The Study of Surveillance around the Ship II

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Abstract. The main causes of maritime accidents are derived from insufficient surveillance. In a narrow channel, there are a lot of opportunities which a ship encounters other ships. Therefore, we need to pay attention to steer ships sufficiently. In this situation, the ship watchers convey accurate information to the ship pilots, then, ship pilots have to provide direction of steering precisely. It is not easy to determine the surrounding circumstances and give instructions to steer the ship in a short time. Therefore, it is needed that the system to support surveillances which shorten the time of transmitting the circumstances to the ship pilots. In this study, we will generate the 3D surveillance model of acquired images with surveillance cameras which set up for all directions on the ship and radar images, and we propose a new method to display information around a ship. In this experiment, we have tested our proposed system with actual images at "Shioji-maru".

Keywords: information system, 3D surveillance model, lookout, RADAR, panoramic image.

1 Introduction

According to statistics provided by The Japan Coast Guard of accidents at sea in 2011, around 800 to 900 collision accidents at sea per year happened in the past five years. Looking at kinds of accidents, collision accidents consist of 30% of all accidents. The main causes are anthropogenic factors, among them, it is indicated that collision accidents caused by insufficient surveillance especially have happened many times. However, there are many opportunities to encounter other ships in congestion of marine areas and navigators always need to grasp their surroundings. It is not easy for them to keep confirming their surroundings in the middle of doing various operations in the ship there are a tiny number of navigators. From the present situation like this, the following two things are important. One is to support navigators to grasp their surroundings more quickly to prevent them from occurring their accidents. The second is to record the situation surrounding ships clearly in order to examine and analyze their accidents.

In this study, we obtain visual information of surrounding ships as images captured from all circumferences by cameras. Then, we make 3D surveillance model from the

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images and radar images, we propose the method which images of arbitrary eye direction are displayed depending on the situation. At the same time, we also aim for establishing systems which are able to record and providing useful information to analyze accidents.

2 Related Research

As the study to support surveillances, it is reported the study to support visual recognition [1-2] and the study about integrated display of navigation information. These studies propose the method of supporting surveillances by using visual information about the direction of bow, however, they do not propose the method that integrate omnidirectional images included backward ship and marine navigation information of other ships, they do not also propose the method that display them on one screen at a time.

In recent years, that is part of the reason that damaging to other ships by suspicious ships has become a problem, it is in great need for keeping an eye on our backward ships. Easily having a wide-angle view that not only images from specific direction but also omnidirectional images in the ship is especially effective in an early detection of suspicious ships and a course decision of burdened ships.

Furthermore, in relating to a way of acquiring images, the method [3] that displays images around our ships by using a fish-eye lens has been proposed. Shooting by using a fish-eye lens makes it possible to shoot omnidirectional images by one camera, therefore, it has some advantages to be easily-controlled and to be inexpensive. However, it is constitutionally difficult to identify small targets like small ships because the resolution acquired images decrease. In this paper, we acquired images by using “camera array system” that some cameras are connected to acquire high-resolution images.

3 Information around Ships

Information around ships consists of visual information, radar information, and direction information of other ships, weather information, AIS information and so on. In these information, navigators actually attach overriding importance to visual information when they keep guard. In case they cannot interpret the situation visually when they keep guard, they complement information, for example, distance to the target, by matching the visual contact to radar information. In doing so, they grasp the situation. In addition to that, moving direction and moving velocity of other ships are estimated by measuring relative directional change which when we watch other ships from our ship. Then, a 3D surveillance model (Fig.1) obtains visual information that we think important during our surveillance as real-time omnidirectional images, makes it possible to streamline surveillances by integrated display of radar information and direction information.

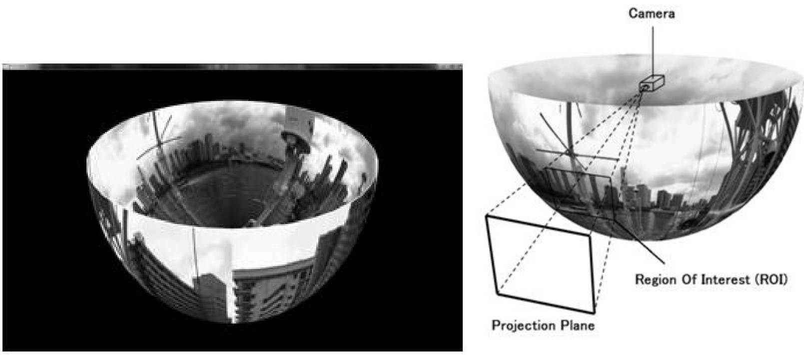

Fig. 1. 3D Surveillance Model

4 3D Surveillance Model

We describe an outline and a rough progression of 3D surveillance model, then we make a proposal about a way of surveillance images, a way of connected surveillance images, a way of making radar images, a way of information integration and a way of information display.

