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Enhancing Driver Safety Using an Intelligent Driver Assistance System

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Abstract- In the modern era, one of the most significant challenges is the widespread occurrence of traffic accidents, which exacts a heavy toll on human lives and well-being. Annually, according to the National Highway Traffic Safety Administration, approximately 50 million people suffer injuries, and nearly 1.2 million lives are lost globally due to traffic incidents. Addressing this critical concern involves exploring the potential of automated technologies to mitigate these alarming statistics. Intelligent Driver Assistant Systems (IDAS) emerge as innovative solutions designed to combat the prevalence of traffic accidents. By integrating advanced warning systems and proactive interventions, IDAS effectively monitors driving conditions. It detects sudden decelerations of nearby vehicles, identifies unexpected obstacles, and recognizes erratic driver behavior through real-time data analysis. By providing timely alerts and interventions, IDAS acts as a crucial safety net for drivers, equipping them with essential information to anticipate and respond promptly to potential hazards, thereby significantly reducing the risks of accidents and improving overall road safety.

Keywords- Adaptive Cruise Control (ACC), Blind Spot Detection (BSD), Driver Drowsiness Detection (DDD), Intelligent Driver Assistant System (IDAS), Lane Departure Warning (LDW).

I. INTRODUCTION

Advanced Driver Assistance System (ADAS) plays a crucial role in enhancing drivers' decision-making abilities by complementing rather than replacing them, through warning systems and interventions, thereby establishing a responsive support framework for navigating complex road conditions [1].

The proposed Intelligent Driver Assistant System (IDAS) distinguishes itself from ADAS by integrating core ADAS functionalities while introducing additional features designed to foster a secure and responsive driving environment and assume control in the event of an accident. Subsequent sections of this research paper will delve into these novel features, which include enhanced accident response capabilities. The system employs advanced warning mechanisms to alert drivers to potential hazards such: sudden deceleration of nearby cars, unexpected obstacles, or erratic driving behaviors. IDAS functions as a safety net by providing real-time warnings, empowering drivers with crucial information to prepare and respond, and reducing the likelihood of accidents.

The IDAS system has three primary subsystems: driver-related modules, road-related modules, and auxiliary modules. Driver-related modules such as Driver Drowsiness Detection (DDD) employ face-monitoring cameras to assess driver alertness, ensuring timely responses to signs of fatigue. Road-related modules like Blind Spot Detection (BSD) and Lane Departure Warning (LDW) enhance situational awareness, while Adaptive Cruise Control (ACC) promotes adaptive driving by adjusting vehicle speed based on proximity to other vehicles.

These features serve dual roles: passive alerts to drivers at varying threat levels and active interventions such as speed reduction or emergency braking, thereby reducing accident probabilities. Additionally, the system includes auxiliary modules for sending SOS messages with vehicle location via GPS and GSM modules in emergencies. It also integrates Emergency-Caused Vehicle Control to park the vehicle automatically when a drowsy driver is detected, thereby preventing collisions.

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Lastly, our system adopts the black box concept by storing sensor data in the ECU memory to document the time and cause of any accident, ensuring clarity in post-accident analysis and response.

In summary, our IDAS system offers a comprehensive approach to vehicle safety, leveraging advanced technologies to enhance driver decision-making and reduce accident risks. Section Ⅲ discusses the system architecture, while Section Ⅴ details the proposed modules.

II. LITERATURE REVIEW

Recent advancements in automotive technology have seen significant strides in enhancing vehicle safety and performance through innovative initiatives and research. From early initiatives like the Automated Highway System (AHS) in the 2000s, which laid the groundwork for vehicle-to-vehicle (V2V) communications, to more recent developments in sensor technology and advanced sensor fusion techniques, the evolution has been marked by continuous improvement. Projects such as those integrating camera, gyroscope, and GPS technologies exemplify this progress, aiming to achieve precise real-time readings and enhance system effectiveness in critical driving scenarios. These advancements reflect a broader trend in ADAS (Advanced Driver Assistance Systems) technology, emphasizing not just warning systems but also active safety measures aimed at preventing accidents and ensuring safer road experiences for all.

A. Early Initiatives: Automated Highway System (2000s)

V2V communications research began under the Vehicle Infrastructure Integration Initiative in 2003, tracing its roots to the Automated Highway System (AHS) research [2]. These early efforts laid the groundwork for advancements in vehicle-to-vehicle communication systems.

B. Advances in Sensor Technology and Implementation (2017)

Helwan University implemented a similar idea in 2017, focusing on vehicle sensor selection. However, their approach had limitations due to incorrect sensor choices, leading to inaccurate measurements. Our project employs rigorous sensor ranking criteria to ensure optimal sensor selection for each feature, enhancing system performance and accuracy.

C. Integration of Advanced Sensor Fusion Techniques (2022)

In 2022, Al-Azhar University had a mentorship program with valeo Company. They utilized a standard camera for lane sensing and highlighting challenges in real-time accuracy. In response, our project integrates camera, gyroscope (MPU6050), and GPS technologies to achieve precise real-time readings. This integration enhances the system's ability to promptly execute appropriate actions whether active or passive, improving overall effectiveness in critical driving scenarios.

D. Research Advancements in ADAS Technology

1. 2020: Research emphasized the critical role of lane-keeping assistance systems (LKASs) in driver safety [3]. Traditional systems were noted for their limited automation levels, prompting the development of advanced LKAS with switchable assistance modes to mitigate reliability issues.
2. 2021**:** Studies explored the integration of Wi-Fi and GPS-based vehicle tracking systems for real-time vehicle location and mapping [4]. These systems aimed to enhance service levels by providing comprehensive vehicle information and historical tracking data.
3. 2023: Manufacturers like BMW, Mercedes, and Ford were known for their advancements in drowsiness detection systems [5]. These systems monitor driver behaviors and environmental conditions to prevent accidents, highlighting ongoing efforts to move beyond mere warnings to active safety measures.

III. IDAS ARCHITECTURE

The IDAS system is a complex technology, which incorporates three main phases, depicted in Figure 1, to execute suitable actions whether warning the driver passively or taking active control of the vehicle to prevent accidents. The first phase is sensing, during which sensors gather data from the surrounding environment. These readings undergo analysis in the processing phase to determine the appropriate action. Finally, the processor

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executes this action. These phases ensure precise data analysis for timely action execution to enhance driver safety.

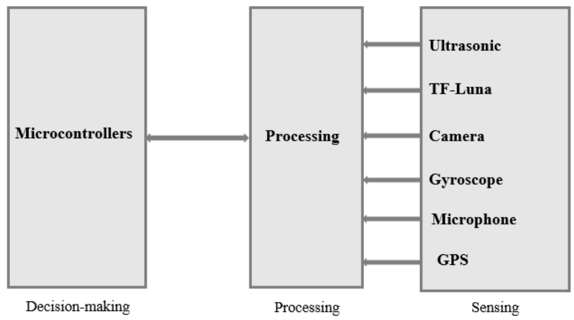

Figure 1 IDAS Architecture

A. Sensing

The initial phase of the IDAS system involves sensor selection based on specific ranking criteria tailored to each feature, detailed in Table 1.

Table 1 Ranking criteria of possible ACC sensors

Parameters	**TF-Luna**	**Ultrasonic**	**3D-Lidar**
Cost	50.00	1.30	200.00
Dimensions	8m	5m	Up to 2000m
Efficiency	Efficient	Medium	Very efficient
Size	Small	Small	Large

The IDAS system utilizes Ultrasonic sensors to detect blind spots around the vehicle, which are areas not directly visible to the driver through side or rear-view mirrors or by turning their head. Blind spot warning systems issue auditory or visual alerts to drivers upon detecting vehicles in adjacent lanes, thereby enhancing safety during lane changes [6]. Operating on the principles of Sound Navigation and Ranging (SONAR), Ultrasonic sensors emit ultrasound waves that reflect off objects. Distance is calculated by measuring the echo's travel time to the receiver [7].

