Estimating the Impacts of Automatic Emergency Braking (AEB) Technology on Traffic Energy and Emissions

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Project Objective

This project aims to develop a framework for quantifying the environmental sustainability due to the introduction of new-generation vehicle technologies. In this study, automatic emergency braking (AEB) system is selected as an example for in-depth analysis. Its effectiveness on the traffic system as a whole, especially in terms of energy consumption and tailpipe emissions, is evaluated as the results of mitigation of traffic accidents.

Problem Statement

Traffic congestion has brought about a variety of socio-economic issues to our daily lives. In particular, congestion caused by traffic accidents could be responsible for more than a half of the total travel delays in many urban cities, which is frustrating to the travelers due to its unexpected and undesirable consequence (e.g., late delivery, missed flights, delayed meeting schedule). In addition, the induced energy waste and excessive tailpipe emissions as well as the associated losses of productivity and quality of life put much heavier burden to our society.

As one of the key advances in vehicle safety, AEB has been introduced in the U.S. approximately a decade ago and the number of vehicles equipped with this technology has increased significantly. There have been numerous studies indicating that this technology is capable of reducing the number and/or severity of relevant crashes and has helped to reduce the number of traffic fatalities. However, most of these studies have evaluated this technology at the individual vehicle level, but not the subsequent impacts of energy consumption and tailpipe emissions along the upstream of traffic flow. To address this gap, the research team proposes to access the environmental influence of AEB technology from the traffic operation perspective.

Research Methodology

In this study, we develop an innovative framework and approach to quantifying the environmental benefits of AEB system. Firstly, based on the review of AEB-related literature, we get more in-depth understanding of the accidents that can be prevented by AEB system. Then, we create an integrated database by synchronizing (in both space and time) the archived traffic accident records (e.g., Highway Safety Information System), real-world traffic data (e.g., Caltrans Performance Measurement System), roadway geometry, as well as weather information. The database also differentiates traffic measurements and other information during the periods with or without occurrences of accident. By leveraging this database and advanced machine learning techniques, we: 1) estimate the spatiotemporal extent of traffic accident impact (in terms of the change in speed) using the Otsu's method and morphological operations; 2) apply the Long Short-Term Memory (LSTM) model to predict the "accident-free" (i.e., "what-if" scenarios) traffic states under the prevailing traffic conditions; and 3) assess the environmental impacts induced by the deployment of AEB technology with the U.S Environmental Protection Agency's MOtor Vehicular Emission Simulator (MOVES) model. Figure 1 illustrates the proposed methodology flow.

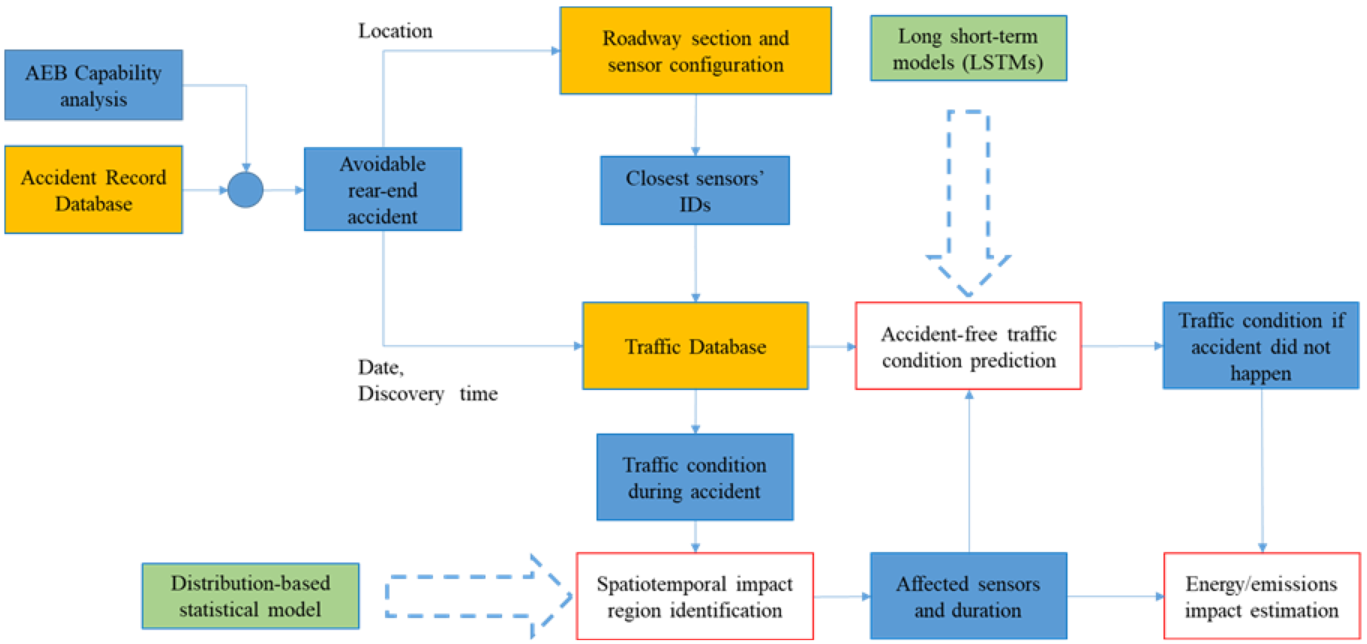

Figure 1. Overall Flowchart of the Proposed Methodology.

Results

We conduct case study with two real-world scenarios (and different data sources), one in Riverside, CA and the other in Las Vegas, NV, to validate the proposed approach. The results show that the AEB technology could improve energy consumption by up to 34.6% and reduce pollutant emissions (such as CO, HC, NOx and PM) by as much as 22.5%, if it were adopted in the accident-involved vehicles and could effectively avoid the studied accidents. More details for these two cases are shown in Table 1.

Table 1. Estimated Environmental Impacts of AEB Technology (If Adopted) on Example Scenarios

Case	Scenario	CO(g)	HC(g)	NOx(g)	PM2.5_Ele(g)	PM2.5_Org(g)	Energy(KJ)	CO2(g)	Fuel(g)
Riverside, CA	Actual	12.14	0.117	0.55	0.008	0.04	107296	7634	2391
	If AEB Applied	10.00	0.115	0.71	0.007	0.03	91213	6490	2032
	Reduction (%)	17.6	1.7	-28.3	12.5	16.7	15.0	15.0	15.0
Las Vegas, NV	Actual	36.92	0.31	1.14	0.024	0.11	378107	26902	8425
	If AEB Applied	28.62	0.30	1.51	0.02	0.09	247451	17606	5514
	Reduction (%)	22.5	4.1	-32.1	16.7	17.4	34.6	34.6	34.6