# Design of Smart Cities BCSE316L (F1+TF1)

# Final Review Report and Research Paper

# Hybrid Accident Detection and Prevention System with Integrated Drowsiness Detection

- **Team Details:**

**Name:** Sayak Ray

**Registration Number:** 21BCE0752

**Contribution:**

I, Sayak Ray, am the team leader and the only member so I did all the research, created the model, and created the repot and research paper.

## 1. Abstract, Scope, Objective

The given project proposes an innovative accident prevention system based on Arduino and sensors and recognition of facial expressions with machine learning to prevent accidents and enhance the safety of vehicle drivers. The causes of most accidents are generally considered as driver fatigue or when the driver gets diverted. With the help of a camera and ultrasonic sensor, my proposed system recognizes facial expressions associated with drowsiness or inattentiveness, such as eye-closed mouth-opened or head-tilted etc., which indicate that there is less driving attention. Arduino recognizes is used with ultrasonic sensor for collision detection. When any alert is found by Arduino, the system responds to these by giving warnings to driver like audio warnings.

The scope of this project includes developing a prototype of an accident prevention system that can detect facial gestures and interpret them as indicators of fatigue or distraction. The system will be designed for real-time monitoring, enabling it to promptly alert drivers when necessary. It is aimed at private, commercial, and public transport vehicles, offering a scalable and cost-effective solution adaptable to different types of vehicles.

Objective of the project is to develop an affordable and efficient system that is successful in saving people from car accidents and injuries that can happen to them by making them alert whenever there is danger of collison or drowsiness.

This is an extremely low-cost system and if implemented on automobiles will save a lot of lives and prevent injuries caused due to the driver not paying attention.

## 2. Literature Survey and Gaps Identified

During the literature survey I found out that the most current systems for accident protection work effectively in detecting the obstruction or collision but do not implement active monitoring of the driver or if they do, they do not use methods to prevent the accident like we have used which are slowing the vehicle at the rate of approaching object, buzzer system, display a message or using voice to alert the driver of his drowsiness state.

Reddy, V. S. give an effective method for detecting an accident but it fails in that its accident prevention system is very weak as it only uses a system of LEDs to alert the drivers and prevent an accident. [1] Mishra, S., Rajendran, P. K.,Vecchietti, L. F., & Har, D. utilize machine learning to identify accident prone areas but again their notification system is not very effective in alerting the driver and preventing an accident. [2]. Uma, S., & Eswari, R. also create a prototype that can detect drowsiness and alcohol but their method of accident prevention is sending an SMS to emergency services and has no active accident prevention method [3]. Soner, B., & Coleri, S. in their given paper focuses on improving the algorithm for detection of collision but does not give a way to implement it for collision prevention so it has not active collision prevention system. [4] Hayashi, H., Kamezaki, M., & Sugano, S. write a paper in which the given system again does a good job of detecting if a person is okay to drive or not but there is no system of further action. If it is detected that the driver is not ok then it should have some measure to prevent accidents. [5] Vatti, N. R., Vatti, P. L., Vatti, R., & Garde, C. The papers main drawback is that compared to other systems it only works after the collision has occurred so it doesn't have any active accident prevention systems and it does not take any steps to stop or prevent the collision. [6]

| SI. Nos. | Paper title and journal/conf details | Inference/Achieved | Gaps identified |
|---|---|---|---|
| 1 | Reddy, V. S. (2024). Enhanced Safety Measures for Accident Prevention in Mountainous Regions. *CVR Journal of Science and Technology*, *26*(1), 39-46. | The author created a fairly effective system for preventing accidents specifically in mountainous regions. When the system detects a vehicle, a light turns on to warn oncoming traffic. | The project is dependent on a single light for everyone to halt their vehicles and may not even be clearly visible. It also has no communication between vehicles that could further advance safety measures. |

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| 2 | Mishra, S., Rajendran, P. K., Vecchietti, L. F., & Har, D. (2023). Sensing accident-prone features in urban scenes for proactive driving and accident prevention. *IEEE Transactions on Intelligent Transportation Systems*, *24*(9), 9401-9414. | This paper utilizes Machine learning to analyze urban city data and identify where accident prone areas are. Once this is done this is used to analyze the dashcam images and notify the driver if an accident-prone area is identified. | This paper focuses on trying to identifying accident prone areas but doesn't have measures to warn others or communicate with nearby vehicles. It is effective for the primary vehicle takes no safety measures for nearby vehicles. |
| 3 | Uma, S., & Eswari, R. (2022). Accident prevention and safety assistance using IOT and machine learning. *Journal of Reliable Intelligent Environments*, *8*(2), 79-103. | This paper creates a prototype that detects if a driver is getting drowsy, if toxic gases are present, if alcohol is detected. If any of these are detected then it will activate emergency services like an alert to the driver and SMS and email to emergency contacts. | The paper gives a good prototype for its topic but it should use this data to alert nearby drivers and police officers so that they can act and stop the driver. |
| 4 | Soner, B., & Coleri, S. (2021). Visible light communication based vehicle localization for collision avoidance and platooning. *IEEE Transactions on Vehicular Technology*, *70*(3), 2167-2180. | In this paper the authors use VLP and propose a VLC based vehicle localization methods that uses multiple parameters to detect and predict collision and hence can be used for collision prevention, | The given paper focuses on improving the algorithm for detection of collision but does not give a way to implement it for collision prevention. |
| 5 | Hayashi, H., Kamezaki, M., & Sugano, S. (2021). Toward health–related accident | The paper proposes a methodology to monitor Body image, dace, heart pulse and steering | The given system again does a good job of detecting if a person is okay to drive or not but |

