



Enhancing Autonomous Vehicle Safety and Efficiency: Implementation of ANN Models on an Existing Scaled Testbed

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Autonomous vehicles (AVs) have transformed the transportation sector by enhancing safety, efficiency, and reliability through reduced human intervention. This research presents the development and evaluation of Artificial Neural Network (ANN)-based autonomous driving models on a scaled testbed, focusing on safety and efficiency. The primary contribution of this research is the development of an autonomous vehicle that achieves reliable autonomy using minimal sensor inputs and low computational resources. The testbed relies solely on a web camera for environmental perception and obstacle detection and uses an NVIDIA Jetson Nano board as the computing unit. ANN-based models are developed and integrated for lane detection, steering control, and object detection to simulate real-world driving conditions. We evaluate two autonomous driving approaches: a modular approach and an end-to-end learning approach. For the modular pipeline, a U-Net model is employed for lane segmentation along with YOLOv8 (You Only Look Once version 8) for object detection. In this approach, steering control is based on explicit lane boundaries and detected obstacles produced by the perception modules. In the end-to-end approach, a CNN (Convolutional Neural Network) directly predicts the steering command from raw images, with a YOLOv8 model running in parallel to provide obstacle awareness. Both approaches are evaluated under different scenarios to measure their performance. To evaluate safety, testing was conducted at three selected speeds for lane-keeping, object avoidance, and pedestrian avoidance accuracies. Experimental results show that the U-Net-based modular pipeline achieves a lane-keeping accuracy of 97% of lap time, while the end-to-end CNN approach demonstrates improved obstacle and pedestrian avoidance, achieving zero collisions in both tasks at low speeds (0.7 km/h), up to 50% obstacle safe-zone operation, 90% pedestrian safe-zone performance, and a reduced inference time of approximately 28 ms.

Keywords: Artificial neural networks, Autonomous vehicles, Computer vision, Vehicle safety