MOBILITY AND SAFETY IMPACTS OF AUTONOMOUS VEHICLES

ABSTRACT

Connected and Autonomous Vehicles (CAV) are revolutionizing the automotive space. We are at the cusp of a once in a century transformation. CAVs are expected to improve upon the safety, efficiency, and economics of conventional automobiles. Previous works have made significant progress in studying the various aspects of this field but many gaps remain. This work focuses on exploring these gaps in the key areas CAVs are expected to make main contributions.

Firstly, we explore the CAV landscape which is in a continuous state of flux. There are several changes taking place in the technology, consumer perception, OEM and DOT outlook and competitor space among others. Past surveys and interviews have acquired public and expert opinions on CAV issues from a wide variety of regions and at various sample sizes. However, individuals with CAV technical and thought leadership backgrounds – those working for OEMs, State DOTs, consulting firms, applications developers, financial institutions and other organizations – have been sparsely covered. In this study we strived to examine, analyze and evaluate this space using semi-structured interviews with experts from multiple industries across the whole country. The interviews were supported additionally by survey questions which captured the expert views quantitatively.

From the results of the 28 interviews and 33 surveys conducted, several key conclusions were made. It is evident that the market introduction of autonomous vehicles (AVs) will take two directions. Vehicles with a low level of autonomy will be available for retail purchase, whereas Original Equipment Manufacturers (OEMs) and transportation service providers will deploy highly automated vehicles via Transportation-as-a-service model. Further-more, CAVs will take an evolutionary, path of development. In addition, the deployment of robo-taxis will be done on a city-by-city basis, because Society of Automotive Engineers (SAE) level 4 vehicles that would be employed will have an operational design domain restricted by geo-fencing. Also, current partnerships between CAV stakeholders are extremely weak. Strengthening these offers the potential to guide CAV evolution in a more efficient and constructive manner. Moreover, the large scale at which CAV technology will be deployed leaves it vulnerable to issues that will cause a poor consumer willingness to purchase, high prices, and OEMs being left behind in a disruptive market. This must be accounted for in future deployment decisions. Lastly, the stakeholders have falling short of building transformative collaborations and disagree on key CAV matters, such as the need for connectivity. A consensus must be built to facilitate efficient CAV evolution in the future

The above CAV landscape analysis, additionally guided the study in terms of identifying the key areas which needed to be understood in greater detail which include (1) Modeling of AVs from SAE from level 0 to level 5 (2) Analysis of mobility and safety impacts of SAE vehicles. (3) Building a predictive model to identify risk level of autonomous vehicles based on trajectory information.

Second part of the work focuses on modeling of the various SAE levels and evaluating their mobility impacts. This work strives to build off already conducted research and contribute to AV knowledge through modeling of SAE levels. Despite the detailed modeling of numerous AV applications that has already occurred, research related to definitive SAE levels, as outlined in the Federal Policy on Automated Vehicles, is very limited.

To address this gap we propose a novel bottom-up approach to model various SAE levels on VISSIM in a two lane highway environment featuring an on-ramp. Our results indicate that mobility in SAE level 1 always exceeds that of SAE level 0, because the former has a consistently higher acceleration forgiven conditions. SAE level 2 provides more lateral stability and therefore less implied accidents than level 1 or 0 due to lower lateral deviations. For level 3, the key consideration is to model the transition between human and system control. In SAE level 4 we model the operation of autonomous vehicles in Operational Design Domain (ODD) and transition to minimal risk conditions outside ODD. SAE level 5 overcomes the impact of these transitions and hence has a better mobility than the lower SAE levels. We also performed penetration studies for various SAE mixes in the road traffic and analyzed their mobility impacts. The models can help policy makers to understand the impact of autonomous vehicles on mobility and guide them in making critical policy decisions

The last part of the thesis focuses on building a model to predict the risk of AVs using the trajectory information. Improvements in safety levels are one of the most important benefits of AVs that has been touted by OEMs and DOTs alike. One of the industries that will significantly get affected by AVs is going to be the insurance industry. A big challenge will be to evaluate the risk level of different SAE classes of vehicles. This is especially true currently as SAE level data is either unavailable or very scarce. At this juncture, we propose a novel methodology to identify risky driver behavior for every SAE level. The framework includes the utilization of surrogate safety measures modified for SAE levels in a microsimulation environment. The trajectory data created from SAE level simulation is used as the data set for model training and testing which predicts no risk, low risk, medium risk and high risk. The models evaluated are logistic regression, neural networks and decision trees. This framework provides foundation

for identifying autonomous vehicles which show risky driving behavior. This methodology can be used by insurance firms for pricing different levels of autonomous vehicles especially in data poor environment.

This dissertation provides useful insights into the various aspects CAVs will have an impact on. The various models developed in this work can be used by policymakers, OEMs, insurance firms among others to prepare themselves for an AV future.