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| | prevention: Symptom detection and intervention based on driver monitoring and verbal interaction. *IEEE Open Journal of Intelligent Transportation Systems*, *2*, 240-253. | angle to analyze if a driver is fit to drive or not. If it detects that there is a problem then it uses verbal interaction and using all the data decides if it the driver is okay or not. | there is no system of further action. If it is detected that the driver is not ok then it should have some measure to prevent accidents. |
| 6 | Vatti, N. R., Vatti, P. L., Vatti, R., & Garde, C. (2018, March). Smart road accident detection and communication system. In *2018 International conference on current trends towards converging technologies (ICCTCT)* (pp. 1-4). IEEE. | This paper proposes a system to detect collisions and if a collision occurs then it informs the stored emergency members, it utilizes and Arduino, gyro sensor and a piezo electric sensor to calculate the angle the car is in and the vibration detected to decide if a collision has occurred. | The papers main drawback is that compared to other systems it only works after the collision has occurred it does not take any steps to stop or prevent the collision or even make the collision less fatal. After the collision has occurred it can implement more features like sending the location of the driver to emergency services etc. |

The gaps have been identified above for each paper. Most of the systems have provided some solution to the issue but each have some drawbacks. The gaps that can be identified are that most papers only try to prevent the collision for the primary car. If they had a communication system with nearby cars then the system could warn nearby cars that a collision can occur so they can slow down and be cautious. Other gaps are that some papers only detect the collision and do not provide a system to prevent it. Lastly some papers have the gaps that they implement the safety measures after the collision has happened and do nothing to prevent it.

The tools that have been used are primarily Arduino/Raspberry Pi based systems. They utilize sensors like ultrasonic sensor for distance measurement, piezoelectric sensors for vibration and pressure detection, gyro sensor for angle measurement, cameras for analyzing real time images and alcohol and toxic gas detectors. All of these are used and controlled by a microcontroller like Arduino and Raspberry Pi. In terms of datasets one of the papers uses a dataset of street view images. The papers also do not use a lot of ML methods.

## 3. Hardware and Software Used

The system is based on Arduino. It uses the following components

1. HC-SR04 Ultrasonic Sensor
2. 16x2 LCD I2C
3. Piezoelectric Buzzer
4. Motors
5. Speakers
6. Camera

Libraries Used for Drowsiness Detection:

1. cv2
2. numpy
3. dlib
4. imutils
5. pyttsx3
6. threading

We will use Ultrasonic sensors for initial detection of object and size and distance measurement.

Constant analysis of distance is done and based on this severity of object is noted. If severe then a buzzer makes a sound to alert the driver and a warning is displayed.

Along with the above the motors are slowed down at a rate proportional to the distance of the object.

If not severe then a warning is displayed on the drivers display to alert them and the situation is constantly analyzed.

If collision occurs then the speaker is used to make an alert noise to get help from nearby drivers.

Constant face detection is done and if the driver is drowsy then they are alerted using the buzzer and speaker system.

The entire system is implemented on Arduino and installed in cars for their security.

