Virtual Reality Technology for Military and Industry Training Programs

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Abstract. This paper presents how the Virtual Reality (VR) technology and Computer Graphics (CG) is used nowadays by industry to reduce productions costs, minimize learning curve and eliminates hazard situations. Few examples of procedural training and VR simulators are being presented, as well as the usage of CG for military training and troops support.

1 Introduction

In production industries it is already a standard to use Virtual Reality and its methods to improve product development, increase quality and optimize final design. Computer visualizations and analysis software significantly helps to reduce growing production costs and allows to avoid prototypes manufacture and arduous testing in science laboratories. This speeds up development project and improves communication between engineers, allowing for intuitive experience and data exchange while using intelligible environment of virtual reality. Today's competitive business climate intensifies the need for well-trained operators with all types of skills and in all industries. Companies are pushing facilities to their limits, while both processes and automated systems are becoming more and more complicated. The projected retirement of many experienced operators in the near future sets the stage for a young workforce. The question is how to maintain a

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profitable production rate and secure a safe and effective work environment with personnel that is new to the job. This is where 3D communications are becoming ubiquitous, independent of specialized software and formats, and cost effective. The use of 3D data and tools is helping accelerate the communication of information. Disconnecting 3D data from burdened systems and making this data available for all people in the organization is considered an important objective that significantly improves the communication quality while reduce time and costs.

2 Virtual Reality for Industry

With safe virtual environments, the ability to make and learn from mistakes while performing complicated procedures and instructions is a hallmark of the way to designs training and educational solutions. Within this 'learning by doing' approach, a user can quickly identify a problem, ask questions, or receive just-in-time mentoring about any consequences of his actions. Photorealistic 3D models of detailed equipment and full-scale facilities are just the beginning. By reusing this data in a real-time software environment, a virtual instructor can interactively guide students through even the most advanced assembly service, maintenance checklist or safety procedure.

The objective of all operator training is to improve a skill set as rapidly and effectively as possible. The realism associated with Virtual Reality training greatly accelerates learning and skill acquisition. In fact, the combination of VR and traditional training has been proven effective again and again.

Having the ability to improve asset utilization, reuse complex models, and visit hazardous locations virtually using 3D simulated environments allows time savings to accumulate. An example of time savings is creating a virtual walkthrough of a production facility. Realistic 3D display technology allows to tour a facility virtually from just about anywhere emulating real-life experiences and remote collaboration among teams. In Fig. 1. a virtual simulator of LNG vessel compressor room operated by Exxon Mobile is presented. Using 1:1 full scale immersive display system an operator is being trained on over 100 pressure valves functionality, which is not possible in real life due to a cost restrains and potential risk. Such a system might be classified as an "Operator Training Simulator" (OTS) which is fundamental to production facility operations and abnormal situation management. OTS allows beginners to learn the basics, while more experienced staff are able to deal with unusual or emergency situations in a safe environment.

Final model quality, physics simulation and equipment behavior control decides how the trainees will absorb the instruction and retain what they learned in their exercise. Almost any machine might be reconstructed as a 3D interactive model with real and virtual controllers or cockpits. These simulators, often called Synthetic Environmental Trainers (SET), blurs the difference between the simulation and the real work environment. SET can dramatically shorten the learning curve, improve operator's skill and support mastery for certification and compliance. As an example Fig. 1. presents a typical simulator where true cockpit of the vehicle was combined with 3D stereoscopic real time environment.

Since last few years CG technologies supports industry with another very powerful training toolkit in the form of Augmented Reality Instructions. ARI delivers computer generated maintenance and operational information on top of visible objects. See-through glasses project digitized models and information layered on top of the existing environment. Operators can interact with equipment controls while service step-by-step instructions augment the user's experience. Applications and simulators can be designed to appear on the mobile devices such as electronic tablets or smartphones, replacing printed material with always current, best practice instructions. This solutions help to transform an employee with general understanding of an environment or equipment into the knowledge worker for the 21st century. Fig. 1. presents an example of ARI project implemented for mining equipment service and weekly maintenance.

