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The Development of Ship Watch Keeping Supporting Aids

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ABSTRACT: This study deals with the development of ship watch keeping supporting aids that will be useful for ship deck officers in recognizing navigational harmful obstacles such as sea marks and small floating objects on the sea. The developed watch keeping supporting aids is made up of four components; a composite video sensor to produce video signal, a laser distance measuring part, a Pan/Tilt part and a central control part. The system was installed in a ship in order to verify its performance of the recognition ability on the sea. The comparison was made between the recognition ability of the system and that of watch keeping deck officers'. The image from the watch keeping supporting system was found to be more recognizable than that of a binocular telescope within a 5 km distance. The newly suggested system is expected to be used to recognize small dangerous floating objects more easily when navigation deck officers have a duty of watch keeping for navigation especially near harbor area.

1 INTRODUCTION

Marine traffic near the Korean sea coast has been increased by economic growth. The increase of marine traffic has caused congestion and has been one of the causes of marine accident [1]. According to the marine accident statistical data from the Korea Coast Guard, the number of marine accidents has increased every year since 2004 showing that 4,172 ships encountered marine accidents between 2004 and 2008. The annual average number of marine accidents in the past five years was 834 [2]. The most frequent marine accident was ship collisions caused by the failure of radar detecting. Human error was a large part of the reason for collision accidents. One of the main reasons of human error is negligence of navigation watching keeping. Therefore, International Maritime Organization (IMO) emphasizes the importance of keeping a navigational watch by regulations [3]

Recently, sea pirate attacks and armed robbery against ships have increased considerably, according to the International Maritime Bureau (IMB) [4]. According to a report from The United Nations International Maritime Organization (IMO) and the IMB, 293 sea pirate attacks were reported and of those 49 ships were kidnapped [5]. The IMO recommends the installation of marine surveillance equipment (Day/Night Vision) to secure navigation safety from pirate attacks and ship collisions [6]. In addition, the United States enacted the ISPS code after the 911 terror attacks and required that ships be equipped with the security and surveillance system [7][8]. Consequently, shipping companies started to install the marine surveillance equipment and the related industrial market is expected to expand gradually. The related regulations was improved [9]

Nowadays, many studies are carried out on navigation visual supporting systems. A study used the data of RADAR ARPA for development of navigation observation system [10][11][12]. According to the E-Navigaton strategic plan of IMO, the importance of maritime situation awareness for safe navigation is emphasized [13]. However the reality is that the major mean of maritime situation awareness is binocular telescopes with the help of ARPA and AIS.

This study describes the development of navigation watch keeping supporting system that can improve recognition ability for navigational harmful obstacles. The system was installed in a ship in order to verify its performance of the recognition ability on the sea. The image from the watch keeping supporting system was found to be more recognizable than that of a binocular telescope within a 5 km distance.

2 CONFUGURATION AND FUNCTION

Radar has been used as one of the essential tools of navigation equipment. However it has trouble recognizing small floating objects on the sea. In case of a binocular telescope, it has limitations of detecting and recognizing floating objects several nautical miles away.

In this study, the navigation visual supporting system was developed to make up for the weakness of existing navigation equipment. Since visual information such as a video image is provided on a monitor, navigators can easily recognize small dangerous objects such as marine marks. The purpose of the system is to improve the recognition ability for maritime situation awareness, one of the important factors for navigation safety on the sea.