## 4. Block Diagram Of the System

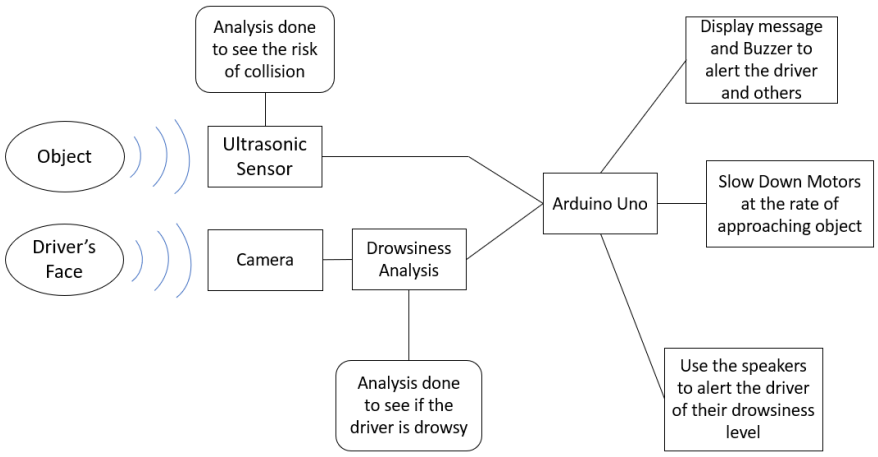


**Fig. 1.** Block Diagram of the System

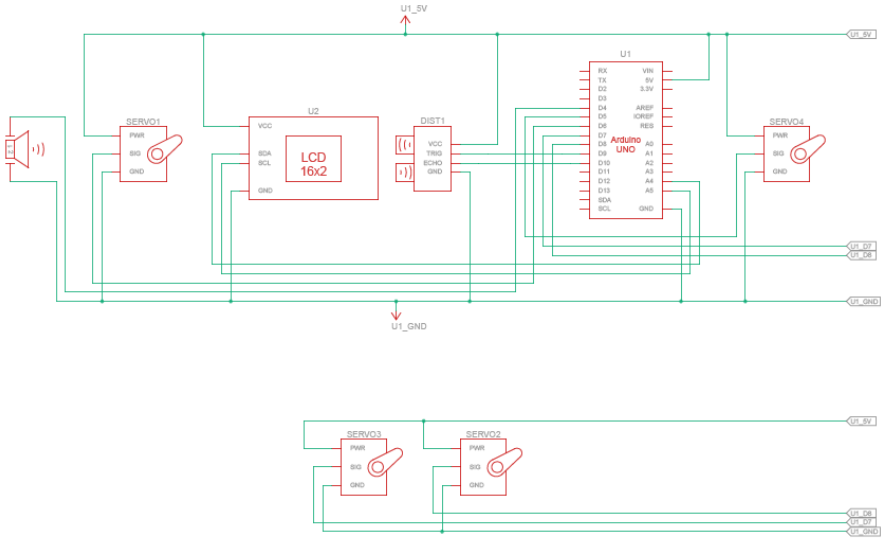


**Fig. 2.** Arduino Schematic of the System

## 5. Objectives of the system

Implement and accident prevention system with facial gesture detection module using camera and machine learning algorithms along with Arduino and ultrasonic sensors to detect obstructions and help prevent them

We will use Arduino microcontroller to do real-time processing of obstruction detection and ML to process facial gesture data and generate alerts if it goes above certain threshold indicating that driver is fatigued or distracted.

Design alert mechanisms, develop alert systems to ensure that the driver gets instant alerts and can concentrate on driving with full attention.

Ensure affordability and adaptability, design the affordable and adaptable system for all types of vehicles without any major modification in the vehicle.

Test and validate the system's accuracy and reliability, test the system performance for detecting fatigue gestures accurately, as well as effectively alerting the driver in different driving situations.

## 6. Methods Used for the objectives

**Arduino Alert and Safety System Algorithm:**

i. Detect if object is ahead
ii. If object is detected ahead. Analyze the severity by detecting distance size of object
iii. If severe:
    a. Use the system buzzer to inform the driver at a high frequency and tone. Closer the object higher the frequency and tone of buzzer.
    b. LCD of the car now displays a warning message.
    c. Decelerate the motors at the rate of approaching object. Closer the object faster the deceleration
iv. If not severe:
    a. Display warning to inform driver.
    b. Play the buzzer at a low frequency and tone
    c. Slow the motors a bit.
    d. Keep monitoring and warning till object is not ahead.
v. If collision occurs:
    a. Use the buzzer to make the sound to alert others
vi. If clear and no object detected.
    a. Keep monitoring the face of the driver for drowsiness
    b. Alert the driver if drowsy

**Drowsiness Detection System Algorithm:**

i. Use the camera to input image frames from video
ii. Convert to grayscale
iii. Place the Face Landmarks
iv. Use Euclid's distance formula to calculate the distance between the length of the eyelid and two points of width of the eyelid
v. Calculate the ratio (width1 + width2) / (2*length)
vi. Depending on this ratio we evaluate whether the driver is sleeping, drowsy or Alert
vii. Calculate the distance between upper and lower lip

viii. If greater than threshold than the driver is yawning
ix. Alert the driver if he is sleeping, drowsy and/or yawning
x. Continue again from step 1

## 7. Results and Discussion

The Accident Prevention System, which is equipped with ultrasonic sensors for detecting obstacles, ML for monitoring drowsiness, and a warning mechanism, showed good performance on all aspects in practical tests. The ultrasonic sensors were assessed for their precision and the time taken to respond to an obstacle. The sensors achieved a remarkable performance in obstruction detection and warning the drivers of the obstacles under normal weather conditions. The search time taken to detect the obstacle was relatively low, due to this analysis was very fast and it was capable of fast responses to the driver.

The system for detecting drowsiness using ML and monitoring facial actions and eye movements went on to record high accuracy while performing under various conditions. This system appropriately identified these symptoms of driver fatigue, which are quite recognized, prolonged closing of eyes and yawning, thereby contributing in averting any risks due to drowsy driving. False positives were very low, which some of the times were because of the facial gestures that imitated drowsiness signs, such as looking down for a short while. As for false negative, were also very low and those were reported in instances where a driver was displaying very mild symptoms of drowsiness, thereby, revealing the potential of the ML model whereby it can be trained to effectively identify micro-expressions indicative of tiredness. Response times of the ML system were very fast, this allowed the system to produce sound and vibration alerts to the drivers quickly and thus, the alerts were effective in drawing the drivers' attention and lessening the chances of risks due to drowsiness.

