

Automobile Collision Detection and Avoidance System

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Abstract—Maintaining road safety and safe driving are the challenges faced by the driver. To support the drive, there are on board safety systems mounted in the vehicles. However, these systems display visual messages that distract the driver's attention from the road. There is a need for a system that can indicate the situations by keeping the attention of the driver on road. This paper is a proposal of a method that can be used to assist the drives while driving by generating the audio output based on the situation. According to research, driver assistance system is a solution for minimizing the time and frequency of drivers moving their eyes off traffic. Different approaches to assist the driver are discussed in this paper along with the challenges involved in executing them. The implementation is carried out using Arduino board and other hardware. The method is tested on samples to generate an audible sound that can be used by the drive to take suitable decision, by keeping eye on the road. This minimizes the need for the driver to look around while driving.

Keywords— Light imaging Detection and Ranging (LIDAR), Radio Detection and Ranging (RADAR), Arduino UNO, driver assistance.

I. INTRODUCTION

The use of Driver Assistance Systems has increased over the years with a wider range of problems being solved. Efficiency, performance and comfort are equally important factors as safety, thus requiring improvement in all these fields for a system to advance. Operating an automobile has always been a complex task because a human can notice only a few instances and process before making any decisions. It has been concluded that driving performance and visual strategy are in tight correlation with each other. This correlation is taken into account by most of the driver assistance system.

II. LITERATURE SURVEY

A. Survey on various methods that assist driver

In method proposed by Averbuck[1], representations are used to exhort the user by reusing standard interface thoughts. It is central to avoid scholarly over-load when making sense of how to use the new structure. In this segment we will mention some current methodologies for assisting driver.

B. Driver Assistance System using Metaphors.

The planning assistant helps the driver get to the destination without the awareness on the route. The driving aid selects the path and makes it easier for the driver. This method consists of different metaphors used in navigation and planning aid systems. Two types of metaphors are

described by Narzt et al [2] for the functioning car assistance system. The instances used for the augmented road give a detailed road to the user when driving as shown in Fig 1a. For example, if there is no back exit, it will aid the drive with an instant solution. The instance used is for planning assistance in any cases regardless of whether the information provided to the driver is used to provide short term information to the virtual car as and when there is change in its motion at times when the car accelerates, brakes or turns as shown in Fig.1b.

The improved augmented road metaphor is as same as unrolled map metaphor. The goal is to give the driver all information about the surroundings. When the automobile is in motion, a map is held. The segment which is on land demonstrates the way that can be taken promptly. Another segment in sky demonstrates the structure of road network. Bended region permits persistent progress in two methods of portrayal. It gives an information of particular street organize in the average term, utilizing the system of Level of Detail. Decrease in route mistakes and issues brought about by partitioned consideration is demonstrated by multiple tests in computer generated reality.

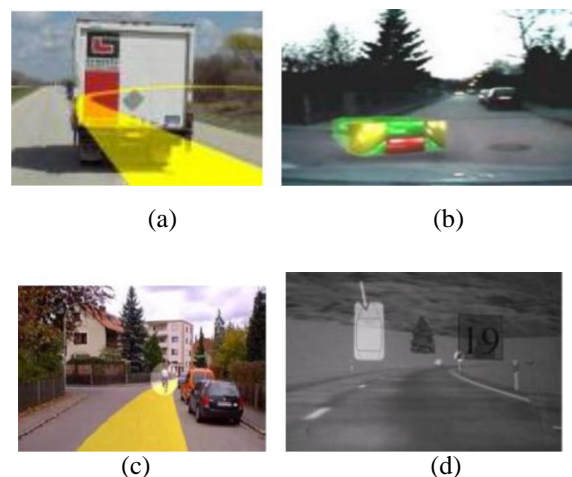


Fig1: Metaphors for assisting Driver

All the required information for a safe drive is provided by utilizing the utmost of available resources. The objective here, is to overcome the possibilities of distraction and provide information about the hazards. Fig.1.c shows few highlighted details for already present entities in the area visible to driver.

