Investigating the Effectiveness of Eco-Speed Control System in the Vicinity of Signalized Intersections using a Driving Simulator

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Snapshot of driving simulator environment

Introduction

Introduction

- Vehicle energy consumption levels in the vicinity of signalized intersections are dramatically increased as a result of vehicles decelerating and accelerating.
- Researchers have attempted to develop eco-driving strategies with the goal of improving fuel efficiency.
- One such application is Eco-Speed Control (ESC).
- ESC optimize individual vehicle fuel consumption levels by recommending fuel-efficient trajectories through intersections.

Introduction

- The provision of information in the signalized intersection would help the driver to pass through the intersection with a suitable speed instead of rapid acceleration and deceleration.
- Matsumoto & Peng (2015) provided different information regarding the speed with which drivers passed through a signalized intersection while following the recommended speed.

Introduction

- Eco-driving was developed by the different researchers to assist drivers with the recommended speed (H. Xia, K. Boriboonsomsin, and M. Barth,2013).
- Yang et al. concluded that the eco-cooperative adaptive cruise control (Eco-CACC) results in vehicle fuel savings of up to 40%.

Driving Simulator

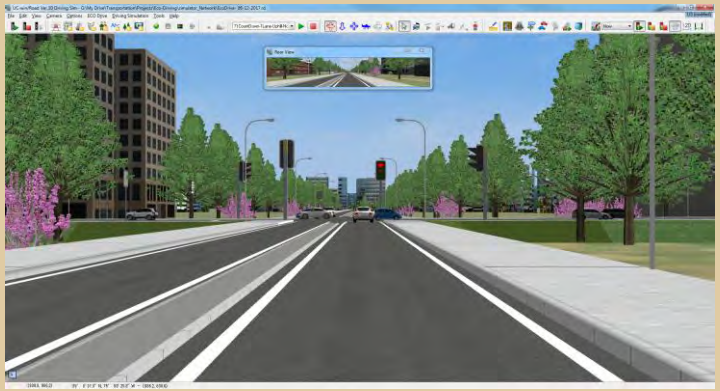
Data Collection

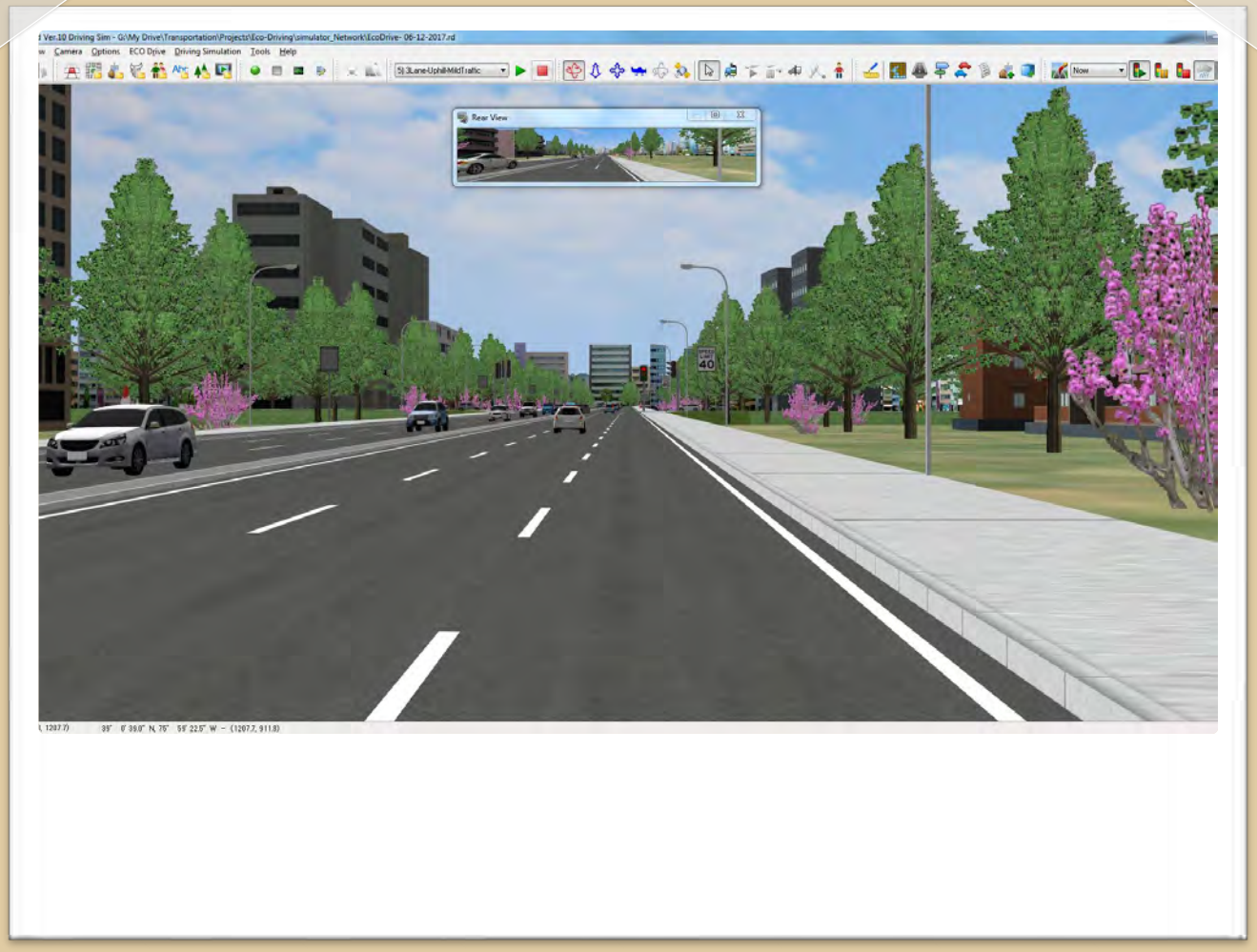
Data Collection

- This study implements the ESC system in the full-scale 3D driving simulator (DS) with VR-Design Studio software provided by Froum8 company to study drivers' behavior in the vicinity of a signalized intersection in the presence of speed guidance.