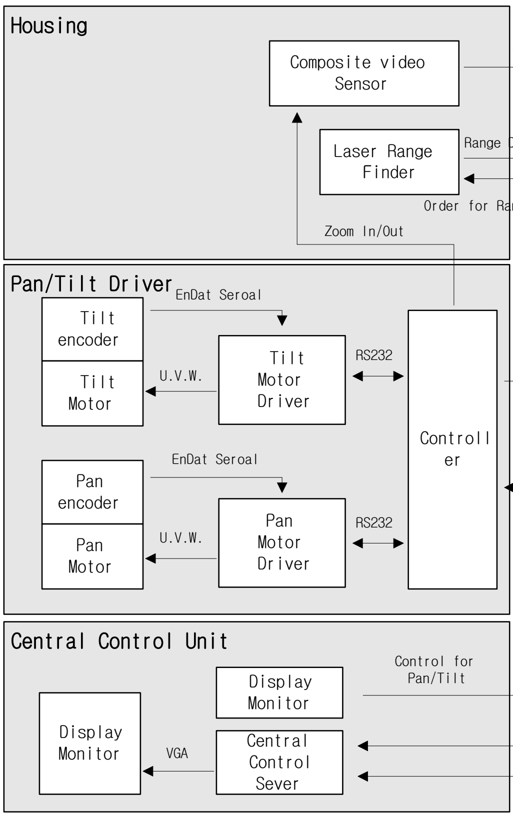

Figure 1. The Operating principle of visual navigational aids

The system provides visual information about dangerous floating objects around a ship using a laser distance measuring technique and video signals from composite video sensors. The system consists of a composite video sensor for video signals, a laser distance measuring unit, a Pan/Tilt unit, and a central control unit. The configuration is shown in figure. 1. The operations of the joy stick in the central control unit give commands to each unit through the controller in the Pan/Tilt unit. Each unit carries out the order according to the signals from the controller of the Pan/Tilt unit.

At this time, the collected data is transferred to the central control unit and the related information such as a target image and the distance between the ship and the target are displayed on the monitor. The particulars of navigation visual supporting system are shown in table 1. The outline and connection between each part are explained in figure 2.

Table 1. Figures of Real time front observation navigation System

Parameter	Unit	Value
Driving range	deg	360
Accuracy of angle	mrad	1mrad
Detection range of rager	m	10,000
Accuracy of distance	m	±5
Power of rager	mJ,ns	4, 30
wavelength of rager	μm	1.54
type of rager	-	Erglass
weight	kg	1.5
Power loss	W	25
loss information	pixel	1.3M
Optical zoom	-	12
Distance of detection	km	< 5.0

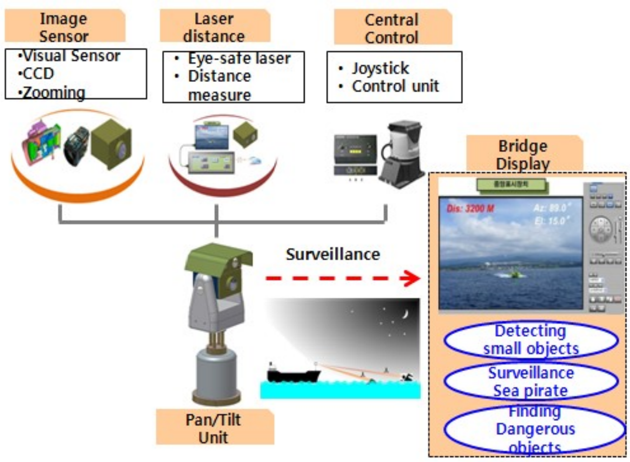

Figure 2. Outline of the system

2.1 *Composite video Sensor*

The Image sensor module for navigation equipment basically has the same observation function compared with a general camera CCD. However, it requires durability and waterproofed structure and design since it is operated in the harsh conditions of sea environment. In addition, visual information connected to ship operations should be provided in real time.

In this study, the composite image sensor is used for the front monitoring and gets the image from camera CCD and LLCCD. With a telephoto lens, magnification can be adjusted appropriately. As shown in figure 3, the image sensor for the front monitoring consists of five main parts. The specifications of each part are explained in Table 2.

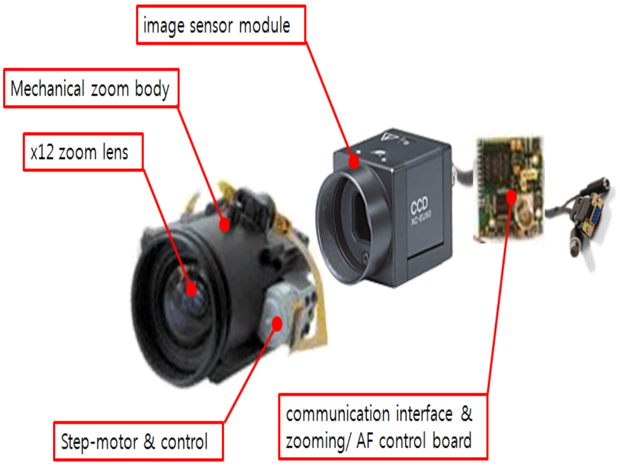

Figure 3. Main element parts of imaging sensor

Table 2. Features of complex imaging sensor

Parameter	Value	Unit
Image Format	½	inch
Focal Length	8~96	mm
Iris	F1.6~1000	Video
Mount Type	C	-
Temp. Range	-10 ~ +50	℃
Size	130×77×87	mm
Weight	1.2	kg
Power	12	VDC
External communication	UART, 12C, SPI	

