Use of Driving Simulators to Investigate Driving Behavior

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Background

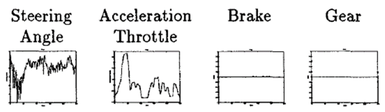
Driving is inherently risky, and is an inescapable daily task for the majority of adults. A 2014 FHWA survey indicates that there are 214 million licensed in the United States. [1] A great deal of the risk comes from how drivers perceive and react to different phenomenon on the road, broadly known as **Driving Behavior**. Attempts to understand these behaviors and model them with equations and measures are ongoing by transportation researchers and officials. This study contributes to categorizing potential driving behaviors of concern, and how these behaviors can be parameterized for study.

Why Driving Simulator?

- Driving simulator based studies are relatively less expensive than field-test based studies
- Test environment is safe
- Additional visual or vestibular cues can be added according to experiment design to study specific behaviors
- Studying human factors using driving simulator has gained popularity and is validated by several researches[2]
- Availability of high fidelity driving simulators

Control

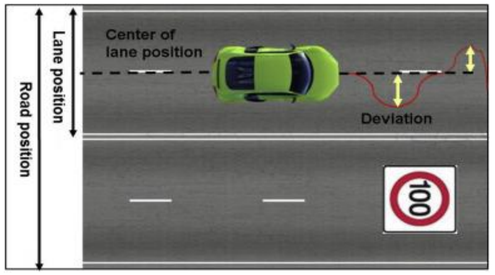
Category	Parameter in Simulator	Additional Device
Vehicle Control	Visual Behavior Tracking [3] Braking Behavior [4]	Eye Tracking Device
Steering Control	Reaction time to initiate action [5] Steering Angle Spectrum [6]	-- Steering Sensor
Speed Control	Speed/Mean speed data [7]	--



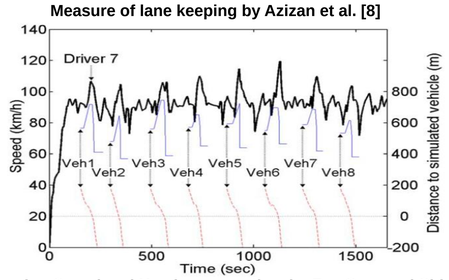
Measuring Steering Angle and Acceleration Throttle by Oliver and Pentland [6]

Guidance

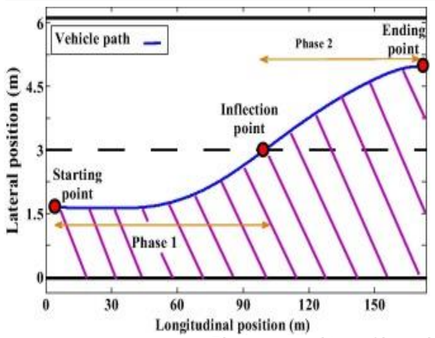
Category	Parameter in Simulator
Safe Path Maintenance	Lateral positioning[8]
Car-following Behavior	Headway over time Gas to brake pedal application ratio [9] Reaction to existing traffic Use of directional indicators [10]
Passing Maneuvers	Trajectory of passed-passing-opposing vehicles Subjective evaluation or rating [11] Speed-acceleration-headway data [12]
Merging Behavior	Vehicle trajectory mapping [13] Before-after speed Movement time Accepted gap time [14]
Lance Changing	Position vector of vehicle [15] Longitudinal and lateral acceleration Headway Time taken to start action [16]
Response to Traffic Control Device	Speed variation Point location of first action in closed loop Variance in acceleration [17]
Avoidance of Pedestrian	Steering rotation time and behavior [18]

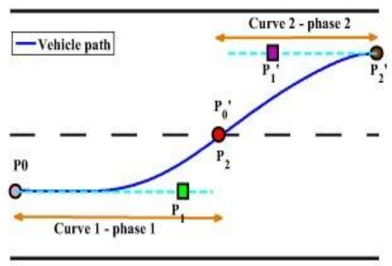


Measure of lane keeping by Azizan et al. [8]

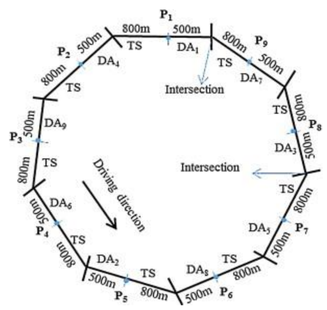


Measuring Speed and Headway over time by Bar-Gera and Shiner [12]





Phase one and two of lane changing by Tehran et al. [15]



A closed-loop route example used by Zhao et. al 2015 [17]

Navigation

Category	Parameter in Simulator
Trip Planning	Visual and auditory cues Interview and survey [19]
Route Following	Following predesigned route No. of abrupt movement [20]

Simulator Sickness

Simulator sickness (SS) is a concern for simulator based research studies. Due to parallax and binocular gap between real driving and simulator, motion sickness is inevitable. In rare occasions drivers report headache, dry mouth, dizziness and disorientation. Including simulator sickness in experimental design is important for validation of simulator based studies. Typically, simulator sickness issues are resolved by practice run before actual experiment and experience is gathered by survey.

State of the Practice Equipment

Four simulator hardware options were studied and compared for this publication. Detailed comparison can be found in conference proceedings. Following are the four simulators discussed.

- Virage Simulator Model VS300 and VS500
- STISIM Drive
- Realtime Technologies Inc. Simulator
- MiniSim Driving Simulator

Features	Virage	STISIM	RTI	NADS-MiniSim
Base	Fixed base	Fixed base	Low fidelity 3 or 6 DOF	Fixed base
Arrangement	Actual quarter Car	Actual half or quarter Car	Actual quarter Car	Desktop setup
Immersion Standard	Fully immersive	Fully immersive	Partially immersive	Partially immersive
Scenario Control	Possible with the help of producer	SDL Tool	SimVista	ISAT
Field of View	180˚	135˚	180˚	180˚
Blind Spot Locator	Yes	No	No	No
Motion Sensitivity	Vibration Sensor	No	Steering overload	Tactile seat
Proven Validity	Training	Clinical Study Human Factor	None found	Transportation Research Clinical Study Training

Poster Figure Citations

[8] A. Azizan, M. Fard, M. F. Azari, and R. Jazar, "Effects of vibration on occupant driving performance under simulated driving conditions," *Appl. Ergon.*, vol. 60, pp. 348–355, 2017.
[12] H. Bar-Gera and D. Shinar, "The tendency of drivers to pass other vehicles," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 8, no. 6, pp. 429–439, 2005.
[15] D. Sadeghi Tehran, A. Nahvi, M. Hajirasouli, H. Naseri, K. Lotfi, and M. Niknejad, "Effects of stimulant and opiate drugs on driver behavior during lane change in a driving simulator," *Travel Behav. Soc.*, vol. 4, pp. 69–78, 2016.
[17] X. Zhao, J. Li, H. Ding, G. Zhang, and J. Rong, "A generic approach for examining the effectiveness of traffic control devices in school zones," *Accid. Anal. Prev.*, vol. 82, pp. 134–142, 2015.

Reference

A. Ahmed and J. Sangster, "Use of Driving Simulators to Investigate Driving Behavior: Literature Review and Design of Experiments," in *5th Urban Streets Symposium*, 2017.