To conclude, the System achieved its objectives regarding the two main accidents risk factors, which are obstacles' detection and monitoring the driver's drowsiness. The ultrasonic sensors worked extremely well for short distances, however there can be a slight drop in performance with exposure to harsh weather, implying that other types of sensors might strengthen the system's performance in different terrains. The ML-based drowsiness detection system appeared to be useful in recognizing fatigue-related movements, however some changes could be introduced to constrain exaggerated false positive detections such as using heart rate data. In general, the integrated system provided a good deal of safety enhancing features supporting all kinds of environmental and driving risk factors, making it a very useful tool in averting accidents in all driving situations.

## 8. Future Enhancement

The given system provides a very efficient system for accident prevention. In the future more features can be added for even more security like communication with emergency services if a collision occurs. More ML technologies can be used for better analysis of collision detection. There are newer algorithms that are still experimental but if successful in the future will definitely increase the efficiency of the system.

The existing mechanism can still be enhanced as it performs in most conditions but its effectiveness can reduce in adverse weather phenomena like fog, rain, or snow. In future studies, issues raised in this study may introduce different sensor types such as cameras or infrared ones in addition to the ultrasonic sensors. These sensors might prove to be more effective in such weather conditions, further enhancing the environments where the system would be effective and its overall strength. Furthermore, extending range and accuracy of the sensors may enable the system to identify such objects at considerable distances thus giving the drivers ample time to react especially under high speeds.

In the end the goal was to decrease accidents and the loss of lives and injuries that can occur due to it. This system may cost a bit but compared to the security and safety it provides it is definitely efficient and worth it. The system if implemented in automobiles can help millions of people and prevent a lot of accidents

## 9. Conclusion

The Accident Prevention System employs ultrasonic sensors for obstruction counting, ML-based monitoring for drowsiness, as well as an alerting system is very effective in promoting road safety by dealing with both external and internal risk factors instantly. The ultrasonic sensors serve their purpose in detecting obstacles over short distances allowing for timely precautions from the drivers. This is despite the fact that sensors accuracy could be affected by external factors such as rain and fog. However, the main purpose of the system is executed quite well. In scenarios where very fast sensing speeds are required or the system has to operate in difficult weather, other sensors such as the infrared or radar can be used for better performance especially in complicated or high-risk areas.

The drowsiness detection system based on artificial intelligence was very effective in recognizing gestures caused by fatigue; this is very important for eliminating accidents caused by drivers' lack of focus. The system helps in immediate intervention upon detection of drowsiness signs using facial recognition software and thus helps to prevent accidents associated with tiredness, and other factors leading to road traffic accidents. The speed and accuracy of the system indicate that integration was effective, however, issues with false identification of signs and differentiating them from normal facial expressions of slight distractions still exist. Adding other body functions such as heart rate monitoring can

enhance the effectiveness of the system detection and on the overall rather than considering the state of the driver solely based on one indicator.

The system, which includes alert mechanisms, has completely changed the approach from passive monitoring to active intervention. Using auditory and visual alerts ensures that a driver is sufficiently warned and sensitized to the need for remedial actions, hence improving the safety potential of the system significantly. Testing showed that such alerts are acceptable and effective but less appealing due to the constant alert in most low-risk situations; alert frequency and sensitivity can be adjusted for better usability. The integration of various forms of alerts was especially helpful in ensuring the attention of the driver, thus making the system applicable to various driving conditions and environments.

**Application towards design and development of Smart Cities:**

The Accident Prevention System (APS) with its ultrasonic sensors for obstruction detection, ML-based drowsiness detection, and a responsive alert system can be of great importance in smart city design and development. With technological advancements being introduced into city infrastructure, the focus shifts to enhanced road safety and optimized means of transport. Smart cities can incorporate traffic management systems within public and private vehicle fleets to minimize road accidents, enhance movement, and provide an urban mobility network that is safe and efficient. The system is a fundamental element in the construction of advanced and secure cities that will not only support the drivers but will also work with other smart city features in enhancing the safety of the public.

Improving situational awareness is one of the key advantages of using accident prevention systems in urban cities. Most urban roads are prone to distractions due to nonvehicular traffic such as jay-walking pedestrians, cyclists going in and out of lanes, vehicles constantly changing lanes in heavy traffic, and so on. To address this, our system makes use of ultrasonic sensors, cameras, ML, and other technologies to alert the driver in real time of any obstacles, changes in traffic, or people where they shouldn't be, in order to avoid crashes. This is more so useful in highly congested areas where the users of the road are extremely close to each other, thus limiting the drivers vision and stopping the driver from seeing every possible risk.

In general, the introduction of the system into the smart city framework makes it more efficient in accident prevention management and encourages more safety in the cities by meeting the demands of both drivers as well as pedestrians. With the help of data, advanced safety measures, and an integrated transport system, APS in the future can be even more efficient and can be perfectly included in the concept of smart cities enhancing safety and a more sustainable urban development.

