

## Development Research of Marine Engine Room Simulator for Offshore Supply Vessel Based On Virtual Reality Technology

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### Abstract

*Aiming at the present status that the absence of marine engine room simulator for OSV (Offshore Supply Vessel) in China market and the need to improve the working ability of engineers in OSV, the marine engine room simulator for OSV based on virtual reality technology is developed which chooses the first high-class horsepower deep-water AHTS (Anchor Handling Towing Supply Vessel) “HAI YANG SHI YOU 681” as the parent ship. The development concept, system structure, development process is elaborated. To improve the training effect, several utilitarian functions are added, such as information-display for interactive entity, two-dimensional visualization system interface, equipment document management, search and locate for interactive entity and equipment. To make the evaluating result convincing, fuzzy evaluating method is adopted to implement the evaluating function. The result shows that the virtual scene is real and delicate, interactive mode is quick and utilitarian, evaluating function is accurate and reliable. The successful development of the system will promote education and training for OSV engineer in China.*

**Keywords:** *Offshore Supply Vessel, Marine Engine Room Simulator, 3D Modeling, Evaluating, Virtual Reality*

### 1. Introduction

Exploitation of ocean oil-gas resource (especially deep-water oil-gas resource) as the important oil-gas resource in the world has become one of import measures in China, so a large number offshore engineering equipment is needed, and OSV which is one kind of offshore engineering equipment is especially important for providing comprehensive support service for the exploration, exploitation, production of ocean oil-gas [1], so to train a large number of marine engineer for OSV is necessary, however, training marine engineer for OSV is different from for other types of cargo vessel (such as tankers, container ships, bulk cargo ship), because a lot of offshore engineering equipment is needed to be operated by marine engineer, and the engine room of OSV also has the characteristics of small space and large number of equipment, so it is necessary to develop a set of OSV marine engine room simulator to train the marine engineer before they work in the real ship, furthermore the formally approved by IMO (International Maritime Organization) stipulate clearly that the marine engineer must accept the training of marine engine room simulator which is also stipulated by Maritime Bureau in China, so this paper chooses “HAI YANG SHI YOU 681” as the parent ship to develop first OSV marine engine room simulator based virtual reality, which will not only make the master the principle of machinery system and the operation method of equipment in OSV, but also get familiar with the engine room structure and work environment, so it has the vital significance for promoting training effect and working ability. The OSV marine engine room simulator developed in this paper has been applied in the COSL (China Oilfield Services Limited) Crew Training Center and has made good training effect.

## 2. Development Concept

The function of virtual marine engine room should not be limited to the simple roaming, furthermore, it should be applied as a self-learning platform to promote and evaluate the professional skill of the marine engineers, based on this development concept and the order that engine room resources management is stipulated as mandatory competency standard specified by the amendments to the convention STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) which is effect on January 1, 2012, several main points should be followed when establishing the virtual engine room.

1) The virtual engine room environment should be real and precise. The virtual environment with high reality can enhance the immersion for users and precise engine structure, pipes arrangement, shape of equipment can promote the overall quality of the software and training effect.

2) The math and logic model of marine machinery system should be precise. The math and logic model is the core part of the whole system, as the equipment running status and data information display in the engine room is driven by it, so establishing precise math and logic model is necessary for promoting reality of the system.

3) Rich interactive content. Rich interactive content (such as the valve, switch, button, instrument, touch screen and so on) will help the user finish various kinds of operations in the virtual engine room.

4) The system should satisfy the function of multiplayer LAN (Local Area Network) running and real-time transmission of simulation data. The function can implement the training of communication ability, leadership and decision-making ability and team corporation ability for marine engineers stipulated in the amendments to the convention STCW.

5) The system should possess the function of saving and loading of system state, which is very helpful to shorten training period and promote training efficiency.

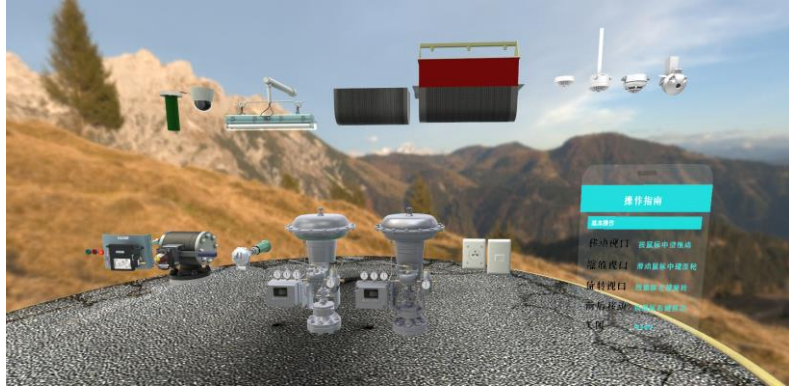
6) The system should possess the function of evaluating, which is helpful to know and judge the professional skills of marine engineers.

## 3. Development Process of OSV Marine Engine Room Simulator

### 3.1 Establishing the Geometric Model of Virtual Engine Room

The virtual marine engine room developed in this paper chooses the first high-class horsepower deep-water AHTS “HAI YANG SHI YOU 681” which is invested by COSL as the parent ship, this ship is very representative for training OSV marine engineer. Before developing, nearly 100000 engine room photos and 1000 videos are shot and complete equipment instructions and machinery system principle diagrams are got, which provide reliable support to establish real and precise virtual engine room geometric model. When establishing the virtual engine room geometric model, the engine room is divided into 23 rooms according to the spatial relationship, such as the Emergency Generator Room, Steering Gear Room, Switchboard Room, ORO Room, the 23 rooms contain most of the machinery system, which ensures the integrity of training.