2.2 *Laser distance measuring unit*

The laser distance measuring unit provides the distance information between targets and a ship. The bearing of the targets can be easily obtained by the Pan/Tilt unit. However, it is necessary to get the distance information from the laser distance measuring unit in order to fix the target's position on a sea chart.

Table 3. Features of laser range finder

Parameter	Value	Unit
Wavelength	1.54	μm
Supply power	5	mJ
Pulse width	30	nsec
Beam divergence angle	0.5	mrad
Repetition ratio	2 (Max.)	Hz
Size	155×110×225	mm
Weight	3.5	kg

The laser distance measuring unit calculates the distance between a target and a ship by measuring the time of flight for a radiated laser. It uses a high output and small pulse laser because it is safer for human eyes. The distance measured by the laser distance measuring unit is more accurate compared to that of existing Radar systems. It has a distance error of less than several meters. Besides, this unit has the advantage of being compact and light.

In this study, the laser distance measuring unit detected and recognized small floating objects and ships within 10km. The specification of the laser distance measuring unit is explained in table 3.

2.3 *Pan/Tilt unit*

The navigation visual supporting system is required to detect dangerous objects from every direction.

The Pan/Tilt unit enables the system to move vertically and to rotate a full 360-degree. The unit consists of an observation window, controlling algorithms, a drive, and a special housing that protects the system in the harsh conditions of a sea environment. Figure 4 shows the main body of the developed Pan/Tilt unit. The image signal sensor and the laser distance measuring unit are mounted inside the housing. A type of slip ring was adopted in the rotary Pan to secure rotary motions. The specification of the Pan/Tilt unit is shown in Table 4.

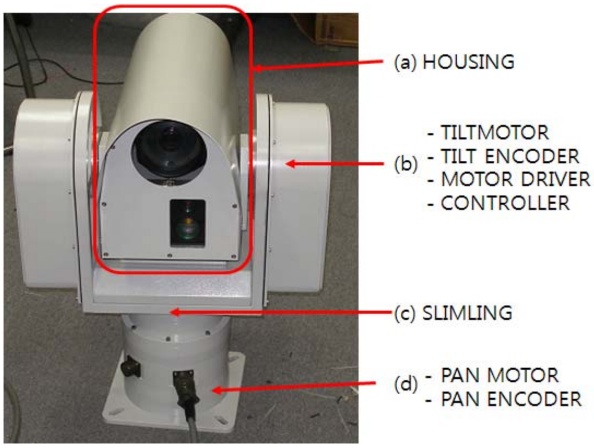

Figure 4. Body of Pan/Tilt

Table 4. Features of Pan/Tilt

Parameter	Value	Unit
Acuator	DD(Direct drive) SERVO SYSTEM	-
Supply power	85V AC ˜ 265V AC	V AC
Action speed	PAN : 0.1~90 TILT : 0.1~40	°/sec
Driving range	PAN : 360 Endless / TILT : -30~+30	°
Temp. Range	-40 ~ +50	°c
Size	530(L) X 280(W) X 390(H)	mm
Weight	60	Kg
Texture	SUS316, AL6061	-
Optical device	f:10~500mm vidual zoom camera	-
Type of Control Signaling	RS-422	-
Signaling speed	9600bps	-
Type of protocol	PELCO-D	-
Software	GUI Software	-

2.4 *Central control unit*

The central control unit receives distance information and bearing data from the laser distance measuring unit and the composite image sensor unit respectively. The information is displayed on the monitor of the central control unit. The monitor also displays the visual image detected by the composite image sensor. Figure 5 shows the central control unit that consists of a monitor, a joystick controller, a control server, and a rack. Each part is accommodated in the rack.

