Development of Virtual Reality and Augmented Reality-Based Occupational Health and Safety Management Systems

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Abstract

In this time that has entered society 5.0, it is hoped that it can further improve the ability of human resources in their fields. The development of the Internet of Things, Big Data, and Artificial Intelligence can be a means of presenting new knowledge that is able to build life. The presence of a concept developed to form a super smart society has the aim of integrating virtual space and physical space as a solution to deal with various problems that remain focused on the humanitarian side. One of them is in the application of Occupational Health and Safety in the company, where in this case it requires a medium as a tool to convey information and provide education to workers within the company. The media is built in the form of a responsive mobile-based application that can display three-dimensional (3D) objects using VR and AR technology which is intended as a more interactive and immersive employee training method in implementing Occupational Health and Safety. Considering that there have been 177,000 cases of work accidents in Indonesia until 2020 based on data from the Social Security Organizing Agency (BPJS) of Employment. The purpose of this paper is to plan a strategy to overcome Occupational Health and Safety risks to achieve zero accidents. The writing of this scientific paper is descriptive analysis with a qualitative approach. The data sources used in the preparation of this scientific paper are primary data sources and secondary data sources with data collection techniques through literature studies and observations. The implementation of good Occupational Health and Safety can increase the level of productivity, in line with the statement that the application of Occupational Health and Safety in the workplace is a major effort in realizing a safe, comfortable, and healthy work environment and protecting and increasing the empowerment of healthy, safe, and high performance workers. Implementing Occupational Health and Safety is a form of providing protection provisions for the world of work, so as to minimize accidents in the workplace.

1. Introduction

The times are growing rapidly along with the development of technology that is increasingly widespread to meet the needs in all aspects of human life. Inseparable from the use of technology, starting from the development of learning methods, the production of goods in the industrial field, or used in supporting the management of the management of a work procedure which of course technology is considered as something that has the value of efficiency and effectiveness in facilitating human activities. Not only that, in the effectiveness of technology, the time and costs that should be incurred can be shortened and can be allocated to other things needed. Therefore, it can bring or maximize profits in an activity or work.

In the era that has entered society 5.0, it is hoped that it can further improve the ability of human resources in their fields. Society 5.0 is a concept that states that technology will coexist with humans to improve the quality of life in a sustainable manner (Sugiono, 2020). Society 5.0 emphasizes the development of the Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) (Putri, 2022). Through AI technology that has previously been built in Industry 4.0, Big Data or data on all aspects of life, can be collected through the internet and transformed into new knowledge that is able to build life (Sugiono, 2020).

The presence of a concept developed to form a super smart society has the aim of integrating virtual space and physical space as a solution to deal with various problems that remain focused on the humanitarian side. In addition, society 5.0 in terms of job completion emphasizes more on expanding job prospects and optimizing the responsibility of working hours. Therefore, in fulfilling this, a medium is needed that can be utilized. The media in question has an important role in conveying information and providing education, especially in terms of maintaining occupational health and safety.

According to the Social Security Organizing Agency (BPJS) Employment, the number of work accidents in Indonesia tends to continue to increase. Until 2020 the number of work accidents reached 177,000 cases. It is also known through statistics in Malaysia showing that there are 14,000 injuries and illnesses occurring every year and employers have to spend RM4 billion on medical expenses. The high rate of injuries among workers is an urgent health problem, especially given the high demand for the job market for new workers. Young or new workers experience the highest rate of work-related injuries of any age group (Shamsudin et al., 2018). To overcome this, Occupational Health and Safety risk management is an effort to manage risks to prevent unwanted accidents in a comprehensive, planned and structured manner in a good system. Accidents that occur in the work environment are mostly 88% caused by unsafe actions, 10% unsafe work environment conditions and 2% are not determined to cause (Ardiansyah et al., 2022).

The presentation on the application of Occupational Health and Safety in the company is intended so that everyone who works for the company understands and knows that it is important to maintain safety at work. But in reality the implementation of Occupational Health and Safety is still underestimated. The average company considers occupational health and safety programs to be not a big deal and less necessary. Meanwhile, human control plays an important role in the production process. In the factors of production in it there are human labor, money, auxiliary materials, raw materials, machines, methods and others, which in the end humans are the main factors. Carrying out occupational safety and health regulations with good implementation is not only the responsibility of the government but also the parties involved in it, namely companies, employees/workers, entrepreneurs, and all levels of society (Haya & Tambunan, 2022).