In conclusion, the Accident Prevention System is an innovative solution against accidents as it incorporates all the possible technologies which are cost effective, expandable and can be used in different kinds of vehicles. The system architecture aims to improve road safety by minimizing non-environmental and environmental related risk factors to the driver and can

be applied in private cars as well as the commercial and public transport. The next step includes improving the detection accuracy in those challenging environments and adjusting the alert level which affects the comfort of the driver without compromising safety. This paper explains the need for timely intervention to prevent the occurrence of accidents and this also paves a way for the advancement of smart cities and development since smart drivers assistance systems are dedicated to lowering accidents on the roads.

**From the next page is the Research Paper in Springer Format**

# Hybrid Accident Detection and Prevention System with Integrated Drowsiness Detection

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**Abstract.** The given project proposes an innovative accident prevention system based on Arduino and sensors and recognition of facial expressions with machine learning to prevent accidents and enhance the safety of vehicle drivers. The causes of most accidents are generally considered as driver fatigue or when the driver gets diverted. With the help of a camera and ultrasonic sensor, my proposed system recognizes facial expressions associated with drowsiness or inattentiveness, such as eye-closed mouth-opened or head-tilted etc., which indicate that there is less driving attention. Arduino recognizes is used with ultrasonic sensor for collision detection. When any alert is found by Arduino, the system responds to these by giving warnings to driver like audio warnings. This is an extremely low-cost and efficient system and if implemented on automobiles will save a lot of lives and prevent injuries caused due to the driver not paying attention.

**Keywords:** Accident, Prevention, System, Arduino, Sensors

## 1 Introduction

The scope of this project includes developing a prototype of an accident prevention system that can detect facial gestures and interpret them as indicators of fatigue or distraction. The system will be designed for real-time monitoring, enabling it to promptly alert drivers when necessary. It is aimed at private, commercial, and public transport vehicles, offering a scalable and cost-effective solution adaptable to different types of vehicles.

Objective of the project is to develop an affordable and efficient system that is successful in saving people from car accidents and injuries that can happen to them by making them alert whenever there is danger of collision or drowsiness.

We will use Ultrasonic sensors for initial detection of object and size and distance measurement. Constant analysis of distance is done and based on this severity of object

is noted. If severe then a buzzer makes a sound to alert the driver. The motors are decelerated at the rate of approaching object.
If not severe then a warning is displayed on the drivers display to alert them and the situation is constantly analyzed. If collision occurs then the speaker is used to make an alert noise to get help from nearby drivers. Constant face detection is done and if the driver is drowsy then they are alerted using the buzzer and speaker system. The entire system is implemented on Arduino and installed in cars for their security.

The systems for the prevention of accidents plays a vital role in enhancing the safety of roads, prevention of injuries and minimizing causes of accidents and the protection of the lives of people, a factor that is very critical almost in all cases especially now that the traffic density and speeds are on the increase around the world.[1] These systems are significant because they try to eliminate the risks involved in each of the areas that cause accidents such as tiredness of drivers, people driving while not focused, danger with the environment and even humans. So, with the help of various tools such as ultrasonic sensors, ML for the detection of drowsiness and prior alert system, Accident Prevention System can reduce these risks and hence frequency and severity of road crashes.[2]

To conclude, the significance of accident-avoidance systems is huge in our urban cities since they help in eliminating risks, saving lives in the process, and enhancing road transport safety and efficiency. They are important in addressing complications brought about by human beings, improving the attention of the driver as well as addressing the creation of advanced automated and ecological transport systems. [3] In essence, with the introduction of these systems in cars, smart cities and transport networks, we are all set on safer, more accident-free roads and better transport systems.

## 2 Literature Survey

During the literature survey we found out that the most current systems for accident protection work effectively in detecting the obstruction or collision but do not implement active monitoring of the driver or if they do, they do not use methods to prevent the accident like we have used which are slowing the vehicle at the rate of approaching object, buzzer system, display a message or using voice to alert the driver of his drowsiness state.

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**Table 1. Literature Survey Table**

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| 4 | Soner, B., & Coleri, S. (2021). Visible light communication based vehicle localization for collision avoidance and platooning. *IEEE Transactions on Vehicular Technology*, *70*(3), 2167-2180. | In this paper the authors use VLP and propose a VLC based vehicle localization methods that uses multiple parameters to detect and predict collision and hence can be used for collision prevention, | The given paper focuses on improving the algorithm for detection of collision but does not give a way to implement it for collision prevention. |

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The gaps have been identified above for each paper. Most of the systems have provided some solution to the issue but each have some drawbacks. The gaps are that none of the systems have active systems for slowing down the car etc, none of them have components that can track drowsiness of the driver, Other gaps are that some papers only detect the collision and do not provide a system to prevent it. Lastly some papers have the gaps that they implement the safety measures after the collision has happened and do nothing to prevent it.

