REPORT OF RESEARCH RESULTS

MSIWF Research Grant 2014

a) Project title

Estimating safety effects of Green-Man Countdown Devices (GMCD) at signalized pedestrian crosswalk based on Cellular Automata (CA)

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c) Summary

The effects of Green-Man Countdown Device (GMCD) at signalized pedestrian crosswalk are evaluated. Pedestrian behavior at crosswalk without and with GMCD are observed and analyzed. A micro-simulation model is developed based on field observations to estimate safety performance. Simulation outputs allow analysts to assess the impacts of GMCD at various signalized crosswalks with different geometric layout, traffic and pedestrian volumes, and the green time. According to simulation results, GMCD increases average walking velocity in all scenarios with different pedestrian and vehicle volumes, especially during the last few seconds. The installation of GMCD improves safety performance generally, especially at more crowded pedestrian crossings. Conflict severity is increased during last 10s after GMCD installation. The findings are useful in helping engineers and authorities decide when to install GMCD at the signalized crosswalk.

d) Aim of Research

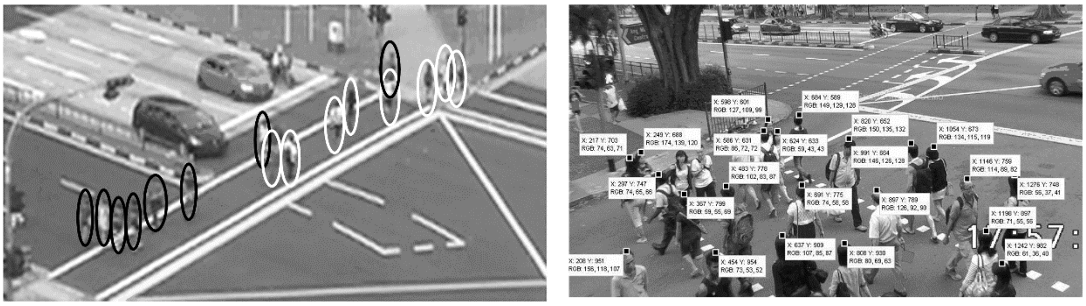
For an urban environment as Singapore, conflicts between pedestrians and vehicles occur frequently at the signalized pedestrian crosswalks. There are more than 1,400 signalized road intersections in Singapore, most with pedestrian crosswalks.

Firstly, the study estimates quantitative safety impacts of GMCD under various traffic conditions. The relationship among safety performance, GMCD and traffic conditions is studied. Simulation results are able to help authorities on making decisions about the installation of GMCD to improve safety level of signalized pedestrian crosswalk. Apart from installation of GMCD, the proposed simulation model is able to estimate safety performance of a certain design. As the design of signalized pedestrian crosswalk entails combination of control strategies under dynamic conditions, a micro-simulation model provides a quick and user-friendly tool to estimate conflict occurrences. Whereas conventional approach relies on historical crash data (which requires adequate accident counts, hence lengthy occurrence period, for numerical stability), the proposed approach simulates traffic movements and, for safety assessment application, generates severity-graded traffic conflicts as the performance indicator.

e) Method of Research & Progression

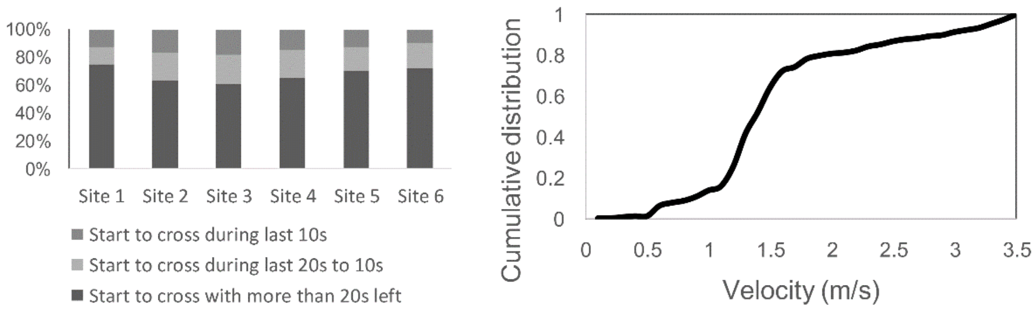
Field observations are conducted at 6 pedestrian crosswalks in Singapore with similar geometrical layouts and same vehicular signal sequences. Each pedestrian crossing is 3m in width, 22-28m in length and green- man time ranges from 21s to 28s. Among the 6 survey sites, 3 are installed with GMCD. There are no traffic red-light cameras (RLCs) at these intersections. The field observations were made on 6:00-7:00 pm peak hour during weekdays. Two pedestrian tracking approaches, namely automated image processing and computer-aided manual tracking, are applied in this study to collect pedestrian's positions, velocities and forwarding directions, as shown in Figures 1a and 1b. Movement characteristics in simulation, including desired velocity, maximum velocity, maximum acceleration and deceleration rates, and minimum gap between road users, are calibrated based on these field observations. Proportions of pedestrians starting to cross and cumulative distribution of crossing velocity are shown in Figure 2.

