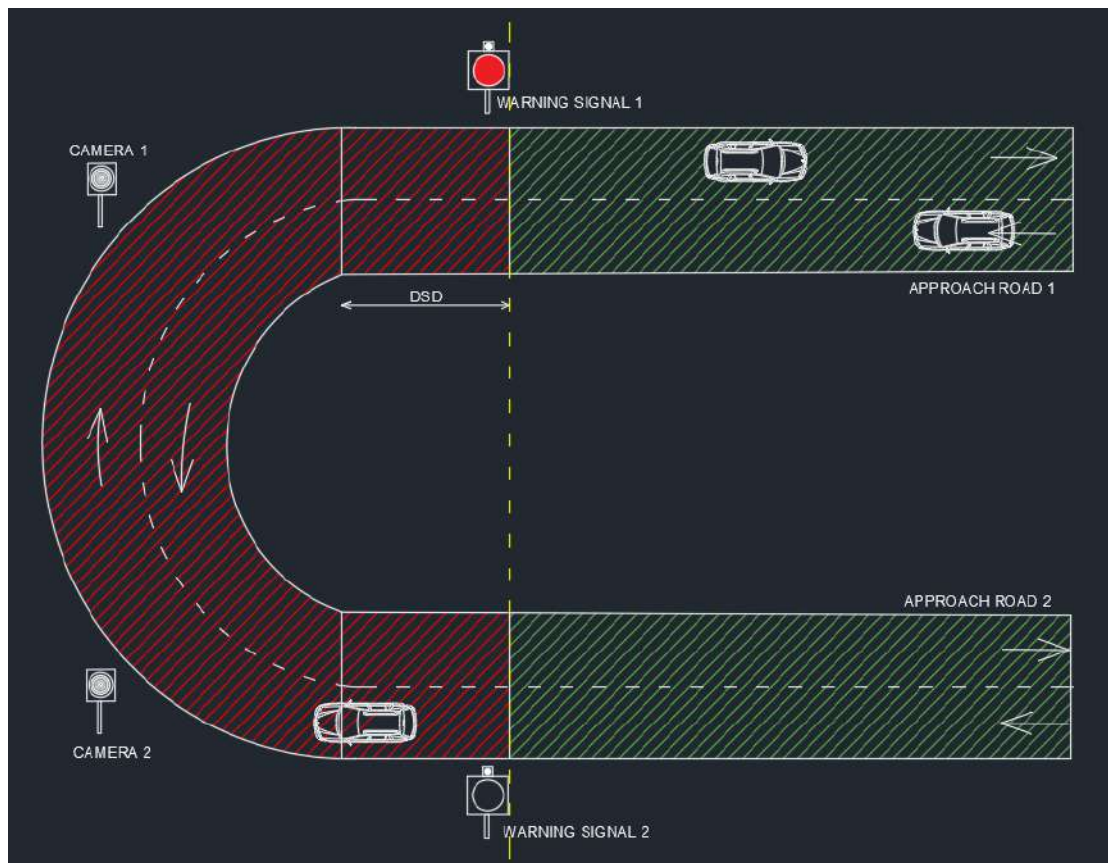


Figure 5.2 CAD Drawing of the Proposed Method

Like a traffic signal it flashes red light to warn the drivers. The red indicates don't try to overtake vehicles and there is the presence of an oncoming vehicle in the curve which leads to conflict.

Prerequisite:

- which one do you think is riskier in curve accidents?

1. Follow vehicles too closely
2. Slow response time (fails in judging vehicles break applying condition in front of us)
3. Abrupt lane change
4. Can't see vehicles coming opposite us
5. All of the above

Statement Questions:

- The presence of flashing LED lights increases the alertness of drivers who negotiate the curve. How do you rate it?
- Through an alerting sign, the system reduces the tendency of the driver's risky overtaking maneuvers. How do you rate it?
- This system improves overall safety through proper guidance. How do you rate it?
- How do you rate the overall idea of introducing the warning signal?

The questionnaire used for the survey is given in Appendix A.

5.3 SUMMARY

The four sections included in the user perception study are very helpful to find out the perception of the driver towards the comfort of existing road, current driving assistance system (eg; convex mirror), new proposed assistance system. Each section contains simple questions, anyone can easily understand it while reading. The last section is about the new advanced assistance system, it is a new idea developed to propose. So it needs some time to explain the concept behind the idea to the users after that ask them the questions in section four. The feedback obtained from each user is collected and analyzed for the overall perceptions.

CHAPTER 6

VEHICLE DETECTION PROCESS

6.1 GENERAL

Vehicle detection is a key area for research in the areas of automatic driving, driver assistance systems, and traffic monitoring. It is also one of the most active areas of research in the field of computer vision (Dong et al., 2022). It is vital to take action to reduce traffic accidents and safeguard the protection of human life and property because the number of vehicles and traffic accidents is rising as the economy develops (Chen et al. 2013). Vehicle localization is a critical issue for the development of intelligent and autonomous systems, such as self-driven driving, surveillance, object detection, or tracking (Mahmood et al. 2019). YoloV5l is used for the process of vehicle detection process because the vehicle orientation data set for YoloV5l is available in GitHub. The YOLO continues to offer higher performance in terms of processing time and accuracy because of improvements in the YOLO-based approaches, like YOLOv3 and YOLOv5 (Rani, 2021). Once successfully trained the model with high accuracy detects the vehicle automatically with good accuracy. Preparation of the dataset for making dataset for training is the most time-consuming process because it requires human effort. The labelling tool is used for preparing the dataset by labelling each vehicle in the frame. The flow chart of the data training process is shown in Figure 6.1.

6.2 DATA COLLECTION

Collecting traffic video for the vehicle detection process needs much more importance. Because of the angle of the camera, the elevation of placing the camera, etc., all have their own importance in the vehicle detection process. In order to avoid the overlapping of the vehicle, the camera should place at a high elevation. Two hand cameras are used for the collection of videos, the cameras are fixed on tripods and placed at high elevations by focusing towards the two approaching legs of the curve. The detailed data collection procedure is discussed in Chapter 4.3.1. Traffic videos of peak and off-peak hours are collected.

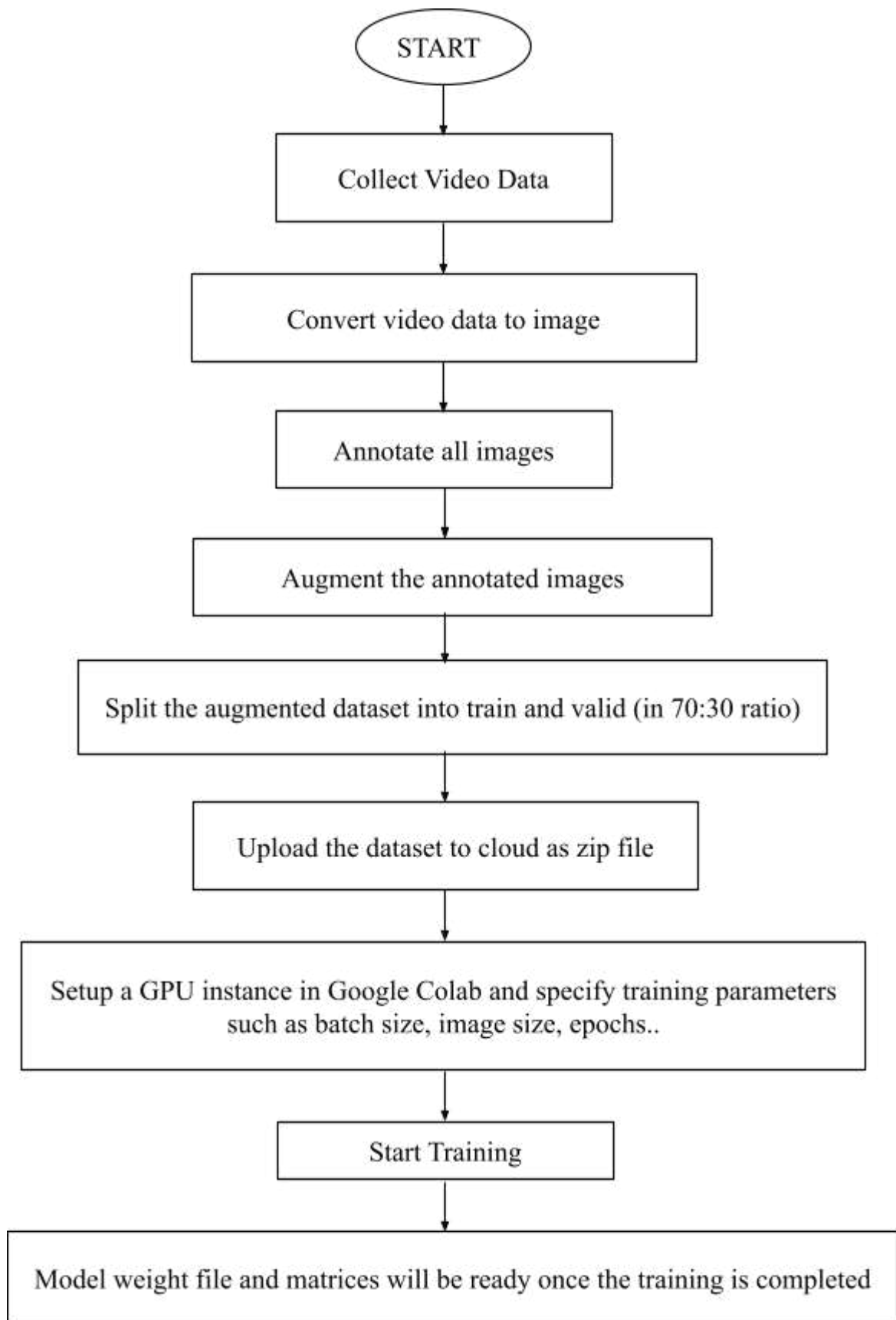


Figure 6.1 Flow Chart of Data Training Process

6.3 CONVERT VIDEO INTO FRAMES

After collecting the traffic video, the next step is to convert the video into frames. For that openCV is used, so it takes the video as input and breaks the video given into frames by frames, and saves those frames in selected folders. Figure 6.2 shows the screenshot of converting videos into frames. Thirty frames are obtained per second which means the camera records 30 distinct images per second (30fps).

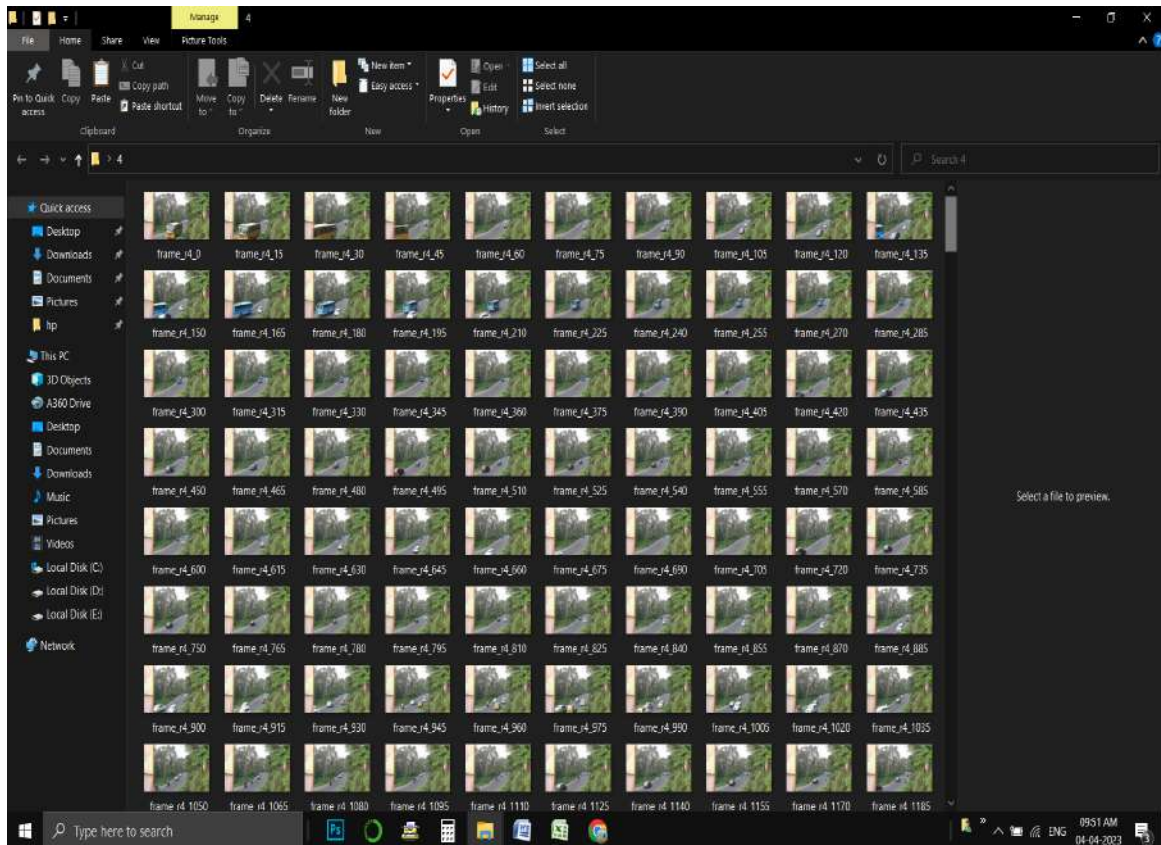


Figure 6.2 Converting Video into Frames

6.4 ANNOTATION PROCESS

In image processing, annotating an image means adding labels, text, or other graphical components to it. Annotations are considered the most time-consuming process in the whole work because annotations are created manually by people. For annotating labelling tool is used. The process of categorizing an object, feature, or aspect of an image or video is referred to as labeling in the annotation. This includes finding the object and designating a particular class or title for it, such as a car, person, tree, etc. The algorithm may learn to recognize and classify comparable objects in new photos by labelling images with particular categories. The quality of labelling is essential to the

machine learning model's performance since poor labeling could reduce the model's accuracy and effectiveness. Overall, labeling is a crucial part of annotation because it gives machine learning models a way to learn about and effectively classify images by giving meaning and context to the objects and regions in an image.