The tools that have been used are primarily Arduino based systems. They utilize sensors like ultrasonic sensor for distance measurement, piezoelectric sensors for vibration and pressure detection, gyro sensor for angle measurement, cameras for analyzing real time images and alcohol and toxic gas detectors. All of these are used and controlled by a microcontroller like Arduino and Raspberry Pi. In terms of datasets one of the papers uses a dataset of street view images. The papers also do not use a lot of ML methods.

# 3 Methodology

## Arduino Alert and Safety System Algorithm:

i. Detect if object is ahead
ii. If object is detected ahead. Analyze the severity by detecting distance size of object
iii. If severe:
    a. Use the system buzzer to inform the driver at a high frequency and tone. Closer the object higher the frequency and tone of buzzer.
    b. LCD of the car now displays a warning message.
    c. Decelerate the motors at the rate of approaching object. Closer the object faster the deceleration
iv. If not severe:
    a. Display warning to inform driver.
    b. Play the buzzer at a low frequency and tone
    c. Slow the motors a bit.
    d. Keep monitoring and warning till object is not ahead.
v. If collision occurs:
    a. Use the buzzer to make the sound to alert others
vi. If clear and no object detected.
    a. Keep monitoring the face of the driver for drowsiness
    b. Alert the driver if drowsy

## Drowsiness Detection System Algorithm:

i. Use the camera to input image frames from video
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iv. Use Euclid's distance formula to calculate the distance between the length of the eyelid and two points of width of the eyelid
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vi. Depending on this ratio we evaluate whether the driver is sleeping, drowsy or Alert
vii. Calculate the distance between upper and lower lip
viii. If greater than threshold than the driver is yawning
ix. Alert the driver if he is sleeping, drowsy and/or yawning
x. Continue again from step 1

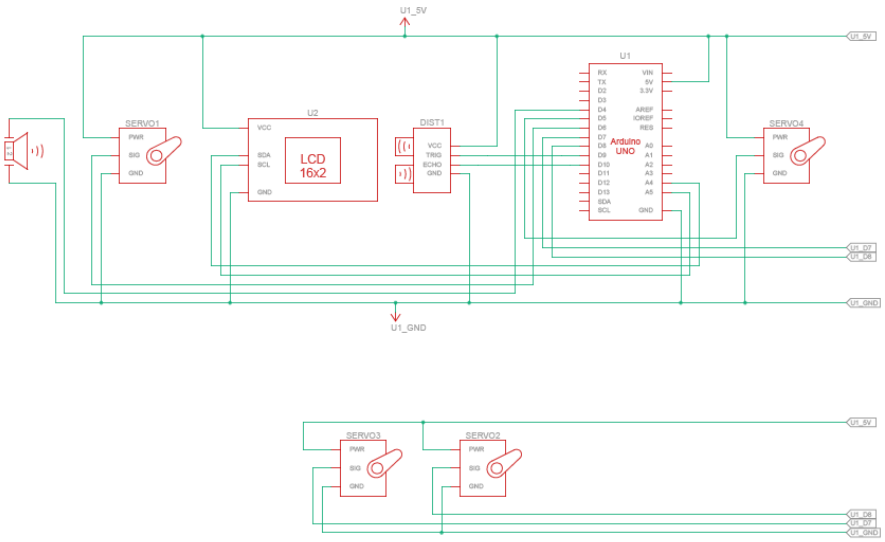


**Fig. 1.** Arduino Schematic of the System

The system is based on Arduino. It uses the following components

1. HC-SR04 Ultrasonic Sensor
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4. Motors
5. Speakers
6. Camera

Our goal which we have achieved was to implement and accident prevention system with facial gesture detection module using camera and machine learning algorithms along with Arduino and ultrasonic sensors to detect obstructions and help prevent them.

We use Arduino microcontroller to do real-time processing of obstruction detection and ML to process facial gesture data and generate alerts if it goes above certain threshold indicating that driver is fatigued or distracted.

The system includes alert mechanisms and systems to ensure that the driver gets instant alerts and can concentrate on driving with full attention

