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Application of Virtual Reality in the Automobile, Aerospace Industry and Medical Surgery

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ABSTRACT

Virtual reality technology and applications to the automotive, aerospace and medical surgery industry were discussed. The advances in computer hardware and software that increased industrial application of VR were discussed for automotive, aerospace and medical surgery industries. Some of the hardware components are projectors, monitors of computers, haptic devices, hand gloves, shutter glasses, head mounted displays and so on. The software used for generating 3D models for automotive, aerospace designs the types of computer imaging for medical surgery simulation were also highlighted. Several virtual reality systems and virtual environments developed over the years for automotive, aerospace and medical surgery industry were discussed. The cost effectiveness of VR technology and the improvement it brought to the automotive, aerospace and medical surgery industries were mentioned. Current limitations to the implementation of the VR technology in automotive, aerospace and medical industries based on realism of simulation, need to improve computer human interfaces and simulator delays were explained. Finally, the legal and regulatory issues to be addressed for full commercialisation of VR in automotive, aerospace and medical surgery industries were highlighted.

Keywords: virtual reality technology, industrial application, software, hardware, cost effectiveness

INTRODUCTION

In other to be successful in the automotive industry with increasing competition and a market requiring quicker time- to-market with improved product quality, a major factor is the application and development of newer technologies(Choi and Cheung, 2008; Lawson, Salanitri and Water field, 2015). One of the technologies that can achieve this aim is virtual reality technology.

Broadly, virtual reality is a method of taking someone into reality which is a virtual environment without the person been there physically but having the feeling as though he/she is there. (Lawson Salanitri and Waterfield, 2016). Virtual reality is simulation technique carried out by the computer with the capability of realistically imitating actual environments in accordance with "their physical laws and appearance" (Piovano et al., 2013). Virtual reality is an emerging design tool that has found applications in many manufacturing industries to aid the design, training, and analysis of products. Some of the virtual reality applications can be found in the automotive, aerospace industries and medical surgery industries.

Virtual reality is a system of projecting a virtual image on the screen with the use of a custom- made computer program by which there is an interaction between the user and the software using of a physical interface and sensor movements (Burden Oestergaard, and Larsen, 2011). This signifies that the virtual systems consist basically of software, hardware, sensors, display unit and a user interface.

A survey conducted by Mousavi, Abdul Aziz and Ismail (2012) on 6 automobile industries in Malaysia showed a response of 38% for virtual reality application. According to (Burden Oestergaard and Larsen, 2011), VR simulation training is aimed at developing surgical skills in an environment that has less stress, safe, controlled and flexible regarding clinical time. They stressed that added opportunities to learning can be acquired and can supplement directly supervised training during hours of work with patients.

The primary motivation behind the application of virtual reality simulation in the medical field was to introduce minimally invasive procedures, reduction in training time, and safety of patients (Willaert et al., 2012). The main focus of this report is on the application of virtual reality technology in the automotive/aerospace and medical surgery industries. The report is in two sections. Section A deal with virtual reality application in the automotive/aerospace industries while section B discusses the application of virtual reality in the medical surgery industry. Over the last ten years, there have been advances in computer imaging, software, hardware and display devices that have increased industrial application of virtual reality technology.

These advances will be discussed in both sections in this report. The cost -effectiveness of virtual reality technology and their ability to improve the quality of design process, reducing the manufacturing lead time (time to market) in the automotive/aerospace industry will be discussed. Also, cost- effectiveness of VR technology and their ability to improve the quality of care in medical surgery so as to expedite their commercialisation will be dealt with.

Current limitations of virtual reality technology as regards realism, time delay in simulators, and the need to improve human- computer interface, will be discussed for both sections A and B. Finally, the legal and regulatory issue that needs to be addressed for the commercialization of virtual reality systems in the automotive/aerospace industry and medical surgery will be discussed.

The advances in computer imaging, software, hardware and display devices in the last 10 years that have increased industrial application of virtual reality technology

Over the last ten years, there have been advances or developments in computer imaging, hardware, software and display devices. Due to these advances, virtual reality technology applications in industries have greatly increased. Computer hardware can be any physical parts of the computer or even connections to the computer that will make it accomplish certain tasks. As regards to virtual reality, and in this report, hard ware consists of display devices and other physical components connected to the computer or used together to achieve the simulation process.

