Basic Study on Construction of Visual Evaluation System for Safety Ship Navigation

Hidenari Makino, Eiichi Kobayashi, Nobukazu Wakabayashi, Shigeaki Shiotani
Faculty of Maritime Sciences, Kobe University
5-1-1 Fukae-minamimachi, Higashinada-ku,
Kobe, Hyogo 658-0022, Japan

***Abstract*- It is important to use various data accurately and effectively in order to ensure the safety of navigation of ships. If such data are integrated and visualized, a reality-based virtual environment can be constructed, which can be used by ship maneuvering simulators. Since such environments are constructed mainly for the purpose of training exercises in ship maneuvering, they are not suitable for the analysis of actual maneuvering. Therefore, in this study, we aim at the development of a simple simulator capable of displaying three-dimensional (3D) graphics for the purpose of providing analysts with a visual evaluation system for safe navigation of ships. In other words, it presents various phenomena that cannot be intuitively understood through animations. The use of 3D data facilitates the recognition of various phenomena due to their realistic visual representation in three dimensions. Furthermore, it can be expected that new aspects and consideration points for analysis can be obtained due to the ability to change the viewpoint freely.**

Keywords : Java, Simulator, 3D animation, safety navigation

I. INTRODUCTION

In order to ensure the safety ship navigation, it is important to use correctly and effectively a variety of data, such as hydrographic readings, weather information, geographical features, the depth of the water, and the features of the ship. If these data are unified and visualized, a realistic virtual environment can be built. In the ship operation field, the ship navigation simulator with a large-scale display is typical as the one technique. However, this technique is employed mainly for the purpose of navigation training, and it is not suitable for use by marine engineers for the analysis of various phenomena. Therefore, in this research, we aim at the development of a simulator capable of displaying simple three-dimensional (3D) graphics which can be used by analysts as a visual assessment system for safety ship navigation. In the first stage, we built a system that allows visualization of ship movement. This system utilizes animation for visualizing various phenomena whose intuitive understanding is difficult. In current methods, data about the hull and the waves as obtained through simulation are displayed in two dimensions. Therefore, such display methods are limited, and it is difficult to present multiple phenomena simultaneously. However, it is possible to achieve higher realism of visualization by displaying data in three dimensions, which allows for various complex phenomena to be understood visually. Moreover, while two-dimensional animation presents data from the same viewpoint from which the analyst performs the observation, by constructing an animation in three dimensions where the viewpoint can be changed freely, it can be expected that new aspects and consideration points for analysis can be discovered.

II. OUTLINE OF PROPOSED SYSTEM

2.1 Outline

An outline of the proposed system is shown in Fig. 1. First, various data, such as the marine phenomenon, the weather, geographical features, sea depth, and ship properties, are acquired and inputted into the system. Then, the inputted data are modeled in three dimensions by using the appropriate expressions. Finally, the model created, respectively is arranged on the same space, and it outputs as 3D-animation by giving a time series.

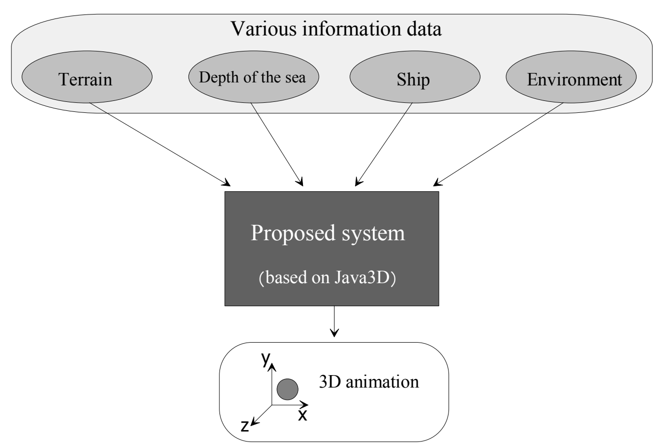

Figure 1. Schematic representation of proposed method

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2.2 Creation of System Using Java3D

The proposed system was built using Java3D [1], which is part of the Java programming language [2]. Java3D is an API (Application Program Interface) for manipulating 3D graphics within Java applications, and has the following features.

- It is freeware.
- Since Java is a multi-platform language, it is not restricted to a particular environment.
- Language acquisition is comparatively fast.
- The viewpoint can be manipulated freely.
- Visualizations can be published on the Web.

The greatest feature of Java3D is that it allows for design based on "scene graphs", an example of which is shown in Fig. 2. The mechanism employed in scene graphs is based on the construction of a single tree structure for all the information necessary for the description of objects in three dimensions, the sources of light, etc. The concept of scene graphs is congenial to the concept of object-oriented programming in the Java language. Therefore, since graphics can also be automatically re-described if scene graphs are changed dynamically, this design provides great flexibility and extendibility to the user interface.