To maintain safe inter-vehicle distances, TF-Luna sensors emit near-infrared modulation waves that reflect off objects and calculate distance based on round-trip phase differences [8]. For lane departure detection, the system integrates Camera, Gyroscope, and GPS data. Gyroscopes measure vehicle acceleration due to gravity, determining sensor orientation relative to the Earth's surface and inferring linear vehicle motion such as turning or deceleration. OpenCV, a powerful Python library for computer vision, is utilized to develop a lane departure warning system, integrating camera data to provide visual alerts and extract metrics like road curvature and lane position. GPS data validates camera and gyroscope readings, ensuring accurate warnings and facilitating vehicle localization on maps to establish its precise relationship with the environment, addressing lane position and proximity to other vehicles [9].

B. Processing

Road hazards including vehicles, pedestrians, and signage are identified through analysis of sensor data, which is collected and processed using various algorithms. Sensor readings are compared against a predefined lookup table encompassing all possible scenarios. Based on this comparison, appropriate actions are determined to minimize collision risks. These actions may range from passive alerts, such as audible warnings to the driver, to active interventions that assume control of the vehicle if an imminent collision is detected.

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C. Decision making

Decision-making in the ADAS system is pivotal to ensure both safety and operational efficiency. Once all sensor data is processed within the vehicle's CPU, the system determines whether passive or active actions are necessary.

If the required action is passive, the system alerts the driver using audible alerts (voice messages) to warn about potential threats.

In cases where an imminent accident is detected, necessitating active intervention, the system takes control of the vehicle itself. This includes adjusting the vehicle's motors to slow down or stop, if needed, to maintain a safe distance between vehicles and prevent collisions.

IV. IDAS BLOCK DIAGRAM

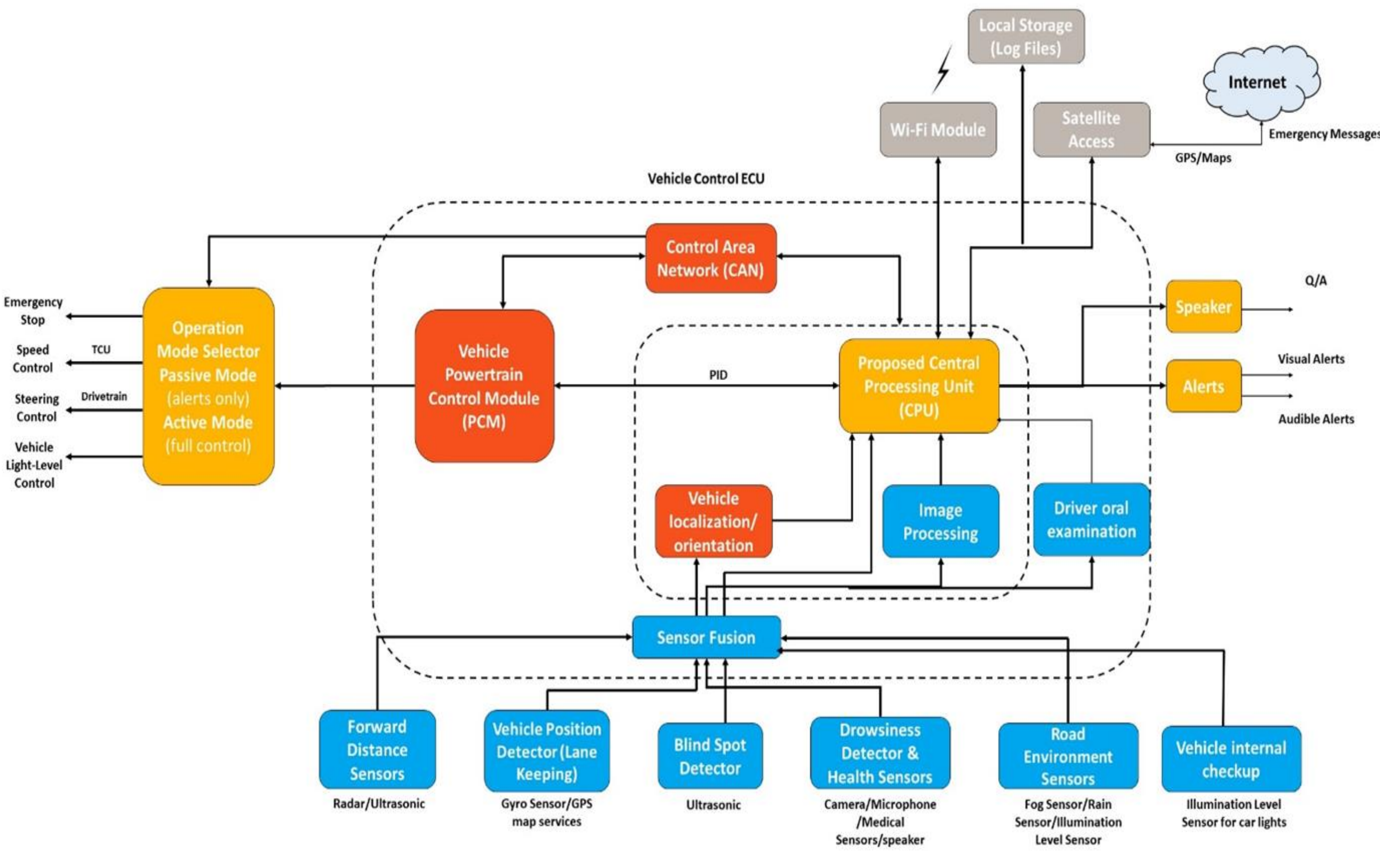

Figure 2 IDAS block diagram

The entire sensor their readings will be combined using sensor fusion and goes to the CPU to take the right decision but before going to the CPU to take an accurate and right decision there are several processes that should be considered:

- Image processing: that takes the reading of the camera, detect the face of the driver, and gives these readings to the CPU to take the action.
- Driver oral examination: and it is a two-way communication with the CPU first translating the text to voice using speaker and then translating the voice to text using the Mic.

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- Vehicle localization/orientation: Takes the reading from the gyro sensor and from the readings it can determine the local position of the vehicle on the road and gives it to the CPU to determine whether the vehicle departs from its lane or not.

Then the CPU from all these reading and comparing it to the standards can take two types of actions whether passive actions, only by giving only visual or audible alerts directly or can take passive actions, and then active actions and the active action when it takes place the CPU must communicate with PCM using CAN protocol (control area network) as the PCM is the brain of the vehicle and PCM will select which active action will take from the four actions: Steering control, Speed control, Vehicle light level control, and Emergency stop and this happens gradually not suddenly

CPU can send directly SOS messages containing the location of the vehicle to the nearest hospital calling for an ambulance using WIFI and satellite communications. We can get used from the log files and sending it to any authority or to any maintenance for any updates using satellite communication.

V. PROPOSED MODULES

A. Driver-related modules

Drowsiness detection is crucial for enhancing safety across various domains, especially within transportation systems. This system employs multiple methods to determine whether the driver is drowsy. The core concept behind Driver Drowsiness Detection involves capturing images from a camera and leveraging data processing to approximate the driver's state. This project utilizes Python for machine learning purposes in conjunction with a camera. Facial and eye detection tasks are achieved using OpenCV and YOLO algorithms, with support from OpenCV libraries.

Once the system detects the drowsiness, it initiates an oral examination by posing a simple question to the driver. If the driver does not respond or gives an incorrect answer, the system will pose a second question. If the driver remains unresponsive, the system activates emergency vehicle control features as a precautionary measure.

1. Driver Drowsiness Detection (DDD)

Drowsiness Detection utilizes different technologies to track and identify indicators of driver weariness. The accuracy and dependability of sleepiness detection systems are improved by the combination of these techniques.

- ***Facial Analysis:***

Facial analysis is a critical component of drowsiness detection systems, employing computer vision algorithms to track and analyze facial expressions and characteristics. This method effectively detects signs of fatigue or sleepiness through facial signal analysis [10]. Monitoring the closure of the driver's eyes is crucial for detecting drowsiness, with algorithms assessing the duration and frequency of eye closures. Extended periods of eye closure can indicate fatigue.

