International Journal of Navigation and Port Research
Vol.29, No.4 pp. 313~318, 2005 (ISSN-1598-7701)

Development of Analysis Module for Marine Traffic Information Using PC Camera

Serng-Bae Moon · Geun-Sil Lee** · Seung-Hwan Jun****

**Div. of Navigation System Engineering, Korea Maritime University, Busan 606-791, Korea*
***Graduate School, Korea Maritime University, Busan 606-791, Korea*
****Div. of Navigation System Engineering, Korea Maritime University, Busan 606-791, Korea*

Abstract : *Usually marine traffic survey has been conducted by some methods like an ocular observation using portable RADAR, a questionnaire, etc. But these should have expended a lot of manpower and expenses. In this paper, we have developed new observation module which could capture the RADAR image using PC camera simply, and allowed as to track targets on the PC monitor directly. And it has been programmed to make a database of RADAR image, target's track and information, and analyze the marine traffic tendency in various ways like vessel number crossed over gate line, vessel's velocity distribution in gate line, traffic density distribution, etc. We have confirmed that this module could observe and analyze the marine traffic efficiently and economically through several on-the-spot experiments.*

Key words : *Marine traffic, RADAR image, PC camera, Target's track and information, Gate line, Traffic density distribution*

1. Introduction

In order to find our way safely from place to place on the water we must rely on road signs just as we do on land. The aids to navigation are the road signs of the water. Some of them are usually used together to form a local aids to navigation system that help the mariner follow natural and improved channels. Such aids to navigation also provide a continuous system of charted marks for coastal piloting. Individual aids to navigation are used to mark landfall from seaward, and to mark isolated dangers. Approximately two thousand of aids to navigation have been operated and placed along coast and navigable waters in Korea, on the basis of the marine traffic survey. The traditional survey had been done by some methods like a visual sighting of marine traffic, a on-the-spot survey, a questionnaire etc. Recently another procedure using the portable RADAR(RAdio Detection And Ranging or RAdio angle Detection And Ranging) has been included in survey, and made it possible to research into the marine traffic information with a scientific accuracy. On the basis of this work, related Adminstration have determined the positions and characteristics of aids to navigation(Jeong, 2001).

Usually the marine traffic survey is carried out by experienced persons on the field with a portable RADAR and a binocular for days(Park, 1998). Although the portable RADAR could simply indicate the relative bearing and range of targets which are very essential information for the marine traffic analysis, the tracking of targets has been still conducted in a manual way which a transparent paper or material is placed on the RADAR screen and the center position of target is marked. And also the researcher should have observed the plotting target's exterior with the binocular, classified and recorded her according to some items like ship's type and size simultaneously. After this traffic survey process, all data is gathered and analyzed. So this sequence of marine traffic survey requires a lot of manpower and expenses.

In this study, we have tried to develop the new system which could perform some functions like a automatic capture of RADAR image, target's tracking, analysis of marine traffic information.

2. Analysis Module for Marine Traffic Information

The developed analysis module for marine traffic information can build the database of RADAR image, target's movement and observed ship's particulars on personal computer or laptop. Specially this module is carried out the observation and analysis simultaneously.

Fig. 1 shows the entire process of this module which is constructed and programmed by 'Visual Basic 6.0'. And it

* Corresponding Author : Serng-Bae Moon, msbae@mail.hhu.ac.kr, 051)410-4280
** mmate@empal.com, 051)405-1751
*** korjun@mail.hhu.ac.kr, 051)410-4245

is separated into three parts. One is an acquisition of RADAR screen image. Another is an user interface which surveyor can set up initial environments for the operation of this program. And the third is an analysis module where a statistical analysis is carried out.

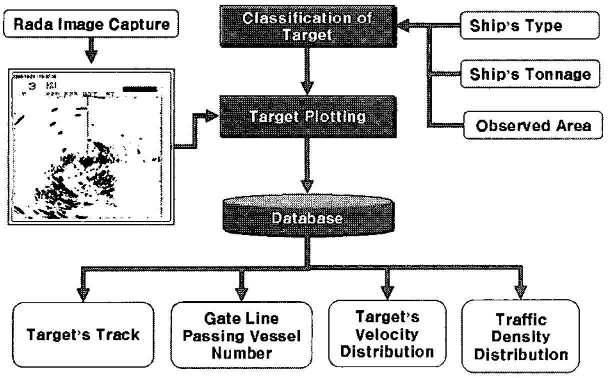

Fig. 1 System configuration of the analysis module for marine traffic information

