MULTIPLE MARKERS TRACKING TECHNIQUE AS TRACKED HANDHELD CONTROLLER FOR SMARTPHONE VIRTUAL REALITY WELDING APPLICATION

MUHAMMAD ISMAIL BIN MAT ISHAM

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Philosophy

School of Computing
Faculty of Engineering
Universiti Teknologi Malaysia

FEBRUARY 2022

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have been that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. I wish to express my sincere appreciation to my main thesis supervisor, Dr. Farhan bin Mohamed for encouragement, guidance, critics, and friendship. I am also very thankful to my co-supervisor Associate Professor Dr. Habibah @ Norehan binti Haron for her guidance, advice, and motivation. Without their continued support and interest, this thesis would not have been the same as presented here.

I am also indebted to Universiti Teknologi Malaysia (UTM) for funding my Master study. Librarians at UTM also deserve special thanks for their assistance in supplying the relevant literatures.

My fellow postgraduate student should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have aided at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family member especially to my parent who always support me and give me strength to finish my master study.

ABSTRACT

Smartphone Virtual Reality (VR) is the cheapest VR technology that can be used to simulate a similar or completely different real-world experience. The smartphone VR utilize simple interaction techniques such as gestures, voice, magnetic buttons, and gaze techniques due to its low-cost development. However, the input controller for smartphones VR is currently limited to up to 3 Degrees of Freedom (DOF) and limits the user's freedom and experience to interact with the virtual environment. Currently, welding VR simulations only use the expensive VR device because of its 6 DOF input controller advantages. Hence, this research recommends a novel input method using a multiple marker tracking method as a 6 DOF input controller for smartphone VR. The idea is to integrate the welding VR simulation into the cheapest VR technology. This approach involves three objectives. In the first phase, a literature review will locate the current input method and research paper involving smartphone VR. This research also conducted few welding expert's interviews to get input about the current welding vocational training problems. The second phase focuses on the design of the smartphone VR integration with multiple-marker tracking methods. The VR welding application is designed based on welding experts' opinions and was named as VR Welding Kit. The last objective oversaw the quantitative and qualitative analysis using a welding torch with markers as the 6 DOF input controller and welding position markers are virtual welding plate objects. The quantitative analysis has three-phase experiments such as accuracy comparison, usability study, and simulation sickness tests. The test compares welding travel speed, work angle and travel angle are the benchmarks for three types of welding position using the Root Mean Square Error (RMSE) method. The multiple markers as smartphone VR input controller have better results for all welding tasks than current popular standalone VR devices, Oculus Quest. The proposed method gets a score of 72.5 on the usability test, when using the System Usability Scales (SUS) method. Participants' susceptibility towards smartphone VR are also lower when using Simulator Sickness Questionnaire (SSQ) method. Finally, for qualitative analysis, an expert's review is conducted. The question asks their opinion towards the VR Welding Kit application in terms of usefulness, teaching aid, mobility, ease of use and handle. The experts have given a good satisfaction result towards the questions. The experts also suggest improving the VR Welding Kit application for future works. This research shows that the use of multiple markers as input controllers allows the welding VR vocational training to be mobile and ubiquitous.

ABSTRAK

Realiti Maya (VR) telefon pintar ialah teknologi VR termurah yang boleh digunakan untuk mensimulasikan pengalaman dunia sebenar yang serupa atau berbeza sama sekali. Telefon pintar VR menggunakan teknik interaksi mudah seperti gerak isyarat, suara, butang magnet dan teknik pandangan kerana pembangunan kos rendahnya. Walau bagaimanapun, pengawal input untuk telefon pintar VR pada masa ini terhad kepada sehingga 3 Darjah Kebebasan (DOF) dan mengehadkan kebebasan dan pengalaman pengguna untuk berinteraksi dengan persekitaran maya. Pada masa ini, simulasi VR kimpalan hanya menggunakan peranti VR yang mahal kerana kelebihan pengawal input 6 DOF nya. Oleh itu, penyelidikan ini mencadangkan kaedah input baru menggunakan kaedah pengesanan berbilang penanda sebagai pengawal input 6 DOF untuk VR telefon pintar. Ideanya adalah untuk menyepadukan simulasi VR kimpalan ke dalam teknologi VR termurah. Pendekatan ini melibatkan tiga objektif. Dalam fasa pertama, kajian literatur akan mencari kaedah input semasa dan kertas penyelidikan yang melibatkan VR telefon pintar. Penyelidikan ini juga telah menjalankan beberapa temu bual pakar kimpalan untuk mendapatkan input tentang masalah latihan vokasional kimpalan semasa. Fasa kedua memfokuskan pada reka bentuk integrasi VR telefon pintar dengan kaedah pengesanan berbilang penanda. Aplikasi kimpalan VR direka bentuk berdasarkan pendapat pakar kimpalan dan dinamakan sebagai Kit Kimpalan VR. Objektif terakhir menyelia analisis kuantitatif dan kualitatif menggunakan obor kimpalan dengan penanda kerana pengawal input 6 DOF dan penanda kedudukan kimpalan adalah objek plat kimpalan maya. Analisis kuantitatif mempunyai eksperimen tiga fasa seperti perbandingan ketepatan, kajian kebolehgunaan dan ujian penyakit simulasi. Ujian membandingkan kelajuan perjalanan mengimpal, sudut kerja dan sudut perjalanan adalah penanda aras bagi tiga jenis kedudukan kimpalan menggunakan kaedah Root Mean Square Error (RMSE). Berbilang penanda sebagai pengawal input VR telefon pintar mempunyai hasil yang lebih baik untuk semua tugas kimpalan daripada peranti VR kendiri popular semasa, Oculus Quest. Kaedah yang dicadangkan mendapat markah 72.5 pada ujian kebolehgunaan, apabila menggunakan kaedah Skala Kebolehgunaan Sistem (SUS). Kecenderungan peserta terhadap VR telefon pintar juga lebih rendah apabila menggunakan kaedah Soal Selidik Sakit Simulator (SSQ). Akhir sekali, untuk analisis kualitatif, semakan pakar dijalankan. Soalan tersebut meminta pendapat mereka terhadap aplikasi Kit Welding VR dari segi kegunaan, alat bantu mengajar, mobiliti, kemudahan penggunaan dan pengendalian. Para pakar telah memberikan keputusan yang memuaskan terhadap soalan-soalan tersebut. Pakar juga mencadangkan menambah baik aplikasi Kit Kimpalan VR untuk kerja-kerja masa hadapan. Kajian ini menunjukkan bahawa penggunaan pelbagai penanda sebagai pengawal input membolehkan latihan vokasional VR kimpalan menjadi mudah alih dan di mana-mana..