Our software receives color frames from a camera positioned in front of the driver, calculating the coordination of facial features. Finally, through comprehensive analysis and interpretation of facial details and image processing data, our software assesses levels of drowsiness. This method is executed in multiple sequential steps to ensure accurate detection. Here are sequential steps of drowsiness detection:

i. Video capturing:

The first and crucial step is to capture the live actions of the driver using the webcam. Video capturing is essential because it enables us to detect the driver's face. In this context, we can liken the webcam to the eyes of our prototype.

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ii. Eye detection:

Eye tracking is a process that occurs after face extraction or face alignment, which involves identifying key facial landmarks such as the eyes, nose, and mouth. Face alignment transforms the image so that these landmarks are in a standardized position relative to each other, achieved through computer vision techniques like facial landmark detection and affine transformations.

Facial landmark detection uses algorithms to locate crucial facial features such as eye corners, nose tips, and mouth corners, serving as reference points for alignment. Affine transformations are mathematical operations used to rotate, scale, and translate images, ensuring that facial landmarks are correctly positioned relative to each other.

The primary objective of this process is to accurately locate and standardize the position of the driver's eyes for tracking purposes.

iii. Eye tracking:

During the eye-tracking stage, the processor receives facial images and initially adjusts their brightness and contrast to reduce sensitivity to varying light conditions [11]. Next, a top-down model approach is used to detect the face region, which helps to localize the eyes. If the driver's face is not initially detected in the input image, the program continues to capture new images from the webcam until the face is successfully identified. Once the face is located, the system extracts the region containing the eyes.

For effective and efficient eye detection extraction, the system utilizes the YOLO technique and the standard AdaBoost (Adaptive Boosting) training method.

iv. Drowsiness detection:

After locating the landmarks of the eyes, we applied the Eye Aspect Ratio (EAR) equations as described in Equation (1):

$$EAR = \frac{\|p2 - p6\| + \|p3 - p5\|}{2 * \|p1 - p4\|}$$

where P1 through P6 represent the 2D landmark locations on the retina. P2, P3, P5, and P6 were used to measure the height of the eye, while P1 and P4 were used to calculate the eye width. This process is illustrated in Figure 3.

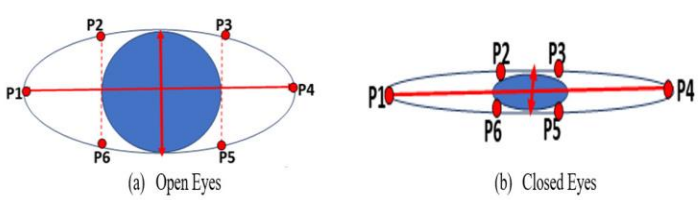

Figure 3 EAR

The EAR equations determine whether the eyes are open or closed based on the ratio calculated from these landmarks. When the eyes are closed, the EAR value rapidly decreases to nearly zero, as depicted in Figure 3. Conversely, when the eyes are open, the EAR value remains relatively constant.

2. Oral Examination

The IDAS system introduced novel module called oral examination, which follows the drowsiness detection process. The examination evaluates the driver's ability to remain awake, focused, and responsive while operating the vehicle.

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Whenever the system detects a drowsy driver, it initiates an alert through an alarm and begins an oral examination process. This involves posing two logical questions with pre-set answers to assess the driver's alertness. Here is how the process unfolds:

1. The system first detects signs of drowsiness, such as prolonged eye closure.
2. Upon detection, the system alerts the driver with a voice message and poses a question.
3. If the driver answers correctly, the system monitors facial features and eye movements continuously to ensure continued alertness and decrease the risk of collisions.
4. If the system cannot verify the voice or source of the answer, it assesses the driver's mouth movements and repeats the question to confirm the response and the driver's wakefulness.
5. If the driver answers the initial question incorrectly, the system poses another question. If the answer remains incorrect, the system intervenes by taking control of the vehicle. It activates emergency vehicle control feature to reduce speed and safely park the vehicle, ensuring the driver's safety.

This process is designed to proactively manage driver alertness and enhance overall safety during vehicle operation.

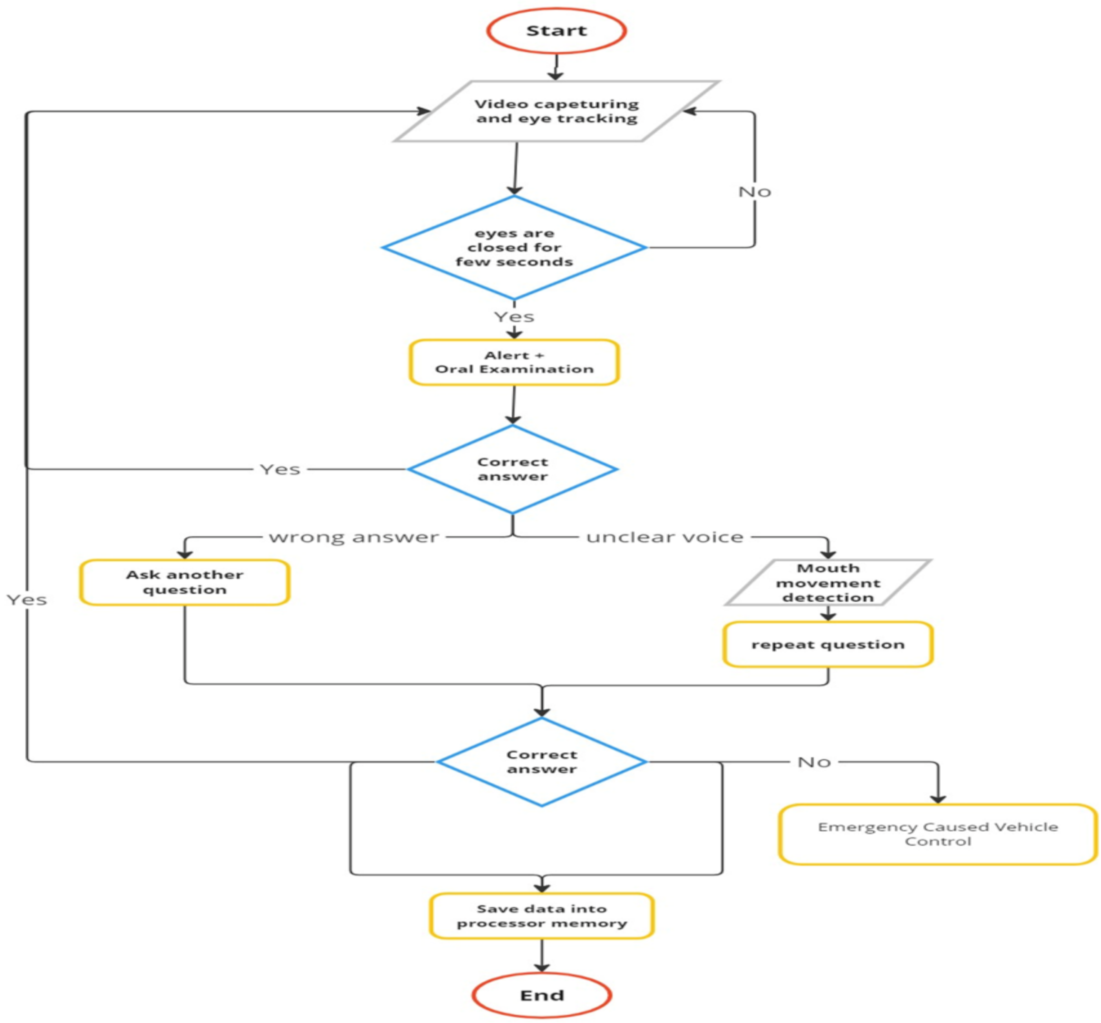

Figure 4 Driver-related modules flowchart

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B. Road-related modules

1. Adaptive Cruise Control (ACC)

The purpose of employing the cruise control system on public highways is to assist, particularly on expansive and straight roads leading to more distant destinations. While traditional cruise control is beneficial for such scenarios, its effectiveness diminishes in heavy traffic situations. The inclusion of adaptive cruise control (ACC) in vehicles is designed to ensure they maintain safe distances from surrounding objects and adhere to speed limits [8].

