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Lane Departure System using YOLOv5 & Raspberry Pi

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ABSTRACT:

This study proposes a comprehensive lane departure prevention system that uses real-time lane detection, vehicle distance measurement, and immediate driver alerts to improve highway safety, advance autonomous car technology, and prevent accidents. The system leverages the characteristics of the YOLOv5 object identification model to provide precise and effective lane border recognition from real-time image capture using a Raspberry Pi camera [1]. The system can determine the risk of leaving the lane by evaluating proximity thanks to the integration of an ultrasonic sensor that calculates the distance to vehicles ahead. This technology aims to address critical road safety issues by providing an achievable solution that works well in a variety of weather conditions while reducing human error and improving overall driving safety. The system's architecture, operational specifics, and performance assessments are all discussed, with a focus on how it could substantially decrease lane departure accidents.

Keywords: Object detection, Highway Safety, YOLOv5, Real-time lane detection, Autonomous Technology.

INTRODUCTION

Lane departure warning systems have become increasingly crucial for modern automobiles, signifying an important advancement in automotive safety technology [2]. Traffic accidents are a massive global concern, with driver negligence being the major contributing factor, particularly considering the number of vehicles on the road increases [2]. Lane departure collisions often lead to serious injuries or fatalities, which constitute an enormous fraction of all accident data. The development and application of effective lane departure systems, which provide drivers with timely warnings and, in certain circumstances, corrective actions to prevent inadvertent lane departures, is a proactive approach to lessen these risks. These technologies have been critical to enhancing road safety, particularly on high-speed roadways and highways where lane changes can lead to catastrophic crashes. Traditional lane detecting algorithms have restrictions in terms of with various road configurations, changing lighting circumstances, and obscured pathway markings [2].

In order to overcome these limits, the system that was suggested employs cutting-edge deep learning methods particularly YOLOv5 to provide accurate and precisely lane detection in real time. The approach, which combines real-time image gathered smart object detection, and distance measurement, improves situational awareness and allows for proactive intervention to reduce lane departure incidents. Furthermore, the system's low- cost design incorporates readily available components and open-source software, allowing for the broad acceptance and accordance with existing vehicle technologies.

The research intends to improve highway safety by reducing the amount of lane departure occurrences and promoting the growth and development of technology for autonomous vehicle technology by providing a reliable and precise lane detection system. This device aims to decrease accidents by informing drivers to potential lane departure in advance. One major consideration is cost- effectiveness; the system is designed to be both scalable Weather related functionality the system was developed to work professionally in rain, fog, and various lighting conditions, ensuring reliable lane detecting performance in harmful situation. By providing an additional level of security, the system ultimately seeks to reduce human error by reducing the potential of collisions brought on by driver inattention, exhaustion, or distraction.

LITERATURE SURVEY:

Traditionally, early lane departure warning systems have been developed using lane detection techniques such as Canny edge detection and the Hough Transform [2]. One feature extraction method that can be used to detect lane markings in photographs is the Hough Transform, which finds straight lines in pictures [2]. In order to determine whether or not a line is present in an image, it maps the pixels of the picture to a parameter space where lines can be represented as points. Another traditional method to identify edges in an image that match lane borders known as "canny edge detection." It involves a number of phases, such as noise reduction, gradient computation, non- maximum suppression, and hysteresis thresholding. However, complex road conditions like shadows, fading or obscured lane markings, and changing lighting can make these approaches unreliable and uncertain for lane recognition. In order to determine the position and trajectory of the vehicle, the geometry of the road, and the intents of the driver, these algorithms analyze data from cameras and sensors [3].

Lane recognition accuracy, efficiency, and real- time processing capabilities have been shown to be substantially improved with deep learning-based methods, especially those that use convolutional neural networks like YOLOv5. The object recognition model YOLOv5, which is renowned for its accuracy and speed, is ideal for real-time lane marking detection since it can predict many objects and their bounding boxes in an image at once. In contrast to conventional techniques that depend on manually created features, deep learning models automatically extract pertinent features from big datasets, improving their ability to generalize to various road conditions and surroundings.