Here in this work, target vehicles are classified into 13 categories like car front, car back, truck front, truck back, motorcycle front, motorcycle back, cycle front, cycle back, auto front, auto back, LCV front, LCV back, bus front, and bus back. The information regarding the annotated vehicle categories in YOLO is shown in Table 6.1.

Table 6.1 Details of Annotation Categories used in YOLO

Annotation Categories Used in YOLO			
Car Front	0	Cycle Back	7
Car Back	1	Auto Front	8
Truck Front	2	Auto Back	9
Truck Back	3	LCV Front	10
Motorcycle Front	4	Lcv Back	11
Motorcycle Back	5	Bus Front	12
Cycle Front	6	Bus Back	13

Figure 6.3 shows labeling each vehicle in labelling and selecting the appropriate annotation category. The annotation of a vehicle is completed after drawing a bounding box around each vehicle and selecting the annotation category of that vehicle. For example, in Figure 6.3 bounding box is drawn to all the vehicles which can be seen by a green rectangular box around each vehicle, and selecting the annotation category (ie., for auto) is also seen in that figure.

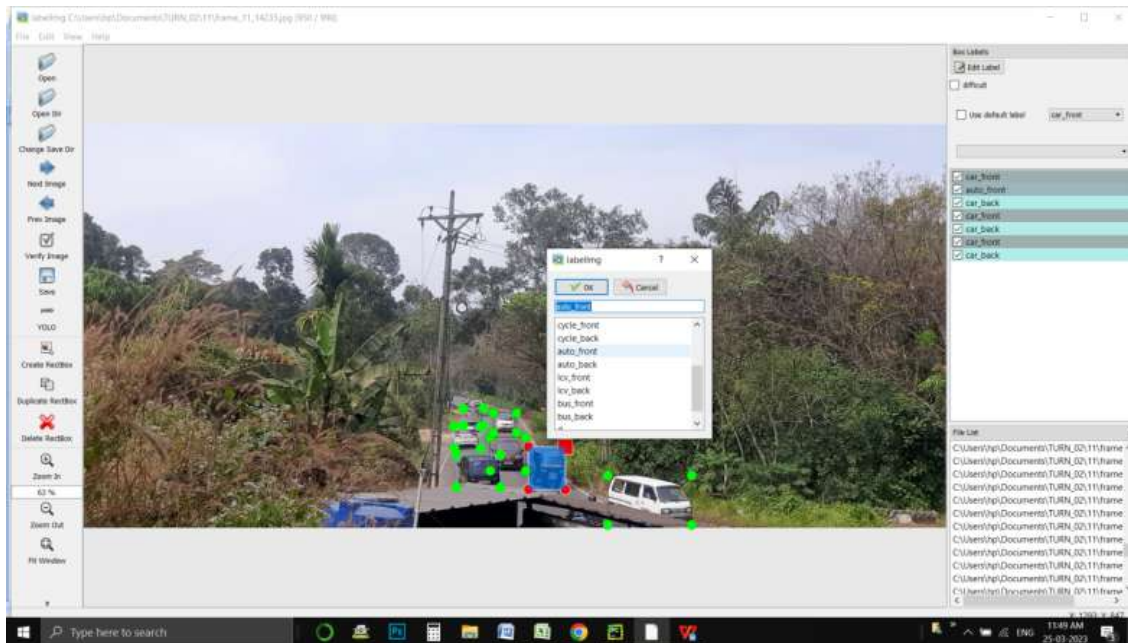


Figure 6.3 Annotation of vehicles in labelling

6.4.1 Dataset Size prepared for training

Data size has very important for training purposes. The accuracy and performance of image processing can be significantly impacted by the amount of the dataset employed. Larger datasets typically offer more representative and diverse samples, which can enhance the model's accuracy and robustness. Figure 6.4 shows the size of vehicles annotated using the Labelling tool before augmentation.

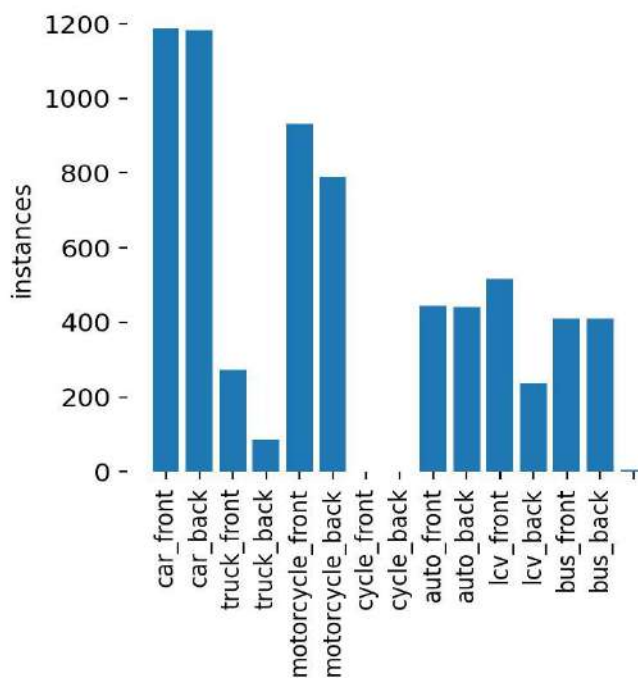


Figure 6.4 Annotated Size of Vehicles Before Augmentation

Augmentation is another useful technique, in image processing, the approach of augmentation involves generating new copies of preexisting images so as to increase the size of a dataset. In order to produce fresh images that are close to the original ones but not exactly the same, this technique involves making numerous transformations to the original images, such as rotating, scaling, cropping, flipping, or adding noise. In machine learning applications like image classification, object recognition, and segmentation, augmentation is frequently used to enhance the performance and generalization of the models (Zhang et al., 2022). Figure 6.5 shows the result obtained after augmentation, here the size of the dataset prepared in the previous stage is increased.

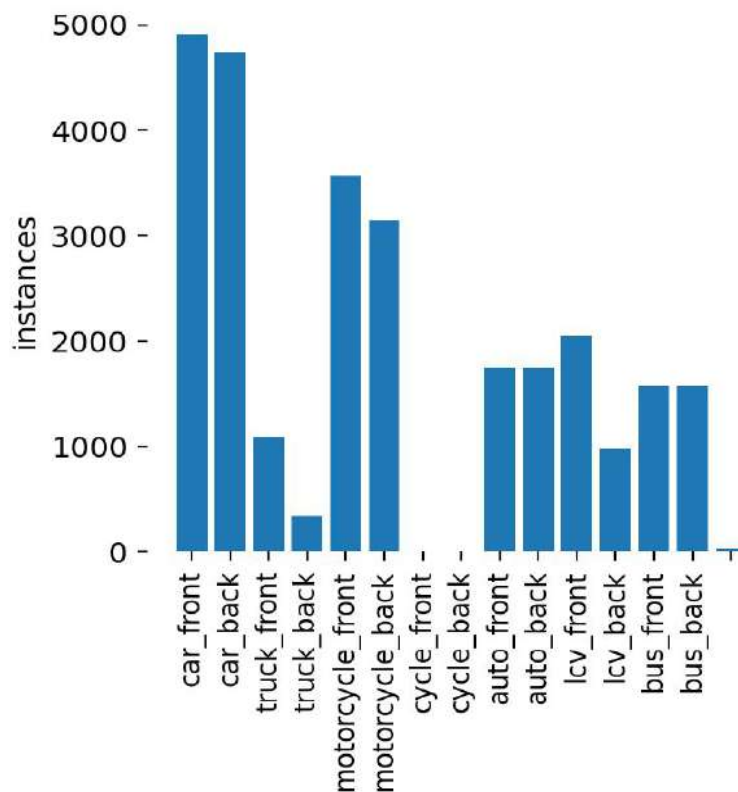


Figure 6.5 Data Size After Augmentation for Training

After augmentation the dataset is ready for the training process. The next step is to divide the dataset into training and testing datasets.

6.5 DISTRIBUTION OF DATASET

The dataset before augmentation contains a total of 6,860 images and the dataset after augmentation contains a total of 27,150 images, as shown in Figure 6.6. The training and testing set is divided into a 70:30 ratio. That means 19005 images were used for the

training dataset and 8145 images were used for testing purposes, and evaluated by algorithms.

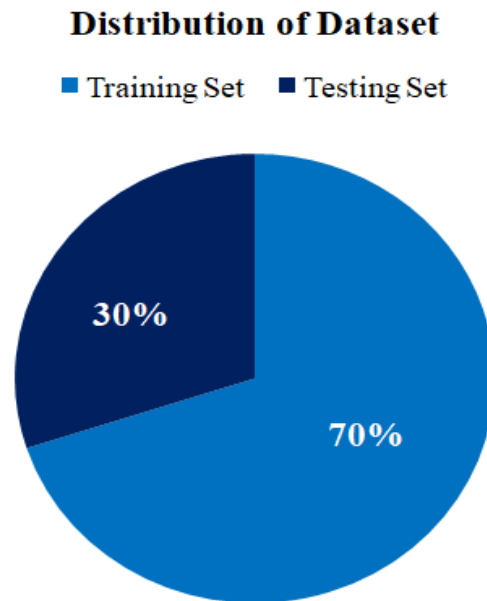


Figure 6.6 Distribution Proportion of Total Dataset

6.6 TRAINING PROCESS

Training should start after splitting the dataset into training and testing. YOLOv5l is obtained from GitHub and is used to train the model into our condition. With the help of Google Colab, the training process is carried out. So before starting training specify training parameters such as batch size, image size, and epoch should be selected. These are the important concepts that relate to the training process of a model. Batch size means the number of samples that are processed at once during the training process. During training, the model updates its weights based on the gradients computed on a batch of data. Here the batch size of 64 is selected. Image size is the input image that the model will use for training. The image size can have a significant impact on the model's performance, an image size of 640 is applied here and finally, epoch is the number of times the entire dataset is used to train the model. During each epoch, the model processes the entire dataset and updates its weights based on the loss computed on the training data. Increasing the number of epochs can lead to better model performance. An epoch of 8 is selected for training, which means eight times the entire dataset is passed through the YOLO architecture. Training is done in two ways, using the dataset before augmentation and after augmentation.

After the training process, the result is also obtained in the form of a confusion matrix and model weight. The weights obtained after training represent the learned parameters of the model that will be used to make predictions on new, unseen data. Once the training is complete, the model can be used for inference, where new input data is fed into the model, and the learned weights are used to make predictions. The quality of the predictions will depend on the accuracy of the learned weights and the quality of the input data. In general, the better the training process, the more accurate the learned weights will be, and the better the model's performance on new data. The result obtained after training is discussed in Chapter 7.

6.7 SUMMARY

The methods adopted in the vehicle detection process are discussed in this chapter. YOLOv5l is used for the vehicle detection process. The annotation process helps with the preparation of datasets. Augmentation helps to enhance the dataset thereby improving the accuracy of the prediction of the dataset. At the end of the training process model weights and matrix is obtained before and after augmented training. The results obtained clearly shows the importance of the augmentation process in the image processing technique. The results obtained are included in Chapter 7. The finally obtained model weight is used for the development of the curve collision warning process.

CHAPTER 7

CURVE COLLISION WARNING PROCESS

7.1 GENERAL

Drivers who are traveling at high speeds and fail to anticipate the severity of a turn run off the road, lose control of their vehicles, and crash into a tree, oncoming vehicles or barrier. When approaching a dangerous bend, a drunk driver is also at risk. There are no signboards placed at the entrance and exit of the curves in many places, if it places the maintenance of the signboards is very less. Some get faded and some sign boards can't see due to the growth of plants over them. Similarly, pavement marking also has importance in the smooth guidance of the driver through the curves. According to the National Highway Traffic Safety Administration (NHTSA), the most important human factors that contribute to roadside accidents are driver distraction, fatigue, driver familiarity with the roadway, blood alcohol content, age, and gender (Stephan and Newstead, 2014), with driver inattention accounting for 30% of these accidents (Roque et al. 2015).

