CPR Virtual Reality Training Simulator for Schools

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***Abstract*—This research project developed a Virtual Reality (VR) training simulator for the CPR procedure. This is designed for use training school children. It can also form part of a larger system for training paramedics with VR. The simulator incorporates a number of advanced VR technologies including Oculus Rift and Leap motion. We have gained input from NHS paramedics and several related organisation to design the system and provide feedback and evaluation of the preliminary working prototype.**

Keywords-component; Virtual Reality; Training Simulator; CPR; Paramedic; Ambulance

I. Introduction

This research presents a developed prototype VR training simulator for teaching Cardiopulmonary resuscitation (CPR) to school children. The project exploits the latest generation of affordable Virtual Reality (VR) hardware to provide an immersive experience whereby the user can practice a CPR procedure on a virtual patient. The patient will typically be at the accident scene, and the virtual environment constructed accordingly. The initial working prototype has been developed, demonstrating feasibility. The simulator currently contains a simulated model of the CPR procedure.

CPR is one of the most common emergency life-saving paramedic procedures. It is performed with patient who suffered cardiac arrest to keep blood flowing. CPR requires chest compressions to be applied onto the patient's chest. This procedure is important to temporarily preserve continuing blood circulation in a person who has had cardiac arrest.

The potential of the ParaVR prototype was demonstrated by receiving awards from the Bevan Commission in 2018 and the winning the 2018 Welsh Health Gadget Hack. ParaVR also received the Pathway to Portfolio award from Health&Care Research Wales in 2019 and was subsequently highlighted by Universities UK in the top 100 lifesaving projects in 2019.

The developed prototype uses the Oculus Rift HMD that is commercially available. This enables use of a pair of sophisticated hand controllers to interact with the contents of the VR environment. This is also combined with the wireless hand tracking system Leap Motion and a physical manikin which provides palpation of a torso.

A requirements phase was conducted between the Welsh Ambulance Service and the University of Chester to determine the optimal functionality of the first version of the VR CPR simulator.

The junior module is designed for simulation with virtual reality the Cardio Pulmonary Resuscitation (CPR) procedure. This module will be used for training school children.

This project is driven by the rapidly growing market for medical simulator technology. Our market research has shown that the global medical simulation market was $863.5 million in 2014 and has rapidly grown to $2,069.2 million in 2019. The Compound Annual Growth Rate (CAGR) is 19.1% from 2014 to 2019.

A. *Importance of CPR*

Out-of-hospital cardiac arrest (OHCA) is the third leading cause of death in industrialised nations [1]. There are an estimated 275,000 cardiac arrests in Europe each year [2], but despite significant advances in interventions provided by Emergency Medical Services (EMS), OHCA survival rates have not improved significantly in 30 years, and range from 8.6%-20% [3-5]. In the UK, average overall OHCA survival is around 8.6% [3], which is significantly lower than other developed countries: North Holland 21% [5] Seattle 20% [6] and Norway 25% [4]. Care recommendations are increasingly emphasizing improvements in Basic Life Support (BLS) training, public education and access to Automatic External Defibrillators (AED's). These are elements of the Chain of Survival (fig 1), which represents a series of sequential actions to be taken to improve chances of survival from OHCA. The Resuscitation Council (UK) Guidelines [7] recognize that survival rates of 50–70% can be achieved with defibrillation within 3–5 min of OHCA [8], through public access defibrillation, when a bystander uses an AED [9,10,11]. Each minute of delay to defibrillation reduces the probability of survival by 10%, yet in the UK, fewer than 2% of victims have an AED deployed before the ambulance arrives [12]. A cardiac arrest victim is 2–4 times more likely to survive OHCA with bystander CPR provision [13]. Up to 70% of OHCA are witnessed by family members, friends and other bystanders [14]. Therefore immediate CPR given by bystanders can increase the number of people who are given a chance of surviving. Teaching CPR to children in school is acknowledged to be the most effective way to reach the entire population. This approach also reflects principals of the Wellbeing of Future Generations (Wales) Act 2015 [15], where a society in which people's health is maximised and choices and behaviours that benefit future health are understood. This act also advocates an inclusive approach to achieving well-being goals by involving children and young people.

B. CPR training in Schools

Plant (2015) [16] identified that CPR, AED and first aid training is effective in children from the age of 4 years up to school leaving age, and that children may retain knowledge and skills years later. Mandatory CPR training of school children has also been identified as having the highest potential impact for improving the bystander CPR rate [7]. Subsequently, the highest bystander CPR rates are in Scandinavia, where CPR training in schools has been mandatory for decades [17]. In support, the World Health Organization (WHO) has endorsed the “Kids Save Lives” Statement, a joint statement from the European Resuscitation Council (ERC), European Patient Safety Foundation (EPSF), International Liaison Committee on Resuscitation (ILCOR) and World Federation of Societies of Anesthesiologists (WFSA) [18]. This statement recommends two hours of CPR training annually from the age of 12 years in all schools worldwide. CPR training in schools is mandatory in England, and most secondary schools in Wales have a BHF’s Call, Push, Rescue kits, free lesson plans, and training videos. However, challenges have been identified in divorcing CPR training in schoolchildren from cost, time and effort involved in implementation of teaching programs and in sustaining delivery [16]. The Welsh OHCA Survival plan [19] acknowledges these challenges, and recognises that CPR is an important component of health education of all the population, and all schools, further and higher education students should be provided with opportunities to learn CPR techniques. This proposal recognises how technology may provide solutions to achieve high rates of CPR learning in schools.

II. METHODS

A. 3D Scanning the Manikin

The simulator contains a physical model of a human torso (manikin). This is used for palpation during the CPR procedure. The user wears a head-mounted display (HMD) and places their hands onto the physical torso. In the virtual world, a model of the torso is also shown in 3D stereo. It could have been possible to use 3D modelling to create a generic 3D virtual torso model, however we required the virtual and physical torsos to exactly match in shape and size.