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

VR	-	Virtual Reality
AR	-	Augmented Reality
MR	-	Mixed Reality
XR	-	Extended Reality
FOV	-	Field of View
SUS	-	System Usability Scales
SSQ	-	Simulator Sickness Questionnaire
RMSE	-	Root Mean Square Error
DOF	-	Degree of Freedom
HMD	-	Head-mounted Display
SDK	-	Software Development Kit
OS	-	Operating System
RAM	-	Random Access Memory
GPU	-	Graphics Processing Unit
CPU	-	Central Processing Unit
GB	-	Gigabyte

LIST OF SYMBOLS

mm	-	Millimeters
cm	-	Centimeters
^{o}	-	Degree
P	-	Percentage
μ	-	Mean

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Overview

Virtual reality (VR) is an imitation experience like or utterly different from the real world that can be interacted with physically by a person using a particular device (Freina & Ott, 2015; Kato & Billinghurst, 1999). The objective is to take advantage of the user's real-world experience and transfer understanding from reality to the simulated environment (Balakrishnan, 2004). The term "virtual reality" was popularized by Lanier in 1988, one of the modern pioneers of the field (Firth, 2013). VR technologies bring many advantages to performing tasks, especially training and education, due to their potential in stimulating interactivity. VR can offer an ideal way to approach study and remember new knowledge for those who prefer a visual, auditory, or kinaesthetic learning style (Choe & Leite, 2017). Milgram and Kishino (1994) produced the Mixed Reality taxonomy called Virtual Continuum. The combination of all real-virtual reality to create the illusion to make people feel as if they are in an entirely new digital world is called Extended Reality (XR). Figure 1.1 explains the classification for each level of immersion from the real world to the virtual world. VR has started to rise again in 2016 after the technology had matured enough to handle the engineering used in VR. Furthermore, VR devices have slowly reduced their size from bulky to high mobility and sophisticated VR technology. These devices are categorized as mobile VR.

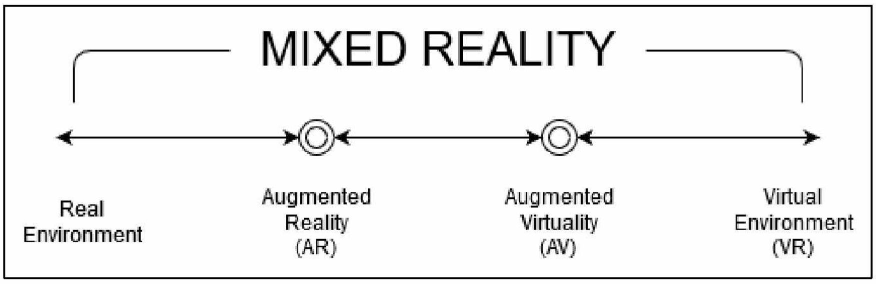

Figure 1.1 Virtual Continuum chart (Milgram & Kishino, 1994)

There are two categories of mobile VR, which are standalone VR or smartphone VR devices. User interaction in smartphone VR brings many advantages in enhancing users' immersion in the virtual world, especially when it involves virtual object selection, manipulation, and movement. Smartphone VR advantages gain researchers' interest worldwide to enhance human daily life tasks. Most research focuses on reducing the cost for the real-world job and solving the common problem that is difficult to conduct in the real world. VR applications provide great potential for user interaction.

Nonetheless, new interaction techniques for mobile VR applications have increased due to different VR interfaces techniques and devices. Hence, the user interaction technique for mobile VR is currently crucial in the VR research area. Adequate user interaction allows the users to interact with virtual data in the VR environment efficiently. User interaction would be more valuable in the VR world if users could control and change the targeted virtual object. The VR interfaces remain flat in perspective and static viewing without implementing the interaction technique. For a human, interaction is a common way to interact with the subject through hand gestures, verbal communication, and walking around. Hence, interaction techniques in a smartphone VR environment are crucial for the user to interact naturally with virtual objects in a VR world and control them seamlessly in real-time.

The most noticeable advantages of VR are that it can simulate vocational training in the virtual world. Vocational training is a term that refers to educational programmes or courses that focus on the skills needed for a specific job function or trade. Currently, vocational training in welding has used VR to simulate its traditional training method to save the cost and time of training (Rusli et al., 2019; Sudhagar et al., 2017). The new welding trainees do not need to attend the welding workshop or require a trainer to train them to learn the basic knowledge in welding. VR simulation can make the welding trainee gain psychomotor skills on properly holding the welding torch before proceeding to the real-world welding situation and facing the more difficult challenge.

Therefore, this research proposed a suitable input technique to produce smooth and natural user interactions in the VR environment to have a good use for VR vocational training. Unlike with high-end standalone VR devices like Oculus Quest, smartphone VR lacks a positional tracking controller. For example, as shown in Figure 1.2, Oculus Quest has an external controller that uses a sensor-based tracking technique to interact in room-scale. In contrast, smartphone VR did not have an external controller to interact with a virtual object in room-scale space. A 6 Degree of Freedom (6DOF) tracked handheld controller is required to improve the freedom of interaction for smartphone VR mainly when the research intended to involve welding simulation as the case study. It intents to reduce user cognitive load and simulation sickness because the translation between an actual controller with virtual object moves relatively.

Figure 1.2 Oculus Quest with an external controller (Oculus, 2019)

This research study leveraged multiple markers-based tracking methods to use on smartphone VR as an external tracked handheld controller to gain the ability to interact with the virtual object freely in 3D free space. The virtual object and environment will design were on the welding environment to tackle the current problem in the current VR welding training method. Besides, this research also focuses on testing the performance comparison with standalone VR devices, usability study, simulation sickness, the proposed method and expert review on the welding simulation application.

1.2 Problem Background

VR has suffered from determining suitable user interfaces with correct user interaction since in 20th century. Figure 1.3 shows the knowledge domain for VR in Association for Computing Machinery (ACM) Computer Classification System (CCS) falls under the interaction paradigms. The user always has difficulty understanding the 3D environment. Using spatial input might help users reduce their cognitive load and get familiar with the 3D environment. Using any spatial reference in VR is better than none (Hinckley et al., 1994). Due to the limitation of technology, VR systems always come with a bulky machine system and require a bulky external device to implement the user interaction technique. The price for VR systems is outside most ordinary consumers' reach (Amer & Peralez, 2014). The cost and space requirements for the VR bulky system, together with the technical limitations, have prevented widespread uptake at a consumer level (Powell et al., 2017).

