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PhD Dissertation Defense

Entitled

AN INTELLIGENT FRAMEWORK TOWARDS FULLY AUTONOMOUS DRIVING FUELED BY SMART ROADS

by

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Abstract

Autonomous vehicles (AVs) are transforming next-generation autonomous mobility. Such vehicles promise to increase road safety, improve traffic efficiency, reduce vehicle emissions, and enhance mobility. The development of AVs involves the integration of various disciplines and technologies, i.e., sensors, communication, computation, and artificial intelligence (AI), to achieve higher levels of autonomous driving (AD). The main objective of this dissertation is to design and develop a novel approach for achieving higher levels of automation in AD through an end-to-end intelligent framework. This involves addressing the challenges of technological augmentation of road infrastructure to support intelligent transport system (ITS) services, service satisfaction in perception systems of AVs, enhancing the orchestration of perceptual tasks for complex driving scenarios, perceiving diverse objects in urban environments, real-time information exchange, decision-making based on distributed information, and integration of heterogeneous technologies. The methodology includes a comprehensive survey focused on 3rd Generation Partnership Project (3GPP) standardization perspectives to identify fundamental components of the proposed intelligent framework. It also encompasses the design of an enhanced Connected Cooperative and Automated Mobility (CCAM) infrastructure, the development of an intelligent perception model, the deployment of Deep Learning (DL) models on a diverse range of devices, and the integration of these components within a hierarchical vehicle-edge-cloud architecture. The dissertation presents several key findings: i) an exhaustive design and specification of sensory technologies and architecture for enhancing CCAM infrastructure, validated through ML algorithms for mobility applications; ii) an analytical model for selecting the right perception for AVs, which is validated through a custom dataset and DL-based model instances fine-tuned for object detection; iii) the proposed intelligent model accurately determined that AdamW-based DL model outperforms the SGD-based DL model when comparing performance at the class level; iv) a computational framework that integrates the perception model with enhanced CCAM infrastructure across a hierarchical structure and show consistent performance metrics and reduced inference times across different devices. The significant contributions of this dissertation include: i) enhancements in CCAM infrastructure imperative for intelligent road systems and decision-making of AVs; ii) the development of an intelligent service model for AV perception, improving service satisfaction and enabling proactive functionalities for AVs in urban environments; iii) The design of a computational framework that smartly stitches together the enhanced CCAM infrastructure and intelligent perception model to facilitate learning across different layers and settings. This research addresses the gap in integrating heterogeneous technologies and disciplines for higher levels of AD. It offers a novel approach that combines enhanced infrastructure, an intelligent perception model, and a computational framework to support advanced AD functionalities, thus filling a crucial gap in the current solution approaches for autonomous driving.

Keywords: 3GPP, Autonomous Driving, Analytical Modeling, Autonomous Vehicles, C-V2X, CCAM Infrastructure, Deep Learning, Model Deployment, Object Detection, Perception, Transportation.