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Sonar Communication

Prachi Mishra

Department of Electronics & Communication, Shri Sant Gadge Baba College of Engg and Technology, India

prachimishra817@gmail.com

Abstract

This Paper presents overall views on SONAR Communication Technology. In this paper we will Highlight on some of the Points, like its Applications , Advantages / uses , Types etc. and we'll see the Working of SONAR. But before that we would like to introduce about SONAR technology in brief.

The term sonar is also used for the equipment used to generate and receive the sound. Sonar (originally an acronym for Sound Navigation And Ranging) is a technique that uses sound propagation (usually underwater, as in Submarine navigation) to navigate, communicate with or detect other vessels. Two types of SONAR mainly Active and Passive , are described in our Paper. Both of these are used as a means of acoustic location and of measurement of the echo characteristics of "targets" in the water.

In its Application we'll see , how it works for Mapping the Seafloor , Determining Water Depth , Locating Fishes…etc. Next , we'll see the Future of this Technology. I have tried to Give a Simple and Clear Idea about SONAR Communication technology in this Paper.

Introduction

SONAR is a type of sound wave propagation technology that is used worldwide and has many applications. The Word SONAR Stands For Sound navigation And Ranging. There are two different types of sonar: Active and Passive.

Active sonar is the process of emitting pulses of sound ("pings") and measuring the time it takes for them to bounce off of objects and return in order to calculate object distances. It may be launched by a submarine under attack to raise the noise level, provide a large false target, and obscure the signature of the submarine itself. Passive sonar is listening for sounds generated by various objects. The frequencies used in sonar vary from very low to extremely high. Passive (i.e.,non-powered) counter measures include:

1. Mounting noise-generating devices on isolating devices.
2. Sound-absorbent coatings on the hulls of submarines, for example anechoic tiles.

In the 19th century an underwater bell was used as an ancillary to lighthouses to provide warning of hazards. The use of sound to 'echo locate' underwater in the same way as bats use sound for aerial navigation seems to have been prompted by the Titanic disaster of 1912. The world's first patent for an underwater echo ranging device was filed at the British Patent Office by English meteorologist Lewis Richardson a month after the sinking of the Titanic, and a German physicist Alexander Behm obtained a patent for an echo sounder in 1913

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The Canadian Engineer Reginald Fessenden, while working for the Submarine Signal Company in Boston, built an experimental system beginning in 1912, a system later tested in Boston Harbor, and finally in 1914 from the U.S. Revenue (now Coast Guard) Cutter Miami on the Grand Banks off Newfoundland Canada.

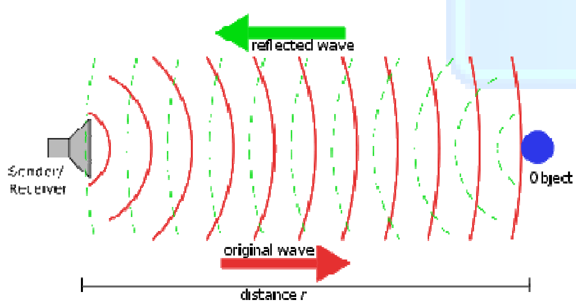
During World War I the need to detect submarines prompted more research into the use of sound. The British made early use of underwater hydrophones, while the French physicist, working with a Russian immigrant electrical engineer, worked on the development of active sound devices for detecting submarines in 1915 using quartz. Although piezoelectric and magneto stricture transducers later superseded the electrostatic transducers they used, this work influenced future designs. Lightweight sound-sensitive plastic film and fibre optics have been used for hydrophones..

During the 1930s American engineers developed their own underwater sound detection technology and important discoveries were made, such as thermo clines, that would help future development. After technical information was exchanged between the two countries during the Second World War, Americans began to use the term SONAR for their systems

Working Of Sonar System

Sound wave sent outward: Animals noises made with their bodies, seismic –explosions or impact plates, ultrasound – transducer converts sound to electricity and back, ships "ping" or emit a burst of acoustic energy.