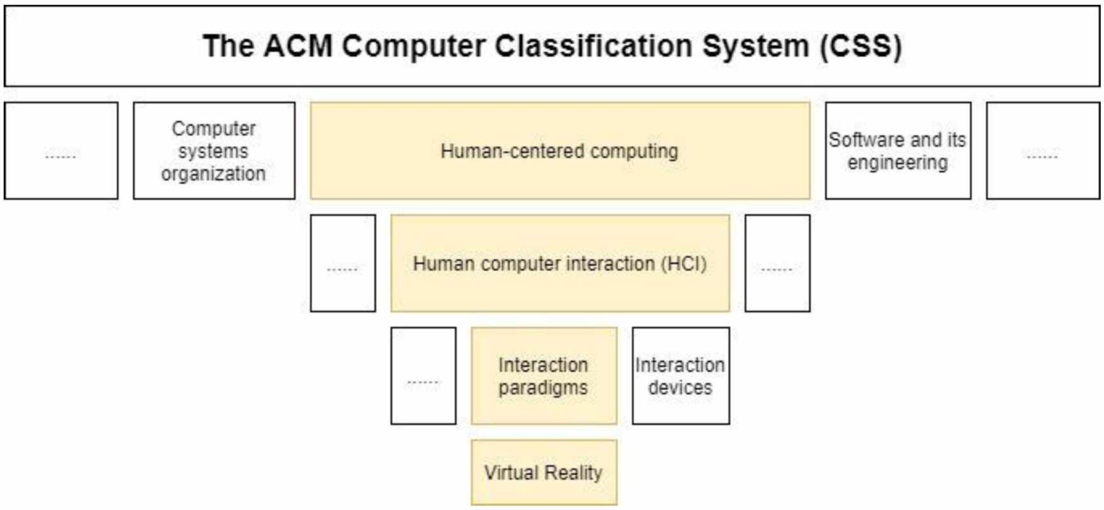

Figure 1.3 Knowledge domain of VR

Technology has slowly developed until VR can run on a small device such as a smartphone in recent years. 2016 is the year of VR because many prestigious companies such as Facebook, Samsung, HTC, and many more have introduced their own mobile VR. For example, HTC VIVE, Samsung Gear, Oculus Rift. It can handle most VR graphics that can even surpass the desktop device (Steed & Julier, 2013). These technologies have gained the attention of many researchers worldwide to focus on mobile VR's user interaction Figure 1.4 shows the graph in VR device shipment since 2016 and the expectancy of its exponential growth. Most of the user interaction technique implemented on mobile has improved and expanded to new forms. However, due to the advanced technology, the price for VR devices was also increasing, and most users cannot own it to experience the VR technology (Powell et al., 2017).

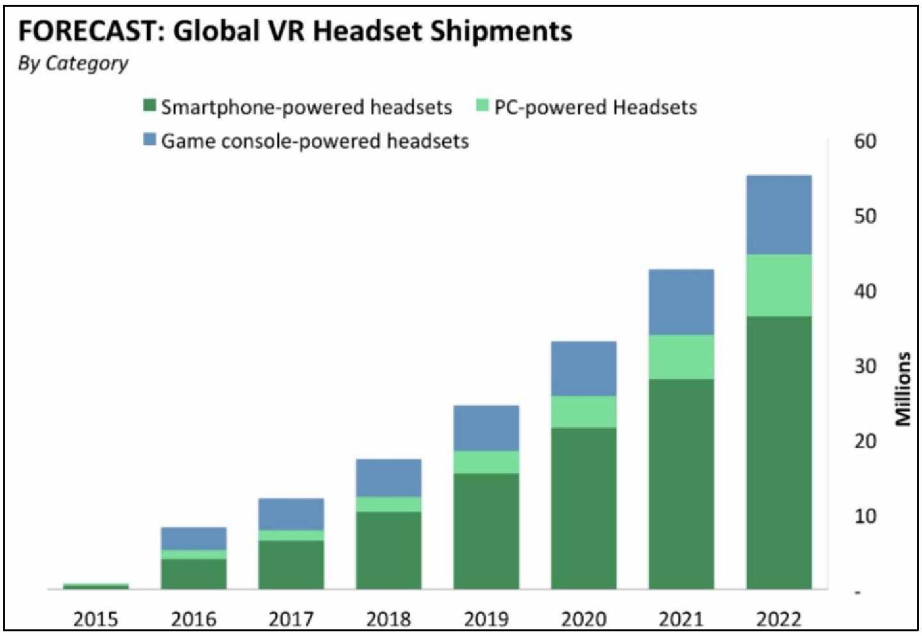

Figure 1.4 VR device shipment estimation (Mark Billinghurst, 2019)

However, Google has introduced an external device called "Google Cardboard", an affordable option to integrate with most modern smartphones to turn it into a mobile VR device (Luo, 2018). Since 2014, Google has shipped 10 million Google Cardboard headsets and have sold between 2 million and more than 1000 VR apps in Google Play Store in 2016 alone (Brown, 2016). Due to its affordable price, mobility, and ease of access, many ordinary consumers can experience their VR easily anywhere and anytime. Researchers have started developing a new input method for smartphone VR.

Al Zayer *et al.* (2016) have introduced a new interaction technique called PAWdio, which can detect a user's hand's relative position while holding the earphone connected to the smartphone. However, this method has only one degree of freedom in operation and is affected by the length of the headphone cable limiting the area of reach. The research continues with StereoTrack, which can detect the position using sound but limits users' freedom to freely explore the environment around them since it cannot move more than 90 degrees (Zayer & Folmer, 2018). Bai et al. (2017) explore asymmetric bimanual interaction with mobile Virtual Reality (VR) using two hand-input methods to interact with the virtual object. This method can detect 6 Degrees of freedom (DOF) relative position in virtual space. This method requires more than one external device related to the mobile smartphone and can cause awkwardness for the user to wear it. Jayaraj *et al.* (2018) has found a solution to detect the 9 DOF motion controller in virtual space via Bluetooth to achieve connectivity to a mobile device. But due to the sensor tracking, it is hard to provide an absolute orientation of the motion controller. Nevertheless, sensor tracking makes it hard to provide an absolute orientation of the motion controller.

As mentioned in Section 1.1, VR has solved the problem in many vocational training areas. One of the most popular vocational training areas using VR is welding (Lavrentieva et al., 2020). Welding is one of the essential and highly demanded skills in the manufacturing sector. Welding is a hot, challenging, and physically tasking job but necessary to various products and infrastructures. Its applications form an essential part of everyday life, from cars to high-rise office buildings, aeroplanes to rockets, pipelines to highways. Students need to undergo many practical sessions to become high-qualified welders to fill in the workforce in the market. However, the number of new generation welders is declining alarming (Bickerstaff, 2015; Yao et al., 2017). Therefore, VR simulations can help to solve the conventional training method. However, the current VR devices used to simulate the welding training are very expensive and bulky (Dalto et al., 2010; Mellet-D'huart, 2005). These limitations have added a new problem to a solved problem.

Although smartphone VR has become more accessible, many issues are still to be solved. One of the crucial aspects is the suitable interaction technique for smartphone VR. Users will need an appropriate interaction method to select and manipulate the virtual object in a VR environment. Currently, smartphone VR only has a few inputs option. Most applications for smartphone VR have simple interactions, such as look-and-see and roller-coaster experiences (Ma et al., 2020). Hence, the new or enhanced interaction technique needs to focus on smartphone VR to improve the user experience and compete with the high-end mobile VR device. This enhanced input method solution could also solve the welding training problem in reducing the cost of the VR device by using a smartphone that is affordable for a lot of people (Luo, 2018).

1.3 Problem Statements

To solve the issues mentioned in Section 1.2, smartphone VR still lacks input devices that can give freedom to users. Despite being the most affordable VR device, the 3DOF position controller devices limit the current input method and user interaction. This issues also reduced the user's experience towards the VR. Some researchers have introduced new input techniques that could improve the current input devices, but it still lacking in certain aspects.