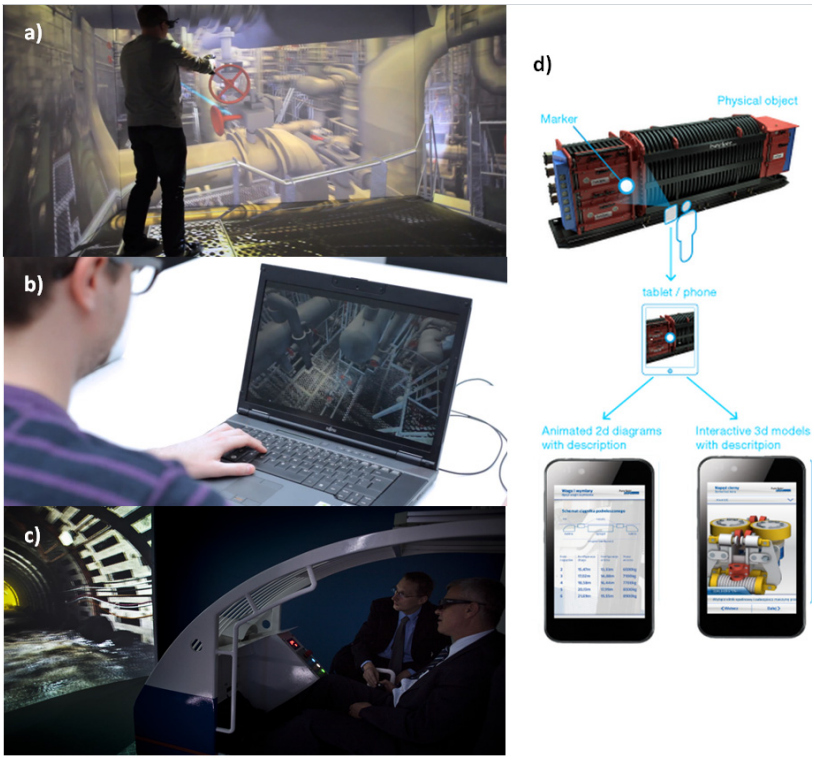

Fig. 1. Virtual Reality training simulators developed by i3D in 2012 for mining industry: a) CAVE immersive simulator developed for Exxon Mobile (OTS), b) Exxon Mobile interactive simulator displayed on a standard laptop, c) Synthetic Environmental Trainer with physical controllers developed for Becker Warkop, d) Augmented Reality Instructions for Android devices developed for Becker Warkop (sources: i3D, Exxon Mobile, Becker Warkop 2012)

Regardless which of the three mentioned above types of Virtual Reality simulators are being used, the general benefits of VR listed below are significant:

- **More Proficient Operators**. Experienced personnel make fewer errors; they can identify upcoming process disruption earlier and initiate the adequate steps and actions to avoid or minimize any detrimental effects.
- **Risk Reduction & Enhanced Skills Development**. Synthetic Environmental Trainers expose operators to a wide range of environment conditions and teach them how to deal with emergencies and unusual conditions in safe and secure conditions – preventing loss & injury when real crises occur.
- **Knowledge Capture for More Effective Training**. The ability to measure what a trainee is doing right or wrong immediately in the virtual work environment provides accurate data on the effectiveness of training and enhanced operator personal skills.
- **Reduced Loss of Production during Training**. Using Operator Training Simulators instead of production machines allows the production process to continue uninterrupted.
- **Increased Crew Efficiency**. Competent and well-trained employees perform tasks quickly and efficiently ensuring product quality and contributing to the development of the company.
- **Average Production per Machine** Improvement. Highly motivated and knowledgeable personnel are more likely to exploit the full potential of equipment, increasing average annual production per machine.
- **Reduced Machine Wear and Damage**. Simulators help operator better understand the machinery, reducing risk of improper use and potential breakage.
- **Improved Reliability and Quality**. Well-trained personnel is able to face more complex tasks, defining new quality standards.

3 Virtual Reality for Defense

Since the begging of CG (Computer Graphics) technology development, Virtual Reality (VR) has been used to support several US army defense projects as well as their command centers. Nowadays, VR software and display equipment go beyond many standard limitations and allow users to communicate and cooperate with each other in digital world as well as reduce the costs and the number of real exercises needed for military personnel training. Presently, computer applications are mostly used to train military pilots and tank crews in safe environments. Soldiers steps into a physical mockup of the vehicle surrounded with projection screens which in the real time generate 3D world around their perception.

The most important assets of the military forces is their experience and the knowledge acquired on the ground in combat. Military officials become concerned how to transfer this knowledge to a young man, ages 18 to 24, in the best effective way to enhance their skills and their ability to think in complex environments.

During the standard military exercises, life of the soldier is usually not in danger. This makes it very hard to study his individual behavioral characteristic, his

ability to analyze threats, identify emerging situation and decision making process under a life – threatening situation. VR allows to arrange dangerous combat conditions in potentially safe environment. Lesson learned would be very important to detect suspicious behavior and actions of individuals. Through such a virtual experience, we can select the best people for the job and prepare them for the mission.

But present VR combat solutions also has some major drawbacks. For example, all the simulators are located in the air-conditioned environments, where soldiers do not feel heat or cold, they do not get tired carrying full weight backpack while walking through the quaggy terrain. Possibility to go through the walls without collision detection also makes it more gaming than serious training.

With today's technology and fast grown of the computer graphics, this might be improved. Among the numerous of standard military Synthetic Environmental Trainers (SET), each year more advanced and complex "first response" simulators are being deployed in the army which brings troops training to the next level. One of such a modern systems is the most common one named VIRTSIM offered commercially on the market by Raytheon. "Utilizing cutting edge software, VIRTSIM creates real-life scenarios for users to immerse themselves in tactical training activities" (source: Raytheon).