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This is done to capture the driver's attention. Even though the highlight method is similar the road metaphor, the functionalities differ in their goals. The case in point here is used to guide the driver in poor visibility conditions and congested lanes. The approaching dangers are marked using arrows (radar) directing the user to see the danger in front of the vehicle as shown in Fig.1.d. These external methods are not preferred. A virtual arrow indicating approaching danger is present in front of the car to prevent cognitive change. By using such egocentric visualization, it helps to free the driver to perform mental transformation before handling information.

In Order to provide extra information about the automobile status to the driver without any distraction, the annotated metaphors with contextual information is proposed in Narzt [2]. It provides information required by the driver like place of availability of petrol along with its cost whenever needed as shown in Fig.2.

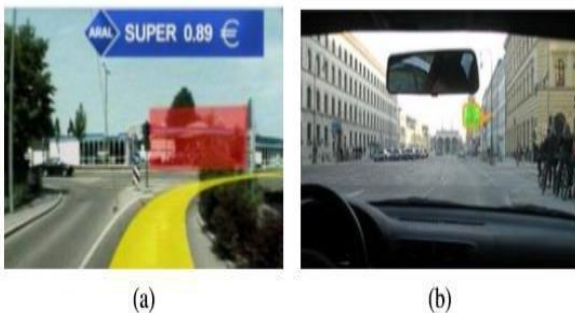


Fig 2: examples for discovered points of interest.

A haptic touch pad offers various annotation metaphor to represent the road and points of interest of the driver. The driver can tap on the required point in order to select them. Since many metaphors are used for discovering and representing each object, there are chances that the haptic touch pad gets crowded and affects the concentration of the driver. However, there's a belief that the metaphors used can be displayed on the entire windshield in future.

C. Driver Assistance System based on vision

Driver assistance system that work on the basis of vision spans multiple disciplines like computer vision, machine learning, robotic navigation, embedded systems, automatic electronics and safety critical software.[3]

The use of cameras initially found only in high end vehicles is flourishing even among vehicles in the lower end of the spectrum because of this increased demand for driver safety. While already providing functions like back-over protection and lane departure warning, it is believed that a lot more can be achieved through these cameras which are the most versatile type of sensors used. Many jurisdictions are implementing laws to allow autonomous vehicles on public roads, thereby showing an acknowledgement to the fact that autonomous vehicles are revolutionary products. [4]

In early 2000's, vision based ADAS (Advanced Driver Assistance System) became prominent with the release of systems such as lane departure warning (LDW). The pace of development further increased when other technologies like processing and imaging hardware underwent radical changes. Generic model for ADAS as proposed in [5].

Some of the recently proposed ideas to enter the market are automated parking and Traffic Jam Assist (TJA)/Highway Driving Assist (HAD). Automated parking began with automating parallel parking and then later included perpendicular parking systems. These are still semi-automated systems with limited usage, appropriate only in controlled environments where the vehicle can safely navigate without risk of collision.

Both the TJA and HAD taken over control of the vehicle in traffic and on highways respectively. The driver's intervention is asked as a short notice for monitoring purposes. Another specification is that it is able to determine if the driver is concentrated or not and deliver a warning appropriately. Since the systems are automated, there is lesser risk of over speeding and collision. A variety of sensors and other systems need to be used in tandem for successful working of such a system.

D. Co-operative Advance Driver Assistance System.

Co-operative advance driver assistance systems (CADAS) came into existence with the development of dedicated short-range communication (DSRC). CADAS systems handle information about the immediate and upcoming surroundings within a few kilometers of the vehicle.

This improved visibility is the highlighting feature of CADAS systems. It is made possible only by using V2V (vehicle-to-vehicle) as well as V2I (vehicle-to-infrastructure) communication. As a result, hard-braking and hard-acceleration can be potentially avoided to improve fuel efficiency and reduce the emission of toxic gases.