One of the technologies that keeps the distance behind the obstructing vehicle while traffic is heavy is the low-speed ACC. This technology automatically adjusts the car's speed, relieving the driver from manual speed control [12].

The adaptive cruise control feature utilizes the TF-Luna sensor, which emits near-infrared modulation waves periodically. These waves reflect off objects and return to the LiDAR sensor, where the round-trip phase difference is detected. This information allows the LiDAR to calculate the flight duration and accurately determine the distance between itself and the detected object [13].

Numerous factors influence the stopping distance. Firstly, the road gradient influences braking distance: uphill grades aid braking efforts, reducing stopping distance, while downhill grades work against braking, increasing stopping distance. Additionally, frictional braking distance is influenced by the traction between tires and the road surface. Lastly, initial vehicle speed plays a crucial role; higher speeds require longer stopping distances when subjected to consistent deceleration.

When computing the safety distance, we integrated these variables and scenarios based on sensor readings. Speed and motor duration adjustments were managed by modulating the duty cycle of the motors.

Figure 5 outlines the algorithm for motor speed control. Initially, the system measures the distance; if the distance exceeds 8 meters, the motor speed remains unchanged. As the distance decreases to between 8 and 6 meters, the motor speed decreases to 75% of the duty cycle. If the distance reduces to between 6 and 4 meters, the motor speed decreases to 50% of the duty cycle. For distances between 4 and 1 meter, the motor speed reduces to 25% of the duty cycle. If the distance falls below 1 meter, the motors cease movement altogether.

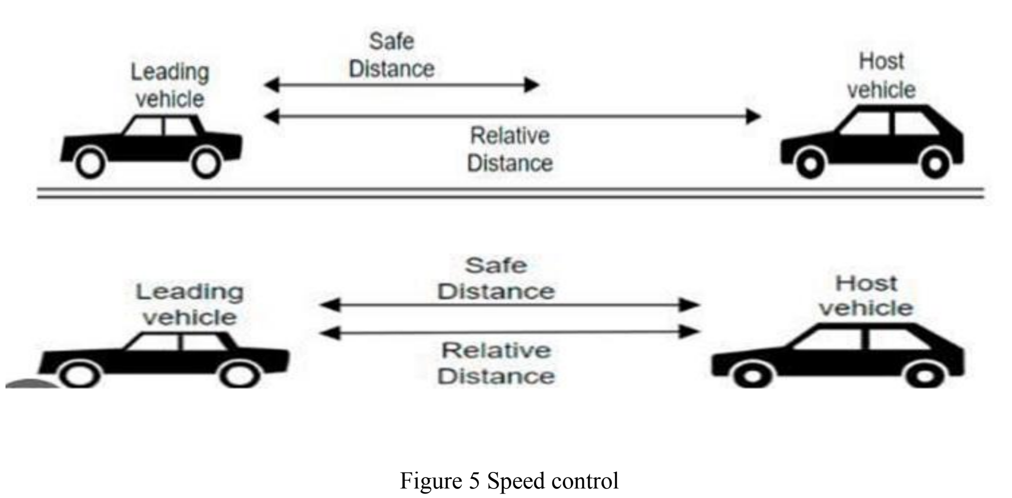

Figure 5 Speed control

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TF-Luna

TF-Luna is a Time-Of-Flight (TOF) based Lidar sensor utilized for range detection. Distance measurement is achieved by emitting a wave and calculating the time it takes for the wave to travel to an object and back $D = S * T$, where D represents distance, S denotes speed, and T signifies time.

TF-Luna specs

- Small in size and light in weight
- Distance resolution: - 1Cm
- Voltage: 5V
- Average: 70mA~150mA
- Communication interface: UART / I2C

Control Methodology

By using all the above components, we start to build our feature by the following steps

1. *Measuring distance:*
   We employ TF-Luna sensors to measure distances between our vehicle and other vehicles or obstacles in the surrounding area.
2. *Distance Cases:*
   Based on safety standards, we establish a safe distance to ensure driver safety, and identify a danger zone where specific actions must be taken by the vehicle.
3. *Action:*

Based on distance measurements, the system initiates specific actions. A safe distance threshold of 8 meters is established; when the distance exceeds this threshold, the vehicle operates normally without intervention. As the distance decreases to between 8 meters and 6 meters, the system reduces speed by adjusting the duty cycle to 80%. Further reduction in distance, ranging from 6 meters to 4 meters, prompts an additional speed reduction to 50% duty cycle. If the distance continues to decrease to between 4 meters and 1 meter, the system further reduces speed to 20% duty cycle. Should the distance fall below 1 meter, indicating critical proximity, the system halts the vehicle by setting the duty cycle to 0%, as shown in Figure 6.

If the distance increases at any point, the vehicle accelerates by increasing the duty cycle. The L293D motor shield actively controls the duty cycle to regulate motor speed based on the detected distances

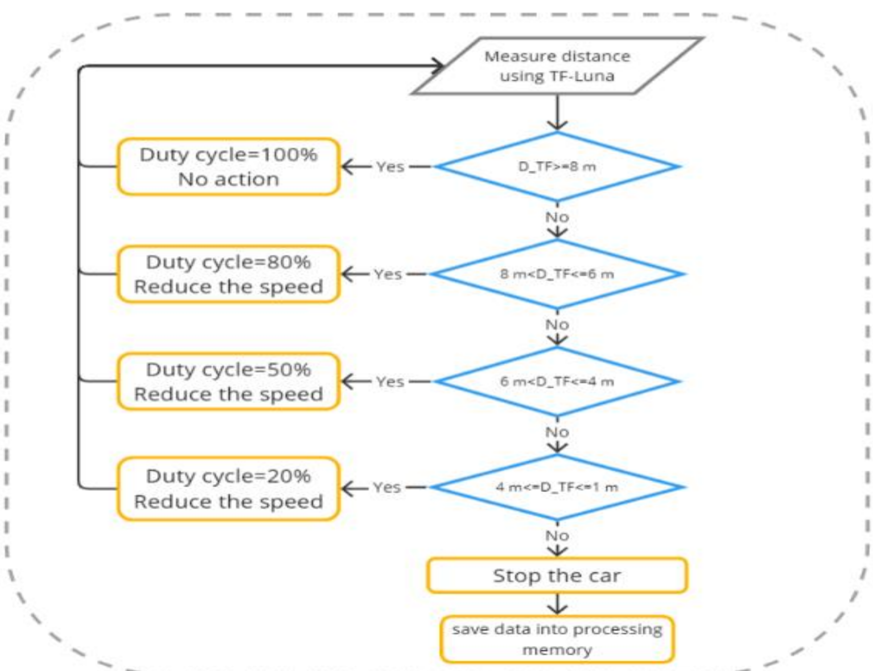

Figure 6 ACC flowchart

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4. Lane Departure Warning (LDW)

The Lane Departure Warning System (LDWS) in this system utilizes a duo of critical devices and sensors to achieve superior performance compared to competitors. These components include a camera and an MPU6050 sensor incorporating gyroscope and accelerometer functionalities. The system's primary output is either a warning voice message or a visual indicator on the car's dashboard, serving a crucial role in mitigating unintended lane departures.

A. LDW using camera

This section delves into the implementation of these systems through the integration of OpenCV, image processing techniques, and computer vision algorithms. The car's camera plays a pivotal role by capturing real-time visuals, which are processed to provide visual alerts for lane departure. Moreover, the system extracts essential metrics such as road curvature and distance from the lane center to enhance its functionality.

