A Collaborative Virtual Environment for Safe Driving in a Virtual City by Obeying Traffic Laws

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***Abstract*—The collaborative virtual city environment provides practice to perform informal unstructured, collaborative, constructivist learning instead of instructing individuals on a formal, structured, and programmed based environment. A collaborative virtual city environment has been created using vizard software that can be used by new drivers to help them learn about traffic laws and traffic safety in a safe controlled environment. Pilot studies have been conducted with the system showing its partial success and demonstrate that collaborative learning approach we propose can succeed with smaller group sizes. A significant number of participants followed the traffic rules. Overall 24% participants did not follow any traffic rule. Interestingly the majority of users who did not follow the traffic rules were novice users. Also, there was no marked difference noted for following the traffic rules between participants using the non-immersive and immersive environment. Subjective responses indicated that the Collaborative virtual environment was realistic and engaging. This environment will allow users to prepare for driving exams and we hope that it could possibly become an alternative, supplement, or replacement for the traditional driver's handbook.**

***Index Terms*—Collaborative virtual environment, virtual worlds training simulations, driving simulator, transportation visualization, driver behavior, driver training**

I. INTRODUCTION

Virtual worlds are becoming ever more prevalent in today's society and have been used to create entire social worlds such as in Second Life. Multiuser virtual worlds can be a useful tool for training and education. This paper focuses on creating a virtual city in which new drivers can learn about traffic safety and the various traffic laws. The aim is to use a constructivist approach in which users learn by doing rather than through the traditional methods normally used [1]. One of the benefits of such an approach is that it arouses the users interest in what they are learning [2]. This approach also promotes collaboration and provides a sense of realism [3]. It is one of the best ways for people to gain valuable knowledge through real world life experiences. Life experiences play an important role in allowing a person to gain new knowledge and develop new skills. Although life experience is a valuable way it is not always plausible or financially possible for people to get access to the resources needed for them to experience these real world lessons. Virtual reality is one possible solution to this problem. Virtual reality is especially useful for education and training. The immersive experience and sense of presence possible in a virtual environment allows the user to gain real world knowledge on how to deal with an emergency situation without the risk of injury to the user. It provides the ability to learn real world tasks in a safe controlled environment. Due to the flexibility of virtual reality practically any scenario or environment can be created with minimal cost and without the risk of damage to property or loss of life. The multiuser virtual reality environment allows people to learn and train for scenarios that could not be enacted in real life such as exposing people to real hazards including smoke and fire as well as loss of life scenarios.

Figure 1. Server (right) and Client (left). The user has a first person view when navigating the city and is represented as a car on the server.

This paper proposes an immersive multi-user environment for teaching traffic safety and driving skills in a virtual city. We hope that users of the application will be able to gain skills and knowledge in the virtual environment that they can apply to the real world due to the sense of presence and realism a virtual environment provides. Our contribution lies in our approach to combine computer simulated agents and user controlled autonomous agents in a collaborative virtual environment to teach traffic safety and driving skills in a virtual city. A collaborative 3D virtual city environment has been created that can be used by new drivers to help them learn about traffic laws and traffic safety in a safe controlled

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immersive and non-immersive environment. Results from this study can be used to measure the effectiveness of current driving procedures, protocols, and the effectiveness of training for school bus drivers, firefighter drivers, and security personals. Training in a real-time environment is very complex because it is both expensive and dangerous. The sense of “being there” develops when a user gets immersed in a virtual environment. The development of collaborative virtual reality environment makes it possible to conduct pilot experiments to explore crowd simulation and safe driving in virtual city using virtual reality to achieve high levels of presence. Our proposed environment implements a multiuser interface to allow multiple users to login as a user controlled vehicle or as a pedestrian to navigate in a virtual city. The virtual city is equipped with everything one would find in a real world city such as traffic lights, signs, pedestrians, public vehicles, and other drivers. Collaboration in learning can be very beneficial which is one of the reasons we chose a multiuser approach [3]. This environment will allow users to prepare for driving exams and we hope that it could possibly become an alternative, supplement, or replacement for the traditional driver’s handbook.

