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Review of Recent Developments in Underwater Acoustic Communication Technology

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Abstract—

Science and technology always goes hand in hand. Same scenario occur for Ocean engineering and Ocean science. Developments are summarize in following aspect of underwater acoustics: (1) Underwater communication affect by variable parameter such as noise, spreading loss, Doppler spread and description of Localization algorithms. (2) Acoustic instruments such as hydrophones, transducers array, transponders, transducers. (3) Underwater acoustic modelling technique such as Acoustic integration model, Energy Flux model, Marine mammal movement model, Wave guide invariant model. (4) Study of ocean acoustic parameter like Noise, Reflection, scattering, which has large influence of acoustic underwater communication, navigation and positioning of sonar system performance.

Keywords— Hydrophone, Spreading loss, Doppler spread, Acoustic integration, Flux model

I. INTRODUCTION

Underwater acoustic is the nothing but the influence of mechanical wave and study of propagation of sound in water and water may be in the ocean, lake, and tank. IEEE Oceanic Engineering Society (OES) mostly work on technological aspect of underwater acoustic technology. Underwater acoustic is vast subject, which is clear form casual inspection of IEEE Journal of Ocean Engineering (JOE) or ocean conference proceedings. Subject is review within circumstances of technology committee of underwater acoustics. The approach that are taken in this review is father defined and identified on the basis of flow and course of recent development.

II. SIGNIFICANCE OF UNDERWATER ACOUSTICS

Underwater acoustic is the vast subject, and the particular aspect are addressed by different technology committee of Ocean Engineering Society. Development infrastructure protection technology committee handle Monitoring, observation and protection devices as well as ocean infrastructure, resources handled by maritime security and critical electromagnetic wave strongly absorbed by water, have their limitation in propagation range in water. Therefore acoustic technology plays an important role in detection and navigation.

Monitoring devices such as unmanned under sea vehicles (UUVs), autonomous underwater vehicles (AUVs), Side scan sonars, pencil-beam scanning sonar, and classification that includes remotely operated vehicle (ROVs) that are operated and powered by the user via an umbilical connection comes under unmanned maritime vehicles and submersibles TC.

Underwater cables and connectors technology committee deal with underwater fiber optic telecommunication systems, networks, underwater observatories, including festooned fiber application and transoceanic, reuse of first and second generation fiber optic technology for data transfer.

OES standards committee work to assemble ocean measurement standards, this committee does not write new standards, rather they only compile existing standards. With number of significance under water navigation and tracking seismic exploration, weather and climate observation.

Sonar signal processing is key aspect in underwater acoustics. Sonar signal and image processing committee handles classification, tracking, detection, localization but its main focus is on signal and image processing.

III. SOME RECENT DEVELOPMENT

A. Underwater Network

Spreading loss, noise, high propagation delay these are the factors that affect the underwater acoustic communication. Underwater acoustic channel have time varying fading and low data rates, because of this factor underwater channel bandwidth is limited and depending on frequency and range. Monitoring task is performed by variable sensors that are constrained by harsh physical environment.

Wave co-operative is new transmission scheme used, in which relay node amplified the received signal from source node that will alter the multipath effect [1]. Range based and range free localization algorithms are used for precise distance or angle measurement to estimate location of node in network and to provide a coarse estimation respectively.

B. Acoustic instruments developments

Triplet arrays of hydrophones is used in reverberation analysis and inversion [2]. While new hydrophones are developed for sonar application, the array consists of 4 sub array channel and each sub array consists of 5 elements wired

in series. This sub array hydrophones used for detection of buried objects or signals used for detection of buried objects or signals from targets [3].

A planar hydrophone array is used to measure acoustic backscattering from the illuminated sediment volume and sonar operates by illuminated sediment volume and sonar operates by illuminating a broad swath of seabed using alien array. Output Optical glasses with low viscosity. Optical attenuation of fluoride glasses is very low. Silica is the material which is used in most of the fiber.

It is chemically purified and has very low absorption loss. Silica has high transmission range, but main property of silica which makes it highly efficient is that it can be doped with various materials such as aluminum oxide, germanium dioxide. Chalcogenide glass is made of one of chalcogenide which is an extremely versatile compound. Phosphate glass is fabricated from metaphosphates of various metals which have high concentration doping.

