Eurasia Journal of Mathematics, Science & Technology Education, 2016, **12**(5), 1477-1485
doi: 10.12973/eurasia.2016.1525a

Application of the Environmental Sensation Learning Vehicle Simulation Platform in Virtual Reality

Kuei-Shu Hsu
Chia Nan University of Pharmacy & Science, TAIWAN
Jinn-Feng Jiang, Hung-Yuan Wei & Tsung-Han Lee
Metal Industries Research and Development Center, TAIWAN

•*Received 6 November 2015*•*Revised 4 January 2016* •*Accepted 26 January 2016*

The use of simulation technologies in learning has received considerable attention in recent years, but few studies to date have focused on vehicle driving simulation systems. In this study, a vehicle driving simulation system was developed to support novice drivers in practicing their skills. Specifically, the vehicle driving simulation system was designed according to various driving environmental factors that may be encountered while traveling, including roads, time, weather, ambient scenery, traffic flow, and vehicle of the driver. Moreover, to improve the reality of the vehicle driving simulation system, software and hardware are redesigned and updated during the research, particularly for increasing the reality of the simulation environment and future extensions of the driving simulation system. Accordingly, drivers can construct their own necessary driving situations so as to improve their skills. Experimentation in the visual simulation environment may reduce external factors of drivers, and may be repeated, so that it is a better approach to conduct research through the visual simulation technology.

Keywords: virtual reality, sensation learning, vehicle simulation platform

INTRODUCTION

The application of virtual reality in computer games and mobile phones is currently popular on the internet. As a user simulates a traveling vehicle situation in a virtual reality scenario, multiple cameras may be utilized to observe the user. Moreover, for analysis of the conditions of operating a vehicle traveling in such a scenario, situation simulation in addition to environmental factors and external variable conditions may be used to test the responses, action changes, and so on of the user. Furthermore, it may be the criterion for developing vehicle equipment and parts. User habits are obtainable through the direct operation of virtual reality.

Correspondence: Kuei-Shu Hsu,
Department of Applied Geoinformatics, Chia Nan University of Pharmacy & Science, No.60, Sec. 1, Erren Rd., Rende Dist., Tainan City 71710, Taiwan (R.O.C.)
E-mail: kshsu888@mail.cnu.edu.tw

State of the literature

- A vehicle driving simulation system was developed to support novice drivers in practicing their skills.
- Improve the reality of the vehicle driving simulation system, particularly for increasing the reality of the simulation environment and future extensions of the driving simulation system.
- The drivers can construct their own necessary driving situations so as to improve their skills.

Contribution of this paper to the literature

- Kinect is used to perform augmented reality effects and to improve system design for the feedback situations of the operating behavior model of driver.
- The 3D drawing software was employed for modeling and mapping to draw the entirety of the street and building models.
- Different situation designs are simulated and evaluated to increase development efficiency together with more security verification test platforms.

The application of a stereo vision system to a virtual reality system is used as the subject of this research. A computer vision system may be divided roughly into plane vision and stereo vision, which are different in their capabilities to estimate the depth information of a target object in an image (also referred to as depth perception), such that a computer vision system is more practical. There are many practical applications, for example, remote sensing and monitoring, medical image processing, robot vision systems, military reconnaissance, mineral exploration, and cartography and so forth. In recent years, there has been a large advance in computer vision systems for both theory and algorithms of image processing or practical applications. However, there are still many core technologies to be broken through for computer visualizations to be comparable with human vision systems (Klancar, Kristan, and Karba,2004 ; KaewTrakulPong, Bowden, 2003). A 3D stereo object in space may be captured as a 2D plane image by CCD (Charge-Coupled Device) camera using image processing methods, such as image transforms, image enhancement, thresholding, filtering, edge detection, thinning, and so on (Tsechpenakis, Rapantzikos, Tsapatsoulis, and Kollias, 2004,. Admiraal, Huizenga, Akkerman, and Dama, 2011.), for it to become a useful image information for applications of feature extraction, recognition, visual servoing, and so forth (Bergasa, Alcantarilla, and Schleicher,2010. Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Carleton-Hug, and Hug, 2010.).