Computer Software drives the hardware to function. They are used for the creation of the product's model either in 2D or 3D, simulation process and virtual prototyping. Computer- aided design (CAD) and computer aided engineering (CAE) are the most commonly used in the automotive industries providing a good virtual prototyping base (Mousavi Abdul Aziz and Ismail, 2012). According to Lawton (2006), cheaper virtual reality systems like CAVE have already been developed by the University of Illinois, while PCs, projectors are also cheaper than before. Other systems like the John-e-box by the Indiana University's Advanced Visualization Lab has been developed equipped with a small rear projection system, Intel pc processors, graphic cards, and open source software tools.

Rangel et al. (2007) developed an auxiliary navigation system using a synthetic vision (VR glasses) for use on unmanned aerial vehicles (UAVs). The navigation system comprises the following hardware components at the ground station: "laptop computer, real time video, telemetry devices, I/O devices boards, flight controls joysticks, hand GPS, and virtual reality glasses that provided complete immersion of the pilot in the navigation system. They also reported the use of navigation Software for the analysis of flight information of an aircraft, the direction and location, acquisition of video in real-time, visual interface building and real-time data navigation update. Images of the synthetic vision system used for navigation, is shown below in fig 1.

Figure 1: showing Navigation system (Rangel et al., 2007)

Abateet al. (2009) reported a haptic- based method of virtual training in the aerospace industry. The system consists of "a one hand-based force-feedback haptic device" with a virtual simulation engine that was real time. The hardware devices used for the study was a "dual quad-core Intel Xeon processor-based PC, Nvidia Quadro5600graphics board magnetic six-degrees of freedom tracker a cybermind Visette SXGA head- mounted display providing 2LCOS displays" with a resolution of 1280 x1024pixels. The figure2 below shows the one hand haptic device.

Fig 2: one hand haptic device (Abateet al., 2009)

They stated that the haptic device has the potential to carry out industrial maintenance in a reduced time. They stated that realism can also be improved using a two-hand system.

The use of haptic feedback has shown the capability of simulating feeling of touch in virtual reality for the evaluation of tool's disposition like the buttons, knobs and imitating actions like door opening (Bordegoni et al., 2006). The haptic feedback has the advantage of prolonging immersion and the capability of use age thereby enhancing confidence in the technology (Durlach et al., 2005; Salanitri et al., 2015). Liang Xianguang and Yebin (2011) carried out a research on major techniques involved in the visual simulation of automobile engine. The simulation comprises of a CATIA, software for 3D solid modelling of the engine, and dynamic simulation software (ADAMS). Other software used were ; MultiGen Creator for creating 3D models of visual simulation in real-time, polyTrans software for converting to "stereo modelling of engine", and a Vega prime which is a real-time cross-platform tool kit and an application programme interface for visual simulation . The Vega prime according to them provides better user interface and interface function that are complete.

Osterlund and Lawrence (2012) reported the initiation of a virtual reality lab known as the Human Engineering Modelling and Performance (HEMAP) Lab in 2008 for human space flight trainings by the USA. This was to tackle interaction problem involving "multiple personnel, ground support equipment and space flight hardware" also capturing the way humans move and perform tasks safely. The HEMAP lab consists of the following; "high resolution VICON cameras, Autodesk Maya animation software, JACKTM Ergonomic (human modelling and simulation) software, ANARKs conversion and polygon reduction software, and Autodesk's 3D Motion Building software, desktop computers. Figure 3 shows a mock-up of the system.

Fig 3: The Orion 606E mock- up (Osterlund and Lawrence 2012)

According to Mousavi Aziz and Ismail (2012), BMW car manufacturing company after the design and production of a car model that was not easy to assemble and disassemble, conducted a test of the model in a CAVE with the use of VR technology. The hardware interactive tools used were; "head- mounted display (HMD), shutter glasses, gloves equipped with position trackers, and finger contact switches (pinch gloves)". The result of the test indicated that virtual reality was advantageous as regards time and cost reduction. They reported that, instead of producing physical mock- ups of new automobile from materials like clay and others, Volvo automobile manufacturing began the transformation of initial CAD files to a format that is agreeable with virtual reality. There was a placement of the virtual car on a square in a town called Linkoping in Sweden. The company had the virtual file compatible with the square. It was the first of its kind for digital mock-ups using VR.

Abidiet al., (2013) in their research simulated human ergonometric in the design of the first Saudi Arabian car in a semi- immersive environment. They employed the use of the following hardware components as reported by Abidiet al., (2013) shown in the figures 4a to f below.

Fig 4: Hardware components

(a) Screen; (b) Rear Projector; (c) Hand wand; (d) VR Hardware Controller; (e) Shutter glasses with head tracker; (f) AMX Controller(Abidi et al., 2013).

