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A Study on the Radar Image Generation Method for Ship Handling Simulator

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Abstract : *This paper proposes a method for generating radar images used in a ship handling simulator, which includes mathematical logics based on radar equations and information from Openflight format files. In order to make radar image much similar to that of real radar in PPI type, the proposed mathematical logic derives radar video signals under the consideration of not only the data form flight format file of simulation scenes, but also geographical radar's position. The proposed method is considered useful to make radar images in ship handling simulator with accuracy and reality.*

Key words : *Ship handling simulator, Radar image generation, 2D raw map, Open flight, Terrain map, 3d database*

1. Introduction

A ship handling simulator, a kind of simulators widely used in maritime education institutes, is designed to improve navigator's ability in ship handling. It should also be designed so as to decide both safety and effectiveness in establishing port facilities such as ship channels, harbor entrance, turning basins, anchorage, berth and berth basins and etc. To achieve these aims, the ship handling simulator should be made after due consideration of both accuracy and sense for the real.

The accuracy of the simulator with sense for the real depends on how exact mathematical models are used to describe ship's motion at sea as well as the performance of navigational equipment. Its reality could be achieved by three dimensional simulation scenes which were made by VR technology and shown to trainees during simulation. Modern high VR technology has contributed to the reality of those scenes in ship handling simulator

However, in spite of the advance of VR technology, radar image of simulator is still in low level, so that trainees have expressed their troubles in getting information from radar image during simulation exercises. Radar image of ship handling simulator bases on radar video signals resulted from calculation of radar performance in three dimensional simulation scenes around the position of radar. Since precise mathematical logic to calculate radar video signal is not so simple and also takes long time to process, most of simulators have used a simple method which considers only information about coastal lines and altitude of terrains in simulation scenes, in disregard of geographical radar's position.

Prior to developing the radar simulator, it is necessary to make 2D raw map using 3D Openflight data which is the basis information for terrain database(Jin and Song, 2003). We proposes a method for generating radar images with mathematical logics based on radar equations and information from Openflight format files. In order to make radar image much similar to that of real radar in PPI type, radar video signals would be calculated under the consideration of not only the data form flight format file of simulation scenes, but also geographical radar's position.

There are two methods to generate a radar map. One thing is using generated radar image in advance. The other is making radar map by the radar signal generator(Transas, 2004; Song, 2000).

The former is used to display the radar image by range based on the generated radar map. It is constantly shows the radar image regardless of the alteration of the ship's position. Therefore the method to display generated radar image can not elaborately display radar image corresponding to varying ship's position. The latter uses a radar signal generated board to display a radar map. The 3D database for Simulator is translated to radar signal and it is inputted to radar signal generator. The generated signal goes into the radar signal generator. But it is not efficient because

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the equipment is expensive and radar display is dependent on the board of radar signal generator(Transas. 2004).

The radar image generation on this study is generating the radar image by developing a S/W of radar signal generator. It is immediately adopted to alterate 3D terrain database and to make free of developing radar interface. Also this method can be displaying radar image more similar with real radar scope.

2. The structure of 3D database

2.1 Concept of 3D database

To analyze the structure of 3D database, we should understand a node in open flight, which is a 3D file format of 3D database. It is an industry standard real time 3D scene format developed, owned and maintained by MultiGen, Inc(Multizen, 1998).

The FLT, a form of hierarchical and logical scene description, is using in open flight. The open flight database hierarchy organizes the visual database into logical groupings and facilitates real-time functions such as field-of-view culling, level-of-detail switching, and in Each open flight database is organized in a tree structure (Multizen, 1998).

The database of tree structure is consisted of nodes, which historically called beads. Most nodes can have child nodes as well as sibling nodes. In general, nodes can be thought of in three hierarchical classes. Starting from the top of the hierarchy, these three node classes include container nodes, geometry nodes and vertex nodes.

2.2 The structure of database node

The 3D database is divided into a few groups and is combined to the database classes. Precisely, information of all models is saved dividing group nodes, each part of model is an object node, polygons of the object node are making the class of face node that is consist of vertexes and edges.

The precaution to construct the node is the object node having only the face node but comparatively group node can have any node below it.

Fig.1 is an example of 3D visual model which is made a pyramid. It has 5 faces and each face holds a vertex, is containing ID and position information and is connected faces as sequence of vertex ID.