Vizard [4] is a virtual reality toolkit for developing immersive interactive 3D content. We have modeled our environment in 3D Studio Max and implemented the client/server functionality using Vizard (refer Fig. 1). We have included features and functionality to allow users to feel that they are present in the virtual world and have applied physics principles to make the environment as true to life as possible. The virtual city was created using a combination of inbuilt models from Vizard and models exported from 3D Studio Max. Vizard was used to implement character and environmental behaviors and the inbuilt Vizard physics library was used to apply real world functionality to the user controlled car. Multiuser functionality was added using Vizard networking scripts and users were given the option of entering and navigating the virtual city as a pedestrian or car. The environment also included a chat feature that allowed users to communicate in real time. Users were able to interact with the environment through traditional inputs such as a keyboard and mouse as well as more immersive methods such as a head mounted display or 3D monitor or wall.

The main focus of this paper is to evaluate the use of immersive and non- immersive multiuser virtual environment as a learning tool for safe driving in a virtual city. The goal for the virtual city gaming environment is to reach an assigned location in the virtual city by following all traffic rules. The environment contains obstacles such as stop signs, schools buses, traffic lights, and pedestrians crossing the street. The rest of the paper is organized as follows: Section II discusses previous work related to this paper; Section III describes the proposed multiuser environment implementation; Section IV focuses on how the environment was simulated and modeled; Section V discusses the results of the pilot study; Section VI discusses the conclusions.

II. Related Work

A vast amount of work has been done in the development of multiuser virtual environments, e-learning, and distance learning. Various theories and approaches have been applied to the virtual environment for education and training. Blais *et al*. have found that constructing and developing knowledge is a social practice and that learners develop meaning through a mix of experiences and interactions [2]. Corbit has developed a virtual environment for science outreach which utilizes a game-like simulation approach for constructivist learning [5]. Callaghan *et al*. discuss situated constructivist learning in distance learning used by colleges and schools in virtual environments most notably Second Life [6]. Students were able to gain an understanding of the software development process through the use of virtual environments [7].

Multiuser virtual environments have also been used in education and training. Slator et al. developed a virtual world used for teaching computer science which focuses on active learning [8]. Shin discusses the usefulness of virtual environments in science education due to the fact that it has been shown to increase student interest and understanding [9]. Liu and Jia discuss the usefulness of a virtual environment that utilizes network and VR technologies to reform current education and training methods [10]. Multiuser systems can be applied to training systems, computer games, and educational systems [11]. VR systems have been applied to teach child safety in areas such as accidents or disasters, traffic safety and education, and fire safety [12]. On the other hand some studies have shown that although gaming aspect of 3D multiuser environments can be helpful and aid in learning, it can also be a distraction [13].

Although virtual reality technologies can be expensive, Abulrub *et al*. argue that recent technological advances have made it more feasible and discuss some of the benefits of using virtual reality technologies in education, teaching and training [14]. These environments can also be useful for distance learning. In fact entire campuses have been developed in virtual environments where instructors and students can engage in real time [15]. Laws *et al*. discuss the development of a virtual campus developed in Second Life and demonstrate how all campus activities such as lectures, labs, meetings, etc. can be recreated in a virtual environment [16]. On the other hand, Bennett and Pilkington discuss the potential of virtual learning environments in contributing to a cultural shift towards independent learning [17]. Liu and He discuss the implementation of emotion simulation and its applications in e-learning [18]. Jaligama and Liarokapis were able to port lecture materials from a university course into a virtual environment and user of the environment found it to be an enjoyable experience [19]. VR can be mixed with other media such as video and user can learn by manipulating environmental models which was done in the system developed by Quy *et al*. [20]. Sharma and Otunba have developed a collaborative training environment to educate users about emergency aircraft evacuations [21]. Guo *et al*. have discussed how virtual reality can be used to teach vocational skills that are not currently being adequately covered in higher education [22].

Virtual environments can be made to seem more realistic and become more useful through the use of alternative modes of input such as gestures [23]. Equipment that applies force feedback has also been use in educational labs to allow students to feel the same sensations they would experience in a real world environment [23]. Some other benefits the virtual environment provides are remote access to educational tools and services [15]. Mu, Yang and Zhang, have developed a means for users in a virtual environment to interact through gestures and express emotions [24]. Research has been conducted to study the role human visual systems play in the use of 3D driving simulators [25]. Lin *et al*. have combine brainwave measuring techniques and equipment to measure user response to traffic signals in a virtual environment in the hopes of reducing the number of accidents that result from human error [26].

