Calibration and Validation of a Bicycle Simulator using Real Bicycle Trajectories

Master's Thesis of Abul Azeem

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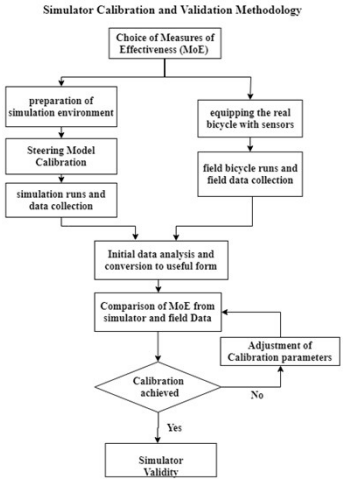
Objectives:

- Literature Review
- Calibration and Validation Methodology Development
- Bicycle sensor selection and instrumentation
- Data collection from real bicycle and simulator
- Comparison of Real bicycle and simulator trajectories
- Improvement of two road environments (Urban Arterial & Signalized Intersection)
- Optimization of bicycle simulator



Calibration Parameters (adjustment)

Lane Alignment (SUMO)

Change of Lane Alignment to "***right***" to allow the participant to *overtake* other *cyclists*

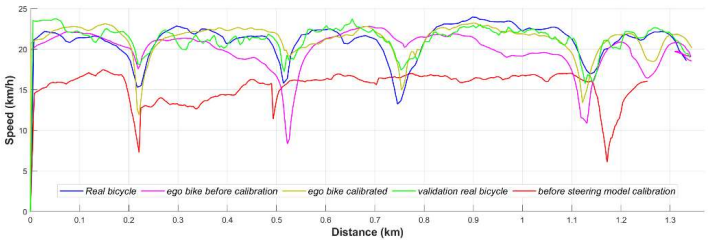
Randomness (SUMO)

Using "***Random seed values***" at every simulation run to bring closer to reality

Speed Sensor Calibration

Adjusting "***multiplication factor***" of speed sensor value to SIMULINK model to get higher speeds

Comparsion of the Speed trajectories before and after calibration



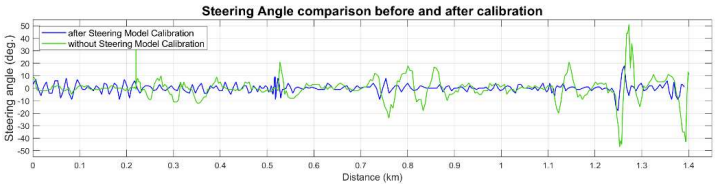
Selected Parameters to be Studied

- Operational Speed (*Measure of Effectiveness* for Calibration)
- Steering angle
- Lateral position of bicycle and impact of parked vehicles
- Travel time

Steering Model Calibration

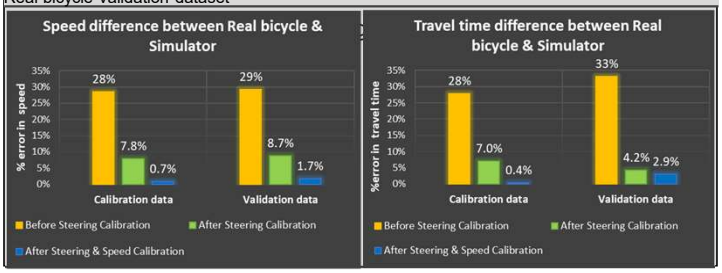
"*Single Track Model*" was Modified to use for a bicycle as vehicle. Omission of forces acting on cars to model bicycle Speed and lateral dynamics more realistically. Steering more responsive after Calibration.

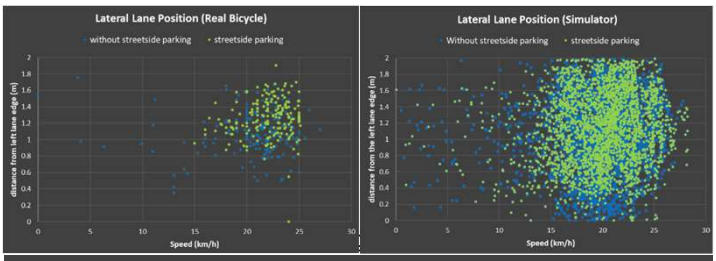
Steering Angle comparison before and after calibration



Mean Trajectory Values for Real Bicycle and Simulator

Parameter	Sample size	Speed (km/h)		Travel Time (sec)	
		Mean	std. deviation	Mean	std. deviation
Simulator (No steering Calibration)	-	15.11	-	297.00	-
Real bicycle	18	21.11	0.693	217.34	8.336
Simulator before (speed) calibration	24	19.47	0.897	232.46	11.391
simulator after calibration	14	20.96	1.374	216.57	14.460
Real bicycle validation dataset	7	21.32	0.588	223.14	6.770





Correlation between distance from the left lane edge with speed and parking

	Real Bicycle Results		Simulator Results	
	parking	Speed	parking	Speed
R-values	0.3479	0.1169	0.0876	0.093
p-values	5.04E-12	0.024	6.27E-12	2.85E-13

Lateral distance from left lane edge

No strong impact of parked vehicles on the lane position. Means of both datasets (real bicycle & simulator) are statistically the same.

* Ego bike = Simulator bicycle

Conclusions:

- There has been found a very weak but significant correlation between the distance of the real bicycle and simulator bike from the left lane edge and the presence of parked vehicle in parking lane.
- The steering of the bicycle highly affects the operational speeds.
- Introducing random seed to the simulation scenario gives high variability for the average trajectory speeds and travel times.

Recommendations:

- It is recommended for the future studies to get higher data sample size.
- In future studies participants of all age group and genders should be included to better study the validity of the simulator for general behavioral studies.
- It is recommended to study the overtaking behavior of participants in future studies.
- Using high frequency data logging techniques in future studies (CV cameras) could be used to study and calibrate acceleration and deceleration regions of trajectories.