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Underwater Localization and Communications for Abandoned, Lost and Discarded Fishing Gears (ALDFG) Monitoring based on ICT

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Abstract*— In water, ultrasonic waves have a property of transmission loss less than electromagnetic waves. In this paper, we propose the use of underwater ultrasonic waves to identify the position of the fishing gear and ALDFG monitoring due to these physical properties. The basic properties and design parameters of the ultrasound used are mentioned in the introduction of this paper. Ultrasonic transceiver systems designed using the mentioned variables are also introduced. The underwater information collected by these systems is connected to ICT-based ALDFG monitoring system and provided to the user in various forms. This has already been announced in [1].

***Index Terms*— Underwater Localization, ultrasonic waves, ALD Fishing Gear, IoT, Fishing Gear Management.**

I. INTRODUCTION

When the ultrasonic signal is transmitted to the underwater space, the time difference between the transmission signal and the reception signal includes the distance information, and the phase difference of the signal includes the azimuth information of the reflection position.

At this time, when the distance becomes longer, the reflection signal becomes very weak, which makes the detection itself difficult. To solve this problem, we use a pinger. By placing the pinger that reflects the ultrasonic waves at a specific target position, it is possible to extract more distant position information.

Here, if the transmission frequency is increased, the wavelength of the signal is shortened, and the distance accuracy is further increased. However, if the signal frequency is high, there is a disadvantage that the underwater transmission loss is increased. Therefore, the typical frequency band for measuring distances of several kilometers in water is several hundreds of Khz or less. A practical acoustic positioning system is divided into LBL (Long Baseline), USBL (Ultra Short Baseline) and SSBL (Super Shot Baseline) depending on the position and position of the receiving sensor to extract azimuth information and we use USBL method for the underwater localization.

As shown in Fig. 1, when the TX is transmitted in order to obtain the position information of the pinger, the ultrasonic waves transmitted from the TX are received by the pinger after a predetermined time. Then, when the pinger responds and transmits the signal back, it can detect the phase difference (dt1) of the received waveform between hd1 and hd2. At this time, the phase difference reflects the sound velocity in the water, and the sound velocity (C) in the water is known to be about 1500 m / s. There is a difference of about 10% depending on the used frequency, the salt concentration and the water temperature.

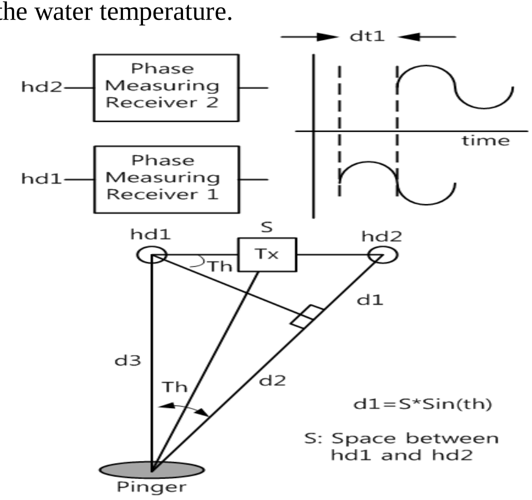

Fig. 1 Azimuth information by time delay

The direction of ultrasonic propagation follows the physical Snell's law. According to the law, the ultrasonic propagation direction is bent depending on the water temperature distribution in the water. These results may also cause spatial coordinate errors in distance information. Such spatial coordinate errors are corrected using the information of the orientation correction sensor, the GPS, and the gyro sensor.

In addition, noise due to aquatic organisms such as whales or crustaceans may also be a problem when receiving a weak ultrasonic signal, and screw noise may cause a strong error that cannot be measured. However, the strong noise of the screw itself is mainly distributed in low frequency band of several Khz or less, several hundred Hz, and has periodicity and is easily removed by digital filtering.

Also, the bubbles (underwater vacuum) that occur naturally or artificially in the water cause strong scattering and reflections in the water, interfering with the progress of the ultrasonic wave, and in some cases such bubbles cause problems by floating in water for several seconds to several seconds. Over time, relatively large bubbles will disappear, but small bubbles of a few um long will cause a lot of errors in devices that use high frequencies in excess of hundreds Khz. In most practical equipment, the error is displayed on the monitor and the error inducing environment is specified. However, not all environmental factors can be taken into consideration, and it is important for the operator to understand the specific characteristics at sea and use the equipment.

II. PROPOSED UNDERWATER LOCALIZATION SYSTEM

Fig. 2 shows a circular array USBL system proposed in practice. The transmitting sensor is a single spherical type and the acoustic energy is transmitted in all directions, and the circular array receiving sensor geometrically detects the phase difference of the receiving signal. This structure is simple structure and convenient to install and maintain.