The virtual marine engine room is established by using 3D modeling software “3D-Max” in this paper. When establishing, an equipment model library is established in view of the feature that a lot of equipment which has the same structure and appears frequently (such as the valve, alarm lamppost, unit heater and so on) exists in the engine room, which can not only accelerate the process of project development, but also make the virtual marine engine room standard, as the Figure 1 shows are some equipment models in the model library established in this paper.

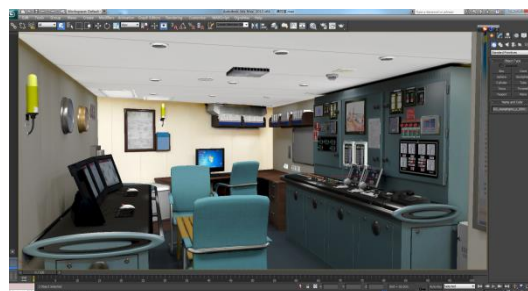


**Figure 1. Model Library**

As the marine engine room belongs to a typical complex large scene, so when establishing engine room geometric model, paying attention to the elaborate degree of the virtual scene excessively will lead to substantial increase of facet numbers and data size of the geometric model, which will eventually make the graphics of virtual scene sluggish and the loading speed too slow, so optimization method should be taken to make the graphics of virtual scene smooth and the loading speed satisfactory on the basis of sufficient reality and immersion, in this paper three optimization methods are taken, they are respectively modeling optimization, mapping optimization and programming optimization, detail introduction of the three optimization methods refers to the author's another paper [2]. As is shown in Figure 2 and Figure 3 is respectively the geometric model of Compressor Air Room and ECR (Engine Control Room) in 3D-Max.



**Figure 2. The Model of Compressed**

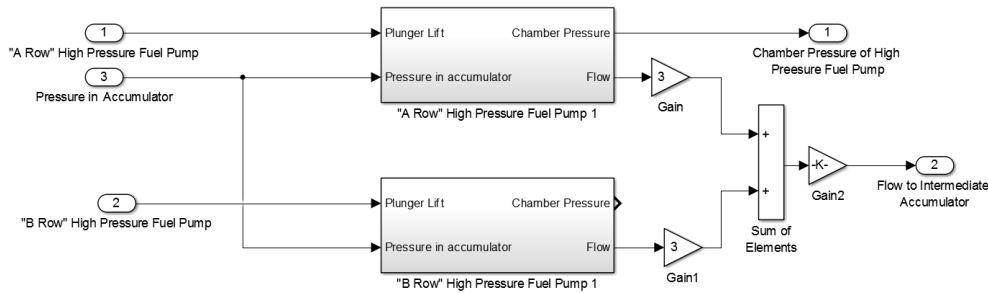


**Figure 3. The Model of ECR Air Room**

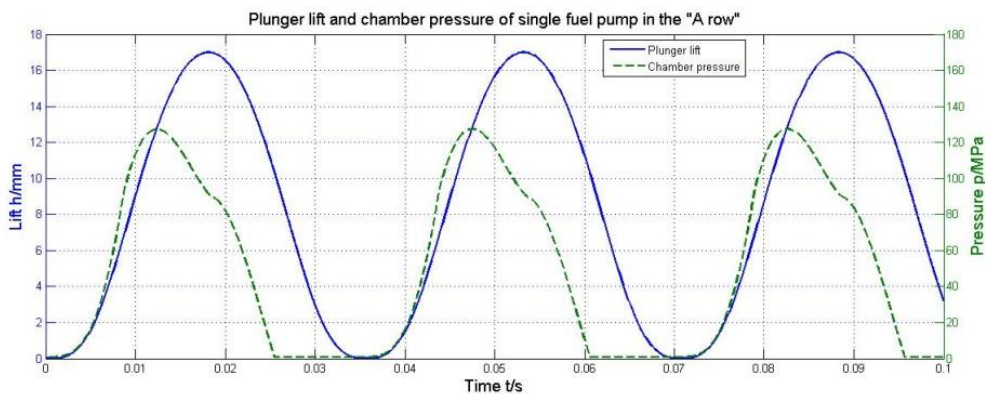
### **3.2 Establishing the Math and Logic Model of Machinery System**

The ship machinery system belongs to a kind of complex system, to make sure the data appeared in the virtual engine room real, the mathematic and logic model of about forty sub-systems in the parent ship, including sea water cooling system, fresh water cooling

system, fuel system, lubricating oil system, compressed air system and so on, are established by using simulation software “MATLAB/Simulink”, as the Figure 4 shows is the math model simulation block diagram of the high pressure oil pump of marine diesel engine in the parent ship by using “Simulink”, due to limited space, the other math model simulation block diagram of machinery system is not introduced in this paper, as the Figure 5 shows is the simulation curve of plunger lift and chamber pressure of high pressure oil pump, and then write the code of the mathematic and logic model after verifying the validity of it using C# programming language on the MONO platform, in the meantime, interface is retained to dock with the interactive entity to implement the authenticity of operation in the virtual engine room.