These networks show exceptional resilience to shifting environmental conditions after being trained on huge data sets to identify patterns and features suggestive of lane markings. Current investigation has demonstrated YOLOv5's efficacy in lane detection, demonstrating its capacity to attain high accuracy and immediate performance on embedded platforms such as the Raspberry Pi [4]. Sobel and Canny edge features are frequently employed for feature extraction as lane division lane features; regardless, noise interference can affect edge features [5].

Deep learning algorithms have grown in prominence because to the limitations of traditional lane detection techniques in tough settings such as changing lighting and unclear lane lines. YOLOv5, which incorporates depth- wise separable convolution, provides a balance between accuracy and real-time performance. This allows the system to process images more efficiently, and a novel feature fusion network combines original feature information from many depth network layers to improve vehicle recognition while reducing processing needs. The YOLOv5 design enables the model to be implemented on devices with limited resources, such as the Raspberry Pi, making it suitable for real-time lane departure warning systems for vehicles [6]. Through the utilization of deep learning, the suggested system may surmount the drawbacks of conventional methods and offer a more robust and reliable lane detection solution.

ARCHITECTURE AND BLOCK DIAGRAM

The following three primary parts make up the lane departure system's architecture: a processing unit, detection components, and motor control. These modules are carefully combined to guarantee smooth operation. The Raspberry Pi 4, the system's central processing unit, was chosen for its strong processing power and flexible interface options. It operates lane departure algorithms and interacts with sensors and actuators to coordinate the entire lane detection and correction procedure [7].

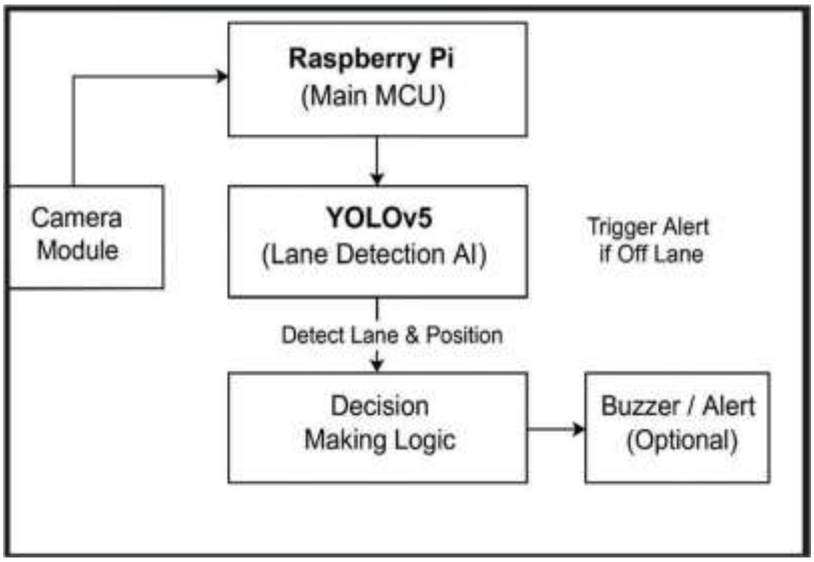

Fig -1: Block Diagram of Lane Departure System

This decision offers an acceptable balance between energy efficiency and performance, which is ideal for real-time data analysis and responsive control in automotive applications. Together, a Raspberry Pi camera module and the YOLOv5 object identification model make up the detection components, which record and analyze the environment around the car. The YOLOv5 is in charge of lane detection; it analyzes the video stream in real time to find lane markers and uses its pre-trained weights to precisely locate and monitor lanes. High-quality image capture is ensured for precise lane detection in a variety of lighting and weather circumstances by the Raspberry Pi camera module, which records real-time video data and provides the visual input required for lane detection and analysis. By combining these elements, a thorough perception of the surroundings is made possible, which helps the system recognize lane borders accurately and react appropriately. With the help of a BJT BC547 transistor, the motor control module controls lane correction and motor speed, converting processed data into physical movements that keep the car in its lane. By acting as a switch to regulate the motor's current flow and allow for exact steering angle adjustments, the BJT BC547 provides an affordable motor control solution that guarantees accurate and dependable lane correction. By ensuring accurate and quick changes, the motor control module strengthens the lane departure system's overall stability and security.