Sound waves returned: Animals – waves sensed through ears (bats) or teeth and bones (whales), seismic – waves sensed through geo-phones, ships – waves sensed by hydrophones or (next)



- Any listening system that consist of
  - (1) a hydrophone
  - (2) an electronic receiver
  - (3) a bearing indicator
  - (4) a speaker or headphones.

The two different types of sonar are :

Active Sonar

Active sonar gives the exact bearing to a target, and sometimes the range. Active sonar works the same way as RADAR. A signal is emitted. The sound wave then travels in many directions from the emitting object. When it hits an object, the sound wave is then reflected in many other directions. Some of the energy will travel back to the emitting source. The echo will enable the sonar system or technician to calculate, with many factors such as the frequency, the energy of the received signal, the depth, the water temperature, the position of the reflecting object, etc

Active sonar is similar to radar in that, while it allows detection of targets at a certain range, it also enables the emitter to be detected at a far greater range, which is undesirable.

Active sonar creates a pulse of sound, often called a "ping", and then listens for reflections (echo) of the pulse. This pulse of sound is generally created electronically using a sonar Projector consisting of a signal generator, power amplifier and electro-acoustic transducer /array. A beam former is usually employed to concentrate the acoustic power into a beam, which may be swept to cover the required search angles .Occasionally, the acoustic pulse may be created by other means, e.g. (1) chemically using explosives, or (2) Air guns or (3) plasma sound sources.

One useful small sonar is similar in appearance to a waterproof flashlight. The head is pointed into the water, a button is pressed, and the device displays the distance to the target. When active sonar is used to measure the distance from the transducer to the bottom, it is known as echo sounding. Similar methods may be used looking upward for wave measurement.

Active sonar is also used to measure distance through water between two sonar transducers or a combination of a hydrophone (underwater acoustic microphone) and projector (underwater acoustic speaker). A transducer is a device that can transmit

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and receive acoustic signals ("pings"). When a hydrophone /transducer receives a specific interrogation signal it responds by transmitting a specific reply signal. To measure distance, one transducer /projector transmits an interrogation signal and measures the time between this transmission and the receipt of the other transducer/ hydrophone reply. The time difference, scaled by the speed of sound through water and divided by two, is the distance between the two platforms. This technique, when used with multiple transducers/ hydrophones/ projectors, can calculate the relative positions of static and moving objects in water.

Passive Sonar

Passive sonar listens without transmitting. It is often employed in military settings, although it is also used in science applications, *e.g.*, detecting fish for presence/absence studies in various aquatic environments. In the very broadest usage, this term can encompass virtually any analytical technique involving remotely generated sound, though it is usually restricted to techniques applied in an aquatic environment.

Although, Passive sonar on vehicles is usually severely limited because of noise generated by the vehicle. For this reason, many submarines operate nuclear reactors that can be cooled without pumps, using silent convection, or fuel cells or batteries, which can also run silently. Vehicles' propellers are also designed and precisely machined to emit minimal noise. High-speed propellers often create tiny bubbles in the water, and this cavitations has a distinct sound.

Unlike active sonar, only one way propagation is involved. Because of the different signal processing used, the minimum detectable signal to noise ratio will be different.

Passive sonar has several advantages. Most importantly, it is silent. If the target radiated noise level is high enough, it can have a greater range than active sonar, and allows the target to be identified. Since any motorized object makes some noise, it may in principle be detected, depending on the level of noise emitted and the ambient noise level in the area, as well as the technology used. To simplify, passive sonar "sees" around the ship using it. On a submarine, nose-mounted passive sonar detects in directions of about 270°, centered on the ship's alignment, the hull-mounted array of about 160° on each side, and the towed array of a full 360°. The invisible areas are due to the ship's own interference. Once a signal is detected in a certain direction (which means that something makes sound in that direction, this is called broadband detection) it is possible to zoom in and analyze the signal received (narrowband analysis).

Another use of passive sonar is to determine the target's trajectory. This process is called Target Motion Analysis (TMA), and the resultant "solution" is the target's range, course, and speed. TMA is done by marking from which direction the sound comes at different times, and comparing the motion with that of the operator's own ship. Changes in relative motion are analyzed using standard geometrical techniques along with some assumptions about limiting cases.