The virtual environment used was called Gazal-1. CATIA V5 R22 was used for the development of the virtual humans and CAD models of the car. Pro-software was used to convert CAD models to mock-up software format, and then exported into the VR system for analysis.

Fillatreau et al. (2013) in their study reported some hardware and software used for virtual reality. The hardware components are; " stereovision 3D immersive visualization system, F2 video projectors equipped with two light filters for light polarization in a circular manner, a stereo screen of 2.25m wideness, 3D glasses, a Virtuoso 6D 35-45" haptic arm for user manipulation and force feedback, and a wireless motion capture data(Cyber Glove 11) for measuring hand positions configurations in real-time". Figure 5 below showing the haptic arm and the cyber glove. The software consist of CAD tools for generating 3D CAD models, a virtual tools 1 environment for the development of simulations interactively and assigning behavioural attributes to the 3D objects.

Fig 5: Haptic arm and cyber glove (Fillatreauet al., 2013)

Meng, Zhang and Yang (2014) developed a virtual reality system for navigation called the panorama manifestation (PM). The system comprises of a 47 inch LCD, a PC, a sound system, and a sensor equipped revolving chair for the purpose of detecting control operations. The system of display for this system is not different from that of the CAVE except for the number of display of which it was increased to six against four for that of the CAVE. The six monitors were arranged in a circular form to display the whole virtual environment around the user. Figure 6 below shows the configuration of the PM system.

The chair served as an input device for navigation direction control in the virtual environment simulating the way people walk by moving forward and backward using a knob connected to a location sensor. The PM system was enclosed with black clothing so as to mitigate interferences from the external environment.

Figure 6: Showing the PM system configuration (Meng, Zhang, and Yang 2014)

Lin et al., (2015), in their work used three display devices to study the effects of visual control in a 3D VR environment. The first was a 3D stereo television of resolution of 1,280×1,024 pixel, 60Hz used to acquire a distinctive image in the eye of each viewer with the brain processing the received the image and making it to be a stereoscopic view. The second device for the display used a head mounted display (glass goggle) weighing 0.226 with a static intraocular distance, two LCDs that gave a stereoscopic view, with a resolution of 800x600pixels. The third device for the display used Benq PB6100 projector that had a light output of 1500ANSI lumens, at a distance of 3m able to project a 1,340mm×1,010mm image with a diagonal of 1,680mm on a non-stereoscopic view. The resolution was 800x600 pixels. The software used for the creation of the environment was an EON professional 5.5.
These advancements in VR display devices with the illustrated features may contribute to increased industrial application.

Lawson et al. (2015) investigated the use of virtual reality as a valid tool for assessing the ease of entry and exiting a passenger vehicle using participants from jaguar land rover. Their study used the following for assessment; a virtual reality CAVE (the holoVis 4KCAVE) with walls and ceiling as the display for the projection of images, stereo glasses, and head trackers. The cave as used in their study provided entry and exit experience from the perspective of the customers and their application provided wider view and driving simulation during the process of developing the vehicle. Figure 7 below shows the 3D stereoscope of the cave.

Figure 7: showing 3D stereoscope of the CAVE (Lawson et al., 2015)

Lawson Salanitri and Waterfield (2016) reported the implementation of virtual reality technology in jaguar land rover (JLR) automotive industry due to the benefits of the technology. JLR now has a world leading centre for design and engineering for the application of virtual reality which is an innovation centre situated in Warwickshire, UK. The virtual reality technologies implemented by the industry are; an automatic virtual environment known as the cave, equipped with a "high performance hardware, photorealistic software, a power wall, and a marker-based body motion tracking suit for ergonomics investigations". Figure 8 showing a demonstration of the device interaction.

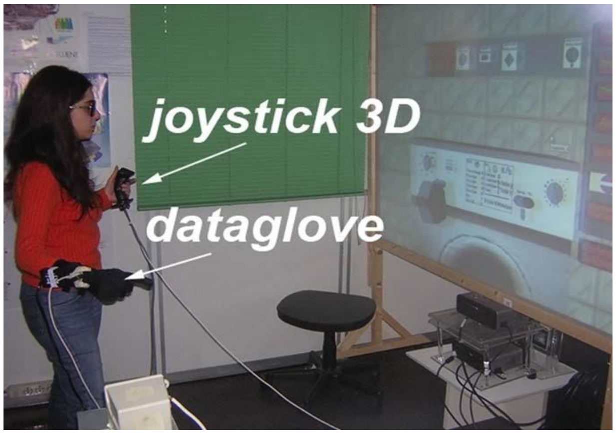

Fig 8: Device interaction (Bruno and Muzzupappa, 2010)

The cost effectiveness of VR technology and their ability to improve the quality of design process and reducing the manufacturing lead time (time to market) in the automotive industry.