First, we define a hemisphere shape in 3D space of Computer Graphic (CG). We make images integrated radar information and direction information in surrounding images as texture. Then, a model done texture mapping [4] to the hemisphere shape is defined as 3D surveillance model. Setting observer's eyes (a camera) in place into the hemisphere shape, users move interactive eye direction with a mouse and so on toward the hemisphere shape. So, they can see (display) arbitrary directional texture (omnidirectional images, radar echo, and amplitude) that put on the hemisphere shape. We show our outline drawing in Fig.1. In this study, we utilize the method of texture mapping for preserving integrated information images in order to display integrated information of omnidirectional images etc. and to analysis as we describe later. Texture mapping might happen to some problems that a delay of display and display of resolution, however, it does not have a big influence on its behavior, if it is used the resolution of this study.

4.1 Creating Image Capture Device

We make connected surveillance images from some images obtained by an image getting equipment (Fig.2) created in this study. We also obtain radar images by using an image distributor from an equipment of radar images display. Radar echo are only extracted from obtained radar images, radar images expressed disk-shaped by Cartesian coordinates conversion are converted into belt-like ones. We produce information integration images (texture images) from these two images. The texture images are superimposed based on location information and direction of bow taken various images, then, echo images are not done projection transformation because of an execution of high-speed processing. By doing this, radar echo are accurately not projected into omnidirectional images, though, the texture images are fully able to convey navigators to the state they should check from radar echo pixels and a direction.

We project these images produced into hemisphere of 3D space in succession, and we display images of arbitrary direction by using a display method we propose in this study.

Fig. 2. Capture Device

4.2 Omnidirectional Image

We consider what we connect images obtained from five cameras and shape omnidirectional visual information into one image as a connected surveillance image. In our shooting equipment set up a disk of cameras, even if we take a picture with a camera and with next to a camera like including the same target, the dimensions of the target in the shooting image are different.

In this study, we consider an amendment by using cylindrical projection. We produce connected images (Fig.3). The way is what we once project images shot by five cameras into cylindrical side, and sticks the images together on the cylindrical side.

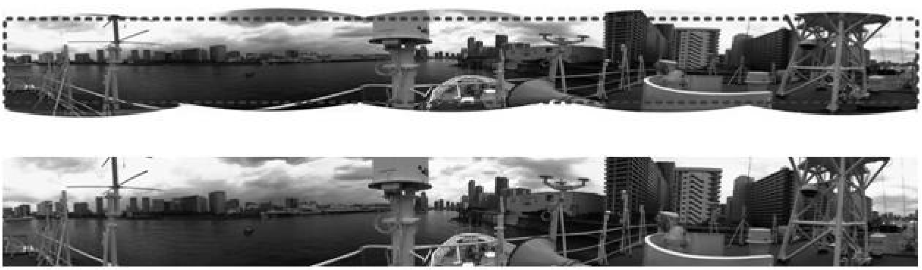

Fig. 3. The omnidirectional image

4.3 Radar Image

We produce radar images expanded to a horizon area from images (Fig.4) obtained by using the image distributor through the equipment of radar images display. At first, we clip radar echo display area of obtained radar images, and extract only radar echo by using arbitrary threshold from brightness value information. We consider the radar echo display area as polar coordinates, convert it to Cartesian coordinates (Fig.5).

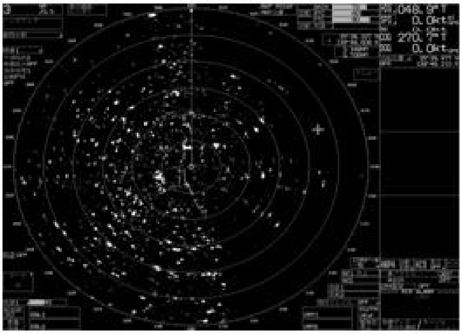

Fig. 4. Captured Radar Image

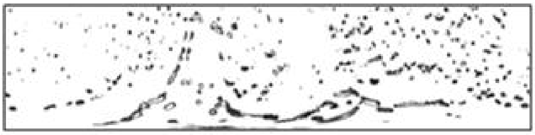

Fig. 5. Radar Echo

4.4 Integrated Information

In the 3-D surveillance model, we integrate radar information and direction information with images obtained around our ship, and we display it. In the integration of radar information, we incorporate the connected surveillance images we made with images we extracted radar echo (Fig.6 circles are a part of echo). On this occasion, we match position of the target on radar information to position of the target on visual information, positioning each horizontal line on their images.