**Figure 4. Simulation Block Diagram of High Pressure Oil Pump**



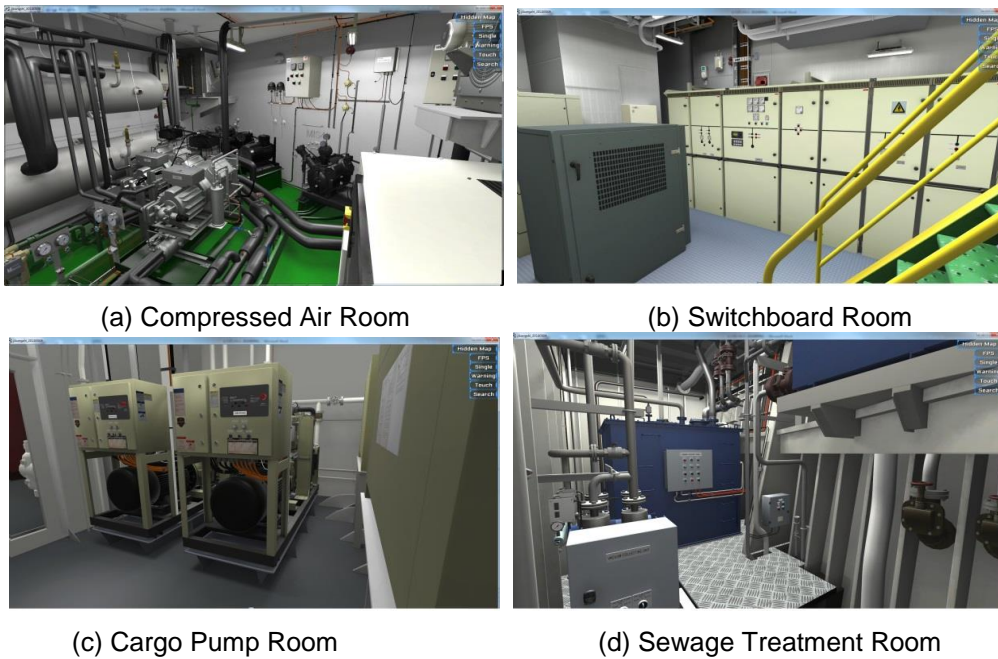
**Figure 5. Simulation Result of High Pressure Oil Pump**

### 3.3 Development of Virtual Marine Engine Room in Unity3D

In this paper, Unity3D developed by Unity Technologies in Denmark is selected as the 3D engine to develop the virtual engine room, Unity3D is a multi-platform comprehensive game development tool that can make the developers easily create 3D video game, architecture visualization, real-time 3D graphics and other types of interactive app [3-4]. Unity3D uses graphics development environment as the primary development method and can run on Windows and Mac OS X, furthermore, the app can be published to Windows, Mac, Wii, iPhone, Windows Phone and Android platform [5], so considering development rapidness and cross-platform capability of Unity3D, this paper adopts Unity3D as the development 3D engine in this project.

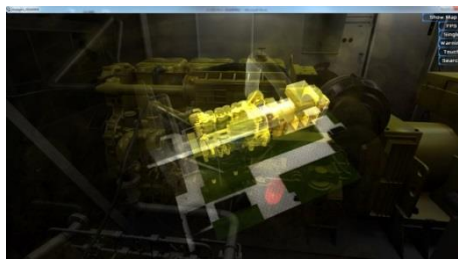
The first person controller component provided by Unity3D is used to implement the roaming function in virtual engine room, and on this basis [6], several modifications are applied to the first person controller to make the operation and interaction more convenient and rapid. As a large number of interactive entities exist in the engine room, making interactive animation and writing interactive algorithm for each interactive entity

will obviously increase the workload and decrease the running efficiency of software, to solve this problem, interactive entities are classified according to the interactive mechanism, so only to make interactive animation and write interactive algorithm for several kinds of interactive entity can implement the interactive function of all interactive entities, which will promote the development efficiency and optimize the software. To make the users feel more strong immersion, the 3D sound component integrated in Unity3D is used to add 3D sound in the virtual engine room, including the equipment running sound, alarm sound, feeder switch sound and so on, so when roaming in the virtual scene, the frequency and amplitude will change with the distance between sound source and virtual character. As the Figure 6 shows is respectively the final effect of Compressor Room, Switchboard Room, Cargo Pump Room, Sewage Treatment Room, when editing the virtual scene in Unity3D, material shader for equipment in the engine room is coded to make the virtual scene more real and delicate.

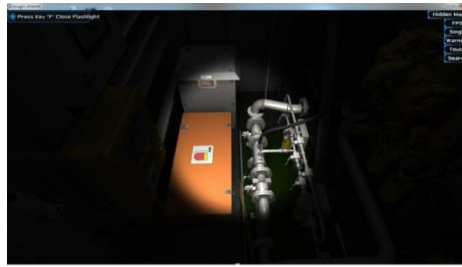


**Figure 6. Final Effect of the Virtual Engine Room**

As the Figure 7 shows is the scene map function and the red spot represents the virtual character, this function will help the user to know clearly where he is in the complex engine room; As the Figure 8 shows is the flashlight function, users can open the flashlight to observe the virtual scene when the error of ship electric system happens.