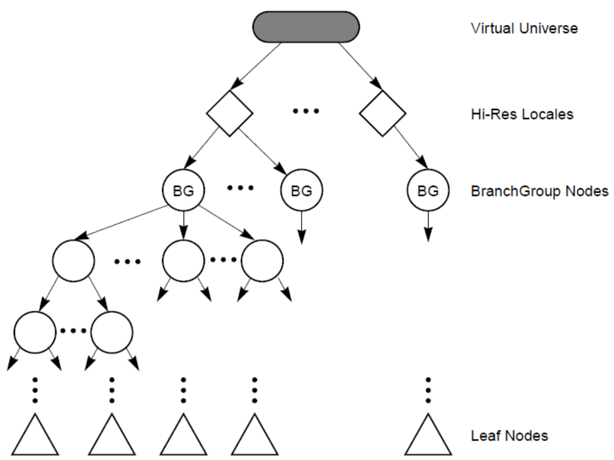


Figure 2. General concept of scene graph on Java3D

2.3 Features of the proposed system

The advantages of the proposed system constructed by using Java3D include the following.

- Since virtual reality can be visualized, it can be used for various simulations.
- Since results which could not be expressed in two dimensions until now can be expressed in three dimensions, it becomes possible to perform extensive analysis and problem solving.
- Regarding the results of the analysis of various data presented by an analyst, it becomes possible to discover new aspects and consideration points based on the viewpoint of the particular user.

III. Visualization of Ship Movement

3.1 Ship Movement in Regular Waves

A ship response model and the frequency response for ships in regular waves were calculated by using RIOS (The Research Initiative on Oceangoing Ships) [3] developed at Osaka University in relation to the creation of 3D animation of ship movement. In this regard, the container ship shown in Table 1 was employed as a model of ship data for the base for building a ship response model. The shape of the hull created on the basis of this data is shown in Fig. 3. Fig. 4 shows the operation screen where the calculation results for the frequency response of the output are presented.

Table 1. Creating data of model ship

1 SHIP-INFORMATION		
KIND	SAMPLE	
TYPE	Container	
NAME	test-Cship	
CONDITIO	FULL	
CAL-CASE	test2	
DIVIDE	40	
1 END		
2 PRINCIPAL-DIMENSIONS		
LOA(m)	245	LENGTH-OVERALL
LWL(m)	235	LENGTH-LOADWATERLINE
LPP(m)	230	LENGTH-PERPENDICULAR
B(m)	32.2	BREADTH
D(m)	19	DEPTH
df(m)	10.8	DRAFT-FORE
dm(m)	10.8	DRAFT-MIDSHIP
da(m)	10.8	DRAFT-AFT
KG(m)	10.5	CENTER-OF-GRAVITY

