Implementing 3D Model LNG Tanker Ship Cargo Handling System Equipment for Training Using Augmented Reality

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Abstract. The learning system of the vessel is very important for a marine engineer to understand the characteristic of machinery system. This can be conducted by looking at the block diagram and seeing the 3D picture or directly observing the system on a vessel in order to get a complete understanding. It is difficult to do direct observation due to safety regulations and company confidentiality, especially for LNG tanker ship. To overcome this restriction, this study will propose a 3D drawing for training that can represent the real operational condition of cargo handling system equipment of an LNG tanker vessel. Augmented Reality 3D is used to recreate the system and put necessary information about the object along with the 3D drawing. The augmented reality 3D object and information showing with the android application by scanning the object augmented reality marker. In this research, the user is satisfied with the experience and interface based on user data collected from the questionnaire method with aspect of attractiveness, uses ability, effectiveness, user interface experience, and measure the understanding about the application with questionnaire value measurement.

1. Introduction

Improvement technology for the maritime industry has become more competitive. Many new technology was added to provide a simple and efficient working environment. Digitization has the main role to improve how to manage work in the maritime industry. Beside improving the efficiency of working, digitization can improve the safety aspect of the maritime industry. The ship has many systems to operate during the voyage. Three main systems are crucial to the ship operation i.e machinery system, electricity system, and cargo handling system.

For some ships, there is a restriction area or even entered the ship due to safety regulation because of flammable and hazardous cargo. In this case is LNG ship cannot be accessed without proper safety equipment and trained crew and had many restriction areas on the cargo area, especially for the visitor cannot be accessed cargo area refers to IACS class society rules [1].

LNG tanker ship has their characteristic of the cargo handling system and constructed for transporting liquefied commonplace gas (LNG). This carriers are purpose-built tank vessels for transporting LNG at sea. During handling, LNG is transferred between the onshore storage tanks and ship tanks at soaring sail rates through single or parallel pipelines. It is forever influenced by outside disturbances outside. In general, these operations are power-intensive and signify stringent safety considerations. It is extremely necessary and vital to control the temperature and pressure to lop the risk of accidents [1][2]. LNG tanker ship has different complexity system due to their cargo is liquified natural gas. Their operation needs to be monitored to control the stability of cargo [2]. Because of this characteristic engineer must understand the map diagram of the system, so if there is any trouble or
accident engineer can easily identify the location of the trouble. Augmented Reality can provide that to help engineers to study their system with a 3D model with their gadget.

To learn how to operate that system, ship engineers or vessel crew need to learn the diagram of it. Mostly the diagram of the system that is available is on paper, so each engineer has to own their copy to learn the system. To digitize, the diagram needs technology called Augmented Reality (AR). Augmented Reality will accelerate engineers to study and identify the part of the system. Augmented Reality will provide a 3D model based on the drawing system and can be operated with a mobile phone or tablet (gadget).

A study using Augmented Reality can be understood clearly and close without worrying about safety and permission to going onboard the vessel. Because of augmented reality, the object can be digitalized and can improve the knowledge about the ship faster in real time with a closer look into the object. applications in design and manufacturing. It consists of seven main sections. The first section introduces the background of manufacturing simulation applications and the initial augmented reality developments. The second section describes the current hardware and software tools associated with AR. The third section reports on the various studies of design and manufacturing activities, such as augmented reality collaborative design, robot path planning, plant layout, maintenance, CNC simulation, and assembly using augmented reality tools and techniques. Augmented Reality, a state of art technology can proceed digital information to the world. For further more Augmented Reality will be use into advance engineering application. Advances in localization technology will enable the deployment of augmented reality in a complex environment [3].