Virtual environment can be used to represent a wide range of environments and has been used by various industries. The business world has also benefited from the use of multiuser virtual environments and they have become useful in establishing economic trade relationships [27]. Virtual environments have also been shown to be useful in marine education. Xiuwen *et al*. have developed a multi-layered web-based marine training environment to improve marine training and education [28]. Abacioglu *et al*. have developed an interactive system to teach medicine which models predefined medical processes [29]. Virtual driving simulator have been used for tourism where users can take virtual driving tours of a real city [30]. Virtual reality has been integrated into embryology courses for medical students as experimentation environments [31]. 3D environments are also useful in teaching users with special needs such as those suffering from autism [32]. Schultheis *et al*. have a VR driving simulator to precisely and successfully evaluate driver competency following a neurological trauma [33]. Simulators have also been developed to test the driving ability of people suffering from disease or injuries resulting from previous accidents as an alternative to dangerous real world road tests [34]. The intelligent driving simulator developed by Fan and Xiong has provided an avenue to train new drivers in an adaptable virtual environment in a natural way [35]. Nanyue *et al* have developed a driving simulator using similar methods to those outlined in this paper with their environment being modeled and assembled in 3D Studio Max and implementation being carried out in other VR development software [36]. Fouladinejad *et al*. have outlined a framework for developing a virtual environment for the purpose of simulated driving [37]. These are just a few of the things being done in the realm of virtual environments for teaching, education, and other industries.

III. Collaborative Environment

The multiuser environment utilizes server/client architecture to allow multiple users to interact in the shared virtual space. In the proposed virtual city environment, vizard's networking scripts are used to create a server and a client application which can be executed on different machines to establish a connection. The networking script makes use of the Vizard network command to create a connection between the server and clients and utilizes the remote computers name or IP address as arguments. Vizard triggers network events when network messages are sent and this data is registered by a callback function which will pass the message on as either a network event or network event object. A network event object contains all the position arguments that are passed. The development of multi-user VR driving system involved 5 modules as follows:

- Server
- Session
- Client
- Network messages
- Distributed objects

A. Server

The server application must be run on the host machine prior to the clients connecting and any computer has the ability to act as host as long as the server application is present. Once the server is running the clients can start their applications and connect to the host environment by entering the host computer's name or IP address. Server environment and client environments are identical and collisions detection is handled in the client's local environment. Only data relating to a user's position and orientation is sent between server and clients.

B. Session

A session is a virtual environment within which an instance of an application takes place. Every instance of a session has a unique identifier and is identical for all users to synchronize actions between different clients.

C. Client

Clients connect to the host (server) environment by entering the host computer name or IP address. After starting, the client application users are prompted to choose an avatar (a car for the purposes of this study) and enter the environment.

D. Network Message

The client and server applications communicate by sending update information back and forth. Each user has the ability to see and communicate with the other users in the environment via a chat interface. The environment supports number of clients in a session. The length of each session is controlled by the server application. When the server application is closed the connection to the clients is terminated and the users are booted out of the virtual environment. Clients are able to enter and exit the environment without effecting the connection of other user.

E. Distributed Objects

Upon entering the environment as client each user is given a third person view positioned behind the car which can be changed to a first person view depending on the user's preference. Other users in the environment are represented as car objects. When users hover over another user in the environment with their mouse, the user's computer name is displayed above the selected user's car. Users can control the virtual car through keyboard and mouse inputs. This information is sent back to the server application and the user's position and orientation in their local environment is updated on the server and a car object is created to represent that user. The updated information is then broadcasted to the other users and updates their local environments simultaneously and a car object is rendered in the local environments of all the other clients.

IV. Modeling and Simulation

Virtual city environment was created using a combination of models obtained from online sources as well as from inbuilt models and avatars available in the Vizard toolkit. The city was constructed and assembled in the 3D Studio Max modeling software and various components of the city were exported in the appropriate formats for use in the virtual environment. Fig. 2 and Fig. 3 show the virtual city complete with buildings, intersections, pedestrians, traffic lights, and signs. We tried to incorporate everything one would normally find in a real world city to increase the sense of presence and realism in the environment.