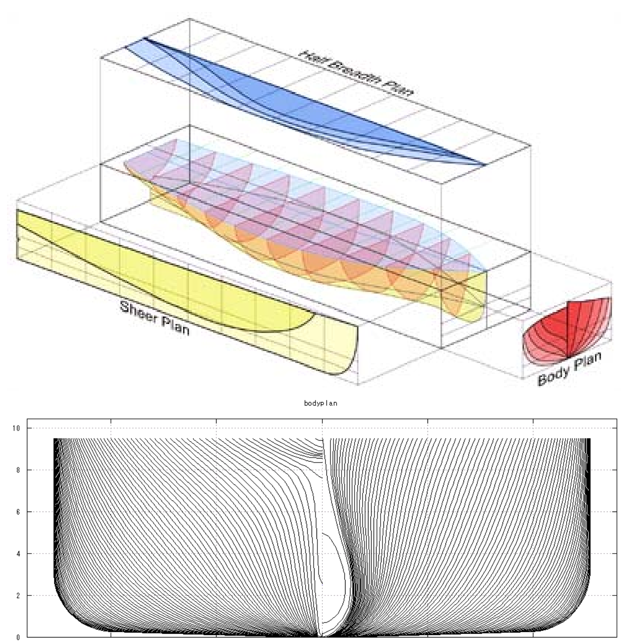


Figure 3. Hull of model ship

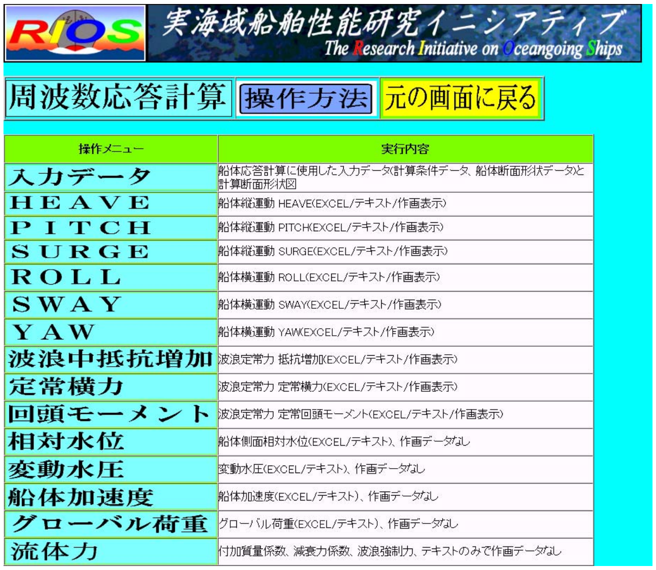


Figure 4. Operation screen of RIOS

The results of the frequency response calculations about six directions (Heave, Pitch, Surge, Roll, Sway, Yaw) required for ship movement analysis are shown in Fig. 5. This figure shows each response calculation result in case the Froude number of a wave is 0.3 and an opposing waves. Regarding Heave and Pitch, when the ratio (λ/L) of the wavelength and the length of the ship is 1.1, it is found that the dimensionless amplitude value reaches a maximum, after which it approaches 1 asymptotically. Also, in the case of Surge, it is found that the ratio (λ/L) of the wavelength and the length of the ship tends to gradually increase the dimensionless amplitude value from the vicinity of 1.1. Regarding Roll, Sway, and Yaw, the dimensionless amplitude value is still 0 due to opposing waves. 3D graphics were created by using this system with the results in Fig. 5.

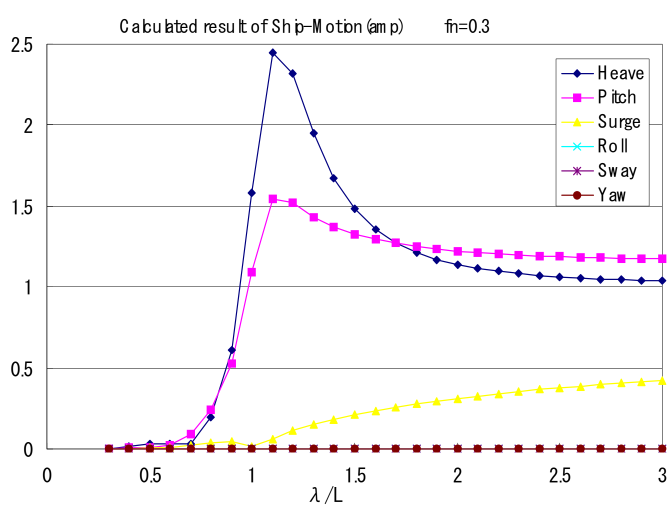


Figure 5. Calculated result of ship motion (amp)

Fig. 6 and 7 show the creation process for the 3D model of a ship. The 3D hull model as designed on the basis of Table 1 is shown in Fig. 6. The model of the designed hull, which was displayed by using Java3D, is shown in Fig. 7. The images on the left in Fig. 7 represent the hull as viewed from the side, and the images on the right represent the hull as viewed from above at an angle of 45 degrees. As mentioned in Section 2, in Java3D, the created object can be freely moved by manipulating all coordinates, including angle, expansion, reduction, etc., by using a human interface device such as a PC keyboard or a mouse. Therefore, detailed visual inspections of the created objects can be performed.

