MPC-600
April 16, 2019

Project Title

Developing a Prototype System for Establishing Passing and No-Passing Zones of Two-Lane Highways

University

University of Wyoming

Principal Investigators

Khaled Ksaibati, Ph.D., P.E.
Professor and Director
Wyoming Technology Transfer Center
University of Wyoming
Phone: (307) 766-6230
Email: khaled@uwyo.edu
ORCID: 0000-0002-9241-1792

Ahmed Farid, Ph.D.
Postdoctoral Research Associate
University of Wyoming
Phone: (407) 530-9360
Email: afarid@uwyo.edu
ORCID: 0000-0002-5101-3237

Suresh Muknahallipatna, Ph.D.
Professor and Graduate Coordinator
Department of Electrical and Computer Engineering
University of Wyoming
Phone: (307) 766-3174
Email: sureshm@uwyo.edu
ORCID: 0000-0003-4153-524X

Victor Bershinsky, P.E.
Senior Electrical Engineer
University of Wyoming
Phone: (307) 766-3188
Email: vbershin@uwyo.edu
ORCID: 0000-0002-9151-8045

Research Needs

The Wyoming Department of Transportation (WYDOT) implements the two-vehicle method to measure passing sight distances on Wyoming's two-lane roads comprising thousands of miles in

order to establish passing and no-passing zones. The method involves a lead vehicle and a following vehicle equipped with an apparatus to measure the passing site distance while traveling along the two-lane road. The apparatus used to conduct the method is no longer functional. Therefore, WYDOT and local jurisdictions in Wyoming are in dire need of a functional, advanced, accurate, cost-effective, easy-to-use, durable, upgradable system to conduct the method. It is essential that the system be accurate because WYDOT is continuously establishing the zones statewide and establishing the zones is costly. With the advanced system, WYDOT will also be able to evaluate existing zone designs. WYDOT is not only establishing zones statewide but also re-establishing the zones due to changes in speed limits, construction or placement of sight obstructions near horizontal curves, roadway re-alignment, crashes, complaints from citizens and other reasons.

Research Objective

- The objective is to provide two state-of-the-art prototypes of the two-vehicle method having advanced intelligent transportation system (ITS) features to WYDOT.

Research Methods

The design standards of passing and no-passing zones of two-lane highways described in design manuals will be strictly followed. The manuals are the WYDOT Pavement Marking Manual, the American Association of State Highway and Transportation Officials' (AASHTO) Green Book and the Manual on Uniform Traffic Control Devices (MUTCD). The advanced components of the two-vehicle method's prototypes to be developed include vehicle-to-vehicle (V2V) wireless access in-vehicle environments (WAVE) communication devices, GPS data collection devices and a graphical user interface (GUI) to present the data collected in real-time. In addition, the following vehicle will be equipped with a camera having software with computer vision and neural network algorithms. The software enables autonomous detection of the lead vehicle and the track. The advanced two-vehicle method's prototypes will also include redundant lidar devices to measure the distances between both vehicles. Field testing of the prototypes will be conducted in multiple locations of two-lane highways based on a statistical experimental design. Passing and no-passing zone plans established as a result of the field tests will be evaluated to ensure that the zone design standards are not violated.

Expected Outcomes

The outcome of the project is a set of two cutting-edge prototypes of the two-vehicle method to be provided to WYDOT. User manuals of the prototypes will be provided as well. WYDOT will be able to continuously implement and re-implement accurate plans of passing and no-passing zones statewide. Furthermore, the two-vehicle method typically requires a three-person team. The third person assists the driver of the following vehicle in the data collection process. Yet, the advanced prototypes to be offered will eliminate the need for the third person. Also, WYDOT can address local governments in Wyoming requesting help in establishing or re-establishing the zones by providing them at least one of the advanced two-vehicle method's prototypes.

Relevance to Strategic Goals

This project is anticipated to enhance the safety of motorists on two-lane highways in Wyoming. Therefore, the project is classified under the safety strategic intent area of the US Department of

Transportation. Since the outcome of the project is a set of advanced prototypes of the two-vehicle method to replace the existing non-operational apparatus of WYDOT, the aim is to accurately implement passing and no-passing zone plans. This contributes to cutting the frequency of passing related crashes which are typically head-on and opposite-direction sideswipe crashes. With the accurate establishment of the zones, passing related crashes and therefore WYDOT's liability in cases of crashes are minimized.

Educational Benefits

The project will require the contributions of a transportation engineering faculty member, a transportation engineering research postdoctoral fellow, comprising the transportation engineering team, an electrical engineering faculty member and an electrical engineer, comprising the electrical engineering team. Input from the transportation engineering team include passing and no-passing zone research. On the other hand, the technicalities of the state-of-the-art prototypes to be offered to WYDOT are addressed by the electrical engineering team. Both teams will contribute to the field testing of the prototypes. The transportation engineering team will contribute by conducting an experimental design to select the appropriate testing locations and run the tests. The electrical engineering team will assist in calibrating and operating the equipment when running the tests. Both teams will also contribute in the drafting of the prototype manuals and the final report.

Technology Transfer

The cutting-edge prototypes and their manuals will be provided to WYDOT. Also, WYDOT will be able to assist local governments in Wyoming in establishing passing and no-passing zones. Furthermore, research findings will be documented in scientific journals such as the American Society of Civil Engineers: Journal of Transportation Engineering and presented in conferences such as the Annual Meeting of the Transportation Research Board. Technology transfer activities will be reported to the Program Progress Performance Reports.