Passive sonar is stealthy and very useful. However, it requires high-tech electronic components and is costly. It is generally deployed on expensive ships in the form of arrays to enhance detection. Surface ships use it to good effect; it is even better used by submarines, and it is also used by airplanes and helicopters, mostly to a "surprise effect", since submarines can hide under thermal layers. If a submarine's commander believes he is alone, he may bring his boat closer to the surface and be easier to detect, or go deeper and faster, and thus make more sound.

Welfare

Modern naval warfare makes extensive use of both passive and active sonar from water-borne vessels, aircraft and fixed installations. The relative usefulness of active versus passive sonar depends on the radiated noise characteristics of the target, generally a submarine. Although in World War II active sonar was used by surface craft—submarines avoided emitting pings which revealed their presence and position—with the advent of modern signal-processing passive sonar became preferred for initial detection. Submarines were then designed for quieter operation, and active sonar is now more used.

Applications

1. **Mapping the Seafloor**

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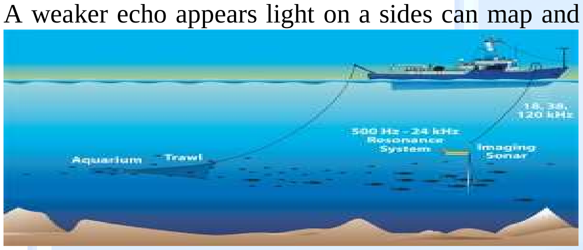
Maps of the sea-floor geology identify the locations where fine-grained sediment and associated contaminants accumulate. Remote-sensing techniques such as side-scan sonar and high-resolution seismic reflection profiling allow detailed mapping of the texture and distribution of sediment types on the sea floor on a regional basis. Side-scan sonar is a method used to map the seafloor.

The strength or intensity of the returning acoustic signal is recorded and this is important because it provides a hint as to what kind of sediment makes up the seafloor. A strong signal means the substrate is relatively hard or contains a lot of texture. Hard surfaces appear dark on the side-scan map and indicate a wreck, a shell, coral, or even shrimp mounds.

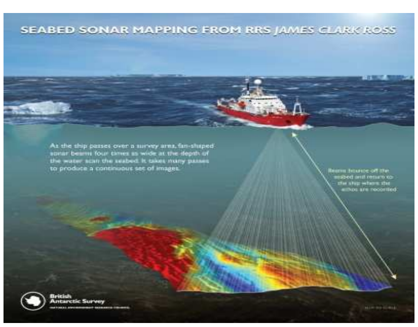
A weaker echo appears light on a sides can map and



indicates a soft or finer surface such as silt and sand.

2. Determining Water Depth

Oceanographers also make use of sonar technology in their line of work quite often. They can use this technology to map out the ocean floor. An echo-sender sends an acoustic pulse directly the seabed and the time it takes for the pulse to reach the bottom and come back to the vessel determines the depth. The sound pulse is generated by a transducer that emits an acoustic pulse and then "listens" for the return signal to determine the depth. Then return signal is recorded and converted to a depth measurement by calculating the speed of sound in water.



3. Locating Fish

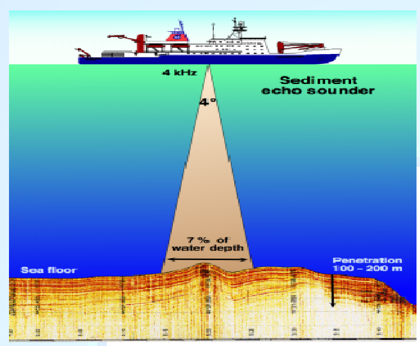
Fisheries is an important industry that rely heavily on sonar for locating fish considering sound travels faster and longer underwater. Passive sonar is used for locating fish and it listens without transmitting sound. Sound waves travel differently through fish than water because a fish's air-filled swim bladder contains a different density than seawater. Biomass estimation uses sonar to detect fish and as the sound pulse travels through water it

encounters objects that are of different density than the surrounding medium, such as fish, that reflect sound back toward the sound source. These echoes provide information on fish size, location, and abundance.