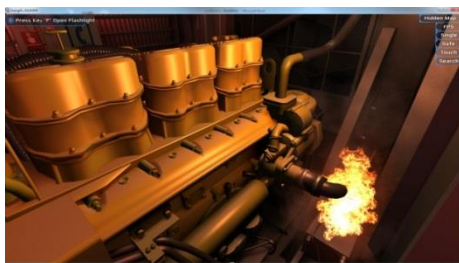


**Figure 7. The Function of Scene Map**

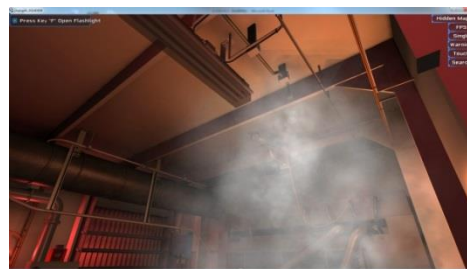


**Figure 8. The Function of Flashlight**

To train the ability of marine engineers to cope with the emergency situation in engine room, fire disaster is added in the virtual engine room, the users must follow the standard fire extinguishing regulations to start water mist system to extinguish fire, in this paper classical “Particle System” [7] is used to implement the fire, smoke and water mist special effect as the Figure 9 shows.



(a) Fire Disaster Effect



(b) Water Mist Effect

**Figure 9. Marine Engine Room Emergency Situation**

#### **4. User-friendly Interactive Function**

For beginners, complex marine engine room and machinery system will make them confused, and lack of experience will make them have no idea of the name and usage of some equipment and principle of some machinery system, even for experienced trainee, it is difficult for them to know the usage of some interactive entity and equipment appeared in the virtual engine room in short time, this will decrease the training efficiency undoubtedly, so to solve this problem, several user-friendly interactive functions are added in the software to increase the training efficiency.

##### **1) Information Display of Interactive Entity**

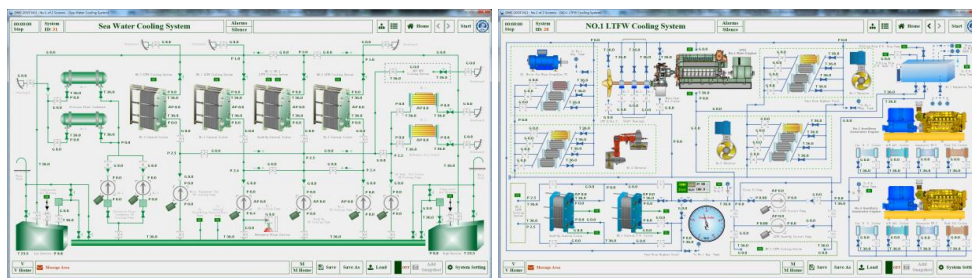
When developing the software, name information and dynamic state information is added for each interactive entity, if the interactive entity is picked up by the mouse, a tooltip will pop up to show the name and status of interactive entity, as the Figure 10 shows, if the picked-up interactive entity is the inlet valve of NO.1 main air bottle, the tooltip shows the name of the interactive entity “Inlet Valve of NO.1 Main Air Bottle” and its status “True”, “True” is the meaning of “The valve is open”, if the picked-up interactive entity is the frequency meter of emergency generator, the tooltip shows the name of the interactive entity “Frequency of Emergency Generator”, the pressure value and its unit “53.3Hz”, this function will help the trainee easily know the usage of the interactive entity and its status in the virtual engine room.



**Figure 10. Information Display of Interactive Entity**

## 2) 2D Visualization System Interface

Although the virtual engine room can provide the trainee intuitive feeling of real-ship, trainee can't complete the operating of marine machinery system successfully only depending on the virtual engine room, to solve this problem, in this paper 2D visualization system interface is integrated in the virtual engine room, the 2D interface displays dynamically the marine machinery system in the form of system principle diagram, the valve, gauge, *etc.* corresponds with the interactive entity in the visual scene and the status keeps synchronization, so the trainee can complete systematic operations in the virtual engine room referring to the dynamic change in the 2D interface, as the Figure 11 shows is respectively the 2D interface of sea water cooling system and low temperature fresh water cooling system.



(a) Sea Water Cooling System

(b) LTFW Cooling System

**Figure 11. 2D Visualization System Interface**

To keep the state of interactive entities synchronous between 2D visualization system interface and 3D virtual engine room, UDP communication protocol is adopted to implement the data transmission between 2D side and 3D side, and the format of communication protocol is shown below:

The first byte is the beginning character, which is defined as 0xFD; the last byte is the final character, which is defined as 0xFF; the second byte represents the length of communication string, which is totally 11 from beginning character to final character; the third byte is the identification of data type, the bool variable is regulated as 0x00, int variable is regulated as 0x01, float variable is regulated as 0x02, string variable is regulated as 0x03; as the naming rule of variable representing the interactive entity is "data type + global identification + actual physical name" in the system data class of the whole system (*e.g.* the variable "B01235\_LowSeaChestInletValve" represents the inlet valve of low sea chest, its global identification is 01235 and the type is bool), so the fourth and fifth type represents the global identification in system data class; the sixth, seventh, eighth and ninth byte is the communication data; the tenth type is checkout, and XOR checkout is adopted in this paper.

