Development of Radar Simulator Software Using AIS Data for Ship Data

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***Abstract*- A radar simulator for ships is a device for effective education concerning safety in ship navigation. In existing radar simulators, it is necessary to simulate surrounding ship data, and much effort is required to input such data. Therefore, this study aims to address this problem using AIS (Automatic Identification System) data. The proposed radar simulator system simultaneously achieves the following functions: (1) the creation and display of simulated radar images based on AIS data and (2) the display and overlay of AIS information on radar screens. As a result, it is possible to train individuals in ship maneuvering using actual ship traffic of a specific ocean area as the environment in the surroundings of one's own ship. Moreover, this proposed radar simulator system works on a general PC. Thus, it is possible to have two or more people simultaneously participate in training using a network with two or more PCs. In this paper, the outline of the proposed system and simulation results are described.**

Keywords: AIS, radar simulator, ARPA, safety navigation

I. INTRODUCTION

For safety in ship navigation, it is crucial for navigators to understand their ever-changing surroundings and to make critical judgments on accurate ship maneuvering. Moreover, it is important to use various types of information accurately and effectively as a criterion for making timely decisions regarding ship navigation. Recently, ARPA (Automatic Radar Plotting Aids), which performs radar plotting automatically, calculates information such as COG (Course Over Ground), SOG (Speed Over Ground), CPA or DCPA (Distance of Closest Point of Approach) of other ships, as well as TCPA (Time to Closest Point of Approach), and displays the information, has been generally used in ship navigation. A radar simulator system is equipment with which a trainer carries out the education about the safety ship navigation effectively about a radar and ARPA using the same equipment as a real ship in simulation. However, problems with existing radar simulators include the following.

- Studying can be done only at a specific location, because a large-scale device is necessary.
- Considerable effort is required to gather data on the surrounding environment.

The purpose of the present study is to develop a system that can be learned easily at any time in any place, in contrast with radar ARPA that can be studied up to now only in a specific location. Such a system should have the following features.

- It should enable ease of preparing data regarding the actual surrounding of a ship.
- It should operate on a general PC.
- It should be available to anyone for actual training, anytime and anywhere.
- It should enable multiple users to simultaneously participate during training on a network of PCs.
- Its technology should be open for improvements while being fun with the introduction of a game element.

In this paper, we propose a technique that uses recorded AIS data to generate surrounding ship data and a radar ARPA simulator for uniform training of ship navigation, and describe the results of adopting this approach.

II. OUTLINE OF PROPOSED TECHNIQUE USING AIS DATA

The proposed system uses information on AIS not as information on AIS but to display it as a radar echo of a ship. The actual situation of the ship can then be reproduced with the recorded AIS data. Therefore, during training, it is also possible to consider the traffic flow of a ship in a specific sea area as an environment in the immediate surrounding of the ship. The outline of the acquisition system for the AIS data used in this study is shown in Fig. 1[1] [2].

Radio signals including AIS data are received by an AIS receiver with an antenna set up at the campus of Graduate School of Maritime Sciences, Kobe University. All the data contained in radio signals are recorded on PC connected with AIS receiver by serial communication (RS-232C) .

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The PC transmits AIS data to a client PC that functions as a server, and is connected to the network. Fig. 2 shows an example of the AIS data file that the server PC transmits.