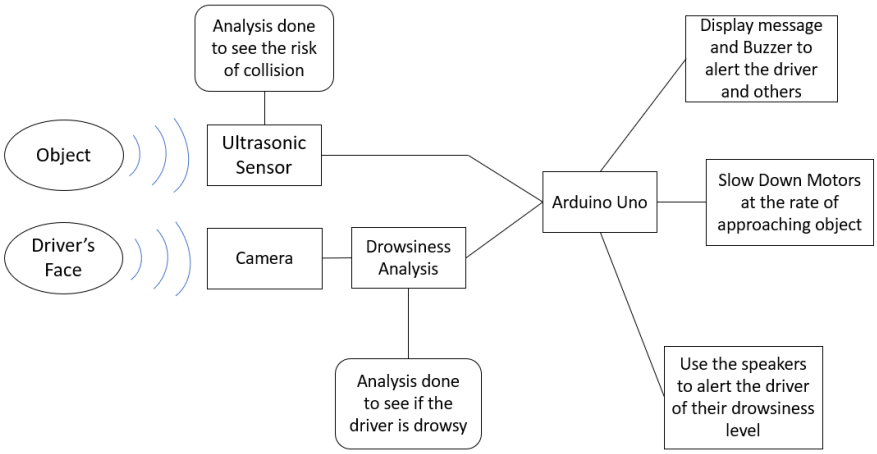


**Fig. 2.** Block Diagram of the System

## 4 Results and Discussion

The Accident Prevention System, which is equipped with ultrasonic sensors for detecting obstacles, ML for monitoring drowsiness, and a warning mechanism, showed good performance on all aspects in practical tests. The ultrasonic sensors were assessed for their precision and the time taken to respond to an obstacle. The sensors achieved a remarkable performance in obstruction detection and warning the drivers of the obstacles under normal weather conditions. The search time taken to detect the obstacle was relatively low, due to this analysis was very fast and it was capable of fast responses to the driver.

The system for detecting drowsiness using ML and monitoring facial actions and eye movements went on to record high accuracy while performing under various conditions. This system appropriately identified these symptoms of driver fatigue, which are quite recognized, prolonged closing of eyes and yawning, thereby contributing in averting any risks due to drowsy driving. False positives were very low, which some of the times were because of the facial gestures that imitated drowsiness signs, such as looking down for a short while. As for false negative, were also very low and those were reported in instances where a driver was displaying

very mild symptoms of drowsiness, thereby, revealing the potential of the ML model whereby it can be trained to effectively identify micro-expressions indicative of tiredness. Response times of the ML system were very fast, this allowed the system to produce sound and vibration alerts to the drivers quickly and thus, the alerts were effective in drawing the drivers' attention and lessening the chances of risks due to drowsiness.

To conclude, the System achieved its objectives regarding the two main accidents risk factors, which are obstacles' detection and monitoring the driver's drowsiness. The ultrasonic sensors worked extremely well for short distances, however there can be a slight drop in performance with exposure to harsh weather, implying that other types of sensors might strengthen the system's performance in different terrains. The ML-based drowsiness detection system appeared to be useful in recognizing fatigue-related movements, however some changes could be introduced to constrain exaggerated false positive detections such as using heart rate data. In general, the integrated system provided a good deal of safety enhancing features supporting all kinds of environmental and driving risk factors, making it a very useful tool in averting accidents in all driving situations.

# 5 Future Enhancements

The given system provides a very efficient system for accident prevention. In the future more features can be added for even more security like communication with emergency services if a collision occurs. More ML technologies can be used for better analysis of collision detection. There are newer algorithms that are still experimental but if successful in the future will definitely increase the efficiency of the system.

The existing mechanism can still be enhanced as it performs in most conditions but its effectiveness can reduce in adverse weather phenomena like fog, rain, or snow. In future studies, issues raised in this study may introduce different sensor types such as cameras or infrared ones in addition to the ultrasonic sensors. These sensors might prove to be more effective in such weather conditions, further enhancing the environments where the system would be effective and its overall strength. Furthermore, extending range and accuracy of the sensors may enable the system to identify such objects at considerable distances thus giving the drivers ample time to react especially under high speeds.

In the end the goal was to decrease accidents and the loss of lives and injuries that can occur due to it. This system may cost a bit but compared to the security and

safety it provides it is definitely efficient and worth it. The system if implemented in automobiles can help millions of people and prevent a lot of accidents

# 6 Conclusion

The Accident Prevention System employs ultrasonic sensors for obstruction counting, ML-based monitoring for drowsiness, as well as an alerting system is very effective in promoting road safety by dealing with both external and internal risk factors instantly. The ultrasonic sensors serve their purpose in detecting obstacles over short distances allowing for timely precautions from the drivers. This is despite the fact that sensors accuracy could be affected by external factors such as rain and fog. However, the main purpose of the system is executed quite well. In scenarios where very fast sensing speeds are required or the system has to operate in difficult weather, other sensors such as the infrared or radar can be used for better performance especially in complicated or high-risk areas.

The drowsiness detection system based on artificial intelligence was very effective in recognizing gestures caused by fatigue; this is very important for eliminating accidents caused by drivers' lack of focus. The system helps in immediate intervention upon detection of drowsiness signs using facial recognition software and thus helps to prevent accidents associated with tiredness, and other factors leading to road traffic accidents. The speed and accuracy of the system indicate that integration was effective, however, issues with false identification of signs and differentiating them from normal facial expressions of slight distractions still exist. Adding other body functions such as heart rate monitoring can enhance the effectiveness of the system detection and on the overall rather than considering the state of the driver solely based on one indicator.

The system, which includes alert mechanisms, has completely changed the approach from passive monitoring to active intervention. Using auditory and visual alerts ensures that a driver is sufficiently warned and sensitized to the need for remedial actions, hence improving the safety potential of the system significantly. Testing showed that such alerts are acceptable and effective but less appealing due to the constant alert in most low-risk situations; alert frequency and sensitivity can be adjusted for better usability. The integration of various forms of alerts was especially helpful in ensuring the attention of the driver, thus making the system applicable to various driving conditions and environments.