Due to advancement in technology, and the increase in efficiencies of producing commodity components, there has been a reduction of the cost of virtual reality systems like processors, projectors, and head mounted displays (HMDs) which are now cheaper than earlier versions. Additionally, Simpler and less costly virtual reality applications have been built saving money and simplifying operations (Lawton, 2006).Virtual reality is capable of reducing cost of manufacturing and time through the replacement of physical models with virtual ones (ShaoRobotham and Hon2012). This means that virtual reality technology when applied can save one the cost of producing a physical prototype in the event of an error at the initial stage.

Choi and Cheung (2008) showed in their study the ease to use virtual reality systems and the cost effectiveness of their tool as regards visualization and the ability to expedite the review of product design and improvement. The training simulation conducted in the virtual reality lab (Human Engineering Modelling and Performance (HEMAP) Lab by participants resulted in the reduction of training cost, and scheduling efficiently (OsterLund and Lawrence 2012). The costs of carrying out the physical training would have been more if not for the use of the VR technology.

The panorama manifestation virtual reality system developed by Meng, Zhang and Yang (2014) was a cost- effective one since it used an array technology industry (ATI) video card as the connection to power six monitors using just one computer and reducing the set-up cost. Therefore, reduction of set-up cost in any industry can also lead to a reduction of manufacturing lead time (time-to-market).

According to Abidiet al. (2013), virtual reality technology affords the designer to ascertain how well humans will perform in a vehicle before it is produced through simulation; and performing ergonomic analysis cost effectively, in a short time when compared to making a physical prototype. This will also reduce the time to market products in the automotive industry. Virtual reality technology affords the designer to ascertain how well humans will perform in a vehicle before it is produced through simulation; and performing ergonomic analysis cost effectively, in a short time when compared to making a physical prototype. This will also reduce the time to market products in the automotive industry (Abidiet al., 2013).

During the initial stage of developing a product, virtual reality can be implemented for design and assessment prior to costly and time wasting production (Lawson and Burnett, 2015; Lawson et al.,., 2015). Due to virtual reality technology, automobile companies are able to design and have a feel of their cars before production. According to Forbes (2014), companies like ford can view the interior/exterior and other details of the car bringing in virtual reality at any stage of the design and testing of ideas. Rework reduction and manufacturing quality improvement were the two main advantages of virtual reality technology by respondents in the survey carried out by Mousavi Abdul-Aziz, and Ismail (2012) on 6 automotive industries in Malaysia.

According to Bruno and Muzzupappa (2010) virtual reality can be a tool for the speedy transmission of the designer's intentions to the users in a virtual environment through designing, analysing and digital testing of the product in a user- friendly way. User interface design occurs as a result of the interaction of users with products (wrist watch, DVD player, a plane etc.) with a general connection with software interfaces and most of the time called human-computer interfaces User Interface (Bruno and Muzzupappa, 2010)

Piovano et al. (2013) in the application of virtual reality technology to represent Martian soils for space explorations noted that the environmental conditions that conforms to the operative scenes needed for set up for the study can be effectively be simulated by virtual reality at a lower cost relatively. They , also pointed out that the use of VR facilities with virtual models by a team of engineers showed clearly the possibility of assessing performances of missions with high degree of accuracy and precision; hence reducing costs effectively through virtual testing and analysis of the product early at the design stage. Due to the nature of competition in the industry, there was the need to employ virtual reality and prototyping since the traditional method of physical prototyping process is slow and time -consuming.

Noon et al. (2012) reported a virtual reality system for creating and assessing conceptual large vehicle designs. The software used was advanced system design suite (ASDS). The importance of the software was to allow fast 3Dmodelling of a design, real-time assessment, and visualization of the results on desktop and virtual reality systems. According to noon et al.,(2012), the design of the user interface is flexible for in-experienced CAD users to be able to create designs at a reduced time. The ASDS was also used for the redesign of a Boeing 777 aimed at increasing the size of the jet by the increase in the wings and fuel age for the transportation of larger number of passengers. Figure 9 below shows the Boeing 777 design.