Fig. 6. Texture including Radar Echo

4.5 Textures Mapping

Original images were thought to be due to record distribution of lights under lighting condition. If a light source becomes fixed, each point of color becomes a function that has only reflectivity coefficient, this coefficient remains unchanged. Therefore, even if observing point changes, each point of color on object surface does not change. This distribution of reflectivity coefficient is called texture in the field of CG. In general, by mapping original images as textures on 3D object surface and curved surface, we can produce images of arbitrary observing points.

In this study, we map textures generated by this method on the hemisphere. In this method, images become unusual shape because textures were compressed and mapped near the poles. Though textures mapped near the poles on the hemisphere do not accurate shape, these are images enough to confirm. The pole in this method, in short, the bottom of the hemisphere is our less important ship or our camera table. We express as moving images through we map texture images generated by integrated processing information in series.

4.6 Information Visualization Method

We propose the way of information display of 3D surveillance model. With respect to a coordinate system, a vertical upwardness in 3D virtual space is plus direction of Z-axis, Y-axis of horizontal XY flat-surface is a depth. There are two display methods we propose, one is a parallel projection from Z-axis direction, the other is a parallel projection to XY flat-surface and vertical flat-surface.

The parallel projection from Z-axis is a method that texture mapped on hemispherical virtual space is projected parallel from Z-axis's upper direction to XY flat-surface and to parallel projection plane. In the projection plane, it is projected what is combined omnidirectional images with radar images. In this way, we make it possible to check on the surrounding situation in a short period of time without moving the visual direction to our circuits and the radar screen during our surveillance due to be able to match radar information as the same time as looking at omnidirectional images.

A parallel projection to XY plane and vertical plane is a method of displaying projection plane by a parallel projection of texture mapped on the hemisphere toward XY plane and vertical projection plane.

It reflects what we scrap parts of area from omnidirectional images in projection plane. We can change our visual line to arbitrary direction, because we can convert the direction of projection plane and the size of clipping area by mouse operation. Especially, we think it proves to be useful in surveillances that we can grasp small ships etc. approaching from backward of our ship even if we are on a bridge.

It is possible to grasp the surrounding situation easily by switching these two display methods depending on the situation. The Parallel projection of Z-axis direction, however, is not shown accurate shape because an icon is compressed toward a center of images. It is not also easy to measure the distance to a target depending on a visual position and a visual direction in a parallel projection to XY plane and vertical plane.

We deal with this as displaying distance information.

5 Experiment

5.1 Experiment Content

In this study, we set up shooting equipment on the deck of training ship “Shioji-maru” of Tokyo University of Marine Science and Technology, then, we made our experiment of taking images. Our experiment was performed when we anchored “Shioji-maru” in the daytime. At the time, it was a sunny day and visibility was good. We sequentially acquired surrounding images and radar images in real time, then, we examined whether these images were displayed or not by our 3D surveillance model. We obtained images from shooting equipment in 2.0 frame/s and radar images in 0.5 frame/s. Computer system configuration diagram at our experiment is as follows (Fig.7). We produced computer programs operating on the top of our operating system Windows, looked into the semantics by outputting images at 27-inch display monitor of 1980×2080 resolution.

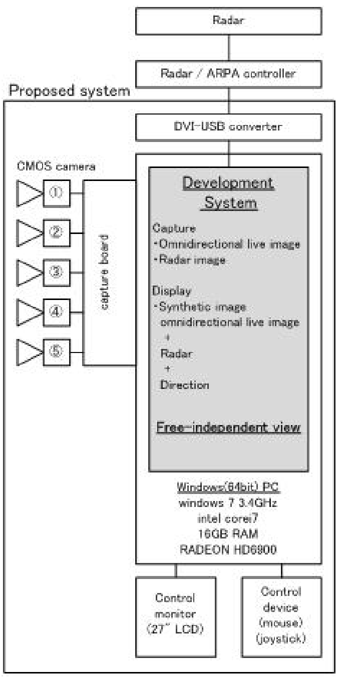

Fig. 7. System Install

5.2 Experimental Result

Fig.8 is the image that we captured displayed-contents when we experimented. We confirmed that radar images were displayed, having an overlap with shooting images and that we are able to overlook complete periphery of our ship by mouse-driven viewpoint switching. We could not confirm ships at all that displayed clearly as radar echo because our experiment environment was located in very narrow marine area when it comes to matching to radar information. Surrounding landform and buildings were displayed as radar echo on the images. On this occasion, we visually confirmed through binoculars and we checked what verification of radar echo and the direction of actual landform was completed.