Figure 2. The developed virtual city environment

Animations and interactivity were added to the environment through a variety of techniques. For instance Vizard scripts were used to animate pedestrians crossing intersections as well as to trigger traffic signals. Animation of a school bus stop signal opening and closing (refer Fig. 3) was done in 3D Studio Max and imported into the Vizard environment. We found it easier to implement the school bus lights flashing in VRML and then importing the lights as separate models in Vizard. Collision detection was implemented through simple Vizard scripts to keep users from passing through buildings, other users, and other objects in the environment. The aim was to create an environment that was as close to a real world environment as possible.

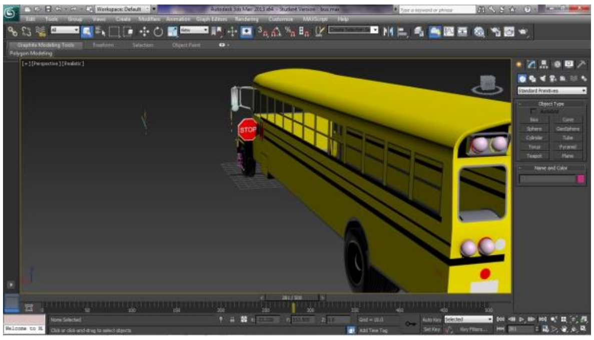

Figure 3. Animation of the school bus stop sign and lights using 3D studio max

A user is able to enter the virtual city environment as either a car or a pedestrian. A pedestrian is represented as either a female or male avatar. Various behaviors can be added to the avatars by selection from a list of available actions provided by Vizard or they can be created in third party software such as 3D Studio Max and Maya and then imported. Vizard also has support for custom built avatars.

The Vizard physics library was used to implement steering behavior and the user controlled car. The physics library was also used to implement braking, acceleration, wheel rotation, friction, and collision effects. Users can control the car through the traditional keyboard buttons, i.e. the arrow keys as well as the mouse. Vizard supports alternative methods of user interaction such as head mounted displays, Kinect, wand, and 3D wall. Users can also trigger environmental conditions such as a day or night mode via the keyboard. Users can also change between first person and third person views based on their preference.

To start the simulation a server application must be started on the host machine. Clients can then connect to the server by entering the host computer name. Once connected, the clients are able to choose from a bank of available objects via a drop down menu. The users then enter the environment and navigate the environment as the selected object. The environment can support up to six users who can choose between three modes of learning and interaction. Users can run the simulation as a single user, with multiple users, and with computer controlled cars. If the user wants to focus on specific learning objectives such as learning traffic signs they may opt for a single user environment that they can explore at their own pace.

Figure 4. Single user mode

Running the simulation with other users is a good way for the users to gain experience in a less predictable environment similar to that they would experience driving in a real city. For a more controlled environment, the focus is to learn right of way and safe following distance through the simulation with computer controlled cars

Figure 5. Pedestrian crossing

As a pedestrian, the users can learn how to navigate safely in a busy traffic intersection in city. This can be especially useful for teaching children traffic safety by allowing them to learn things such as how to safely cross the street using a crosswalk and to look both ways and wait for oncoming traffic (refer Fig. 5). Due to the flexibility and scalability of virtual environments it is possible for users to simulate a wide range of driving conditions and learning objectives.

V. Results and Pilot Study

We have tested the VR city environment with multiple clients and the results were promising. In the study, there were 32 groups (75% male and 25% female) and they participated in the study in two sessions: 1) Non-Immersive environment (Desktop computer), 2) Immersive environment through HMD (Head Mounted Display). Each group consisted of 4 human users and 10 randomly driving artificial agents (cars) which obeyed all traffic rules. The participants were not paid and their participation was voluntary. The HMD used in the experiment were nVisor SX111 with Advanced Video Control Unit and Z800 Dual Pro Ruggedized HMD.