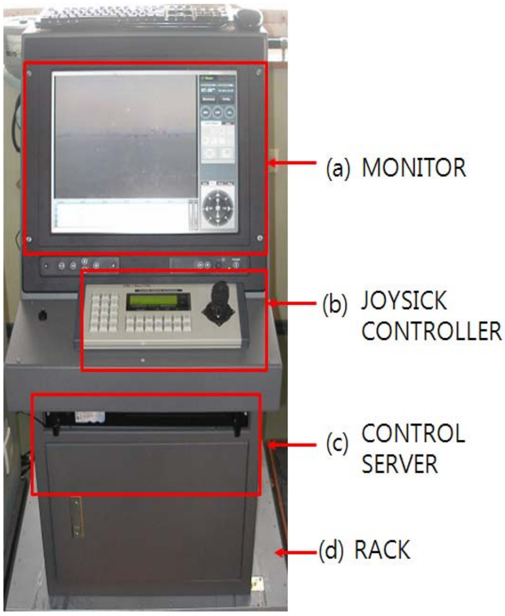

Figure 5. Central Controller

2.4.1 *Monitor*

A marine type monitor is adopted in order to identify the screen data more easily in navigation environments. The monitor display consists of a main screen and menu tools that enable users to zoom in and out of the main screen. Figure 6 shows the picture of the monitor and its specification is shown in table. 5.

Figure 6. The monitor of Central Controller

Table 5. Features of the monitor of central controller

Parameter	Value	Unit
Size	20.1	inch
Active Area	408*306	mm
Resolution	1600 * 1200	dpi
Contrast	300:1	-
Light	250	Cd/m
Field of View	85	°

2.4.2 *Keyboard*

The keyboard of this system has multi-function controls since it is specifically designed to control a CCTV system. A receiver can control the Pan/Tilt motions, its power systems and the laser distance measuring unit. The status of the system is displayed on the LCD monitor. The details of the keyboard and its specification is shown in table 6.

Table 6. Features of the Joystick of central controller

Parameter	Value
Type of Control Signaling	RS232 , RS485 , RS422
Preset	256
Step of Control Speed	10
Supply power	12

2.4.3 *Control sever*

The control server receives an analog image signal from the composite image sensor. The analog image is saved in a built-in HDD using the compression algorithm of the H. 262. The control server displays the saved image in the monitor in real time. The saved image can be replayed and searched by the built-in software. The control software displays split screens and provides several functions like the control of Pan/Tilt through the GUI, the logging of status data, the adjusting of a search range, and the display of a laser distance. The specification is shown in table 7.

Table 7. Features of the control sever

Parameter	Values
Type of Processor	Intel CoreTM 2 duo
HDD	2.5” 160
Embedded Cache	256KB ´ 4, L2
processor FSB	1333
Main Memory	2 x 240-pin DDR2 667 to 2.0GB.
Onbord Lan Features	Two Realtek RTL8111C PCI Express Gigabit controllers
Audio Features	Realtek ALC662 High Definition audio CODEC

3 SEA TRIAL TEST

Sea trial test were carried out in order to verify the performance of the system. One of the training ships of Mokpo maritime university was used for the sea test in the area between Mokpo and Kwang-Yang.

3.1 *The installation of the system on board*

The Pan/Tilt was mounted on the campus deck, the highest floor on the training ship, in order to easily detect targets from a high position. The central control unit was installed on the bridge deck where navigation officers watch the image on the system’s monitor. Figures 7 and 8 show the Pan/Tilt unit on the campus deck and the central control unit on the bridge deck.

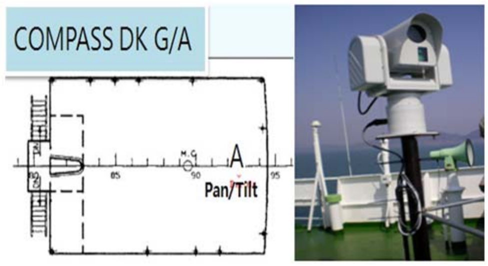

Figure 7. The Pan-tilt on compass deck

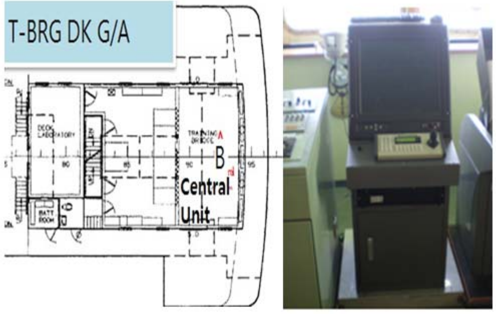

Figure 8. The central controller in the bridge

3.2 *The result of sea trial tests*

The sea trial tests were carried out on the condition of the weather and the sea state as shown in Table. 8.The arrangement of the targets and the ship is indicated in figure 9.