2. Experimental

2.1. Data Collecting
The LNG ship that will be using on this research is 30,000m3 LNG carrier with 3 cargo storage tank on board. The ship type is membrane tank and have 6 main cargo component to loading unloading LNG from storage or shore connection. The cargo handling equipment will be shown on this task is cargo pipe, cargo pump, condenser, compressor, cargo tank vent, and manifold. These components will be drawn in 3D and attach to complete ship hull drawing. The ship specification dimension is,

| Table 1. Ship Specification (Humpus Fleet Profile) |
|-----------------------------------------------|
| IMO               | 9187356       |
| Name             | TRIPUTRA     |
| Vessel Type – Generic | Tanker       |
| Vessel Type – Detailed | LNG Tanker   |
| Gross Tonnage     | 20017        |
| Summer DWT        | 12493 t      |
| Length Overall x Breadth Extreme | 151.03 x 28 m |

3D ship hull drawing is based on General Arrangement of TRIPUTRA LNG SHIPS. The goal to developing of 3D drawing ship hull is to recreate the 3D object to come as near as possible to the real condition and position of the object on the ship, so user can experience the same thing when user visit the vessel directly.
2.2. 3D Drawing Object

3D drawing is created using software called UNITY. This software can process complex 3D drawing and produce smooth detail of a particular object in a system, so when the object projected on augmented reality application it can reach decent result. The final result is to modelling the 3D of LNG Cargo handling system equipment and divide in to some objects to be detail [4].

![Figure 1. General arrangement of LNG ship.](image1)

![Figure 2. LNG Tanker 3D drawing object.](image2)

![Figure 3. LNG cargo pump 3D drawing object.](image3)
Others equipment such as LNG condenser and LNG compressor will featured in the augmented reality 3D object. The user will get the complete system equipment to more understand.

Figure 4. LNG ship cargo condenser 3D drawing object.

Figure 5. LNG ship cargo compressor 3D drawing object.

Modelling 3D drawing will include the diagram of the system. This can help to understand and give experience the user the real world sensation of visiting LNG tanker ship.

Figure 6. LNG ship cargo handling system 3D drawing.

3D created based on the data of the ship and other reference such as on the internet, this can archived closed drawing object look.
3. Result and Discussion

The result of this research is the 3D object drawing can be showing as augmented reality, it means the object need application to facilitate the result. Author using vuforia software engine by unity. Vuforia is an augmented reality software development kit with SDK format for mobile devices that allows the creation of augmented reality applications for phone. It uses computer vision technology to recognize and track planar images and 3D objects in real-time. This image registration capability allows developers to position and redirects virtual objects, such as 3D models and other media, concerning real-world objects when they are viewed through a mobile device's camera [4].

The main purpose the application is to acknowledge about LNG ship tanker cargo handling system equipment. Therefore, all the object is available at the ship so the user is keep experience things like real world reality. To excellent the work author using Vuforia engine version 9.8 to produce smooth and decent resolution for the augmented reality object. Vuforia helps to create the better user interface of the augmented reality application with format android application, the application can be access only with android OS.

Augmented reality development will be using marker based augmented reality. This type of AR is utilizing recognition as said by object. Marker Based AR supply databases about the thing after AR intention focused on the recognition of the object. Marker Based AR has different utilizes according to market purposes. This AR detects the thing at the fore of the camera and supplies databases about the thing on the screen. It can replace the marker on the AR intention shroud with a 3D version of the corresponding object. Markers are square and constitute a black thick border or other types of border. The benefit of the border is to separate markers from a background in a seized frame easily. The tracking module is the vast majority of necessary things on this type of AR. It calculates the relative pose of the camera in genuine time. Degrees of Freedom (DOF) is the allowance for situation and orientation thing of 3D design [5].