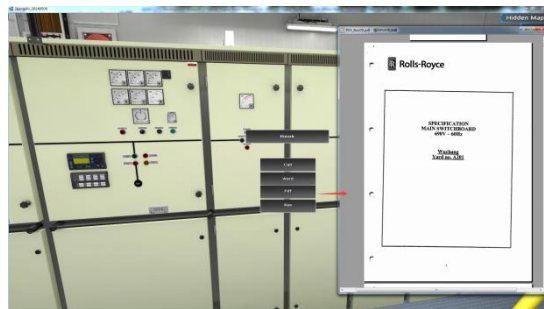
## 3) Equipment Document Management

When training the trainee, it's necessary for them to get knowledge of the documentation of the equipment and system and the operation instructions, it's very

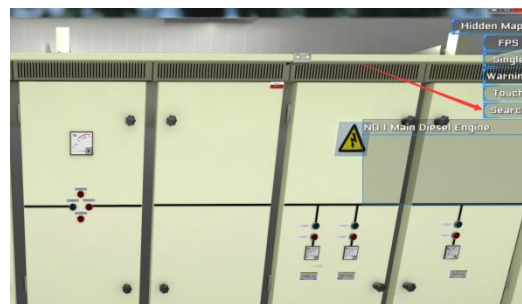
helpful for the marine engineers to foster standard operation habit and enrich professional knowledge, so as the Figure 12 shows is document browsing function added in the virtual scene, four types of file document format, including .PDF, .DWG, .DOC, .WPS, can be browsed in this system.

#### 4) Search and Locate for Interactive Entity and Equipment

When training the trainee in the virtual engine room, trainees usually need to switch between equipment and interactive entity for accomplishing one training task, to save the training time, the switch function should be fast and convenient, so in this paper searching and locating function for interactive entity and equipment is developed besides moving to equipment and interactive entity by roaming, as the Figure 13 shows the trainee can switch to the equipment easily by opening the searching tooltip, input the name information and click the switch button.



**Figure 12. Equipment Document Management**

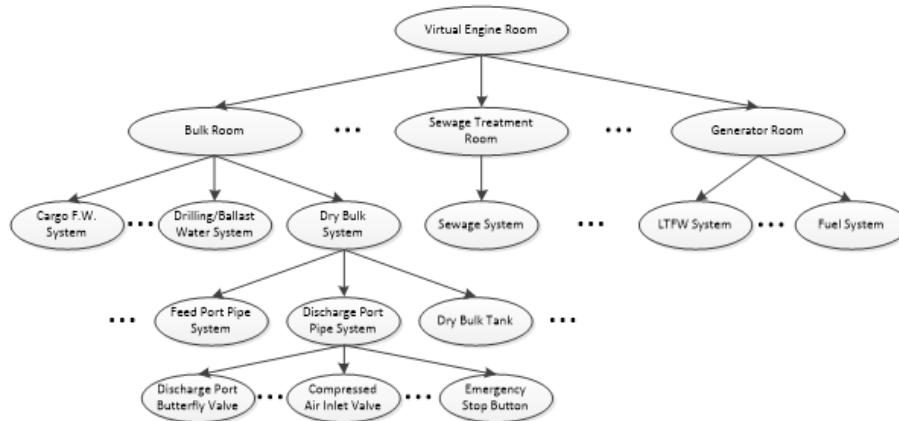


**Figure 13. Search and Locate for Interactive Entity and Equipment**

To implement the function of equipment document management and search and locate for interactive entity and equipment, in this paper, a tree hierarchical structure of room-marine engineering system-interactive entity/equipment of marine engine room is established as the Figure 14 shows. First the whole marine engine room is divided into several rooms according to space structure, such as the bulk pump room, sewage treatment room, generator room and so on; Each independence room can be divided into several parts according to marine engineering system, such as the bulk pump contains dry bulk system, cargo fresh water system, drilling/ballast system and so on; Every system also contains several equipment and pipe system, for example, the dry bulk system contains the dry bulk tank, feed port pipe, discharge port pipe and so on, and each pipe system and equipment contains several valves, instrument, switch and other interactive entity, and when constructing the tree hierarchical structure of marine engine room, the room information, type of marine engineering system, and the space coordinates of equipment and interactive entity is stored in the form of database, so when searching and locating for interactive entity and equipment by the trainee, the database is linked dynamically to determine the position of interactive entity and equipment, at the meantime, when constructing the tree hierarchical structure, the equipment document is



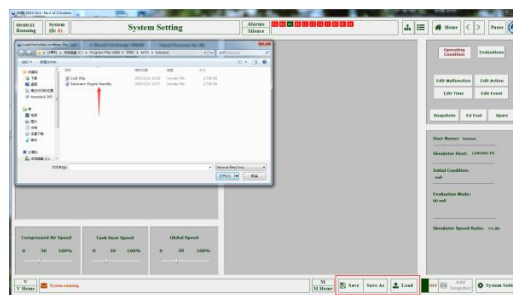
classified and bound with the name of equipment, which is used for the function of equipment document management.