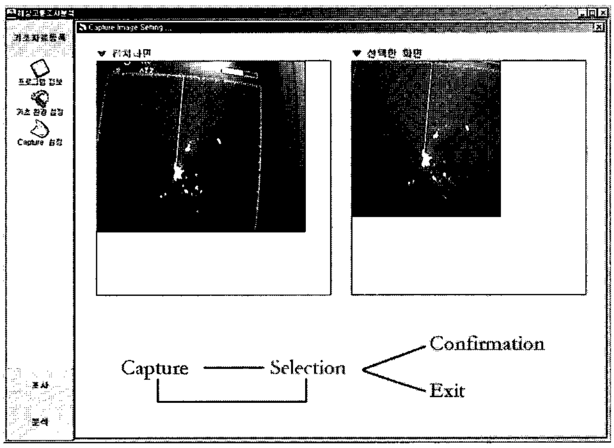

Fig. 2 Initial selection of observation area from captured RADAR image

2.1 Acquisition of RADAR Screen Image

RADAR is a very useful system or technique for detecting the position(range and bearing), movement, and nature of a remote object which is difficult to be sighted by naked eye. And RADAR is also used to map geographical areas and to navigate and fix positions at sea. RADAR involves the transmission of pulses of electromagnetic waves by means of a directional antenna. Some of the pulses are reflected by objects that intercept them. The reflections are picked up by a receiver, processed electronically, and converted into visible form by means of a cathode-ray tube(Lee, 1999).

There are two methods for drawing the RADAR scan data on screen. One is a PPI(Plan Position Indicator) method, and another is an A-scope method. The PPI method is possibly the best known of all RADAR displays where the targets are shown in a plan format. The display, therefore, resembles a map with the RADAR site at the centre of the display. Range is indicated by displacement from the centre of the display, and the radial displacement from the vertical represents the target's azimuth angle(Song, 2003).

Usually the RADAR image data can be obtained through three ways. One is to receive a raw prototype scan signal from video terminal of RADAR scanner, convert this analog signal to digital scan data by means of ADC(Analog to Digital Converter) like a RSC(Radar Scan Converter). And all scan data is transformed to PPI type RADAR image using a proper computer program. Another is to get the PPI type data generated by the main processor of RADAR from some specialized terminals like NMEA0183, RS232, etc. If these interfaces are not built, we have to intercept the data at a certain pathway to CRT device by means of ADC. The third method is to capture a RADAR screen image directly by means of a independent image device.

The first and second methods require a high price ADC and/or a conversion program transforming the A-scope data to PPI image. So they are possible to be a large scale system. But the last one can be easily built by a low cost and small system owing to a soaring development of IT technology. In this study, we adopted the last way, and made the system(module) to acquisite the RADAR screen image automatically.

Fig. 2 illustrates the beginning of the whole process. At this step, user is able to limit the RADAR image size, that is, the boundary that the RADAR observation will be done. In the Fig. 2, the left picture shows the received whole video image data through PC camera. And the right picture is directly selected from the left side picture by way of a drag and drop(DND) function of computer program. Therefore we can easily exclude an unnecessary section from the orignal image data. If the real observation area is decided throughthis process, all received RADAR images are equal to the area. However, PC camera and RADAR screen should have been kept the same distance throughout the marin traffic survey job.

2.2 User Interface

A surveyor must establish some standards and plans to accomplish the purpose of survey perfectly before starting the observation. At this step, the user can set up the categories which a plotted target should be classified on the basis of ship's particulars like ship's type and tonnage.