E. CADAS to manage Vehicular Traffic Shockwave.

In this case, CADAS tends to the issue of shock wave data in thruways caused by high traffic and unforeseen drivers' activities. CADAS frameworks propose a convention that tackles this problem by utilizing non – instinctual speed decreases. This helps to redistribute traffic more consistently and expel traffic crests. This leads to better traffic management and reduces travel time. To achieve this, a special protocol called DRIVE (density redistribution through intelligent velocity estimation) is used. The system fails if the Wi-Fi range is short or there is mis-communication between devices. The reason behind this is because the data given by phone with Wi-Fi is the core of the DRIVE protocol. Also, the data is at greater risk when present in smart phones. A lack of enough number of vehicles with vehicle to vehicle communication leads to reduction in performance efficiency.

III. METHODOLOGY

The functionality of proposed system can be classified into two categories. The first sub functionality being "detecting vehicle and measuring distance" and the other being "Alerting the driver".

A. Sensors for measuring distance.

Sensor is used by proposed work is to sense the vehicle and to measure distance of separation.

There are three major types of sensors that can be used for this purpose and each have their own advantages and disadvantages as mentioned below.

- Ultrasonic sensors:

Ultrasonic sensors effectively produce high-recurrence sound over 20Hz-20kHz. The ultrasonic sensors have a poor coverage compared to others. As sound waves show contrast in a shorter range, they are best suited for closer 3D mapping. They function paying little heed to light dimensions and, because of the lesser separations, they work with same accuracy in states of snow, mist, and rain. Like other two sensors mentioned below, ultrasonic sensors don't give any shading, differentiate visual nature acknowledgment capacities. Ultrasonic sensors cannot be used for checking speed as they can cover only short distances. Ultrasonic sensors are being expensive nowadays as they are the inseparable part of Adaptive cruise control system. However, the additional cost of implementation is lowered [6].

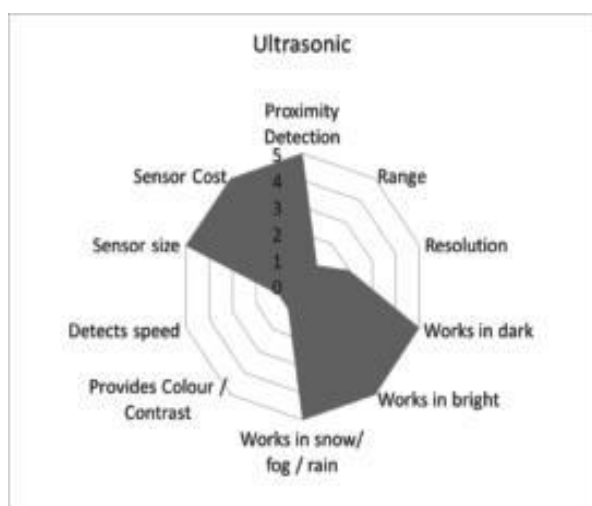


Fig 3: Attributes of ultrasonic sensors.

- Lidar sensors:

LIDAR frameworks costly frameworks that are fixed on outer part of automobiles. Due to the restrictions the frameworks cannot recognize anything close to the vehicle. Currently the range of LIDAR has increased from 30 meters to 170 meters along with improvements in accuracy.

The cost of frameworks with high coverage and accuracy keep on increasing. The LIDAR estimation of the separation depends on the time required for travelling by the laser between two obstacles.

It discharges short infrared waves and calculate the time taken by the wave to return from the time its emitted [7]. They function admirably in every single light condition. But fails with increments in snow, mist, rain, and residue particles.

They can't recognize shading or differentiate, and can't give optical character acknowledgment abilities. Thin bar LIDAR has been utilized for a long time, yet current- generation of these sensors that are utilized on self-sufficient automobiles are less viable for continues speed monitoring.

