ADAS-PeVision

NAME	ROLLNO	SECTION	SIGNATURE
Kartik Solanki	2118685	I	
Aman Yadav	2118198	J	
Anuj Kapri	2118271	F	
Shaurya Pratap Singh	2119171	F	

Under Supervision of Dr. Prof. Vikrant Sharma

1. Project Overview

The ADAS-PeVision project aims to enhance driver safety in urban settings by leveraging machine learning technology to create a real-time pedestrian detection and movement prediction system. This system utilizes the vehicle's camera to track the movements of pedestrians, vehicles, and other objects on the road. By providing real-time future direction updates of surrounding elements, it enhances driver awareness and helps prevent potential collisions.

Unlike traditional Advanced Driver Assistance Systems (ADAS), which rely heavily on LiDAR or radar sensors, ADAS-PeVision is designed to function effectively using a camera-based approach. This makes it a cost-effective alternative while still ensuring high accuracy and reliability. The system's ability to operate in diverse environmental conditions further strengthens its applicability for real-world deployment.

2. Key Features

Pedestrian Detection:

- Utilizes YOLOv8m for real-time, high-accuracy pedestrian detection.
- The model marks pedestrians with bounding boxes, ensuring robust detection in varied environments.
- Enhanced data preprocessing methods improve detection performance by reducing noise and ensuring standardized input sizes.
- Capable of detecting multiple pedestrians simultaneously in complex scenarios.

Tracking and Prediction:

- The predictive model avoids RNNs to better align with the project’s needs for real-time processing.
- Enhanced pedestrian trajectory tracking to improve prediction reliability.
- Upgraded prediction accuracy from 72% to 91% through model refinements and an improved dataset.

- Future trajectory predictions help drivers anticipate pedestrian movements and react proactively.

Speed Detection System:

- Integrated speed detection system estimates the velocity of detected objects, aiding in assessing potential collision risks.
- Allows dynamic alert adjustments based on real-time speed data.
- Enhances situational awareness by providing critical speed-related insights.

Vehicle Classification and Confidence Estimation:

- Detects and classifies different types of vehicles on the road, such as cars, buses, motorcycles, and trucks.
- Provides confidence scores for each detection, ensuring reliability in decision-making.

Free Space Detection System:

- Analyzes the road environment to determine available free space for safe navigation.
- Helps in avoiding obstacles and making better path-planning decisions.

Alert Mechanism:

- Embedded within a mobile application, the system provides audible alerts when a pedestrian's predicted trajectory intersects with the vehicle's path.
- Pygame is used for generating beep sounds to alert drivers effectively.
- Real-time alert system ensures instant feedback for the driver, enhancing situational awareness and preventing accidents.
- Alerts are dynamically adjusted based on speed, distance, and the likelihood of collision.

3. Technology Stack

- **Detection and Prediction:** YOLOv8m for object detection.
- **Speed Detection:** Computer vision-based speed estimation.
- **Vehicle Classification:** YOLO-based classification system with confidence estimation.
- **Free Space Detection:** Deep learning techniques for road segmentation.
- **Alert System:** Pygame for generating beep alerts and a mobile-based application for notifications.
- **Data Collection and Preprocessing:** Utilizes video data from vehicle-mounted cameras, pre-processed to standardize frame sizes and reduce noise for optimal detection accuracy.
- **Computational Optimization:** Lightweight model optimizations ensure efficient processing on low-power hardware.

4. Testing and Evaluation

The system undergoes rigorous testing across varied urban scenarios to assess:

- **Detection Accuracy:** Evaluates the reliability of the YOLOv8m model in detecting pedestrians and vehicles.
- **Prediction Accuracy:** Measures the effectiveness of the predictive model, now achieving 91% accuracy.
- **Speed Detection Performance:** Ensures accurate velocity estimation for dynamic object assessment.
- **Vehicle Classification Reliability:** Verifies correct classification and confidence estimation of vehicles.
- **Free Space Detection Efficiency:** Tests road segmentation capabilities to ensure safe path guidance.
- **Alert Responsiveness:** Verifies the timely activation of alerts, ensuring real-time driver assistance.
- **Environmental Adaptability:** Tests how well the system functions under different lighting and weather conditions.
- **Scalability Testing:** Evaluates performance on different hardware configurations to ensure broad applicability.

5. Expected Outcomes

Accuracy and Reliability:

- High accuracy in pedestrian detection and movement prediction.
- The enhanced predictive model and lane detection system significantly improve performance and real-time application.
- Improved detection rates in various environmental conditions, including rain, fog, and low light.

Cost-Effectiveness:

- By utilizing cameras instead of expensive LiDAR sensors, the project remains an affordable solution for pedestrian safety.
- The use of open-source libraries like Pygame reduces software development costs.
- Reduced reliance on proprietary hardware ensures easier adoption in different vehicle models.

Enhanced Safety:

- The alert system provides drivers with timely warnings, reducing the likelihood of pedestrian-related accidents.
- The integration of lane detection further refines predictions and alert generation, enhancing overall road safety.
- Future iterations will improve response times, ensuring even better reaction speeds for drivers.

6. Future Scope

Improved Predictive Models:

- Plans to explore more advanced machine learning techniques such as transformer-based models for greater accuracy.
- Potential implementation of deep reinforcement learning to improve trajectory forecasting.
- Adaptive learning mechanisms to continuously improve model accuracy over time.

Integration with Additional Sensors:

- Future versions may incorporate LiDAR or radar sensors to enhance environmental understanding.
- Multi-sensor fusion techniques will be explored to combine data from multiple sources for better decision-making.
- Advanced stereo camera systems may be utilized to enhance depth perception and obstacle differentiation.

Scalability and Real-World Deployment:

- Future assessments for integration with smart infrastructure to facilitate broader deployment.
- Expansion to mobile devices for real-time pedestrian detection and warning systems.
- Cloud-based data processing for improved computational efficiency and scalability.
- Development of a modular system that can be integrated into both modern and older vehicle models.
- Plans for real-world pilot studies in urban environments to assess system performance under real driving conditions.

7. Conclusion

ADAS-PeVision represents a significant step forward in driver safety by integrating cost-effective technology with advanced algorithms. The enhancements, including the speed detection system, vehicle classification, free space detection, and an upgraded predictive model, have made the system more reliable and effective.

By focusing on pedestrian detection, movement prediction, real-time driver alerts, and environmental awareness, this project contributes to reducing road accidents and supporting the broader adoption of autonomous vehicle technologies. Future iterations will continue to refine the system, integrating additional sensors and improving predictive capabilities to create an even more robust safety solution.