DESIGN AND IMPLEMENTATION

To produce a robust and dependable system, the lane departure system's layout and the execution must take into account circuit design, component details, and power and protection systems. The power supply requirements are carefully calculated to guarantee that all components receive steady and constant power, and the electronic connections are designed to minimise interference and ensure signal integrity. The Raspberry Pi 4 serves as the processing unit, responsible for image processing and sensor interfacing. Its GPIO ports enable communication with its camera module, ultrasonic sensor, and motor driver. The system involves an LCD16x2 status display that allows you to easily monitor the system's working state while receiving real- time feedback on lane detection accuracy and system performance. LEDs (with 470Ω resistors) provide visual alerts. They provide motorists with immediate advice in the event of lane departure, ensuring rapid and visible signs to avoid potential collisions. A buzzer is used for aural warnings, providing an audio indicator that successfully attracts the driver's attention in addition to the obvious alerts.

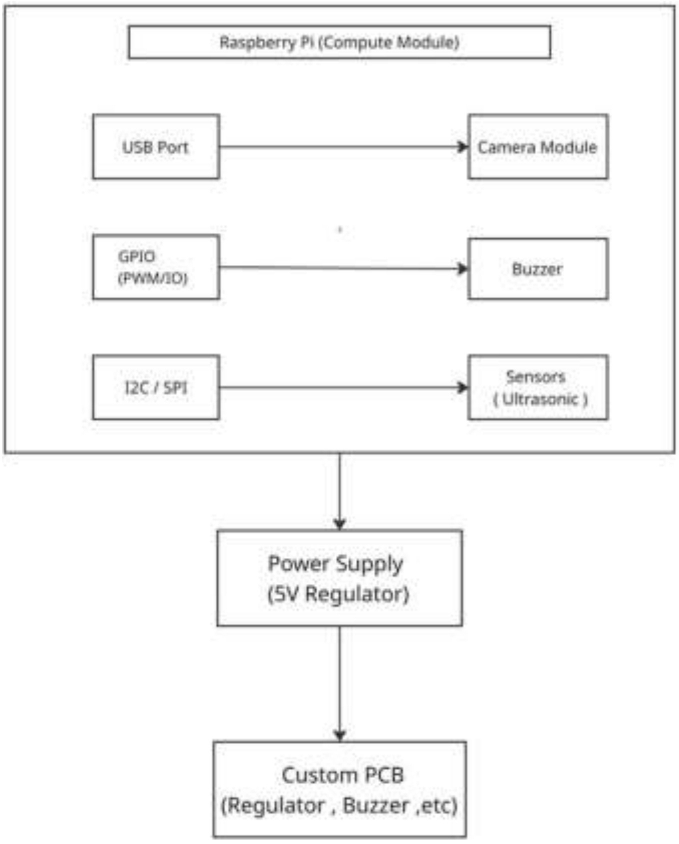

Fig -2: Detailed Diagram of the Lane Departure System with Interconnections

Accurate and responsive lane keeping can be made possible by the L293D motor driver,that is employed for lane correction and offers bidirectional control of the motor for accurate steering changes. A steady voltage supply is guaranteed by an LM7805CT regulator, shielding the system from voltage swings and guaranteeing reliable operation. The lane departure system provides reliable and effective assistance with lane maintaining by combining these elements with meticulous circuit design and strong protection measures. In an uncertain context, a networked proactive adaptation may result in a system failure [8]. When the system recognizes that a car is leaving its lane, it gives the driver a hearing and visual warning and applies a small counter-steering torque in an attempt to stop the car from leaving the lane [3]. Systems like these can reduce the amount of traffic accidents that occur annually [9]. Modern vehicles now feature assistance systems that execute tasks autonomously, including lane keeping, adaptive cruise control, and automated braking [10]. Lane departure warning systems alert the driver when the vehicle begins to move out of its lane unintentionally [2] [11]. Advanced driver assistance systems have been developed to support human drivers [12]. These systems are designed to observe the surrounding environment and internal states, helping vehicles to improve situational and self-awareness [13].

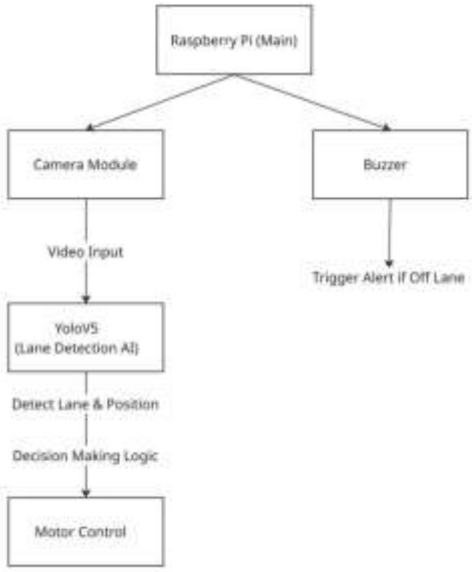

Fig -3: Flow Diagram of the Lane Departure System

