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BSc (Hons) in Information Technology Specializing Data Science

Research Project - IT4010 MLOPs Report

Group ID: 24_25J_213

Project Title: ManthraX: Pioneering Precision, The Future of autonomous Mobility

1. IT21160448: Perception and Scene Understanding
2. IT21155048: Decision Making and Collison Avoidance
3. IT21162978: Driver Monitoring and Ethical Decision-Making
4. IT21174780: In Cabin Security in Autonomous Vehicles

		IT21160448	IT21155048	IT21162978	IT21174780
Data Pipeline	**Data Sources:**	CARLA simulation environment for object detection, lane-keeping, and behavior classification.	CARLA-based collision avoidance and traffic navigation datasets.	Media Pipe Face Mesh for eyeball tracking and CARLA simulations for ethical decision-making.	FER2013 dataset for emotion detection, audio datasets for harmful status detection, and custom datasets for YOLOv5-based weapon detection.
	Data Preprocessing:	Image resizing, annotation formatting for YOLOv5, normalization of CNN-based lane-keeping inputs, and graph structuring for GNN	Normalization and scaling images, resizing, reward clipping and shaping prevents exploding Q-values and stabilizes learning, convert raw sensor data into a structured format.	Facial landmark extraction for eyeball tracking, Eye Aspect Ratio (EAR) calculation for drowsiness detection and reinforcement learning setup for	Grayscale conversion for emotion detection, Noise injection for harmful status detection, and brightness/contrast enhancement for weapon detection.

		behavior classification.		ethical decision-making. (Normalization of sensor input data)	
	Data storage and versioning	Firebase	Firebase	Firebase	Firebase
Model Development	**Model Selection**	YOLOv5 for object detection, CNN for lane keeping, and GNN with Transformer for behavior classification.	Deep Q-Networks (DQN) to evaluate reinforcement learning strategies.	Media Pipe and EAR for eyeball tracking, Threshold-based drowsiness detection model and DQN for ethical AI.	MobileNetV2 for emotion detection, 1D CNN for harmful status classification, and YOLOv5 for weapon detection.
	Model Training	YOLOv5 trained on a custom dataset with 416x416 image resolution, batch size of 16, and 100 epochs. CNN-based lane-keeping model trained using Adam optimizer with MSE loss for 20 epochs. GNN model trained CARLA-generated temporal graphs using TransformerConv layers.	Deep Q-Network (DQN) uses a multi-layer perceptron model with two hidden layers with 256 and 128 units and ReLU activation. The model was optimized using the Adam optimizer. PID is parallel with DQN model.	Media Pipe-based eyeball tracking fine-tuned for driver attention detection. Ethical decision-making agents trained in CARLA using DQN with a k-value balancing altruism and egoism.	Emotion classification model trained using MobileNetV2 fine-tuning. 1D CNN trained on spectrogram-based audio features with 30 epochs and Adam optimizer. YOLOv5 trained for weapon detection with brightness/contrast adjustments.

Model Integration	**Tools used**	YOLOv5 is integrated with CARLA for real-time object detection, CNN-based lane-keeping model integrated into vehicle steering control, and GNN-based behavior classification integrated with vehicle decision-making.	CARLA environment to simulate vehicle behaviors, and DQN integrated with the self-driving agent for collision avoidance.	MediaPipe-based eyeball tracking integrated with driver alertness monitoring, and RL-based ethical decision-making embedded in the AI-driven navigation system. OpenCV, TensorFlow/Keras	MobileNetV2-based emotion detection integrated into driver monitoring systems, CNN for harmful status detection applied to in-car audio safety systems, and YOLOv5 for weapon detection embedded in vehicle surveillance modules.
Model Deployment	**Testing Environments**	CARLA simulations and real-time vehicle testing for object detection, lane keeping, and behavior classification.	Collision scenarios in Carla simulation, reinforcement learning-based decision evaluations.	Local testing on edge devices such as Raspberry Pi and simulated test case in Carla simulation.	Controlled facial emotion classification, real-time audio evaluation, and custom dataset evaluation for weapon detection.
	Deployment Platform & Method	The model is deployed on edge devices powered by RTX 4060, using TensorFlow for efficient inference serving	The model is deployed on edge devices powered by RTX 4060, using TensorFlow for efficient inference serving. It is also integrated with a mobile app for real-time alerts.	Edge-based AI for real-time gaze tracking using Raspberry Pi. It is also integrated with a mobile app for real-time alerts.	Edge-based AI for real-time gaze tracking using Raspberry Pi integrated with IOT. It is also integrated with a mobile app.
Future Enhancements	**Model Improvement:**	Further fine-tuning of YOLOv5 with additional real-world	Integration of multi-agent reinforcement learning for more adaptive traffic navigation.	Enhancing gaze tracking with additional deep	Expansion of datasets for harmful status and weapon detection to cover

		datasets for improved accuracy.		learning techniques for better accuracy.	more real-world scenarios