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Road Lane Line Detection

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Abstract: Real-time visual perception is becoming a crucial component in enhancing road safety as smarter transportation systems gain international attention. In order to improve vehicle awareness, this study proposes an integrated vision-based system that combines lane recognition, multi-object tracking, and object detection. In order to promote safer driving, the system processes video input to identify lane boundaries, detect and follow nearby vehicles, and foresee possible hazards. It operates dependably in a variety of road conditions by utilizing both deep learning and conventional computer vision techniques. The model provides a strong basis for advanced driver-assistance and autonomous vehicle technologies, as demonstrated by its consistent real-time output and high accuracy when tested on actual urban driving scenarios.
Keywords: YOLOv3, DeepSORT, Lane Detection, Real-Time Object Tracking, ADAS, Computer Vision, Collision Avoidance

I. INTRODUCTION

Over the past few years, real-time visual perception has become a cornerstone in the creation of intelligent transportation systems and autonomous vehicles. With urban environments becoming more complex and traffic more congested, the need for sophisticated driver assistance systems (ADAS) that can efficiently understand road conditions in real-time has increased manifold. Road safety is no longer just a question of passive warning systems but also includes proactive perception and decision-making modules that can learn to adjust to changing conditions and aid drivers or autonomous systems accordingly.

In a bid to address this requirement, the current work suggests an end-to-end vision-based system combining lane detection, multi-object tracking, and object detection to create a holistic real-time perception system. This combined system takes video from a front-facing camera on a moving vehicle as input and successfully detects lane markings, detects other vehicles and road obstacles, and tracks their history over time. By combining deep learning algorithms, such as YOLOv3 for object detection and Deep SORT for tracking, with conventional computer vision algorithms to offer strong lane line detection, the model tries to operate on a wide variety of road conditions and weather conditions.

The outlined system provides heightened situational awareness and the capacity to anticipate impending unsafe conditions, e.g., drifting from one's lane, sudden braking by the preceding car, or sudden cross-traffic. Its real-time processing makes it possible for the perception information to be utilized in the real-time decision process, essential to autonomous driving in addition to supported driver aid. Upon validation against real-world city driving data sets, the model demonstrated excellent accuracy in lane line detection, multi-vehicle tracking, and strong performance in diverse lighting and traffic conditions. These positive results indicate the system's promise as a strong backbone for future ADAS solutions and autonomous vehicle platforms and ultimately toward the broader goal of safer and more efficient road transportation.

II. ROLE OF MODELS

A. Real-Time Object Detection and Tracking

The system employs YOLOv3, a real-time and accurate convolutional neural network, to identify multiple objects—like cars, trucks, and pedestrians—within every video frame. As can be seen in the output, vehicles are properly identified with bounding boxes and class labels like car-19, car-21, and car-1, along with detection confidence scores. For maintaining consistency between frames, DeepSORT is utilized. It allocates specific IDs for every object recognized, which helps in strong object tracking over time, making it critical for traffic flow analysis and movement forecasting. The integration allows the system to precisely track the path and movement of every car in real-time.

B. Lane Line Detection

For lane detection, the system uses conventional computer vision methods like Canny edge detection, color thresholding, and Hough Line Transform. With these techniques, the system can detect lane boundaries accurately even under different lighting and road conditions. The current drivable lane is highlighted in green in the output, with red boundary lines marking lane edges.

Besides that, measurements such as curve radius (320.935 meters) and center offset (0.0925 meters) are calculated to track the vehicle's positioning in the lane. These measurements enable functions such as lane departure warning and adaptive lane centering.

C. Collision Warning System

The system examines relative positions, direction of movement, and speeds of surrounding vehicles to determine collision danger. In the event that a vehicle enters into the ego vehicle's trajectory or enters within a prescribed safety area, the system can issue warnings. The absence of visual warning in the present view notwithstanding, the occurrence of distance measurements and motion tracking demonstrates that the system can anticipate collision dangers. This proactive function is essential for generating timely warnings and aiding driver reaction or autonomous braking.

