Bicycling Simulator Calibration: A Proposed Framework

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1 INTRODUCTION

Bicycle simulation allows for the careful examination of bicyclist behavior and interaction with various elements in the built environment in a controlled experimental setting. Novel or existing infrastructure can be analyzed to determine the effectiveness of traffic control devices, or the interaction between conflicting modes of travel can be evaluated with surrogate safety measures to better understand crash risk. Distributed simulation between a bicycling and a driving simulator at Oregon State University also allows for real-time evaluation of the interaction between an actual driver and bicyclist. The controlled and repeatable nature of simulator experimentation provides a means to develop explanatory mechanisms for user behavior, which is difficult to extract from real world experiments (1). A simulated environment also provides significant risk reduction for participants, who can be exposed to risky scenarios while avoiding potential harm (2).

Our ability to extrapolate the conclusions from simulation studies to real world practice requires particular attention to calibration, determining the accuracy of measurements, and validation, matching simulation performance to real world performance. Simulated environments may not yet be able to emulate every nuance of real world experiences, but as the focus is human factors and user performance, it is sufficient to create an environment where users respond in a way that is similar to the real world environment (1). This relative validity means users are responding in the same direction or magnitude as the real world, but does not include absolute validity, where the simulation response is identical to the real world response (2). In fact, reducing some of the variability that is experienced in the real world contributes to the power of simulation in controlled experiments, as almost all of the environmental factors are administered. However, due to the limited number of bicycle simulators worldwide, the results from bicycle simulators have been considered less rigorous than similar results from more mature field of driving simulation (3).

2 CALIBRATION PROCEDURE

Calibrating each of the inputs, wheel speed and handlebar latency, between the real world and virtual bicycling will increase the validity of a bicycling simulator.

2.1 Wheel Speed

Calibration of the wheel speed is achieved through an independent bike computer, which calculates the physical speed of the wheel based on the size of the wheel and a spinning magnet attached to a spoke as shown in Figure 1. Speed data from the bike computer is exported and compared to the speed data recorded by the simulation computer as shown in Figure 2. The simulation software multiplies the input rotational speed by a gain factor to calculate the simulated speed of the bicycle. This gain factor is adjusted to minimize the difference between the observed bike computer speed and the simulated bicycle speed.