The implementation of good Occupational Health and Safety can increase the level of productivity of workers due to the creation of a warm and healthy work environment. That way, of course the workers in the company feel satisfied with their work. This is in line with the statement written by Hasbi Ibrahim in his book entitled "Strategies for Implementing an Occupational Health and Safety Management System" that the implementation of Occupational Health and Safety in the workplace is the main effort in realizing a safe, comfortable, and healthy work environment and protecting and increasing the empowerment of healthy, safe, and high-performance workers (Hasbi I, 2013). The existence of job satisfaction which results in an increase in productivity is something that company managers want. Therefore, with the development of technology, especially in information and communication technology, it can be used to handle this.

Information and communication technology can realize digital innovation in the field of work. Especially when combined with technology that is currently being intensively developed in the metaverse world. The Metaverse is a combination of several technological elements, including Virtual Reality (VR), Augmented Reality (AR), and video.

Virtual Reality is a new paradigm of technology that has been done a lot of research. Pioneered by Jaron Lanier, this new technology can undergo rapid development to increase people's expectations. Starting from the invention of the sensory machine, it was first in 1962, in the form of a multimodal experience display system. Sensorama is a well-made but not interactive enough VR system. In 1992, Cave was introduced as a new version of Virtual Realty. It was a stereoscopic picture of the project on the wall of the room. This approach assures a better resolution for the image. Interestingly, it can allow more than one user to have an optimal look (Shamsudin et al., 2018).

Virtual Reality that exists today is a technology created so that users can interact with an environment simulated by a computer (computer-simulated environment). The twisted environment can become similar to the real world, a representative Virtual Reality experience by including a simulation of a combination of sensing results (visual, audio, touching) (Nugraha Bahar, 2014). VR makes it possible to design applications accurately, interactively and can be presented in real-time. A 3D model that is simulated against an object so that it makes the user seem to be physically involved. The form is a 360° video that captures the entire scene where the user can look up, down, and around (Pandita & Stevenson Won, 2020).

Meanwhile, Augmented Reality (AR) is a variation of VR. AR is similar to VR in the sense that both use virtually machine-generated data. Virtual Reality tries to produce a complete environment, simulation or synthetic conditions, that surround or drown the subject. AR differs from Virtual Reality in that it does not try to block the surrounding real environment from the user. The AR system is not intended to immerse the user in a virtual environment but to compromise real objects generated by computer graphics in the actual space so that the user seems to perceive the object as existing in the real world (Nugraha Bahar, 2014).

There are many examples of Virtual Reality, one of which is like an FPS (First Person Shooter) game that will make users feel like they are in the game. Another example of the use of VR technology in human activities is that one of them is found in library services as a knowledge center presented in creative way. The following unique experience illustration is from a commentary by Jeff Peachey, a book conservator who visited a virtual reality exhibition of the interior of the library resulting from the Alberto Manguel/Robert Lepage collaboration "La bibliotheque, la nuit" at the Bibliotheque et Archives Nationales du Quebec, in Montreal, Canada in 2016 (Pandita & Stevenson Won, 2020).

"When I first read about the Alberto Manguel/Robert Lepage collaboration "La bibliotheque, la nuit" at the Bibliotheque et Archives Nationales du Quebec, in Montreal, Canada, it sounded crazy. A Virtual Reality exhibition of the interior of the library? ... As soon as I visited the exhibition, I was fascinated. Ten libraries from around the world are presented virtually, with a short 2-3 minute narrative describing them. The printed books form the background of many scenes and we are in the center of the reading room, and can see in all directions. The Oculus Rift VR simulator is impressive. The experience felt so real that it was confusing to look down and not see my own body in the virtual space."

Regarding strategies in managing the implementation of Occupational Health and Safety, VR and AR technology is used to build an application that can introduce and provide information about personal protective equipment and the use of equipment used while working and provide information about the spaces as well as evacuation routes in the company building. Virtual Reality is able to provide real information and can interact directly with the environment and space in the company.