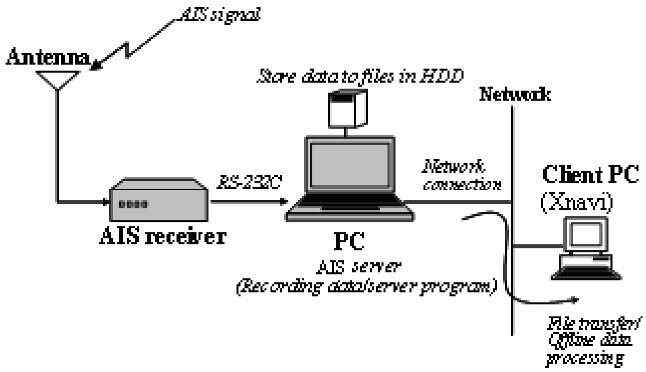


Figure 1. Receiving system for AIS data

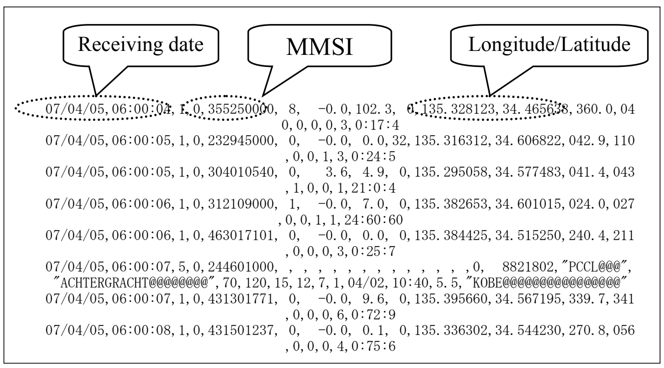


Figure 2. AIS data file

III. SYSTEM DEVELOPMENT AND SIMULATION OF SHIP MANEUVERING

A. *Outline of proposed system*

Fig. 3 shows a conceptual diagram of the proposed system. The system is composed of one server PC and one or more client PCs. The server PC transmits the recorded AIS data to each client PC. Each client PC displays the AIS data that has been sent as an environment in the surroundings of one's own ship. The users who are training in ship handling control their own ships on the basis of radar images displayed on each client PC. In addition, the information obtained when a user navigates a ship on a client PC is converted to virtual AIS data, which are transmitted to all PCs. The broadcast packets of UDP (User Datagram Protocol) are used for the data communication between each PC in real time (note that high-speed and slow-motion replays are also possible). In this system, maximum number of clients can be increased to about 250 in proportion to the number of general IP (Internet Protocol) addresses which can be distributed in the same subnet of LAN. In other words, a maximum of 250 users can simultaneously execute the ship maneuvering simulation in the same scenario at the same time.

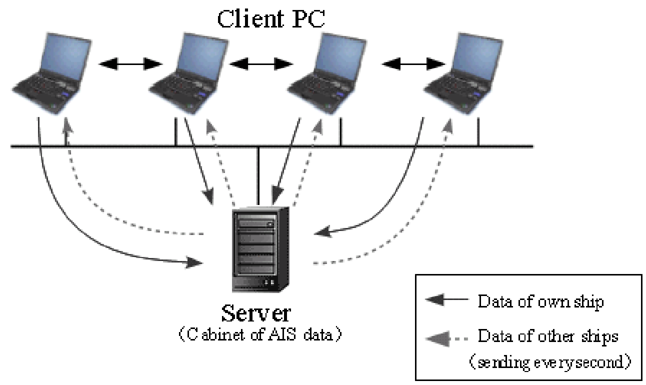


Figure 3. Conceptual diagram of the proposed system

B. *Implementing the proposed system using Java programming language*

The proposed system was developed as a Java application [3] using Java programming language. The reason for the use of Java is as follows.

(1) The difference in display depending on OS (Operating System) is minimal in AWT (Abstract Window Toolkit), which is the GUI (Graphical User Interface) of Java.

(2) Application operation of processing speed, the display speed of a screen, etc. is lilt.

Therefore, it is suitable to implement the proposed system such that it shows no dependence on OS and can be executed on a general PC.

C. *Radar display and manipulation interface*

The radar display of the proposed system is shown in Fig. 4. A comparison between the radar display part of the system and an actual radar screen is shown in Fig. 5 (actual radar image in upper left and display of developed radar simulator in lower right). The radar display of developed simulator consists of a radar display part, a data display part, and an explanation part. In the radar display part, a map and radar echoes of the ship and land part, the vector of one's own ship and other ships, VRM and EBL are displayed. In the data display part, information on one's own ship, on other ships, and on the range are precisely reproduced and presented.

As the radar simulator function, the ship position is moved and the heading flash, the vector, the ship track, and other information are displayed. Moreover, as a function which displays the ARPA information about other ships, it has a vector mode of display (TRUE, REL), ACQ TARGET (acquire

target), TARGET DATA (data display), CANCEL TARGET, etc. Fig. 6 shows the user interface, and Fig. 7 shows a comparison between the operation panel of the proposed system and an existing operation panel. The operation panel of the proposed system has the same functions as the operation panel of the existing system, such as range change of a display, and operation of VRM and EBL. The following panels are included in the user interface.