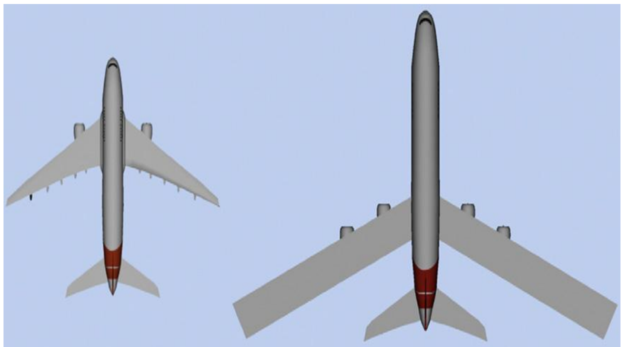

Fig 9: Boeing 777 design (Noon et al., 2012)

The figure below shows the model of the Boeing 777 in the ASDS software with the loading of the individual part files into functional groups within minutes and displayed on the interface at the right hand side.

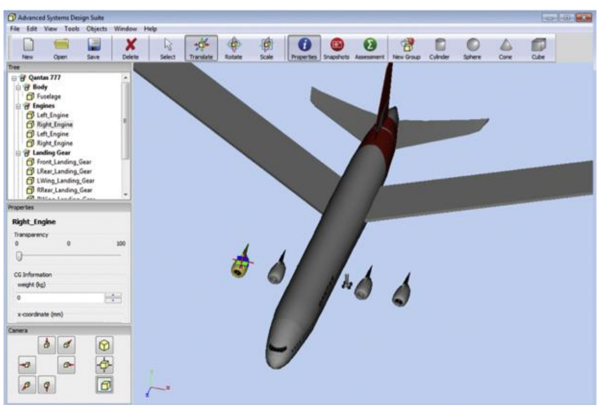

Fig 10: Boeing 777 primitive wing positioning for aggressive sweep angle (Noon et al., 2012)

According to Noon et al. (2012), the user interface of the ASDS, has the ability to reduce the constraints involved in creating complex models using CAD themes. This was as a result of legacy geometries and libraries of shapes that have been built into it avoiding building geometries or models from a blank slate. The ASDS can also be used for the translation of parts, rotation, and scaling in different directions irrespective of other "objects in the design". The scale manipulation tool is shown in fig 11below.

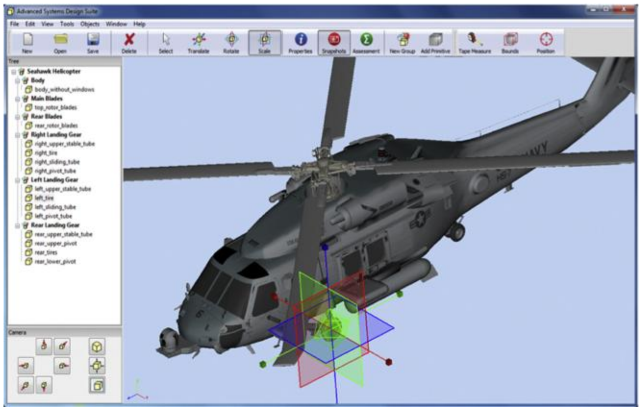

Fig 11: Scale manipulation (Noon et al., 2012)

According to Teixera et al. (2008), one of the critical conditions for product development process optimization is the adoption of virtual design concept. Many industries that used this design concept all the time had a reduction in time in developing a new car from sixty months to twenty four months. This reduction in time in developing a new car has a direct relationship with the cost, and permits the enhancement of product ranges to satisfy the demands of a particular industry creating market stratification resulting to turnover for the company. Virtual reality technology is essential during the process of design and implementation of a product. One of the major benefits of the technology is that, it allows analysis and development to be carried out in joint manner involving experts in various production areas for the viewing and manipulation of virtual the object in real-time in an easy way just like physical object.

Becker, Toivonen and Leino (2011) reported that virtual reality greatly improved clarity and increased the speed of solving problems when used in the design of a car assembly process. Immersive virtual environments in the automotive industry are implemented extensively in assembly simulations for assembly process testing and optimisation, and defining the sequence of the assembly.

Current limitations of VR implementation in terms of realism of the simulation, needs to improve human-computer interfaces, the time delays in simulators.

According to Lin et al. (2015), the projection display has the limitation of display quality, immersion degradation, and the inability to function well in bright settings. The poor display quality in bright environment, can affect the degree of realism. Abate et al. (2009) in their study reported that the use of the one hand haptic device (cyber-force) with Force Generation of 8.8N max/6.6Nmin has limitations in terms of mechanical and operational design.