Advanced first response simulators based on Virtual Reality technology gives us a significant benefits:

- **Repeatability** – each mission can be repeated many times, results might be stored, and played to analyze and compare individual behave.
- **Knowledge transfer** – years of ground in combat experience might be captured and documented for young soldiers training.
- **Safe training** – the highest risk possible combat scenarios might be simulated to deceive soldiers perception without putting them for any physical risk of injury.
- **Economic factor** – soldiers deployment might take place without moving expensive military equipment and troops to foreign country or ally polygons, ammunition and fuel expenses are eliminated.
- **Behavior evaluation** – VR allows to detect suspicious behavior and actions of individuals in dangerous combat conditions, and their decision making process.

Custom made systems integrates real environments with advanced Virtual and Augmented Reality technologies, which delivers innovative and up-to date training solutions to the military. Additionally Virtual Reality applications are commonly used as a therapy treatment for military veterans to deal with Post Traumatic Stress Disorder. By recreating an exact combat situation, dangerous and stress location or past battle conditions, therapist can manipulate veterans to effect their perception and help to deal with psychology outcomes as well as reduce veterans trauma.

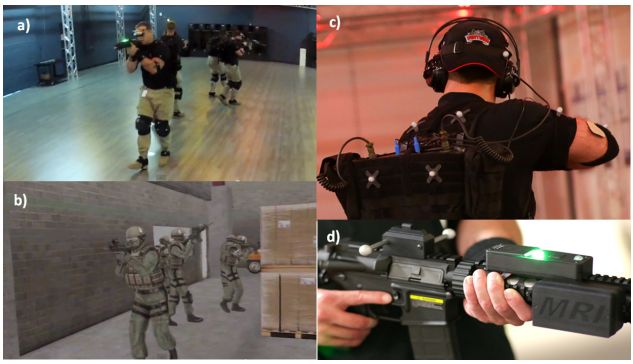

Fig. 2. Example of the first response military simulator offered commercially on the market: a) Picture of the training hall with soldiers equipped with tracking system, Head Mounted Display glasses, electric shock bandages and weapon replicas, b) Solders as a 3D avatars in simulation environment, c) Individual equip per solder, d) Fire arms replica with tracking system (sources: Raytheon 2012)

Fig. 3. Post Traumatic Stress Disorder behavior research using immersive CAVE display system (source: i3D 2012)

4 VR for Safety

Every year emergencies from man-made to natural disasters, take their toll on businesses and industry in lives and costs. This can be changed. Business and industry can limit injuries and damages and return more quickly to normal operations if they plan ahead. Management today is augmenting their recovery plans and safety trainings for effective emergency preparedness with 3D models and simulations of a facility, locale or specific situations.

One of the best ways to prevent and control occupational injuries, illnesses and deaths is to “design out” or minimize hazards and risks early in the design process. Using 3D models and simulations of building, structures, work environments,

machinery and equipment are cost-effective means to enhance occupational safety and health.

Classic safety training is generally comprised of several days of lectures supplemented with simple video presentations and compute-based training (CBT) modules. Focused primarily on knowledge transfer, this classic approach does not fully engage trainees to develop problem solving or critical thinking skills.

Virtual Reality changes the approach with meaningful interactive 3D content designed to actively engage students and keeps them focused on the subject matter, encouraging discussion while working within the environment virtually. Research has shown that trainees use gaming-type applications are much better prepared and retain the instruction longer. Interactive 3D technology is a flexible way to represent and experience safely complex, potentially hazardous processes or environments regardless of the geography or industry. With VR technology, engineers are able to analyze risky scenarios and minimize potential incident-prone areas, also VR works to make employees or even soldiers more aware of potential hazards at a site, the proper use of safety equipment and the procedures to maximize everyone's safety should problems occur.

Safety training should be continuous and ongoing. New devices, new technologies, new processes, all require new safety instruction, protocols and practice. Fig.4. presents an example of typical step by step approach safety application developed by i3D for Oil and Gas industry leader, where safety protocols decides of the life of many.

Fig. 4. Gas and oil separator unit safety instruction developed in 2011 by i3D using Quazar3D real-time interactive environment: a) classroom with 3D stereoscopic projection system, b) individual safety test on a laptop (source: i3D, 2011)

5 Summary

Thanks to newly affordable, newly accessible VR technology, it's a brand new day in Information Communications. Teams working virtually and collaboratively in 3D are the norm for the 21st century workforce. By detaching 3D data from complex systems and making this data accessible to all people in the organization, VR methodology dramatically improves communication effectiveness while reducing time and costs.

Synthetic Environmental Trainers and Operator Training Simulators continuously evaluates and monitors each individual student's actions, quickly identifying weak spots that require additional attention teaching the most effective way and best working practices. Virtual Reality simulators optimize the training cycle while providing a very high standard in terms of skills improvement and safety consciousness. Simulators and Augmented Reality Instructions can be used for beginners' basic training, or to help experienced operators refine their skills to increase production levels.

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