For conventional welding training problems, past research shows that the VR intervention in welding training can improve knowledge transfer, save a lot of consumables costs, and support a new pedagogical approach and learning experiences. Besides, evidence shows that the integration of VR technologies can bring various benefits to education and increase students' performance (Ali et al., 2019; Armas et al., 2020). However, most welding simulations consist of bulky device that lacks mobility (Dalto et al., 2010; Lavrentieva et al., 2020; Mellet-D'huart, 2005). The enhanced input method for smartphone VR could improve the current VR welding simulation devices in terms of cost. Consequently, the VR welding simulation using smartphone VR can solve the material cost, time and mobility.

Hence, the current input devices for smartphone VR need to be improved to ensure it can compete with other powerful VR devices despite the low price. Smartphone VR needs an input controller that can return the 6DOF position for more effective user interaction with the virtual object in the VR environment without any movement restriction. This solution could improve the current VR devices used for welding simulation into more high mobility devices and reduce the set-up costs.

1.4 Aim

This research proposes multiple marker tracking techniques to improve the current smartphone VR tracked handheld controller using VR welding simulation.

1.5 Research Objectives

The objectives of the research are:

1. To investigate and compare the current interaction approaches for smartphone VR input method for vocational welding training.

2. To design and implement a novel multiple markers tracking interaction approach as a tracked handheld controller for smartphone VR.

3. To evaluate the multiple markers tracking interaction approach using welding vocational training VR simulation.

1.6 Scope

The scopes of the research are:

1. **Data:** The welding simulation used in the case study is based on the UTM syllabus, course code SPPE 2322, Metal Inert Gas (MIG) Welding.

1.7 Research Significance

This research aims to create a possibility for smartphone VR to have a tracked handheld controller that can return relative position. Multiple marker tracking methods do not require external equipment to connect with the smartphone to access the 6DOF position controller. This method only requires the integrated camera on the smartphone to work. This solution indirectly still maintains the affordability of smartphone VR. Furthermore, the multiple markers tracking techniques can be applied in any form depending on the VR content. The marker can be attached to a dummy welding torch device for welding training simulation to act like a welding controller in VR simulation. Any VR training that requires intensive hand-eye coordination gets the benefit.

1.8 Report Organization

This thesis is divided into six chapters, which are ordered as follows:

Chapter 2 discusses the literature review of the research. This chapter presented the analysis on the literature of the VR, mobile VR types, existing input method for smartphone VR, existing tracking technique, welding experts interview, a case study about vocational training, focusing on welding and past VR research. Besides that, the reason for multiple markers tracking techniques is chosen to solve the smartphone VR as the enhanced input method is discussed.

Chapter 3 discusses the research methodology. The research methodology plays an essential role as a research guideline to sort the implementation process toward the research aims and objectives. This chapter presented the research methodology framework that contains several essential phases to actualize the research objective.

Chapter 4 presents the proposed method integrated with smartphone VR with welding training as the VR application. The details of each method are discussed succinctly together with its pseudo code.

Chapter 5 shows the evaluation results of the proposed method. There were two sorts of tests conducted: a qualitative and quantitative analysis. The qualitative results compare accuracy with high-end VR devices using RMSE scores, usability test using System Usability Scales (SUS) and simulation sickness check using Simulation Sickness Questionnaire (SSQ). Expert evaluation for the VR welding application as qualitative is also discussed in this chapter.

Chapter 6 discusses the contributions of the research and the limitations of current research progress. In addition, future work is proposed to address these limitations.

REFERENCES

Al Zayer, M., Tregillus, S., & Folmer, E. (2016). PAWdio: Hand input for mobile VR using acoustic sensing. *CHI PLAY 2016 - Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play*, 154–158. https://doi.org/10.1145/2967934.2968079

Ali, A. A., Dafoulas, G. A., & Augusto, J. C. (2019). Collaborative Educational Environments Incorporating Mixed Reality Technologies: A Systematic Mapping Study. *IEEE Transactions on Learning Technologies*, *12*(3), 321–332. https://doi.org/10.1109/TLT.2019.2926727

Ali, N. S., & Nasser, M. (2017). Review of virtual reality trends (previous, current, and future directions), and their applications, technologies and technical issues. *ARPN Journal of Engineering and Applied Sciences*, *12*(3). https://doi.org/10.5281/zenodo.3366890

Amber, G. (2017, June 1). *HoloKit - Open Source Mixed Reality for Everyone*. https://holokit.io/

Amer, A., & Peralez, P. (2014). Affordable altered perspectives: Making augmented and virtual reality technology accessible. *Proceedings of the 4th IEEE Global Humanitarian Technology Conference, GHTC 2014*. https://doi.org/10.1109/GHTC.2014.6970345

Angel-Urdinola, D. F., Castillo-Castro, C., & Hoyos, A. (2021). Meta-analysis that assesses the effects of virtual reality training on students' learning and skills development. *World Bank Group*, *9587*, 1–50.

ARToolKit. (2004). *Artoolkit*. https://artoolkit.org/

Atienza, R., Blonna, R., Saludares, M. I., Casimiro, J., & Fuentes, V. (2016). Interaction techniques using head gaze for virtual reality. *Proceedings - 2016 IEEE Region 10 Symposium, TENSYMP 2016*. https://doi.org/10.1109/TENCONSpring.2016.7519387

Azizo, A. S. B., Mohamed, F. Bin, Siang, C. V., & Isham, M. I. M. (2020). Virtual Reality 360 UTM Campus Tour with Voice Commands. *6th International Conference on Interactive Digital Media, ICIDM 2020*. https://doi.org/10.1109/ICIDM51048.2020.9339665

Bai, H., Nassani, A., Ensx, B., & Billinghurst, M. (2017). Asymmetric bimanual interaction for mobile virtual reality. *International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments, ICAT-EGVE 2017*, 83–86. https://doi.org/10.2312/egve.20171343

Bajura, M., & Neumann, U. (1995). Dynamic registration correction in augmented-reality systems. *Proceedings Virtual Reality Annual International Symposium '95*, 189–196. https://doi.org/10.1109/VRAIS.1995.512495

Balakrishnan, R. (2004). “Beating” Fitts’ law: Virtual enhancements for pointing facilitation. *International Journal of Human Computer Studies*, *61*(6). https://doi.org/10.1016/j.ijhcs.2004.09.002

Batmaz, A. U., & Stuerzlinger, W. (2019). Effects of 3d rotational jitter and selection methods on 3d pointing tasks. *26th IEEE Conference on Virtual Reality and 3D User Interfaces, VR 2019 - Proceedings*. https://doi.org/10.1109/VR.2019.8798038

Bhatnagar, D. K. (1993). Position trackers for Head Mounted Display systems: A survey. *University of North Carolina, Chapel Hill TR93-010*, 1–22. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.104.3535&rep=rep1&type=pdf

Bhowmick, S., Darbar, R., & Sorathia, K. (2018). Pragati: Design and evaluation of a mobile phone-based head mounted virtual reality interface to train community health workers in rural India. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3240167.3240201

Bickerstaff, G. F. (2015). *The Use of Welding Simulators Improve Proficiency in Entry-Level Welding Students*. 44.