A comprehensive layout of the lane departure warning system's components is shown in the top view, which also makes it easy to see how the Raspberry Pi, camera module, ultrasonic sensors, motor driver circuit, and power supply connections are arranged systematically. This view highlights the hardware's compact design and methodical organization, which guarantee effective communication between parts and optimal efficiency in real-time operation.

Fig -4: Top View of Hardware Setup

The side view provides information on how the system components are installed and stacked vertically. It emphasizes the Raspberry Pi camera's positioning and elevation for optimal field of vision and image capturing.

Fig -5: Side View of Hardware Setup

It also shows the mechanical alignment of motors and steering control units, which provides stability and accurate lane correction, as well as the intentional arrangement of ultrasonic sensors for precise distance measurement.

METHODOLOGY

The suggested lane departure system uses the following workflow:

Fig -6: Detailed Flow Chart of Lane Departure System

1. Image Capture: The Raspberry Pi's camera module records real-time visual data surroundings. of the vehicle's

2. Lane Detection: The YOLOv5 deep learning model examines camera feeds to detect and track vehicle lane markers, resulting in precise lane position information.

3. Processing and Decision-Making: The Raspberry Pi 4 processes lane detection data, analyzes remedial actions, and provides control signals to the motor driver.

4. Speed Control: The BJT BC547 transistor and L293D motor driver work together to adjust the motor speed and steer the vehicle back into the detected lane.

5. Distance Monitoring: Ultrasonic sensors measure the distance to surrounding vehicles, providing additional data to enhance the system's awareness of the driving environment.

6. Driver Alerts: Visual alerts through LEDs and audible warnings from the buzzer notify the driver of any unintended lane departures, prompting them to take corrective action individual limitations.

By enabling the system to accurately identify lane markers, track the position of the vehicle within the lane, and quickly provide alerts and corrective actions to stop lane departure incidents, this technique improves overall roadway security and driver assistance.

EXPERIMENTAL RESULTS

The lane departure system undergoes extensive testing in a range of driving scenarios to evaluate its accuracy, reliability, and real-time performance. The system's durability and adaptability were evaluated by simulating various weather situations, such as bright, wet, and foggy ones. Even under difficult weather circumstances, the YOLOv5 model demonstrated remarkable precision in recognizing lane arkers, and the findings consistently demonstrated excellent accuracy in lane recognition. The distance measuring system based on ultrasonic sensors demonstrated dependable performance in recognizing adjacent cars, offering useful information for adaptive cruise control and collision avoidance features.