Concerning a display speed, we recognized that displaying frame rate of surveillance images in the present system was 1.0 frame/s. About a record, we preserved the texture produced as JPEG images of 1frame/s (about 2.0MB per flame). Owing to this, it was possible to record without omissions with the capacity of about 2.9GB in four hours. We also checked that the texture recorded was able to display of playing by making use of this method.

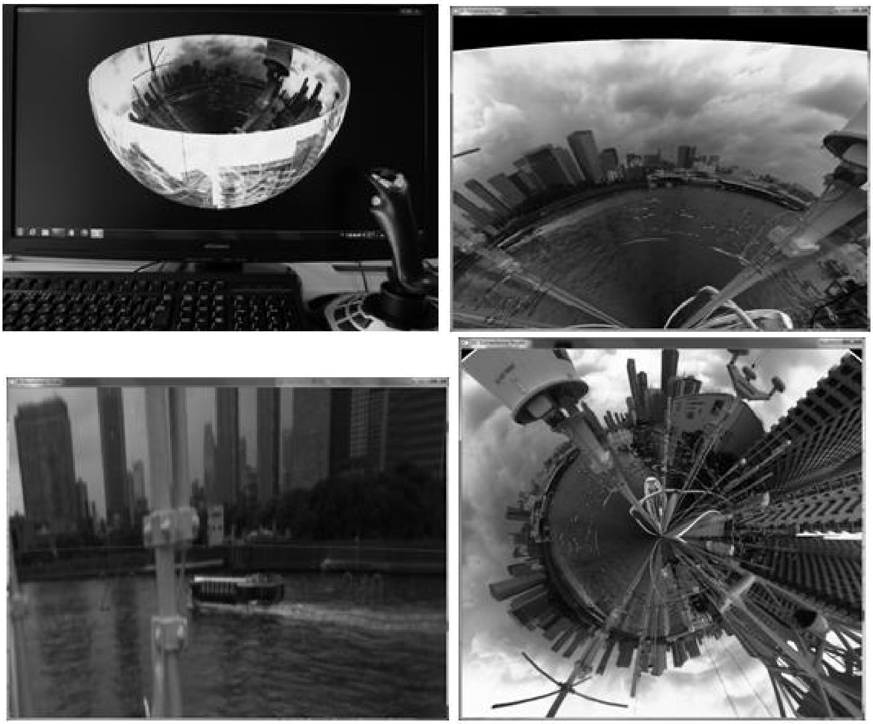

Fig. 8. Result Image

6 Discussion

Through this experiment, we confirm that it is possible to display some necessary parts in response to surrounding situations even if we are on a bridge by using two display methods we propose as the situation demands. Especially, when we check the surrounding situation, it was an efficient way to grasp our ship that we overlook around our ship by the parallel projection from Z-axis direction, then, as soon as we check other ships, we grasp directional information, we switch to the other display method and enlarge the images. At this time, if we lost other ships, we could find these easily because we can enlarge and scale down display areas.

When we displayed radar information with images, a space between targets of radar information was kept, then, we could display a positional relation in an easy-to-understand manner.

We also displayed our ship on the image any numbers of times in this experiment, circumstances surrounding which is necessary information were displayed as compressed images. We need to set up shooting equipment on higher position and confirm this movement.

In this study, we easily display integrated information of arbitrarily-visual line direction and utilize the method of texture mapping in order to preserve integrated information images which we displayed to analyze. In the texture mapping, we assume some problems such as a delay of display and low-resolution images. Although the level of resolution images we use in this study has not significant impact on this movement. Then, like Imazu's method, it is easy to change 3D visual line direction to the image projection on the hemisphere (texture mapping) than the image projection on 2D surface. Therefore, we can easily realize the display all-round at one time such as fish-eyes lens.

In the future, we consider a correspondence of hopping. We also do not take measures about swing in this study. It is reported [5] that if we use our equipment under the situation of shaking when we keep guard, recognition rate of our equipment becomes diminished. So, we need to take measures. Relation to this, we consider that we clear away swing by using swing elimination algorithm [6].

7 Conclusion

In this study, we set up the hemisphere face in the virtual space and integrated information on the hemisphere. From our experiment, we confirm that it is reasonable to support that the method of integration, the method of display and visual line switching. We also make it possible to provide useful information to analyze the situation when accidents happen by recording pictured images and radar images simultaneously. As future subjects, we will deal with taking pictures when it is rain and when it is at night, then, we will display integrated AIS date and weather date into images by cooperating with other systems.

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