Based on the explanation above, the author intends to design an application that can introduce various personal protective equipment and work equipment and how to use them, as well as a series in the use of personal protective equipment before starting work so as to minimize the risk of danger or accidents when working by

utilizing Virtual Reality technology which can be run mobile via a smartphone with the android operating system. The basis of the goal is to be able to know and get to know information about the workplace environment through applications using three-dimensional (3D) objects. Implementing Occupational Health and Safety is an effort to improve and maintain physical, mental, and social health at the highest level for all types of work. Occupational Health and Safety is a form of providing provisions for protection for the world of work so that it can minimize accidents in the workplace. If the workers are well equipped, then they can find out how to behave and what to do or avoid when working to protect themselves, for example, such as the use of Personal Protective Equipment (PPE) in the workplace such as masks, suits, lab goggles and gloves for those who work with chemicals as well as hard hats and boots for field workers. Simple things are the basis for working healthily and safely so that they can provide protection to employees (Wardah et al., 2022).

1.1 Literature Review

This study is in line with several previous studies, including research conducted by Suandi, Suryo Adi Wibowo, and Karina Auliasari entitled Introduction to Work Safety Tools Using Android-Based Augmented Reality: JATI (Journal of Informatics Engineering Students) Vol. 4 (1) (2020) 93-101 in its conclusion stated that the application of introduction to occupational safety tools can help workers in studying occupational safety tools. In his research, it is also said that the problem of work accidents in Indonesia is still relatively high. The purpose of making the application is to help workers to better know what work safety tools are needed when working so as to reduce the number of work accidents. The application of introduction to occupational safety tools can display 3D objects that contain work safety tools and work safety signs.

Compared to previous research, the research carried out today uses technology that is being developed, namely in addition to Augmented Reality, it is also added by using Virtual Reality technology so that the object or environment that is twisted can be displayed more realistically. In addition, previous research included audio and narration as intermediaries in conveying explanations or information in the designed application, while in the current research it uses video as a means of conveying information to users. Technology can help in conveying understanding. Attractive display with 3D images so that it can be used as a learning medium to make it easier for workers to capture and understand. This mobile-based application can be an alternative that can be used anywhere and anytime.

Another research conducted by Firman Setiawan Riyadi, A.Sumarudin, and Munengsih Sari Bunga in the Journal of Informatics and Computers (JIKO) entitled 3D Virtual Reality Application as a Medium for Introduction to the Mobile-Based Indramayu State Polytechnic Campus: 2017. Vol. 2 (2). The purpose of this study is to replace the previous promotional media with more interesting modern technologies. It is said that Virtual Reality is able to provide real information and can interact directly with the environment and buildings on campus. The built application will display 3D objects that resemble campus buildings. Then if the user focuses on the 3D object, information will appear about the building. So, users and prospective students can find out and get to know information about the campus environment through the application using three-dimensional (3D) objects. This has similarities with the research currently being carried out, which aims to develop an Occupational Health and Safety management system with new modern technology to provide information and introduce employees to the environment and building where they work.

2. Research Methods

A. Types of research

Research is carried out to reveal or provide explanations in accordance with facts, both in the form of phenomena, circumstances, events, variables and conditions that occur in the field. The writing of this scientific paper is descriptive analysis with a qualitative approach. The descriptive method of analysis is an effort to collect data which is then carried out by analyzing the data and with qualitative descriptive techniques, the data described tends to be in the form of words or sentences rather than numbers (Wardah et al., 2022). Descriptive qualitative aims as a tool to understand and display a clear picture related to the problems in the research, and the analysis method is used so that the author can compile it systematically (Haya & Tambunan, 2022).

B. Location

The main focus in this study is employees or workers and people who carry out work activities. So the nearest research location chosen is a place to make observations, where this will be used as a reference in the idea of designing a system regarding personal protective equipment and VR and AR-based Occupational Health and Safety facilities. The research location is at STMIK Indonesia Padang which is located at Jalan Khatib Sulaiman Dalam No. 1, Padang, West Sumatra.

C. Time

The research and writing time for this scientific paper starts from July to August 2022.

