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Comparison of the Applied of Car Navigation System and Developed Marine Navigational System

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ABSTRACT: A watch officer in sailing a ship uses many kinds of navigational information to prevent marine disasters. Especially in coastal sea area such as narrow bay or port, many ships crowds and marine disasters tend to occur more often. In these regions, effective presentation of variety navigational information is very important. On other hand, a car navigation is very effective in road traffic, However, it is not used almost in sea traffic. Our objective in this paper is to apply a car navigation to ship sailing. Also, a marine navigation system proposed by us was compared with a car navigation system. In this study, authors tried some ways of utilizing car navigation technology for the sea. To improve navigational security and safety, we investigated whether car navigation systems could be applied to marine traffic. The applicability was evaluated through several comparisons of our navigation assistance device using GIS.

1 INTRODUCTION

Over time, ship hull structures and motor functions have been improved and various advanced navigation devices have been developed to ensure the safety of marine vessels (Imazu et al. 2003). However, according to statistics from Japan Coast Guard, the number of marine disasters involving vessels has not declined significantly during the past 10 years (Japan Coast Guard 2007). Moreover, the increasing number of vessels may result in an increase in the number of marine disasters. Study about navigational assistant method has been discussed during the past decades. First is about the widespread usage of 3D navigational chart. 3D navigational charts idea was from Ford. The conclusion of this idea is that 3D visualization of chart data had the potential to be an information decision support tool for reducing vessel navigational risks. (C. Gold et al.2005, Wang et al.2013) Peng et al. discussed the structure of a navigation-aids information system which integrated of navigation-aids information GIS platform, navigation-aids monitoring system and navigation-aids distribution system in use of GIS, GPS, AIS and World-Wide-Web and modern communication. (Peng et al.2008) Goralski and Gold proposed a new type of GIS system for maritime navigation safety aimed at tackling the main cause of marine accidents- human errors – by providing navigational aid and decision support to mariners which, based on kinetic data structures, a sophisticated 3D visualization engine and a combination of static and real-time data and intelligent navigation rules. This system targeted specifically for small boat owners and ship navigators, and is aimed at providing navigational aid and decision support. (Goralski R.I et al. 2007) Gold et al. outlined the difficulties and resolutions in developing a real "Marine GIS". They challenged to produce a dynamic three dimensional "Pilot Book" which provides marine markers such as lighthouses, buoys, simulate fog and darkness also contains the rules for navigation in the proximity of individual harbors. (C. Gold et al.2005) The authors have conducted a study of effective and appropriate provision of a variety of navigational information with the aim of improving the ease of navigation and the safety of marine travel. Navigational information currently being utilized is based on paper charts or an electronic chart display and in-formation system(Wakabayashi et al. 2002). Our methodology involves a realistic display of the land-scape that ship operators would see from the bridge and overlaying a variety of critical navigational in-formation onto this display (Shiotani et al. 2011; 2011). Our methodology is based on a two- and three- dimensional geographical information system (GIS) (Kawasaki 2006; Sadohara 2005). A three-dimensional chart display is a new concept for the provision of navigational information. Car navigation systems already utilize three-dimensional displays to assist drivers; however, no such device has been sufficiently developed for marine traffic. The objective of this study is to propose a new and improved navigational information provision methodology to supplement traditional charts using a car navigation system. In recent years, car navigation systems have been developing rapidly and their performance has improved dramatically. We aim to determine the effectiveness and the problems associated with utilizing car navigation systems for marine vessels and to further develop the provision of navigational information.

2 NORMAL CAR NAVIGATION SYSTEM USAGE

Normal car navigation system has two-dimensional display. A triangle mark indicates the location and direction of the vehicle. On the display screen, the system indicates detailed building shape and provides the names of primary buildings. The name of the road is also displayed in the corner of the screen. The route options at the next intersection with lights are also shown. In addition, car navigation system provides other helpful information such as the location of bridges and various geographical features. Some car navigation system also provides three-dimensional display. The primary buildings that can be seen from the driver's seat are displayed, which makes checking the vehicle's current location easier. The identification of bus stops also facilitates determining the vehicle's location. However, the buildings are shown as rectangular parallelepipeds and their colors, windows, and detailed shapes are obscure and not realistic. If the vehicle is on a road that is familiar to the driver, the display would be understandable. However, if it is an unfamiliar road, the obscure information would be less understandable. Therefore, it is assumed that more realistic and more detailed information would be necessary in unfamiliar environments.