The implementation involves the application of thresholding techniques on captured images to create binary representations that highlight specific lane features. Techniques such as color and gradient thresholding are employed to enhance the visibility of lane markings within the image. Figure 7 illustrates the lane detection process, depicting how thresholds between lane markings are measured and visually indicated on the screen using square overlays [14] [15].

Image processing techniques used:

1. *Camera Calibration ('CameraCalibration' class):*
   - The camera calibration process corrects for lens distortion in images.
   - It involves taking pictures of a known pattern (chessboard) from different angles to calculate distortion coefficients, as shown in Figure 7.

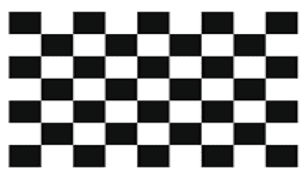

Figure 7 Callibration chessboard

2. *Perspective Transformation ('PerspectiveTransformation' class):*
   Implement a perspective transform to obtain a bird's-eye view of the road. This transformation aids in simplifying lane detection algorithms by making lanes appear as parallel lines in the transformed image.

3. *Thresholding ('Thresholding' class):*
   Thresholding techniques are applied to create binary images, emphasizing certain features. In this context, it is likely that color and gradient thresholding are used to enhance lane lines in the image.

4. *Lane Line Detection ('LaneLines' class):*
   - Lane line detection is a crucial step in the pipeline.
   - Techniques such as sliding windows, polynomial fitting, and averaging are likely used to identify and track the lane lines.
   - The pipeline probably includes methods for plotting the detected lane lines on the original image or video frames.

5. *Integration of Pipeline ('FindLaneLines' class):*
   - The FindLaneLines class integrates the camera calibration, thresholding, perspective transformation, and lane line detection steps into a coherent pipeline.
   - It provides methods for processing both individual images and entire videos.

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6. *Command Line Interface ('docopt'):*
   The script uses docopt to define a command-line interface for running the pipeline with various options, such as specifying input and output paths and choosing between image or video processing.

7. *Video Processing ('moviepy' library):*
   - The 'moviepy' library is used for processing video files.
   - The script reads a video file frame by frame, applies the lane detection pipeline to each frame, and saves the processed frames back into a video file.

Coding for LDW using OpenCV:

1. *Setting up the environment:*
   Figure 8 illustrates the setup process for the Lane Departure Warning (LDW) environment.

```
import matplotlib.image as mpimg
import cv2
from docopt import docopt
from IPython.display import HTML, Video
from moviepy.editor import VideoFileClip
from CameraCalibration import CameraCalibration
from Thresholding import *
from PerspectiveTransformation import *
from LaneLines import *
```

Figure 8 Setting up the environment for LDW

2. *Lane Detection Algorithms:*

- 'fit_poly': Fits a polynomial to the detected lane pixels. It is a crucial step in determining the shape and position of the lane lines.
- 'search_around_poly': If the lane polynomial has been detected in the previous frame, this method searches around that polynomial to find new lane pixels.
- 'fit_polynomial': The main function that orchestrates the lane detection process. It combines 'fit_poly' and 'search_around_poly' to fit polynomials to lane pixels in the current frame.
- 'visualize': Responsible for creating a visualization of the detected lane lines on the original image.
- 'plot': The entry point for applying the entire lane detection pipeline to an image. It calls 'fit_polynomial' to detect lane lines and then uses visualize to overlay the detected lanes on the original image.

3. *Integration with Camera:*

   The 'CameraCalibration' class, as shown in Figure 9 handles the integration with the camera.

```
class CameraCalibration():

    def __init__(self, image_dir, nx, ny, debug=False):

        fnames = glob.glob("{}/*".format(image_dir))
        objpoints = []
        imgpoints = []

        # Coordinates of chessboard's corners in 3D
        objp = np.zeros((nx*ny, 3), np.float32)
        objp[:,:2] = np.mgrid[0:nx, 0:ny].T.reshape(-1, 2)

        # Go through all chessboard images
        for f in fnames:
            img = mpimg.imread(f)

            # Convert to grayscale image
            gray = cv2.cvtColor(img, cv2.COLOR_RGB2GRAY)

            # Find chessboard corners
            ret, corners = cv2.findChessboardCorners(img, (nx, ny))
            if ret:
                imgpoints.append(corners)
```

Figure 9 Integration with camera for LDW

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Figure 10 displays the results of the lane detection process.

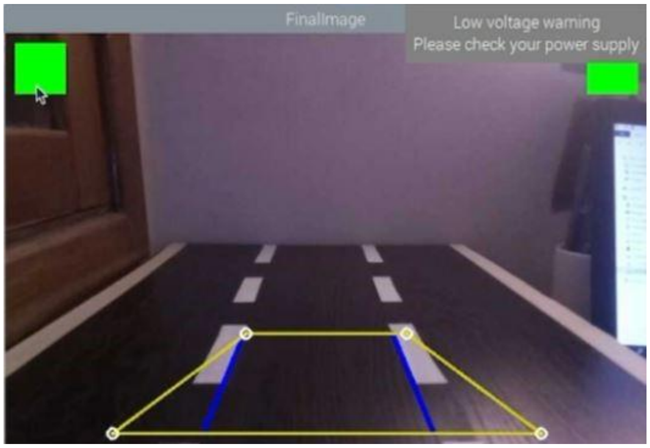

Figure 10 Lanes' detection

B. LDW using MPU6050

The MPU6050 sensor integrates three key components: an accelerometer, gyroscope, and temperature sensor. For this project, the feature utilizes only the accelerometer and gyroscope functionalities.

The accelerometer measures acceleration, encompassing gravitational effects, enabling the determination of the sensor's orientation relative to the Earth's surface. This capability facilitates inference of linear vehicle motion such as turning, decelerating, or directional movement. The accelerometer offers selectable scales of 2g, 4g, 8g, and 16g. The selection of these scales depends on the magnitude of vehicle acceleration: 2g for low-acceleration vehicles, 4g for higher acceleration, 8g for significant acceleration, and 16g for very high acceleration scenarios.

The MPU6050 provides accelerometer data along three axes designated as Ax, Ay, and Az. The chosen specific scale (e.g., 2g) determines the range of measurable acceleration values, which are acquired as raw data from the sensor and processed accordingly [16]. This configuration and data collection setup is essential for accurate analysis and interpretation of vehicle dynamics based on MPU6050 sensor outputs.

$$A_{axis} = \frac{Accelermoteter\ scale}{Accelermeter\ raw\ data_{axis}}$$

The gyroscope detects changes in rotational motion and angular velocity of the vehicle. It offers four scales: 250, 500, 1000, and 2000, each affecting sensitivity levels inversely proportional to the scale value. Lower scales, such as 250, provide higher sensitivity, detecting minute changes in rotation, whereas higher scales like 2000 offer lower sensitivity, suitable for capturing significant rotational movements.

MPU6050 sensor data includes three axes of gyroscope readings designated Gx, Gy, and Gz, as shown in Figure 11. The scale chosen (e.g., 250) dictates the range and resolution of rotational velocity measurements. These measurements are obtained as raw data from the sensor and are subsequently processed for further analysis and interpretation [17]. This setup ensures precise evaluation of vehicle dynamics based on MPU6050 gyroscope outputs, facilitating detailed insights into rotational behavior and angular changes during operation.

$$G_{axis} = \frac{Gyroscope\ scale}{Gyroscope\ \ raw\ data_{axis}}$$

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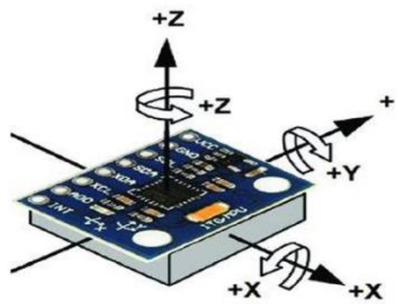

Figure 11 the rotation motion of Gyroscope in (x, y, z) axis

In this study, the accelerometer is set to a scale of 2g, which is ideal for applications involving low acceleration. Concurrently, the gyroscope operates at a scale of 1000 deg/s, providing moderate sensitivity to focus on significant changes in the car's rotation direction while filtering out minor fluctuations.