The structure of model is formated as Fig. 2. It is a picture to draw the database structure of pyramid model. It can add some egypt group nodes beside the egypt group nodes under the head node. There is contained information of each face and vertex below the egypt group node.

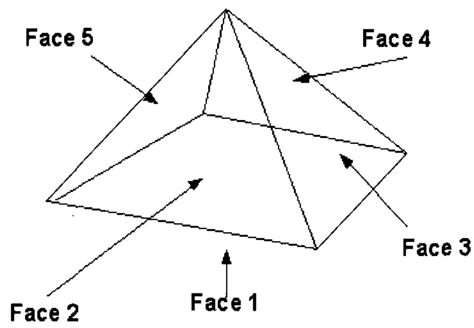

Fig. 1 The picture of 3D model

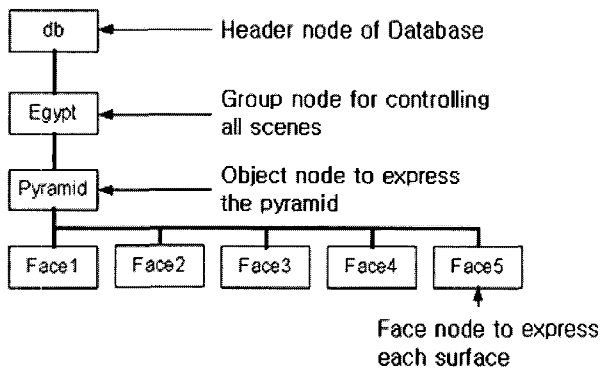

Fig. 2 The structure of the pyramid database

3. Technique of 2D raw map generation

3.1 Concept of transformation 2D raw map

This chapter shows the method to generate 2D raw map image by adding necessary data. The method is to extract open flight files using graphic tool. The 3D database will be passing 3 steps.

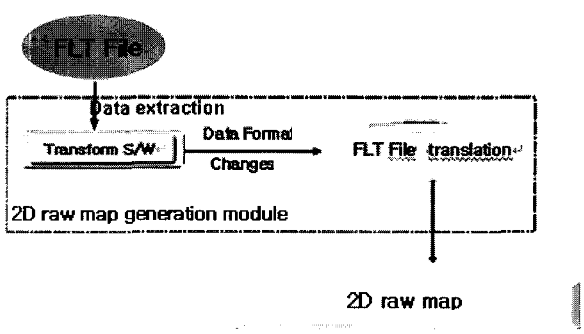

Fig. 3 Transformation processes of 2D raw map

The first step is the procedure of 3D database analysis. It reads all 3D database files and parses it by each node and then extracts the included real data.

The second step is the converting procedure. It converts to necessary data for the 2D raw map with the extracted data from open flight files.

The last step is building the BRI using the converted data on step-2. Fig. 3 is a simple diagram to generate the 2D raw map image by above three steps. The original FLT file is passing data extraction by a data extraction S/W in 2D raw map generation module. The formated file from 2D raw map generation module will be transformed to 2D raw map.

3.2 The procedures of transformation image

1) Step 1 - Analysis of open flight files

In this procedure, all nodes of the open flight database are parsed to the tree structure. Also this procedure classifies all nodes wether it is essential or not for building the 2D raw map image. Also unnecessary data of the nodes containing the information of movement and sound are deleted. Then the number of 3D polygon and the coordinates value of each point belonging to the essential nodes are extracted.

Fig. 4 The Openflight image of Busan port

Fig. 5 Processed image by the step1

Fig. 4 shows an example of 3D image of the Busan port. Fig. 5 is the image after deleting textures of the surface and splitting into small polygons only with altitude and coordinates(x, y) information.

2) Step 2 - Conversion to dots.

Due to the shape of polygon, it is not always possible to get precise data around of all area concerned. Therefore, in order to get more precise terrain data, additional information should be added to the result of step 1.

Fig. 6 explains this step. The left image in Fig. 6 shows a polygon which has only three points information and right image is the result of this step.