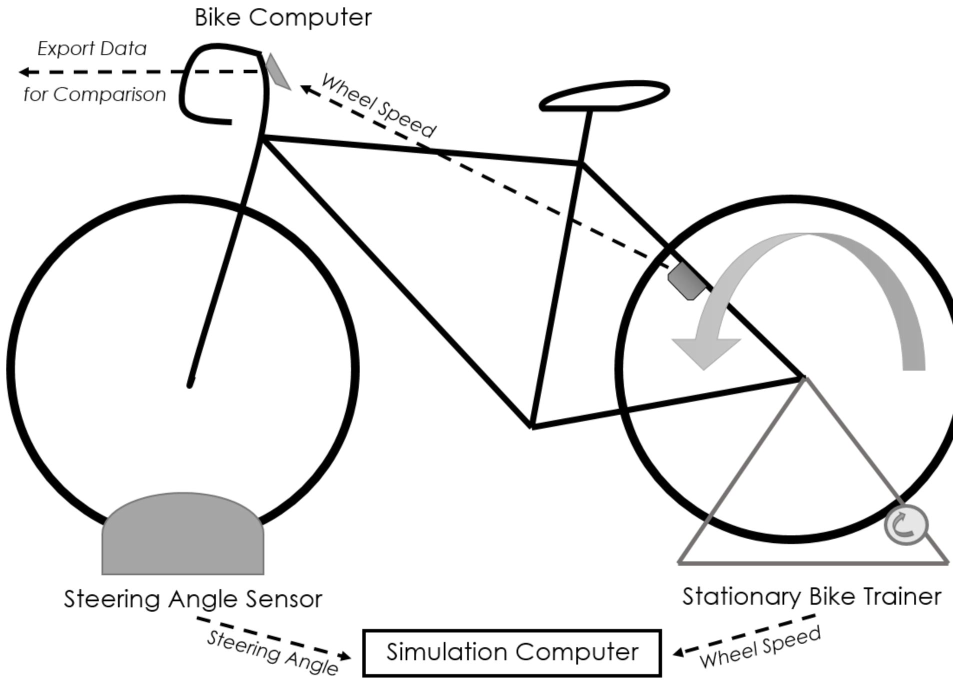

Figure 1: Wheel Speed Calibration Diagram

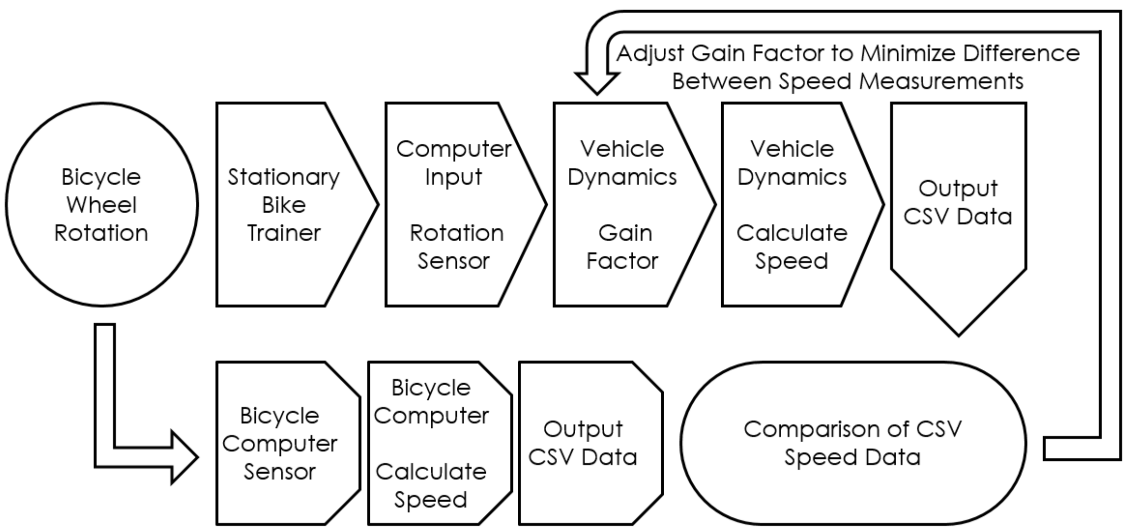

Figure 2: Wheel Speed Calibration Flowchart

2.2 Handlebar Latency

Latency is the time delay between an input stimulus and an observable system response. High latency can contribute to simulator sickness, as there is too much delay between a user's input and the system response compared to a real world system where physics provides extremely responsive feedback. Figure 3 shows how latency can be observed in the bicycle simulator. A video camera recorded both the handlebars and visual field. The first observable movement of the handlebars initiates the latency time interval. A count of video frames until the visual field responses with lateral movement multiplied by the framerate provides the latency time. The vehicle dynamics package can then be optimized to minimize the amount of latency time observed.

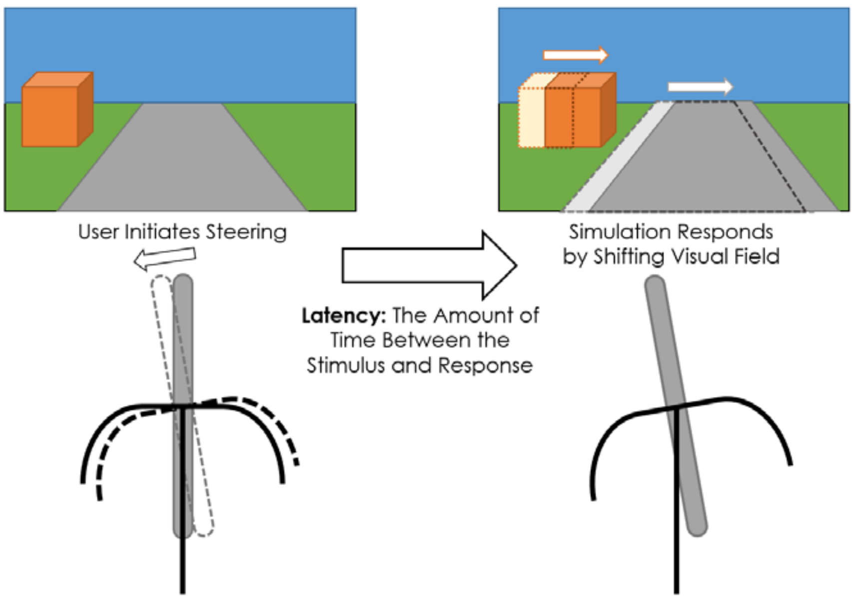

Figure 3: Handlebar Latency Diagram

3 CONCLUSIONS

Bicycle simulator studies provide an experimental framework to evaluate novel and existing infrastructure and human factors while controlling for environmental factors and reducing potential harm to participants. Calibrating the inputs of the bicycle simulator will improve the validity of experimental results. The calculated speed of the rear wheel was compared to an independent speed observation from a bike computer to minimize the difference between the measurements. Observing video of the handlebars and the forward visual display can be used to calculate the latency. Minimizing latency and calibrating the speed improves user interaction with the simulator by reducing potential occurrence of simulator sickness and can improve the fidelity of the simulated bicycling experience.

REFERENCES

[1] S. Hern, J. Oxley, M. Stevenson, "Validation of a bicycle simulator for road safety research", *Accident Analysis & Prevention* Vol. 100 (2017), pp. 53-58. http://dx.doi.org/10.1016/j.aap.2017.01.002

[2] N. Kaptein, J. Theeuwes, R. Van Der Horst, "Driving simulator validity: Some considerations" Transportation Research Record, Transportation Research Board, 1550 (1996), pp. 30-36

[3] L. Nehaoua, H. Arioui, S. Mammar, "Review on single track vehicle and motorcycle simulators" 19th Mediterranean Conference on Control and Automation, Corfu, Greece, 20-23 June, 2011, pp. 940-945