Figure 6. Students participating in the user studies in immersive environment

Participants below 18 years of age were excluded from the study. One session had 4 students participating in a multi-user gaming environment on a desktop and also through the HMD. Figure 7 shows the majority of participants in the study were intermediate and expert users. In our study we used a small road map with 10 simulated cars and 4 simulated school buses on it. 4 users participated in the study in one session, once in the desktop environment and another in immersive environment using a head mounted display. As a result, there were 14 cars, 4 school busses, and a number of stop signs on the track during the session. We expected the participants to reach the assigned goal while following the traffic laws.

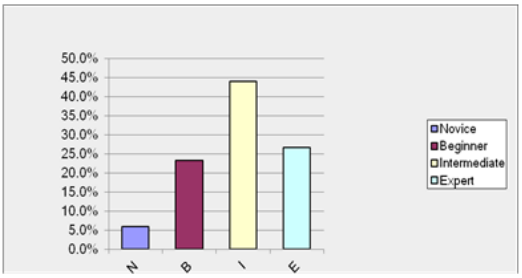

Figure 7. Level of experience

In the following discussion of evaluation results, we focus on whether the participants followed traffic rules. Our data analysis shows two results. First, the data stresses the importance of group size in these multi-user environments. If we do not consider the simulated cars but only the participant actors, the average number of created situations was 0.9 for stop signs, 2 for school buses, 0.7 for traffic lights, and 0.9 for pedestrians. All these values were low considering the driving time of 10 minutes. It reflected well with what happens when there are fewer cars in the city. The second finding is that larger group size can partially solve this problem, but will not be sufficient in creating complex situations. Fig. 8 shows that a significant number of participants followed the traffic rules. Overall 24% participants did not follow any traffic rule. Interestingly the majority of users who did not follow the traffic rules were novice users. Also, there was no marked difference noted for following the traffic rules between participants using the desktop computer and immersive environment.

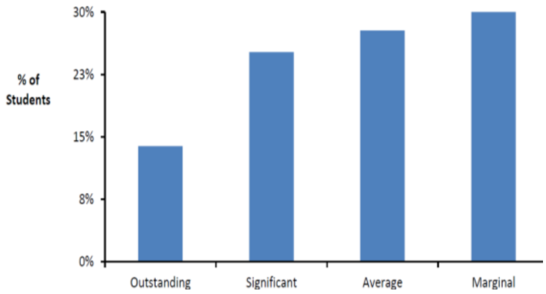

Figure 8. Did follow the traffic rules? (Stop sign, school bus, traffic lights, and pedestrians)

The users participated in the multi-user gaming environment for the VR city environment were scheduled for a 45-min session. Upon arrival at the study the participants underwent informed consent procedures in which the study personnel explained the study procedures and how to navigate inside the virtual environment. 4 participants were asked to participate in the VR city multi-user gaming environment in 2 sessions. During the first session, participants sat on the table and used the gaming environment on a desktop computer while in the second session the participants used HMD (Head Mounted Display). The users navigated in the virtual city gaming environment by avoiding obstacles to reach the assigned goal.

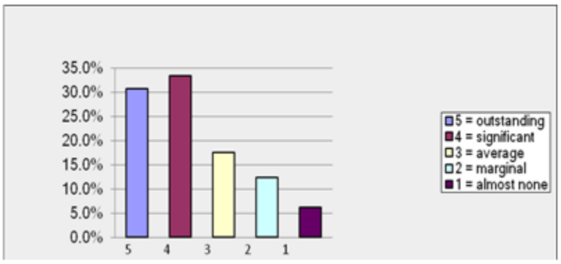

Figure 9. Will participating in trial help in training for driving skills test

Fig. 9 shows that 94% of the participants agreed that participating in the proposed virtual city 3D simulation system will help in training for driving skills test. A desktop based virtual car driving simulation system makes it possible for most users to learn driving knowledge anytime anywhere.

A. User Experience in the VR Environment

The goal for the virtual city gaming environment was to reach an assigned location in the virtual city by following all traffic rules such as stop signs, schools buses, traffic lights, and pedestrians. After the task had been completed, the participants were given a demographic questionnaire including questions on their technical experience of playing games. Survey respondents were asked to describe their experience pertaining to specific aspects of the experience related to each VR environment. For the City Traffic VR environment, users were asked about the contribution of the animated cars, the extent of obeying traffic laws, and difficulty in navigation due to the presence of pedestrians and school buses.

