The Development of Fire Safety Appliances Inspection Training using Virtual Reality (VR) Technology

T Pitana¹, H Prastowo², A P Mahdali³
¹,²,³Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia.

Email: trika@its.ac.id

Abstract. Nowadays, inspection training is still in a conventional way, and the inspector should provide their time and effort to go on-site to conduct an inspection and take a risk or by face to face learning. Considering the not efficient and what is at stake, it is crucial to seek a reliable inspector. Creating competencies and skill for the professional inspector is need many experiences and training. For Conducting inspector training, an environmental simulation based on the conditions of what needs to be inspected is required. Expensive to make environmental simulations and reasons for limited space and time spent on conducting inspection training for surveyors. Virtual reality technology can be a solution to this problem because virtual reality does not become risky and does not take many costs invested. This research will start with problem identification, data collecting, analysis phase, creating a virtual object, and Trial Phase. The deliverable of this research would be a remotely controllable virtual reality application based android operation system which is the model and design based on the container ship. The application was design with two main modes, which is Ship Tour Mode that can bring the user to explore the ship environment and see the explanation of fire fighting appliances and Inspection Mode that bring the user to finish a 15 minutes mission to find all the fire fighting appliances in the entire ship and fulfill the inspection checklist. Virtual Reality is beneficial for any sector because it can increase competencies, experience, easy access and easy to use. Based on the objective of this application, it can be concluded that the application can develop and simulate fire safety appliances inspection by making a model of the real condition of the fire safety appliances into 3D modelling and install into a virtual reality application maker. And based on the user questionnaire result, this application in the excellent category because the total value is 364 which is between 360 and 450 (maximum), which is the excellent category.

1. Introduction
With the rapid advancement of technology today, it is possible to be implemented in the maritime industry. Moreover, in Indonesia, which incidentally is an archipelago where many islands are connected by the sea, which means that it has significant potential to develop technology in the maritime industry. The scope of the maritime industry in Indonesia is not only about ships but includes banks, insurance, shipyard industries, machinery industries, consultants, sports boating, cruise industry, trucking, shipping lines, bunkering services, logistics providers, port operators, agent/brokers, traders/cargo owners, custom, and classification society, marine education, and marine survey. That is means that there are still many opportunities in various fields to integrate industrial
maritime with technology [6]. All this business field has interconnection and has one of orientation to marine safety so that there is safety regulation to control and prevent from an accident.

Safety of a ship is a paramount concern, so that needs to do routine inspection and survey for every safety equipment to make sure the equipment can properly working when it is needed immediately. Safety on a ship includes fire fighting equipment and safety equipment, and another safety aspect. All ship should prove information about their safety that can be found in a Fire Control Plan that mandatory from SOLAS. Fire Control Plan provides information about fire stations on each deck of the ship, on various bulkheads, and explains about the type of fire detection system and fire fighting systems available on the ship [1]. To create an experience and maximise surveyor competencies, also emphasise to focus on a sure thing, and accessible learning in simple and effective ways, marine survey field has to implement Virtual Reality technology to create virtual survey training in anywhere and anytime.

Virtual reality is a technology that can mimic/visualise an environmental situation and involve the human senses using a computer system and emphasises the interaction between users and systems [10].

Virtual reality can create an artificial environment that is created with software and presented to the user so that the user suspends belief it as a real environment, primarily experienced through two senses: sight and sound [5].

Virtual reality becomes a rapidly developing topic and can become a solution to support the maritime industry sector, such as in a marine survey, and inspection. The significant advantages of using virtual reality are simple and effective, do not need to spend a lot of effort and time, also less expense than real training methods [8][9][12]. This research also has intended to keep up the educational world with modern information technology[11].

Figure 1. The example of ship fire plan in ‘A’ Deck
2. Method

The methodology flowchart shows every step of creating virtual reality application which is shown in figure 2 below:

![Method Flowchart](image)

**Figure 2: Method**

2.1. Problem Identification

Nowadays, inspection training for a surveyor to do fire fighting appliances inspection in the ship is still in a conventional way, and the inspector should provide their time and effort to go on-site to conduct an inspection and take a risk or by face to face learning. Considering the not efficient and what is at stake, it is crucial to seek a reliable inspector. Creating competencies and skill for the professional inspector need many experiences and training[14]. For conducting inspector training, an environmental simulation based on the conditions of what needs to be inspected is required. Expensive to make environmental simulations and reasons for limited space and time spent on conducting inspection training for surveyors. Virtual reality technology can be a solution to this problem because virtual reality does not become risky and do not takes many costs invested and give the surveyors a different experience. Some aspect is needed to identify for creating the virtual reality application for training inspection, such as modelling the actual condition of the fire safety appliances to the 3D object and converting the 3D model of fire safety appliances to the virtual reality application[13].