D. Data sources

The data sources used in this study are primary data sources and secondary data sources. Primary data is data collected and processed by researchers themselves by directly entering the field (research location) (Wardah et al., 2022). Primary data is obtained from the results of observations made, namely from the results of observations about anything that is included in the idea of designing the application system to be used. Meanwhile, secondary data is data produced by literature study techniques. This technique is an effort to present data or information in accordance with the problems discussed in research from various literature so that a new understanding of the technology used is obtained which is based on the concept of society 5.0. A literature review can provide an overview of the context or current issues. Secondary data used as a reference in this scientific work is obtained from several journals, scientific articles, and books sourced from the internet.

E. Data collection and analysis techniques

Data collection is intended to obtain the information needed in order to achieve research objectives. Data collection techniques are carried out through literature studies and observation activities. Literature studies are carried out in order to obtain information relevant to the topic of the problem in order to strengthen and as a complement to the statement. Writing is sought to be interrelated between one another (Putri, 2022). Meanwhile, observation activities are carried out to obtain information on field facts as a source of data in designing applications for the application of Occupational Health and Safety.

The data analysis process is carried out after all the data is collected. The collected data is selected by reading, studying, and reviewing. Then the results of the analysis are interpreted into writings that are arranged logically and systematically.

F. Presentation of data

The presentation of data is useful for seeing the overall picture of the research results. The stage before presenting the data is to reduce the data obtained first. Data reduction is done by choosing the things that are important, focusing on the things that are important, and discarding the unnecessary ones. Thus, the data that has been reduced will give a clear picture.

In qualitative research, data presentation can be done in the form of brief descriptions, charts, relationships between categories, flowcharts and the like (Hoffmann, 2009). In this study, the presentation of data was carried out using narrative texts. From the results of the presentation of the data, researchers can draw conclusions to be verified so that it becomes the meaningfulness of the data.

3. Result and Discussion

In designing mobile applications based on Virtual Reality (VR) and Augmented Reality (AR) it takes several stages to create 3D objects that will be displayed. The following are the stages of designing the application which can be seen in Figure 1:

Fig. 1 Stages of Application Design

In the application of Occupational Health and Safety, use case diagrams are used as an illustration that can explain how the flow of activities by the system to be built. In this application, there is a start button and several main menus such as room selection, evacuation route, personal protective equipment, assistance, and exit. The design of this use case diagram for running the application can be seen in Figure 2 as follows:

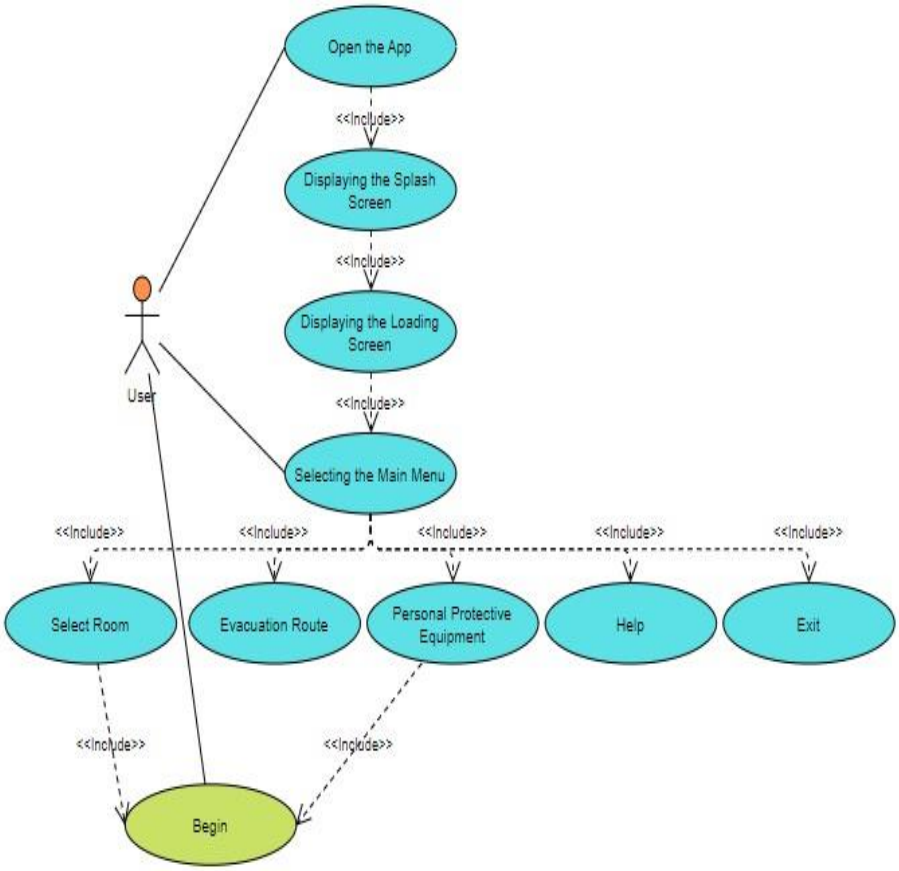

Fig. 2 Use Case Diagram

The design of 3D Virtual Reality (VR) and Augmented Reality (AR) applications as seen in the image above, starts from the user running the application by opening the application. The system will respond by displaying a splash screen which then also displays a loading screen to display the main menu of the application. Users can select the menu as needed. If the users click the select room button, the system will display all workspaces (rooms used in work activities) in the building. Then the user can select the intended workspace and click the start button to display the picture of the room along with the tools or objects in it in real terms with a 3D view. In the application of Occupational Health and Safety, users can click on objects or tools in the room to display videos that contain information about the name of the tool, the use of the tool, and education about how to use the tool appropriately and correctly so that nothing happens that can harm themselves.

Likewise with other main menus. The evacuation route menu if clicked, the system will display an image of the building as a whole and the surrounding environment as a 3D object. Users can click on the building object to bring up a selection of room names so that the system can display a video that includes self-rescue directions in the event of a disaster or work accident from the position of the selected room to the provided gathering point. For the personal protective equipment menu, the system works in the same way as the room select menu. Meanwhile, the help menu was created with the aim of helping users understand how to use the application, overcome obstacles, and so on.

The form of the user interface design on the application's main menu page can be seen in Figure 3 as follows:

Fig. 3 User Interface Main Menu Page

The 3D display as modeling in a designed Virtual Reality (VR) and Augmented Reality (AR) based application can be seen in Figure 4 below:

Fig. 4 3D View of The Use of Fire Extinguishers

To get a truly real simulation experience, users can enable VR by pairing a Google Cardboard device (VR glasses) to the mobile phone used. Google Cardboard is a Virtual Reality vehicle developed by Google using folded cardboard material and using a smartphone as the screen. Users can view and walk and freely interact directly in the 3D world.

Based on the research that has been carried out, results were obtained regarding the design of an application system that will be used as a medium in the application of Occupational Health and Safety in the company to protect employees or workers from the threat of risk of danger while working. For the company itself, the implementation of Occupational Health and Safety is useful for preventing losses caused by work accidents that can hinder production and work productivity. As for the environment and society, the implementation of Occupational Health and Safety can prevent the emergence of negative effects from tools or sources of production.

The driving factor for the importance of implementing Occupational Health and Safety is the first, humanitarian reasons by considering safety and the impact that affects the employee's family in the event of a work accident. Second, in the rules in force in Indonesia, it is mandatory to comply with government regulations and laws as stated in the Manpower Law Number 13 of 2003 Article 87 states that every company is required to implement an Occupational Health and Safety management system that is integrated with the company's management system. Third, economic reasons take into account the figures that will be issued by the company as a result of work accidents in its business activities.

The presence of VR and AR-based applications in the development of Occupational Health and Safety management systems has the purpose of not only protecting and ensuring the health and safety of every worker and others in the workplace, but also using work equipment as well as possible and selectively so that workers can feel safe, comfortable, and protected at work. The completeness of the features in the designed application is expected to provide sufficient information and understanding to employees about the building where they work so that they can carry out all procedures in doing work properly, safely, and in an orderly manner.

4. Conclusions

Based on the results of the above research, it can be concluded that Occupational Health and Safety is very important in an enterprise. Understanding and applying Occupational Health and Safety can make every job carried out will feel safe. The implementation of Health and Safety Cooperation by providing protection to avoid and minimize the consequences of work accidents. Occupational Health and Safety is an instrument that can protect the workforce, companies, society, and the surrounding environment from adverse things.