There is clearly room for improvement of car navigation systems. Furthermore, two- and three-dimensional information displays are highly useful features for car navigation systems.

3 MARINE NAVIGATION SYSTEM USING A CAR NAVIGATION SYSTEM

A car navigation system makes it possible to observe all of the landscape including areas behind obstructed views. Therefore, it would be easy to comprehend what is going on ahead of the ship. Furthermore, the primary buildings are displayed in three dimensions and the names of the locations are easy to understand. Therefore, it is more comprehensive than the information provided by charts. The width of the Ashiya Canal is approximately 100 m that is very narrow. There are many houses near the coast and the coastal roads are well organized. Consequently, the car navigation system was able to provide detailed road and traffic information.

Weather such as rain or fog reduces visibility; however, a car navigation system can provide the same information regardless of the weather. In addition, car navigation systems can provide clear landscapes in a daylight view at night and vice versa.

On comparison of the information obtained from a car navigation system with that obtained from video images and an electronic chart, it is evident that a car navigation system is more useful as a marine navigational safety device because it is capable of displaying clear three-dimensional landscapes and facilitates ship navigation in the same manner it does for road navigation. After an assessment of the advantages and disadvantages of such a system, we believe that it would be effective to use a car navigation system as a supplement to traditional two-dimensional electronic charts.

At present, a car navigation system can be purchased for several ten-thousand yen, which is significantly less expensive than a generic navigational device. Therefore, when utilized on small vessels such as pleasure boats, it would be both cost-effective and a satisfactory aid to navigation.

3.1 *Sample vessel and test device*

In our study, a car navigation system, portable automatic identification system (AIS), and video camera were loaded on a small vessel to investigate the performance and effectiveness of our proposed methodology.

The AIS was used to capture the position of the vessel and the video camera filmed the adjacent land space.

Figure 1. Sample Vessel "Muko Maru"

Muko Maru is a training vessel that belongs to Kobe University's Graduate School of Maritime Sciences. Figure 1 shows the Muko Maru, and Table 1 indicates the boat's primary specifications. The Muko Maru is a pleasure craft and is usually used for operational training or for surveying the coastal area.

Figure 2 shows the simplified AIS display system. We stored the received signals from the antenna on a computer and used this information to determine the rhumb line. On the left side is the car navigation system, Sanyo's Gorilla SSD portable navigation system (NV-SD760FT), we used in this study.

Table 1.Primary specifications of Muko Maru

Item	Mukomaru
Lpp (m)	9.33
B (m)	2.54
D (m)	0.89
Δ (ton)	3.4
V (knot)	30
Pw (HP)	270

Figure 2. AIS device used for our test on the "Muko Maru"

To utilize car navigation technology for the sea, it must be limited to a certain distance from the coast.

It is most effective when utilized at very close proximity to the coast. More specifically, it is suitable for sailing in areas where vessel congestion is high and the geography is complicated such as a bay or channel.

Figure 3 shows the Muko Maru's traced route in experimental sailing. We overlaid the ship location data from the AIS onto a satellite image from Google Earth. The Muko Maru departed from the pond at the Fukae Campus of Kobe University's Graduate School of Maritime Sciences and sailed westward along the coast. The ship made a U-turn at Port Island in Kobe Port and followed the same course east. After passing Fukae, it sailed along the Ashiya Canal and made a U-turn at the mouth of the Shukugawa River prior to returning.

In Figure 3, Rokko Island is in the center, Port Island is in the lower left corner, and the mouth of the Shukugawa River is in the upper right corner.

The Muko Maru sailed at approximately 6 knots, with a rotational frequency of approximately 1,000 rpm. Because the Muko Maru is a pleasure boat, it is only capable of travelling at a maximum of 30 knots. At a higher speed, there was significant vertical motion of porpoising that made it difficult to record stable images.

Figure 3. Route of the Muko Maru

Figures 4 (a) and (b) show still images from the video taken while sailing near Rokko Bridge. Figure 4 (a) shows Rokko Bridge and Figure 4 (b) shows waterside warehouses and cranes.