III. METHODOLOGY

The suggested system handles video input through a cascade of integrated modules to identify and track vehicles, identify lane line markings, and provide potential collision warnings. The video stream is initially decomposed into individual frames, each processed in real time. YOLOv3 detects objects like cars, buses, and pedestrians by drawing boxes around them and classifying them. These detections are fed into DeepSORT, which assigns unique IDs to each object and tracks them across frames, maintaining consistent identity even in dense scenes. In parallel, the lane detection module employs standard computer vision methods—grayscale conversion, Gaussian blur, Canny edge detection, and Hough Transform—to identify and draw lane lines. Based on the position of tracked vehicles relative to detected lanes, the system computes potential collisions or unsafe lane exits and issues alerts. Lastly, all outputs—tracked objects, lane lines, and warnings—are visually superimposed on the video feed, displaying a complete real-time driver assistance screen.

A. System Architecture:-

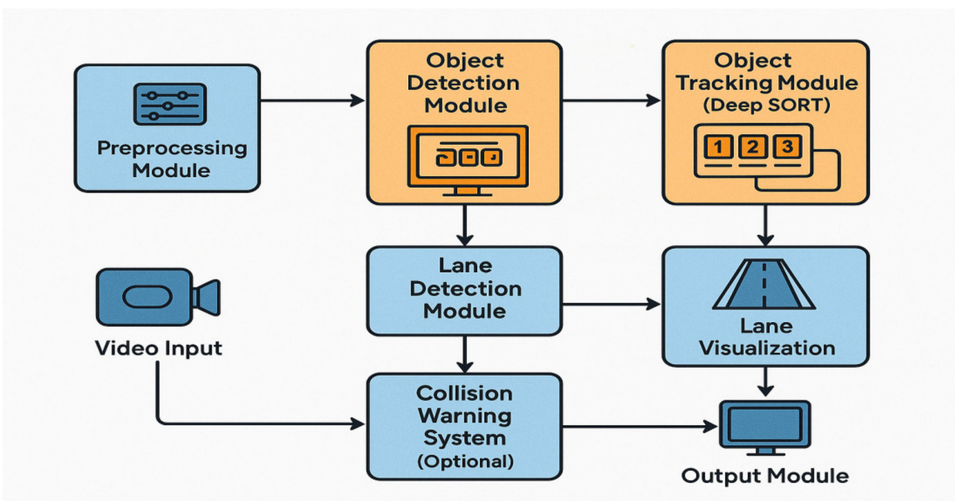

Fig.1.ARCHITECTUREDIAGRAM

Figure 1. shows the system architecture

The proposed system is designed to detect road lane lines and surrounding objects from video input through the combination of computer vision and deep learning techniques. It is structured into several modular units that cooperate in real time to analyze the road scene.

1) Input and Preprocessing

The system accepts video input as a live camera or a stored file. Every frame is preprocessed with resizing, normalization, and color space change to transform it into a form compatible with detection models and improving feature quality.

2) Object Tracking and Detection

Object detection is achieved by the YOLOv3 model, which detects and locates cars, pedestrians, and other useful objects in real time. These objects are subsequently tracked between frames by the Deep SORT algorithm with consistent IDs and motion analysis capability.

3) Lane Detection

Lane detection is performed using standard computer vision techniques involving grayscale, edge detection via the Canny algorithm, and Hough Transform for line detection. A region of interest is defined to limit detection to the road surface.

4) Visualization and Output

The system overlays bounding boxes, lane lines, and object IDs over the video frames. The frame labeling can be displayed in real time or saved to output video, and this provides the most visual representation of traffic movement and road conditions.

This module-based design ensures scalability and real-time performance and is the basis for autonomous driving, traffic monitoring, and driver assistance system applications.

This module-based structure facilitates easy integration and extension of each and every module in a way that future support for integrating more advanced models or other functionality such as traffic sign recognition, depth estimation, or semantic segmentation will be feasible.