First, lighthouses and sea marks were designated as targets of which distances were measured by radar and a sea chart. Then, these targets were detected by the system and their images were displayed on the monitor in order to verify the system's recognition ability. Finally, the images were compared with that of a binocular telescope and naked eyes. The details of targets are shown in table. 9.

The detected images from the system are shown in figures 10 -13.

Target A in table 9 was a lighthouse 5200m away from the sea trial ship. The target was dimly visible but not clearly recognizable by a binocular telescope and naked eyes at that time. However it was found that the system provided the image as shown in figure 10 where the target was more recognizable. Target B in table 9 was a small lighthouse which was not visible with naked eyes at the distance of 3700 meters. A vague figure was just seen even by a binocular telescope. However, the system showed more a clear and recognizable image as shown in figure 11. The image provided by the system made it possible to recognize the target as a lighthouse.

Target C and D in table 9 were small floating sea marks. It was relatively difficult to recognize these targets with naked eyes or a binocular telescope. Figure 12 shows the image of the target C obtained by the system. It was possible to recognize the target at the distance of 3300 meters. The image of Target D is shown in figure 13. It was easily recognizable by the system at the distance of 5370 meters. The results of the sea trial tests indicated that the images from the system were more clear and recognizable than that of a binocular telescope within a 5 km radius. The system detected and recognized the targets more effectively and easily compared to a binocular telescope or naked eyes.

These tests indicated that the developed system could be used to recognize small buoys or dangerous floating objects in a harbor area more easily and quickly

Table 8. The state of sea

Items	Dimensions
Sea Condition	Beaufort Scale 3
Wind Seed	5 knot
Visibility Scale	4
Sea Wave	0.6 m

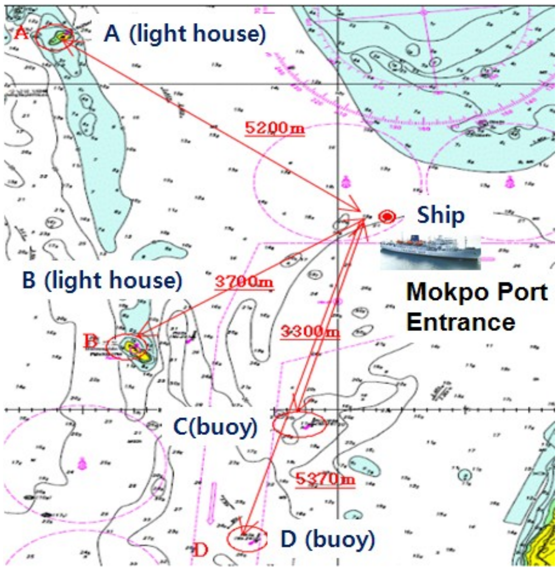

Figure 9. The arrangement of targets

Table 9. The features of targets

	Target-A	Target-B	Target-C	Target-D
Type	Light house		Lighted Buoy	
Distance(m)	5200	3700	3300	5370
Height(m)	11	9.3	5.6	5.6
Breath	4-5	2.3	2.0	2.0

Figure 10. The snapshot of target A

Figure 11. The snapshot of target B

Figure 12. The snapshot of target C

Figure 13. The snapshot of target D

4 CONCLUSIONS AND FUTURE WORKS

This study described the developed navigation visual supporting system which will improve maritime situation awareness. The system has the merit of showing targets in a monitor visually and recognizing small targets in real time. It could be used to make up for the weakness of existing Radar, since Radar can't provide any information about the recognition of targets.

The developed system was mounted in a training ship for sea trail tests to evaluate the recognition ability for buoyage and lighthouses. The images from the system were compared with that of a binocular telescope. It was found that the images from the system were more clear and recognizable than that of a binocular telescope within a 5 km radius. The developed system could be used to recognize small buoys or dangerous floating objects in a harbor area more easily and quickly.

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