**Figure 14. Tree Hierarchical Structure of Marine Engineering Room**

5) State saving, loading and parameter, fault setting

The whole training process is unable to finish in short time, if every training task always starts from the cold-ship state, it will lead to a lot of insignificant operations which will waste training time, in the meantime, for some experienced trainees, some operation steps can be omitted and only specific training task is needed, so the state saving and loading function is added in the software, the trainee can save the operation state according to different running stage and load the state file to continue a certain training task, in the meantime, the coach can also make some state file and distribute it to the trainee for the a certain training task, as the Figure 15 shows is the state saving and loading interface, the trainee can load the state “Generator Engine Standby” with the ID 3, once the state is loaded, the virtual engine room will satisfy the condition to start the generator engine, as the Figure 16 shows, the indicator light “Ready To Start” turns on, so the trainee can start the generator engine immediately to continue the coming training task. In the software, a function of quick modifying certain state parameter is added, as the Figure 17 shows, trainee can set the pressure of main compressed air bottle at 3MPa, which can shorten the time of inflating for the main compressed air bottle and quicken the training speed, in the meantime, a function of fault setting is added in the virtual engine room, as the Figure 18 shows, faults such as block of valve, leakage of cooler, *etc.* can be set for fostering the ability of fault analysis and checking for the trainee.



**Figure 15. State Saving and Loading**



Figure 16. Engine Ready To Start

PAGE 3700 : Start Air System						UP	DW	HOME	EXIT
A	P23212:	2	Mpa	Pressure NO.1 Starting Air Reservoir	0	3			
B	P23213:	0.01	Mpa	Pressure NO.2 Starting Air Reservoir	0	3			
C	Z23251:	0	%	Water Content NO.1 Starting Air Reservoir	0	100			
D	Z23252:	0	%	Water Content NO.2 Starting Air Reservoir	0	100			
E	Z23253:	1.25	%	Water Content NO.1 Starting Air Compressor Outout	0	100			
F	Z23254:	1.25	%	Water Content NO.2 Starting Air Compressor Outout	0	100			
G	Z23255:	1.21	%	Water Content NO.1 M/E Start Air Pipe	0	100			
H	Z23260:	1.21	%	Water Content NO.2 M/E Start Air Pipe	0	100			
I	Z23256:	1.21	%	Water Content NO.1 D/G Start Air Pipe	0	100			
J	Z23257:	1.21	%	Water Content NO.2 D/G Start Air Pipe	0	100			
K	Z23258:	1.21	%	Water Content NO.1 D/G Start Air Pipe	0	100			
L	Z23259:	1.21	%	Water Content NO.4 D/G Start Air Pipe	0	100			

Figure 17. Quick Parameter Modify

PAGE 3700 : Start Air System						UP	DW	HOME	EXIT
A	M23321:	OFF	0.6	NO.1 Starting Air Compressor First Cooler Block	0.6				
B	M23322:	OFF	0.6	NO.1 Starting Air Compressor Second Cooler Block	0.6				
C	M23323:	OFF	0.6	NO.1 Starting Air Compressor First Inlet Valve leakage	0.6				
D	M23324:	OFF	0.6	NO.1 Starting Air Compressor First Exhaust Valve leakage	0.6				
E	M23325:	OFF	0.6	NO.1 Starting Air Compressor Second Inlet Valve leakage	0.6				
F	M23326:	OFF	0.6	NO.1 Starting Air Compressor Second Exhaust Valve leakage	0.6				
G	M23327:	OFF	0.6	NO.1 Starting Air Compressor Third Inlet Valve leakage	0.6				
H	M23328:	OFF	0.6	NO.1 Starting Air Compressor Third Exhaust Valve leakage	0.6				
I	M23329:	OFF	0.6	NO.1 Starting Air Compressor First Piston Ring leakage	0.6				
J	M23330:	OFF	0.6	NO.1 Starting Air Compressor Second Piston Ring leakage	0.6				
K	M23331:	OFF	0.6	NO.1 Starting Air Compressor Third Piston Ring leakage	0.6				
L	M23332:	OFF	0.6	NO.1 Starting Air Compressor MotorFault	0.6				
M	M23333:	OFF	0.6	NO.2 Starting Air Compressor First Cooler Block	0.6				
N	M23334:	OFF	0.6	NO.2 Starting Air Compressor Second Cooler Block	0.6				
O	M23335:	OFF	0.6	NO.2 Starting Air Compressor First Inlet Valve leakage	0.6				
P	M23336:	OFF	0.6	NO.2 Starting Air Compressor First Exhaust Valve leakage	0.6				
Q	M23337:	OFF	0.6	NO.2 Starting Air Compressor Second Inlet Valve leakage	0.6				
R	M23338:	OFF	0.6	NO.2 Starting Air Compressor Second Exhaust Valve leakage	0.6				
S	M23339:	OFF	0.6	NO.2 Starting Air Compressor Third Inlet Valve leakage	0.6				
T	M23340:	OFF	0.6	NO.2 Starting Air Compressor Third Exhaust Valve leakage	0.6				

Figure 18. Fault Setting

## 5. Evaluating Function

One of the vital functions of the virtual engine room is evaluating the professional skills of the trainee in virtue of the training platform, as the Figure 19 shows, several built-in evaluating items are set in the software according to the seafarers competency standard stipulated by STCW[8], in the meantime, to satisfy various evaluating demands, the evaluating items can be modified and expanded, in this paper the modified and expanded function is implemented by using XML configuration files, Figure 20 shows the structure of XML file, each evaluating item is composed of several sub-item, the coach can add or subtract sub-item, modify the types of membership function and weight according to the working experience to make the evaluating process more real and the results more convincing.