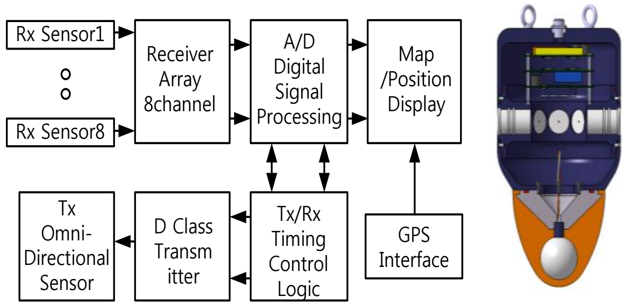

Fig. 2 Functional block of receiver system

This structure is suitable for implementation of ALDFG monitoring system, and it is convenient for positioning by mounting on fishing and management vessel. Actually, the transmit sensitivity (TVR) of the spherical sensor is about 135dB, and the receiving sensitivity (RVR) of the receiving sensor is about -195dB.

The gain of the preamplifier connected to the receiving sensor is about 80dB. The preamplifier also has a band-pass filter at the beginning to remove noise from the received waveform to maintain system reliability. Regarding the noise problem, the structure of the receiver has an array structure, which maintains a very good noise ratio compared to a single receiving sensor structure.

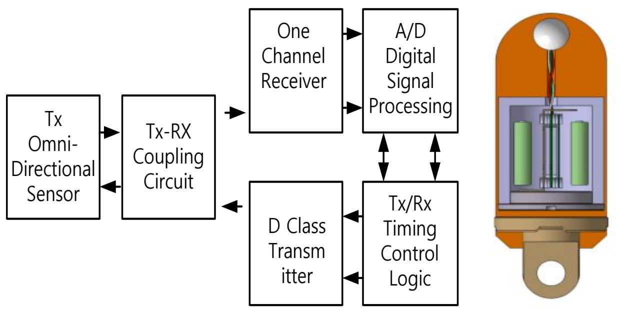

Fig. 3 Functional block of pinger system

Fig. 3 shows the simple structure of the pinger and a large number of pingers will be installed at fishing gears in practical use. These pingers are composed of a spherical sensor for transmitting and receiving ultrasound, a transmit and receive switch, D-class switching transmitter, a receiver, and a signal processing modules. The total power consumption is several mW and has a survival period of 2 months or more. In order to save battery power, the transmission duty is adjusted and the receiver operates with the minimum power consumption condition. Mechanically, the outer case is also one of the important factors that make the structure strong in the underwater environment. On the surface of the ultrasonic sensor, marine organisms stick together over time. Under these conditions, ultrasonic waves are difficult to radiate and reception sensitivity is also reduced. Therefore, it is necessary to apply a thin coating on the ultrasound emission surface to prevent microorganisms from sticking, and after a certain period of time, clean this area cleanly. In addition, ultrasonic waves may slowly penetrate the water surface, which may degrade the performance of the sensor. Usually, life in water is about 7 years. The ultrasonic wave emitting surface uses epoxy resin as rubber, which is similar to underwater impedance.

III. RELATED ISSUES

Establishment of fishery management system becomes an emerging problem, to monitor, restrict fishing gears (FG) over-usage and control the abandoned, lost and discarded fishing gears. Although fishing gear marking standards are expected to be determined around Feb. 2018 by UN/FAO, the technical challenges remain to implement the standard guidelines of the FG marking and subsequent realistic management. As a consequence, development of the FG management system is expected to enable responsible fishing and sustainable fishery. It's noteworthy that the last decade observed a dramatic evolution in the information and communication technologies (ICT), over the broad range from high-speed electronics and source sensor devices, low-cost wideband internet of things (IoT), visualization based on big data and user experience (UX) techniques, to artificial intelligent (AI) learning and semantic awareness techniques.

The sources of the FG information correspond to the terminal sensor devices, typically attached with a buoy, and the management system monitors the ownership, status and information of fishery-centric sensors as variables.

In this paper, for the problem of development of automatic identification buoy (AIB) monitoring system, and propose an approach to IoT-based solutions enabling smart monitoring of underwater/surface monitoring of the Abandoned, Lost and Discarded Fishing Gears.

A. Technical Issues of Fishery Management

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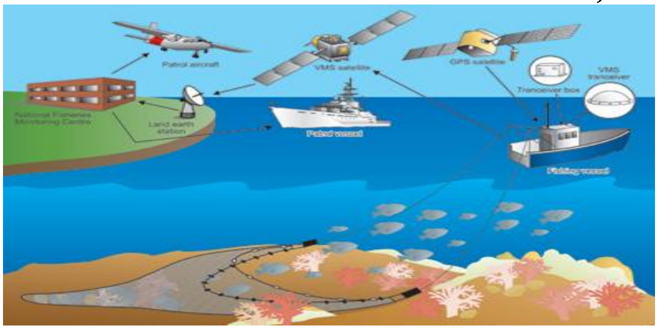

Fig. 4 Known concept of fishery management systems

The fishery management system, shown in Fig. 4, includes fishing gears, floating buoys, fishery boats, inspection vessels and land-based monitoring system.