The research on 3D VR applications on education is seen in the following research: Monahan, McArdle, Bertolotto, (2008) Chang, Chen, & Hsu, (2011) developed a 3D VR interaction system in 2007 to assist teachers in teaching students about optical waves. Chittaro, Ranon used 3D VR for medical education and training in 2007, providing great advantages for medical interns to enter medical field. Brenton et al. utilized 3D VR to teach anatomy for students to be familiar with key points of dissection practice in 2007, saving a great expense in experimental materials, together with environmental protection issues. Crohn, & Birnbaum, developed a set of learning platforms in 2010, which instructed students to learn sign language, such that the learning effectiveness of sign language is better compared to learning in classroom because students were in the 3D VR domain. Lee et al. applied 3D VR further for education and training for accident handling in hydrogen fuel stations by constructing various possible accidents on a 3D VR platform through knowledge construction of experienced hydrogen fuel station staff, such that the staff could understand standard handling process and troubleshooting in an accident. It also provided a perfect platform for education and training of operators in hydrogen fuel station by means of this 3D VR platform. Sampaio et al. applied 3D VR, in combination with real objects, for engineering education in 2010 for students to understand structure monitoring of engineering construction with an actual result of effective learning for students using those teaching methodologies.

This research plans to construct a “Vehicle VR Test System” shown as Figure 1. Users are invited to take an of an improved A-pillar structure evaluation test under different environmental variables. The conditions of operators being tested are recorded using cameras, and questionnaires are filled out after the test. With the

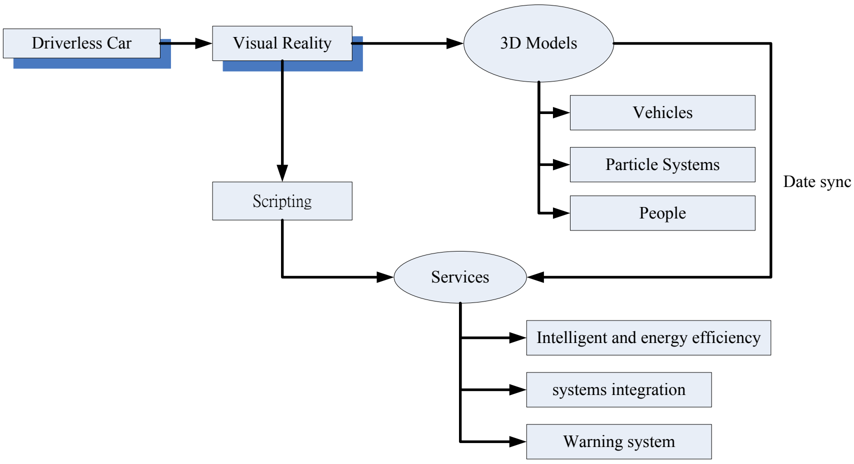

Figure 1. Research Flow Chart

questionnaires and the quantified and qualitative data from observations, future mobile learning may be structured through a mobile learning gaming system for researchers to add various variables for evaluation tests in advance, reducing development cost and uncertain factors in development, in order to achieve the benefits of improving new product development. Therefore, this research was conducted with vehicle carriers and VR.

In summary, it is possible to apply 3D VR to vehicle development evaluations, which is advantageous for increasing specific effectiveness of product development. Therefore, this research applies the Unity 3D gaming engine together with VR to develop vehicle products. The acceptance level of the author is understood through survey of questionnaires after the operation test. The results of this experiment will facilitate the research of subsequent researchers.

RESEARCH METHOD

In this research, the streetscape, which is more commonly used in driving, is used as the main scenario. Sketchup software is used for modeling and mapping to draw an entire building model of a city. After the building model is drawn, it is imported into Unity to make a virtual reality interface. As for scenarios, multiple and more representative scenarios would be made for testing after discussions in order for more accurate and sufficient multi-dimensional data collection.

In the project, an "augmented reality driver test system" is to be constructed. The functions of such platform include virtual reality and augmented reality, such that the platform is one of the most difficult human computer cooperation machine systems. In the system, the interactive motion simulator allows the behavioral model of the driver to enter the virtual scenario and operate the vehicle with a steering wheel. Active and augmented reality technologies are integrated, and two different interactive models of augmented reality action interactions are proposed to invite the driver to perform a practicability test for different emergency situations. Several 3D streetscape environment models were established for the project.

Therefore, the project aims at providing a unique prior-to-development operation test by testing driver behavior. At first, the driver is allowed to perform driving behavior analysis under an emulated environment by using it for driver behavior testing, and also, it may be used as a test platform for vehicle products. Secondly, virtual reality is used as a teaching tool to derive a new teaching and learning strategy. Such a learning model may be performed even though the

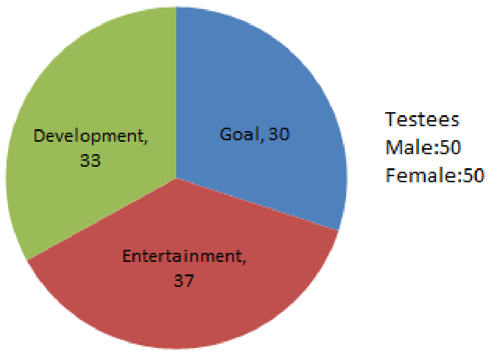

Figure 2. Descriptive statitics diagram for different background variables

Figure 3. The driving behavior for different weather- sunny

operator has no prior computer experience. The fact that that virtual reality allows learners to be immersed into the learning experience allows drivers to provide information feedback from the testing process for product development.