In order to align the virtual torso to the physical torso, a stage of alignment is required. In order to ensure proper alignment, we created a 3D scanned model of the exact physical torso, so that the virtual and physical torso models exactly match (Fig. 1).

The 3D scanning was completed at the University of Chester using a custom designed smartphone app in comparison to a 3D structure sensor.

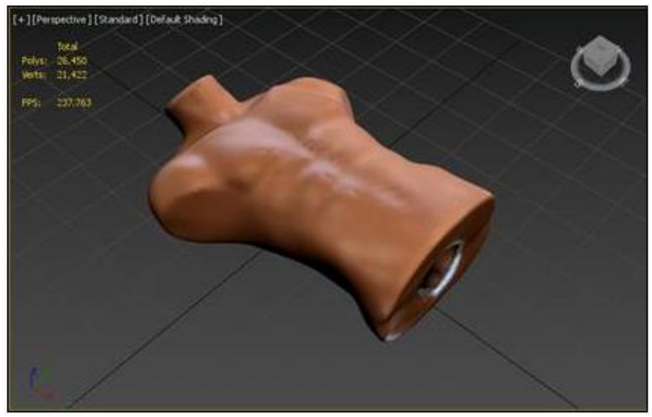

Figure 1. 3D Scan of thephysical mannikin Torso.

B. Hands Free Lap Motion Interaction

The Leap Motion hands tracking device was used for a user interface. The leap motion sensor is attached into the front of the oculus rift headset (Fig. 2). This is useful because both hands are required to be used together to compress the chest wall during the CPR and the hands remain in sight of the Leap Motion sensor during the simulation.

Figure 2. Leap Motion Hand Tracking sensor on the Oculus Rift HMD.

Figure 3. VR model of the CPR manikin with Leap Motion Hands.

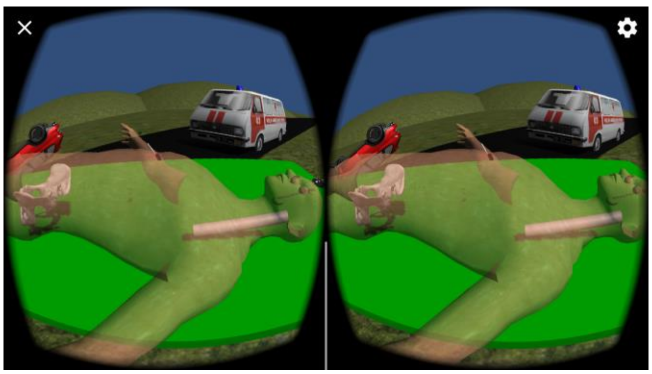

Figure 4. The virtual reality models ported onto Google Cardboard HMD.

The leap motion sensor provides superior hand tracking with no requirement to wear gloves or handheld controllers. This sensor simultaneously tracks the movement of all joints in the hands and fingers.

When the training simulator begins, the user can then see a virtual model of their own hands which move in relation to their real hands (Fig. 3).

C. Virtual environment 3D software development

The virtual environment for the CPR simulator was designed to reflect the spontaneous nature of CPR which could occur in unpredictable locations such as at the scene of a car accident at the roadside (Fig. 4). The environment was developed using 3D modelling software.

Additionally, the virtual training simulator was ported onto the Google cardboard VR platform (Fig. 4), to demonstrate the feasibility of CPR training using a smartphone, without the need for a dedicated PC or HMD. However in the Google cardboard version, the Leap Motion sensor cannot be used and so the virtual model of the hands is not present. However it is still possible to use the Google cardboard version with the physical manikin as the same 3D torso model can be used with both HMDs.

III. EVALUATION AND TESTING

A. Feedback from Paramedics

Feedback has been provided by input from various paramedics and organization. This has included British Heart Foundation Cymru, Wales Ambulance Service NHS Trust and College of Paramedics (UK).

We are working closely with our supporting team members in the NHS and key stakeholders to demonstrate our developed system and gather feedback. This phase will gather critical evidence and evaluation. This will further demonstrate the commercial potential, applicability and potential of the developed technology in the NHS.

We are aiming to complete further in-depth clinical evaluation. This could be strengthened by having support from other paramedics, services, trusts or medical companies, supporting clinical evaluation of the developed prototype. Clinical evaluation may recruit two cohorts of trainees, one cohort trained on the simulator and one trained in the conventional manner. Clinical evaluation would demonstrate efficacy and validity of the VR training simulator, reducing risks for future NHS commercialisation.

IV. CONCLUSION

The project has developed a Virtual Reality (VR) training simulator for the CPR procedure. This is designed for use training school children. It can also form part of a larger system for training paramedics with VR. The simulator incorporates a number of advanced VR technologies including Oculus Rift and Leap motion. We have gained input from NHS paramedics and several related organisation to design the system and provide feedback and evaluation of the preliminary working prototype.

A. Future Work

An assessment system will be incorporated for scoring and feedback. This will enable paramedics to identify how accurately they have performed the procedure in the VR training. Scoring will use an AI system based on data generated within the simulator during training. This will provide objective feedback to the clinicians which is critical to identify aspects of their performance that can be improved to focus future practice.

The next stage of the project will be to further develop the simulator, aiming to produce a more advanced version of the prototype that will be ready for formal evaluation, clinical testing and future commercialisation.

The target is to port the VR into the new head mounted display: the Oculus Quest – a tetherless device due for release in 2019.

The intention is to deploy the CPR trainer for use in schools. This will have benefit that children will be able to learn the CPR procedure using a virtual model.

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