Piovano et al. (2013) in the application of virtual reality technology for the representation of Martian soils for space explorations argued that one of the limitation in terms of realism of the simulation was the absence of the representation of some terrain elements like; "rocks, small craters and dust" in the Martian terrain models. The absence of these terrain elements in their simulation made it impossible for a true representation of the Martian soil in the simulation.

According to (Lawson, Salanitri and Waterfield 2016) some of the main devices used for real-time interaction in virtual reality are the sensing gloves and motion trackers. The sensing gloves are used for object manipulation but that they have the following limitations; they are lacking in tactile or haptic feedback, they need to be calibrated for a particular user and not all hand sizes can use them. According to Bruno and Muzzupappa (2010), it is presently not easy for the simulation of "tactile stimuli and reactions coming from real objects". Therefore, these limitations will affect their implementation in terms of computer- human interfaces since the sensing hand gloves may not fit everyone.

Other limitations of virtual reality implementations according to Lawson, Salanitri and Waterfield (2016) are in terms of their display devices. They are listed below;

1. The use of LCD display which is non-immersive affects realism of the simulation since users still see their physical environment.
2. The consequent illness associated with the technology also reported by many authors affects realism of the simulation, and the human-computer interface especially in using the head mounted displays.
3. The visualization device known as the CAVE has the limitation of space within the room causing a form of restrictions to the users. The prolong use of the hand gloves can result to complications.

The complications resulting from prolonged use of the gloves are a limitation of the computer -human interface.

The cave is shown in figure 12 below while the gloves are shown in the figure13.

4. The temporal delay in many virtual reality simulators in terms of processing times and rate of updates affects realism. Since the uses of computers are involved, possible delays affecting the simulation can also have real life effects.

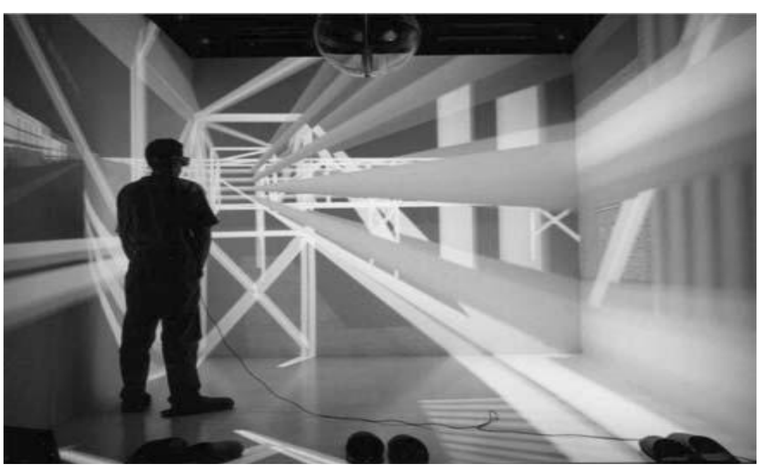

Fig 12: An example of virtual inspection in a CAVE environment (Lawson, Salanitri and Waterfield, 2016)

Fig 13: showing the hand gloves (Lawson, Salanitri and Waterfield, 2016)

Legal and Regulatory issues that need to be addressed for full Commercialization of VR Systems in the Automotive and Aerospace Industry.

Virtual reality is a technology that is growing at a fast rate. Due to its popularity, it is attracting legal issue and questions. Some of the questions range from the use of copy rights and trademarks in virtual reality. How are they really protected? In a case of defamation, how does virtual reality handle it? How can these issues be defended in law as it relates to platform manufacturers, users, developers? The main issues to be addressed here is that of copyright and trademark. When someone reproduces another person's work, without permission of that person, it is regarded as an infringement on the rights of the originator or creator. The work can be a music, image, computer software, and so on. The owner of the work reserves the right to reproduce, or even make it public.

A trademark can be a name symbol or even device used for business and distinguishes from itself from other goods. In real life, copyright laws apply so also in virtual reality. So this law needs to be properly addressed for the benefit of the user, and platform manufacturers. Trade mark is different from copyright Since the right only apply when a particular product or work is been commercialized (Revision legal 2016).

The Advances in Computer Imaging, Software, Hardware and Display Devices in the Last 10 Years that have Increased Medical Application of Virtual Reality Technology.

Arora et al. (2015) in their work on virtual reality simulation training in temporal bone, viewed the displayed images by the simulator with the aid of a shutter glass, while the haptic feedback is provided by a hand-piece used for the drill simulation (Arora et al., 2015).