Specifically, Ax and Gz axes are utilized in this research. Ax identifies the vehicle's motion direction (e.g., Forward or Backward), utilizing data from the accelerometer. On the other hand, Gz detects the rotation direction (e.g., Left or Right) of the vehicle, leveraging data from the gyroscope. These insights are crucial for aiding drivers in maintaining their lane position effectively on the road, enhancing overall vehicle control and safety.

Figure 12 indicates the sequence on which LDW operates. The main sensor used in lane departure warning (LDW) is the camera. In the first stage, the system checks if the driver signals to change lanes. If yes, the warning system will not activate. If no, it proceeds to the second stage. The camera then begins detecting the lane, alerting the driver to stay within it, and identifies whether the lane markings are solid or dashed lines. This information is crucial for accurately transmitting the car’s position to the Raspberry Pi, which is used in the Emergency Caused Control feature.

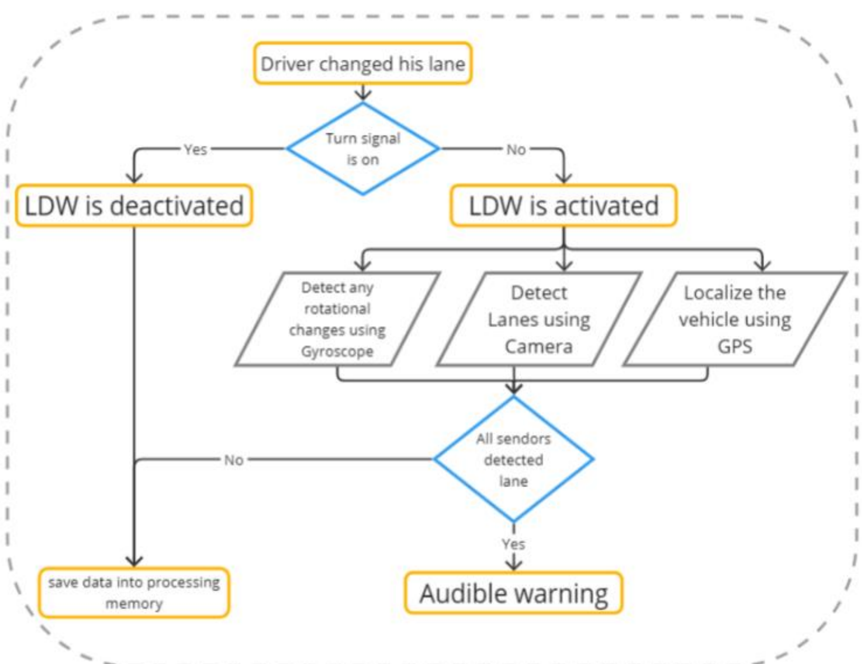

Figure 12 LDW flowchart

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5. Blind Spot Detection (BSD)

Blind spots in a vehicle are usually located behind the driver's seat, on both sides and sometimes in front of the vehicle. They can make it difficult for the driver to detect other vehicles, pedestrians, or objects in their path, especially when changing lanes, merging, or backing up. To mitigate these risks, many modern vehicles are equipped with technologies such as blind spot monitoring systems, which use sensors or cameras to detect objects in the blind spot and alert the driver with visual or auditory warnings. However, it is still important for drivers to be aware of their vehicle's blind spots and to check them manually before making any maneuvers.

The system facilitates collision avoidance for the driver via the detection of vehicles within the blind spot region during lane changes. Upon discerning the presence of a vehicle in a neighboring lane approaching the rear section of the driver's vehicle, a frequent blind spot area, the system promptly alerts the driver via activation of an indicator. Blind spot warning systems provide auditory or visual notifications to drivers in the event of the presence of vehicles within adjacent lanes, which may remain imperceptible to the driver during the execution of a lane change maneuver [6].

In the BSD system, we simulate a real-life scenario that takes place when there are areas around the car that are not visible to the driver through the side or rear-view mirrors, Hence the driver of the front vehicle may not be able to see a back vehicle and a collision may occur as shown in Figure 13.

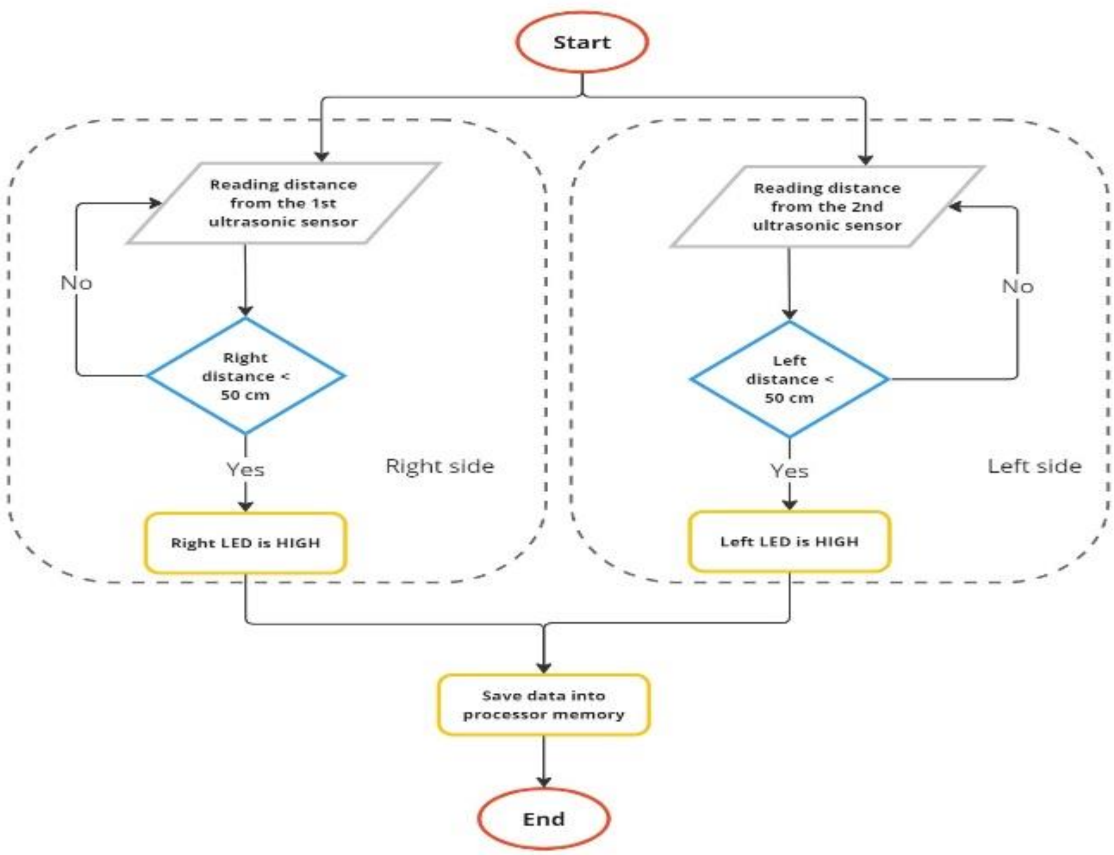

Figure 13 BSD flowchart

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In our implementation, the ultrasonic sensors are integral to our system setup. Placed on both the right and left sides of the RC car, these sensors measure distances to nearby vehicles in blind spots. If either sensor detects a vehicle less than 50 centimeters away, an LED warning alerts the driver. Conversely, if the distance measured meets or exceeds 50 centimeters, the vehicle proceeds in that direction without warning. Sensor readings are logged for performance evaluation and accident investigation purposes.

C. Auxiliary modules

1. GPS & GSM modules

Based on the reference contact, who can take action to control the condition if necessary. Due to the system's usage of GPS and GSM technology, operation is straightforward. The accident site's coordinates are captured by GPS, and the location contact receives them via GSM. As Arduino serves as the system's primary control component, all controls are created utilizing it. This technology will facilitate access to emergency assistance for individuals. We can save human lives by reducing the causes of traffic accidents in a timely manner.