### 6.1 Application towards design and development of Smart Cities:

The Accident Prevention System (APS) with its ultrasonic sensors for obstruction detection, ML-based drowsiness detection, and a responsive alert system can be of great importance in smart city design and development. With technological advancements being introduced into city infrastructure, the focus shifts to enhanced road safety and optimized means of transport. Smart cities can incorporate traffic management systems within public and private vehicle fleets to minimize road accidents, enhance movement, and provide an urban mobility network that is safe and efficient. The system is a fundamental element in the construction of advanced and secure cities that will not only support the drivers but will also work with other smart city features in enhancing the safety of the public.

Improving situational awareness is one of the key advantages of using accident prevention systems in urban cities. Most urban roads are prone to distractions due to nonvehicular traffic such as jay-walking pedestrians, cyclists going in and out of lanes, vehicles constantly changing lanes in heavy traffic, and so on. To address this, our system makes use of ultrasonic sensors, cameras, ML, and other technologies to alert the driver in real time of any obstacles, changes in traffic, or people where they shouldn't be, in order to avoid crashes. This is more so useful in highly congested areas where the users of the road are extremely close to each other, thus limiting the drivers vision and stopping the driver from seeing every possible risk.

In general, the introduction of the system into the smart city framework makes it more efficient in accident prevention management and encourages more safety in the cities by meeting the demands of both drivers as well as pedestrians. With the help of data, advanced safety measures, and an integrated transport system, APS in the future can be even more efficient and can be perfectly included in the concept of smart cities enhancing safety and a more sustainable urban development.

In conclusion, the Accident Prevention System is an innovative solution against accidents as it incorporates all the possible technologies which are cost effective, expandable and can be used in different kinds of vehicles. The system architecture aims to improve road safety by minimizing non-environmental and environmental related risk factors to the driver and can be applied in private cars as well as the commercial and public transport. The next step includes improving the detection accuracy in those challenging environments and adjusting the alert level which affects the comfort of the driver without compromising safety. This paper explains the need for timely intervention to prevent the occurrence of accidents and this also paves a way for the advancement of smart cities and development since smart drivers’ assistance systems are dedicated to lowering accidents on the roads.

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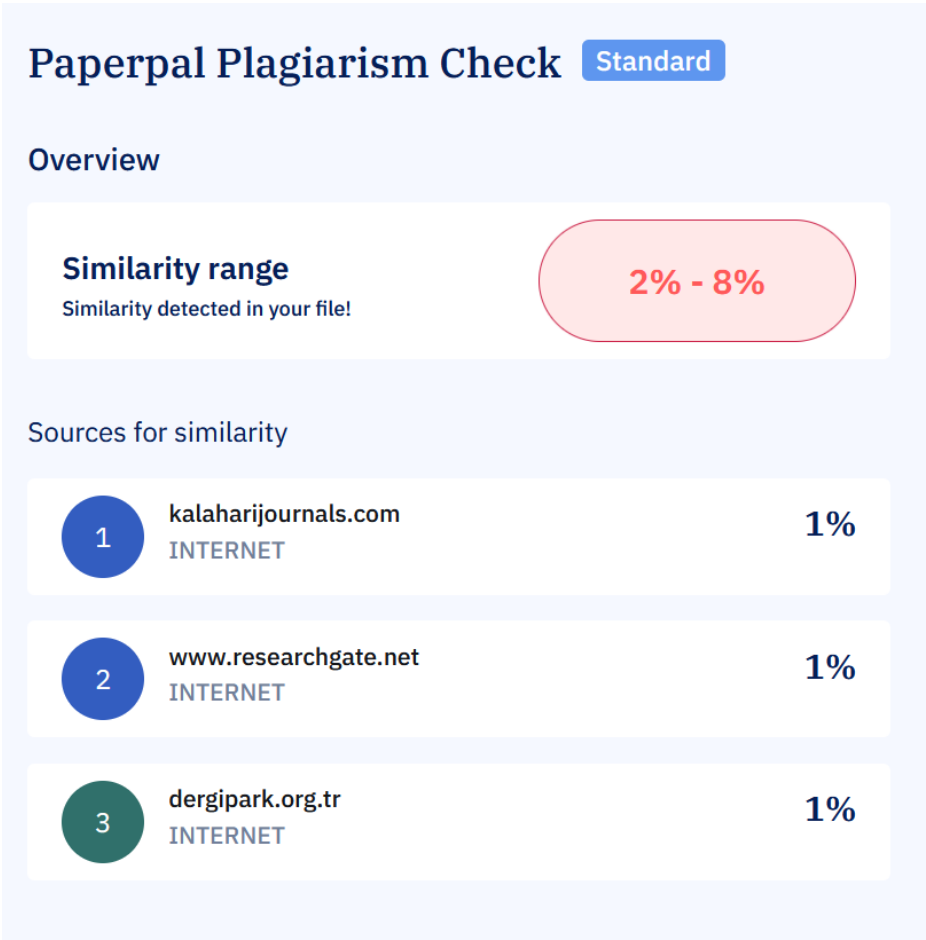

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