Here warning in the form of red flashing light is given to the drivers who enter into the curves, so they can easily notice the lights compared to a convex mirror. The presence of vehicles on the curve is conveyed through the lights, so noticing the warning reduces the overtaking tendency of the drivers.

7.2 DECISION SIGHT DISTANCE

Decision sight distance (DSD) is a distance at which motorists can identify a hazard or a signal in a road environment, choose an acceptable speed and course, and carry out the necessary action safely and effectively (Alexander and Lunenfeld, 1975). DSD is determined using Equation 7.1.

$$\text{Decision Sight Distance (DSD)} = 0.278 \times V \times T \quad (7.1)$$

Where,

V = 98th percentile speed - design speed (km/hr)

T = reaction time (2.5sec)

Figure 7.1 shows the location of the camera and signal on the road, where the signals are placed DSD distance from the transition point of the road towards the straight line.

7.3 SPEED DATA ANALYSIS

The analysis is done to find out the speed characteristics of the vehicles that pass through the study stretch. The free flow speed of vehicles in one hour is considered here to analyze the design speed. Spot speed data refers to the measurement of individual speeds of vehicles. The frequency distribution data of speed is shown in Table 7.1.

Table 7.1 Frequency Distribution Data

Speed Range (m/s)	Mid-speed (m/s)	Frequency	Percentage Frequency	Cumulative Frequency
0-10	5	0	0	0
10-20	15	14	3.43	3.43
20-30	25	228	55.88	59.31
30-40	35	112	27.45	86.76
40-50	45	47	11.52	98.28
50-60	55	0	0	98.28
60-70	65	0	0	98.28
70-80	75	7	1.72	100
80-90	85	0	0	100
90-100	95	0	0	100

7.4 CONCEPT BEHIND CURVE COLLISION WARNING

For the warning process two cameras and two flashing red LED signals are used. The cameras are placed on two ends of the curve facing toward the approaching straight legs. The signals are placed in Decision Sight Distance (DSD) away from the curve's transition point (where the straight road meets the curved road). So that the drivers entering the curve can be able to understand the presence of vehicles on the curve and can avoid the overtaking tendency of slow-moving vehicles before entering the curve also they can slow down their speed while entering the curve. A clear pictorial

representation of the concept of providing a curve collision warning system is shown through a CAD drawing in Figure 7.1.

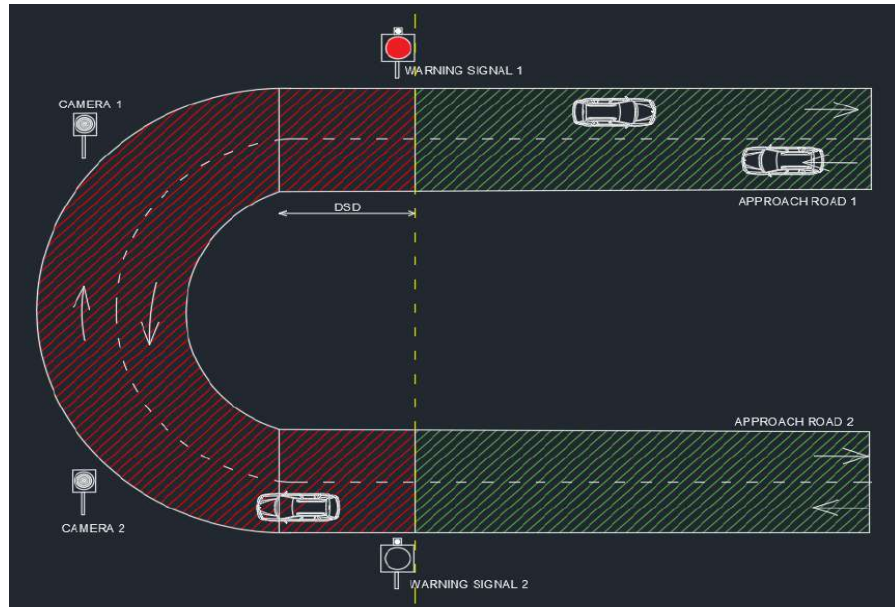


Figure 7.1 Pictorial Representation of Placing Signal and Camera on Road

In Figure 7.1 there are 2 approaching roads, approaching Road 1 and approaching Road 2 meet a curve, and the road is divided into 2 regions one is green and another is a red region. Figure 7.2 shows the flow chart of providing a warning.

First, a curve collision warning system is developed in Python then a video is given into it. Then the system receives the frame, here only the front view of the vehicle is considered. So the object detection algorithm detects whether there is any front view of the vehicle in the frame. If there is no front view of the vehicle the frame is skipped and take another frame. If there is a front view of a vehicle, the code will detect the vehicle and go to the next step. Figure 7.3 is the pictures showing the absence and presence of the vehicle in the frame



Figure 7.3 Absence and Presence of the Front View of the Vehicle

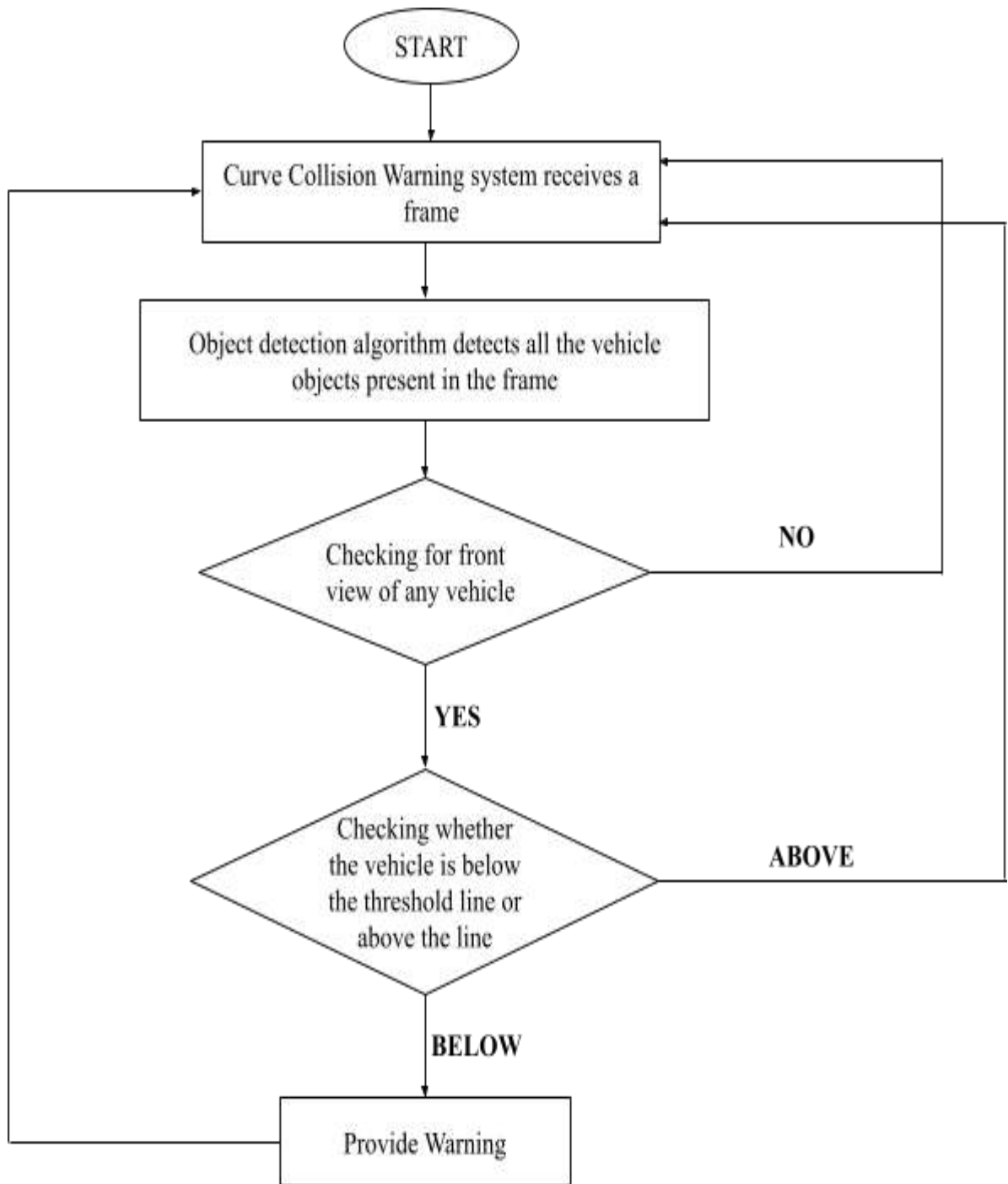


Figure 7.2 Flow Chart for Warning Process

In the next step, the program detects whether the vehicle crosses the threshold line or not. If the vehicle is above the threshold line that means the vehicle will not cross the threshold line, no danger warning is shown. When the vehicle crosses the threshold line (below the threshold line) the program detects the presence of a vehicle entering into the curve and gives a danger warning to the drivers using red LED signals. Figure 7.4 is

the images of vehicles above and below the threshold line. The threshold line is a line considered DSD distance from the transition line, it is indicated by a yellow line in Figure 7.1. The result obtained in this section is given in Chapter 7.



Figure 7.4 Vehicle above and below the threshold line

7.5 CONFUSION MATRIX FOR DETECTION PROCESS

		ACTUAL VALUE	
		Positive Danger	Negative Danger
PREDICTED VALUE	Total 384	TP (True Positive)	FP (False Positive)
	Positive Danger	FN (False Negative)	TN (True Negative)
	Negative Danger		

Figure 7.5 Confusion Matrix Format

High TP and TN rates and low FP and FN rates are indicators of a strong model. A confusion matrix is a table that lists how many predictions a study made were accurate and how many were inaccurate. It is employed to evaluate a classification model's effectiveness. Figure 7.5 is the model of the confusion matrix used to represent the result. It can be used to calculate performance metrics like accuracy, and precision, in order to assess the effectiveness of a classification model.

a) True Positive (TP)

- The predicted and actual value matches
- As predicted by the model, the actual value is positive

b) False Positive

- The value predicted is wrongly predicted
- The model predicted a positive result, but the actual value was negative.
- This error is also known as the type I error

c) False Negative

- The predicted value is wrongly predicted.
- The model projected a negative result, while the actual value was positive
- This error is also known as the type II error

d) True Negative

- The actual value matches the predicted value.
- The model predicted a negative result, while the actual value was negative.

7.5.1 Accuracy of Prediction

In simple terms, accuracy measures how frequently the classifier predicts accurately. It's the ratio between the number of correct predictions and the total number of predictions. Equation 7.2 is used for the calculation of accuracy.

$$Accuracy = \frac{TP + TN}{TP + TN + FN + FP} \quad (7.2)$$

7.5.2 Precision of Prediction

Precision is defined as the ratio of the total number of correctly classified positive classes divided by the total number of predicted positive classes. Equation 7.3 is used for the precision of this prediction process.

$$Precision = \frac{TP}{TP + FP} \quad (7.3)$$

7.6 SUMMARY

This chapter discussed the methods of the curve collision warning process. Topics like DSD, speed calculation, the concept behind the warning system, the flow chart of doing the process, the confusion matrix obtained, and the accuracy and precision of the result are discussed in this Chapter.

CHAPTER 8

RESULT AND DISCUSSIONS

8.1 GENERAL

The result section discusses the findings obtained from this study, which involves the results obtained from the user perception study, vehicle detection process, and curve collision warning process. For the user perception study, the result was discussed in four sections. Results obtained in the form of a confusion matrix are discussed in the vehicle detection process. In the curve collision warning process the results from speed calculations, determination of decision sight distance, and confusion matrix are included.

8.2 BASIC DETAILS

8.2.1 Gender

In the total response of 385 data collected from the study area, 53.2% are males and 46.8% are females. Figure 8.1 shows the distribution chart of the gender of users who responds to the survey.

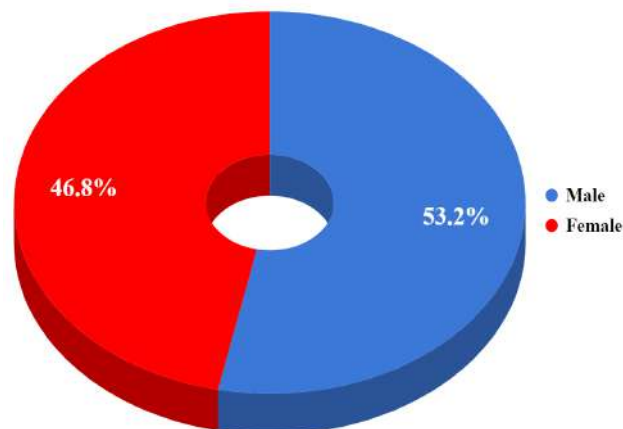


Figure 8.1 Gender Distribution

8.2.2 Age Classification

Figure 8.2 shows the percentage of different age groups of users who participated in the survey. Age is classified into three categories. Most of the participants were in the age group between 18-30 years about 37.6%. 35% is the people with age 31-45 years and 27.4% comes under greater than 45 years age.