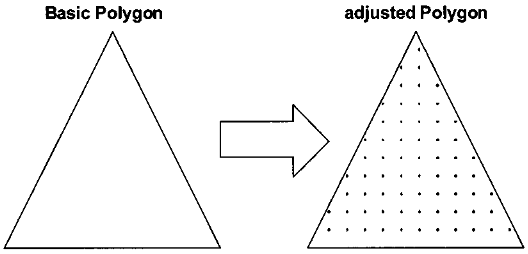

Fig. 6 Example polygon adding additional points

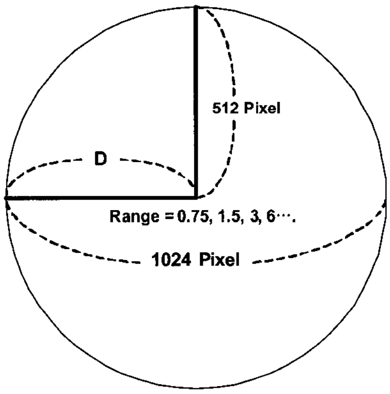

Fig. 7 Deriving the distance of radar screen

When adding some points on each polygon, the interval of each point is decided by both the resolution of radar screen and minimum detection range. If the radar screen resolution is 1024 x 1024 pixel and the minimum detection range(MDR) is 0.75 nautical mile, the display distance(D) of the screen and the interval of each point(G) will be as following.

$$D = MDR \times 1852m = 0.75 \times 1852 = 1389m \quad (1)$$
$$G = 1389m/512pixel \approx 2.5$$

3) Step 3 - Generation of the 2D raw map image

Using the converted data after step 2, this step generates the 2D raw map image with RGB value. RGB value indicates the height of each polygon's center with interval of five meters unit. Fig. 8 shows the whole procedure for making 2D raw map image.

Fig. 9 shows the open flight file of Young Do area and Fig. 10 indicates the results of the step 1 in which the texture information of image file data were removed. Fig. 11 shows the 2D raw map image obtained through whole procedures.

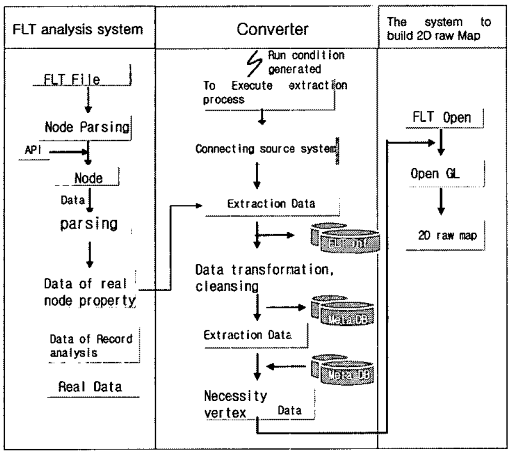

Fig. 8 The embodiment chart for building 2D raw map

Fig. 9 The origin Openflight file for step 1

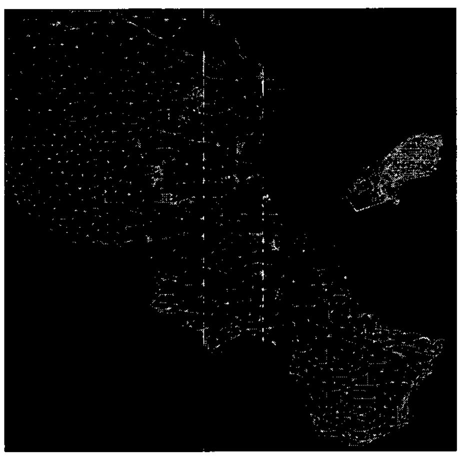

Fig. 10 The processed image of step1

4. Building basic radar image

Fig. 12 shows the outline of procedure for generating basic radar image(BRI) from 2D raw map. The BRI is made with information about the altitude and the position(Latitude, Longitude) in 2D raw map image.

The maximum detection distance is calculated by Eq. (2) for drawing a real radar image similarly.

$$R_{\max} = \left[\frac{P_t \lambda^2 G^2 \sigma}{(4\pi)^3 S_{\min}} \right]^{\frac{1}{4}} \tag{2}$$

Where, $R_{\max}$ = maximum detection range

p_t = transmitter power (watt)

G = antenna gain

σ = target radar cross-section (m^2)

$S_{\min}$ = minimum detectable signal (watt)

λ = wave length (m)

Here, the minimum detection signal can be derived by the Eq. (2)(Lee, 1997).