After the application created, to operate the application user must be downloading the object marker picture, the by scanning the marker with augmented reality application then the object will shown like the figure 7 until figure 10,

![Figure 7. LNG ship augmented reality object.](image1)

![Figure 8. LNG ship cargo handling system augmented reality object](image2)
Beside the 3D object there’s information about the object based on selected augmented reality object, so the user can knowing more about the showing object. After the application is completely built, it needs to test the product to the user. In the user experience test, the author needs to test the application to the user target and collect the data to measure the ability and user satisfaction with the product. The category that needs to be measured is, Application user interface, Application Performance, Quality of Augmented Reality object, Quality of information inside the application, Application benefit to the user, and collect feedback from the user. There're a lot of often two ways to measure UI and UX, either by objective methods or subjective methods. Yet a mixture of both methods perhaps supplies more dependable results. Unbiased methods supply results utilizing experimental evidence, while subjective methods supply results from the user’s point of view. The subjective methods are repeatedly utilized to know to archive that, the author use questionnaire to measure by giving the score to each category.

Creating user test questionnaire based on basic product user test questionnaire chart flow. User test questionnaire must include aspect of attractiveness, uses ability, effectiveness, user interface experience, and measure the understanding about the application. Author create questionnaire chart flow based on the product that author created, so the basic questionnaire flow chart will match with the product that about to be tested [6] [7].

**Figure 9.** LNG ship cargo condenser augmented reality object.

**Figure 10.** LNG ship cargo compressor augmented reality object.
The questionnaire is divided into two categories, i.e., (i) to measure the user interface quality, and (ii) to measure the application ability to give understanding about the augmented reality objects. User interface quality measurement will be measure quality of showing the object and how close object with the real world, then the object information, it is showing or no. For the ability quality measurement will be measure user understanding before and after using the app, the understanding of the information and object, and effectiveness. Author will showing the questionnaire on the table 2.

**Table 2.** User experience test questionnaire.

| No | Question                                                                 |
|----|--------------------------------------------------------------------------|
| 1  | How do you understand Cargo Handling Equipment before using the 3D AR LNG Tanker Cargo Handling Equipment system? |
| 2  | Is the appearance of the AR application easy to understand?                |
| 3  | Is the 3D AR Object available in the application to present its original form on the ship? |
| 4  | Is the explanation of the AR object in the application understandable?     |
| 5  | Is the app easy to use?                                                   |
| 6  | If you are a surveyor trainee / marine student / other practitioners, is the Application of 3D AR LNG Tanker Cargo Handling Equipment very helpful to understand part of the cargo handling system of LNG ships? |

The user experience test was conducted by letting the user try the augmented reality application and explore it. After exploring the application, user fills a questionnaire to measure the application performance. Each respondent give a value for each question from one (1) to five (5) in which one (1) is the lowest and value five (5) is the highest.

The measurement score is based on the basic system usability scale method. This method is usually used to measure the ability and quality of the product. Measurement to score the value of each question.

![Diagram](image-url)
by the scale of 1 to 5 which means, 1 is very bad, 2 is bad, 3 is good, 4 is very good, and 5 is perfect. After scaling the questionnaire answer, then there will be the score for the question using equation
\[
\text{score equation } = \text{score equation itself is by total all of the question scores. To evaluate the overall result of the Ship. However, the total score of the user experience test questionnaire is 1037 out of 1230. The total this augmented reality application is helping to improve learning about cargo handling system of LNG application smoothly, but there's some respondent can't smoothly access the application due to phone AR 3D Object, the information is provided on each AR 3D Object. Respondents can access the improvement to reach perfectly alike. Most of the respondents can understand the information about the ship, although 43% of them do not. The respondents agree that the application interface can be easily understood, this means the base of the application interface device can retain. The respondents measured On the Table 3 shows that most respondents already understand about the cargo handling equipment on the ship, although 43% of them do not. The respondents agree that the application interface can be easily understood, this means the base of the application interface device can retain. The respondents measured the augmented reality 3D object likely alike based on table 3, this means the object needs more improvement to reach perfectly alike. Most of the respondents can understand the information about the AR 3D Object, the information is provided on each AR 3D Object. Respondents can access the application smoothly, but there's some respondent can't smoothly access the application due to phone OS (operating system). Respond as a marine student or surveyor trainer, etc. based on the table3, agree this augmented reality application is helping to improve learning about cargo handling system of LNG Ship. However, the total score of the user experience test questionnaire is 1037 out of 1230. The total score equation itself is by total all of the question scores. To evaluate the over all result of the questionnaire, there are several value that need to be determine. Those value are,