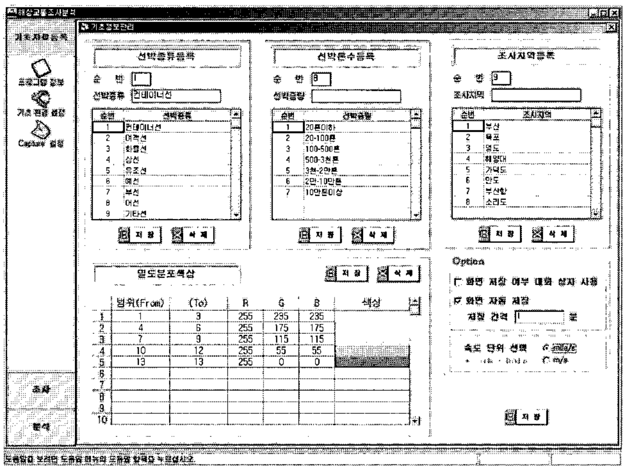

Fig. 3 Initial set-up window for basic environment

Fig. 3 is the window which an initial set-up is being conducted. This window has five sub frames. At the first frame, the user can make a list of various ship's type like container, passenger, general cargo, oil tanker, fishing, etc. And also a class number is given to each ship's type. This number will be used to select the ship's type in target tracking mode. The second frame is programmed to classify the ship's size according to some proper tonnage bands. As might be expected, the user is able to adjust the range of these bands. The third frame is provided for registering the survey area. At the fourth frame, the user can build a color table for representing the traffic density, and determine the range of density scale. The color can be designated by the RGB value or computer's color palette. And the last frame is the dialog box named as 'Option'. The saving period of the captured image is decided, and the unit of target speed can be chosen between the nautical mile per hour and meter per second.

2.3 Target Tracking

The RADAR image data is transferred from the acquisition module, and displayed on the computer monitor with the regular interval. There are two methods for tracking target on 2-dimensional image plane. One is the automatic tracking method. If an object is selected, its position and velocity are detected and calculated by the system continuously. This is similar to the function of ARPA(Automatic Radar Plotting Aid). Another is to track the object manually by user throughout the work. That is to say, the selected object image center should be plotted again by user after the lapse of some time. It can be regarded as Semi-ARPA function.

In this study, we have made the system to track the object's positions using the second method. It is of benefit to be able to compose the system easily and simply. But when the tracking work is carried out using this algorithm, the center of object's image should be carefully marked to make an accuracy in observation.

