Modeling Children's Pedestrian Safety Skills in an Intelligent Virtual Reality Learning Environment

Yecheng Gu, Sergey Sosnovsky, Carsten Ullrich

German Research Center for Artificial Intelligence (DFKI)
Stuhlsatzenhausweg 3, 66123 Saarbrücken, Germany

{yecheng.gu, sergey.sosnovsky, carsten.ullrich}@dfki.de

Abstract. This work presents an intelligent virtual reality environment for training child traffic safety. Key pedestrian skills are discussed. The overall system design is described together with a set of implemented practical exercises. An evaluation study shows that the approach is well accepted and that children struggle with the same skills in the virtual environment as in the real world.

1 Introduction

Children are endangered traffic participants. They are hard to see, fragile, have limited perceptual-motor abilities and lack both knowledge and experience in traffic situations [1]. Existing traffic education programs focus on theoretical aspects and needs to be supplemented with individualized practical street side training [2]. However, such training is hard to provide in the real world due to safety reasons and dependence on environmental conditions. One promising alternative is to employ Virtual Reality (VR) technologies and conduct training in safe and controllable virtual environments. In fact, a number of previous studies have investigated the use of VR as a tool for practical child pedestrian training. Thomsen et al. showed in a study that children aged 7-11 were able to better their skill of finding appropriate gaps in traffic to cross a road through VR training [3]. Further, Schwebel et al. were able to show that children exhibit consistent road crossing behavior in VR and in the real world [4]. However, these systems were very limited in terms of tutoring capabilities and diversity of training scenarios. At the same time, the combination of Intelligent Tutoring Systems (ITS) with VR training has shown to be successful in other domains [5]. In this work, we build on the early success in the field by implementing SafeChild – a VR-based training environment with ITS capabilities for the domain of child pedestrian safety.

2 Pedestrian Safety Skills

Children need to learn a number of behavior rules and master corresponding skills in order to become safe pedestrians. These skills differ greatly in their cognitive demand and some are especially difficult for young children as many studies show. This includes the detection of non-obvious threats [6], paying selective attention to those parts of traffic that affects safety while ignoring others [7] and observing the traffic situation from a global perspective [8]. We have conducted a cognitive analysis of this domain informed by the existing literature on pedestrian traffics safety [9] and in consultation with traffics safety experts. As a result, we have identified two groups of skills. The basic skills, which are less demanding cognitively and should be easier for children to apply and master, include: crossing in designated areas; crossing at green light; keeping distance to roads unless trying to cross; stopping at a curb; looking both sides for incoming traffic; crossing straight without stopping (unless an emergency is detected). The advanced skills involve more complex decision making and planning procedures and maintaining the awareness of other traffic participants. They include: making sure that cars are stopping; observing traffic while crossing; recognizing dangerous cars; selecting appropriate gap to cross; recognizing shortcomings of a crossing place; anticipating traffic light change; finding a suitable place to cross; plan route through multiple crossings. We anticipate that children in a VR environment will have fewer problems with basic skills, but will struggle with the advanced skills that pose difficulty in real-word traffic education. For the SafeChild platform, this means that its instructional component should especially support acquisition of advanced skills.

3 Exercises in SafeChild

The SafeChild system provides a freely explorable virtual city environment with simulated traffic. The standard interface is based on a single monitor as display and a keyboard as input device. Other interfaces with higher degree of immersion are supported and panned for future research. In order to train the skills described in Chapter 2, a preliminary set of ten road-crossing exercises have been designed. Each exercise requires a set of skills to cross the road under different conditions (ranging from five to ten skills per exercise depending on the difficulty) and to reach the goal safely. The set of exercises consists of three tasks related to using traffic light; three exercises related to using zebra crossing, three exercises related to unregulated crossings and one combination exercise. For traffic light and zebra crossing, the learner starts once directly in front of the designated crossing area; once, within a small distance, but with the traffic light / zebra crossing still in sight; and once, further away, where a turn in the virtual city environment is required to find the designated place to cross. In all cases, the final goal is directly visible and the learner is supposed to utilize the available regulated crossing to reach it. For the unregulated crossings tasks, the user starts once on a sidewalk next to a straight road without obstacles; once, with a parking truck as an obstacle; and once, close to a road curve obstructing the field of vision. The task is to recognize shortcomings of the crossing place if they are present and cross the road safely. In the final exercise the learner can plan own route to the goal and is given the opportunity to either cross the road once with an unregulated crossing or to cross twice using traffic light and zebra crossing; the expected behavior is to prefer the combination of traffic light and zebra crossing over the unregulated crossing. Fig. 1, shows a screenshot from a “traffic light” exercise, with the yellow arrow designating the goal. It also shows two feedback screens for reaching the goal and failing it (if hit by a car). Finally, it shows the help screen explaining key-binding controls for navigating in the environment.

