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Automatic Lane Assistance with Real Time Emergency Alert Response

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Abstract: This paper discusses an Automatic Smart Lane Assist System with Ultrasonic Safety and Emergency Response. It aims to improve road safety and driving efficiency by combining artificial intelligence, ultrasonic sensors, and automated alerts. Key functions include real-time lane curvature detection, obstacle detection, and emergency lighting to prevent collisions and secondary accidents. The system ensures safe navigation and timely warnings, contributing to safer roads and intelligent transportation.

Keywords: Emergency Response System, Lane Curvature Detection, Accident Prevention, Ultrasonic Sensors.

1. INTRODUCTION

Road accidents due to lane drifting and inadequate obstacle detection are increasingly common, often leading to fatalities. The car industry has been changing and improving over time to implement Smart features in cars that help the driver stay safe and make driving easier.to minimize such risks. Our proposed system addresses the limitations of conventional systems by incorporating real-time sensor fusion and computer vision, making it robust under varying conditions like poor lighting or faint road markings.

The Automatic Lane Assistance with Real-Time Emergency Alert Response project utilizes a cost-effective hardware prototype that mimics the functionalities of modern autonomous navigation systems. With the integration of LED alerts and ultrasonic-based obstacle avoidance, it lays a foundation for scalable implementation in real-world vehicles.

II. SYSTEM DESIGN AND ARCHITECTURE

The system includes both physical components and software modules to facilitate autonomous lane detection, real-time obstacle monitoring, and emergency response alerts. The core architecture consists of a vision subsystem, proximity sensing unit, control logic hardware, and visual alert interfaces.

At the hardware level, a Logitech webcam captures live road footage which is worked on by a computer to understand or improve the image. to identify lane boundaries and deviations. Simultaneously, two ultrasonic sensors positioned at the front of the prototype monitor distances to detect obstacles. The Arduino Nano microcontroller acts as the control unit, interfacing with the sensors, display units, and LEDs. The system includes a 7805-voltage regulator to ensure consistent power delivery across components.

On the software side, Python scripts powered by the OpenCV library are responsible for visual data processing, including grayscale conversion, edge detection, and Hough Line Transformation. A PyQt5-based graphical interface provides real-time status updates. Sensor data from the ultrasonic modules is evaluated in parallel, and the combined results are used to make decisions such as triggering LED alerts or displaying warnings on an LCD.

III METHODOLOGY

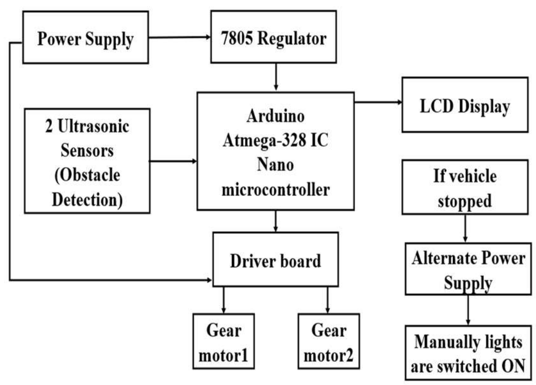

Fig 1: Hardware Block diagram of Alert system

The Figure 1 illustrates an obstacle detection and response system designed for autonomous or robotic vehicles, utilizing an Arduino-based microcontroller (Atmega-328 IC on an Arduino Nano board). The system initiates with a power supply, which is stabilized through a 7805-voltage regulator to deliver a consistent 5V power to all electronic components. Two Ultrasonic sensors are added to the system for real-time obstacle detection. These sensors continuously monitor the environment and send distance data to the Arduino microcontroller. Upon detecting an obstacle within a critical range, the Arduino processes this data and sends control signals to a driver board, which then operates two gear motors (motor1 and motor2), enabling the vehicle to either stop or navigate around the obstacle.

An LCD display is connected to the Arduino to provide real-time feedback or status updates, such as distance readings or alerts. Furthermore, the system includes a safety feature for vehicle stoppage: if the vehicle halts due to an obstruction, an alternate power supply is activated, ensuring that essential functions remain operational. During this condition, lights are manually switched on to enhance visibility and alert nearby entities. This intelligent integration of sensors, motor control, and safety mechanisms makes the system highly suitable for autonomous vehicle navigation, especially in environments requiring rapid obstacle detection and response. The use of dual ultrasonic sensors increases the accuracy and coverage of the obstacle detection range. The modular design also Makes it simple to update or sensor additions for improved performance. Since the Arduino Nano is compact and power-efficient, it is ideal for embedded robotic applications. The system's logic can be programmed and fine-tuned to suit specific operating conditions, such as speed limits or obstacle sensitivity. Overall, this project serves as a foundational model for more advanced intelligent transportation or mobile robotics systems.