2.2. Data Collecting

Data will be taken from one of the Shipping Company which is MV. Meratus Benoa. The data will be collecting are:

1. List of fire safety equipment that should be checked on board,
2. Parameter indicator to determine whether the equipment is worth to use or not,
3. The task of surveyors on board,
4. General Arrangement & Fire Control Plan of the ship (Figure 1)
5. Dimensions of every equipment on fire safety appliances,
6. Certificate of fire safety appliances.

2.3. Analysis Data

Analyse phase is to defining every equipment that needs to build in virtual reality application such as the proportional dimension and location and make as same as onboard based on drawing on fire control plan, and analysis every possible scenario that may be happening in real condition and faced
by surveyors on the virtual reality application. The input of this phase is the data from the surveyor and actual condition of the appliances and become the list of scenario that will appear in the virtual reality application

2.4. Create VR Object
Creating and design virtual obstacle as the same close as possible to the real object as shown as figure 3, using an application to create a 3D object which is a Blender and become an input to the virtual reality application maker which is Unity. This process must be done with care and focused because minor faults in this phase will steer the direction of progress and inaccuracy will cause repetition in this phase.

![Virtual Reality Object]

Figure 3. (a) Real Picture EEBD, convert to (b) 3D Object (c) Real Picture of Portable Fire Extinguisher convert to (d) 3D Object

2.5. Trial Phase
In this stage will be thoroughly tested for the virtual reality program that has been made in android platform base by ten respond with different specification of their device due to the compatibility. The purposes of this phase are to make sure the application is working correctly without no error and bug, also confirm that it is progressing by requirements. In the trial phase will be done by giving a try of 10 respondent with different background such as a marine engineer lecturer, marine engineer student, and ship surveyor then evaluate their advice comment. If it passes in this trial phase, it will be finished, and the conclusion can be made, and if it does not pass or there is an error or bug, it will analyse why the error happens and back to creation Virtual Reality object or the step before. Furthermore, there will be an assessment using a questionnaire form to the user/respondent.

2.6. Conclusion
Conclusion stage is the last stage of this research, and after the virtual reality application has been successfully worked and get a review of the minimum ten responded

3. Result and Discussion
The data and material to build the fire control plan virtual reality application consist of:
1. General Info of the ship, general info is used to know the dimensions of the ship for 3D modelling in virtual reality application, so the dimension is on a comparable scale.

2. Ship general arrangement (GA) is used as a basis of room design and location of its room.

3. Fire Control plan of MV. Meratus Benoa, Fire Control Plan is used as a guided to the placement and to list and define every object of fire fighting equipment

4. Visual data such as photos and videos on the actual condition based on a survey that has been conducted.

To determine the list and location of fire fighting equipment, fire plan, as shown in Figure 1 can be a reference, but with the validation in the actual condition, and precision location of each equipment. Then, creating the assets of the virtual environment using Blender application. The 3D models are drawn in Blender, which is a free and open-source 3D computer graphics software used for creating 3D models, visual effects, 3D interactive application, etc. The model is finalised to be as close as the actual object. The requirements for some assets can be precise from earlier phases of the analyses or even from the scenario draft.

There are two main 3D models, such as ship deck with all the environment and fire fighting equipment 3d model. All the ship should convert into a 3D model which is Navigation Deck or B deck, A-deck, Upper Forecastle deck, Lower Forecastle deck, Maindeck, Engine Room, Engine Control Room, Corridor below the main deck, Bow Thruster Room as shown in Figure 4.

The 3D model is using Blender Application. The finished 3D Model will be added to the Unity, which is also a free and open-source cross-platform game engine software. The independent objects that have been made in Blender such as the ship decks and fire-fighting equipment are put together to create the virtual application.