The combination of VR and AR technologies used is suitable for intensive visualization of information. It is useful as a solution in the development of occupational health and safety management systems. 3D applications with Virtual Reality and Augmented Reality function as an educational medium that can introduce and provide information about personal protective equipment and the use of tools used while working. In addition, with this responsive mobile-based application, it can also help workers to get to know the environment where they work.

In carrying out an activity, humans are between a safe point (one hundred percent safe) and a danger point (one hundred percent risk). Risks that are not addressed in the first place will be able to open up a potential. The greater the potential for an event to occur, the greater the impact it will have.

5. References

Ardiansyah, M. K., Irawan, S., & Purba, H. H. (2022). Identifikasi Faktor Risiko Keselamatan Pada Proyek Konstruksi Bangunan Gedung di Indonesia dalam 10 Tahun Terakhir (2011-2021): Kajian Literatur. Jurnal Teknologi dan Manajemen, 20(1), 45–58. Available from: https://doi.org/10.52330/jtm.v20i1.46

Hasbi I. (2013). Strategi Penerapan Sistem Manajemen Kesehatan dan Keselamatan Kerja. Makassar: Alauddin University Press.

Haya, S. F., & Tambunan, K. (2022). Pentingnya Strategi Manajemen Keselamatan dan Kesehatan Karyawan Pelayanan Jasa untuk Menciptakan Kepuasan Kerja Pada Bank Syariah Indonesia KC Medan Adam Malik. Jurnal Ilmu Komputer, Ekonomi dan Manajemen (JIKEM), 1(1), 129–138.

Hoffmann. (2009). Metode Penelitian. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 53(9), 1689–1699.

Nugraha Bahar, Y. (2014). Virtual Reality Technology Application for Conservation Architecture Building. Jurnal Desain Konstruksi, 13(2), 34–45.

Pandita, S., & Stevenson Won, A. (2020). Clinical Applications of Virtual Reality in Patient-Centered Care. Technology and Health, 2017, 129–148. Available from: https://doi.org/10.1016/b978-0-12-816958-2.00007-1

Putri, Fadila Amanda. (2022). Transformasi Sistem Pelayanan Medis dalam Penanganan Masyarakat Berstatus Orang Terlantar (OT) dengan Konsep Society 5.0. Padang: STMIK Indonesia Padang.

Riyadi, F. S., Sumarudin, A., & Bunga, M. S. (2017). Aplikasi 3D Virtual Reality Sebagai Media Pengenalan Kampus Politeknik Negeri Indramayu Berbasis Mobile. JIKO (Jurnal Informatika dan Komputer), 2(2), 75. Available from: https://doi.org/10.26798/jiko.2017.v2i2.76

Shamsudin, N. M., Mahmood, N. H. Ni., Rahim, A. R. A., Mohamad, S. F., & Masrom, M. (2018). Virtual Reality for Construction Occupational Safety and Health Training: A Review. Advanced Science Letters, 24(4), 2444–2446. Available from: https://doi.org/10.1166/asl.2018.10976

Shamsudin, N. M., Mahmood, N. H. N., Rahim, A. R. A., Mohamad, S. F., & Masrom, M. (2018). Virtual Reality Training Approach for Occupational Safety and Health: A Pilot Study. Advanced Science Letters, 24(4), 2447–2450. Available from: https://doi.org/10.1166/asl.2018.10977

Suandi, S., Adi Wibowo, S., & Auliasari, K. (2020). Pengenalan Tools Keselamatan Kerja Menggunakan Augmented Reality Berbasis Android. JATI (Jurnal Mahasiswa Teknik Informatika), 4(1), 93–101. Available from: https://doi.org/10.36040/jati.v4i1.2334

Sugiono, S. (2020). Digital Content Industry in Society 5.0 Perspective. Jurnal Ilmu Pengetahuan dan Teknologi Komunikasi, 22(2), 175–191. Available from: http://dx.doi.org/10.33164/iptekkom.22.2.2020.175-191

Wardah, S., Yoanda, D., & Ihwan, K. (2022). Model Keselamatan dan Kesehatan Kerja (K3) di PT. PJB Services PLTU Tembilahan. Jurnal Teknik Industri UNISI (JUTI-UNISI), 6(1), 39–46