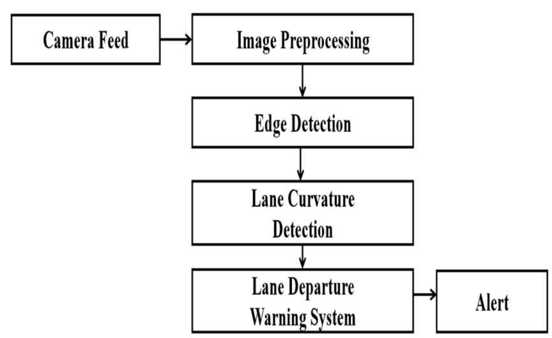

Fig 2: software flow diagram of Lane assist

The Figure 2 illustrates the architecture of a A system in cars that alerts the driver if the vehicle starts to drift out of its lane without using a turn signal, an essential component of a part of today's smart car safety and driving help systems aimed at enhancing vehicular safety by preventing unintentional lane drifting. The system workflow begins with a camera feed, typically from a front-mounted camera on the vehicle that

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captures live video frames of the road. These pictures are sent into the system that works with the image. preprocessing stage, where the raw images are enhanced using techniques such as grayscale conversion, histogram equalization, and noise reduction. This step ensures that the image quality is suitable for further analysis by removing irrelevant visual noise and highlighting lane features.

The next stage is edge detection, where algorithms such as the We use a technique called Canny Edge Detector to detect the outlines that extract significant features, particularly the lane markings. These edge maps help to differentiate the lane boundaries from the road surface. After edge detection, the system moves to lane curvature detection, where it analyses the shape, position, and bending of the lane lines. This is crucial for understanding road geometry, especially on curved roads or highways, and is often implemented using polynomial fitting or Hough Transform techniques. The Lane Departure Warning System module takes the output of the curvature detection and continuously monitors the vehicle's position relative to the detected lanes.

IV IMPLEMENTATION

This flowchart illustrates a smart A self-driving system made for rovers or vehicles, integrating both lane departure warning and obstacle detection mechanisms. The system begins with the activation of a centralized power supply, which energizes all modules including sensors, controllers, and actuators. Ensuring a stable power supply is critical for the proper functioning of embedded systems, as voltage fluctuations could cause malfunction or false triggering of sensors. This step initiates the groundwork for a reliable autonomous process.

After the power supply is activated, the system checks whether the controller is initialized. This includes verifying that the microcontroller or embedded processor has loaded the required firmware and is communicating with connected modules. If the initialization fails, the system immediately proceeds to shutdown mode to avoid erratic behavior. In such a case, the system enables manual light triggering, likely as a safety or warning indicator. unintended behaviour. Additionally, users are given the option to manually activate light indicators, serving as a visual alert mechanism in case of system errors or environmental hazards.