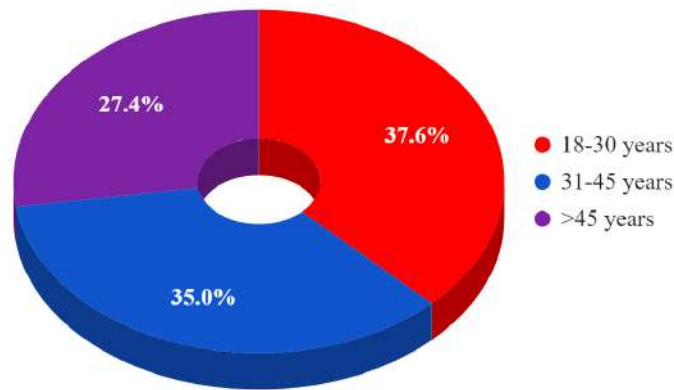


Figure 8.2 Age Distribution

8.2.3 Driving Experience

By collecting the driving experience of the users it helps to find out the range of experience of each one on driving the vehicle and obtaining a good valuable response. The majority of the data is collected from people with driving experience of greater than 15 years (32.5%), which means from well-experienced people. The least response was obtained from the zero years category (5.2%) people that are the people who travel among the drivers, based on their travel experience attended the survey.

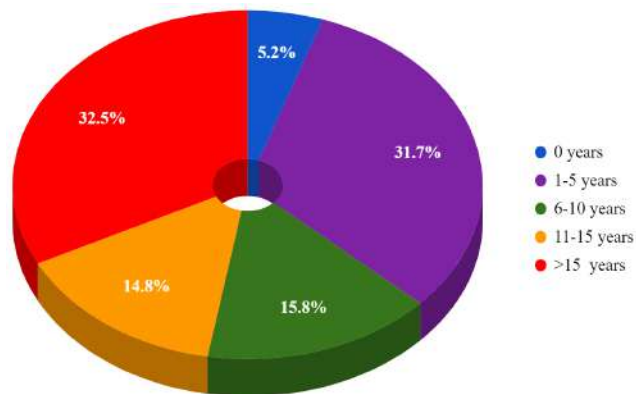


Figure 8.3 Driving Experience Distribution

8.2.4 Purpose of the Trip and its Frequency

The majority of travelers with 42.3% traveled for their work purpose, shopping (20.8%), education (20.0%), Other purposes (9.1%), and Recreation (7.8%).

Coming to the frequency of travel through the curves 29.4% of people are daily travelers, then monthly, weekends, and very rarely travelers with 27.3%, 24.9%, and 18.4% respectively. Figure 8.4 and 8.5 shows the graph of traveling purpose distribution and traveling frequency distribution.

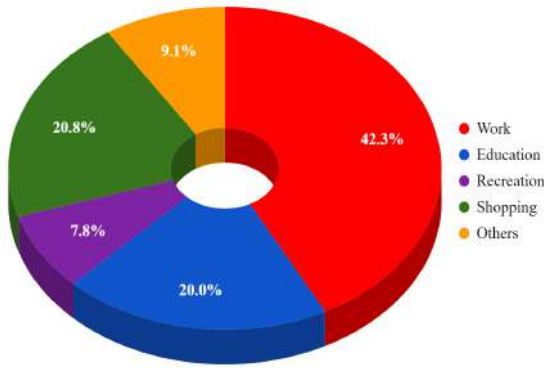


Figure 8.4 Traveling Purpose Distribution

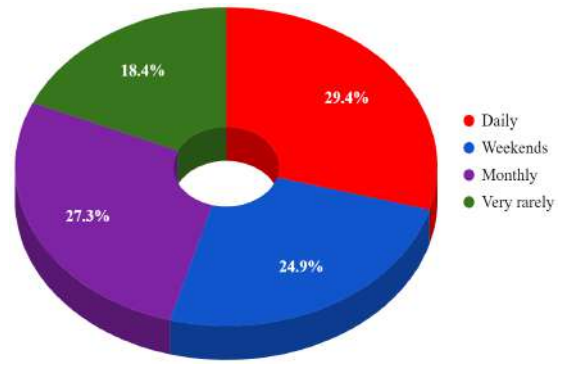


Figure 8.5 Traveling Frequency Distribution

8.3 COMFORT THROUGH EXISTING ROAD CURVES

In this section the users respond to the questions based on their experience while traveling through the curves. Figure 8.6 shows the percentage chart of people who feel unsafe while traveling through the curves, where 63.6% of people feel unsafe.

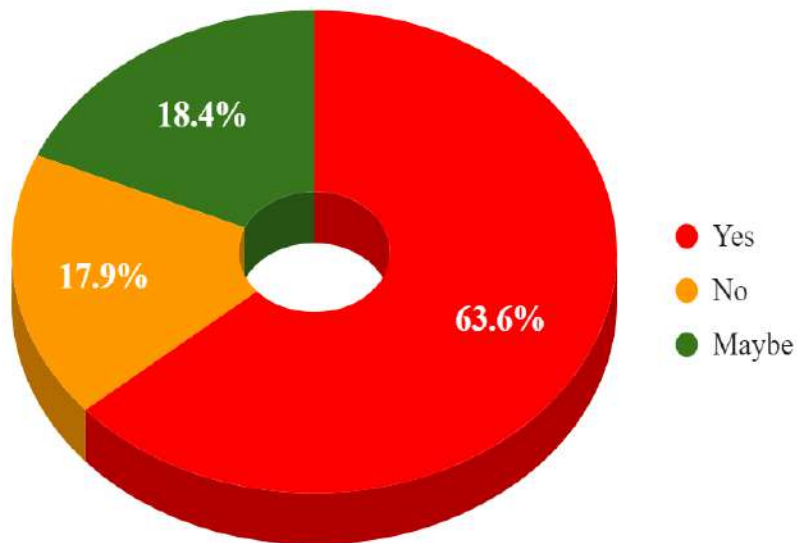


Figure 8.6 People Safety Distribution

8.3.1 Effectiveness of Using Current Driving Assistance Technology

Here questions is asked to know how effective are the current driving assistance technology (eg: Convex mirror) in improving road safety on curved roads. Figure 8.7 shows the response of users, where 58.2% says the systems used nowadays are less effective.

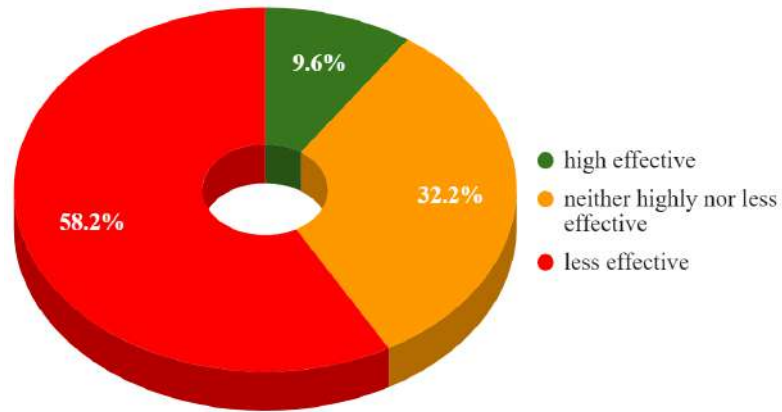


Figure 8.7 Responses for Effectiveness of Current Driving Assistance

8.3.2 Comfort And Satisfaction Through Curves

75.3% of people say that they don't feel any smooth traveling while negotiating through the curves. Figure 8.8 and 8.9 shows the total responses against the driver's comfort and overall satisfaction charts. 39.7% responded that the overall degree of satisfaction when you navigate through a hairpin curve compared to normal is highly dissatisfied and 36.4% are dissatisfied.

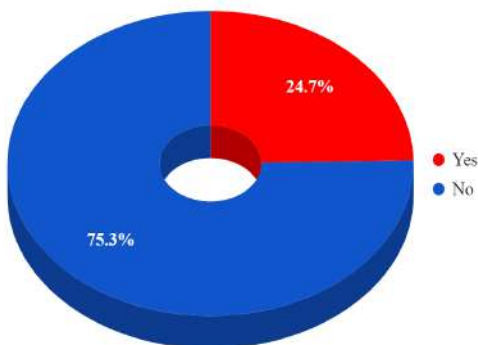


Figure 8.8 Response of Comfort Through Existing Roads

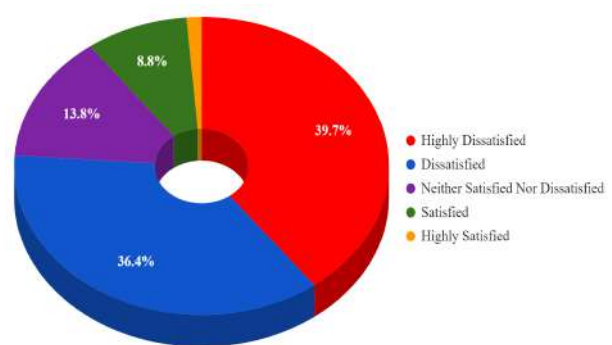


Figure 8.9 Response of overall satisfaction

8.3.3 Analysis of Selected Factors

Responses are collected on a 1 to 5 rating scale, in that five factors are selected for finding out the most influencing factor. The surface quality of the road, pavement markings, presence of sign boards, landscaping, and advertisement boards, and presence of heavy vehicles are the five selected factors. Users rate this factor based on their experience while traveling through the curves. Figure 8.10 was the responses of users on a 1-5 rating scale for each selected parameter. Table 8.1 is the Relative Important Index (RII) calculation table to find out the most influencing factor among the five.

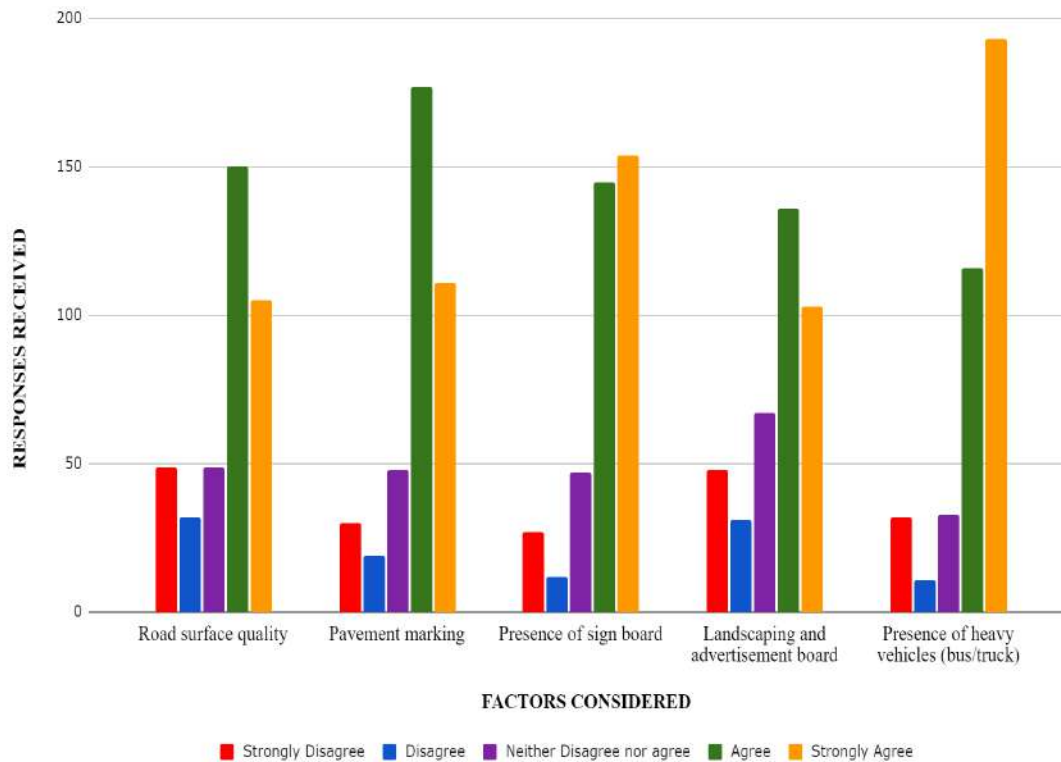


Figure 8.10 Responses Chart of the Selected Factors

From the calculation table 8.1 presence of a heavy vehicle is the most influencing factor to the drivers with an RII of 0.82.

Table 8.1 Relative Important Index of Factors

Factors considered	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	RII	Rank
Road surface quality	105	150	49	32	49	0.72	4
Pavement Markings	111	177	48	19	30	0.77	3
Sign Boards	154	145	47	12	27	0.80	2
Landscaping and advertisement boards	103	136	67	31	48	0.71	5
Presence of heavy vehicles	193	116	33	11	32	0.82	1

8.4 CONVENTIONAL DRIVING ASSISTANCE SYSTEM

Nowadays convex mirrors and curve warning sign boards are majorly used to provide warning to drivers about the curves. Figure 8.11 shows the curve warning systems used nowadays to warn the drivers who negotiate through the curves. The main disadvantage of using this system is that it is only visible when reaching near the convex mirrors. Also, the surface gets faded as time passes, and at night time it's difficult to judge the vehicles clearly. Figure 8.12 shows the chart of people who know the current assistance systems. 93.5% of people know this type of system and 4.9% doesn't give any attention to this system.