Bickerstaff, S., & Cormier, M. S. (2015). Examining faculty questions to facilitate instructional improvement in higher education. *Studies in Educational Evaluation*, *46*. https://doi.org/10.1016/j.stueduc.2014.11.004

Billinghurst, M., Weghorst, S., & Furness, T. (1998). Shared space: An augmented reality approach for computer supported collaborative work. *Virtual Reality*, *3*(1), 25–36. https://doi.org/10.1007/BF01409795

Billinghurst, Mark. (2019a, August). *Lecture 1 - introduction to VR*. https://www.slideshare.net/marknb00/lecture1-introduction-to-vr

Billinghurst, Mark. (2019b, September). *Lecture 3 - VR Technology*.

https://www.slideshare.net/marknb00/lecture3-vr-technology

Brooke, J. (1996). SUS -A quick and dirty usability scale Usability and context. *Usability Evaluation in Industry*, *189*(194).

Brown, T. (2016). *Google Cardboard Review*. 5.

Burdea, G. C., & Coiffet, P. (2003). Virtual and Augmented Reality Applications. *Department of Engineering for Innovation, University of Salento, Lecce, Italy*. http://publicservicesalliance.org/wp-content/uploads/2018/04/VR-Introduction.pdf

Butcher, P. W. S., Roberts, J. C., & Ritsos, P. D. (2016). Immersive Analytics with WebVR and Google Cardboard. *Posters Presented at the IEEE Conference on Visualization (IEEE VIS 2016), Baltimore, MD, USA*.

Byrd, A. P., Stone, R. T., Anderson, R. G., & Woltjer, K. (2015). The use of virtual welding simulators to evaluate experienced welders. *Welding Journal*, *94*(12), 389s-395s.

Çakir, A. (2015). Handbook of virtual environments: design, implementation, and applications, second edition, edited by Kelly S. Hale and Kay M. Stanney, CRC Press, 2014. *Behaviour & Information Technology*, *34*(7). https://doi.org/10.1080/0144929x.2015.1013791

Chiu, P., Takashima, K., Fujita, K., & Kitamura, Y. (2019). Pursuit sensing: Extending hand tracking space in mobile vr applications. *Proceedings - SUI 2019: ACM Conference on Spatial User Interaction*, 0–4. https://doi.org/10.1145/3357251.3357578

Choe, S., & Leite, F. (2017). Construction safety planning: Site-specific temporal and spatial information integration. *Automation in Construction*, *84*(October), 335–344. https://doi.org/10.1016/j.autcon.2017.09.007

Chuah, S. H.-W. (2019). Why and Who Will Adopt Extended Reality Technology? Literature Review, Synthesis, and Future Research Agenda. *SSRN Electronic Journal*, *2018*. https://doi.org/10.2139/ssrn.3300469

Corrêa, A. G. D., Kintschner, N. R., Campos, V. Z., & Blascovi-Assis, S. M. (2019). Gear VR and leap motion sensor applied in virtual rehabilitation for manual function training∗ an opportunity for home rehabilitation. *ACM International Conference Proceeding Series*, 148–151. https://doi.org/10.1145/3364138.3364169

Dalto, L. D., Benus, F., & Balet, O. (2010). The use and benefits of virtual reality tools for the welding training. *Proc. of the Int. Conf on Advances in Welding Science and Technology for Construction, Energy and Transportation, AWST 2010, Held in Conj. with the 63rd Annual Assembly of IIW 2010, December*, 587–592.

De Armas, C., Tori, R., & Netto, A. V. (2020). Use of virtual reality simulators for training programs in the areas of security and defense: a systematic review. *Multimedia Tools and Applications*, *79*(5–6), 3495–3515. https://doi.org/10.1007/s11042-019-08141-8

Deering, M. F. (1998). The limits of human vision. *Frontiers in Optics, FiO 2014*. https://doi.org/10.1364/fio.2014.fw2f.1

Drakopoulos, P., Koulieris, G. A., & Mania, K. (2020). Front Camera Eye Tracking for Mobile VR. *Proceedings - 2020 IEEE Conference on Virtual Reality and 3D User Interfaces, VRW 2020*. https://doi.org/10.1109/VRW50115.2020.00172

Dujović, M., Popović, O., & Prokić - Cvetković, R. (2020). *Possibilities of the Application of ghe Software for Welding in Virtual Reality on the Welders Training*. 181–187. https://doi.org/10.15308/sinteza-2020-181-187

Eckert, W., & McGlashan, S. (1993). *Managing Spoken Dialogues for Information Services*. *Informatik 5*, 2–5. https://www.researchgate.net/publication/2522470_Managing_Spoken_Dialogues_for_Information_Services

Fajardo Tovar, D., Jonker, V., & Hürst, W. (2020). Virtual Reality and Augmented Reality in education: A review. *Virtual Reality*, *January*.

Fiala, M. (2005). ARTag, a fiducial marker system using digital techniques. *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, *2*, 590–596. https://doi.org/10.1109/CVPR.2005.74

Firth, N. (2013). Interview: The father of VR Jaron Lanier. *New Scientist*, *218*(2922). https://doi.org/10.1016/s0262-4079(13)61542-0

Fox, B. I., & Felkey, B. G. (2017). Virtual reality and pharmacy: Opportunities and challenges. *Hospital Pharmacy*, *52*(2), 160–161. https://doi.org/10.1310/hpj5202-160

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. *Proceedings of ELearning and Software for Education (ELSE)(Bucharest, Romania, April 23--24, 2015)*.

Georgiadis, A., & Yousefi, S. (2017). Analysis of the user experience in a 3D gesture-based supported mobile VR game. *Proceedings of the ACM Symposium on Virtual Reality Software and Technology, VRST, Part F1319*, 3–4. https://doi.org/10.1145/3139131.3141224

Google. (2018). *Google Maps & Google Earth GeoGuidelines*. Google.Com.

Greenwald, S. W., Loreti, L., Funk, M., Zilberman, R., & Maes, P. (2016). Eye gaze tracking with Google cardboard using Purkinje images. *Proceedings of the ACM Symposium on Virtual Reality Software and Technology, VRST, 02-04-Nove*, 19–22. https://doi.org/10.1145/2993369.2993407

Grill, J. (2006). *Weld Guru*. https://weldguru.com/about/

GSMArena. (2020). https://www.gsmarena.com/google_pixel_2_xl-8720.php

Gugenheimer, J. (2016). Nomadic virtual reality: Exploring new interaction concepts for mobile virtual reality head-mounted displays. *UIST 2016 Adjunct - Proceedings of the 29th Annual Symposium on User Interface Software and Technology*. https://doi.org/10.1145/2984751.2984783

Hassan, H. F., Abou-Loukh, S. J., & Ibraheem, I. K. (2020). Teleoperated robotic arm movement using electromyography signal with wearable Myo armband. *Journal of King Saud University - Engineering Sciences*, *32*(6). https://doi.org/10.1016/j.jksues.2019.05.001

Hinckley, K., Pausch, R., Goblel, J. C., & Kassell, N. F. (1994). A survey of design issues in spatial input. *Proceedings of the 7th Annual ACM Symposium on User Interface Software and Technology, UIST 1994*, 213–222. https://doi.org/10.1145/192426.192501

Hirzle, T., Gugenheimer, J., Rixen, J., & Rukzio, E. (2018). Watchvr: Exploring the usage of a smartwatch for interaction in mobile virtual reality. *Conference on Human Factors in Computing Systems - Proceedings*, *2018-April*, 1–6. https://doi.org/10.1145/3170427.3188629

HTC Corporation. (2015). *HTC Vive*. Vive.Com.