The user interface of the application needs to be designed. The design of the user interface is indeed fundamental because it will determine how a person interacts with the application[7]. The user interface is a visual part of virtual reality application that ensures how a user interacts with the VR application and how information is displayed on the screen, in the other ways is a communication mechanism between user and the application system. Figure 5, is showing the user interface of the main menu in the application with consist of option such as “Ship Tour”, “Inspection”, “Exit”, “Play”, “Help”. The white dot in the middle of the screen is the cursor for a choice menu in the application, and the user must be given the direction to the dot by moving the head-mounted VR glass to the menu until the dot change to the white circle, and push the remote button to action. The remote button function is guided in the “Help” menu.

The mode and features also need to be designed. The mode is made to deliver and describe the value of education in the virtual reality application. There will be two scenario mode in this virtual reality application which is Ship Tour mode and Inspection mode. In Ship Tour mode has an intention to give an introduction to the ship in the virtual world so that, the user can be free to explore the entire deck and ship environment. Ship Tour mode also has a feature of interaction in every fire fighting equipment, will appear an explanation of each equipment. Inspection mode is a mode to training the inspector with a mission in the application, and the user must finish the mission within 15 minutes by finding all the fire fighting appliances. Furthermore, full filling the inspection report by considering the actual condition of Fire Fighting Equipment.

The question and the recommendation answer will appear in the application in inspection mode. The inspection checklist question will be comply from CMID (Common Marine Inspection Document) [2] that mention in Table 1. CMID is the document that has a purpose of providing the marine industry with a standardised format for vessel inspection reports and to reduce the number of inspections carried out on individual marine vessels, through the adoption of a common inspection process.
Table 1. Inspection Questions

| No | Question |
|----|----------|
| 1  | Is the vessel provided with fixed fire fighting equipment in accordance with applicable regulations for vessel type? |
| 2  | Is the certificate from each fire fighting equipment available? |
| 3  | Is sufficient fire fighting equipment available for use and defect-free? |
| 4  | Are records of fire fighting equipment maintenance available? |
| 5  | Are fixed fire and gas detection systems fully operational and tested regularly accompanied by a test document? |
| 6  | Are vessel personnel familiar with the operation of fire fighting, life-saving and other emergency equipment? |
| 7  | Any manual operation guide to be posted on each fire fighting appliances? |
| 8  | Are measures in place to effectively isolate ventilation to enclosed spaces, e.g. engine room, accommodation, galley, storerooms? |
The VR application needs to be testing. The test was doing intending to find errors and deficiencies in the software. The test is intended to determine whether the software is made to meet the criteria under the purpose of software design by asking some question to the user via a questionnaire form. The questionnaire is a tool to assess and test the virtual reality application and give the feedback to develop and complete the shortcomings. The questionnaire is consist of ten questions that are the last three question is especially for surveyor as a respondent.

The respondent must be given a score that's stated by number range of five (5) until one (1). The excellent score is (5), and the poor score is (1). With the result that explains in Table 3, The question is:

1. Is the display in this VR application easy to understand?
2. Do all the button, and each fire fighting appliances displayed work properly?
3. Does the object displayed represent fire fighting equipment on board?
4. Is learning with VR technology more interesting, helpful and easy learning?
5. When using VR glasses, is the VR application comfort to used?
6. Are learning and training using VR be conveyed compared to face-to-face learning?
7. Does the inspection training use VR adequately illustrate hands-on learning on board?
8. If you are a surveyor, is the placement of the object in accordance with the Fire Safety Plan?
9. If you are a surveyor, Is this Virtual Reality application very helpful for surveyor training purposes?
10. If you wish, write down the brand and type of your smartphone to match the compatibility of the application with the specifications of your smartphone

| Question | Score | % | Avg. Score |
|----------|-------|---|------------|
| 1 | 6 4 0 0 0 | 92 | 4.6 |
| 2 | 5 4 1 0 0 | 82 | 4.1 |
| 3 | 5 2 3 0 0 | 86 | 4.3 |
| 4 | 5 5 0 0 0 | 90 | 4.5 |
| 5 | 0 3 5 2 0 | 62 | 3.1 |
| 6 | 3 5 2 0 0 | 82 | 4.1 |
| 7 | 2 6 2 0 0 | 74 | 3.7 |
| 8 | 2 5 3 0 0 | 78 | 3.9 |
| 9 | 2 7 1 0 0 | 82 | 4.1 |

Average Total 4.04

From Table 2 it explains the assessment of each question. The highest score is 4.6 in question number 1, which mean the application is easy to understand. The lowest score is 3.1 in question number 5, which mean the application is comfortable enough to use because most of the user feel sickness motion, that occurs of headache due to eye unfamiliarity for using VR glasses; also the low graphic quality becomes a small cause and the low specification of the VR glasses. However, the average score is 4.05 out of the maximum score of 5.