Of planar hydrophone array undergoes near field focusing. So sonar operate near the seabed which reduces scattering noise by approximately 12db [4]. Vector hydrophone measures the acoustic wave field's pressure. Source's direction of arrival are determined from sources acoustical particle velocity component, which are extracted using the lower dimensional Eigen vectors [5, 6]. Vector sensor array has block diagonal structure and because of sensor placement accuracy is being assured [7].

Autonomous underwater vehicle (AUV) technology explore entirely new sonar concept based on mono-static, multi-static, bi-static configurations. Performance of sonar highly dependent on accurate platform navigation and timing. That's why Autonomous underwater vehicle (AUV) is used statically to form a synthetic aperture [8]. Bistatic scattering used in studies of tric scattering of sediment, which depend on two assumptions, effect of assuming the compressibility and density of sediment and half space effect [9]. In underwater acoustic technology parametric sonars are being used as sources in studies of seafloor scattering [10, 11].

C. Underwater acoustic modeling techniques

Modeling of underwater acoustic is very important field, which helps in studies of sonar performance. It will also affect ambient noise, scattering, propagation and reverberation. Acoustic integration mode (AIM) combines a movement simulator with underwater acoustic model. It will or edict the potential effect of sound on marine mammals [12].

Acoustic integration model (AIM) is just Monte Carlo statistical model. Based on whale movement. Animals and sound source is moved in depth at exact location because of precise programing. Tracking model and whale movement is the key aspect in acoustic integration mode model. High resolution is set up with global coverage in AIM model. Energy Flux model used where extremely high fidelity model outputs are not requires. It also useful for rapid calculation of transmission loss by boundary-reflected multipath [13]. If acoustic frequency is high than field oscillation considered random. Energy Flux model concept is only valid in environment where the sound speed is not constant. They will be also valid where there is slight losses at boundaries [14]. Marine mammal movement models has developed for modeling marine mammal movement and their behavior which is used in environmental impact assessments. By estimating impact of anthropogenic sound on marine animals, animal location can be estimated [15]. Waveguide invariant models summarizes the pattern of destructive and constructive interference between acoustic modes propagating in the ocean waveguide [16].

D. Study of ocean acoustic parameter

Study of ocean acoustic is depend on number of parameters like noise, reflection, scattering, reverberation. Change in this parameter will may change entire course of action in underwater acoustic. Ambient noise is the one parameter which badly affect the acoustic communication. Ambient noise is sound other than primary sound that's why it cause interference and pollution. In oceans ambient noise is described by spatial, spectral and temporal characteristic of sound. This sound generate by industrial and natural sources.

Reflection is one of the important parameter of ocean acoustic which is nothing but the change in direction of wave at an interface between two media and that media could be anything such as water, air, or seabed because of reflection echo is generated. In reflection of wave, amount of energy is lost that will affect the overall result. Another parameter of ocean acoustic is reverberation.

Reverberation is perseverance of sound, after sound is produced. It is happen when reflection of signal take place and then that signal decompose. Reverberation is easy to notice when sound source stop but reflection continue. It is frequency dependent and it also decrease the amplitude of signal until it reach zero amplitude value. Reverberation is product of acoustic scattering by the surface and bottom boundaries, time reversal mirror (TRM) method is used.

IV. TRENDS IN UNDERWATER ACOUSTIC

There are varies research paper published in ocean conference and JOE (Journal of Ocean engineering) define the trends in underwater acoustics. Some of these trends are address in this review paper with brief discussion. Basic documentation of each mentioned area is provided in Journal of oceanic engineering. Many application depend on scattering and propagation of sound in water. Study of propagation and scattering in underwater communication, bathymetric mapping is becomes necessary. Unmanned underwater vehicle technology becomes very popular in past several decades. This technology bring revolution in oceanographic measurement.

V. COMMENTS

Many advance technology has been occurred in the past several decades. Few technology and modeling technique are noted in this review paper. IEEE Journal of ocean engineering (JOE) contain extensive amount of information.

Professional Ocean engineers will hopefully benefited from this review paper. Literature review serves the purpose of proper communication. This review paper encourage ocean engineers, which is an ultimate goal behind publishing this paper.

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