Data Collection

Scenario	Information Type	Traffic Type	Road condition	Number of lane
1	No Information	No Traffic	Uphill	1 lane
2	Eco- Speed	No Traffic	Uphill	1 lane
3	Eco- Speed	No Traffic	Downhill	1 lane
4	Eco- Speed.	Mid Traffic	Uphill	1 lane
5	Eco- Speed	Mid Traffic	Downhill	1 lane
6	Eco- Speed	Mid Traffic	Uphill	3 lanes
7	Eco- Speed	Mid Traffic	Downhill	3 lanes
8	Countdown	No Traffic	Uphill	1 lanes
9	Countdown	No Traffic	Downhill	1 lanes





Result

Result

Age	
18-25	35%
26-35	40%
36-45	10%
46-55	3%
56-65	10%
>65	2%

Gender	
Male	64%
Female	36%

Work Status	
Unemployed	28%
Work part-time	38%
Work full-time	34%

Household Size	
1	28%
2	24%
3	22%
≥ 4	26%

Education level	
High school or less	29%
Associate degree	21%
Bachelor's degree	29%
Post-graduate	21%

Income Level	
No answer	17%
< $20K	19%
$20K- $30K	12%
$30K- $50K	21%
$50K- $75K	14%
$75K- $100K	10%
> $100K	7%

Result

Panel A. Between Gender and Following Speed

Variable	N	Mean	Std. Dev.	t-statistic	Sig. (2-tailed)
Males who follow the recommended speed	295	50.997%	25.1629%	2.527	.012
Females who follow the recommended speed	173	44.817%	26.1589%	2.502	.013

Panel B. Between Age and Following Speed

Variable	N	Mean	Std. Dev.	t-statistic	Sig. (2-tailed)
Greater than 45-year-old people who follow the recommended speed	71	40.637%	19.9958%	-2.9	.004
less than 45-year-old people who follow the recommended speed	397	50.157%	26.3316%	-3.505	.001

Result

Panel A. Comparison Between Base Scenario and Scenario 2

Variable	N	Mean	Std. Dev.	t-statistic	Sig. (2-tailed)
CO2 Emissions in base Scenario	23	108.309	18.694	3.012	.003
CO2 Emissions in Scenario 2	58	97.151	13.355	2.610	.014

Panel B. Comparison Between Base Scenario and Scenario 8

Variable	N	Mean	Std. Dev.	t-statistic	Sig. (2-tailed)
CO2 Emissions in base Scenario	23	108.309	18.694	.803	.425
CO2 Emissions in Scenario 8	56	103.998	22.768	.872	.387

Result

Comparison Between ESC' Scenarios and Countdown 'Scenarios

Variable	N	Mean	Std. Dev.	t-statistic	Sig. (2-tailed)
CO2 Emissions in ESC' scenarios	116	75.97	25.06	-2.041	.042
CO2 Emissions in Countdown' scenarios	110	83.63	31.12	-2.030	.044

Comparison Between ESC' Scenarios with No Traffic and ESC' Scenarios with Mild Traffic

Variable	N	Mean	Std. Dev.	t-statistic	Sig. (2-tailed)
CO2 Emissions in ESC'scenarios with no traffic	116	75.97	25.08	-1.695	.092
CO2 Emissions in ESC'scenarios with mild traffic	109	81.56	24.35	-1.696	.091

Comparison Between ESC' Scenarios with 1 lane and ESC' Scenarios with 3 lanes

Variable	N	Mean	Std. Dev.	t-statistic	Sig. (2-tailed)
CO2 Emissions in ESC' scenarios with 1 lane	109	81.56	24.35	8.290	.000
CO2 Emissions in ESC' scenarios with 3 lanes	110	53.66	25.42	8.292	.000

Result

Results for the regression of Emission level on following recommended speed and vehicle speed variance (Uphill Scenarios)

Variable	B	Sig. (2-tailed)
Intercept	96.402	.000
Following the recommended speed	-.252	.000
Vehicle speed variance	.155	0.000

Adjusted R Square: .576

Results for the regression of CO2 Emission on following recommended speed and vehicle speed variance (Downhill Scenarios)

Variable	B	Sig. (2-tailed)
Intercept	50.886	.000
Following the recommended speed	-.203	.000
Vehicle speed variance	.195	.000

Adjusted R Square: .653

Conclusion

Conclusion

- A sample of 58 participants took part in driving simulator experiments.
- Males followed the recommended speed 6.2 percent more than females.
- Younger participants followed the speed recommendations 9.6 percent more than did people in the older age groups.
- the ESC system reduces the emission by 10.2 percent for the whole trip.
- the ESC system reduces the emission by 9.1 percent in comparison with countdown timing.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