(a) Rokko Bridge to Rokko Island

(b) Waterside warehouses

Figure 4. Video images of the coastal area around Rokko Bridge

Shipping/transportation companies maintain docks on both sides of Rokko Bridge. The width of the waterway is approximately 300 m.

Figure 5 shows the images displayed on the car navigation system while sailing close to Rokko Bridge. The triangle in the bottom center indicates the location of the ship. The thin line coming out of the triangle indicates the sailing course. Figures 5 (a) and (b) show the car navigation system's two-dimensional display and three-dimensional display around Rokko Bridge, respectively. In addition, the names of the bridges and primary locations on land are shown, which would make it easier for ship operators to determine their current location. In addition, the coastal area is clearly indicated. Therefore, the geographical features are clearly represented, enabling the ship operators to recognize the immediate sailing environment. Although Figure 5 (a) indicates primary buildings in several locations, the total number of buildings is less and many buildings are omitted, which is similar to the usage of normal car-based navigation system. We attributed this to a general lack of public roadways in the area, and therefore, detailed information would not be relevant to a car-based navigation system.

Furthermore, Rokko Bridge is identified as a road shown in Figure 5 (b). For a vehicle operator driving over a bridge, the detailed appearance of the bridge is not always necessary information; however, for ship operators, bridges and piers are important navigational details.

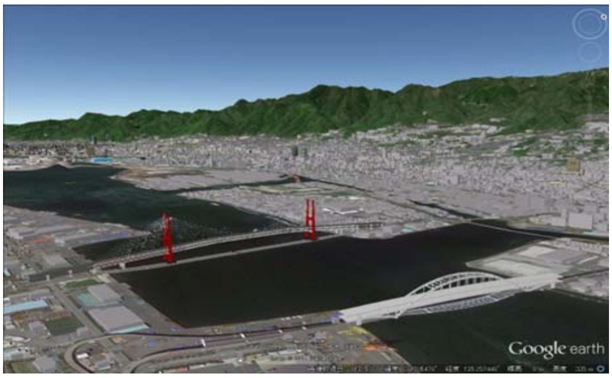
Car navigation systems identify undersea tunnels as roads; however, if they are indicated as such when used for marine navigation, they could be mistakenly identified as bridges. Therefore, proper identification of undersea tunnels is unnecessary information for marine traffic.

(a)Two-dimensional display

(b) Three-dimensional display
Figure 5. Displays on the car navigation system around Rokko Bridge

Figure 6 shows a GIS image of Rokko Bridge and Rokko Island Bridge using a navigation simulator that we have developed. A three-dimensional model was created using SketchUp software that is compatible with ArcGIS. Then, we overlaid the image on a satellite image on ArcGIS. Using GIS with our system, it is possible to overlay bridges, buildings, and navigational aids separately over the geography shown in a satellite image. If we could overlay a three-dimensional image of a bridge over a satellite image using a car navigation system, it would be beneficial to marine navigation.

(a) Image of Roko Island Bridge



(b) Image of Roko Island Bridge and Roko Bridge
Figure 6. GIS 3D Image of Bridges in Virtual Environment

However, Figure 6 does not indicate any navigational aids, such as lighthouses and buoys, primary targets, recommended navigation courses, water depths, sea bottom quality, or other necessary navigational information. Such information is unnecessary for road traffic but important for marine traffic.

Next, we compared a car navigation system with an electronic marine chart. Figure 7 shows the electronic chart of the coastal zone in the course taken by the Muko Maru. It only shows a few pieces of navigational information, such as geography, water depths, lighthouses, and lighted buoys. Therefore, the amount of information that an electronic chart can provide is limited. Normally, ship operators receive basic navigational information from paper charts. In an electronic chart, the detailed information for each navigational aid, such as name, color, and character of each aid, can be provided via text on the right side of the screen upon clicking each aid's icon. If all of the navigational information is provided simultaneously on such a small screen, it would be too complicated to understand.

After we compared a car navigation system and an electronic chart, we found almost no difference other than the amount of navigational information provided. Moreover, the car navigation system indicates more names of locations and buildings, and therefore, is easier to understand.

The navigational information provision system that we have developed can indicate information regarding weather and other marine phenomena. However, currently, car navigation systems are not capable of providing such information. A chart only shows the average tidal flow rates. Therefore, using our GIS would be more useful.