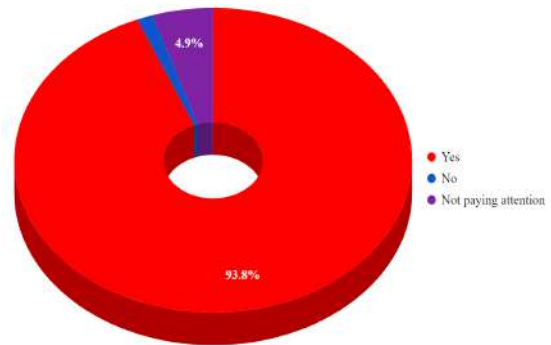
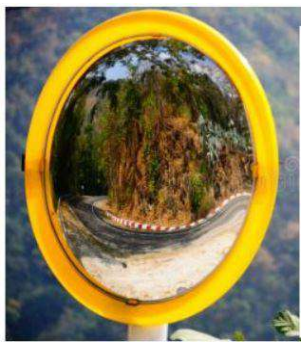


Figure 8.11 Conventional Curve Warning system

Figure 8.12 Responses Against the Familiarity of Conventional System

Figure 8.13 shows that 49.4% of users see this mirror while reaching near the mirror and 16.1% of people can't use this type of mirror, most of them are females and young generations.

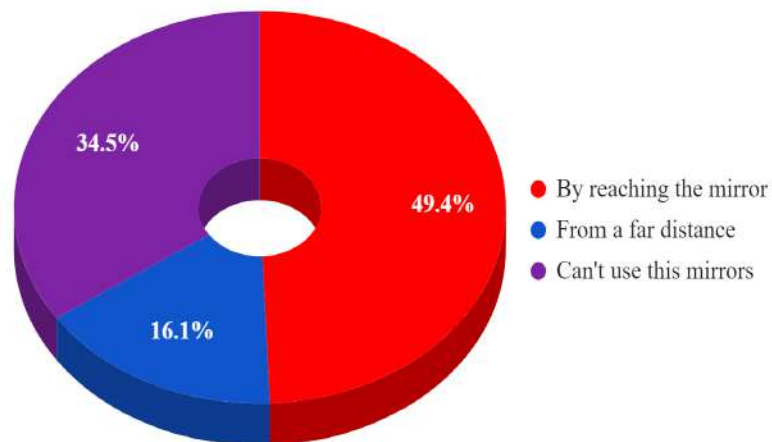


Figure 8.13 Responses for Noticing the Mirror

8.4.1 Statement Questions Related to Conventional System

Three statement questions are asked to the users. Figure 8.14, 8.15, and 8.16 is the response obtained for statement questions one, two, and three respectively.

“The convex mirror gives a distorted size and shape to the vehicle coming opposite to us” is the first statement question. 45.71% of people agreed and 19.22% of them strongly agreed with the statement. Because the distortion of shape and size that users observe when looking at an image reflected by a convex mirror is due to the way that the light rays are reflected. The image formed by a convex mirror appears smaller than the actual object and is distorted or "squished" towards the edges. This distortion is a result of the variation in the angles at which the light rays reflect off the mirror, which results in a compressed and distorted image.

Statement two is “In a curve using a convex mirror is difficult to judge the opposite vehicle's distance from our vehicle”. 39.74% agreed and 28.31% strongly agreed with the statement asked of them. The objects seen in a convex mirror appear smaller than they actually are, and the farther away they are, the smaller they appear. As a result, it can be challenging to accurately estimate the distance of an oncoming vehicle in a convex mirror, especially if it is far away.

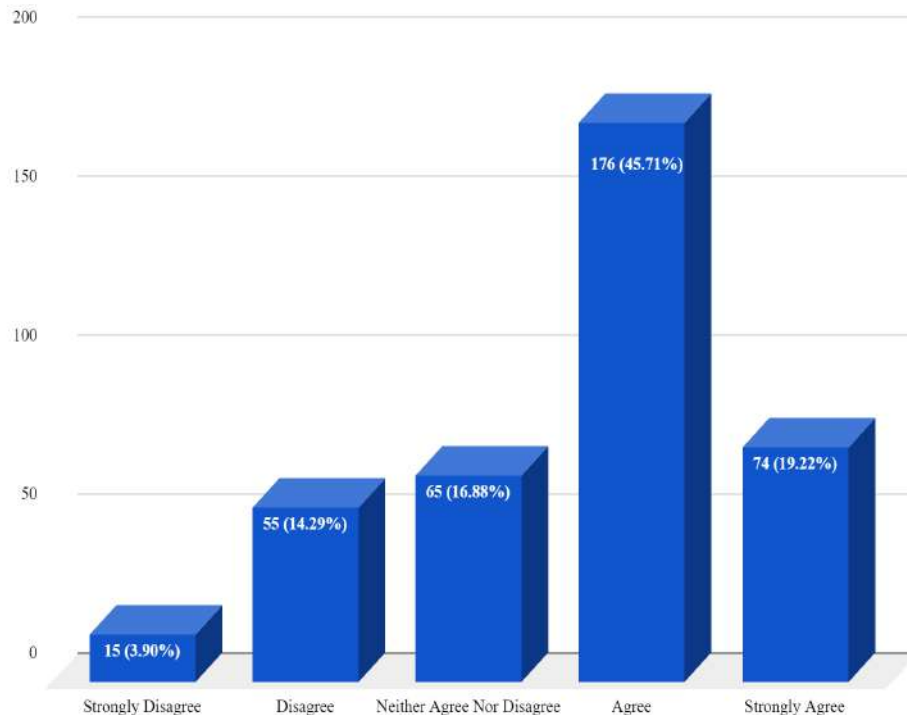


Figure 8.14 Responses Obtained for Statement One

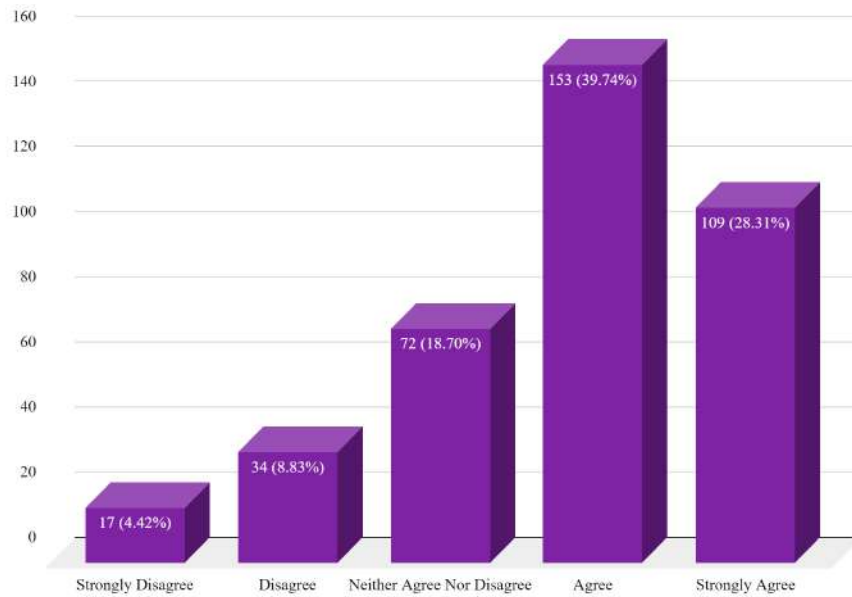


Figure 8.15 Responses Obtained for Statement Two

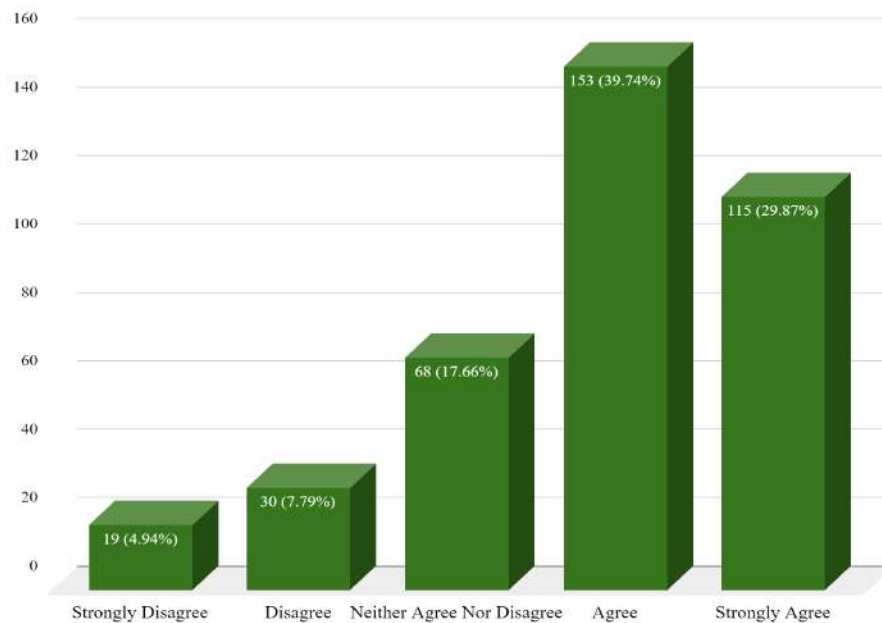


Figure 8.16 Responses Obtained for Statement Three

The third statement is about the vision during night time and the question is “During the rainy season, a convex mirror is complex to judge the opposite vehicles, which causes stress and reduces safety”. The total agreed users are 39.74% and 29.87% are comes under the strongly agreed category.

So from the analysis of three statements asked by the users, it is understood that the current driving assistance system is less effective in providing safe guidance through curves. A new assistance system is developed for the users for safe guidance is discussed in section 8.3.

8.5 NEW ADVANCED DRIVING ASSISTANCE SYSTEM

A concept of a new advanced driving assistance system was developed to overcome the drawbacks of a conventional assistance system (convex mirror). So through this, the users can identify the presence of vehicles on the curve from a far distance itself, so they can reduce the speed while entering the curve. Also, this system provides a warning at night time also whereas the convex mirror doesn't provide a proper warning during night and rainy times.

8.5.1 Analysis of Riskier Factors

Five options related to causing accidents on a curve is asked of the drivers. In Figure 8.17, 35.6% says that the presence of heavy vehicle opposite us is the main reason for causing an accident because heavy vehicles like bus/truck need more space while turning the curve and for that, they use the lane of opposite vehicles. 37.4% say all factors considered like following vehicles too closely, slow responding time, abrupt lane change, can't see vehicles opposite to us cause accidents.

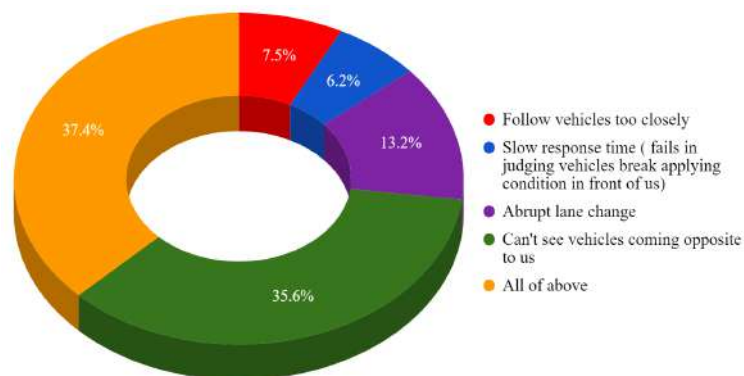


Figure 8.17 Responses of Risk Factor

8.5.2 Analysis Towards Statement Questions

Analysis of four statement questions is done in this section. People responded positively to the four questions asked of them. The first question is whether “the presence of flashing LED signal increases the alertness of drivers who negotiate the curve”. Figure 8.18 shows the graph of people’s responses to the first question. Here 47.2% agreed with the statement and 31.95% strongly agreed with the statement asked to them. Compared to a convex mirror the LED signal gives more attention to the drivers due to the blinking of red lights, also the signal is visible from a far distance. In Figure 8.19

47.53% and 32.73% of responses are positive to the second statement asked to the users. That is it reduces the tendency of the driver's risky overtaking by using the LED warning signal.