VIRTUAL REALITY DRIVER REAL TIME SIMULATION

Experiment for the test system of an A-pillar structure for vehicle virtual reality

The vehicle's A-pillar structure of the research verifies the virtual reality system, while at the same time simulating improvement of a vehicle A-pillar structure. A computer aided modeling software is utilized to build virtual fields and build realistic streets and virtual environments to first be presented in the Unity3D virtual reality system using model construction, such that different vehicle A-pillar structures and environmental variables are compared, and the development benefit is tested and evaluated. Also, for the virtual reality system, various unexpected condition simulations are added to mutually compare the data of the simulation environment and the real data from the user driving the vehicle to provide developers reference norms for an A-pillar structure design and subsequent improvement. The Unity3D game engine was utilized for integrated simulation. Through tests and operation data in the scenario and their motion behavior, multiple different environmental variables were subsequently applied. An A-pillar structure influences drivers to induce an accident situation during the general driving process. The impact of each environmental variable with respect to a change of a vehicle's A-pillar structure, and the visual impact angle of testers with respect to different A-pillar structures are analyzed to improve the development benefit of vehicles' A-pillar development and reduce development cost. In the following Figure 3 and Figure 4, possible impacts of vehicle's A-pillars from emergency situations of motorcycles and pedestrians on the road during the driving process are shown.

Figure 5 and Figure 6 performs use analysis by improving different environmental variables presented in the system through change simulation of different A-pillar structures.

Background variable items illustrative statistics of the usage motivations with respect to the evaluation test system of an A-pillar structure improvement for the vehicle's virtual reality

After the questionnaire survey, the research eliminated ineffective surveys and obtained 100 viable surveys. From Table 1, there are total two groups in the "Gender" background variable items, including "Male" and "Female". There was total of 100 testers, wherein 50 were in the "Male" group occupying 50% of all testers, while 50 are in the "Female" group occupying 50% of all testers. As seen in the above data, the numbers of testers in the two groups are fairly close in the "Gender" background variable items. There was a total of three groups in the "Major Use Purpose" background variable items, including "Goal", "Entertainment" and

Figure 4. The driving behavior for Different weather- cloudy

Figure 5. Impacts caused by vehicles for different environmental conditions in driving process

Table 1. Abstract table of illustrative statistics for different background variable items

Background Variable Item	Group	Number	Percentage
Gender	Male	50	50%
	Female	50	50%
Major Use Purpose	Goal	30	30%
	Entertainment	37	37%
	Development	33	33%

"Development", wherein 30 people are in the "Goal" group, occupying 30% of all testers; 37 people are in the "Entertainment" group, occupying 37% of all testers; and 33 people are in the "Development" group, occupying 33% of all testers. From the above data, the distribution of testers among the three groups is quite uniform in the "Major Use Purpose" background variable item shown as Figure 2

Single factor variance analysis of use motivation for evaluation test system for vehicle's virtual reality

For the individual aspects and the entirety of different major use purposes in the three groups with respect to the use motivation for evaluation of the test system for an A-pillar structure improvement of the vehicle's virtual reality, significant differences existed for testers of each group in the two associative quantitative tables of "Entertainment Motivation", "Development Motivation", and post comparison is necessary. In the post-comparison of the "Entertain Motivation" aspect, the variances of "Development Motivation" were homogeneous, and the F test of ANOVA achieved a significant difference. The post-comparison results of the Games-Howell method was adopted for post-comparison. As for the major usage purposes of testers being "Development", its social motivation is superior to those of "Goal" and "Entertainment". In the post-comparison of the "Development Motivation", due to the variances of "Development Motivation" being homogeneous and the F test of ANOVA achieving a significant difference, the entertainment motivation for the major use purpose of testers being "Entertainment" is obviously superior to "Goal" and "Development". From the above data, entertainment and development are still the major purposes for motivation of testers when using the evaluation test system of an A-pillar structure improvement for vehicle virtual reality.