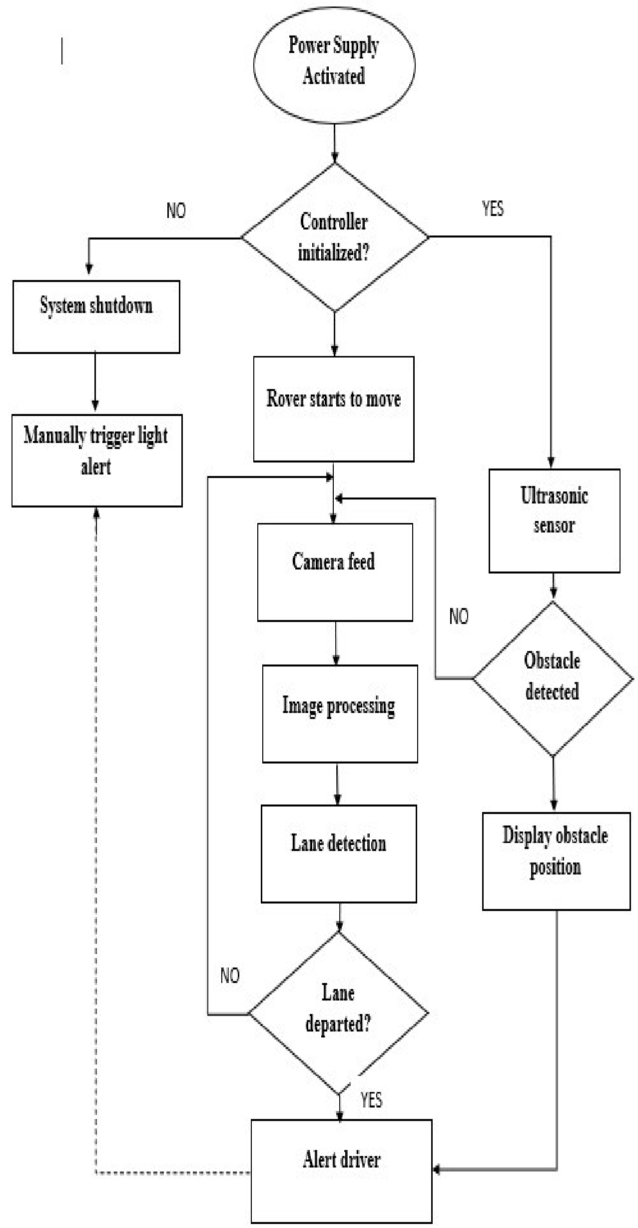

Fig 3: Flow chart of Rover system flowchart

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If the controller is successfully initialized, the rover begins to move. Movement begins only under validated and safe startup conditions to prevent collisions or unplanned actions. As soon as the rover starts moving, its navigation systems, including cameras and sensors, are activated to begin environmental monitoring. The system engages the camera feed to continuously capture real-time visual data from the environment. These images are then processed by a system that performs tasks like filtering, detecting edges, and improving contrast. This step is important to clearly identify road features such as lane markings and boundaries

Once the image is processed, the lane detection algorithm is applied. This module analyzes the image to locate lane lines using methods such as Hough Transform or deep learning-based segmentation. The goal is to keep the rover centered within the lane. If the rover remains within bounds, it continues to move forward. However, if a lane departure is detected, the system proceeds to alert the driver or onboard controller.

When a lane departure is confirmed, the system generates an alert to the driver or operator. This alert could come in various forms—auditory signals (beeps), visual notifications on a screen, or haptic feedback like a vibrating steering control. Such alerts help the operator quickly respond to unintended deviations, minimizing the risk of accidents.

In parallel to lane tracking, an ultrasonic sensor continuously checks for obstacles in the rover's path. If no obstacle is detected, the system allows normal movement. But if the sensor detects an object or obstruction, the data is relayed to the controller, and the position of the obstacle is displayed, likely through an LCD or control interface. This feature helps in real-time decision-making, whether manual or autonomous.