Table 1 Objectives of the monitoring system and corresponding techniques

Objectives	Technology needed
Ownership identification	Marine IoT communications Buoy fabrication
TX and processing control	FG identification Underwater/surface communications
Situation control	ALD situation awareness Situation context processing
Visualization and monitor	Identification monitor User satisfaction implementation

Managing while fishermen are under fishing activities means whether fishery activities are under control in the sense of legality or responsibility, to keep the Ocean sustainable. Technically, the monitoring systems have multiple objectives shown in Table 1, which can be classified into 3 distinctive engineering areas such as 1) underwater localization and communications, 2) surface communication networks, and 3) autonomous situation awareness, and visualization and control.

B. Autonomous Situation Awareness and Visualization

Information may be gathered from the buoy during either underwater or surface fishing while the stakeholders may reside at the float buoys, fishery boats, inspection vessels and ground fishery/safety monitoring systems. Additionally, Identification, location and status of FG are the basic information for monitoring while fishing or ALD situations, and the information need to be properly conveyed, displayed and controlled for value fishery, especially when unusual events have been acquired, like theft, lost and out-of-control situations. For two scenarios of regular fishing and unusual situations, fishermen's attitudes are quite different for the monitoring system: the strong against for the former, and the mild for the latter. Considering those former attitudes, visualization and monitoring should seriously consider the privacy issues, not to hurt the property of each fisherman, or, the monitoring system may have trouble while deploying and operating. Further latter, simple improvement of visualization is not sufficient, and more added values should be demonstrated to persuade the meaningful public and safety services of the monitoring system. Prompt notification of any unwanted event, proper localization and tracking of the fishery gear assets, and smart support to handle and carry the unwanted situations, financially and socially.

There exist already several display and control solutions for ocean vessel safety and maritime management system, mainly aware of human lives, vessel safety and container tracing, such as e-Navigation and AIS. Similarly, more things including buoys and fishing gears can be monitored and augmented with prioritized services depending on the design specifications. The specification basically works as it is, and additional low priority things could be served if the communications resources are available, while conventional maritime safety services are guaranteed. Further emergent situations related to fishery could be reactively served on demand.

In Fig. 5, the monitoring system consists of two parts: one for physical components for the fishery and the other for the ICT-based fishing gear monitoring system for efficient fishing gear management. Note that the things in Fig. 5 have been conceptually extended to include AIBs, additionally to the AISs.

Fig. 5 Concept of the fishing gear monitoring

The physical components are similarly composed of various entities for traditional fishery, such as fishing nets, gears and fishery boats, coastal guard boats and land-based fishery safety management offices. The physical components of fishery already uses VHF communications, Cellular systems, fishery navigation and mapping systems to manage the maritime safety. however, those complex systems are very complicate and inconvenient to use due to its naturally evolution and unorganized patching. Fortunately, e-navigation projects are just imagined to provide seamless and up-to-date maritime services, and the subsequent services will be provided for the fishing gear issues, considering that the abnormal control of the lost and discarded fishing gears leads to maritime safety.

Fig. 6 Visualization stand and an example of full-scale display and site

The ICT-based fishing gear monitoring system includes underwater/surface sensors pertaining to a net, by using Automatic Identification Buoy (AIB), and IoT-based network management system. In Fig. 4, there are physical components such as 1) FG Identification Buoy electronics including communication modules for buoy and boats, 2) Buoy mechanical chassis, 3) Buoy embedded controller and 4) FG-specific Buoy antenna. The acquired information needs to be visualized in such diverse displays as i) fishermen's smart terminals, ii) coastal inspectors' pad, iii) dashboard on land, and iv) full-scale AIB control center for maritime safety, etc. One example of the full-scale display and the land-based site is shown in Fig. 6.

IV. RESULTS

In the water, ultrasonic waves are used as information transmission means. In order to confirm the position of the fishing gears installed in the water, we proposed the ultrasonic transmission and reception equipment. Also, this paper proposes an approach to 5G-based solutions enabling smart monitoring of underwater/surface monitoring of the Abandoned, Lost and Discarded Fishing Gears, for the development of automatic identification buoy (AIB) monitoring system. The FG management is classified into 3 distinctive engineering areas such as 1) underwater localization and communications, 2) surface communication networks, and 3) autonomous situation awareness, and visualization and control. The system is expected to provide information about the ownership, type and location of fishing gears. Subsequently, it will promote responsible and effective fishing by FG marking, reinforce the applicability of fisheries control measures including regulations, and effective resources control [1].

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