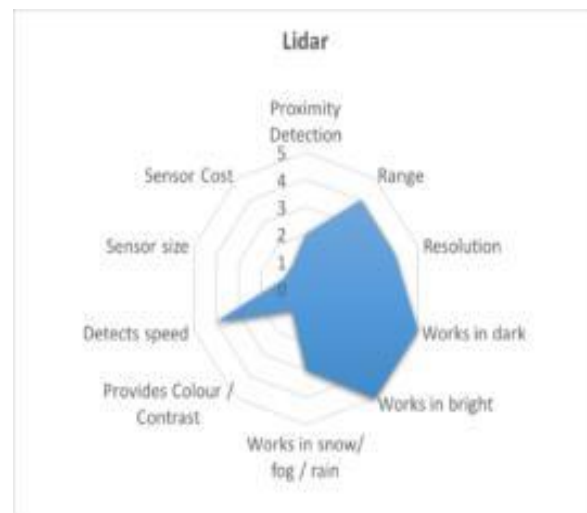


Fig 4: Attributes of Lidar sensors.

- RADAR sensors:

RADAR frameworks are comparatively small in size, economical. RADAR sensors have great range but are less accurate. RADAR functions well during both in light and dim conditions. Some frameworks(77Ghz) can function well even in mist, rain, and snow, which is a challenge in LIDAR. Similar to LIDAR, RADAR does not show shading. RADAR is highly powerful in deciding relative velocity of traffic. In close vicinity location, system performance increases but they are less successful than sonar at short separations. RADAR sensors are not preferred by the proposed approach as it is larger in size, expensive and less accurate.

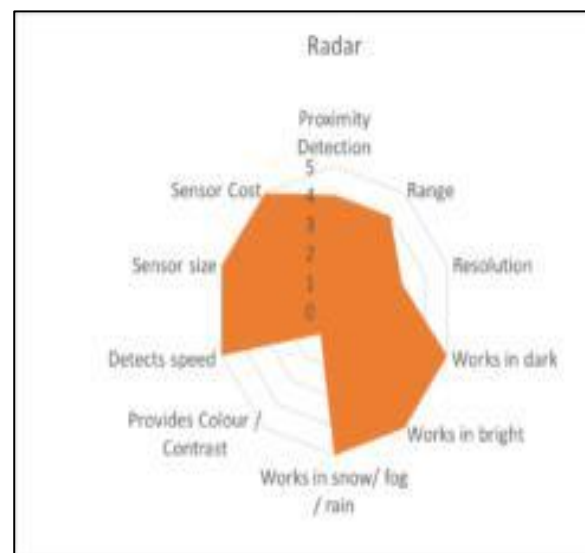


Fig 5: Attributes of Radar sensors.

The proposed work will inform the driver about the vehicles approaching from the rear side. For this, the system needs to measure the distance between two automobiles and alert the driver accordingly. Both LIDAR and Ultrasonic serve this purpose. According to the measured distance, the driver is alerted through mobile notifications, sound or via LED or LCD screens with suitable message.

TABLE 1 COMPARISION BETWEEN ULTRASONIC AND LIDAR SENSORS

FEATURES	Ultrasonic Sensor	Lidar Sensor
Model name	HCSR04	VL53L0X
Wavelength	75nm	940nm
Power Delivered	5V(DC)	5.5V(DC)
Operational Current	15mA	10mA
Frequency	40kHz	400kHz
Efficient Angle	$<15^0$	$<15^0$
Calculating Angle	30^0	0^0
Pulse Width of Trigger Input	10 μ S	+ve single TTL pulse
Aspect	45mmx20mmx15mm	13mm x 18mm x 2mm

While the ultrasonic sensor has good efficiency and accuracy, it is unsuitable for use in outdoor conditions. There is a possibility of external interference to the sound waves emitted by the ultrasonic sensor. This introduces a margin of error to the measurement which is not acceptable. Another disadvantage of this sensor is its wide sensing angle. The sound waves constantly increase with the distance traveled. After a certain distance, this wide angle of measurement is not feasible. The time taken by sound waves to travel to the remote object and return is exponentially slower than the light waves used by laser sensors. The position of the approaching object will differ greatly to its original position at the time of calculation in ultrasonic sensors. This is not affordable since immediate results and calculations are a must in the proposed system.