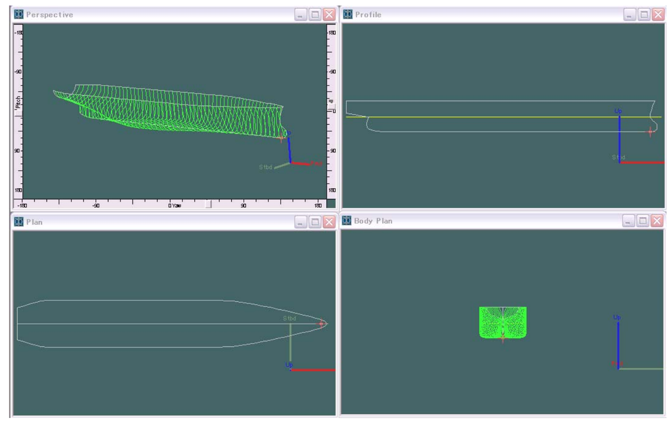


Figure 6. Design of model ship

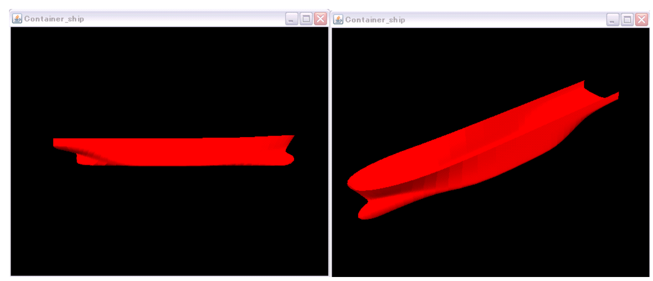
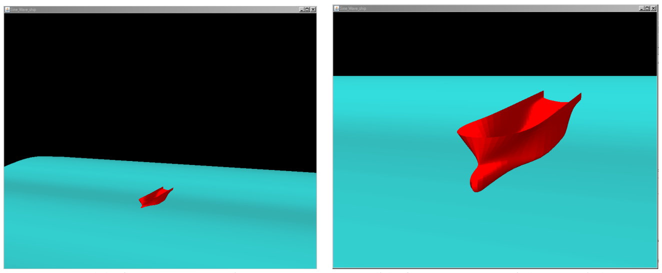


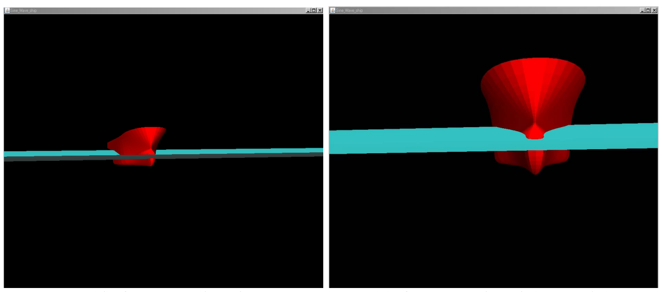
Figure 7. Display on Java3D

Next, on the basis of the hull response results shown in Fig. 5 for the created model ship, Fig. 8 presents an example of hull movement in the presence of a regular wave when the ratio (λ/L) of the wavelength and the length of the model ship is 1.5. In the actual display screen, the hull and the regular wave are expressed as a 3D animation, and it is found that the upper and lower sides of the hull appear to oscillate in an approximately vertical direction. Fig. 8(a) presents a view of the hull from an angle of 45 degrees and indicates that the hull moves in the presence of a regular wave. Fig. 8(b) shows a zoomed-in version of the same figure from the same viewpoint, and Fig. 8(c) sets the viewpoint further away from the side of the hull. Furthermore, Fig. 8(d) presents a viewpoint from which the front of the hull can be seen from the sea surface, and Fig. 8(e) presents a zoomed-in image from the same viewpoint as in Fig.

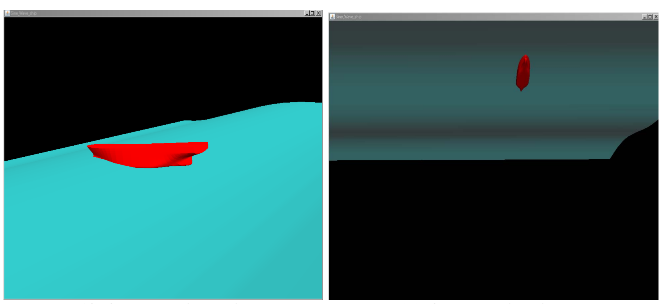
8 (d). Finally, Fig. 8(f) presents a viewpoint from which the bottom of the hull is visible from below the sea surface. All the images from various viewpoints in Fig. 8 are obtained once as screenshots, and the viewpoints can be changed in real time.



(a) from Forward (b) from Forward (zoom in)



(d) from Sea level (e) from Sea level (zoom in)