The GPS concept relies on time and the precise positions of specialized GPS satellites. These satellites carry exceptionally stable atomic clocks, synchronized with each other and with ground clocks, correcting any drift from true time on a daily basis.

Due to the system's usage of GPS and GSM technology, operation is straightforward. This technology will facilitate access to emergency assistance for individuals. We can build a system in cars to help emergency to reach faster to the accident site and to help to save critical conditions.

Car localization involves determining the vehicle’s precise position on the map, allowing it to establish its exact relationship with the surrounding environment. Questions about the car’s lane position, proximity to other vehicles, and more can be addressed through effective localization. In our project, we implemented various modules to achieve localization before transmitting the necessary data over a communication protocol [18].

Our project will employ the Autonomous Navigation class, representing the most straightforward technique utilized by GPS receivers to provide users with instant position, height, and/or precise time. The accuracy achieved surpasses 100m (typically falling within the 30-50m range) for civilian users and 5-15m for military users. The devices used in this procedure are often inexpensive, small, and extremely portable handheld equipment. Although they have clocks as well, GPS receiver clocks are less accurate and steady [19].

By uploading the data of GPS on a website to be easier for the emergency to find the car’s position in case of emergency, so the role of Application Programming Interface (API) is referred to as API. A system of guidelines and procedures enables various software programs to speak with one another. Applications can request and share information using the methods and data formats defined by APIs. Due to their ability to provide smooth communication and integration between many components, APIs are essential to GPS safety systems.

These systems use APIs to compute routes, retrieve location information, give real-time updates, and provide a range of safety features including geographic boundaries, alarms for emergencies, and tracking capabilities. Additionally, APIs enable to integrate other services like traffic or weather updates to improve the general effectiveness and safety of GPS systems. Figures 14 and 15 illustrate the login process and the GPS detection process, respectively.

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Figure 14 Login process

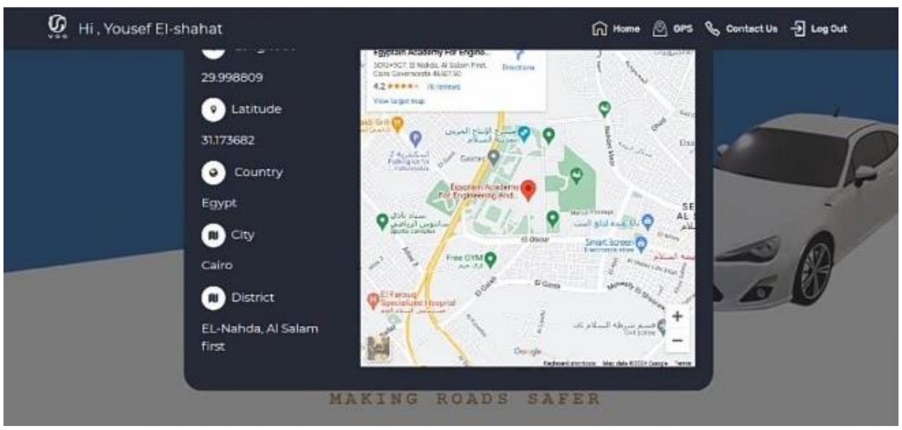

Figure 15 Detection process

2. Emergency Caused Vehicle Control

This feature used to improve the safety of the driver during his driving to decrease the percentage of happen an accident if he loses consciousness or in some cases dies, so after that send the location of the car and calling the emergency.

When the system indicates that the driver is drowsy the emergency caused will turn on, in this feature all sensors reading are used whether sensors of DDD, LDW, ACC and BSD. By applying some analysis on these data, start making a decision whether move to right or not.

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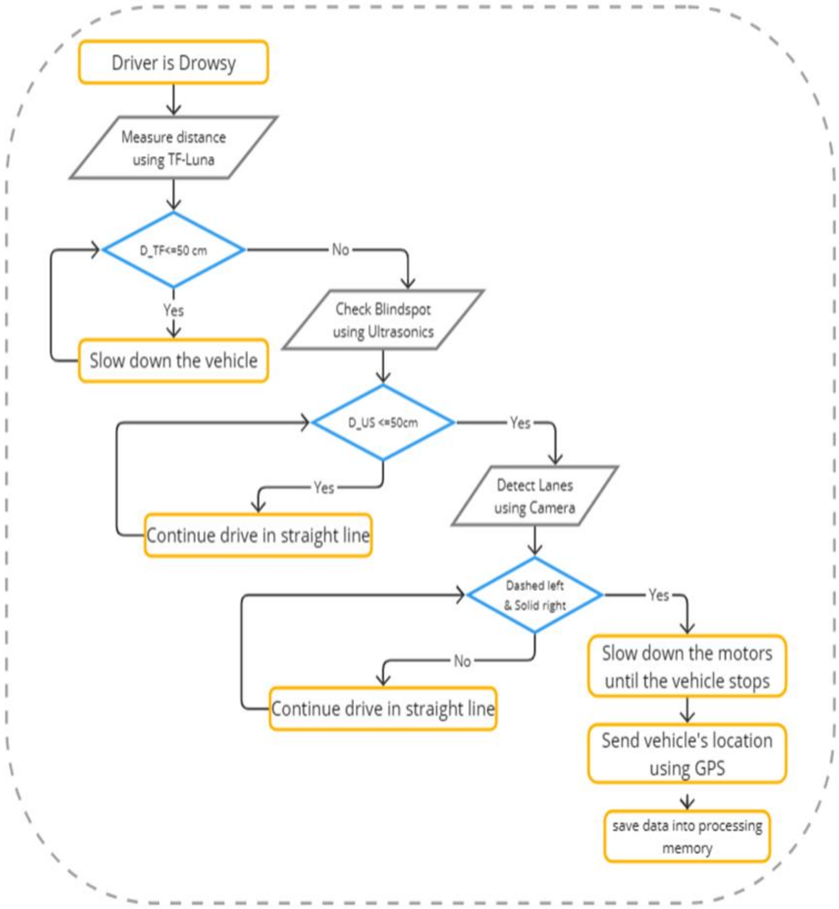

Figure 16 Emergency Caused Vehicle Control

From Figure 16, we know that the system firstly detects if the driver is drowsy or not. After the first stage is satisfied move to the second stage that measures the front distance and check if this distance is suitable to move or not and the car still moving in straight line, so if this distance is suitable start to move the third stage.

The third stage measures the blind area on the right side and check if this distance between the sensor and another object behind the car is suitable to start steering to the neighboring lane or there is an object in the blind spot so the vehicle should continue in straight line.

The forth and the final stage while the vehicle continues steering, the system detects the lanes to check if the lane is dash or solid line, as we target the solid line to park safely on the side of the road.

If the detection indicates that the lane is dashed continue move the car to the right until detect the solid line and then stop the car and send the final location of the car and send SOS message to the emergency.

3. Log Files

As a part of the IDAS technology's novelty, the system adopts the black box idea in order to determine the time and cause of an accident if any. The system saves all the readings from all sensors in its binary representations and saves the date and time of this reading for all feature. This process is not optional, as the system saves all this data whenever the car is moving. This can help the governmental authorities in several ways and ease their Investigations. An example of the log files as shown in Figure 17.

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1	Date	Time	Drowsine:	ACC	Lane	BSD
2	2024-06-1	00:17:46	1	0	0	1
3	2024-06-1	00:17:51	0	1	0	1
4	2024-06-1	00:17:56	1	1	0	1
5	2024-06-1	00:18:01	0	1	0	0
6	2024-06-1	00:18:06	1	0	0	1
7	2024-06-1	00:18:11	0	0	1	1
8	2024-06-1	00:18:16	0	1	1	0
9	2024-06-1	00:18:21	0	0	0	1
0	2024-06-1	00:18:26	0	0	0	1
1	2024-06-1	00:18:32	1	0	1	0
2	2024-06-1	00:18:37	0	0	1	0
3	2024-06-1	00:18:42	0	0	1	0
4	2024-06-1	00:18:47	0	0	0	1
5	2024-06-1	00:18:52	0	1	1	1
6	2024-06-1	00:18:57	1	1	0	1
7	2024-06-1	00:19:02	1	0	0	1
8						

Figure 17 Log file

VI. INTEGRATION

This part is crucial in our project as it integrates all features, ensuring high operational efficiency. We utilized various communication protocols such as UART (Universal Asynchronous Receiver/Transmitter) and SPI (Serial Peripheral Interface) to integrate the system components.