- A panel for selecting the type of ship is displayed as the start screen (Fig. 6(a))
- A panel for adjusting the speed and angle of one's own ship (Fig. 6(b))
- An operation panel for changing the range of each value, as on an actual radar system (Fig. 6(c))

Additionally, a frame that can change the transmission speed of the AIS data is included in the operation panel (Fig. 6(d)) on the server side. Therefore, training at speeds faster or slower than real time is possible.

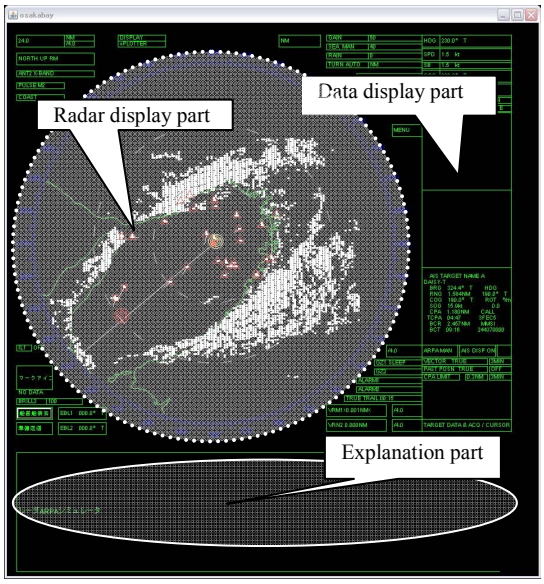


Figure 4. Radar display

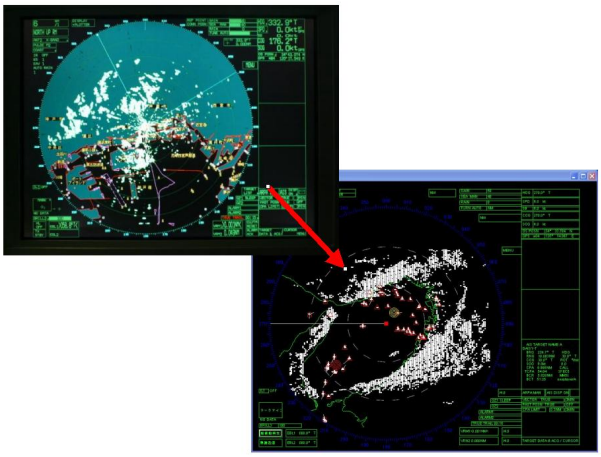
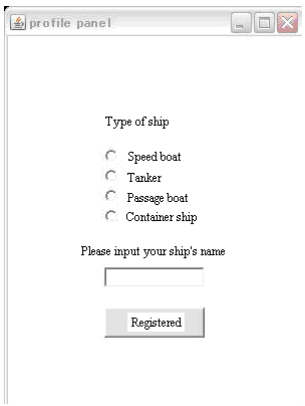
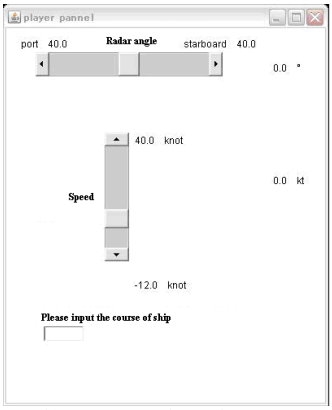