In this study, CA model is established to simulate a typical cross-intersection with pedestrian crosswalks. The safety performance is modeled in terms of occurrence of conflict between hybrid objects (pedestrian versus vehicle) which is recorded as the occurrence of deceleration caused by the other vehicle/pedestrian. Details of the proposed CA model can be found in attached journal manuscripts.



(a) Automatic tracking (b) Computer-aided manual tracking

Figure 1 Validation of pedestrian tracking methods



(a) Proportions of pedestrians starting to cross (b) Cumulative distribution of crossing velocity (Site 1)

Figure 2 Observed pedestrian distribution

f) Results of Research

To produce generalized safety impact of GMCD, various simulation scenarios were designed to provide vehicle movements and conflicts at pedestrian crosswalks without and those with GMCD. Geometric layout and signal timings of simulated crosswalk are shown as Figures 3a and 3b. Cycle length of case intersection is 100s, with 30s for vehicular straight-through green phase with permissive right-turn and 20s of exclusive right-turn phase for each approach. Four scenarios with different pedestrian vehicle volumes are created for pedestrian crosswalks both without and with GMCD, as shown in Table 1. The simulation ran for 1 hour. Outputs were calculated according to average results of 5 runs. The impact of GMCD at different traffic conditions can be summarized in Table 1. Findings are summarized as follows:

1) Effect of GMCD on average walking velocity

GMCD increases average walking velocity in all the 4 scenarios. This is consistent with previous studies. The impact is more obvious on average velocity at last 10s of green-man signal. Furthermore, when pedestrian volume is higher (Scenarios 3 and 4), the effect of GMCD is reduced, as walking velocity is also much affected by neighboring pedestrians when density increases.

2) Effect of GMCD on pedestrians starting to cross within last 10s

According to simulation results, in most scenarios, compared with non-GMCD crosswalk, a lower proportion of the crossing pedestrians would cross during the last 10s at GMCD crosswalk, especially when vehicle volume is higher. However, in Scenario 3, when pedestrian volume is high and vehicle volume is low, a higher proportion of pedestrians cross during the last 10s at GMCD crosswalk.

Table 1 Simulation outputs

Statistics		Scenarios				**Overall**
		1	2	3	4	
Pedestrian volume (ped/h)		100	100	300	300	
Vehicle volume (straight-through) (veh/h/lane)		50	100	50	100	
Vehicle volume (left-turn) (veh/h/lane)		25	50	25	50	
Vehicle volume (right-turn) (veh/h/lane)		25	50	25	50	
Average velocity (m/s)	non-GMCD	1.49	1.43	1.35	1.24	
	GMCD	1.56	1.54	1.37	1.25	
	Impact of GMCD	5%	8%	1%	1%	4%
Start to cross during last 10s of green-man signal (ped/h)	non-GMCD	9.24	12.15	8.01	10.76	
	GMCD	9.12	9.95	8.33	8.21	
	Impact of GMCD	-1%	-18%	4%	-24%	-10%
Average velocity during last 10s of green-man signal (m/s)	non-GMCD	1.51	1.46	1.37	1.24	
	GMCD	1.67	1.72	1.52	1.43	
	Impact of GMCD	11%	18%	11%	15%	14%

g) Future Areas to Take Note of, and Going Forward

To extend current study, a decision-making model based on simulation outputs can be developed to help engineers on deciding whether to install GMCD and evaluating safety impact of installing GMCD on existing crosswalks.

h) Means of Official Announcement of Research Results

To report research results of this project, two journal papers are submitted.

Chai, C., Shi, X., and Wong, Y. D. “Estimating safety effects of Green-Man Countdown Devices (GMCD) at signalized pedestrian crosswalk based on Cellular Automata (CA).” Accident Analysis & Prevention.

Shi, X., Chai, C., Wong, Y. D. “Crowded pedestrians’ movement analysis at signalized crosswalks based on image processing” ASCE: Journal of Transportation Engineering.