Annie Waye

Dr. Tabitha Clark

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Annotated Bibliography

Chen, R., Arief, M., Zhang, W., & Zhao, D. (2020). How to evaluate proving grounds for self-driving? A quantitative approach. *IEEE Transactions on Intelligent Transportation Systems*, 1-12. https://doi.org/10.1109/TITS.2020.2991757

This scholarly research article is published in one of IEEE's peer reviewed journals and describes a qualitative approach to evaluating self-driving-vehicle test and validation systems. Chen et al. draw a connection between proving ground performance and public street performance. Evaluating proving grounds themselves is not commonly researched in relation to testing self-driving vehicles. One major challenge to evaluating proving grounds is the static nature of physical roads for testing. This challenge limits the range of test cases, but Chen et al. outline how they define a baseline effectiveness with respect to road structure. After setting this baseline, the following sections of the research proposal contain many complex equations for quantifying specific elements of the test, such as the set of driving events and vehicle trajectories (Chen et al., 2020, p.3). The equations and figures further the purpose of the research article to inform fellow expert readers in the IEEE discourse community and document the in-depth research process.

Chen et al. note that this is their first attempt at a systematic evaluation. They are detailed in their methods and early results sections, providing detailed evidence of proposed algorithms and data handling techniques. The array of technical figures provides visual examples of traffic scenarios and vehicle trajectories. Chen et al. include plots of baseline effectiveness results for multiple proving ground scenario sets. The proposed evaluation is thorough and believed to strengthen the autonomous vehicle performance once the evaluation is verified.

Chen, S., Chen, Y., Zhang, S., & Zheng, N. (2019). A novel integrated simulation and testing platform for self-driving cars with hardware in the loop. *IEEE Transactions on Intelligent Vehicles*, *4(3)*, 425-436. https://doi.org/10.1109/TIV.2019.2919470

In this peer reviewed journal article, Chen et al. highlight how critical thorough simulation and testing research is in the development of self-driving vehicles. One main weakness in mainstream simulation systems is the disconnect between the carefully crafted simulation environment and the real-world testing circumstances. This disconnect hinders the speed and efficiency of vehicle development. Thus, this technical research paper proposes a new simulation system that explicitly includes “Hardware-in-the-loop (HiL)” (Chen et al., 2019, p.425). The first figure in the research proposal depicts the scope of the HiL simulation, labeling critical elements and how they connect across systems.

Related peer reviewed research from other IEEE journals is considered in this article. Chen et al. compare existing offline simulation and testing platforms with the proposed novel, more holistic HiL platform. A section of the research proposal is dedicated to informing technical readers of specific hardware sensors, such as stereo cameras, LiDAR, IMU and GPS. Chen et al. explore multiple experimental algorithms with figures and complex equations to validate the simulation. The variety of experiments leads to a flexible simulation, adaptable to different scenarios, vehicles, and sensors. One main drawback of the article is the lack of highly complex scenarios.

Coicheci, S., & Filip, I. (2020). Self-driving vehicles: Current status of development and technical challenges to overcome. *Proceedings of the IEEE International Symposium on Applied Computational Intelligence and Informatics (SACI), Romania*, 000255-000260. https://doi.org/10.1109/SACI49304.2020.9118809

This research report evaluates the status of self-driving vehicles, predominantly providing highly organized information for an audience of technical readers. The article was published to one of IEEE's peer reviewed conferences in 2020. Coicheci and Filip (2020) cite the six levels of autonomy, established by The Society of Automotive Engineers, to classify the range and potential of self-driving cars. Many vehicles on the road are categorized in Level 1 with minimal driver assistance such as cruise control. The car companies that are actively developing autonomous vehicles are mainly focused on low-level autonomy at a Level 2 or 3. Level 3 vehicles can be considered autonomous, but the driver must be alert and able to take control in the event of an emergency. Coicheci and Filip (2020) give a detailed overview of a variety of Level 3 advanced driving assistance systems (ADAS) currently available in many vehicles.

Coicheci and Filip document related research from other expert-level literature before completing their evaluation and drawing their own conclusions. A prominent challenge to advanced autonomous driving is "vehicle-to-vehicle communication (V2V)," which is not typically a focus in surrounding research work (Coicheci & Filip, 2020, p.000257). Additional challenges to advancing self-driving vehicle technology are safety, price, and regulation. One drawback of the research article is the lack of detailed examples of suggested solutions to the challenges identified.

Menouar, H., Güvenc, I., Akkaya, K., Uluagac, A. S., Kadri, A., & Tuncer, A. (2017). UAV-enabled intelligent transportation systems for the smart city: Applications and challenges.

IEEE Communications Magazine, *55(3)* 22-28.

https://doi.org/10.1109/MCOM.2017.1600238CM

The focus of this peer reviewed journal article is to inform expert readers of the necessary components of a future smart city, specifically those that include unmanned aerial vehicles (UAVs). Intelligent transportation systems (ITS) will be required to communicate effectively with connected, autonomous vehicles, personal vehicles, and UAVs. Menouar et al. share multiple specific applications and examples of UAVs in smart cities, including accident report drones, roadside assistant drones, and traffic police drones (Menouar et al., 2017). The research article figures depict these possible scenarios, labeling important connections between UAVs and other elements. Additionally, the article contains a complex equation and detailed technical jargon to describe UAV path planning and data routing (Menouar et al., 2017, p.26). UAVs follow a complex system to securely communicate with other UAVs, encrypting private information. Privacy and safety are major challenges to developing smart cities; unfortunately data privacy is particularly challenging with dynamic, configurable UAV networks.

Even with the adoption of UAVs, Menouar et al. note the necessary advancement of other road and transportation infrastructures. One necessary industry to consider and include in successful ITS networks, according to Menouar et al., is the shipping of consumer goods across the world. The large system of commercialized shipping has not been researched extensively in the context of autonomous vehicle networks.

Salazar, M., Rossi, F., Schiffer, M., Onder, C. H., & Pavone, M. (2018). On the interaction between autonomous mobility-on-demand and public transportation systems. *Proceedings of the IEEE Intelligent Transportation Systems Conference (ITSC)* Maui, HI, USA, 2262-2269. https://doi.org/10.1109/ITSC.2018.8569381

This research article was published to an IEEE peer reviewed conference and studies the potential success of a network of self-driving vehicles when connected to public transportation. This study focuses more on the realistic ramifications of an autonomous public transit system on a community, compared to most other expert level research. Salazar et al. introduce the problem in detail, explaining how traffic congestion is economically and environmentally harmful. They promptly propose intelligent solutions involving Autonomous Mobility-on-Demand systems (AMoDs). Some solutions to harmful vehicle emissions, such as ride-hailing systems, can unfortunately worsen traffic congestion and cause vehicles to drive miles passenger-less (Salazar et al., 2018). Alternatively, AMoD systems with fleets of autonomous vehicles are controlled by a central operator and collect information to route vehicles to passengers, replacing taxi and car-sharing networks, constantly rebalancing routes for empty vehicles, reducing wasted travel.

Salazar et al. share how their work explicitly contributes to related research topics. The final sections of the research article outline technical optimization models and design an ideal price and toll system. The section on flow optimization contains complex equations to model an urban environment and traffic congestion (Salazar et al., 2018, p.2264). The section proposing a pricing plan for intermodal AMoD systems also contains complex equations to describe the factors that determine toll pricing. The research article concludes with a case study for New York City. The optimized AMoD system resulted in a dramatic reduction in travel time, costs, and emissions (Salazar et al., 2018).