High-Resolution Modeling of Vehicle-Pedestrian Interactions for Estimating Pedestrian Risk at the Black Spots

Gennady Waizman, Itzhak Benenson
Department of Geography and Human Environment, Tel Aviv University, Israel

The geo-referenced police data on the number of traffic accidents clearly point to "Black Spots", where the accident rate remains high in months and years. Road safety research, however, is still far from understanding why a certain place on a road is risky. Moreover, the very question of what constitutes a safe or unsafe road facility is yet under discussion (Gettman, Head, 2006).

The reason for a lack of consensus regarding road safety is the deficit of knowledge of how pedestrians and drivers interact when facing a potentially dangerous traffic situation (Zegeer, Sandt, 2006). In the same time, various aspects of pedestrian and driver behavior are investigated in laboratory experiments and field studies (Endsley, 1995; Klauer et al., 2006; Rensink et al., 1997; Schiff, Detwiler, 1979; Seward, 2007; Tresilian, 1995). The time came to combine this multi-facet knowledge within the spatially explicit agent-based model of the on-road vehicle-pedestrian interaction. Such a model enables estimating the influence of environmental and human factors and their interaction and provides the tool for assessment of safety measures, including changes in the Black-Spot geometry and architecture.

The paper presents the SAFEPED - microscopic 3D simulation of the Black Spot dynamics. The SAFEPAD simulator is build using Microsoft DirectX Technology (Figure 1) and its agents can behave autonomously, according to a predetermined set of rules or be guided by one or more human users. We consider SAFEPAD as a test platform for evaluating experimentally estimated drivers' and pedestrians' behavioral rules and employ it for estimating accident risks in different traffic scenarios.

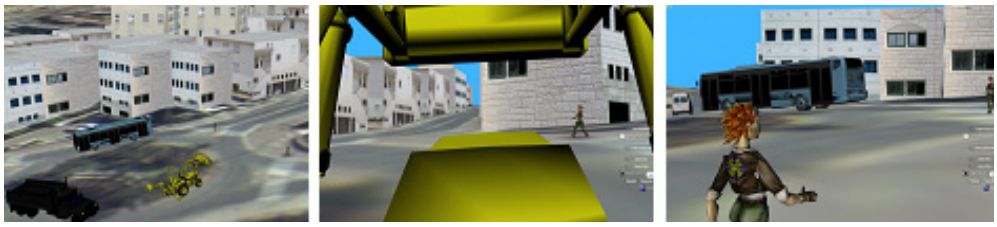

Figure 1: SAFEPAD, the views of the same traffic scene from several viewpoints.

SAFEPAD builds on externally constructed 3D environments (all industrial CAD formats are accepted). The user interface enables establishing agents' behavioral rules, interactive management of the model runs and scheduling agents' appearance and motion. When applied at an early stage of the planning and development process, SAFEPAD can reveal a disadvantageous design of the Black Spot and serve for assessing alternative architectural solutions (Archer, 2005).

The set of the behavioral rules of the SAFEPED agents – drivers and pedestrians – consist of two subsets. The subset describes the rules of agents' cognition and perception. The second subset describes the rules of agents' movement. The parameters of the cognition rules are established on the base of accident-related experimental data, including Time-To-Contact judgment, reaction time, driver inattention and pedestrian caution (Seward, 2007; Bonsalla et al., 2005; Bungum et al., 2005; Klauer et al., 2006). The parameters of motion rules include acceleration and deceleration rates, dependency of driving speed on curves on lateral acceleration, performance limitations for vehicles,

estimated range of velocities, and acceleration and deceleration rates for different pedestrian modes - walking, jogging, and running (Bonsalla et al., 2005; TranSafety, 1998; Daniel, Fittanto, 2004).

Importantly, SAFEPED records all crash and near-crash episodes as well as the entire life-history of every agent during the simulation run thus enabling re-run of the simulation starting from any moment of time. In this way, the user can observe accidents from various viewpoints (including the viewpoints of the crash participants) and estimate accidents' characteristics. The replay mode enables intervening into the crash or near-crash dynamics by taking the full control over one or more agents.

The paper presents the implementations of the SAFEPED for verification and calibration of pedestrians' and drivers' behavioral models, and for estimating pedestrian risks at two Black Spot.

BIBLIOGRAPHY

Archer, J., 2005. Indicators for traffic safety assessment and prediction and their application in micro-simulation modeling study of urban and suburban intersections. Sweden Royal Institute of Technology, Stockholm.

Bonsalla, P., Liua, R., and Young, W., 2005. Modeling safety-related driving behavior—impact of parameter values. Transportation Research Part A: Policy and Practice 39:425-444

Bungum, T.J., Day, C., Henry, L.J, 2005. The association of distraction and caution displayed by pedestrians at a lighted crosswalk. Journal of Community Health, 30.

Daniel, A., Fittanto, A.S., 2004. Passenger vehicle steady-state directional stability analysis utilizing EDVSM and SIMON HVE. White Paper Session Engineering Dynamics Corporation.

Endsley M., 1995. Towards a theory of situation awareness in dynamic systems. Human Factors 37.

Gettman, D., Head, L., 2006. Surrogate safety measures from traffic simulation models final report, In: USDO TRANSPORTATION, National Highway Traffic Safety Administration

Klauer, S.G., Dingus, T.A, Neale, V.L, Sudweeks, J.D, Ramsey, D.J, 2006. The impact of driver inattention on near-crash/crash risk: an analysis using the 100-car naturalistic driving study data. In: USDO TRANSPORTATION, National Highway Traffic Safety Administration

Rensink, R., O'Regan, K, Clark, J, 1997. The need for attention to perceive changes in scenes. Psychological Science 8:368-373.

Schiff, W., Detwiler, M.L., 1979. Information used in judging impending collision. Perception 8, 647-658.

Seward, A.E., 2007. Using virtual environments to assess time-to-contact judgments from pedestrian viewpoints. Computer Science, Graduate School of Vanderbilt University, Nashville, Tennessee.

TranSafety, Inc., 1998. Canadian researchers test driver response to horizontal curves. Road Management & Engineering Journal.

Tresilian, J.R., 1995. Perceptual and cognitive processes in time-to-contact estimation: analysis of prediction-motion and relative judgement tasks. Perception and Psychophysics 57:231-245.

Zegeer, C.V., Sandt, L., 2006. How to develop a pedestrian safety action plan. In: USDO TRANSPORTATION, National Highway Traffic Safety Administration