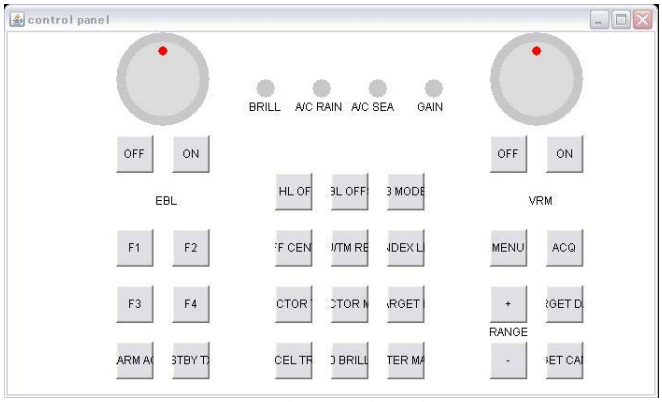
Figure 5. Comparison of radar display



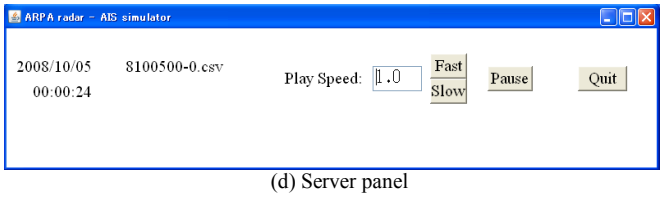
(a) One's own ship profile panel



(b) User control panel



(c) Radar control panel



(d) Server panel

Figure 6. Manipulation interface

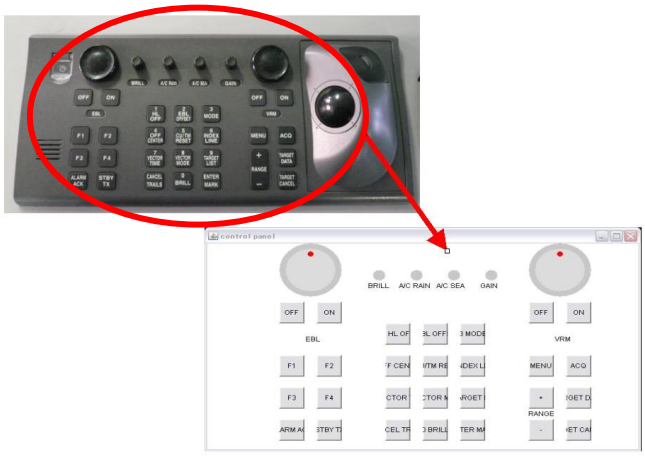
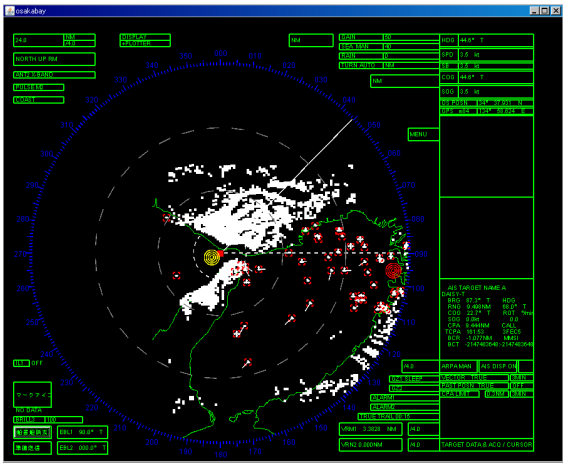


Figure 7. Comparison of operation panel

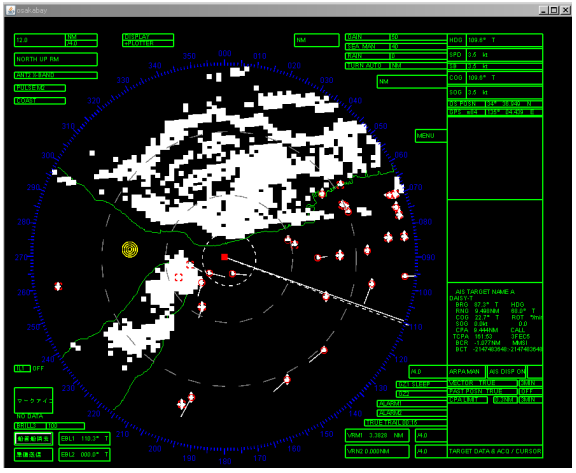
D. Appearance of system execution

A scenario where one's own ship is navigated from the west of the Akashi Strait toward the Osaka port in Japan was taken as representative training scenario. First, the type of one's own ship is selected from the ship decision panel shown in Fig. 6(a). The container ship was selected in this example. Next, start point and destination point were selected in the radar display area in Fig. 4, and a simulation of ship navigation was started. Fig. 8(a) to 8(c) show the radar display of one's own ship under simulation. Fig. 8(a) shows a radar display at the start point, while Fig. 8(b) shows a radar display for the own ship passed over the Akashi strait. In this system, the displayed region can be zoomed in or out, in the same manner as an actual radar system.