1. The maximum value, by multiplying the largest answer value by the total question and then multiplied with total respondent
\[
5 \times 6 \times (41 \text{ respondent}) = 1230
\]

2. The minimum value, by multiplying the smallest answer value by the total question and then multiplied with total respondent
\[
1 \times 6 \times (41 \text{ respondent}) = 246
\]

3. The median value, by adding the maximum value with the minimum value and divided by two
\[
\frac{1230 + 246}{2} = 783
\]

4. The quartile I value, by adding minimum value with median value and divided by two
\[
\frac{246 + 783}{2} = 514
\]

5. The quartile II value, by adding the maximum value with the median value and divided by two
\[
\frac{1230 + 783}{2} = 956.5
\]

And the percentage of the score equation is
\[
\frac{\text{Score}}{\text{question total score}} 
\times 100\% \quad (2)
\]

| Question No | Respondent | Score | % |
|-------------|------------|-------|---|
| 1           | 5 7 13 10 6 | 128   | 62% |
| 2           | 0 0 2 9 30  | 192   | 94% |
| 3           | 0 0 5 24 12 | 171   | 83% |
| 4           | 0 0 3 19 19 | 180   | 88% |
| 5           | 0 2 15 23 183| 183   | 89% |
| 6           | 0 2 18 21 183| 183   | 89% |
| Total Score |            | 1037  |    |
| Total Percentage |    | 84%   |    |

Note : score measurement (1 very bad), (2bad),(3 Good),(4 Very good),(5 Perfect)
6. The Quartile III Value, by adding the quartile II value with maximum value and divided by two

\[
\frac{1230 + 783}{2} = 1006
\]

The score calculation on (3),(4),(5),(6),(7), and (8) is basic range to categorize the application score criteria. Application score criteria will be categorized based on the value of maximum, quartile III value, median value, quartile I value, and the minimum value. Score in the range of quartile III value and the maximum value will be categorized as excellent (1118-1230). Score in the range quartile II value and quartile III categorize as very good (1006-1118). Score in the range median value and quartile II value is categorized as good (783-1006). Score in the quartile I value and median value will categorize as enough (514-783). Last, score in the minimum value and quartile I value will categorize as bad (246-514). Based on scoring categorize, the result of user experience test consisting of 6 question with 41 respondent of LNG tanker Cargo handling System Equipment 3D augmented reality application is very good because the total score is 1037 out of 1230 (the maximum value), in between range of the quartile II value and the quartile III value (1006-1118).

4. Conclusion

Augmented Reality can project the object of LNG tanker cargo handling system equipment by scanning the marker object with the augmented reality application. The process to make the augmented projection by construct the application software to provide 3D object become augmented reality object, software that the develop is UNITY 3D and Vuforia. The object that showing on Augmented Reality program is 3D drawing object of LNG tanker cargo handling system equipment. The 3D object develop using software UNITY 3D, where the object is recreation by the original model of the ship cargo handling system equipment. The augmented reality object that showing is the LNG ship tanker, LNG condenser, LNG compressor, LNG cargo pump, and LNG loading unloading system. To project the Augmented reality can be done using AR application that can be used as educational media. Based on the user experience test with calculation on (3),(4),(5),(6),(7), and (8) the score value reach 1037 out of 1230 and categorize as very good. The categorize is based on, Score in the range quartile III value and the maximum value will be categorized as excellent (1118-1230). Score in the range quartile II value and quartile III categorize as very good (1006-1118). Score in the range median value and quartile II value is categorized as good (783-1006). Score in the quartile I value and median value will categorize as enough (514-783). Last, score in the minimum value and quartile I value will categorize as bad (246-514).

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