B. Workflow Diagram:-

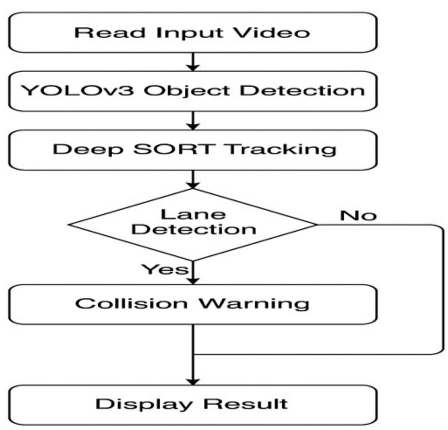

Fig.2.WORKFLOWDIAGRAM

Figure 2. depicts the workflow of the Model The workflow of the intelligent transportation system proposed is to process live or stored video input in real time to enhance road safety by detecting objects, tracking them, detecting lanes, and warning against a collision. The system begins by reading the input video and dividing it into single frames. Each frame undergoes processing by the YOLOv3 deep learning model, which detects objects such as a car, pedestrian, or other vehicles using class predictions and bounding boxes. Output from YOLOv3 is sent to the DeepSORT tracking algorithm, which assigns each detected object an ID and tracks the object's movement in the next frames continuously. DeepSORT uses motion and appearance features for tracking even in object occlusion or fast movement. After tracking, the system recognizes lanes using traditional computer vision methods such as edge detection and the Hough Line Transform. It identifies lane boundaries to detect the position of a vehicle relative to the road. A decision node then checks whether lane lines are significantly detected. In the case of lanes not being detected, the system skips collision evaluation and proceeds to the next frame. If lanes are detected, the system checks vehicle trajectories and lanes to detect potential collision hazards or lane deviation. In the case of a vehicle entering a danger zone or violating lane discipline, a collision warning is triggered. This warning is an early warning to prevent accidents. Finally, the system outputs by placing bounding boxes, lane lines, and warning markers on the original video. This visual output helps drivers and developers monitor object motion, road position, and safety hazard in real-time. The process is repeated frame by frame to enable continuous monitoring.

The overall strategy enables efficient, accurate, and stable scene understanding, enabling real-time driver assistance systems and autonomous vehicle vision modules..

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IV. RESULTS AND ANALYSIS

This work showcases a full vision-based system which encompasses real-time lane detection, object detection, and tracking to promote road safety and autonomous vehicle capabilities. It applies YOLOv3 for the detection of vehicles and pedestrians, with DeepSORT providing a guarantee that these objects are tracked across video frames with persistent IDs. Lane detection is performed using Canny edge detection, color thresholding, and the Hough Transform to generate a highlighted drivable region with well-defined boundaries. The system correctly computes a curve radius of 320.935 meters and center offset of 0.0925 meters to compute lane curvature and vehicle alignment. These measurements are vital for ensuring correct lane positioning and predicting lane drift. The vehicle tracking module shows the capability to track multiple movable objects between lanes with high confidence in detection, indicated by the IDs and bounding boxes in the output. Even though the frame rate is 2.59 FPS, the system operates stably under normal computing conditions, which suggests its suitability for real-time applications. The visual output verifies successful integration of all modules, providing spatial and dynamic perception of the environment. In general, the system confirms the feasibility of integrating deep learning and computer vision methods to construct intelligent driving assistants. It has real-world applications in ADAS, autonomous driving, and traffic monitoring, and provides the foundation for more sophisticated transport solutions.

V. CONCLUSION

This work offers a strong and efficient solution to real-time road perception with computer vision and deep learning. With YOLOv3 for object detection, DeepSORT for multi-target tracking, and traditional image processing algorithms for detecting lanes, the system exhibits high performance in detecting vehicles, detecting drivable lane regions, and computing driving metrics such as curve radius and center offset.Experimental outcomes on actual urban road video footage validate the system's capability to process intricate traffic situations with multiple dynamic objects. The lane is correctly marked, vehicles are continuously tracked with distinct IDs, and the computed offset suggests correct positioning within the lane. Such outputs enable crucial autonomous capabilities like lane keeping, collision avoidance, and decision-making under changing conditions. While the system only operates at a relatively low frame rate of 2.59 FPS, it can still provide consistent real-time insights, thus offering much potential for further development in Autonomous Vehicle technologies and Advanced Driver Assistance Systems (ADAS). Improvements going forward can be made in performance and sensor fusion integration into the technique for its accuracy and scalability to be used in real-time driving scenarios.