Fishermen also use active sonar and echo sounder technology to determine water depth, bottom contour, and bottom composition

4. Submarine navigation

Submarines rely on sonar to a greater extent than surface ships as they cannot use radar at depth. The sonar arrays may be hull mounted or towed. Information fitted on typical fits is given in Oyashio class submarine and Swift sure class submarine.



5. Ocean surveillance

For many years, the United States operated a large set of passive sonar arrays at various points in the world's oceans, collectively called Sound Surveillance System (SOSUS) and later Integrated Undersea Surveillance System (IUSS). A similar system is believed to have been operated by the Soviet Union. As permanently mounted arrays in the deep ocean were utilised, they were in very quiet conditions so long ranges could be achieved. Signal processing was carried out using powerful computers ashore. With the ending of the Cold War a SOSUS array has been turned over to scientific use.

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In the United States Navy, a special badge known as the Integrated Undersea Surveillance System Badge is awarded to those who have been trained and qualified in its operation.

6. Aircraft

Helicopters can be used for antisubmarine warfare by deploying fields of active/passive son buoys or can operate dipping sonar, such as the AQS-13. Fixed wing aircraft can also deploy son buoys and have greater endurance and capacity to deploy them. Processing from the son buoys or dipping sonar can be on the aircraft or on ship. Helicopters have also been used for mine countermeasure missions using towed sonar such as the AQS-20A

Fig. AN/AQS-13 Dipping sonar deployed from an H-3 Sea King.

Underwater Communications And Security

Dedicated sonars can be fitted to ships and submarines for underwater communication. See also the section on the underwater acoustics page

Underwater security: Sonar can be used to detect frogmen and other scuba divers. This can be applicable around ships or at entrances to ports. Active sonar can also be used as a deterrent and/or disablement mechanism. One such device is the Cerberus system.

Hand-Held Sonar

Limpet Mine Imaging Sonar (LIMIS) is a hand-held or ROV-mounted imaging sonar designed for patrol divers (combat frogmen or clearance divers) to look for limpet mines in low visibility water. The LUIS is another imaging sonar

for use by a diver. Integrated Navigation Sonar System (INSS) is a small flashlight-shaped handheld sonar for divers that displays range.

Intercept Sonar

This is a sonar designed to detect and locate the transmissions from hostile active sonar's. An example of this is the Type 2082 fitted on the British Vanguard class submarines.

Each sensor is equipped with one or more acoustic transducers depending on its specific function. Data is transmitted from the sensors using wireless acoustic telemetry and is received by a hull mounted hydrophone. The analog signals are decoded and converted by a digital acoustic receiver into data which is transmitted to a bridge computer for graphical display on a high resolution monitor.

Disadvantages

All the Great Inventions have Some Disadvantages . Even This Technology Carries Some of it, Although its very Few, but we can't neglect it.It has been discovered that high powered sonar may harm animals,(research still needs to be completed). Marine animals such as whales and dolphins use echolocation to find predators and prey. Echolocation acts like sonar and it may actually confuse or harm the animals if sonar is used. The fear by many biologists is that the sonar will confuse the animals and prevent them from eating or mating.But, now there are laws to protect these animals through the National Environmental Policy Act, the Marine Mammal Protection Act, and the Endangered Species Act

Drawback

However, there is one drawback to the invention of the acoustic mine that disturbs its effectiveness. Its ability to accumulate dirt and other sea organisms is quite intense meaning that at anytime it may fail to work or detonate on accident

Future Of Sonar Technology

a. Technology and Applications

Currently, researchers are looking for new and better ways to improve sonar technology. Sonar has important applications in the sciences as well as the military. We can learn more about the earth by using sonar to map out the ocean floor while perhaps discovering new species lurking in the depths in the process. Ensuring the United States of protection from threats of foreign enemy submarines is a top priority. Advancements in SONAR technology will further minimize the risk of attack on US ships.

