Proposal Defense

Doctor of Philosophy in Information Science

“Advanced Autonomous Vehicles Analytics for Predicting Navigation Performance” by Mohammed Alharbi

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Place: Room 828, Information Science Building, 135 N. Bellefield Ave, Pittsburgh PA 15260

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Abstract:
Autonomous Vehicles (AVs) stand as a monumental leap in modern transportation technology, offering the potential to enhance road safety and optimize transportation efficiency. However, their broad adoption is hindered by uncertainties associated with their sensors that allow for perceiving their surroundings. These uncertainties, arising from sensor noise, varying environmental conditions, and inherent limitations in sensor design, pose substantial risks to the reliability of AV navigation. Considering the high stakes involved, including human safety, traffic management, and infrastructure integrity, it is crucial for AVs to operate with minimal sensor uncertainty. As driving on roads is dynamic and filled with unpredictable elements, like sudden weather changes, AVs must be designed to handle planned or unforeseen changes with unwavering precision. Failure to account for such uncertainties can cause unsafe driving and culminate in catastrophic outcomes, thereby deteriorating public confidence in AV technologies.

Common approaches to identifying and handling sensor uncertainties (SUs) involve data fusion and machine learning techniques. Despite their acceptable performance, these techniques possess significant limitations. For instance, conventional sensor fusion techniques often assume SUs to be independent and Gaussian-distributed, an oversimplification that produces suboptimal solutions. Additionally, these techniques lack the flexibility needed to adapt to varying environmental conditions. On the other hand, machine learning techniques suffer from a lack of interpretability, inhibiting a comprehensive understanding of their decision-making processes. Furthermore, the extant literature is void in furnishing robust evaluative metrics and tools that could facilitate the systematic analysis of AV navigation performance, both before and after occurrence of incidents.
This thesis addresses these critical gaps by introducing an advanced AV analytics (AVA) framework and making the following contributions. Firstly, it introduces a novel ontology that represents and formalizes major concepts related to SUs in AV navigation. This ontology serves as a foundation for automated reasoning about navigation safety. Secondly, the thesisformulates essential metrics to evaluate the performance and reliability of sensors utilized in AVs. Thirdly, the AVA framework incorporates predictive models that not only quantify AV navigation performance but also identify factors contributing to SUs. These models are unique in their multidimensional scope, encompassing environmental variables, sensor specifications, and dynamic system states, and are of two types: online and offline. Online models focus on real-time evaluation of uncertainties for immediate decision-making, while offline models, also called forensic models, allow to analyze factors behind any unexpected behaviors. Finally, the thesis introduces a global path finder that optimizes AV route planning using AVA results. These contributions are thoroughly validated using simulated and real data. The outcomes of the proposed research will help develop AV navigation solutions that are reliable and safe.