APPLIED COMPUTER GRAPHICS: WRENCH VIRTUAL REALITY SIMULATOR

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Abstract: Using interactive computer graphics and simulated virtual reality environments in everyday lives, either for leisure, work or learning is becoming ever more widespread and simplified. Digital markets are filled with low-cost (even free) high-quality applications and simulations. Computer graphics in real-life quality certainly became available and affordable to common everyday users as modern GPUs and appropriate hardware have achieved superb price-performance ratios. The paper presents a novel approach in learning mechanics using Wrench software combined with Oculus Rift platform.

Key words: Computer Graphics; Virtual Reality; Computer Simulation; Wrench; Oculus Rift

1. INTRODUCTION

The idea or incorporating virtual reality (VR) in educational process probably sparkled even before the technology itself was available, as it clearly represents more human approach in interacting with digital technology and computers. VR can be defined as a set of digital computer technologies that generate image, video, sound and other sensations in order to represent a virtual digital environment and simulate user physical presence (Steuer, 1992). The specifics of learning and teaching auto mechanics is that it basically combines theoretical knowledge about mechanics, mechanical engineering and automotive industry with the set of practical skills that include handwork, assembly logarithms and techniques, measurement and control. However, schools usually offer couple of basic engine and mechanical assembly sample models for students to practice on. This clearly can limit the contemporaneity of knowledge, skills and competences as students will not be able to keep pace with current technology which is constantly evolving. The solution can be found in using mixed reality (MR) in the educational process, thus combining real and virtual contents provided by digital technologies (Cabiria, 2012). MR also can include the augmented reality (AR) technology by representing digital 3D objects in immersive manner and finally augmented virtuality (AV) by capturing features of reality in the immersive virtual 3D environment (Milgram et al., 1995). The expectance and the educational potential of using AR and AV technologies is extremely high as its wider commercialization and price lowering is due in near future.

Having beforementioned in mind, a new and innovative approach to learning mechanics was developed by the Faculty of Technical Sciences Čačak staff. Utilization of Wrench computer simulated virtual reality environment was carried out via the Oculus Rift platform. User immersion involved activating several senses by using 3D animation, stereo audio, and tactile hand or finger spatial movement sensors. This novel model of learning practically does not require any particularly high level of digital, mathematical or linguistic literacy, so its intuitive student use is possible with only a minimum mechanics pre-knowledge.

2. VIRTUAL REALITY ENVIRONMENT AND LEARNING AUTO MECHANICS

The research in using VR technology in education defined some clear gains from it, such as economics i.e. cost saving via out-of-workshop access, extending user experience beyond physical limitations of the reality, safe working and experimenting and immersive experience (Freina & Ott, 2015; Martín-Gutiérrez et al., 2017).

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To utilize the VR technology in education two prerequirements has to be met. First, the institution/individual has to have a VR device. As the IT industry clearly still holds a great momentum it for one gave birth to smartphones, mobile devices, gaming consoles and PCs powerful enough to make them suitable for VR/AR. In addition, affordable headsets and head-mounted displays (HMDs) (e.g. Oculus Rift, Samsung Gear, HTC Vive) flooded the market in the past few years, so one can state that owning the VR device is no longer expensive nor exclusive. Second, we need the educational contents. This is where the industry still has not catch up. Like with other educational software or games, the market for it exists but the cost/price ratio is extremely unfavorable, so the software companies has yet to turn from commercial gains and maybe sometimes do a "pro bono" case.

Learning auto mechanic implies acquiring the knowledge, skills and habits necessary to perform tasks like auto mechanic parts assembly and enabling to be quickly involved in the process of specific work technology. Learner master the technological procedures and methods of disassembly and assembly of subassemblies, assemblies and systems of a motor vehicle in their maintenance. Training should also be oriented towards the proper, rational and economic use, application and maintenance of work tools. The learner should apply its knowledge in the determination of failures and resulting defects in the functioning of devices and systems of a motor vehicle.

After the extensive analysis of currently available hardware and software VR solutions for learning auto mechanics a combination of Oculus Rift and Wrench motorsports mechanic simulator was identified as the most extensive, adaptive and of highest quality, thus currently being the best overall solution. The Oculus Rift (Image 1) solution uses HMD to project separate 2D images for each eye thus allowing the perception of 3D stereoscopic view with the field of view of approx. 100 degrees. The HMD is combined with the stereo audio headphones and two wireless 3D touch controllers which significantly improves the immersive experience.