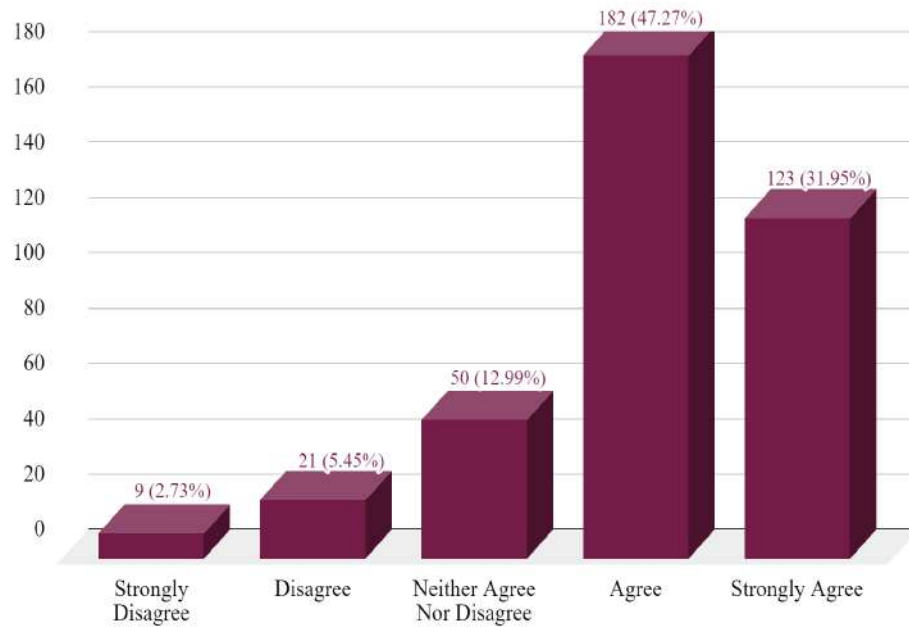


Figure 8.18 Responses Obtained for statement one

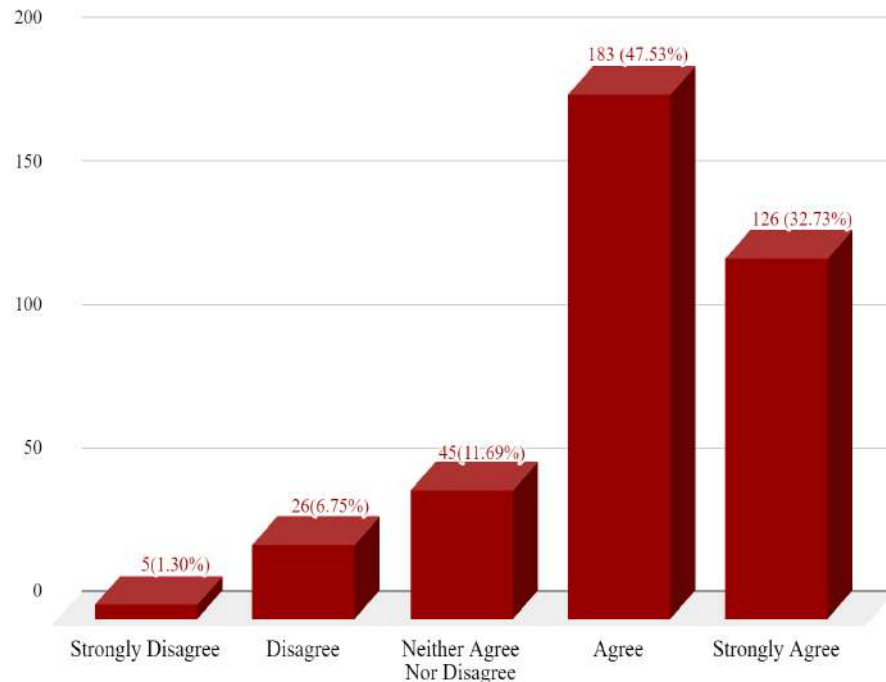


Figure 8.19 Responses Obtained for Statement Two

In the analysis of Figure 8.20 41.04% and 43.12% people positively responded that introducing the system it will improve overall safety through its proper guidance.

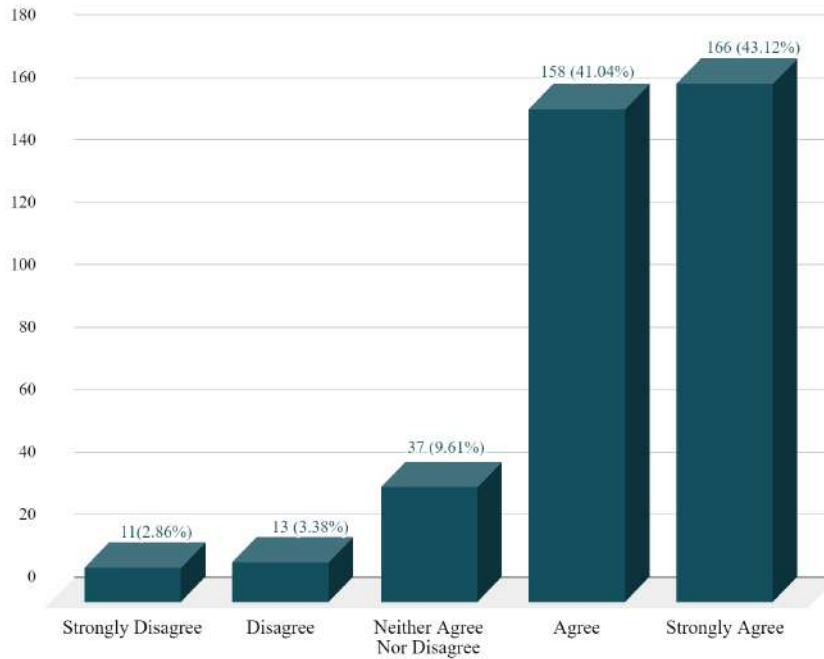


Figure 8.20 Responses Obtained for Statement Three

Figure 8.21 is the response chart of people about the overall idea of introducing the warning signal. More the half of the total respondents support the idea of introducing this helps them in reducing their tendency to overtake maneuvers, increases safety, to understand the presence of vehicle before entering into the curves.

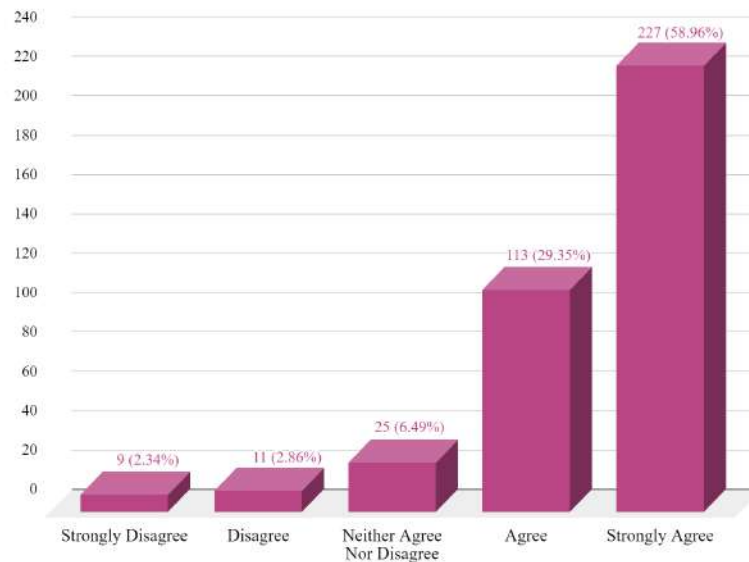


Figure 8.21 Responses Obtained for Statement Four

So the analysis result of the user perception study clearly shows that the current driving assistance system has many drawbacks, and the users also feel discomfort. So they agreed that the idea behind the new driving assistance system makes a positive impact.

8.6 RESULT FROM THE VEHICLE DETECTION PROCESS

Before training the model run the vehicle detection algorithm using the vehicle orientation dataset obtained from GitHub. Figure 8.22 shows the result of vehicle detection using the dataset taken from GitHub. Here the result shows that some category vehicles like Auto and LCV don't detect correctly, they are misclassified as another category of vehicle. For example, the auto back is miss classified as the car front. And the accuracy of detection is also displayed in the figure except for car all other categories of vehicle shows less accuracy.



Figure 8.22 Detection of Vehicles Using Vehicle Orientation Dataset

Misclassification and less detection accuracy shows the need of improving the model performance. For that annotation is done. The details of the annotation procedure are discussed in section 6.4. The confusion matrix obtained after model training using the annotated dataset (first training process) is shown in Figure 8.23.

The accuracy of detecting vehicles is improved after the first training process. Vehicle categories like the truck front, truck back, LCV front, and LCV back show an accuracy of less than 0.9 except all show better accuracy of prediction. So to improve the accuracy of the prediction augmentation process is done with the prepared dataset and created a new dataset after augmentation. Then again the model is trained using the dataset obtained from the augmentation process (second training process). Figure 8.24 is the confusion matrix obtained after the augmentation process. The second confusion matrix obtained shows the well-improved result from the first confusion matrix. So the

weight file from the second training process is used for the curve collision warning process.

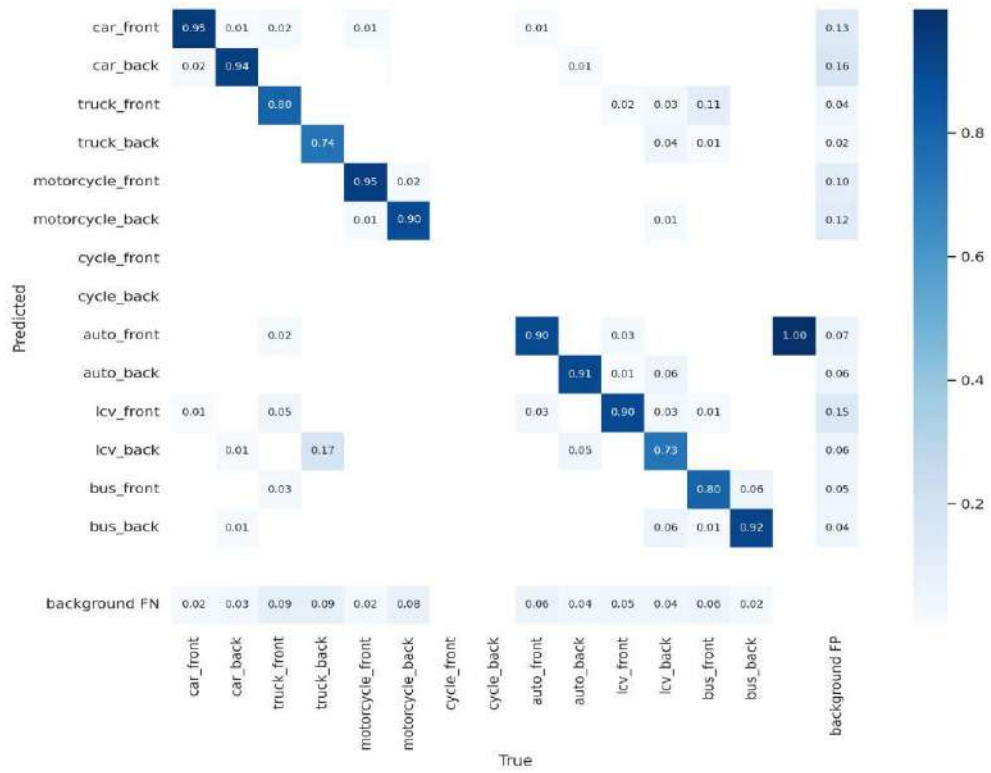


Figure 8.23 Confusion Matrix from First Model Training

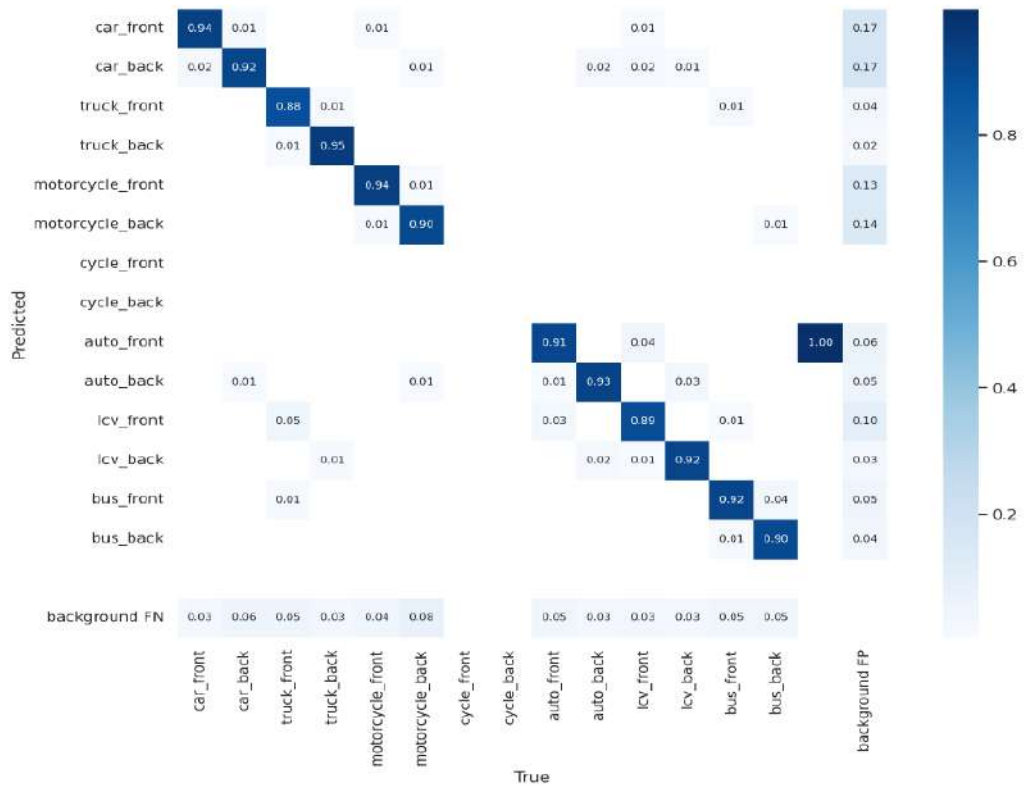


Figure 8.24 Confusion Matrix After Augmentation

Figure 8.25 is the result of detecting the vehicle after the second training process, here auto and LCV are clearly detected.