Isenberg, T., Isenberg, P., Chen, J., Sedlmair, M., & Moller, T. (2013). A systematic review on the practice of evaluating visualization. *IEEE Transactions on Visualization and Computer Graphics*, *19*(12), 2818–2827. https://doi.org/10.1109/TVCG.2013.126

Ishii, A., Adachi, T., Shima, K., Nakamae, S., Shizuki, B., & Takahashi, S. (2017). FistPointer: Target Selection Technique using Mid-air Interaction for Mobile VR Environment. *ACM*, 474.

https://dl.acm.org/doi/abs/10.1145/3027063.3049795

Ismail, M. E., Faziehan Zakaria, A., Ismail, I. M., Othman, H., Samsudin, M. A., & Utami, P. (2019). Design and Development of Augmented Reality Teaching Kit: In TVET Learning Context. *International Journal of Engineering & Technology*, *8*(1), 129–134.

Izard, S. G., Juanes, J. A., García Peñalvo, F. J., Estella, J. M. G., Ledesma, M. J. S., & Ruisoto, P. (2018). Virtual Reality as an Educational and Training Tool for Medicine. *Journal of Medical Systems*, *42*(3). https://doi.org/10.1007/s10916-018-0900-2

Jayaraj, L., Wood, J., & Gibson, M. (2018). Engineering a Mobile VR Experience with MEMS 9DOF Motion Controller. *2018 IEEE Games, Entertainment, Media Conference, GEM 2018*, 476–483. https://doi.org/10.1109/GEM.2018.8516496

Jerald, J. (2015). Human-Centered Interaction. In *The VR Book*. https://doi.org/10.1145/2792790.2792821

Kahol, K., Leyba, M. J., Deka, M., Deka, V., Mayes, S., Smith, M., Ferrara, J. J., & Panchanathan, S. (2008). Effect of fatigue on psychomotor and cognitive skills. *American Journal of Surgery*, *195*(2), 195–204. https://doi.org/10.1016/j.amjsurg.2007.10.004

Kato, H., & Billinghurst, M. (1999). Marker tracking and HMD calibration for a video-based augmented reality conferencing system. *Proceedings 2nd IEEE and ACM International Workshop on Augmented Reality (IWAR'99)*, *May 2014*, 85–94. https://doi.org/10.1109/IWAR.1999.803809

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator Sickness Questionnaire: An Enhanced Method for Quantifying Simulator Sickness. *The International Journal of Aviation Psychology*, *3*(3), 203–220. https://doi.org/10.1207/s15327108ijap0303_3

Kim, D., Park, J., & Ko, K. H. (2018). Development of an AR based method for augmentation of 3D CAD data onto a real ship block image. *CAD Computer Aided Design*, *98*, 1–11. https://doi.org/10.1016/j.cad.2017.12.003

Krevelen, D. W. F. V. W. F. V. D. Van, Poelman, R., Van Krevelen, D. W. F., Poelman, R., Krevelen, D. W. F. V. W. F. V. D. Van, Rabbi, I., & Ullah, S. (2010). A survey of Augmented Reality Technologies, Applications and Limitations. *The International Journal of Virtual Reality*, *9*(2), 1–20.

https://doi.org/10.1155/2011/721827

Lavrentieva, O. O., Arkhypov, I. O., Kuchma, O. I., & Uchitel, A. D. (2020). Use of simulators together with virtual and augmented reality in the system of welders' vocational training: Past, present, and future. *CEUR Workshop Proceedings*, *2547*.

Lee, S. H. (Mark), Sergueeva, K., Catangui, M., & Kandaurova, M. (2017). Assessing Google Cardboard virtual reality as a content delivery system in business classrooms. *Journal of Education for Business*, *92*(4). https://doi.org/10.1080/08832323.2017.1308308

Lewis, J. R., & Sauro, J. (2009). The factor structure of the system usability scale. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *5619 LNCS*, 94–103. https://doi.org/10.1007/978-3-642-02806-9_12

Li, T., Liu, Q., & Zhou, X. (2019). Ultra-Low-Power Gaze Tracking for Virtual Reality. *GetMobile: Mobile Computing and Communications*, *22*(3). https://doi.org/10.1145/3308755.3308765

Lu, Y., Xu, Y., & Zhu, X. (2021). Designing and Implementing VR2E2C, a Virtual Reality Remote Education for Experimental Chemistry System. *Journal of Chemical Education*, *98*(8), 2720–2725. https://doi.org/10.1021/ACS.JCHEMED.1C00439/SUPPL_FILE/ED1C00439_SI_001.PDF

Luo, S. (2018). *Camera-Based Selection with Low-Cost Mobile VR Head-Mounted Displays by Affairs in partial fulfillment of the requirements for the degree of Master of Computer Science*. https://curve.carleton.ca/f67feeb7-79e9-43f9-b618-609c55c1b54c

Ma, Z., Chen, H., Bai, Y., & Qiu, Y. (2020). Research on the Input Methods of Cardboard. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *12250 LNCS*, 18–29. https://doi.org/10.1007/978-3-030-58802-1_2

MacIsaac, D. (2015). Google Cardboard: A virtual reality headset for $10? *The Physics Teacher*, *53*(2). https://doi.org/10.1119/1.4905824

McGlashan, S., & Axling, T. (1996). A Speech Interface to Virtual Environments. *Swedish Institute of Computer Science.* https://www.researchgate.net/publication/2575618_A_Speech_Interface_to_Vir tual_Environments

Mellet-D'huart, D. (2005). Virtual Reality for Training and Lifelong Learning. *THEMES IN SCIENCE AND TECHNOLOGY EDUCATION Special Issue*, 185–224. https://files.eric.ed.gov/fulltext/EJ1131316.pdf

Mellet-D'huart, D. (2013). Virtual Reality for Training and Lifelong Learning. *THEMES IN SCIENCE AND TECHNOLOGY EDUCATION Special Issue*, 185–224.

Microsoft. (2018). *Xbox Adaptive Controller*. Microsoft. https://www.xbox.com/en-US/accessories/controllers/xbox-adaptive-controller

Milgram, P., & Kishino, F. (1994). Taxonomy of mixed reality visual displays. *IEICE Transactions on Information and Systems*, *E77-D*(12), 1321–1329. https://doi.org/10.1.1.102.4646

Mixare. (2010). *mixare | Free Open Source Augmented Reality Engine*. http://www.mixare.org/static/index.html

Mosco, V. (2003). S. Woolgar (ed.) Virtual Society? Technology, Cyberbole, Reality. *EUROPEAN JOURNAL OF COMMUNICATION*, *18*(3).

