Framework for Accommodating Emerging Autonomous Vehicles

Technology Transfer Activities

by

Burak Eksioglu, University of Arkansas
Matthias Josef Al Schmid, Clemson University
Nathan Huynh, University of South Carolina
Gurcan Comert, Benedict College
Dahui Liu, Clemson University

Contact information
Burak Eksioglu, Ph.D.
Department of Industrial Engineering, University of Arkansas, Fayetteville, AR 72701 email: burak@uark.edu

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CLEMSON UNIVERSITY

Benedict College | The Citadel | SC State University | University of South Carolina

200 Lowry Hall, Clemson University
Clemson, SC 29634

DISCLAIMER

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TECHNOLOGY TRANSFER ACTIVITIES

1 Summary of Research Study and Findings

In this study, we developed and evaluated three models: a platoon formation optimization model, a traffic microsimulation model, and an energy prediction model.

- The optimization model divides the freeway link into platooning zones, then determines whether or not each vehicle should join a specific platoon within each zone. This determination is based on each vehicle's destination and the estimated energy savings at the macro level.
- The experimental results indicate that considering the destinations in the vehicle-to-platoon assignment decisions leads to lower total energy savings for the single freeway network.
- The microsimulation model takes the vehicle-to-platoon assignments as input and simulates the movement and behavior of each platoon and each vehicle using Vissim's car-following model to provide realistic traffic flow and conditions. Each vehicle's location, speed, and destination are recorded from the simulation model and utilized as input to the optimization model every 20 seconds. This iterative process continues for four hours.
- From observations, it takes two hours before the steady state is reached. Thus, our conclusions are drawn from observations over the last two simulation hours (i.e., in steady-state).
- Every 0.5 second, detailed vehicle and platooning states are collected from the simulation model, which is subsequently processed utilizing the developed prediction model to determine the energy consumed by each vehicle. Before employing the prediction model for energy consumption estimations, we validated its accuracy through a regression model.
- The results were encouraging as we demonstrated a significantly improved fit of our prediction model to empirical data compared to other models proposed in the literature.
- In particular, our analytical prediction model can accurately reproduce empirical results for short inter-vehicle distances where other existing models fail. Furthermore, we included the additional energy required to form and maintain platoons in our assessment which has not been performed in any previous studies. Therefore, a key contribution of this work is the developed energy prediction model that is more applicable to real traffic systems. Its reported energy savings are much more realistic compared to previous studies.
- Our numerical experiment results indicate that savings are maximized if the focus lies on forming as many platoons as possible and forming longer platoons. In this study, we limited the platoon size to five vehicles.

2 Outputs

At the end of the study, the research goals were accomplished. We shared research results through conference presentations and published a journal article shortly. Below is the outline plan to disseminate the research results.

2.1 Accomplished Outputs

Journal Article

D. Liu, B. Eksioglu, M. J. Schmid, N, Huynh, & G. Comert. Optimizing energy savings for a fleet of commercial autonomous trucks. IEEE Transactions on Intelligent Transportation Systems. 2021 Apr 16.

Conference Article Presentation

M. J. Schmid, D. Liu, B. Eksioglu, N. Huynh, & G. Comert. Prediction Model for Energy Consumption in Heavy-Duty Vehicle Formations. In IIE Annual Conference. Proceedings 2020 (pp. 1176-1181). Institute of Industrial and Systems Engineers (IISE).

D. Liu, B. Eksioglu, M. J. Schmid, N. Huynh, & G. Comert. Simulation-Optimization Platooning Model for of a Fleet of Commercial Autonomous Trucks. In IIE Annual Conference. Proceedings 2020 (pp. 1-6). Institute of Industrial and Systems Engineers (IISE).

Dissertation

D. Liu. Optimizing Energy Savings for a Fleet of Commercial Autonomous Vehicles via Centralized and Decentralized Platooning Decisions (Doctoral dissertation, Clemson University), 2020.

2.2 Future Output

Peer-Reviewed Journal Article

Currently, we are planning to submit a decentralized version of our experiments to another journal publication.

Conference Poster and Podium Presentation

Prediction Model for Energy Consumption in Heavy-Duty Vehicle Formations was selected best paper at IISE 2020 conference for simulation and modeling division.

Transportation Practitioners Comments

None

3 Outcomes

The research has produced the following critical outcomes:

3.1 Modeling and Simulation

The study modeled energy saving within platoons building on existing models. These models can calculate saving based on vehicle trajectories, which we obtained using the VISSIM microscopic simulation software.

4 Impacts

We expect this study to add knowledge to the transportation community and the public. We anticipate that this research to have an impact on the efficiency measures implementation related to truck platooning as follows:

(i) *Transportation agencies, enforcement agencies, and public officials:* for safety, we were able to measure at what vehicle headways we could save fuel or energy. Longer headways can also result in savings; thus, based on safety and vehicle characteristics, models can be revised for safety objectives.

(ii) *Transportation professionals:* Analysis shows that we can save at least 3% fuel by joining a platoon without sacrificing mobility. Certainly, the position in the platoon impacts which vehicle saves how much. A careful management program can be planned using similar models.