Figure 7. Electronic chart display of sailing area

4 APPLICATION OF CAR NAVIGATION SYSTEM FUNCTION TO A MARINE NAVIGATION SYSTEM

We investigated the car navigation system's functions in detail to determine its effectiveness as a marine navigation system. Our objective is to integrate the advantages of a car navigation system with the GIS navigation system that we are currently developing in an attempt to upgrade the whole system. The GIS is capable of an overlapped displaying with various navigational information that enable the provision of detailed and effective navigational information. When the advantages of a car navigation system are combined with the GIS, it becomes capable of providing more effective information.

The following outlines the results of our investigation of the primary functions of car navigation systems that could be applied to marine traffic (Sanyo Electric Co. 2011).

1 Minimize the difference between the actual and current locations detected on the map because of the errors in GPS satellite frequency caused by autonomous navigation (estimation of the current location by judging the direction of travel using the self-contained gyroscope and speed sensor) and map matching. As with cars, small marine vessels such as pleasure boats have the ability to switch between high and low speed. Therefore, having a function to minimize navigational errors can be an effective navigational aid. The function would be particularly appropriate while sailing in narrow waters such as a harbor.

2 Provide route guidance by displaying a potential route when a destination is specified. Currently, no vessel navigation systems are capable of route finding. A function that considers weather and various ocean phenomena and determines the best and alternative routes would be a useful future endeavor.

3 Determine destination from the data stored in the software upon inputting a telephone number or an address. This function would be useful for commercial vessels entering a port. In addition, when a pleasure boat needs to import at small fishing ports, this function would be highly useful when searching for port information.

4 Indicate names of buildings on the map display when the cursor hovers over each facility (object). Furthermore, upon clicking "Setting" or "Tenant information," tenant information is indicated. These functions have already been implemented in our navigation assistance device. For example, upon clicking on the marine traffic aid icons, such as primary lighthouses and lighted buoys, detailed information on each aid, such as lighting, light characteristic, color, shape, and photos, can be provided. A function that provides additional navigational information would increase the utility of the system.

5 Saving locations and routes to a SD card by accessing a specific website (NAVI) from a computer; the saved data can be displayed on a navigation system. As vessels often take the same route, saving routes would be useful for a marine navigation system as a supplementary log book function.

6 Routes to destinations are searchable. In relation to route guidance, the ability to search and correct routes during navigation would enable more efficient navigation by minimizing travel time and fuel consumption.

7 Provide voice guidance on names of intersections, entrances/exits of highways, names of roads, junctions, etc. Of course, there are no intersections in marine traffic. However, if voice guidance could indicate the estimated distance or time to a veering point, a port of entry, an entrance, or a crossing route, it would be helpful for ship operators to anticipate navigational changes. We are considering installing a voice guidance function in our navigation assistance device.

8 Display an enlarged three-dimensional view and provide route guidance when approaching primary junctions or exits. To assist entering or exiting a port by a specific route, a three-dimensional geographical display would be an effective navigational simulation. Therefore, it would be a useful function to include in a navigation assistance device.

9 Simultaneous criteria-based searches (recommended, toll highways, distance, road width) for different routes to a specific destination. It would be useful if various options for routes were searchable using relevant criteria, such as navigation time, fuel consumption, minimum waiting time, safety level.

10 Display an announcement (sign board) indicating a direction to a national highway or general road during route guidance. The display of general warnings or guideposts for navigation while clearing the Akashi Channel or other narrow aqueducts would be an effective function for a navigation assistance device.

11 Display a virtual three-dimensional intersection during route guidance. If a three-dimensional landscape image is displayed while approaching a veering point, a narrow aqueduct, or a destination port, it would assist navigation and increase security.

12 Display realistic three-dimensional images of buildings in metropolitan areas. Three-dimensional displays of buildings and marine traffic aids that can be navigational targets would help effective verification of these objects.

13 Provide information on traffic congestion in text, diagrams, or map displays. The provision/display

of marine traffic congestion information received from an organization such as Marine Traffic Information Service Center would assist safe navigation.

14 Indicate one-way traffic restrictions. During navigation of a particular route that has regulatory traffic restrictions such as the Kurushima Channel displaying the details of the restrictions could alert ship operators in a timely manner.