Also, the cross section of effective reflection is calculated by Eq. (3) for displaying the reflection intensity and the shape of 3D terrain in open flight file. The cross section of effective reflection of normal target is nearly not according with the physical area of the target. But if the target is large, the cross section of effective reflection would be large in proportion to this(Lee, 1997).

$$\sigma = 4\pi \lim_{R\to\infty} R^2 \frac{|E_r|^2}{|E_i|^2} \tag{3}$$

Where E_r = reflected field strength

E_i = beamed field strength

The BRI would be generated by above equations and Fig. 13 shows its result. In this Fig. 13, the yellow circle indicates the radar scanner position. The image is displayed by only two bits. But the image will be processed to eight bits levels in the next study by considering the signal strength of pixel's range from the center(Bole, 1990).

5. Conclusion

We proposed a method for generating basic radar image used in ship handling simulator. The proposed method used both radar equations and 2D raw map came from 3D terrain database in format of open flight type.

The 2D raw map was built under the processes described as belows;

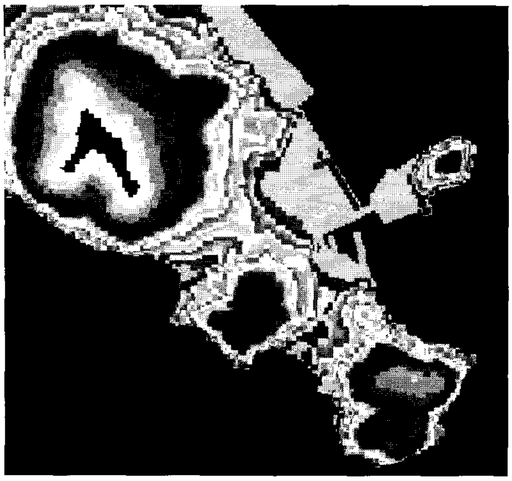

Fig. 11 2D raw map image around Young Do area

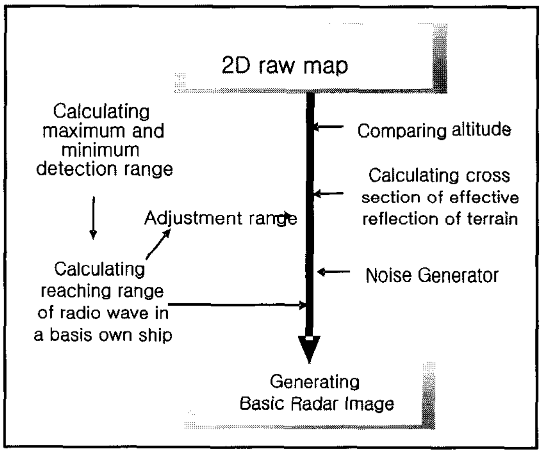

Fig. 12 The outline of generation BRI from 2D raw map

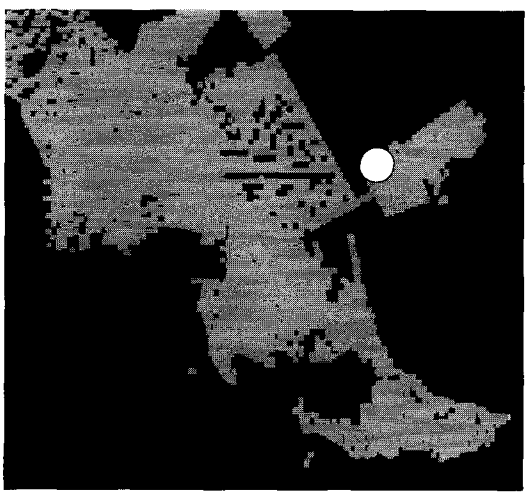

Fig. 13 An example of generated BRI

1) Step-1: Analysis of open flight files of 3D terrain image.
2) Step-2: Converting the 2D raw map from open flight files.
3) Step-3: Generation of 2D raw map using the converted data.

We examined the proposed method with the open flight file of the Young Do area, and made the BRI as a basis image of radar simulator. We found that this method provides easy access to make radar image more similar to those of real radar scope.

In this study, the BRI is just a basic image for using radar simulator, therefore it leaves something to be desired. There are not included effects of signal strength and some noise which are sea clutter and rain clutter(Jeong, 2002). Therefore it has to be processed some stages which are a noise generator, more detailed expression of signal strength to make image having reality.

In next study, we will have to consider the factor of signal strength to radar cross section and display the image with the eight levels of strength. Also we will consider some noise of reflector by developing a noise generator.

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