In the user study we were interested in knowing the extent to which users obeyed traffic rules, such as stopping for a stop sign, school bus, traffic lights and pedestrians, as well as users' perceptions of the contribution of other objects in the overall experience. While the overall results for obeying traffic rules reveal that more users did obey traffic rules than not, 39% reporting adherence at either an outstanding or significant level, a substantial proportion followed traffic rules only marginally. Fig. 8 shows that when reviewing results by single reporting category, users tended to ignore traffic rules marginally compared to the other frequency adherence levels. Slightly more than a third of the survey respondents indicated they adhered to traffic rules only marginally, followed by 28% obeying traffic rules to an average extent, 25% at a significant level and only 14% obeying traffic at a level considered outstanding.

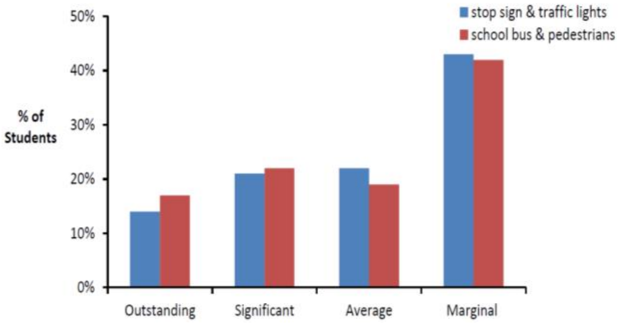

Figure 10. User adherence to traffic rules for stopping

Fig. 10 shows the extent of user adherence to the traffic rules encountered in the VR environment. Specifically users in the city traffic environment encountered traffic rules for stopping their vehicle at a stop sign and traffic lights as well as for a school bus and pedestrians. When users did not obey traffic rules, 43% did not stop at stop signs and traffic lights, and 42% did not stop for school buses and pedestrians. When traffic rules were obeyed, more users followed at a significant level for the traffic rules or average level for the stop sign and traffic lights.

VI. Conclusions

One of the main focuses of this research is to determine if the use of virtual environments is a viable option for teaching real world skills and gaining real world knowledge. We wanted to determine if it was possible to create an immersive environment that was as true to the real thing as possible with the current technology available. In the current system people can navigate the virtual city as a pedestrian or car similar to how they would in the real world through the use of keyboard inputs. Although the system is still under development our approach has had some promising result. The multiuser aspect has been implemented and tested which allows for collaboration among participants and is a key component to our constructivist approach to learning. Currently the system supports up to three modes.

Advances in technology have improved the sense of presence and realism in virtual environments. This advance coupled with support for multiple users is very conducive to developing collaborative virtual environments. These environments can mimic and recreate real world environments and are a safe place for users to learn skills and techniques that can be applied to the real world. In this paper we present a virtual environment that may be used as a training tool for new drivers with the aim that a system like this could be used as a replacement for the traditional drivers' handbook and teaching methods.

Subjective responses indicated that the collaborative virtual environment was realistic and engaging. Overall, the study results confirm the effectiveness of the collaborative VR environment for research. Survey respondents were generally positive about the realistic quality of the navigational experience within the VR environment overall. Seventy-five percent reported having a realistic navigational experience with a third indicating an outstanding level of realism in navigation. Slightly more a third felt the realistic nature of the navigational experience was average to marginal for City Traffic environment. Survey respondents also rated the user-controlled avatars used to navigate the VR environments. Users were positive about the both user controlled object features in the environments with 76% rating them either outstanding or significant.

The CVE environment allows monitoring of pedestrian behavior through complete street crossings, collision detection, and providing 3D positional audio. The most important safety benefit of our CVE is that it provides a minimal level of risk to participants. Even if participants make bad judgments and enter the path of a virtual car or collide with a pedestrian, there is no physical risk of injury. The time needed to reset the CVE to next trial is minimal bordering on non-existent, which allows a greater number of trials and participants to be run in a relatively shorter time.

There are some draw backs to using the CVE for Safe Driving in a Virtual City by obeying traffic laws as a research tool. The development tool have a steep learning curve, especially for someone with no gaming experience.