Figure 8.25 Results of Vehicle Detection

8.7 RESULTS FROM CURVE COLLISION WARNING PROCESS

8.7.1 Speed Calculation

Speed is extracted manually by taking a known distance and time taken to cross the distance. Figure 8.26 shows the graph of cumulative frequency v/s speed. 43Km/hr is the 98th speed (design speed) obtained from the graph. This speed is used to find out the DSD value for taking offset from the transition region of the road. Based on the design speed of the vehicle traveling on the road the decision sight distance is calculated. DSD depends upon the design speed of the vehicles calculated and the reaction time of the drivers. Usually, the reaction time of 2.5 seconds is considered for calculation purposes.

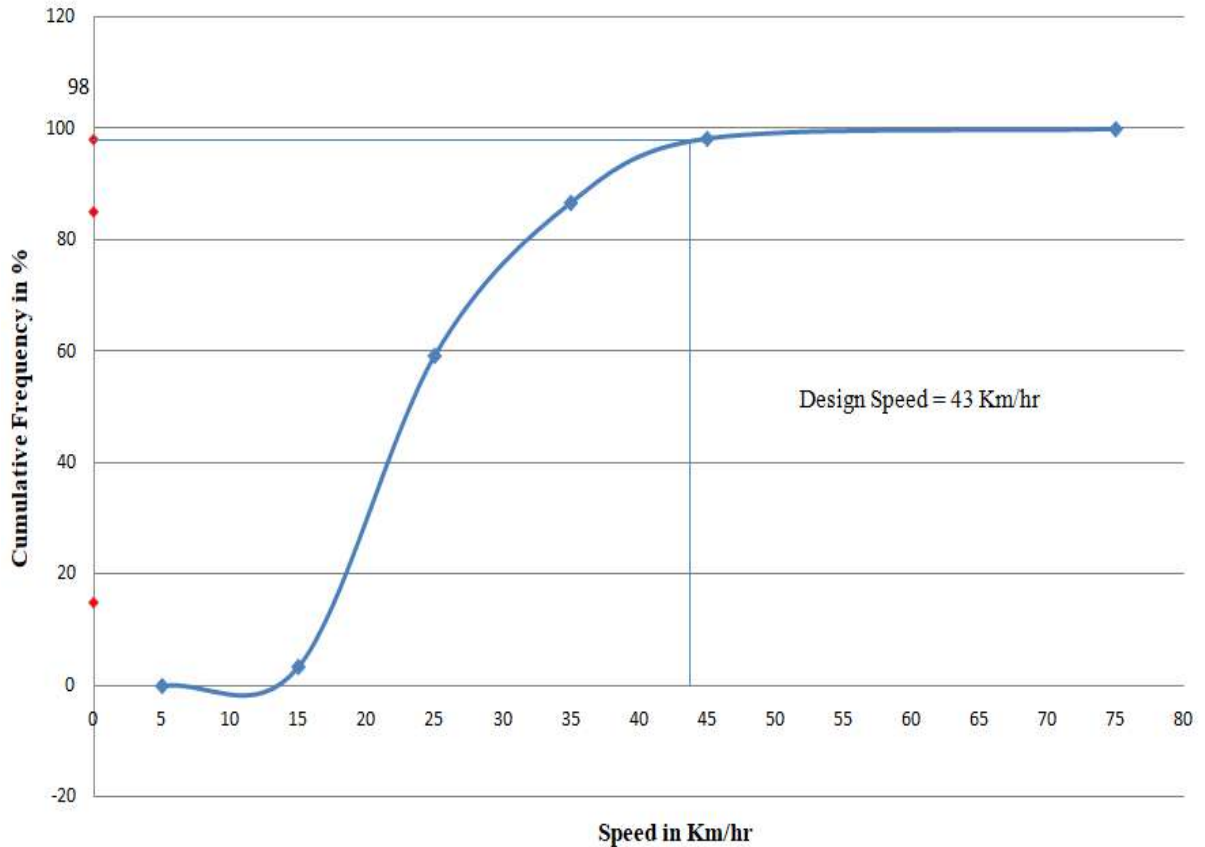


Figure 8.26 Cumulative Frequency v/s Speed Graph

8.7.2 Determination of Decision Sight Distance

DSD is calculated by using the 98th percentile speed obtained from the cumulative frequency v/s speed graph and the reaction time of the driver is taken as 2.5 seconds.

$$\begin{aligned}
 DSD &= 0.278 \times V \times T \\
 &= 0.278 \times 43 \times 2.5 \\
 DSD &= 29.88 \text{ m} = 30\text{m}
 \end{aligned}$$

The DSD value obtained here is used as the threshold distance from the transition point of the road. For developing the curve collision warning system first the weight files obtained from the model training process are used as the input to this curve collision warning process. So the system only detects the vehicles crossing the threshold line and a danger warning is produced. If the vehicle is behind the threshold line no danger warning sign is shown. Figure 8.27 shows the threshold line selected for the study.



Figure 8.27 Threshold Line Selected for the Study

Figure 8.28 shows the detection of dangerous vehicles on the two sides of the road when they cross the threshold line considered for this study. The danger warning is provided to the vehicle which enters the curve by crossing the threshold line. If the vehicle enters the left leg of the curve the curve collision warning system detects the presence of the vehicle in the curve and provides a red indication to the right side of the curve.



Figure 8.28 Detecting the Dangerous Vehicle Coming into the Curve

8.7.3 Confusion Matrix of Curve Collision Warning Process

Confusion matrix for the curve collision warning system is developed for taking one hour of data. Table 8.2 is the confusion matrix obtained for the curve collision warning process. The accuracy and precision for the curve collision warning process are calculated using equations 7.2 and 7.3.

Table 8.2 Confusion Matrix for Curve Collision Warning Process

		ACTUAL VALUE		
		Total 384	Positive Danger	Negative Danger
PREDICTED VALUE	Positive Danger	200 (True Positive)	4 (False Positive)	204
	Negative Danger	17 (False Negative)	163 (True Negative)	180
		217	167	384

$$Accuracy = \frac{200 + 163}{200 + 163 + 17 + 4} = 0.945 = 94.5\%$$

$$Precision = \frac{200}{200 + 4} = 0.98 = 98\%$$

The accuracy of 94.5% and precision of 98% shows a good prediction of vehicles.

8.8 SUMMARY

The result obtained from the user perception study, vehicle detection process, and curve collision warning process are discussed in this chapter. User perception study reveals the negative impacts of the current driving assistance system on the users and also helps to find out the importance of introducing the idea of a new driving assistance system. The importance of annotation and augmentation steps in the vehicle detection process is clearly shown through the confusion matrix obtained after the first training and second training. Depending upon the dataset preparation the accuracy of detection increases. The confusion matrix and model weight file is the final output obtained from model training. Using the model training curve collision warning is developed. For that threshold, distance is considered on the road for providing time for the drivers to take decisions while entering the curve. A danger warning is shown to the vehicle that enters into the curves because those vehicles have the chance of head-on collision with the vehicles from the opposite lane, especially a bus/ truck negotiating the curve. The accuracy and precision obtained for this process are 0.945 and 0.98, which shows a good result.

CHAPTER 9

CONCLUSION

9.1 GENERAL

Curve collision warning systems are crucial as they can save lives and aid in accident avoidance. In order to warn the driver to slow down or take other corrective action when a vehicle is approaching a curve too quickly, these systems use sensors and algorithms. In this project, algorithms are used to provide warnings to the drivers while entering to the curves. Curve collision warning systems can prevent drivers from losing control of their vehicles, which could lead to rollovers or collisions with other cars, objects, or pedestrians, by issuing a timely warning. These devices can be specifically helpful when a driver is unsure about the road or when the weather is bad, such as when it's raining or snowing.

9.2 SPECIFIC CONCLUSION

In user perception study while traveling, 63.6% of all travelers feel unsafe through hairpins. Unawareness of the presence of heavy vehicles on the opposite road was the most influencing factor rated by respondents. 58.2% agreed that the current system (convex mirror) is less effective in providing safe guidance. Among travelers, 34.5% do not use this convex mirror, and the majority of them are females and young people. Due to the distorted shape and size of the vehicle, difficult in judging vehicle speed and distance, and during the rainy season it's difficult to use a convex mirror. 79.22% of people positively respond that flashing LED signals alert the driver. 80.26% of people positively respond that it helps them to reduce overtaking behavior in drivers. and 88.31% of people say that implementing this new driving assistance system will help them.

In the vehicle detection process, YOLO algorithm is used. YOLO performs classification and is much faster than any other vehicle detection program, and satisfactory results are obtained when YOLOv5l has compared with manual counting. In Indian conditions, YOLO needs to be trained for identifying vehicles like auto-rickshaws and commercial vehicles. Annotation and augmentation procedure helps to improve the accuracy of the detection process. Model weights and confusion matrix

were obtained after the training process, confusion matrix obtained shows the accuracy of the prediction of each vehicle greater than 85%. The model weights obtained were used for the development of the curve collision warning process.

Curve collision warning was done by detecting the vehicles that come into curves. Python logic was applied to develop the curve collision warning system. DSD of 30m was provided as an offset from the starting of the curve to the straight leg, which helps the driver to take decisions like analyzing the warning indication, reducing the speed, etc, while entering into the curves. So making a proper decision while entering the curve helps to reduce accidents due to the rolling of vehicles when turning at high speeds, reduces head-on collisions, etc. The accuracy and precision of the developed curve collision warning process are found using the confusion matrix developed for the warning process. The result of accuracy and precision was obtained by more than 90%, which shows a good prediction of vehicles.

9.3 APPLICATION AND SCOPE FOR FUTURE STUDY

On roads with lots of curves and low visibility areas, curve collision warning systems are extremely useful. These roads are more difficult to properly maneuver since they have frequent turnings, narrow and have steep inclines and drops. This system can be very helpful for drivers of heavy vehicles, like truck/bus drivers. Curve collision warning systems are intended to increase road safety by lowering the possibility of collisions brought on by drivers who approach curves too quickly or with poor vision. These devices have the potential to save lives by giving drivers a proper warning about potential hazards.

The future research scope of the work is to increase the accuracy of detection from 90% to 100%, annotating more vehicles. The lane detection process can be included in the curve collision warning stage by considering the two lanes into two separate sections. So the vehicles changing the lane (Overtaking) can be easily found out.

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ANNEXURE A:
USER PERCEPTION STUDY ANALYSIS QUESTIONNAIRE

SECTION 1: BASIC DETAILS

1) Gender: Male Female Others

2) Age (പ്രായം) :

3) Driving Experience

0 year

1-5 years

6-10 years

11- 15 years

>15 years

4) Purpose of the trip (യാത്രയുടെ ഉദ്ദേശം)

Work (ജോലി)

Education (വിദ്യാഭ്യാസം)

Recreation (വിനോദം)

Shopping (ഷോപ്പിംഗ്)

Others (മറ്റുള്ളവ)

5) Occupation (തൊഴിൽ):

6) Have you ever traveled through hairpin curves? (നിങ്ങൾ എപ്പോഴെങ്കിലും ഇത്തരത്തിലുള്ള hair pin വളവുകളിലൂടെ യാത്ര ചെയ്തിട്ടുണ്ടോ?)

Yes (ഉണ്ട്)

No (ഇല്ല)

7) Frequency of travel through hairpin curves (ഹെയർപിൻ വളവുകളിലൂടെയുള്ള യാത്രയുടെ ആവൃത്തി)

Daily (ദിവസേന)

- Weekends (വാരാന്ത്യങ്ങൾ)
- Monthly (മാസത്തിൽ ഒരിക്കൽ)
- Very Rarely (വളരെ വിരളമായി)

SECTION 2: COMFORT THROUGH THE EXISTING ROAD



1. Have you ever felt unsafe while driving on curves? (വളവുകളിൽ വാഹനമോടിക്കുമ്പോൾ നിങ്ങൾക്ക് സുരക്ഷിതത്വമില്ലെന്ന് തോന്നിയിട്ടുണ്ടോ?)

- Yes (ഉണ്ട്)
- No (ഇല്ല)
- Sometimes (ചിലപ്പോൾ)

2. In your opinion how effective are the current driving assistance technology (eg: Convex mirror) in improving road safety on curved roads? (നിങ്ങളുടെ അഭിപ്രായത്തിൽ, വളഞ്ഞ റോഡുകളിൽ സുരക്ഷ മെച്ചപ്പെടുത്തുന്നതിന് നിലവിലെ ട്രെയിഡിംഗ് സഹായ സാങ്കേതികവിദ്യ എത്രത്തോളം ഫലപ്രദമാണ്?)

