Monitoring of Illegal Removal of Road Barricades using Intelligent Transportation Systems in Connected and Non-Connected Environments

Technology Transfer Activities

by

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TECHNOLOGY TRANSFER ACTIVITIES

1 Summary of Research Study and Findings

This study aimed to propose smart monitoring and warning system to warn road users and emergency officials of the impending danger of the illegal removal of barricades. The proposed system utilized low-cost modules for effective monitoring and warning. This system considered both the non-connected environment when there is no interaction with other surrounding features and the connected environment where there is communication with the Roadside Units (RSUs) and On-Board Units (OBUs). In the non-connected environment, Wireless Fidelity (WiFi) offers smooth information sharing, and the Global Positioning System (GPS) module broadcast the geolocations for easy monitoring. In the connected environment the GPS module, the Radio Frequency (RF) modules, the RSUs, and OBUs communication frameworks were proposed. This system is expected to reduce traffic accidents and property damage. The following are the major summaries of this study:

In the non-connected environment part of the project:

1. Using a non-parametric data bootstrapping method, the low-cost GPS sensor's mean positional error was estimated to be *3.2 meters (10.5 feet)* and filtered out during geolocation and distance measurement.

2. The estimation of geofenced radius for alerting the public was estimated using the summation of three distances, the *Critical Safety Distance (CSD), the Stopping Sight Distance (SSD),* and *the Extra Buffer Distance (EBD).* The CSD was defined by the NSC as such that the final warning sign should be placed *25 feet* from the end-point of operation or traffic incident. The SSD is defined as the sum of the perception-reaction time distance and braking distance from AASHTO. The EBD was defined as the system-level performance requirements for TransGuide Intelligent Transportation System where the Dynamic Message Sign (DMS) updates. This geofenced radius was approximately *1.04 miles* estimated when the posted speed limit is at *70mph* and the provision of extra distance for the driver to decide on the alternative route.

3. Experimental GPS data from a clear sunny day showed the best response since the difference in barricade movements can be seen for *1m* and *2m* movements compared to the cloudy day where movements can't be easily explained. This might be caused by ionospheric effects where refraction and diffraction in the atmosphere change the apparent speed of satellite signals.

In the connected environment part of the project:

1. The proposed communication through the RF module is capable to be used in rural areas where GSM and GPRS system coverage is limited.
2. The system is capable to work with RSUs and OBUs to enhance communication in a limited connected environment.
3. The system offers secure communication between road users, emergency officials, and the barricade on site due to the presence of an encryption layer between the RF transmitter and RF receiver.
4. Safety for road users during barricades' illegal removal is assured at a low cost and property damages are reduced.

2 Outputs

At the end of the study, the research goals were accomplished. We are planning to disseminate research results through conference presentations and publish multiple journal articles shortly. Below is the outline plan to disseminate the research results.

2.1 Accomplished Outputs

C^2M^2 Report

Frank C. Ngeni; Judith L. Mwakalonge; Gurcan Gomert; and Saidi Siuhi (2022*). Monitoring of Illegal Removal of Road Barricades Using Intelligent Transportation Systems in Connected and Non-Connected Environments*. Center for Connected Multimodal Mobility (C^2M^2) Tier 1 University Transportation Center (UTC), USDOT.

Journal Article Submitted

The team submitted the paper titled " *Monitoring of Illegal Removal of Road Barricades Using Intelligent Transportation Systems*" to the *Journal of Intelligent Transportation Systems* for publication and is currently under review.

Conference Article Presentations

Ngeni, F., Mwakalonge, J.L., Gomert, G., Siuhi, S. " *Smart Monitoring of Illegal Removal of Road Barricades using Asset Tracking Technologies in Connected and Non-Connected Vehicles*", 5th Annual C^2M^2 Fall Conference, October 15, 2021, Clemson University, Clemson, SC

Ngeni, F., Mwakalonge, J.L., Gomert, G., Siuhi, S. " *Monitoring of Illegal Removal of Road Barricades in Connected Environment*", 6th Annual C^2M^2 Fall Conference, November 4th, 2022, University of South Carolina, Columbia, SC

2.2 Future Output

Peer-Reviewed Journal Article

Currently, we are planning to submit a paper titled "*Monitoring of Illegal Removal of Road Barricades in Connected Environment*" for publication.

Transportation Practitioners Comments

None

3 Outcomes

The research has produced the following important outcomes:

3.1 Alerting and Warning System for Emergency Officials and Road Users

The study proposed a low-cost alerting and warning system using the GPS module by setting it, correcting the positional error, and generating detection after a threshold distance equivalent to the smallest dimension of the car in the market has been exceeded. The barricade on-site continuously broadcast GPS positions and updates google maps through JavaScript APIs. Furthermore, the system alerts emergency officials first for impending danger, and once approved the officials warn road users within a geofenced area.

3.2 Roadside Units (RSUs) and On-Board Units (OBUs) Communication Framework

The study proposed the Radio Frequency (RF) communication system to alert on the illegal removal of road barricades and prepared the frameworks for the Roadside Units (RSUs) and On-Board Units (OBUs) communication. The secure communication was achieved using symmetric encryption in the transmitter at the barricade site and receiver at the monitoring station. Furthermore, a signature was embedded in the data packet transmitted to control the type of data transmitted. These data packet signatures were matched in the transmitter and receiver algorithms for the information received to be decrypted

4 Impacts

It is expected that this study will add an Intelligent Transportation System to the barricades for the safety of road users and reduce property damages due to illegal barricades' removal. Emergency officials are encouraged to use the algorithms for road asset monitoring to be simplified in real-time.