The limitation of our constructivist learning approach for car driving is that there were fewer interesting learning situations and there were not enough users involved in a collaborative driving place. This is due to the fact that in our study we had 10 simulated cars and 4 simulated school buses. Only 4 users participated in the study in one session, once in the desktop environment and another in immersive environment. The results of our pilot study shows that a significant number of participants followed the traffic rules while still in a gaming goal oriented environment. The number of challenging learning situations the participants encountered did not increase as much as we hoped. This might be overcome by randomly placing school buses in the virtual city. A prototype multiuser virtual environment has been implemented and pilot studies with multiple users have demonstrated the feasibility of our approach. In future we plan to develop alternate forms of guidance such as verbal and augmented graphics in the virtual city. Furthermore, audio communication is planned to be integrated into the system.

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REFERENCES

[1] C. Jen, T. Chong, and W. Fauzy, “Virtual reality: A potential technology for providing novel perspective to novice driver education in Malaysia,” *Information Technology*, pp. 184–188, 2003.

[2] N. Di Blas, P. Paolini, and C. Poggi, “3D worlds for edutainment: educational, relational and organizational principles,” *Pervasive Computing and Communications Worksho*, pp. 2–6, 2005.

[3] H. Xue and J. Zhang, “Applying Virtual Reality to Web-based Education,” in *Proc. First International Multi-Symposiums on Computer and Computational Sciences*, Jun. 2006, pp. 789–791.

[4] WorldViz. [Online]. Available: http://docs.worldviz.com/vizard/

[5] M. Corbit, “Building virtual worlds for informal science learning (SciCentr and SciFair) in the Active Worlds Educational Universe (AWEDU),” *Presence: Teleoperators & Virtual Environments*, pp. 21–26, 2002.

[6] M. Callaghan, K. McCusker, J. L. Losada, J. Harkin, and S. Wilson, “Integrating virtual worlds & virtual learning environments for online education,” in *Proc. International IEEE Consumer Electronics Society’s Games Innovations Conference*, Aug. 2009, pp. 54–63.

[7] T. Wang and Q. Zhu, “A Software Engineering Education Game in a 3-D Online Virtual Environment,” in *Proc. First International Workshop on Education Technology and Computer Science*, 2009, pp. 708–710.

[8] B. Slator, C. Hill, and D. D. Val, “Teaching computer science with virtual worlds,” *IEEE Transactions on Education*, vol. 47, no. 2, pp. 269–275, 2004.

[9] Y. Shin, “Virtual experiment environments design for science education,” in *Proc. International Conference on Cyberworlds*, 2003, pp. 388–395.

[10] L. Liu and Q. Jia, “Research on education and training oriented virtual collaborative training environment,” in *Proc. Second International Conference on Computer Modeling and Simulation*, Jan. 2010, pp. 169–172.

[11] B. Ulicny and D. Thalmann, “Crowd simulation for interactive virtual environments and VR training systems,” *Computer Animation and Simulation*, 2001.

[12] W. Meiliang and P. Qiaoming, “Design of safety education system for children based on virtual reality technology,” in *Proc. International Conference on Computer Science and Electronics Engineering*, Mar. 2012, pp. 196–199.

[13] P. Sancho, “Do multi-user virtual environments really enhance student’s motivation in engineering education?” *Frontiers in Education*, pp. 1–6, 2009.

[14] A. Abulrub, “Virtual reality in engineering education: The future of creative learning,” *Engineering Education*, pp. 751–757, 2011.

[15] J. Wang, F. Yan, and J. Rao, “Web-based multi-user virtual campus for distance learning,” *Computer Science and Education*, no. 9, pp. 1560–1563, 2010.

[16] A. Laws, H. Forsyth, and M. Baskett, “MUVE, the Future of e-learning: Building a virtual learning world,” *Developments in eSystem*, 2009.

[17] C. Bennett and R. Pilkington, “Using a virtual learning environment in higher education to support independent and collaborative learning,” *Advanced Learning Technologies*, pp. 285–288, 2001.

[18] Z. Liu and S. He, “Emotion simulation in interactive virtual environment for children’s safety education,” in *Proc. Fifth International Conference on Natural Computation*, 2009, pp. 117–120.

[19] V. Jaligama and F. Liarokapis, “An online virtual learning environment for higher education,” in *Proc. Third International Conference on Games and Virtual Worlds for Serious Applications*, May 2011, pp. 207–214.