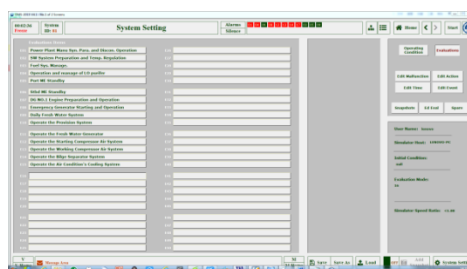


Figure 19. Evaluating Item

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<EvaluationItem Name="Emergency Generator Starting and Operation" Weight="100" ID="8">
  <EvaluationNote Name="Evaluation operation duration" Weight="150" ID="1">
    <SlaveRelation param2="15" param1="10" ParameterID="time" SlaveType="SlaveRelationoldType"/>
  </EvaluationNote>
  <EvaluationNote Name="EG fuel oil inlet valve" Weight="100" ID="2">
    <SlaveRelation param1="T" ParameterID="06018" SlaveType="SlaveRelationBoolType"/>
  </EvaluationNote>
  <EvaluationNote Name="EG control box power switch position" Weight="100" ID="3">
    <SlaveRelation param1="T" ParameterID="06026" SlaveType="SlaveRelationBoolType"/>
  </EvaluationNote>
  <EvaluationNote Name="EG control position shifting switch " Weight="100" ID="4">
    <SlaveRelation param1="T" ParameterID="06003" SlaveType="SlaveRelationBoolType"/>
  </EvaluationNote>
  <EvaluationNote Name="EG LO sump tank level" Weight="150" ID="5">
    <SlaveRelation param2="0.7" param1="0.4" ParameterID="06043" SlaveType="SlaveRelationRegulateType"/>
  </EvaluationNote>
  <EvaluationNote Name="EG running at rating speed" Weight="150" ID="6">
    <SlaveRelation param2="1800" param1="1750" ParameterID="06051" SlaveType="SlaveRelationRegulateType"/>
  </EvaluationNote>
  <EvaluationNote Name="EG fresh water expansion tank temperature" Weight="100" ID="7">
    <SlaveRelation param2="65" param1="50" ParameterID="06063" SlaveType="SlaveRelationRegulateType"/>
  </EvaluationNote>
  <EvaluationNote Name="EG fresh water expansion tank level" Weight="150" ID="8">
    <SlaveRelation param2="0.7" param1="0.4" ParameterID="06060" SlaveType="SlaveRelationRegulateType"/>
  </EvaluationNote>
</EvaluationItem>

```

**Figure 20. XML Structure of Evaluating Item**

In this paper, the sub-items of each evaluating item are divided into two types, one is “Operation Type”, the other is “State Parameter Type”[9-10], the “Operation Type” represents the operations of interactive entity such as valve, switch, *etc.*, and the operation result is “True” or “False”; “State Parameter Type” belongs to numeric indicators representing the marine machinery running state, such as pressure, flow, frequency, *etc.*, but both the “Operation Type” and “State Parameter Type” are described and stored in the form of variables in this paper, the type of variables for describing “Operation Type” is Bool in general and the type of variables for describing “State Parameter Type” is Int or Float in general, so the evaluation process is actually tracking the variables real-time by the evaluation system. In this paper, fuzzy comprehensive evaluation based on fuzzy set theory is adopted to implement the evaluation function, the operation result for “Operation Type” is true or false, so single-point membership function can be adopted to implement its evaluation function, the single-point membership function is as shown in formula1, the membership grade is 1 or 0; For “State Parameter Type”, a membership function “ $\mu_A(x)$ ” can be defined as the formula2 shows, if the evaluation element  $x$  doesn’t belong to  $A$  totally, its membership grade is 0; if the evaluation element  $x$  belongs to  $A$  totally, its membership grade is 1; if the evaluation element  $x$  belongs to  $A$  partly, its membership grade is a continuous value in the closed interval  $[0,1]$ , considering the characteristic of each state parameter and the suggestions of experts in this domain, four kinds of membership function are defined for the “State Parameter Type” variables, first three types are respectively “Peak Type”, “Ascending Type” and “Falling Type” as the Figure 1 shows, the “Peak Type” is appropriate for the state parameter that has the optimal value in a certain section; the “Ascending Type” is appropriate for the state parameter which is bigger and better in a certain section; the “Falling Type” is appropriate for the parameter which is smaller and better in a certain section; the membership function of the fourth type is as the Figure 21 shows, which is used to evaluate the time element.

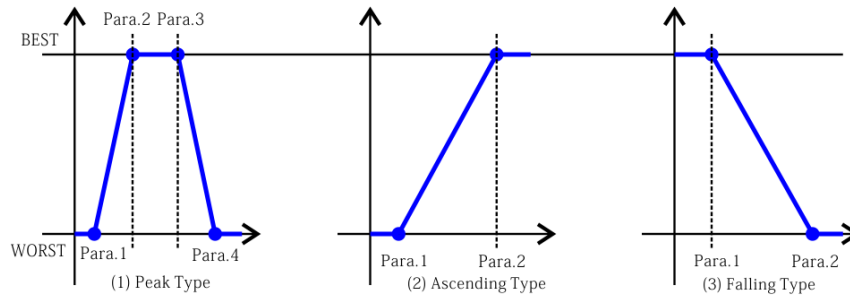
A fuzzy set “ $A$ ” is defined in the domain of discourse “ $U$ ”, membership function  $\mu_A(x)$  represents the membership grade of evaluation  $x$  relative to fuzzy set “ $A$ ”.

Single-point membership function is adopted for “Operation Type”:

$$\mu_A(x) = \begin{cases} 0 & x = x_i \\ 1 & \text{others} \end{cases} \quad (1)$$

Fuzzy membership function is adopted for “State Parameter Type”:

$$\mu_A(x) = \begin{cases} 0 & x \text{ doesn't belongs to } A \text{ totally} \\ (0,1) & x \text{ belongs to } A \text{ partly} \\ 1 & x \text{ belongs to } A \text{ totally} \end{cases} \quad (2)$$



**Figure 21. Membership Function**

The membership function for evaluate time element is as shown in Formula 3:

$$\mu(t) = \begin{cases} 0 & t \leq t_1 \\ \frac{1}{2} - \frac{1}{2} \sin \left[ \frac{\pi}{t_2 - t_1} \left( t - \frac{t_2 + t_1}{2} \right) \right] & t_1 \leq t \leq t_2 \\ 1 & t \geq t_2 \end{cases} \quad (3)$$