V RESULTS

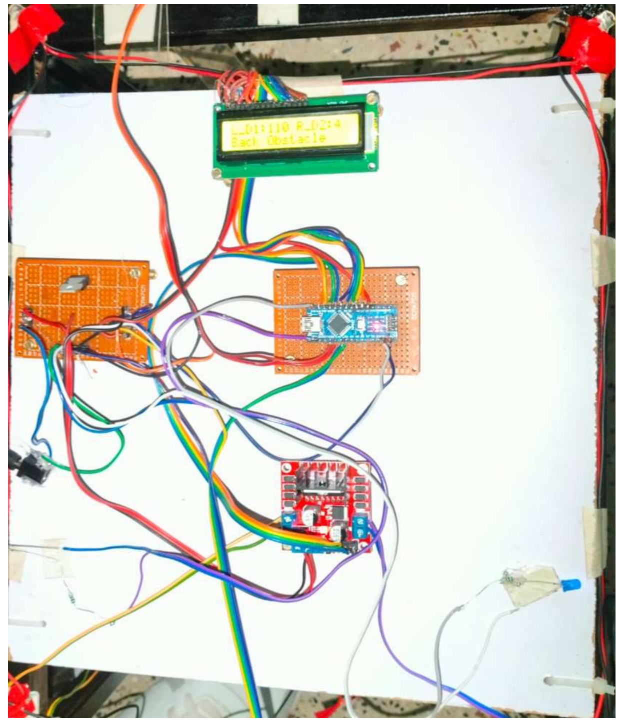

Fig 4 : Ultrasonic Sensor Obstacle Detection Module

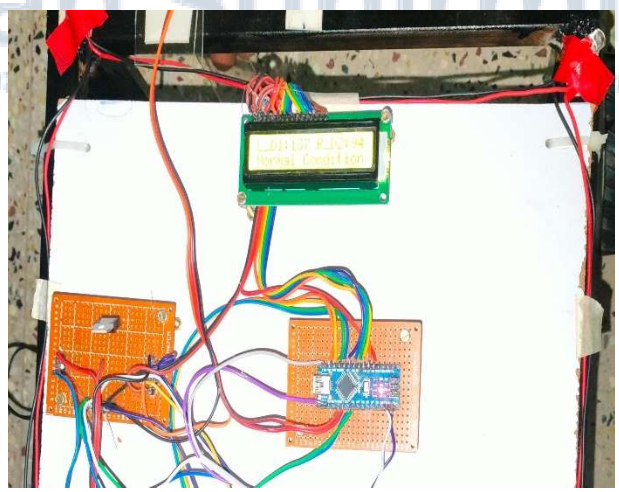

Fig 5: Normal Condition

The prototype vehicle model as shown in figure 4 and figure 5 is the built in of ultrasonic sensors for effective obstacle detection in both forward and reverse directions. The front and rear-mounted ultrasonic sensors continuously scan their respective zones, providing distance measurements to the Arduino Nano microcontroller, which processes the

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input data and determines whether an object is within a critical range.

Depending on the detected position, the system relays this information to an LCD display, providing real-time feedback such as "Front Obstacle" or "Back Obstacle" with precise distance readings, as shown in the captured detection test conditions.

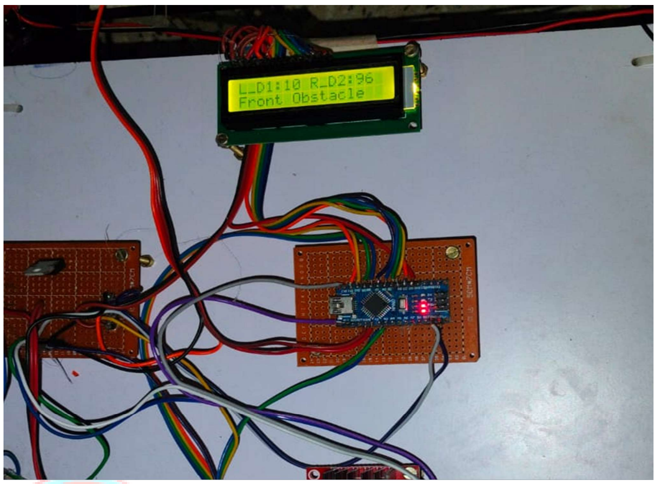

Fig 6 : Detection of front Obstacle

Fig 7 : Detection of Back Obstacle

The Figure 6 and Figure 7 demonstrates the functioning of the obstacle detection system, showcasing both front and back obstacle identification ability of the prototype vehicle. When an object is detected in front of the vehicle, the ultrasonic sensor sends distance data to the Arduino Nano microcontroller, which displays “Front Obstacle” along with the calculated distance on the LCD screen. Similarly, if an object is present behind the vehicle, the rear ultrasonic sensor triggers a “Back Obstacle” alert on the same display. The clearly organized wiring and integration of microcontroller and sensor modules further validate the effectiveness and reliability of the system during testing.