Image 1 – Oculus Rift VR HMD with wireless touch controllers

Wrench is a highly detailed race car mechanic simulator that is primary developed for maintaining team race cars by the Missing Digit company. It has a growing library of parts and assemblies in detail including: Engine bottom end, Cylinder head, Front and rear suspension, and the braking systems. Wrench also enables diagnosing mechanical issues with a variety of tools. With its numerous components modelled to extreme detail thanks to an efficient photogrammetry technique, the game ideally suited to VR, as each part is best appreciated at very close range, and motion controllers allow for precise manipulation (Image 2).

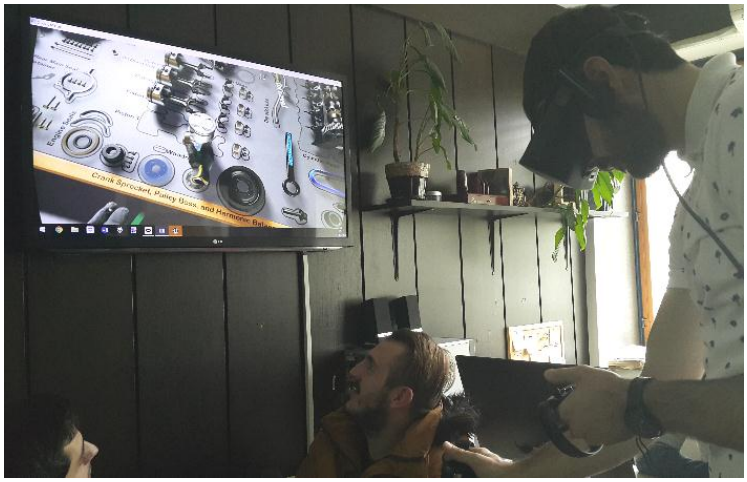

Image 2 – Using Wrench with Oculus Rift motion controllers

The assets are built with very high texture details. Wrench can be observed as a non-linear shop manual that lets dry run all of the assembly. Rather than reading an index, finding the chapter, then locating the relevant paragraph, users can scan the part they want to know about, and they can see relevant diagrams and written install instructions. The assembly process is already detailed enough to be applicable. Fasteners all have torque specs, etc. Dimensional accuracy is hugely important for a VR environment like the Wrench. Typically, when cars are modeled for games or film, the mechanical components only look correct from an external view--they don't actually fit together and proportions can be off without major consequences. In this instance, everything needs to actually fit together. To solve this, about half of the high-res geometry in Wrench is from scan data. The other half is clean models and sculpting done in Zbrush. As all the parts are dimensionally accurate the complete attention was on each part as a singular prop. Most of the effort is front loaded into the high-res art. Using the VR environment provided unmatched spatial awareness and the ability to precisely control position and orientation of the camera and motion controllers, but has only a few controller inputs. Wrench was developed using Unreal Engine 4. Combined with the exceptionally detailed parts that Alec produces, the rendering quality has allowed the simulation to look great in VR (Image 3).

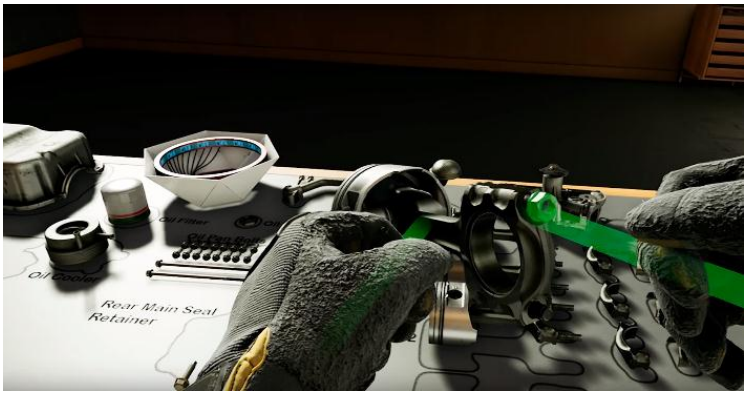

Image 3 –Wrench VR interface

The introduction of this new learning approach in a classroom setting can have its difficulties as it is important to consider the attitude of students and/or teachers towards the implementation of technology (Squires, 2017). Another potential problem lies with the teachers discomfort of no longer having control of what students were doing and weather they fulfill the given task (Dalim et al, 2017).