Na, K. S., Mohamed, F., Isham, M. I. M., Siang, C. V., Tasir, Z., & Abas, M. A. (2020). Virtual Reality Application Integrated with Learning Analytics for Enhancing English Pronunciation: A Conceptual Framework. *2020 IEEE Conference on E-Learning, e-Management and e-Services, IC3e 2020*. https://doi.org/10.1109/IC3e50159.2020.9288478

Oculus. (2017). *Oculus Rift | Oculus*. Oculus.Com. https://www.oculus.com/rift/

Oculus. (2019). *Oculus Quest | Oculus*. Oculus.Com. https://www.oculus.com/

Okimoto, M. L. L. R., Okimoto, P. C., & Goldbach, C. E. (2015). User Experience in Augmented Reality Applied to the Welding Education. *Procedia Manufacturing*, *3*(Ahfe), 6223–6227. https://doi.org/10.1016/j.promfg.2015.07.739

Perl, T., Venditti, B., & Kaufmann, H. (2013). PS Move API: A Cross-Platform 6DoF Tracking Framework. *Proceedings of the Workshop on Off- The-Shelf Virtual Reality*, 8. https://www.semanticscholar.org/paper/PS-Move-API-%3A-A-Cross-Platform-6-DoF-Tracking-Perl-Venditti/654c7f3222dcf729209b5cbee5e2b01b1f684054?sort=relevance&citationIntent=methodology

Petrolo, L., Testi, D., Taddei, F., & Viceconti, M. (2010). Effect of a virtual reality interface on the learning curve and on the accuracy of a surgical planner for total hip replacement. *Computer Methods and Programs in Biomedicine*, *97*(1), 86–91. https://doi.org/10.1016/j.cmpb.2009.11.002

Pimentel, K., & Teixeira, K. (1993). Virtual reality: through the new looking glass. *Choice Reviews Online*, *30*(09). https://doi.org/10.5860/choice.30-5051

Powell, W., Powell, V., Brown, P., Cook, M., & Uddin, J. (2017). Getting around in google cardboard - Exploring navigation preferences with low-cost mobile VR. *2016 IEEE 2nd Workshop on Everyday Virtual Reality, WEVR 2016*, 5–8. https://doi.org/10.1109/WEVR.2016.7859536

Pressigout, M., & Marchand, É. (2007). Hybrid tracking algorithms for planar and non-planar structures subject to illumination changes. *Proceedings - ISMAR 2006: Fifth IEEE and ACM International Symposium on Mixed and Augmented Reality*, 52–55. https://doi.org/10.1109/ISMAR.2006.297794

Raskar, R., Van Baar, J., Beardsley, P., Willwacher, T., Rao, S., & Forlines, C. (2003). iLamps: Geometrically aware and self-configuring projectors. *ACM SIGGRAPH 2003 Papers, SIGGRAPH '03*. https://doi.org/10.1145/1201775.882349

Roberto, D. (2019). Introduction to VR and Google Cardboard. In *2D to VR with Unity5 and Google Cardboard*. https://doi.org/10.1201/9781315155272-12

Rolland, J. P., Davis, L., & Baillot, Y. (2001). A survey of tracking technology for virtual environments. *Fundamentals of Wearable Computers and Augmented Reality*, *8*(September), 1–48. https://doi.org/10.1.1.89.8135

Rusli, F. N., Zulkifli, A. N., bin Saad, M. N., & Yussop, Y. M. (2019). A study of students' motivation in using the mobile arc welding learning app. *International Journal of Interactive Mobile Technologies*, *13*(10), 89–105. https://doi.org/10.3991/ijim.v13i10.11305

Samsung. (2015, November). *Samsung Gear VR with Controller - The Official Samsung Galaxy Site*. https://www.samsung.com/global/galaxy/gear-vr/

Seligmann, R. L. (2018). *Creating a mobile VR interactive tour guide*. https://urn.fi/URN:NBN:fi:amk-201805036402

Siang, V., Ismail, M., Mohamed, F., Yusman, Khalid, Bazli, & Asyraf. (2017). *Interactive Holographic Application using Augmented Reality EduCard and 3D Holographic Pyramid for Interactive and Immersive Learning*.

Siegler, R. S. (1976). Three aspects of cognitive development. *Cognitive Psychology*, *8*(4), 481–520. https://doi.org/10.1016/0010-0285(76)90016-5

Smith, A., Balakrishnan, H., Goraczko, M., & Priyantha, N. (2004). Tracking moving devices with the cricket location system. *MobiSys 2004 - Second International Conference on Mobile Systems, Applications and Services*. https://doi.org/10.1145/990064.990088

Smus, B., & Riederer, C. (2015). Magnetic input for mobile virtual reality. *ISWC 2015 - Proceedings of the 2015 ACM International Symposium on Wearable Computers*, 43–44. https://doi.org/10.1145/2802083.2808395

So, R. H. Y., & Chung, G. K. M. (2005). Sensory motor responses in virtual environments: Studying the effects of image latencies for target-directed hand movement. *Annual International Conference of the IEEE Engineering in Medicine and Biology - Proceedings*, *7 VOLS*. https://doi.org/10.1109/iembs.2005.1615599

Soares, A. B., Júnior, E. A. L., de Oliveira Andrade, A., & Cardoso, A. (2012). Virtual and Augmented Reality: A New Approach to Aid Users of Myoelectric Prostheses. *Computational Intelligence in Electromyography Analysis-A Perspective on Current Applications and Future Challenges,* 409–426.

Soares, L. P., Musse, S. R., Pinho, M. S., & Boussu, J. B. (2019). Evaluation of Selection Techniques on a Mobile Augmented Reality Game. *Brazilian Symposium on Games and Digital Entertainment, SBGAMES*, *2018-Novem*, 127–136. https://doi.org/10.1109/SBGAMES.2018.00024

Sony Interactive Entertainment. (2016). *PlayStation VR*. PlayStation.Com.

Steed, A. (1993). A Survey of Virtual Reality Literature. *Technical Report (QMW),Queen Mary and Westfield College*, *623*.