Figure 18 illustrates the microcontroller setup and their respective functionalities connected via suitable communication protocols. The primary microcontroller, Raspberry Pi I, incorporates Driver Drowsiness Detection (DDD), Log files, and a Screen. Raspberry Pi II manages Lane Departure Warning (LDW) and Global Positioning System (GPS). Additionally, Arduino Mega controls Adaptive Cruise Control (ACC), Blind Spot Detection (BSD), Emergency Caused Control (ECC), and the transmission of SOS messages.

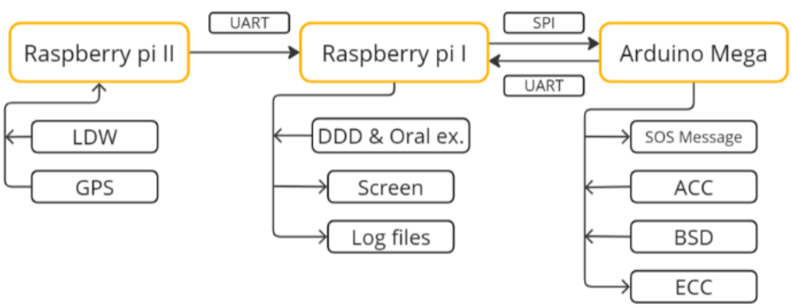

Figure 18 integration's block diagram

We utilized the UART communication protocol between both Raspberry Pis to transmit the car's position and lane location information. This data is sent in the form of a bit stream. Upon receiving and analyzing this bit stream, actions are taken or it is utilized in emergency scenarios.

Additionally, the SPI communication protocol was employed between Raspberry Pi I and the Arduino Mega. This protocol transmits a bit stream indicating the driver's drowsiness status. Based on this information, actions are taken such as controlling the vehicle or activating the Emergency Caused Control (ECC) feature and sending an SOS message. If the driver is drowsy, the car's position on the road is also transmitted.

Furthermore, UART communication was also used between Raspberry Pi I and Arduino Mega to transmit bit streams indicating the outputs of Adaptive Cruise Control (ACC) and Blind Spot Detection (BSD). This data is utilized for visualizing on the screen and is logged for future reference.

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Our ADAS (Advanced Driver Assistance System) project harnesses the Raspberry Pi 4s' simultaneous processing capabilities and the Arduino Mega's real-time data-gathering capabilities through efficient communication between these microcontrollers. This well-coordinated network of devices forms the foundation for robust and intelligent driving assistance.

VII. IDAS REPRESENTATION

A. Maquette

The purpose of designing a maquette is to install the sensors for the Driver Drowsiness Detection (DDD) system, which includes an oral examination feature and screen visualization, behind the RC car that integrates other features. This maquette is intended to present the DDD’s functionalities and provide a framework for testing and simulating the system. The following figures illustrate the design of the maquette.

The maquette dimensions are 80*120* 100 cm and consists the main microcontroller (Raspberry pi I), wheel, chair, screen, camera and microphone for oral examination.

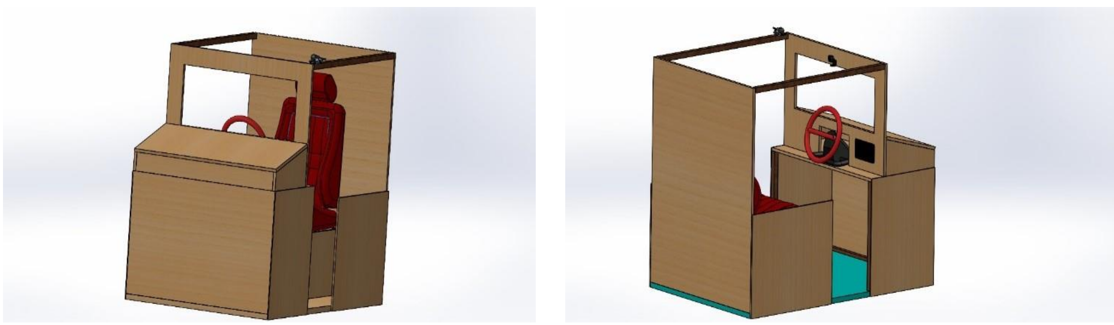

Figure 19 Maquette’s design

Connect between the raspberry pi in the maquette and the second raspberry pi on the RC car by wires to transfer the data from the raspberry pi II to the raspberry pi I as we explained in integration’s section. The Figure 20 indicates to the RC that consists The Raspberry pi II and Arduino mega with their features.

Figure 20 RC car

B. Screen

The screen contributes a significant role in visualizing the software features discussed before, as it synchronizes with the various sensors used in the system and placed all over the maquette, and whenever and

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whatever the reading is, immediately, the screen displays this case with a video that simulates the real environment.

The screen uses the driver-related (DDD and Oral Examination) and the road-related modules (LDWM ACC, BSD) to display all possible scenarios of Emergency Caused Vehicle Control feature, as shown in Figure 21. This occurs through receiving the bit stream representing the readings of the sensors and the processor compares them with the lookup table to identify the case and displays the video associated with this case.

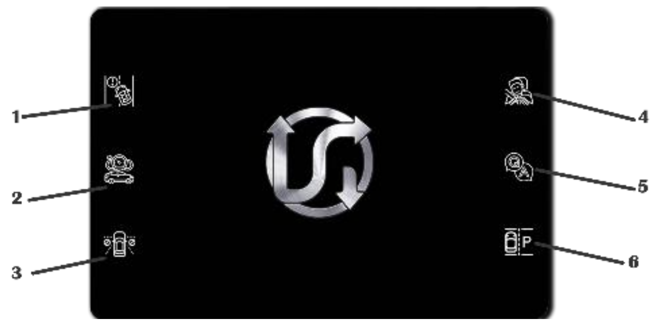

Figure 21 Screen

Emergency Caused Vehicle Control Scenarios displayed:

Firstly, the system detects whether the driver is conscious or drowsy. If the driver is drowsy the system takes the full control of the vehicle, integrates all the features together to park safely. This happens through detecting whether it can slow down the speed or not, if yes then it detects whether there is any vehicle in its blind spots to make sure it can turn to the neighboring lane safely and it will continue steering until reaching the solid line so it will park safely. If there is any vehicle in vehicle's blind spot it will continue in straight line until the blind spot becomes clean so the vehicle can steer to the neighboring lane unscathed.

VIII. CONCLUSION AND FUTURE WORK

In conclusion, it should be noted that intelligent driver aid systems, or IDAS, have the potential to significantly increase both driver convenience and road safety. IDAS can lessen driver fatigue, boost overall driving enjoyment, and assist avoid accidents by leveraging cutting-edge technologies like cameras, sensors, and AI algorithms. Manufacturers and regulators must persist in their responsible development and implementation of these systems, guaranteeing their dependability, security, and avoidance of any potential compromises to driver attention or control. IDAS can drastically lower the number of collisions and fatalities on the road with continued development and broad use. Features like automated emergency braking, driver drowsiness detection, adaptive cruise control, and lane departure warning are examples of IDAS features. IDAS is anticipated to be essential to the future of car convenience and safety as technology develops. IDAS maintains the parameter representation, and constant updating while the interpretation of a critical scenario is done. Relevant safety technologies have been implemented, including adaptive cruise control, collision avoidance, lane departure warning, and driver drowsiness detection. These systems continuously generate warnings and alerts to the driver.

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