Burden, Oestergaard and Larsen (2011),reported simulators such as LapSimGyn, SimSurgery, and Simbionix, equipped with pre -recorded examples of teaching programs. They are also offer combined fundamental skills such as handling of instruments, coordination of the eyes, and able to simulate thoroughly operational procedures. While simulators like proMISare equipped with computers that can generate assessments and feedbacks. Others systems reported were a video box trainer that is enhanced by a computer with virtual reality software.

According to Soler (2008) Software for medical image processing now allows for 3D volume rendering and manipulation of CT or MRI patient imagery in a virtual environment in haptic surgery using a haptic interface device. Patient's specific model can be incorporated and interacted with on the virtual simulator system through the haptic interface device (Soler, 2008).

According to Parikh et al (2009), the virtual surgical environment simulator set-up is such that, the CT images are automatically volume rendered and subsequent simulation created in a very fast manner which is just in seconds.

Willaert et al. (2012) reported the development of a "PROcedure Rehearsal module for endovascular simulation for carotid artery stenting procedures" by simbionix in the United States of America. The software/hardware are has an interface that is user friendly and allows VR rehearsals to be created by the surgeons within a duration of below one hour.

The Cost Effectiveness of VR Technology and their Ability to Improve the Quality of Care in Medical Surgery that can expedite (or has facilitated) Commercialization of VR Systems in Medical Surgery.

Parikh et al. (2009) in the creation of a patient specific endoscopic sinus surgery simulator used a Stanford Virtual Surgical Environment (VSE) to visualize the necessary anatomy and navigate through the sinus area of the endoscope.

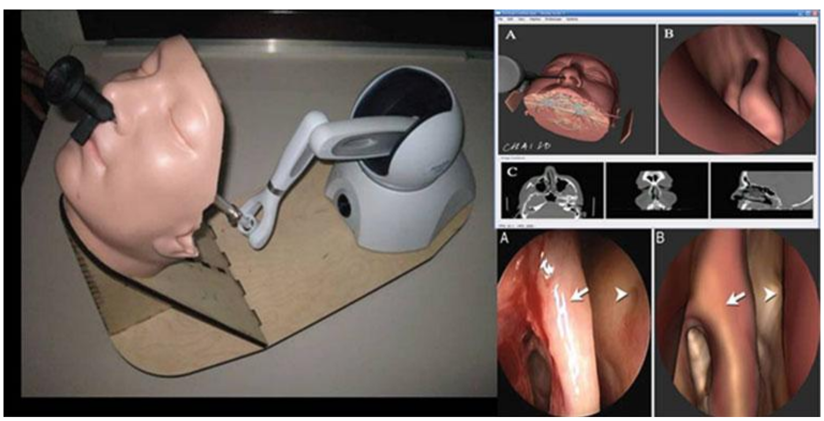

Fig 16: Stanford Virtual Surgical Environment (VSE) for rhinologic procedures (Parikh et al., 2009).

VR simulation training enhances the safety of patients, providing better outcomes for women, and reducing the cost of health services by the increase in clinical throughput (NHS Institute for Innovation and Improvement, 2009).

According to Parikh et al. (2009), the virtual surgical environment simulator set-up is such that, the CT images are automatically volume rendered and subsequent simulation created in a very fast manner which is just in seconds. They argued that the cost of the commercial alternative of this simulator is$10,000 and cheaper than other simulators in other medical fields. They also stated that as a result, implementation can be expediated to be used regularly, and making it accessible by many physicians. This overall, will also facilitate their commercialization within the medical surgery field.

Burden, Oestergaard and Larsen (2011), reported that VR simulation training helps trainees in the management of surgical errors that can be encountered in skills laboratory with the ability to protect patients during clinical surgery if they errors arises. According to them, trainees will be better familiar with the procedures involved in the surgery and the laparoscopic instruments used. They reported various laparoscopic training models that are cheap and can be used with real laparoscopic instruments that uses items like a box, light bulbs a web cam and a computer monitor. However, this type of model according to their report does not have systematic feedback and documented examples.

Willaert et al. (2012) an automated and manual segmentation of MRI and CT DICOM data of the arch and carotid vessels is readily performed. This allows the creation of VR rehearsals by the intervention list or surgeons themselves in less than an hour. The resulting simulation contains a model of the patient's anatomy and reproduces the sense of sight, hearing, and feeling of touch aspects of the carotid stenting procedure for that particular patient. The simulator also records various objective quantitative metrics, tool selections, and fluoroscopy use and enables the user to record certain procedure steps to create a preoperative strategic plan.

Dharmawardana et al. (2015), in their study validated and demonstrated a cost- effective virtual reality sinus simulation for anatomy teaching ,and process with sufficient face and content validity; which with further improvement can be used byotolaryngology head and neck surgery(OHNS). The validation of simulations for surgery is very necessary because it increases confidence in surgeons and their patients.