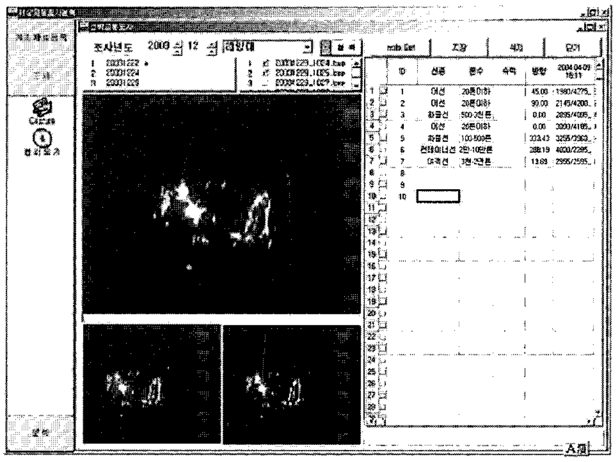

Fig. 4 Target Tracking Window

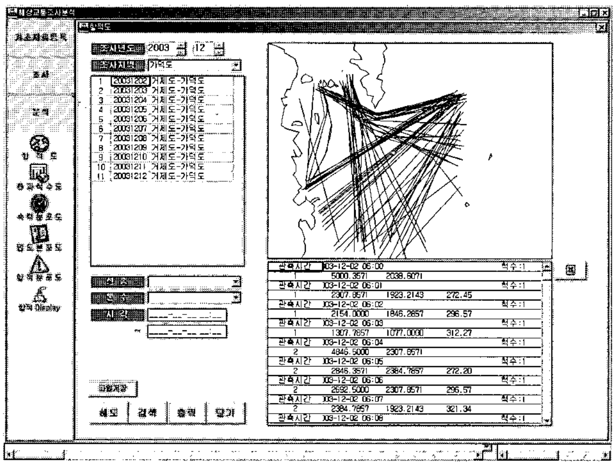

Fig. 5 Vessel' tracks analysis window

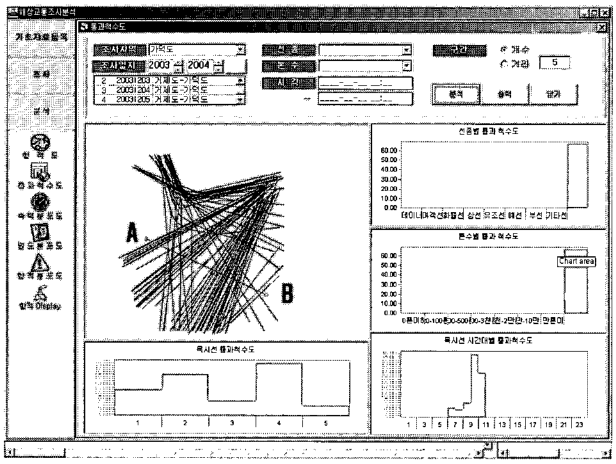

Fig. 6 Analysis window of vessel number crossed over the gate line

Fig. 4 shows the aspect that various type of targets are selected and tracked on the computer screen by the mouse. This window has two fields. Target tracking work is carried out in left field composed by three small sectors, and the list of tracking target is displayed in right side. At first, if the user determine a specific target by way of one click of mouse in RADAR image data field, an identification number is attached to the around target. At that moment, the clicked time and position(2-dimensional coordinate value) are saved and listed at the right table in order. And the user can register the tracking ship's type and tonnage according to the categories classified in Fig. 3. The observation area and name or code are registered at the input boxes of this window.

2.4 Marine Traffic Analysis Module

Usually the marine traffic information can be produced by means of various analysis methods or theories. In this paper, we have programmed the marine traffic analysis to be done by four representative ways using the track of vessel, the vessel number passed across a specific gate line, the distribution of target's velocity and the traffic density.

Fig. 5 displays the window that vessel's track is analyzed. At this module, the track is drawn by the connection of positions. And we programmed the track to be drawn according to the specific periods of time, vessel's type and tonnage. So it can enhance the efficiency of survey and make the analysis easier than the traditional method. The coast line data is opened by clicking of 'Chart' command button. It can be drawn and stored as the form of track data at the Fig. 4 Fig. 6 illustrates the analysis course about the traffic flow of tendency at one gate line. To the start with, a analyst should select the necessary traffic data on the basis of various items like observed area and date, ship's particulars. After the selected data is loaded, a required gate line can be drew by designating the start and end points using the mouse. In this figure, the line AB indicates the user made gate line. We programmed that the user can input a number of points dividing the line segment into the same portion. And if the analysis command button is down, four basic graphs are automatically showed up under the conditions of ship's type, tonnage, time zone.

Fig. 7 is for finding out the tendency of ship's running speed at a certain gate line. So this line is essential to this analysis. But new one is not needed to be established right here. Because the line AB is already fixed in the process of Fig. 6. The graph of Fig. 7 displays the distribution how many vessels corresponding to a specific velocity range passed across the gate line(Park, 1998).

Fig. 8 shows the window that a density of marine traffic is analyzed and calculated over the entire area. The user can decide the resolution of analysis by inputting the size of mesh. In this program, the unit of mesh is a twip(twentieth of a point). It is a measure used in laying out space or defining object on a page or other area that is to be displayed or printed on a computer screen. Because Microsoft's Visual Basic adopted it as a protype unit in programming. A twip is 1/1440th of an inch or 1/567th of a centimeter(Lee, 2000). And we programmed the observed coast line to be overlaid in order to enhance the efficiency and availability of this module.