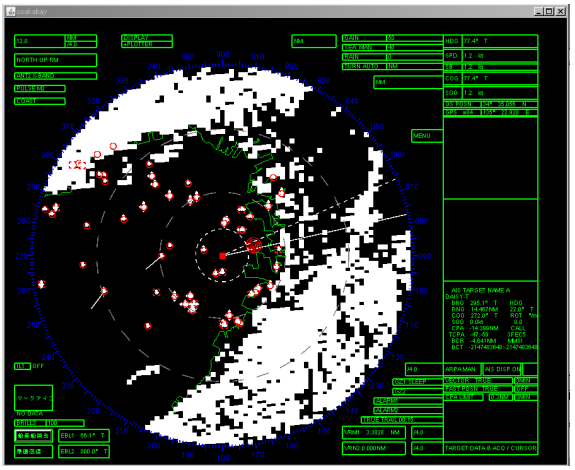
Fig. 8 (c) shows the radar display of one's own ship approaching the target attainment point. This system also has the function which makes variable replay speed of the AIS data transmitted from a server as another ship data, and it is also possible the navigation simulation which spends a long time in real time, and to shorten and perform time. Therefore, it is possible to execute the simulation in a time period that is shorter than that required for simulations in real time. Moreover, because the simulation can be replayed at reduced speed, more careful training is possible for situations in which close attention is necessary, for example, in a crowded sea area. In addition, more detailed consideration can be taken during confirmation after the training. Because the recorded AIS data to play can be chosen arbitrarily, various scenario of simulation can be performed by changing the hours, the day of the week, and the season. Therefore, the feature of the specific sea area including the AIS data can be easily understood. That is, even if only the data of the specific sea area is acquired, an actual sea area can be faithfully reproduced in this system. This is because of the use of AIS data as surrounding ship data. Therefore, ship navigation that suits the actual environment and situations in specific sea areas can be simulated. Fig. 9 shows the appearance of the system operated on a laptop PC. Thus, it was confirmed that, by using the system, one can learn skills in ship navigation without depending on the environment or on the location of the PC. It is also possible that many people can simultaneously learn skills in ship navigation using the system. Fig. 10 shows the appearance of two networked PCs using the proposed system.



(a) Start point



(b) After passage through the Akashi Channel



(c) Near the destination point

Figure 8. Result of radar simulation

Figure 9. Proposed system operated on laptop PC

Figure 10. Simultaneous execution

IV. Conclusion

In this study, a radar ARPA simulator system that can be learned easily was designed and constructed. This system has the following features.

(1) It enables easier understanding of the features of a particular sea area. Because this system uses recorded AIS data on surrounding ships, an actual sea area can be faithfully reproduced. Therefore, ship handling can be simulated under the same conditions as the actual situation.

(2) It facilitates effective training. The proposed system requires no specific execution environment, that is, it can be used independently of the OS on a general PC. This is because the system is implemented in the Java programming language. Therefore, the user can use the technology irrespective of PC environment and the place of training.

(3) Multiple users can train at the same time with each controlling a ship. The data of the ship is transmitted to other users as virtual AIS data through the network. The data is then displayed as another ship on the PCs of other clients, in addition to recorded AIS data.

As for future tasks, we need to improve the radar echo image to be more realistic. Moreover, the evaluation of the proposed system by users is important. In other words, we should identify problems with the operation of this system on the basis of users' opinions, and improve the system accordingly. We are considering the addition of a game element to the system, for example, an element for quantifying ship maneuvering. In this way, the technology can be improved and made more enjoyable for the user. Finally, we are also considering whether to allow control of other ships. The movement of other ships is presented only as a reproduction of the past situation because it uses recorded AIS data obtained under the present situation. Therefore, for example, even in the situation where one's own ship is on course to collide with another ship, the other ship does not attempt to avoid collision; that is, an evasive maneuver should be performed. Certainly, this might be beneficial for improving skills in evasive ship maneuvering in comparison with the current system. However, in order to build a system more suitable for practical use, we should examine the necessity of adding the function of evasive maneuvering of another ship.

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