However, the benefits of the right instructional approach that foster cognitive processes during learning should guide students to select, organize and integrate relevant knowledge (Mayer, 2009). Both visual and textual information, supported by a narration, should be integrated with the proposed learning model, as in (Azer & Azer, 2016; Hu et al., 2016; Moro et al., 2017).

Using HMDs is often related to cybersickness, which can have detrimental effect on the overall learning experience. Cybersickness is a result of a sensory mismatch occurring when the human brain visual subsystem tells the body it is moving whilst the vestibular subsystem reports it stationary (Kim & Shin, 2018; Settgast et al., 2016). However, this effect can be greatly reduced simply by sitting, which in the case of the proposed learning setting does not significantly reduces user experience.

3. CONCLUSIONS

VR presented itself as an effective method in supplementing the knowledge of auto mechanics. In a manner of speaking it potentiated the right amount of combining the theoretical background and the practical skills in the safe and economic environment. As students tested the setting, they quickly became accustomed to using HMD and touch controllers, which was expected as the device had top-level ergonomics.

The limits of using VR in an educational environment is not in technology itself, but in how this technology is used and how students learn (Martín-Gutiérrez et al., 2017). In the case of combining Oculus Rift with Wrench a bridge was made between gaining knowledge and skills thus enabling pure constructivist approach by which students benefited the most.

4. REFERENCES

[1] Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of communication, 42*(4), 73-93.

[2] Cabiria, J. (2012). Augmenting engagement: Augmented reality in education. In *Increasing student engagement and retention using immersive interfaces: Virtual worlds, gaming, and simulation* (pp. 225-251). Emerald Group Publishing Limited.

[3] Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995). Augmented reality: A class of displays on the reality-virtuality continuum. In *Telemanipulator and telepresence technologies* (Vol. 2351, pp. 282-292). International Society for Optics and Photonics.

[4] Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: state of the art and perspectives. In *The International Scientific Conference eLearning and Software for Education* (Vol. 1, p. 133). "Carol I" National Defence University.

[5] Martín-Gutiérrez, J., Mora, C. E., Añorbe-Díaz, B., & González-Marrero, A. (2017). Virtual technologies trends in education. *EURASIA Journal of Mathematics Science and Technology Education, 13*(2), 469-486.

[6] Squires, D. (2017). Augmented Reality Application Classroom Development: New Technology and New Media, Education and Intelligent Classrooms. *i-Manager's Journal of Educational Technology, 14*(1), 1.

[7] Dalim, C. S. C., Kolivand, H., Kadhim, H., Sunar, M. S., & Billinghurst, M. (2017). Factors influencing the acceptance of augmented reality in education: A review of the literature. *Journal of Computer Science, 13*(11), 581-589.

[8] Mayer, R. E. (2009). *Multimedia Learning*. New York, NY: Cambridge University Press.

[9] Hu, A., Shewokis, P. A., Ting, K., & Fung, K. (2016). Motivation in computer- assisted instruction. *The Laryngoscope, 126*, S5-S13.

[10] Azer, S. A., & Azer, S. (2016). 3D anatomy models and impact on learning: a review of the quality of the literature. *Health professions education*, *2*(2), 80-98.

[11] Moro, C., Štromberga, Z., & Stirling, A. (2017). Virtualisation devices for student learning: Comparison between desktop-based (Oculus Rift) and mobile-based (Gear VR) virtual reality in medical and health science education. *Australasian Journal of Educational Technology*, *33*(6).

[12] Settgast, V., Pirker, J., Lontschar, S., Maggale, S., & Gütl, C. (2016, September). Evaluating experiences in different virtual reality setups. In *International conference on entertainment computing* (pp. 115-125). Springer, Cham.

[13] Kim, E., & Shin, G. (2018, September). Head rotation and muscle activity when conducting document editing tasks with a head-mounted display. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 62, No. 1, pp. 952-955). Sage CA: Los Angeles, CA: SAGE Publications.