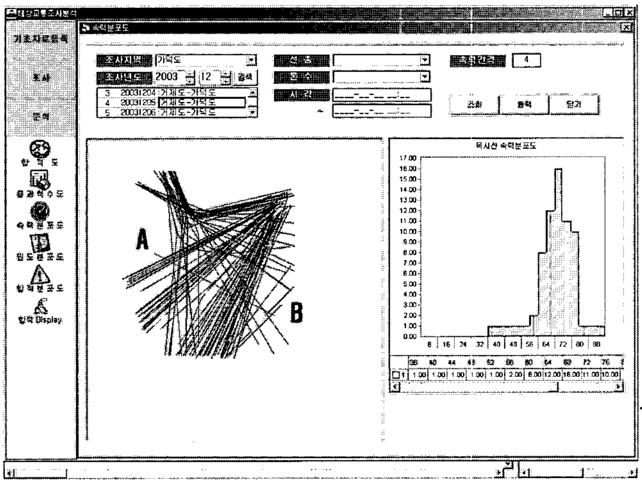

Fig. 7 Analysis window of target's velocity distribution at the gate line

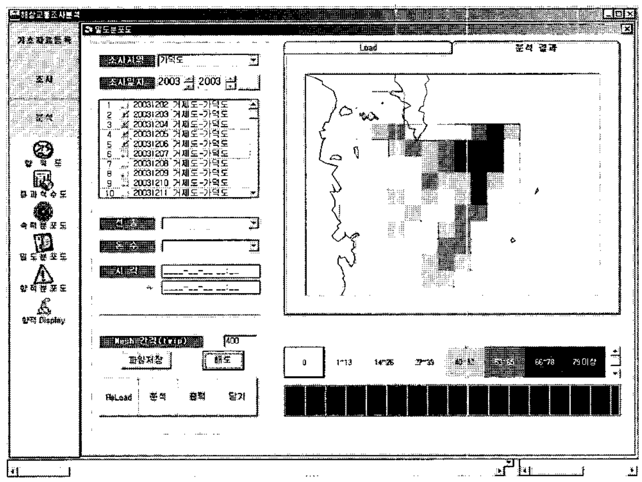

Fig. 8 Analysis window of traffic density distribution

Fig. 9 is a additional window which can help us to understand and overlook the overall flow of marine traffic. If user choose a data file according to the observed area, date, ship's type and tonnage, the target's movements are replayed with a designated speed. And we have programmed the window of Fig. 9 to include some check box items like vessel's wake, chart, speed of display, etc. So this function make the marine traffic analysis module more powerful than the traditional method.

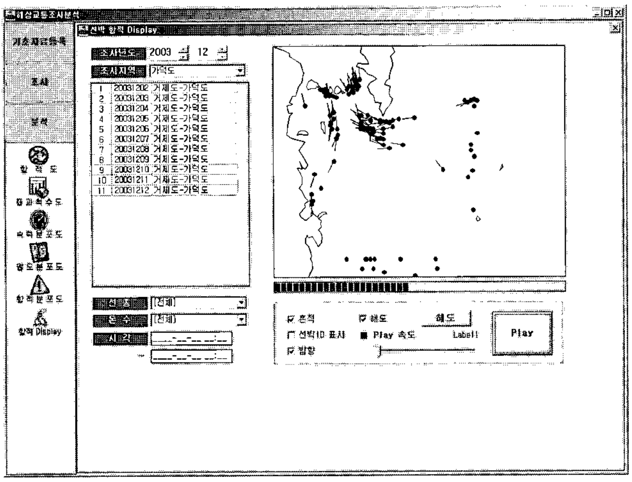

Fig. 9 Replay window for marine traffic flow

3. Experiments and Evaluations

Several experiments were conducted to find out whether this module could work well or not. Fig. 10 shows entire configuration of the system used in the experiments. It is composed of the portable RADAR, laptop computer and PC camera. Table 1 and Table 2 illustrate the principal specifications of the PC camera and the RADAR. We have set up the video image size to 640×480 pixels and sampling interval to 8 frames/second. Because PC camera should capture the wide sector image of RADAR screen at a very close distance.

Table 1 Specification of PC camera

ITEM	SPECIFICATIONS
Model	KODAK DVC325
Image Sensor	1/4" progressive scan CCD with VGA
Photo Resolution	640×480 pixels, 24-bit colour
Video Image	30 frames/s : QCIF(176×144) 20-25 frames/s : CIF(352×288) 8 frames/s : VGA (640×480)
Illumination	Minimum 200 lux
Lens Focal Length	4.6 mm; f/2.3
Field of View	50° diagonal
Shutter Speed	1/15 second, 1/30~1/500second
Dimensions	110mm(L)×52(W)×82mm(H)
Weight	207g
Interface	USB Series A connector

Table 2 Specification of RADAR

ITEM	SPECIFICATIONS
Model	RA770UA, Simrad Anritsu
Range	0.125 ~ 36.0 NM
Range discrimination	Better than 20 meters
Minimum detection range	Better than 20 meters
Bearing accuracy	Within +/- 1 degree
Bearing discrimination	Better than 3.9 degree
Range accuracy	Within +/-0.8% of setting range, or +/- 1 meters, whichever greater
Internal power voltages	10.2 ~ 41.6 VDC
Power consumption	Less than 65W
Antenna Type	Center-fed slotted array
Number of revolutions	approximately 24 rpm
CRT	10 ″ monochrome CRT
Range scale and range rings	PPI presentation on raster-scan base