An important implication of sonar technology is its effect on marine life. Whales and other creatures use sound to navigate the waters, find food, and other such things. Sonar can interfere with these processes by confusing the animals or even damaging their hearing.

b. General Public view vs. Scientific Community View

Important to keep in mind while thinking of new ways to further develop any technology are the concerns of the public. One important public concern over sonar technology is the effect on marine life. Sonar can disrupt natural processes and in turn increase the probability of harming the planet. While the safety of animals is important to maintaining the ecosystem, the U.S. government must ensure the safety of the country. In fact, the US Navy is required by U.S. Law to be prepared to defend the United States from an attack by sea.

The view of the scientific (and military) community is that sonar is the only technology available to protect against enemy submarines, therefore it must be used, despite any negative effects. Because of these two viewpoints, and the credibility of both, a compromise must be reached until the technology can be improved upon or replaced. The Navy is always looking for ways to cut down on environmental impact of sonar. The future of this technology will depend on our ability to minimize effects which are detrimental to the environment.

Scientific Applications

BIOMASS ESTIMATION Detection of fish, and other marine and aquatic life, and estimation their individual sizes or total biomass using active sonar techniques. As the sound pulse travels through water it encounters objects that are of different density or acoustic characteristics than the surrounding medium, such as fish, that reflect sound back toward the sound source. These echoes provide information on fish size, location, abundance and behavior. Data is usually processed and analyzed using a variety of software such as Echo view

WAVE MEASUREMENT

An upward looking echo sounder mounted on the bottom or on a platform may be used to make measurements of wave height and period. From this statistics of the surface conditions at a location can be derived.

WATER VELOCITY MEASUREMENT

Special short range sonar's have been developed to allow measurements of water velocity.

BOTTOM TYPE ASSESMENT

Sonar's have been developed that can be used to characterize the sea bottom into, for example, mud, sand, and gravel. Relatively simple sonar's such as echo sounders can be promoted to seafloor classification systems via add-on modules, converting echo parameters into sediment type. Different algorithms exist, but they are all based on changes in the energy or shape of the reflected sounder pings. Advanced substrate classification analysis can be achieved using calibrated (scientific)

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echo sounders and parametric or fuzzy-logic analysis of the acoustic data.

BOTTOM TOPOGRAPHY MEASUREMENT

Side-scan sonar's can be used to derive maps of the topography of an area by moving the sonar across it just above the bottom. Low frequency sonars such as GLORIA have been used for continental shelf wide surveys while high frequency sonar's are used for more detailed surveys of smaller areas.

SUB BOTTOM PROFILING

Powerful low frequency echo-sounders have been developed for providing profiles of the upper layers of the ocean bottom.

SYNTHETIC APERTURE SONAR

Various synthetic aperture sonar have been built in the laboratory and some have entered use in mine-hunting and search systems. An explanation of their operation is given in synthetic aperture sonar.

PARAMETRIC SONAR

Parametric sources use the non-linearity of water to generate the difference frequency between two high frequencies. A virtual end-fire array is formed. Such a projector has advantages of broad bandwidth, narrow beam width, and when fully developed and carefully measured it has no obvious side lobes: see Parametric array. Its major disadvantage is very low efficiency of only a few percent. P.J. Westerville's seminal 1963 JASA paper summarizes the trends involved.

Types Of Imaging Sonar

1. Side Scan SONAR System.

The sound frequencies used in side-scan sonar usually range from 100 to 500 kHz; higher frequencies yield better resolution but less range.

2. Single Beam SONAR System.

Single beam sonar data are collected along transect lines and typically cannot provide continuous coverage of the seafloor. The output resolution of the data are determined by the footprint size, sampling interval, sampling speed, and distance between transects.

3. Multi Beam SONAR System.

Instead of just one transducer pointing down, "multibeam bathymetry systems" have arrays of 12 kHz transducers, sometimes up to 120 of them, arranged in a precise geometric pattern on ships' hulls.

References

1. *http://wikipedia.org*
2. *http://inventors.about.com/od/sstartinventions/a/sonar_history*
3. *http://www.findtoyou.com/sonar+technology*
4. *http://web.cecs.pdx.edu/~mperkows/CLASS_573/573_2007/sonarpc.pdf*
5. *http://wikis.lib.org*