In this formula :  $\mu(t)$  represents the time membership function ;  $t$  represents the time consumed by the trainee ;  $t_1$  represents the standard evaluation time ;  $t_2$  represents the regulated maximum evaluation time.

### 5.1 Evaluating Example Analysis

In this paper, evaluating item “Emergency Generator Staring and Operating” is selected to test the feasibility of evaluating function, as the Figure1 shows, select the evaluating item and click “Start” button to start evaluating and click the “Finish” button to submit after finishing evaluating.

#### 5.1.1 Initialization of Evaluating

After selecting the evaluating item, the system will load the initial state of evaluating item, so the trainee can start evaluating immediately without operating from the cold-ship state, take the evaluating item “Emergency Generator Staring an Operating” for example, once this evaluating item is selected, the system will supply power for 24V charge and discharge panel to emergency generator local control box automatically and set the liquid level of emergency generator fuel tank at regular liquid level.

#### 5.1.2 Evaluating Example

The scene of evaluating item “Emergency Generator Starting and Operating” is as shown in Figure 22 and Figure 23, the Figure1 is the virtual emergency generator and the Figure2 is the local control box of emergency generator.



**Figure 22. Emergency Generator**



Figure 23. Local Control Box

As described in the XML evaluating file in the Figure1, the trainee should complete such operations:

- 1) Open the inlet valve of emergency generator, the weight of this sub-item is 0.1.
- 2) Switch the power switch of local control box from “Off” to “On”, the weight of this sub-item is 0.1.
- 3) Switch the control position of emergency generator form “Remote” to “Local”, the weight of this sub-item is 0.1.
- 4) Ensure that the liquid level of lubrication oil sump tank is between 40% to 70% of full liquid level, the weight of this sub-item is 0.15.
- 5) Stable the speed of emergency generator between 1750r/min to 1800r/min, the weight of this sub-item is 0.15.
- 6) Ensure that the temperature of emergency generator fresh water expansion tank is between 50°C to 60 °C, the weight of this sub-item is 0.1.
- 7) Ensure the liquid level of emergency generator fresh water expansion tank is between 40% to 70% of full liquid level, the weight of this sub-item is 0.15.

In the meantime, the normal evaluating time is regulated between 10min to 15min, the weight of this sub-item is 0.15, if the trainee complete evaluating less than 10min, 15 will be got for trainee or 0 will be got; if the complete time is between 10min to 15min, certain score will be deducted. If the trainee can complete the evaluating less than 10min, follow the operation and each parameter stables with normal limits, the trainee will got full score.

As the Figure 24 shows is the evaluating report, as the liquid level of lubricating oil sump tank is too high, the speed of emergency generator doesn't stable between 1750r/min to 1800r/min and the temperature of fresh water expansion tank is too low, 66.3 is got for the trainee. The evaluating report shows the operation result for each sub-item which can make the evaluating result convinced.



Item Name	Current Value	Target Value
Evaluation operation duration	0.3395167	10
E0 fuel oil inlet valve	True	True
E0 control box power switch position	True	True
E0 control position shifting switch	True	True
E0 llo sump tank level	0.7346039	0.7
E0 running at rating speed	1098.117	1800
E0 fresh water expansion tank temperature	36.12067	65
E0 fresh water expansion tank level	0.925813	0.7

Figure 24. Evaluating Report

## 6. Conclusion

This paper proposed a marine engine room simulator for offshore supply vessel based on virtual reality technology, specific work is as follows: To guide the development direction of the whole system, development concept and main points are given; The geometric model of marine engine room is established by using 3D-Max, and according to the feature of marine engine room, the equipment model library is established which can shorten the development period and make the virtual scene more standard; The virtual marine engine room is developed by using Unity3D and several interactive function are added in the software, such as scene map, flashlight, emergency situation and other user-friendly functions, the graphics of the virtual scene is real and delicate and which gives the user higher immersion and the interactive function is practical and fast which makes the training process more convenient and improve the training efficiency; At last, a evaluating function based on fuzzy evaluating method is added and a evaluating example is introduced to test the feasibility of evaluating function, the result shows that the evaluating example is real and convinced. The marine engine room simulator for OSV has already successfully been applied in the COSL (China Oilfield Services Limited) Crew Training Center and has made good training effect.

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