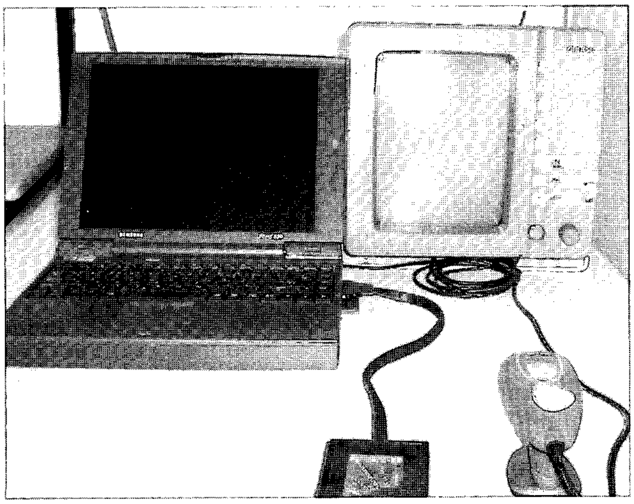

Fig. 10 Configuration of survey system

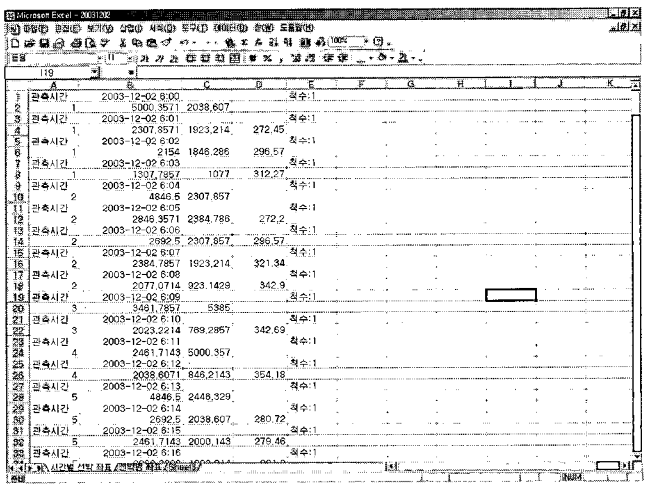

Fig. 11 Database of observed targets

The filed experiments were carried out at two places. One was the entrance of the Gulf of Jin-Hae located in the southern part of Gyeong-Sang province. The data demonstrated on Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8 and Fig. 9 was obtained at this area. And another was the coastal waters near the An-Do located in the southern part of Jeol-La province. Fig. 11 illustrates that the database observed at the entrance of the Gulf of Jin-Hae is written in a form of 'work sheet' of 'MS Office Excel' program. This database consists of four categories which are the target's click time and date, the coordinate values in the screen, the registered ship's particular and ship's speed and course.

As a result, we have found that this marine traffic survey system could do all functions like the capturing of RADAR image, target tracking, marine traffic analysis in a good condition. And also we have confirmed that all data could be finely sorted and saved according to the observation time or target ID.

4. Conclusion

Because the portable RADAR can easily detect the target's position(bearing and range) movement, and improve the reliability of the survey. It is essential equipment to the marine traffic survey. But the tracking of targets using it has been still conducted by marking those image center on transparent paper placed on the RADAR screen manually. After this, a traffic analysis can be done. So above traditional method expends a lot of expenses, time and manpower on it.

In this paper, we have developed new marine traffic observation module which could receive the RADAR image data being displayed on the screen from a general purpose PC camera, and allowed us to track targets on the computer monitor directly. And also this module could establish the integrated database of RADAR image, target's track and exteriors efficiently and systematically. We have programmed four sub-modules to analyze the marine traffic information in real time. These are the windows of vessel's track, vessel number crossed over gate line, vessel's velocity distribution in gate line, traffic density distribution.

Several experiments were carried out for verifying the effectiveness of this module. As a result, we have found that it could observe and analyze the marin traffic efficiently and economically. Because it could be easily operated by a few researchers, and reduce the time and expenses. And also we expect that it shall produce more accurate and helpful to determine a certain marine policy about management and maintenance of aids to navigation, traffic separation schemes etc.

References

[1] Jeong, J. Y.(2001), A Study on the Cost Benefit Analysis Model of Aids to Navigation, Graduate School of Korea Maritime University, pp.6-9.

[2] Lee, S. S., Kang, J. S.(1999), Radar Engineering, Bo-Seong Mun Hwa Sa, pp. 17-40.

[3] Lee, S. Y.(2000), Windows Programming Bible, Young-Jin, 2nd. pp. 309-314.

[4] Park, J. S.(1998), Marine Traffic Engineering, Maritime Books Publisher of Korea Maritime University, pp.33-60.

[5] Song, J, U., Kim, C. J, Moon, S. B.(2003), A Study on the Estimation of Ocean Surface Wave Information from Marine Radar Signals, Journal of the Korean Institute of Navigation, Vol. 27, No. 5, pp. 500-501.

Received 9 May 2005
Accepted 24 June 2005