According to Arora et al. (2015), the incorporation of virtual reality simulation in medical curriculum as part of the trainings given to bone surgeons, will improve the skills of novices in the field, as well as resolve the problem of training variations in ear, nose and throat surgeons.

Current Limitations of VR Implementation in terms of Realism of the Simulation, needs to improve Human-Computer Interfaces, the time delays in Simulators that impede Application of VR Systems in Surgery.

Burden, Oestergaard, and Larsen (2011) argued that due to variations in virtual reality facilities, eagerness of trainers and organization of training programmes, the general implementation of virtual reality simulation curriculum is not easy. This means that realism of the simulation can also be affected since there is no homogeneity. According to Willaerteta l (2012), the first patient- specific virtual reality procedure rehearsal was for a "complex endovascular intervention" at EuroPCR in 2006. The rehearsal uses "Procedicus Vascular Interventional System Trainer" in rehearsing before time a carotid artery of a man who was 64 years of age. This first attempt consumed a lot of time in pre-processing the patient's imagery making the set-up of the rehearsals unrealistic in real clinical situation.

Pederson et al., (2014) conducted a research on the simulation of a patient's specific hip fracture surgery using 3D rendering for visual purpose and provision of a true haptic feedback in the course of drilling with varying bone densities. However from their research, there was a limitation in realism because an affector pen was used in place of a simulated hand drill.

Legal, and Regulatory issues that need to be addressed for full Commercialization of VR Systems in Medical Surgery

According to Coons, MacArthur and Borowick (2015), Legal issues that may affect Virtual reality commercialization are from "rights, trademarks, and copyright". Some of the legal issues are highlighted below: The importation of logos, images of people, music or even brand names into a virtual environment by stakeholders without permission or authorization attracts copyright, trademark and right of publicity. A copy right infringement may be attracted if there was a reproduction of or public display of someone's photograph, video and music without the person's permission. When a virtual reality environment/experience uses an IP from the real world enabled or created by users, platforms or brands, it is regarded as an infringement. There is need to obtain the required rights or license before using the IP.

Virtual reality is not appropriate for all kinds of people due to varying health conditions like high blood pressure pregnant women, those with ear infection and those with symptoms of motion sickness, epilepsy, and seizure (Free flyer, 2016).

When users with these health issues use the technology, and they are affected, they may sue the providers of the technology. Therefore, there should be clear terms of reference or warnings to avoid such legal issues. Alsomedical history of prospective users is to be known before the use of the technology to avoid legal problems. Prospective users or patients are to be fully informed of the possible side effects of virtual reality technology before usage. More validations of virtual reality technology should be performed to instill confidence and trust in the minds of both surgeons and be generally accepted by surgeons in all fields so that it becomes accepted by the regulatory bodies. This can also affect the commercialization of virtual reality technology in the medical surgery industry. Therefore, the issue of validation of the designs needs to be done to instill confidence in the application of the technology.

CONCLUSION

Virtual reality technology and applications to the automotive, aerospace and medical surgery industry were discussed. The advances in computer hardware and software that increased industrial application of VR were discussed for both automotive/aerospace and medical surgery industries. Some of the hardware components are projectors, monitors of computers, haptic devices, hand gloves, shutter glasses, head mounted displays and so on.

The software used for generating 3D models and providing the virtual environment for the simulation were also highlighted. Virtual reality technology is cost effective when applied to the automotive/aerospace industries and the medical surgery.

There are still limitations to the implementation of the VR technology in automotive/aerospace and medical industries based on realism of simulation, need to improve computer human interfaces and simulator delays.

Finally, the legal and regulatory issues to be addressed for full commercialisation of VR in automotive/aerospace and medical surgery industries needs to fully understood by providers for a successful commercialization..

RECOMMENDATIONS

Based on the discussions in this report, the following recommendations are drawn;

1. That virtual reality be included in the academic curriculum of universities for employed for training engineering students.
2. That all manufacturing companies should employ the use of VR technology in the design and development of their products particularly automotive/aerospace companies.

3. That automotive/aerospace industry should use the technology for their staff training and virtual simulations.
4. That virtual reality technology be used in medical surgery for training junior and inexperienced surgeons.
5. That VR technology be used in medical surgery to perform virtual simulation so as to improve the life of their patients.
6. That virtual reality technology providers should improve on their systems in terms of realism of simulation, time delay in simulators, and human-computer interface

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