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VIRTUAL REALITY SIMULATION TECHNOLOGY FOR MILITARY AND INDUSTRY SKILL IMPROVEMENT AND TRAINING PROGRAMS

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

Keywords: Simulator, Virtual Reality, Training, Immersive.

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 research 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 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 to all people in the organization is considered an important objective that significantly improves the communication quality while saving 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

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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 oil platform named EYESIM is presented. Using 1:1 full scale immersive display system an operator is being trained on a complex functionality, which is not possible in real life due to cost restraints 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 [1,2,3].

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), blur 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.

Systems such as EYESim (Fig.1.) can use modern technology to familiarize with plant operations and processes without coming in contact with the actual machinery. Large facilities can benefit from using virtual training tools due to the size of the facility and range of equipment in use.

Since a few years CG technologies support 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 knowledgeable worker for the 21st century. Fig. 2 presents an example of an ARI project prepared by the OBRUM R&D institute for the power sector in the field of onsite service and daily maintenance.

Fig. 1. Oil & Gas typical simulation. EYESIM is an immersive 3D virtual reality training tool designed to train personnel to work on facilities such as oil and gas rigs. EYESIM is currently being used for training projects by the Department of Energy, BG Group and Sumitomo [1, 2]

Fig.2. Augmented Reality demo application developed by OBRUM

Regardless of 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 environmental 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 beginning 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 step 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 are their experience and the knowledge acquired on the ground in combat. Military officials become concerned how to transfer this knowledge to a young man, aged 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 in 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 have some major drawbacks. For example, all the simulators are located in air-conditioned environments, where soldiers do not feel heat or cold, they do not get tired carrying full weight backpack while walking through the boggy terrain. Possibility to go through the walls without collision detection also makes it more like a game than serious training.

With today's technology and progress in 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 the most complex simulation environments is well known under the name of DTS (Dismounted Training Soldier program). Several producers offer systems were the trainee, together with his squad colleagues using a high advanced technology and 3D Head Mounted Display Systems, are completely immersed in Virtual Reality, where each of their moves is being copied by an optical motion capture systems. Utilizing cutting edge software and hardware technology, DTS creates real-life scenarios for users to immerse themselves in tactical training activities (Fig.3).

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

- Repeatability – each mission can be repeated many times, results may be stored, and played to analyze and compare individual behavior.
- Knowledge transfer – years of ground in combat experience may be captured and documented for young soldiers' training.
- Safe training – the highest risk possible combat scenarios may be simulated to deceive soldiers perception without exposing them to any physical risk of injury.
- Economic factor – soldiers deployment may take place without moving expensive military equipment and troops to foreign country or ally training ground, 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 integrate real environment with advanced Virtual and Augmented Reality technologies, which delivers innovative and up-to date training solutions to the military. Additionally military commonly uses Virtual Reality applications as a therapy treatment for military veterans to deal with PTSD. Posttraumatic Stress Disorder is classified as an anxiety disorder; the characteristic symptoms are not present before exposure to the violently traumatic event. In the typical case, the individual with PTSD persistently avoids all thoughts and emotions, and discussion of the stressor event and may experience amnesia. However, the event is commonly relived by the individual through intrusive, recurrent recollections, flashbacks, and nightmares. By recreating an exact combat situation, dangerous

and stress location or past battle conditions, therapist can manipulate veterans to affect their perception and help to deal with psychology outcomes as well as reduce veterans' trauma in a safe and controlled environment of VR [5].

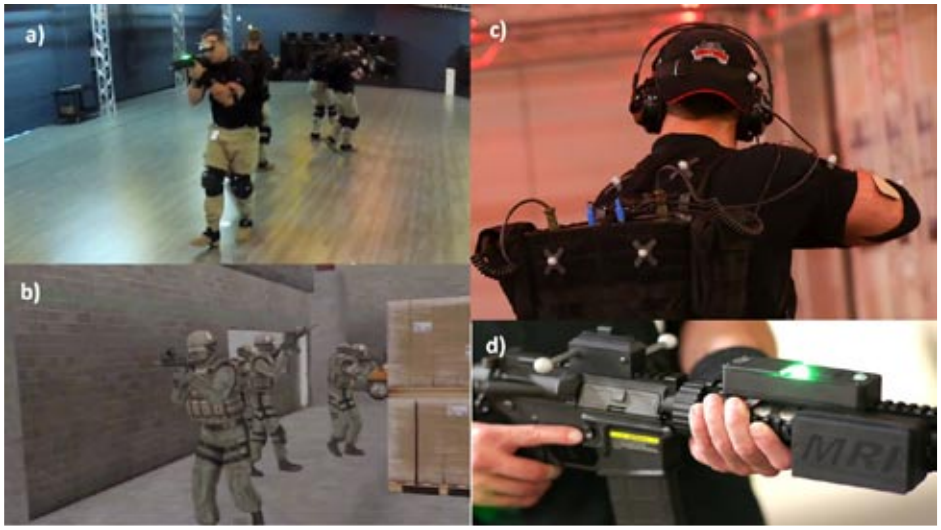

Fig. 3. Example of the first response military simulator offered commercially on the market:
a) View of the training hall with soldiers equipped with tracking system, Head Mounted Display glasses, electric shock bandages and weapon replicas, b) Solders as 3D avatars in simulation environment, c) Individual equipment for solder, d) Fire arms replica with tracking system [4]

Fig. 4. Post Traumatic Stress Disorder behavior treatment using immersive display system
(Dr. Greg Reger, left, works with a soldier to demonstrate how virtual reality is integrated with prolonged exposure therapy to treat PTSD. Doctors take the service member back to their traumatic experiences one by one and help them work through the events. The departments of Defense and Health and Human Services are currently conducting what has been called the highest quality scientific evaluation on virtual reality exposure therapy at Fort Bragg and Joint Base Lewis-McChord to see if the therapy is a proven treatment method. Courtesy National Center for Telehealth and Technology) [6]

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 computer-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 who use gaming-type applications are much better prepared and retain the instructions 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.5 presents an example of typical step by step approach safety application developed by OBRUM both for civil and military customers, where safety protocols decide on the life of many and a smallest mistake make be fatal in consequences.

Fig. 5. Procedural training application in a safe and controlled virtual environment

5. CONCLUSIONS

Thanks to affordable, 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 and meat the performance expectations.

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