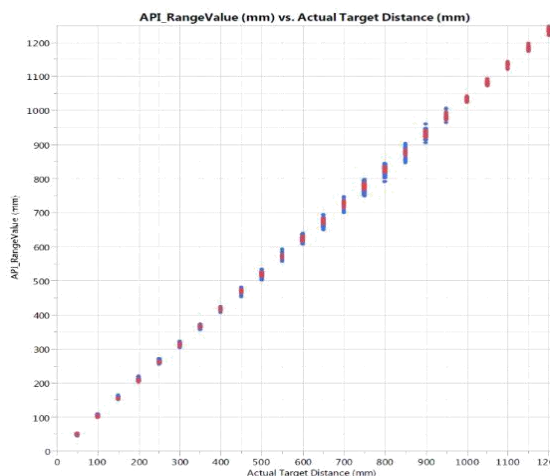


Fig 6. Performance graph of VL53L0X

This graph in Fig 6 shows the general performance of the VL53L0X laser for distances ranging from 0 to 1200 cm. It shows the actual distance against the distance measured by the API. These are taken with reflective surfaces which are either black or grey in color represented by red and blue colors respectively.

B. Implementation.

In the metaphors-based method, use of metaphors or instances for discovering and representing each object might get crowded and be a burden to the driver. In other surveyed methodologies making improvisation in the techniques might be difficult.

Having understood the advantages and disadvantages of the surveyed methodologies, we would like to propose a system that is effective and simple to understand.

The implementation uses the Arduino Uno microcontroller as its core. Distance measurement is done with the use of the VL53L0X Tiny-lidar. The operational range for this is between 3cm to 1400cm. It is efficient and precise in this range and gives a large number of readings consecutively. This completes the first task of distance measurement.

The latter part consists of alerting the driver when an object crosses the set safety distance. We list the following features for achieving this task:

1. A loud alerting sounds.
2. An alert message/call sent to the designated cellphone number.
3. A display of the rear view.

TABLE 2 LEVELS OF ALERT

	Distance between user's vehicle and approaching vehicle(mm)	Mode of alert
Level 1	500<d<800	Soft beep with text message.
Level 2	200<d<500	Moderate beep with phone call.
Level 3	d<200	High beep.

Alarming sound or beep makes use of a simple speaker connected to the microcontroller. Messaging and phone call are possible with the use of a GSM shield which can connect to a cellular network. The third feature of displaying the rear view is achieved through a raspberry pi 3B+ operated, camera. It is a night vision camera that captures monochromatic view of the vehicle's rear side and displays it on the LCD/LED screen. If automobile does not have its own LCD/LED screen, then there might be a necessity for a small display unit. Raspberry pi can be termed as a mini computer. Raspberry pi operating system contains pre-installed functionalities that makes it code friendly.

It is smaller in size hence easily portable and is cost effective. Raspberry pi set up is done by writing an image file into the SD card and then inserting that card into the module.

The Raspberry Pi is a low-cost micro-computer from the Raspberry Pi Foundation that can be used by simply plugging into a display device along with a standard keyboard and mouse. It contains a program memory (RAM), CPU, power source connector, graphics processing unit (GPU), general-purpose input/output (GPIO) pins, Ethernet port and interfaces for external devices. The storage here is in the form of an SD-card which will contain the required operating system (OS). This OS is booted in a similar fashion to the Windows/Linux OS booted on computers from their hard drives.

The Raspberry Pi 3B+ model used in proposed approach is the latest product in the Raspberry Pi 3 range. It now contains an updated 64-bit quad core processor with a clock speed of 1.4GHz along with a built-in metal heat sink. It also features dual-band 2.4GHz and 5GHz wireless LAN and PoE capability via a separate PoE HAT. The mechanical footprint of this model is the same as its predecessors.

In order to provide a night vision, view to the user, the proposed project uses night vision camera module compatible with raspberry pi 3B+. The camera has a resolution of 5MP and works well in daylight as well as in night conditions. There are a few red distortions in the resultant image during daytime but its effect on overall performance is negligible. Also, to present an even clearer image at especially during night, we use 2 Infrared LEDS as attachments to the camera. These help by providing better illumination when the amount of ambient light is below the threshold value. It is connected to the raspberry pi directly via the CSI (Camera Serial Interface) and is capable of providing resolutions up to 1080 pixels.