- Highly effective (വളരെഫലപ്രദമാണ്)
- Neither highly nor less effective
- Less effective (കുറവ് ഫലപ്രദമാണ്)

3. Do you experience a smooth travel through this curve ? (നിങ്ങൾ എപ്പോഴെങ്കിലും ഈ വളവിലൂടെ സുഗമമായ യാത്ര അനുഭവിച്ചിട്ടുണ്ടോ?)

- Yes (ഉണ്ട്)

No (ഇല്ല)

4. Overall degree of satisfaction when you navigate through a hair pin curve compared to normal curve ? (നിങ്ങൾ ഒരു ഹെയർ പിൻ കർവ് v/s സാധാരണ കർവ് ലൂടെ സഞ്ചരിക്കുമ്പോൾ ഉള്ള സംതൃപ്തിയുടെ അളവ്?)

Highly Dissatisfied (വളരെഅസംതൃപ്തി)

Dissatisfied (അസംതൃപ്തി)

Neutral

satisfied (തൃപ്തിയായി)

Highly Satisfied (ഉയർന്നസംതൃപ്തി)

5. Rate the below statements based on your experience while traveling through hairpin curves. (ഹെയർ പിൻ വളവിലൂടെ യാത്ര ചെയ്യുമ്പോഴുള്ള നിങ്ങളുടെ അനുഭവത്തെ അടിസ്ഥാനമാക്കി താഴെയുള്ള പ്രസ്താവനകൾ റേറ്റുചെയ്യുക ?)

1- Strongly Disagree (ശക്തമായി വിരോധിക്കുന്നു)

2- Disagree (വിരോധിക്കുന്നു)

3- Neither Agree Nor Disagree (സമ്മതിക്കുകയോ വിരോധിക്കുകയോ ഇല്ല)

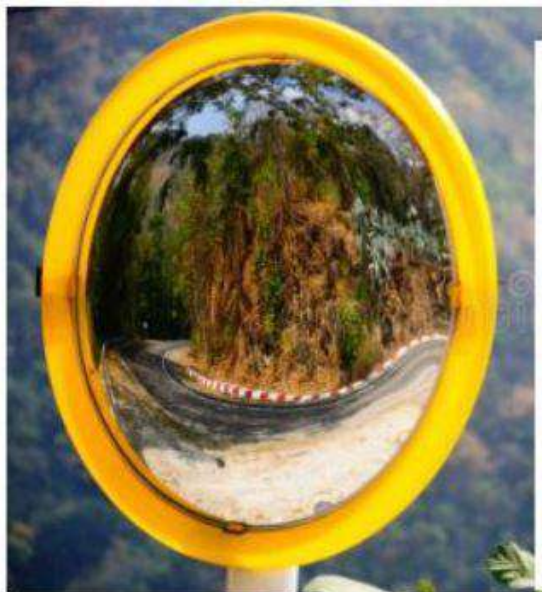
4- Agree (സമ്മതിക്കുന്നു)

5- Strongly Agree (ശക്തമായി സമ്മതിക്കുന്നു)

	1	2	3	4	5
<p>Road surface quality (eg: potholes) affect the movement through curves? (റോഡിന്റെ ഉപരിതല ഗുണനിലവാരം (ഉദാ: കുഴികൾ) വളവുകളിലൂടെയുള്ള ചലനത്തെ ബാധിക്കുന്നുണ്ടോ?)</p>					
<p>Pavement marking influence the guidance of vehicle along the curve (റോഡിലെ അടയാളപ്പെടുത്തൽ വളവിലൂടെയുള്ള വാഹനത്തിന്റെ മാർഗ്ഗനിർദ്ദേശത്തെ സ്വാധീനിക്കുന്നു)</p>					

<p>Presence of sign board alert the driver at the entrance and exit points of curve</p> <p>(വളവുകളിൽ പ്രവേശിക്കുമ്പോഴും പുറത്തുകടക്കുമ്പോഴും ട്രൈബിൾ ബോർഡിന്റെ സാന്നിധ്യം ഡ്രൈവർക്ക് മുന്നറിയിപ്പ് നൽകുന്നു)</p>					
<p>Landscapping and advertisement board distract the concentration of driver</p> <p>(പ്രകൃതി ഭംഗി, പരസ്യബോർഡുകൾ തുടങ്ങിയവ ഡ്രൈവറുടെ ഏകാഗ്രതയെ വ്യതിചലിപ്പിക്കുന്നു)</p>					
<p>Presence of heavy vehicles (bus/truck) against you cause distractions</p> <p>(നിങ്ങൾക്ക് എതിരെ ഹെവി വാഹനങ്ങൾ (ബസ്/ട്രക്ക്) വരുന്നത് ശ്രദ്ധ വ്യതിചലിപ്പിക്കുന്നു)</p>					

SECTION 3: CONVENTIONAL DRIVING ASSISTANCE SYSTEM



1. Do you know this type of system on curved roads? (വളഞ്ഞ റോഡുകളിൽ ഇത്തരത്തിലുള്ള സംവിധാനം നിങ്ങൾക്കറിയാമോ?)

Yes (ഉണ്ട്)

No (ഇല്ല)

Not paying attention (ശ്രദ്ധിക്കാറില്ല)

2. From where do you see the vehicles opposite to us on this convex mirror? (ഈ കോൺവെക്സ് കണ്ണാടിയിൽ നമുക്ക് എതിർവശത്തുള്ള വാഹനങ്ങൾ എവിടെ നിന്നാണ് കാണുന്നത്?)

From a far distance (ദൂരെനിന്ന്)

By reaching near the mirror (കണ്ണാടിയുടെ അടുത്തെത്തുമ്പോൾ)

Can't use this mirrors (ഈ കണ്ണാടിയിൽ ശ്രദ്ധിക്കുന്നില്ല)

3. Rate the below statements using a 1 to 5 scale. (1 മുതൽ 5 വരെയുള്ള സ്കെയിൽ ഉപയോഗിച്ച് താഴെയുള്ള പ്രസ്താവനകൾ റേറ്റ് ചെയ്യുക.)

1- Strongly Disagree (ശക്തമായി വിരോധിക്കുന്നു)

2- Disagree (വിരോധിക്കുന്നു)

3- Neither Agree Nor Disagree (സമ്മതിക്കുകയോ വിരോധിക്കുകയോ ഇല്ല)

4- Agree (സമ്മതിക്കുന്നു)

5- Strongly Agree (ശക്തമായി സമ്മതിക്കുന്നു)

3A) The convex mirror gives a distorted size and shape to the vehicle. How do you rate the statement? (കോൺവെക്സ് മിറർ വാഹനത്തിന് വികലമായ വലിപ്പവും രൂപവും നൽകുന്നു. നിങ്ങൾ പ്രസ്താവനയെ എങ്ങനെ വിലയിരുത്തുന്നു?)

1

2

3

4

5

3B) In a curve using a convex mirror it's difficult to judge the opposite vehicle's distance from our vehicle. How do you rate the statement? (ഒരു കോൺവെക്സ് മിറർ ഉപയോഗിച്ച് വളവിൽ നമ്മുടെ വാഹനത്തിൽ നിന്ന് എതിർ വാഹനത്തിന്റെ ദൂരം നിർണ്ണയിക്കാൻ പ്രയാസമാണ്. നിങ്ങൾ പ്രസ്താവനയെ എങ്ങനെ വിലയിരുത്തുന്നു?)

1

2

3

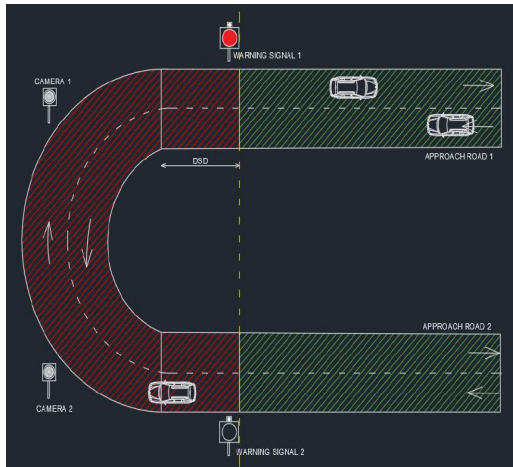
4

5

3C) During the rainy season, a convex mirror is complex to judge the opposite vehicles, which causes stress and decreased safety. How do you rate the statement? (മഴക്കാലത്ത്, എതിർ വാഹനങ്ങളെ വിലയിരുത്താൻ ഒരു കോൺവെക്സ് കണ്ണാടി സങ്കീർണ്ണമാണ്, ഇത് സമ്മർദ്ദത്തിനും സുരക്ഷ കുറയുന്നതിനും കാരണമാകുന്നു. നിങ്ങൾ പ്രസ്താവനയെ എങ്ങനെ വിലയിരുത്തുന്നു?)

12345

SECTION 4: NEW ADVANCED DRIVING ASSISTANCE SYSTEM



Like a traffic signal it flash lights for alerting the drivers (ഒരു ട്രാഫിക് സിഗ്നൽ പോലെ ഇത് ഡ്രൈവർമാർക്ക് മുന്നറിയിപ്പ് നൽകുന്നതിന് ലൈറ്റ് ഫ്ലാഷ് ചെയ്യുന്നു)

Red - Danger - Don't try to overtake slow moving vehicle (shows the presence of opposite vehicle on curve which leads to conflict)

മുവപ്പ് - അപകടം - പതുക്കെ ഓടുന്ന വാഹനത്തെ മറികടക്കാൻ ശ്രമിക്കരുത് (വളവിൽ വാഹനങ്ങൾ തമ്മിൽ ഏറ്റുമുട്ടാനുള്ള സാധ്യത ഉണ്ട്)

1. which one do you think is riskier in curve accidents? (വളവിലെ അപകടങ്ങളിൽ ഏതാണ് അപകടകരമെന്ന് നിങ്ങൾ കരുതുന്നു?)

- Follow vehicles too closely (വാഹനങ്ങൾ വളരെ അടുത്ത് പിന്തുടരുന്നത്)
- Slow response time (fails in judging vehicles break applying condition in front of us) (മന്ദഗതിയിലുള്ള പ്രതികരണ സമയം (നമുക്ക് മുന്നിൽ വാഹനങ്ങൾ ബ്രേക്ക് ചെയ്യുന്ന അവസ്ഥ വിലയിരുത്തുന്നതിൽ പരാജയപ്പെടുന്നു))
- Abrupt lane change (പെട്ടെന്നുള്ള ലെയിൻ മാറ്റം)
- Can't see vehicles coming opposite to us (എതിരെ വരുന്ന വാഹനങ്ങൾ കാണുന്നില്ല)
- All of above (മുകളിൽ പറഞ്ഞവയെല്ലാം)

2. Rate the below statements using a 1 to 5 scale. (1 മുതൽ 5 വരെയുള്ള സ്കെയിൽ ഉപയോഗിച്ച് താഴെയുള്ള പ്രസ്താവനകൾ റേറ്റ് ചെയ്യുക.)

- 1- Strongly Disagree (ശക്തമായി വിരോധിക്കുന്നു)
- 2- Disagree (വിരോധിക്കുന്നു)
- 3- Neither Agree Nor Disagree (സമ്മതിക്കുകയോ വിരോധിക്കുകയോ ഇല്ല)
- 4- Agree (സമ്മതിക്കുന്നു)
- 5- Strongly Agree (ശക്തമായി സമ്മതിക്കുന്നു)

2A) The presence of flashing LED lights increases the alertness of drivers who negotiate the curve. How do you rate it? (മിന്നുന്ന എൽഇഡി ലൈറ്റുകളുടെ സാന്നിധ്യം വളവിലൂടെ കടന്നുപോകുന്ന ഡ്രൈവർമാരുടെ ജാഗ്രത വർദ്ധിപ്പിക്കുന്നു. നിങ്ങൾ ഇത് എങ്ങനെ വിലയിരുത്തുന്നു?)

1 2 3 4 5

2B) Implementing the red alerting sign, reduce the tendency of the driver's risky overtaking maneuvers. How do you rate it? (റെഡ് അലർട്ടിംഗ് ചിഹ്നം കാണിക്കുന്നത്, ഡ്രൈവറുടെ അപകടകരമായ ഓവർടേക്കിംഗ് പ്രവണത കുറയ്ക്കുന്നു. നിങ്ങൾ അതിനെ എങ്ങനെ വിലയിരുത്തുന്നു?)

1 2 3 4 5

2C) This system improves overall safety through proper guidance. How do you rate it? (ശരിയായ മാർഗ്ഗനിർദ്ദേശത്തിലൂടെ ഈ സംവിധാനം സുരക്ഷ മെച്ചപ്പെടുത്തും. നിങ്ങൾ അതിനെ എങ്ങനെ വിലയിരുത്തുന്നു?)

1 2 3 4 5

2D) How do you rate the overall idea of introducing the warning signal ? (വളഞ്ഞ റോഡുകളിൽ മുന്നറിയിപ്പ് സിഗ്നൽ അവതരിപ്പിക്കുന്നതിനുള്ള ആശയത്തെ നിങ്ങൾ എങ്ങനെയാണ് വിലയിരുത്തുന്നത്?)

1 2 3 4 5