Analysis of concurrent situation for motivation using vehicle product test system

As a whole, the operators with driving experience belong to middle level for the vehicle product test system with an average score between 3.62 and 3.80 (as Table 2). In the "entertainment motivation" aspect, the average score is 3.62. In the "goal motivation", the average score is 3.80. In the "possibility motivation" aspect, the average score is 3.66. It shows that the operators with driving experience belong to middle level (the average score is 3) for entertainment motivation, goal motivation and possibility motivation with respect to Unity 3D VR vehicle product test system.

Product moment correlation analysis of utilization motivation for vehicle product test system

The research utilizes product moment correlation to analyze the product moment correlation between the three aspects (entertainment motivation, goal motivation, possibility motivation) of the utilization motivations for the vehicle product test sytem and the entire aspect, and finds significant positive correlation wherein, the product moment correlation between the "entertainment motiviation" and "possibiilty motiviation" is $r(100)=.485$, $p<.001$; the product moment correlation between the "goal motivation" aspect and the "possibility motiviation"

Table 2. Summary table for descriptive statistics of various aspects with respect to vehicle product test development motivations

Aspect	Minimum	Maximum	Average	Standard Deviation	Order
Entertainment Motivation	1	5	3.62	0.81	3
Goal Motivation	1	5	3.80	0.67	1
Possibility Motivation	1	5	3.66	0.73	2

aspect is r(100)=.418, p< .001 from the Table 3. According to the definition of correlation coefficient, the correlation coefficient r value ranged from .40 to .69 belongs to middle correlation. Therefore, it is known that there are significant middle possitive correlations between the "entertainment motiviation" and the "goal motiviation" and between the "goal motiviation" and the "possiblity motivation" for the utilization motivations of the vehicle product test system, that is, the higher the entertainment motivation is, the higher the level of the possiblity motiviation is; in a similar way, the higher the goal motiviation is, the higher the level of the possibility motiviation is. However, the product moment correlation between the "entertainment motiviation aspect" and the "goal motiviation" aspectis r(100)=.370, p<.001. there is low positive correlation between both of them. As for the intire aspect, "entertainment motiviation", "goal motiviation" and "possiblity motivation" all have significantly high positive correlation with the entire aspect.

CONCLUSION

In this research, the streetscape was the main scenario. The 3D drawing software was employed for modeling and mapping to draw the entirety of the street and building models. After all building models were drawn, they are imported into Unity to make a virtual reality interface. For the scenario, in order for better accuracy and multi-dimensional data collection, a real streetscape was made, and there were various sudden changes in conditions, wherein an augmented reality vehicle traveling simulation system is built with vehicles, pedestrians, roadblocks, and animals. Plans and updates were redone for software and hardware to pay attention to increasing the reality of the simulation environments and future extensibility of the driving simulation system. Kinect is used to perform augmented reality effects and to improve system design for the feedback situations of the operating behavior model of driver. New 3D technology and program designs are utilized to construct lifelike road environments and traffic characteristics that the road deserves, including dynamic traffic flow and cross signal control, etc. An example of the application of this subject plan is the research of the interactions between people, vehicles, and roads. Suitable vehicles, road systems, and situations are selected as research examples.

In the project, a real streetscape is simulated, followed by evaluating driver behavior and vehicle products. It is easy to see various different visual effects and effectively further reduce error rates. Moreover, the reliability and reality of this project may be improved and the test security may be increased considerably. Different situation designs are simulated and evaluated to increase development efficiency together with more security verification test platforms. This is done with technology in conjunction with vehicle driving tests, vehicle fitting developments, and vehicle driving environment factors, etc.

Table 3. Product moment correlation analysis of utilization motivations with respect to evaluation test system of an a-pillar structure improvement for vehicle virtual reality

Aspect	Entertainment Motivation	Goal Motivation	Possiblity Motivation	Entire Aspect
Entertainment Motivation	-	-	-	
Goal Motivation	.370***	-	-	
Possiblity Motivation	.485***	.418***	-	
Entire Aspect	.752***	.763***	.830***	-
Mean Value	14.52	22.93	22.05	59.5
Standard Deviation	2.80	3.35	3.69	7.75

N=100, *** *p*<.001

ACKNOWLEDGMENTS

This research is supported by the Ministry of Science and Technology, R.O.C. under contract MOST 104-2622-E-041-003-CC3 and MOST 104-2221-E-041-006.