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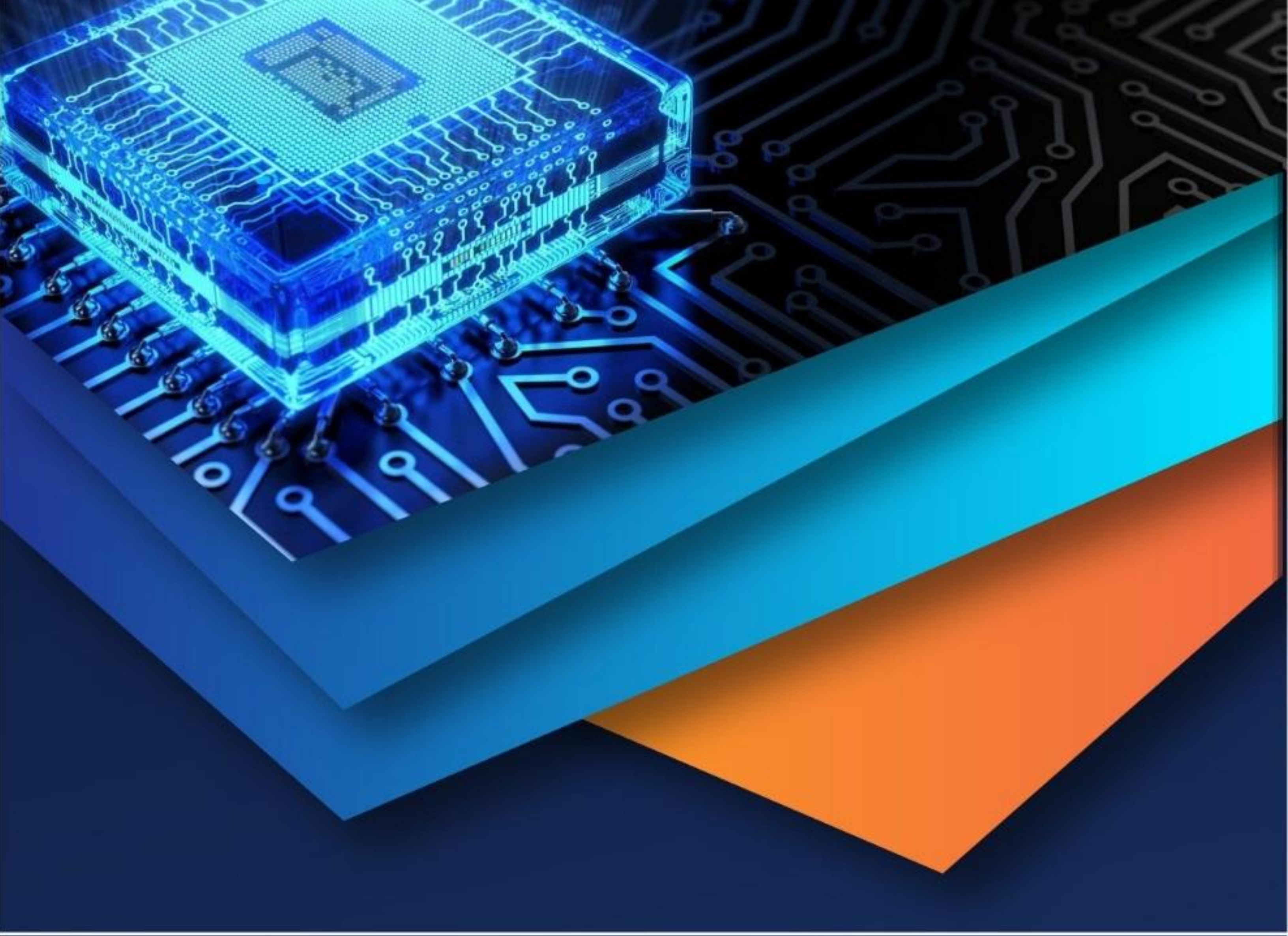

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