Steed, A., & Julier, S. (2013). Design and implementation of an immersive virtual reality system based on a smartphone platform. *IEEE Symposium on 3D User Interface 2013, 3DUI 2013 - Proceedings*. https://doi.org/10.1109/3DUI.2013.6550195

Steuer, J. (1992). Defining Virtual Reality: Dimensions Determining Telepresence. *Journal of Communication*, *42*(4). https://doi.org/10.1111/j.1460-2466.1992.tb00812.x

Sudhagar, S., Sakthivel, M., Mathew, P. J., & Daniel, S. A. A. (2017). A multi criteria decision making approach for process improvement in friction stir welding of aluminium alloy. *Measurement: Journal of the International*

Measurement Confederation, *108*. https://doi.org/10.1016/j.measurement.2017.05.023

Sutherland, I. E. (1968). *HEAD-MOUNTED THREE DIMENSIONAL DISPLAY*. *33*(pt 1). https://doi.org/10.1145/1476589.1476686

Tamura, H. (2002). Steady steps and giant leap toward practical mixed reality systems and applications. *In Proceedings of the International Status Conference on Virtual and Augmented Reality*, 3–12. https://www.researchgate.net/publication/279920553_Steps_toward_a_giant_leap_in_mixed_and_augmented_reality

Teather, R. J., Pavlovych, A., Stuerzlinger, W., & MacKenzie, I. S. (2009). Effects of tracking technology, latency, and spatial jitter on object movement. *3DUI - IEEE Symposium on 3D User Interfaces 2009 - Proceedings*. https://doi.org/10.1109/3DUI.2009.4811204

Tregillus, S., Al Zayer, M., & Folmer, E. (2017). Handsfree omnidirectional VR navigation using head tilt. *Conference on Human Factors in Computing Systems - Proceedings*, *2017-May*, 4063–4068. https://doi.org/10.1145/3025453.3025521

Tuckman, B. W., & Waheed, M. A. (1981). Evaluating an individualized science program for community college students. *Journal of Research in Science Teaching*, *18*(6), 489–495. https://doi.org/10.1002/tea.3660180603

UltraLeap. (2018). *Getting Started with the Leap Motion SDK*. Ultraleap.

VIT. (2000). *Augmented Reality / 3D Tracking | ALVAR*. http://virtual.vtt.fi/virtual/proj2/multimedia/alvar/

Vuforia. (2012). *Vuforia Developer Portal*. https://developer.vuforia.com/vui/develop/licenses

Ware, C., & Balakrishnan, R. (1994). Reaching for Objects in VR Displays: Lag and Frame Rate. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *1*(4). https://doi.org/10.1145/198425.198426

Webster, R., & Dues, J. F. (2017). System usability scale (SUS): Oculus Rift® DK2 and Samsung Gear VR®. *ASEE Annual Conference and Exposition, Conference Proceedings*, *2017-June*. https://doi.org/10.18260/1-2--28899

Wheatstone, C. (2011). The Scientific Papers of Sir Charles Wheatstone. In *The Scientific Papers of Sir Charles Wheatstone*. https://doi.org/10.1017/cbo9781139057950

Worrall, A., Marslin, R. F., Sullivan, C., & Baker, K. D. (1991). Model-Based Tracking. *Procedings of the British Machine Vision Conference 1991*, 39.1-39.9. https://doi.org/10.5244/C.5.39

Wu, T. H., Wu, F., Liang, C. J., Li, Y. F., Tseng, C. M., & Kang, S. C. (2019). A virtual reality tool for training in global engineering collaboration. *Universal Access in the Information Society*, *18*(2). https://doi.org/10.1007/s10209-017-0594-0

Wuest, H., Vial, F., & Stricker, D. (2005). Adaptive line tracking with multiple hypotheses for augmented reality. *Proceedings - Fourth IEEE and ACM International Symposium on Symposium on Mixed and Augmented Reality, ISMAR 2005*, *2005*, 62–69. https://doi.org/10.1109/ISMAR.2005.8

Yang, C., Ugbolue, U., Carse, B., Stankovic, V., Stankovic, L., & Rowe, P. (2013). Multiple marker tracking in a single-camera system for gait analysis. *2013 IEEE International Conference on Image Processing, ICIP 2013 - Proceedings*. https://doi.org/10.1109/ICIP.2013.6738644

Yao, J., Peleshenko, S. I., Korzhik, V. N., Khaskin, V. Y., & Kvasnitsky, V. V. (2017). Concept of creation of an improved artifical intelligence system and computerized trainer for virtual welding. *The Paton Welding Journal*, *2017*(6), 19–26. https://doi.org/10.15407/tpwj2017.06.04

Yoo, S., & Kay, J. (2016). VRun: Running-in-place virtual reality exergame. *Proceedings of the 28th Australian Computer-Human Interaction Conference, OzCHI 2016*, 562–566. https://doi.org/10.1145/3010915.3010987

Yoo, S., & Parker, C. (2015). Controller-less interaction methods for google cardboard. *SUI 2015 - Proceedings of the 3rd ACM Symposium on Spatial User Interaction*. https://doi.org/10.1145/2788940.2794359

Yousefi, S., Kidane, M., Delgado, Y., Chana, J., & Reski, N. (2016). 3D gesture-based interaction for immersive experience in mobile VR. *Proceedings - International Conference on Pattern Recognition*, *0*, 2121–2126. https://doi.org/10.1109/ICPR.2016.7899949

Yue, W. S., & Zin, N. A. M. (2013). Voice Recognition and Visualization Mobile Apps Game for Training and Teaching Hearing Handicaps Children. *Procedia Technology*, *11*. https://doi.org/10.1016/j.protcy.2013.12.218

Zander Buel. (2020, August). *What Are the Different Welding Positions? - Tulsa Welding School*. https://www.tws.edu/blog/welding/what-are-the-different-welding-positions/

Zayer, M. Al, & Folmer, E. (2018). StereoTrack: 180-degree Low-cost Acoustic Positional Tracking for Mobile VR Platforms. *CHI PLAY 2018 - Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, 143–154. https://doi.org/10.1145/3270316.3273044

Zhong, P., & Stone, R. T. (2013). Automated kinesthetic trainer enhances kinesthetic memory development. *International Journal of Industrial Ergonomics*, *43*(3), 238–245. https://doi.org/10.1016/j.ergon.2013.02.007

LIST OF PUBLICATIONS

1. Mat Isham, Muhammad Ismail & Mohamed, Farhan & Haron, Habibah & Vei Siang, Chan & Mokhtar, Mohd Khalid. (2020). Welding Training Simulation: Combination of Virtual Reality and Multiple Marker Tracking. (FUSION)

2. M. I. M. Isham, H. N. H. Haron, F. b. Mohamed, C. V. Siang, M. K. Mokhtar and A. S. b. Azizo, "Mobile VR and Marker Tracking Method Applied in Virtual Welding Simulation Kit for Welding Training," 2020 6th International Conference on Interactive Digital Media (ICIDM), 2020, pp. 1-5, doi: 10.1109/ICIDM51048.2020.9339657.

3. M. I. M. Isham, H. N. H. Haron, F. b. Mohamed, C. V. Siang, " VR Welding Kit: Accuracy Comparison Between Smartphone VR and Standalone VR Using RMSE" 2021, IEEE International Conference on Computing (ICOCO), 2021 (unpublished).

4. Isham, M.I.M, Mohamed, F., Haron, H. @ N., Siang, C., & Mokhtar, M. K. (2021). VR Welding Kit: Welding Training Simulation in Mobile Virtual Reality using Multiple Marker Tracking Method. Journal of Advanced Computing Technology and Application (JACTA), 3(1), 1-9. Retrieved from https://jacta.utem.edu.my/jacta/article/view/5217