15 Display a top-down view of the surrounding area. The ability to view the vessel's location from a three-dimensional top-down perspective would facilitate broader understanding of the surrounding waters. Our navigation assistance device has already adopted this function.

16 Provide map color options. By choosing a particular color, the geography can be expressed more realistically. Our navigation assistance device has already adopted this function for sea bottom geography and water depth displays.

17 Copy and replay music, picture, and video files using self-contained flash memory. Viewing recorded navigational information and simulations, including voice, image, and video data, could be used as an effective training tool.

18 Capable of receiving terrestrial digital television broadcasting through a self-contained tuner. The ability to receive up-to-date weather forecasts and other pertinent information via television signals would be very helpful for navigation.

From the above investigation of car navigation system functions, we consider that a car navigation system could be converted to a marine navigation system. Our proposed marine navigation system would be capable of providing highly useful information if combined with the navigational information that is generally indicated on a marine chart. Furthermore, if all the car navigation system functions are added to the marine navigation assistance device that we have been developing, it would be more effective.

5 CONCLUSION

To improve navigational security and safety, we investigated whether car navigation systems could be applied to marine traffic. The applicability was evaluated through several comparisons of our navigation assistance device using GIS with paper charts, electronic charts, and video images.

As a result, we reached the following preliminary conclusions.

1 A car navigation system is capable of providing three-dimensional geographical information, which is not possible with a two-dimensional chart. A marine navigational system that includes a three-dimensional chart would be useful.

2 A car navigation system has a self-contained GPS. If integrated in a marine navigational system, determining ship speed and position as well as plotting and displaying routes would be possible.

3 With a car navigation system, it is possible to obtain surrounding geographical information. If geographical information such as the location of bridges and buildings was available, we would be able to provide more detailed information than is offered by a generic chart.

4 A car navigation system is not capable of providing necessary navigational information such as water depth, the location of lighthouses, and other navigational aids. If such navigational information could be added to a car navigation system, it could become an effective marine navigation system

5 We found that it would be possible to provide highly effective navigational information by integrating the functions from a car navigation system into the navigation assistance device that we have been developing.

In the future, we will conduct more studies of the effective provision of information to improve navigational security and safety.

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REFERENCE

Gold, C. et al. 2005. 3d geographic visualization: The marine gis. Developments in Spatial Data Handling, *Springer Berlin Heidelberg*, 17-28.

Goralski R.I et al. 2007. The Development of a dynamic GIS for Maritime Navigation Safety, *ISPRS Workshop on Updating Geo-spatial Databases with Imagery & The 5th ISPRS Workshop on DMGISs*, 47-50.

Imazu, H. et al. 2003. Study of the Integration and Presentation of Navigational Information. *The Journal of Japan Institute of Navigation*,109: 133-140.

Japan Coast Guard, 2007. Condition of generation and rescue of marine disaster and accident involving a human life. pp.16-19.

Kawasaki A. 2006. Illustration, Step up for practice of GIS. Kokin Shoin, p.174.

Peng, G et al. 2008. Research on Navigation-aids Information System, International Conference on Cyberworlds (2008):601-604

Sadohara S. 2005. Illustration, Study on Near Example of ArcGIS, Kokin Shoin, p.176.

Sanyo Electric Co. 2011. Manual of SSD Portable-Navigation. No. NV-SD760FT，p.A-14 - A-38.

Shiotani, S. et al. 2011. ON STUDY OF SUP-PORT OF NAVIGATIONAL INFORMATION FOR PREVENTION OF ACCIDENT ON MARINE TRAFFIC IN COASTAL SEA AREA -INFORMATION OF WATER DEPTH-. *Journal of Civil Engineering D3(Infrastructure Planning)* 28: I_1039-I_1047.

Shiotani, S. et al. 2011. STUDY ON NAVIGA-TIONAL SIMULATION FOR SAFTY OF SHIP SAILING IN COASTAL SEA AREA. *Journal of Civil Engineering D2 (Ocean Development)*. 67(72): I_838-I_843.

Wakabayashi, N. et al. 2002. Acquisition and Transfer System for Ship Navigation using IP Net-work – Implementation on T.S. Fukae maru-. *The Journal of Japan Institute of Navigation* 106: 29-37.

Wang, Y. et al.2013. Integration of Google Maps/Earth with microscale meteorology models and data visualization, Computers & Geosciences (2013),23-31