To get the results of the respondent's overall assessment of the quality of the application, we have to know:

1. The maximum score, which is the largest answer score multiply by total questions, multiply by the total respondent.
   \[ 5 \times 9 \times (10 \text{ respondent}) = 450 \]
2. The minimum score, which is the smallest answer score multiplied by total questions, multiply by the total respondent.
   \[ 1 \times 9 \times (10 \text{ respondent}) = 90 \]
3. The median value, with the sum of the maximum total score with a minimum total score divided by two.

\[ \frac{(500+100)}{2} = 270 \]

4. The quartile I value, with the sum of the minimum total score with a median divided by two.

\[ \frac{(90 +270)}{2} = 225 \]

5. The quartile III value, which is the sum of the maximum scores with the median divided by two.

\[ \frac{(450+270)}{2} = 360 \]

The assessment of the application can be categorised based on the value of the maximum score, quartile III, median, quartile I and the minimum score that calculated above which is, the excellent categorise is between quartile III value and maximum score (360-450), the good categorise is between median value and quartile III value (270-360), the enough categorise is between quartile I and the median value (225-270), and the bad categorise between minimum score and median value (90-225).

Based on the results of the respondents of the nine questions, it can be concluded that the virtuality application for training inspector for fire fighting appliances is in the excellent category because the total value is 364 which is between 360 and 450 (maximum), which is the excellent category.

4. Conclusion

Based on the objective of this application, it can be concluded that the application can develop and simulate fire safety appliances inspection by making a model of the real condition of the fire safety appliances into 3D modelling and install into a virtual reality application maker. Moreover, based on the user questionnaire result, this application in the excellent category because the total value is 364, which is between 360 and 450 (maximum), which is an excellent category. However, there must be further development with improvement in high-quality resolution and detail of 3D models, and development on how to minimalise the motion sickness when the user using VR glasses.

References

[1] SOLAS, "Safety Life of Sea," 1974.
[2] CMID, "Common Marine Inspection Document," 2016.
[3] Inc, "Fire Hose," 09 12 2019. [Online]. Available: https://www.canstockphoto.com/fire-hose-14104908.html.
[4] J. S. M. C. Ltd., "Mobile Trolly Marine Fire Extinguisher Wheel 45L," 2009. [Online]. Available: http://maritimesafetyequipment.sell.everychina.com/p-104670743-mobile-trolly-marine-fire-extinguisher-wheel-45l-foam-for-ship-fire-fighting.html.
[5] S. Smith and S. Lee, "A pilot study for integrating virtual reality into an introductory," Journal of Industrial Technology, 2004.
[6] R. Zulfauzi, "The Development of Life-Saving Appliances Inspection Training," International Journal of Marine Engineering Innovation and Research, 2019.
[7] O. M. Okechukwu and E. F. Udoka, "Understanding Virtual Reality Technology," InTech, 2011.
[8] M. Neil, "Architectural Virtual Reality Applications," 1996.
[9] G. Wittenberg, "Assembly Automation," Training with virtual reality, 1995.
[10] D. S. A. Gomes and Z., "Computers and Graphics," Virtual Reality as a tool for verification of assembly and maintenance processes, 1999.
[11] H. Haufmann, "Education and Information," Construct 3D : A virtual reality.
[12] Abshire and Barron, "Virtual maintenance: Real World Applications," IEEE Proceedings Annual Reliability and Maintenability, 1998.
[13] R. Kalawsky, "The Science of Virtual Reality and Virtual Environments," 1993.
[14] B. and W., "The example of experiential," Designing virtual worlds for use in mathematics education, 1992.

Acknowledgments
The authors wish to acknowledge ship data support from PT Meratus Line Shipping Company for Marine Operation and Maintenance Laboratory, Marine Engineering Department, ITS, Surabaya, Indonesia. And acknowledgements for Blender 3D maker and Unity as a game engine.