(f) from Backward (g) from Under the sea

Figure 8. Various view points

3.2 *Mooring Simulation*

In consideration of hull movement, in the case of a billow or when other dynamically acquired data are included, 3D animation was created with regard to a mooring simulation in a fishing port at the time of a tsunami. In particular, when there are a large number of moored or anchored ships in close proximity to each other, such as in a fishing port, various phenomena can be observed, such as repeating contact, mutual leading and movement under the influence of the flow of the tsunami, water level fluctuation, and so forth. Therefore, it is appropriate to examine whether 3D animation can be used as a new analysis tool. In this regard, a simulation was performed by assuming conditions approximating the emergence of tsunami, where hulls of the target vessels had a length of 14.8 m and a width of 4.49 m, and two ships were connected with ropes at the front, center, and back of their hulls. One rope of each ship was connected to the mooring mast on a quay. Regarding the anchor, it was assumed that both ships were anchored in the direction of a fishing port center with the anchor of one of the ships. The movement simulation of the mooring fishing ships in consideration of the disturbance caused by the tsunami was carried out under the above conditions. An example of a 3D animation is shown in Fig. 9. As mentioned above, the features of Java3D include the ability to change the viewpoint and to have two or more viewpoints displayed simultaneously. Taking advantage of these features, two or more viewpoints are set up simultaneously in multiple windows. Fig. 9 shows the circumference of the deflection of the ships at the arrival of a tsunami. It can be seen in the top figure that the wave exerts almost no influence and the rolling of the ship is minimal. The second figure shows a notable displacement of the ships to the left under the influence of the undertow produced by the tsunami. Moreover, the wave quantity also increases and the mooring cable is pulled tight, and the anchor is also moving. The bottom of the second figure shows that the ships experience bow shake under the influence of the spilling wave. The bottom figure shows the position which the ships have been displaced by the undertow. In Fig.10, the viewpoint is set under the sea surface, and the stretching of the mooring cable is observed.

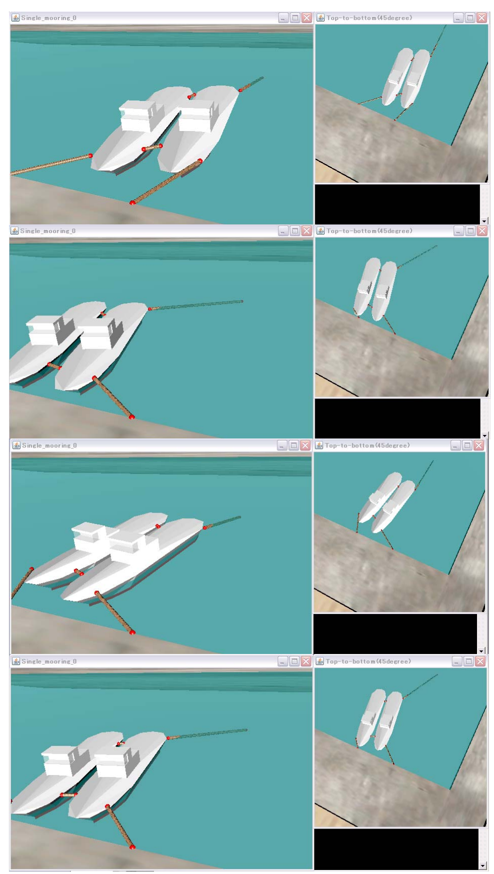


Figure 9. Movement of ship

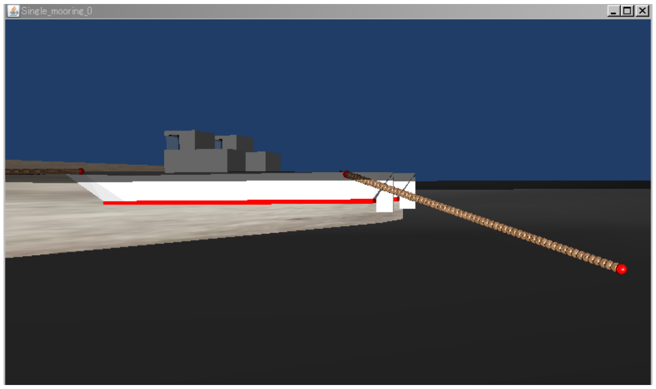


Figure 10. The viewpoint is set under the sea surface

IV. CONCLUSION

In this paper, we verify the usefulness of 3D animation with respect to ship movement as an early stage of a development aiming at the construction of a visualization system for safe ship navigation. As a result, by using 3D animation capabilities of this system with regard to ship movement, and by performing analysis of the environment variables, we also showed that it is possible to understand the details of the movement of the hull as well as to recognize previously unnoticed phenomena. Moreover, since this system can display two or more objects simultaneously, it is possible to perform simultaneous tracking of the movements of multiple ships, mooring cables, anchors, and waves by constructing a mooring simulation. In addition, the ability to display two or more viewpoints simultaneously facilitates the verification of movement from various directions and the identification of problematic areas. In future research, we will focus on the construction of 3D animation with this system by using various data, such as hydrographic phenomena, the weather, geographical features, water depth, and ship features required for safe ship navigation. Furthermore, we will focus on the creation of simulations approximating actual situations more realistically by displaying them simultaneously in the same space, thus aiding the investigation of various phenomena

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