The arrangement of the components in proposed system can be generally shown in Fig 7.

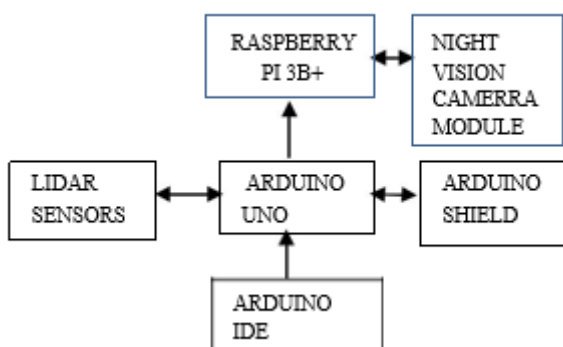
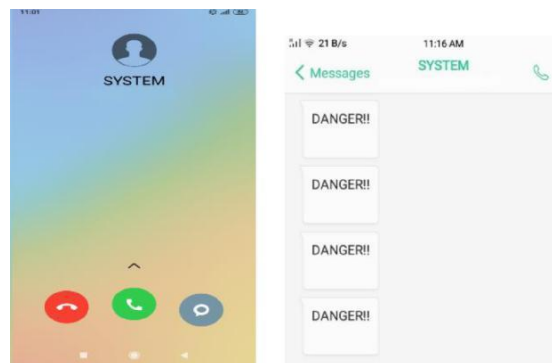


Fig 7: Block diagram of proposed system.

IV. RESULTS

The proposed work provided output depending on the distance of separation between two automobiles. Fig.8a shows a level of alert given by the system through call to the user's phone. The system alerts through phone call when the distance of separation is between 200 mm and 500 mm. When the distance is from 500mm to 800mm, user is alerted through a text message as shown in Fig.8b.



(a) (b)

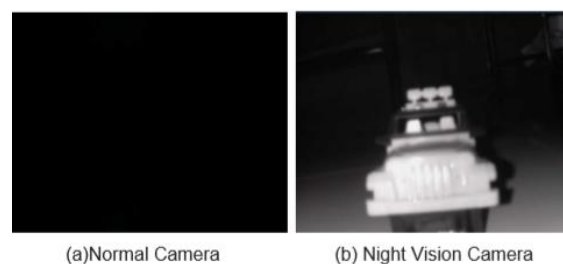
Fig 8: Alerts given by proposed system

The Fig.9 shows the image captured through the night vision camera module in presence of visible light when an approaching vehicle has crossed the safety distance. This shows the efficiency of the module to operate during daytime.



Fig 9: Image captured by night vision module in visible light

The purpose of using night vision camera along with special IR-LED is to better illuminate the rear end of vehicle and provide a clear view when the amount of visible light is very low. This advantage is further highlighted in the images shown in Fig 10(a) and Fig 10(b).



(a) Normal Camera (b) Night Vision Camera

Fig 10: Images captured by two cameras

The proposed system is capable of streaming video of an approaching vehicle on to the LED /LCD display present in user's automobile. This video streaming is active for all the three levels of alert i.e. when distance of approach is between the ranges, 50-800mm.

The surrounding conditions have limited effect on the visibility of the night vision module and it is still operable and efficient.

To illustrate the usage of the module in such conditions, we show the visibility and clarity of image taken in the following two conditions:

1. In presence of some amount of smoke (Fig 11.a)
2. During rain (Fig 11.b).



(a) In presence of smoke



(b) During rain

Fig 11: Images captured by night vision camera.

V. CONCLUSION

Automobile collision detection and avoidance system is studied and implemented. This system uses the sensors to detect the objects and alerts the driver when a vehicle is approaching from rear side. The three levels of alerts given by the system makes it more user friendly for the driver. Poor visibility of the rear side during night is also solved by the implementation of night vision camera. The system is easy to implement and is cost effective due to the use of low powered embedded boards.

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