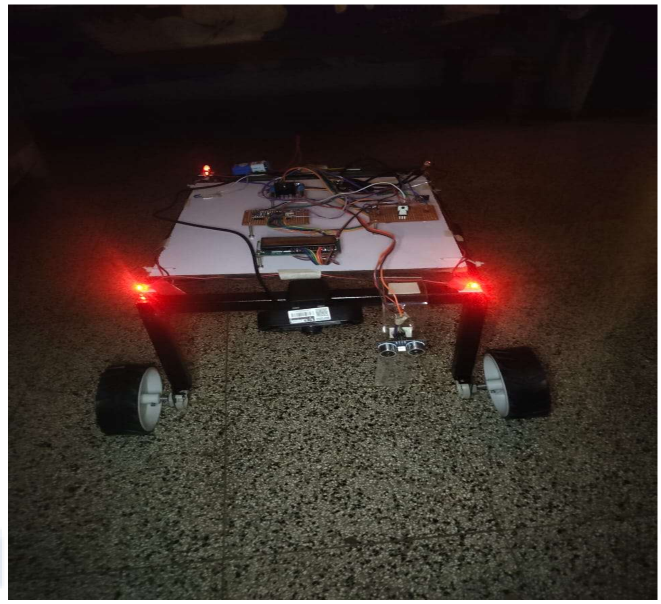

Fig 8: Emergency Alert System

The Figure 8 illustrates the Emergency Alert System feature of the prototype, designed to enhance vehicle safety during unexpected stops. As shown in the accompanying flowchart, when the vehicle halts—either due to an obstacle or system-triggered command—the microcontroller detects the stoppage condition and immediately switches to an alternate power supply. This ensures that the essential alert mechanisms remain functional even if the main power system is compromised. In this emergency mode, LED indicator lights are manually or automatically switched ON, as visibly demonstrated in the image, where red LEDs at the corners of the vehicle are illuminated. These lights act as visual hazard warnings, notifying nearby entities or drivers of the vehicle's presence, especially in low-light or high-traffic scenarios. This is crucial during night time or critical situations where visibility and signaling are essential for safety. In this prototype,

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bright red LED lights are placed at the rear corners of the model to act as hazard indicators, warning nearby vehicles or individuals of a stopped or disabled vehicle. The emergency lights are manually triggered by the driver using a switch integrated into the system. The integration of This feature doesn't just contribute to accident prevention but also reflects a real-world emergency response strategy, mimicking hazard lights in commercial vehicles. Overall, the emergency alert system adds a practical and safety-focused dimension to the prototype's autonomous capabilities.

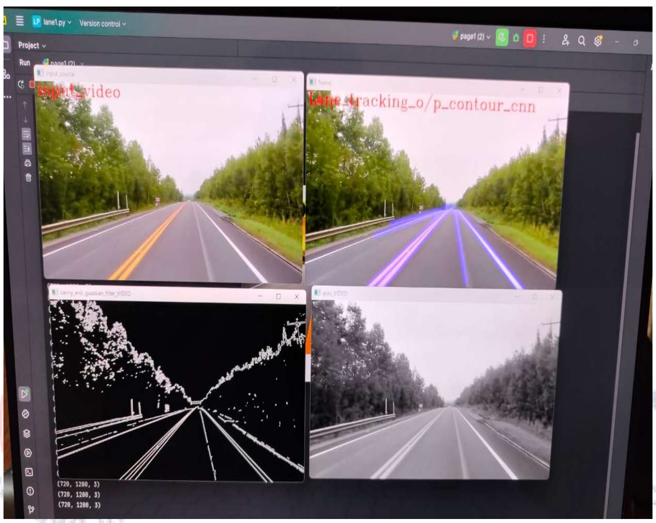

Fig 9: Lane Adjustment Module

The figure 9 demonstrates the implementation of a lane detection that uses computer vision to detect lanes on the road. The system processes a real-time video feed of a roadway, as seen in the top-left frame which shows the raw input video.

The top-right frame displays the output of the lane tracking module, where lane markings are highlighted using contour detection and tracking algorithms. This provides a visual reference for the vehicle's current alignment on the road.

The bottom-right frame presents a grayscale version of the input video, which simplifies the visual data and enhances contrast, making it easier for the system to process important features like lane lines.

The bottom-left frame shows the result of edge detection, most likely performed using the Canny algorithm, which is essential for detecting the boundaries of the road lanes.

This multi-stage lane detection process includes preprocessing steps such as grayscale conversion and noise reduction, followed by edge detection, lane curvature recognition, and finally overlaying the detected lanes onto the original video. Deep learning models, possibly involving Convolutional Neural Networks (CNNs), are integrated to improve detection accuracy and adaptability to varying lighting and weather conditions. Overall, this lane detection system serves as a critical component of a smart lane assist project aimed at enhancing road safety through real-time lane tracking and departure alerts.

VI CONCLUSION

In the proposed accident prevention system integrates cutting-edge technologies such as AI, ultrasonic sensors, and automated alert mechanisms to create a comprehensive solution for enhancing road safety. By providing real-time assistance in lane keeping, distance calculation, and emergency alerts, the system significantly reduces the risk of accidents and improves driver awareness. The seamless combination of hardware and software ensures that the system operates effectively, even in dynamic driving conditions. Ultimately, this advanced system offers a promising approach to minimizing 4oad accidents, saving lives, and contributing to a safer driving experience for all.

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