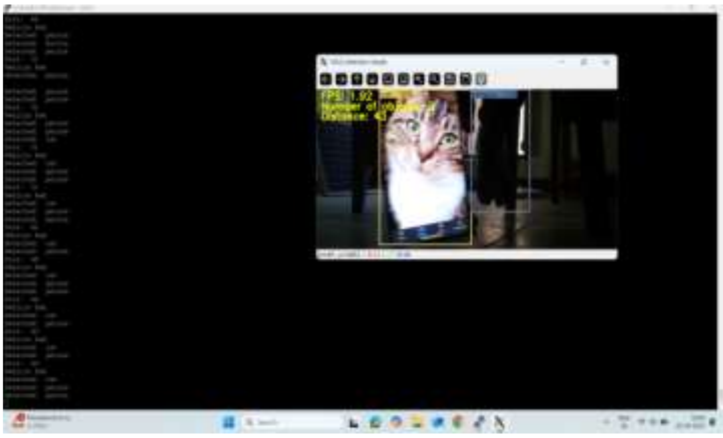

Fig -6.1: Result Image

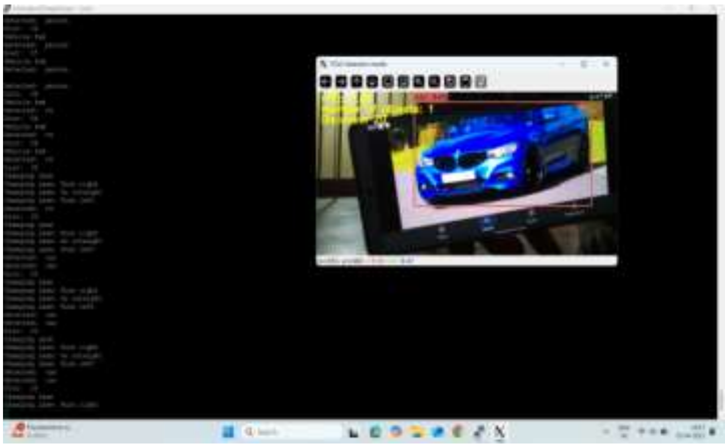

Fig -6.2: Result Image

Evaluation of the motor control system's response time showed that it could perform lane correction operations with speed and efficiency while guaranteeing that there was little departure from the designated lane. To enhance autonomous maneuverability, it may also integrate a number of algorithms, including course planning, obstacle avoidance, and multi-vehicle collaboration. The driver received timely information thanks to the integration of visual and audio alarms, which allowed them to take immediate corrective action. The cost- effectiveness of the system was also evaluated, taken into consideration the components' affordability and the possible reduction in accident- related expenses.

CONCLUSION

In conclusion that the lane departure system developed in this study demonstrates favorable outcomes in terms of increasing highway safety and promoting the development of self-driving vehicles. Unintentional lane departures and accident risk have been substantially reduced by combining YOLOv5 for precise lane detection, a Raspberry Pi camera for real-time image recording, and ultrasonic sensors for vehicle distance measurement.

The system's affordability, visible and audible alerts, and dependability in a variety of climate conditions make it a useful addition to modern automotive safety systems. This lane departure system has the potential to significantly improve road safety and progress technological advances in autonomous

driving by reducing human error by providing timely corrections. Advanced algorithms for course planning, obstacle avoidance, and multi-vehicle interaction may be added to the system in the future to improve its total autonomy. The system's performance and robustness may be further improved by looking into the application of machine learning techniques for more accurate and adaptable lane identification. Overall, the findings of this study show how feasible real-time lane departure devices might improve highway safety and contribute to the evolution of autonomous driving technology. The currently accepted framework makes it possible to test lane departure correction devices, compare designs, and measure their societal benefits [14].

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