[20] P. Quy, J. Lee, J. Kim, J. I. Kim, and H. Kim, “Collaborative experiment and education based on networked virtual reality,” in *Proc. Fourth International Conference on Computer Sciences and Convergence Information Technology*, pp. 80–85, 2009.

[21] S. Sharma and S. Otunba, “Collaborative virtual environment to study aircraft evacuation for training and education,” in *Proc. International Conference on Collaboration Technologies and Systems*, May 2012, pp. 569–574.

[22] G. Guo, Q. Zhan, and G. Liu, “Construction of a training model of vocational skills in information technology environment,” in *Proc. International Symposium on Computer Network and Multimedia Technology*, Dec. 2009, pp. 1–4.

[23] C. Venkittarayan, “Virtual soldering environment using touch and gesture for engineering labs education,” Students’, no. 4, pp. 206–210, 2010.

[24] B. Mu, Y. Yang, and J. Zhang, “Implementation of the interactive gestures of virtual avatar based on a multi-user virtual learning environment,” in *Proc. International Conference on Information Technology and Computer Science*, Jul. 2009, pp. 613–617.

[25] W. Yan and X. Weijian, “Design of virtual vision for a driving simulator,” *Robotics, Intelligent Systems and Signal*, no. 10, pp. 244–248, 2003.
[26] C. T. Lin, I. F. Chung, L. W. Ko, Y. C. Chen, S. F. Liang, and J. R. Duann, “EEG-based assessment of driver cognitive responses in a dynamic virtual-reality driving environment,” *IEEE Transactions on Bio-medical Engineering*, vol. 54, no. 7, pp. 1349–52, Jul. 2007.
[27] I. Remolar, M. Chover, R. Quiros, J. Gumbau, F. Ramos, P. Castello, and C. Rebollo, “Virtual trade fair: A multiuser 3D virtual world for business,” in *Proc. International Conference on Cyberworlds*, pp. 208–214, Oct. 2010.
[28] L. Xiuwen, X. Cui, and J. Yicheng, “Multi-level virtual reality system for marine education and training,” *Education Technology and Computer Science*, 2009.
[29] H. Abacio, “Üç boyutlu sanal ortamlar kullanarak etkileşimli tip ve mühendislik eğitim sistemi interactive education system for medicine and engineering using three dimensional virtual environments,” pp. 2–5, 2009.
[30] L. Jia, S. Han, L. Wang, and H. Liu, “Development and realization of a street driving simulator for virtual tour,” in *Proc. 40th Annual Simulation Symposium*, 2007, pp. 133–136.
[31] S. D. Abreu, “Construction of multiuser virtual environments for the virtual teaching of embryology,” *Computer Graphics and…*, no. 1, p. 7695, 2000.
[32] E. I. Konstantinidis, A. Luneski, C. A. Frantzidis, P. Costas, and P. D. Bamidis, “A proposed framework of an interactive semi-virtual environment for enhanced education of children with autism spectrum disorders,” in *Proc. 22nd IEEE International Symposium on Computer-Based Medical Systems*, Aug. 2009, pp. 1–6.
[33] M. T. Schultheis, L. K. Simone, E. Roseman, R. Nead, J. Rebimbas, and R. Mourant, “Stopping behavior in a VR driving simulator: A new clinical measure for the assessment of driving,” in *Proc. Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference*, Jan. 2006, vol. 1, pp. 4921–4924.
[34] H. Ahn, J. Ku, B. Cho, and H. Kim, “The development of virtual reality driving simulator for rehabilitation,” in *Proc. Engineering in Medicine & Biology Society Proceedings of Annual International Conf.*, 2001, pp. 3780–3783.
[35] J. Fan and L. Xiong, “Intelligent driving training simulation system based on virtual reality,” in *Proc. Intelligent Transportation Systems*, 2003, pp. 27–30.
[36] A. Nanyue and B. Hanwu, “Modeling of virtual traffic environment for driving simulator,” *Industrial Design and Conceptual Design*, 2006.
[37] N. Fouladinejad and N. Fouladinejad, “Modeling virtual driving environment for a driving simulator,” in *Proc. IEEE International Conference on Control System, Computing and Engineering*, 2011, pp. 27–32.

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