Work Plan

- Prototype instrumentation development and software set-up

It is assumed that the project is to start by January 2019. The initial step is to develop both prototypes, Prototype 1 and Prototype 2. That includes both hardware and software development.

- Delivery of Prototype 1

By July 2020, Prototype 1 will be developed and tested in the field. It will not have all the state-of-the-art ITS features. Instead, it should be accurate and reliable. Prototype 1 and its manual will be provided to WYDOT while Prototype 2, which has the latest ITS features, is under development.

- Delivery of Prototype 2

By July 2021, Prototype 2 will be fully developed and tested in the field. It will have all the cutting-edge ITS features. Prototype 2 and its manual will be provided to WYDOT.

- Delivery of Upgraded Prototype 1, Final Report and Implementation Plan

Once, Prototype 2 is delivered to WYDOT, Prototype 1 will be retrieved from WYDOT, upgraded to include all the state-of-the-art ITS features and tested in the field again. Prototype 1's manual will be updated as well. By January 2022, Prototype 1 upgraded and its manual will be provided to WYDOT once more. Also, the project's final report and implementation plan will be provided to WYDOT.

Project Cost

Total Project Costs:	$281,371
MPC Funds Requested:	$109,472
Matching Funds:	$171,899
Source of Matching Funds:	Wyoming Department of Transportation

References

AASHTO, 2011. A Policy on Geometric Design of Highways and Streets. AASHTO, Washington, D.C.

Betke, M., Haritaoglu, E., Davis, L., 2000. Real-Time Multiple Vehicle Detection and Tracking from a Moving Vehicle. Machine Vision and Applications, 69 – 83.

Brown, R., Hummer, E., 2000. Determining the Best Method for Measuring No-Passing Zones. Transportation Research Record 1701, 1-67.

FHWA, 2009. Manual on Uniform Traffic Control Devices. FHWA, U.S. Department of Transportation, Washington, D.C.

FHWA, 2009. Highway Safety Improvement Program Manual. FHWA Report FHWA-SA-09-029. U.S. Department of Transportation, Washington D.C.

FHWA, 1994. The Magnitude and Severity of Passing Accidents on Two-Lane Rural Roads. FHWA, U.S. Department of Transportation, Washington D.C. https://www.fhwa.dot.gov/publications/research/safety/humanfac/94068.cfm. Accessed October 4, 2018.

GTI Vehicle Image Database, 2012. http://www.gti.ssr.upm.es/data/Vehicle_database.html.

Gurghian, A., Koduri, T., Bailur, S., Carey, K., Murali, V., 2016. DeepLanes: End-To-End Lane Position Estimation using Deep Neural Networks. IEEE Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), 38 – 45.

Harwood, D., Gilmore, D., Richard, K., Dunn, J., Sun, C., 2008. National Cooperative Highway Research Program Report 605: Passing Sight Distance Criteria. Transportation Research Board of the National Research Council, Washington, D.C.

Hayworth, 2013. What's the Most Missed Question on Iowa Driver's License Test. Sioux City Journal, Sioux City, Iowa. https://siouxcityjournal.com/news/local/a1/what-s-the-most-

missed-question-on-iowa-driver-s/article_71822ebe-343c-5b4e-adeb-877a7b901d12.html. Accessed September 26, 2018.

High Bandwidth Application Over WI-FI Connection with IEEE 802.11P, and IEEE P1609 (WAVE) Protocols, White Paper, ARADA Systems.

Hutton, J., Cook, D., 2016. Developing a System to Identify Passing and No Passing Zone Boundaries on Rural Two-Lane Highways. Report No. cmr 16-017 Submitted to the Missouri Department of Transportation. Contract No. 110906. Missouri Department of Transportation, Kansas City, Missouri.

IEEE P1609.4/D08, IEEE P1609.4 Trial-use Standard for Wireless Access in Vehicular Environments (WAVE) - Multi-Channel Operation, Jul 2006

KITTI Vision Benchmark Suite, 2012 http://www.cvlibs.net/datasets/kitti/.

Put Information Center, 2007. Autodesk, San Rafael, California. http://www.putic.com/. Accessed September 25, 2018.

Sight Distance, 2018. Engineer Babu Lal. https://engineerbabulal.blogspot.com/2018/02/sight-distance.html. Accessed September 25, 2018.

Stanford Vehicle Data Set, 2018. http://ai.stanford.edu/~jkrause/cars/car_dataset.

The Hoosier Company Inc. The Range Tracker System. The Hoosier Company Inc., Indianapolis, Indiana. http://www.hoosierco.com/2e384292ad43b698645a108066d54bca.html. Accessed September 25, 2018.

TRB, 2018. Highway Capacity Manual. Transportation Research Board of the National Research Council, Washington, D.C.

What is Meant by a “Two-Lane” Road, 2018. English Language and Usage. Stack Exchange Inc., New York City, New York. https://english.stackexchange.com/questions/270607/what-is-meant-by-a-two-lane-road. Accessed September 25, 2018.

WYDOT Traffic Program, 2012. Pavement Marking Manual. Wyoming Department of Transportation, Cheyenne, Wyoming.