REFERENCES

Admiraal, W., Huizenga, J., Akkerman, S., & Dama G. T. (2011). The concept of flow in collaborative game-based learning. *Computers in Human Behavior, 27*(3), *1185-1194*. doi: 10.1016/j.chb.2010.12.013

Amoako-Gyampah, K., & Salam, A. F. (2004). An extension of the technology acceptance model in an ERP implementation environment. *Information & Management, 41*(6), 731-745. doi: 10.1016/j.im.2003.08.010

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. Educational Technology Research and Develo*pment, 53*(1), 86-107. doi: 10.1007/BF02504859

Bergasa, L. M., Alcantarilla, P. F., & Schleicher, D. (2010). Non-Linearity Analysis of Depth and Angular Indexes for Optimal Stereo SLAM. *Sensors, 10*(4), 4159–4179. doi: 10.3390/s100404159

Brenton, H., Hernandez, J., Bello, F., Strutton, P., Firth, T., & Darzi, A. (2007). Using multimedia and Web3D to enhance anatomy teaching. *Computers & Education, 49*(1), 32–53. doi: 10.1016/j.compedu.2005.06.005

Carleton-Hug, A., & Hug, J. W. (2010). Challenges and opportunities for evaluating environmental education programs. *Evaluation and Program Planning, 33*(2), 159-164. doi: 10.1016/j.evalprogplan.2009.07.005

Chang, C-S., Chen, T-S., & Hsu, W-H. (2011). The study on integrating WebQuest with mobile learning for environmental education. Computers & Education, 57(1), 1228-1239. doi: 10.1016/j.compedu.2010.12.005

Chittaro, L., & Ranon, R. (2007). Web3D technologies in learning, education and training: motivations, issues, opportunities. *Computers & Education, 49*(1), 3–18. doi: 10.1016/j.compedu.2005.06.002

Crohn, K., & Birnbaum, M. (2010). Environmental education evaluation: Time to reflect, time for change. *Evaluation and Program Planning, 33*(2), 155-158. doi: 10.1016/j.evalprogplan.2009.07.004

Heiler, M., & Schnörr, C. (2003). Natural image statistics for natural image segmentation. *Proceedings Ninth IEEE International Conference on Computer Vision, 2*, 1259-1266. doi: 10.1109/ICCV.2003.1238635

KaewTrakulPong, P., & Bowden, R. (2003). A real time adaptive visual surveillance system for tracking low-resolution color targets in dynamically changing scenes. *Image and Vision Computing, 21*(10), 913–929. doi: 10.1016/S0262-8856(03)00076-3

Kim J., Fisher J.W., Yezzi A., Cetin M., & Willsky A.S. (2005). A nonparametric statistical method for image segmentation using information theory and curve evolution. *IEEE Transactions on Image Processing, 14*(10), 1486–1502. doi: 10.1109/TIP.2005.854442

Khamaiseh, A., & ALBashtawy, M. (2013). Enhancing Botswana children's environmental knowledge, attitudes and practices through the school civic clubs. *British Journal of School Nursing, 8*(4), 194-199. doi: 10.12968/bjsn.2013.8.4.194

Klancar, G., Kristan, M., & Karba, R. (2004). Wide-angle camera distortions and non-uniform illumination in mobile robot tracking. *Robotics and Autonomous Systems, 46*(2), 125–133. doi: 10.1016/j.robot.2003.11.001

Kobayashi, N., & Shibata, M. (2008). Visual Tracking of a Moving Object Using a Stereo Vision Robot, *IEEJ Transactions on Industry Applications, 91*(1), 19-27. doi: 10.1541/ieejias.127.643

Lai, C-M., Huang, H-M., Liaw, S-S., & Huang, W-W. (2009). A Study of User's Acceptance on Three-dimensional Virtual Reality Applied in Medical Education. *Bulletin of Educational Psychology, 40*(3), 341-362. doi: 10.6251/BEP.20080422

Mahony, R., & Hamel, T. (2005). Image-based visual servo control of aerial robotic systems using linear image features. *IEEE Trans Robotics, 21(2)*, 227–239. doi: 10.1109/TRO.2004.835446

Monahan, T., McArdle, G., & Bertolotto, M. (2008). Virtual reality for collaborative e-learning. *Computers & Education, 50*(4), 1339–1353. doi: 10.1016/j.compedu.2006.12.008

Pan, Z., Cheok, A. D., Yang, H., Zhu, J., & Shi, J. (2006). Virtual reality and mixed reality for virtual learning environments. *Computers & Graphics, 30(1)*, 20–28. doi: 10.1016/j.cag.2005.10.004

Rosenhahn, B., Brox, T., & Weickert, J. (2007). Three-Dimensional Shape Knowledge for Joint Image Segmentation and Pose Tracking, *International Journal of Computer Vision, 73*(3), 243–262. doi: 10.1007/s11263-006-9965-3

Vacchetti, L., Lepetit, V., & Fua, P. (2004). Stable real-time 3D tracking using online and offline information. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 26*(10), 1385–1391. doi: 10.1109/TPAMI.2004.92

◈◇◈