New England University Transportation Center
77 Massachusetts Avenue, E40-279
Cambridge, MA 02139
617.253.0753
utc.mit.edu

Year 24 Final Report

Grant Number: DTRT12-G-UTC01

Project Title:

Modeling Drivers' Lateral Motion Control

Project Number:	Project End Date:	Submission Date:
UMAR24-24	8/31/15	12/31/15

Principal Investigator:	Daiheng Ni	**Co-Principal Investigator:**	
Title:	Associate Professor	**Title:**	
University:	University of Massachusetts/Amherst	**University:**	
Email:	ni@engin.umass.edu	**Email:**	
Phone:	413.545.5408	**Phone:**	

Vehicle lateral motion including lane change, merging, and turning is a major contributor to traffic accidents. Realistic modeling of drivers' lateral motion control can not only improve our understanding of the mechanisms that trigger these accidents but also permit the design of advanced systems that are capable of warning drivers of potential hazard during lateral movements. Departing from conventional, descriptive approach to modeling vehicle lateral motion which fits statistical models to field data, this research takes an explanatory approach by capturing the mechanism that underlies drivers' lateral motion control. A clear understanding of what factors are involved in driver lateral control and how these factors function in driver decision-making will lead to the formulation of Lateral Control Model. This model incorporates lane changing and gap acceptance decisions into a single model and applies to both highways and intersections. This research responds to the Grant Theme of Safety. In particular the research focused on not only human factors research as it relates to elderly drivers but also technology-related research which leads to better traffic simulators and on-board lateral collision warning systems.

Central to effective roadway design is the ability to understand how drivers behave as they traverse a segment of roadway. While simple and complex microscopic models have been used over the years to analyze driver behavior, most models: 1.) incorporate separate car following and lane-changing algorithms, and thus do not capture the interdependencies between lane-changing and car-following vehicle; 2.) do not capture differences in the drivers' cognitive and physical characteristics; and 3.) are constructed from observed vehicle movements and make no attempt to model the discrete differences between how each roadway element alters each driver's behavior.

This research employs a modified field theory to construct a conceptual framework for a new microscopic model. In field theory, an agent (e.g. the driver) views a field (i.e. the area surrounding the vehicle) filled with stimuli and perceives forces associated with each stimuli once these stimuli are internalized, see Figure 1. Based on this theory, the resulting model would be designed to directly incorporate drivers' perceptions to roadway stimuli along with vehicle movements for drivers of different cognitive and physical abilities. It is postulated that such a model would more effectively reflect reality, and if this model were accurately calibrated, could potentially model the effects of external stimuli such as innovative geometric configurations, lane closures, and technology applications such as variable message boards.

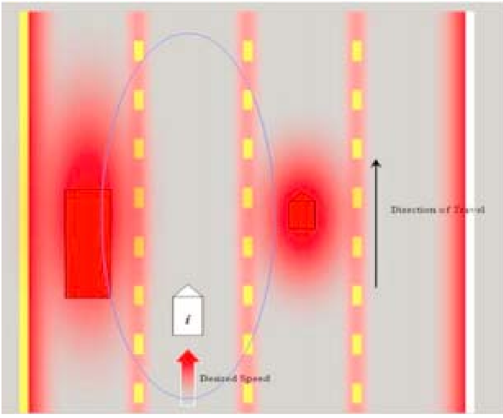

Figure 1. An example field perceived by a driver

In Figure 1, the perception bubble represents the visual field of each driver. When a roadway stimulant enters the perception bubble, the forces associated with the stimulant are perceived by the driver. Portions of the perception bubble update, to include presence and location of observed stimuli, depending on the locations and frequencies within the bubble that each driver scans (i.e. a driver that checks their blind spot twice every 10 seconds will have a 'refresh rate' of once every 5 seconds for that location). As the driver continues, his or her perception bubble is dynamically updated as new stimulants enter and active ones exit. The perception bubble can change size and shape. Elements that might affect the size and shape of a perception bubble include: driver speed (may scan further down a roadway when traveling at higher speeds), vehicle type (i.e. blind spots), driver characteristics (i.e. older drivers have different scanning patterns and frequencies in intersections), and elements present in the driving environment (i.e. zebra stripped crosswalks or pedestrian crossing signage might cause a driver to slow down and scan the side of a roadway more frequently for pedestrians).

By including all stimuli affecting the driver, modified field theory can show a driver's cumulative response to roadway stimuli, whereas other models describe individual aspects of how a driver behaves. Complex situations with multiple roadway stimuli could be modeled and analyzed because the force fields allow for an "apples to apples" comparison regarding the impacts of each stimulus on the driver. Additional stimuli can be added to the model by simply calibrating the forces associated with them, making modified field theory expandable and easily "updateable" as we learn more about agent-based vehicle movements and develop new innovative geometric design and roadway elements.

The modified field theory could be applied to model and address numerous current issues in traffic. Because the model structure is rooted in sound psychological theories, applying the model to various driver types, driving scenarios, and even capturing additional stimuli would require a simple calibration of additional stimuli (and any behaviors these stimuli might provoke). Elaborated below are a few implementation examples.

1. Incorporation of Roadway Elements such as ITS Solutions. An optimal microscopic model should be capable of modeling ITS technologies and corridor and network management strategies with little to no changes in the actual model structure. Calibrating, assessing, and adding the impacts of new technologies (ITS), design elements (such as adjusting taper length or modifying signage), and other traffic management strategies can be achieved in modified field theory without changing the underlying model structure by calibrating the effects of each element on drivers (such as a perceived force or adjustments to scanning patterns) and adding the element to the model. The model structure of field theory has a driver perceiving a stimulant and then reacting to the perceived force, which makes adding new stimulants (such as a different pavement marking, or new ITS technology) to the model simple.

2. Modeling Compromised Driving, Recent studies indicate that distracted and compromised drivers negatively impact traffic flow, creating delays and adding to congestion. Distracted and intoxicated drivers can be modeled by altering the perception bubble of these drivers based on roadway scanning habits and frequencies. Distracted drivers don't observe roadway hazards as often as they should because of their distraction, causing a delay in reaction time. By slowing down how often the perception bubble updates, you could create a situation where the distracted driver might react to a stimuli when it's very close, causing the driver to make an evasive maneuver (such as slamming on the brakes or veering into another lane), much like we can observe in the field. The impacts of distractions can be calibrated and added in to modified field theory, and the impacts of distracted drivers on traffic flow could be predicted. A driver's frustration, or road rage, can be predicted and modeled in modified field theory. A driver surrounded by stimuli and forces who cannot remove himself from the situation will experience "pressure" from these forces, exerted over a prolonged period of time. If properly calibrated, this pressure felt over time could help predict locations or areas where drivers feel uncomfortable or may succumb to road rage. In this way, modified field theory can predict instances where road rage can be provoked, and if certain work zone set-ups will create areas, either in the merge or the queue, where road rage could occur. This, theoretically, could allow engineers to avoid creating set-ups that create excessive instances of road rage.

3. Modeling the Impacts of a Work Zone. Some freeway work zones close one lane at a time. The lane closure forces vehicles traveling in the closed lane to merge onto an available lane prior to the start of the taper zone. Some vehicles merge immediately, whereas others wait until they cannot travel an further without merging. To model the lane closure, a work zone force will be added in the lane that is closing, forcing vehicles traveling in the closing lane to merge to another lane.

Web links:
http://ntl.bts.gov/lib/51000/51900/51944/Berthaume_Towards_social_psychology-based.pdf