The system logs all interactions in real-time to generate lossless replays of learner performances and assist in detecting if a skill has been applied correctly or not. It is important to mention that a leaner might fail one or more skill, but still reach the goal.

The system does not restrict such behavior and does not yet generate formative feedback reflecting it.

Fig. 1. Road Crossing Tasks in SafeChild.

4 Pilot Evaluation

We have conducted a pilot study with ten children aged 6-9 solving road crossing tasks in a Web-version of SafeChild. The main goals of the study were to elicit a general attitude that children would have toward training pedestrian safety in a game-like VR environment; observe typical patterns of their interaction with SafeChild, and get initial understanding of how they apply various pedestrian safety skills in VR settings. A pre-questionnaire collected children's demographics and experience with traffic education and computer games. The main session consisted of a familiarization task and the ten exercises described in chapter 3. A post-questionnaire at the end asked for children's feedback on the exercises and the city environment. Overall, it took about 20 minutes for children to finish the experiment. The entire study was conducted over Internet using the browser-based version of SafeChild. All interactions and answers to questionnaires were logged at a central web-server. Parents were asked to supervise and monitor the performance of their children, but not help with the traffic exercises.

Children liked SafeChild in general, thought it was realistic and believed they could improve their traffic skills with it. However, they provided mixed opinions about the difficulty of exercises and the ease of control. This confirms the overall potential of the approach and indicates possible value of adaptive support. It also shows the need for control refinement. The log analysis shows that children made only a few errors when applying basic skills, and when they did, they were able to correct them during the next exercise. However, rarely they were able to correctly apply all the advanced skills, and when they had a problem, the current simplistic feedback of SafeChild did not help them correct it at the next attempt. This observation is consistent with the literature on application of advanced and basic pedestrian safety skills in the real world and hints toward implementing an instructional support component of the SafeChild system especially targeting advanced skills.

5 Conclusion

The results of the conducted pilot study indicate that the general approach of SafeChild has been well received and that the system is capable to reproduce the real-world problems of child pedestrians. This forms a solid basis for future research toward assisting children in acquiring theses skills. This includes not only the development of an ITS that can model these skills automatically [10] but also research on the use of different VR interfaces [11] that could facilitate the transfer of skills acquired in a VR environment to the real world situations.

Acknowledgments. This research was conducted within the SafeChild project funded by BMBF (grant 01IS12050) under the Software Campus program.

References

1. Whitebread, D., Neilson, K.: The contribution of visual search strategies to the development of pedestrian skills by 4-11 year-old children. British Journal of Educational Psychology 70.4, 539-557 (2000).
2. Schwebel, D.C., Aaron L. Davis, and Elizabeth E. O'Neal: Child Pedestrian Injury A Review of Behavioral Risks and Preventive Strategies. American Journal of Lifestyle Medicine 6(4), 292-302 (2012).
3. Thomson, J.A., Tolmie, A.K., Foot, H.C.,Whelan, K.M., Sarvary, P., Morrison,S.: Influence of virtual reality training on the roadside crossing judgments of child pedestrians. Journal of Experimental Psychology: Applied, 11:175–186 (2005).
4. Schwebel, D. C., Gaines, J., Severson, J.: Validation of virtual reality as a tool to understand and prevent child pedestrian injury. Accident Analysis & Prevention, 40(4):1394–1400 (2008).
5. Lane, H. C., Hays, M. J., Core, M., Gomboc, D., Forbell, E., Auerbach, D., & Rosenberg, M. Coaching intercultural communication in a serious game. In Proceedings of the 16th International Conference on Computers in Education, 35-42 (2008)
6. Ampofo-Boateng, K., Thomson, J.A.: Children's perception of safety and danger on the road. British Journal of Psychology, Vol. 82, 487-505 (1991).
7. Hill, R., Lewis, V., Dunbar, G: Young children's concepts of danger. British Journal of Developmental Psychology, 18, 103–120 (2000).
8. Underwood, J., Dillon, G., Farnsworth, B & Twiner, A.: Reading the road: the influence of age and sex on child pedestrians' perceptions of road risk. British Journal of Psychology, 98, 93-110 (2007).
9. Van der Molen, H. H., Rothengatter, J. A., & Vinjé, M. P. Blueprint of an analysis of the pedestrian's task—I: Method of analysis†. Accident Analysis & Prevention, 13(3), 175-191 (1981)
10. Gu, Y., & Sosnovsky, S. Recognition of student intentions in a virtual reality training environment. In Proceedings of the companion publication of the 19th international conference on Intelligent User Interfaces, 69-72 (2014).
11. Orlosky, J., Weber, M., Gu, Y., Sonntag, D., & Sosnovsky, S. (2015). An Interactive Pedestrian Environment Simulator for Cognitive Monitoring and Evaluation. In Proceedings of the 20th International Conference on Intelligent User Interfaces Companion, 57-60 (2015).