A Research survey on implementation of Artificial Intelligence in underwater autonomous vehicles by using MIMO-OFDM for Underwater wireless communication

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Abstract

The interest in customary checking for marine environment and examination is growing rapidly. Limited bandwidth and slow speed of signals brief the result of uninformed throughput. The objective of this work is to make the modem more responsive and act automatically for disturbances in case of both optical and acoustic signal transmission during plate disturbances, signals from underwater living organisms, detecting submarines, other underwater vehicles, etc., can be tackled. The basic principle of Deterministic Artificial Intelligence (DAI) is asserting the deterministic self- awareness programs based on the self-identification or physics of underlying problems. An optoacoustic communication system that provides high throughput with reduced latency to an underwater vehicle. The optical links make modem operations much easy in cluttered environments without the need for a tether. Controlling the modem is done through automatic devices. Python is used for development with OFDM. The real-time applications are set as the future study.

Keywords-- underwater communication, Artificial Intelligence, low power, bandwidth- light sound, Opto-acoustic modem, optical sensor.

I. INTRODUCTION

We aim at fixing artificial intelligence in the most adopted way as the first principle for the need of autonomous way of desired trajectory. This paper briefs the exploratory effects of framework for controlling the submerged robot which utilizes our proposed opto-acoustic modem interface using the computerized reasoning. The proposed modem accomplishes high speed with low dormancy. The range of applications varies from pipeline perxception, improvement acknowledgement in ocean side to submarines where there is need of tracking the moving articles is needed. First all the systems in correspondence are arranged and natural communication channels is made through and then they are modified for lowered correspondence communication channels suiting the need of artificial intelligence. Hence submerged opto-acoustic is viewed as the most ideal arrangement. A wider area of survey is done for the implementation of AI applications in underwater communication.

Our proposed modem allows a onland user to operate the robot using the human input device for real time study. The system is found to achieve a real time control with OFDM. A link and the acoustic sensor are used for a quick update of the link between the land and underwater connectivity which is being operated from land with the mission parameters and goals. The optical link also enables the receiving high fidelity images and videos that are transmitted from the robot. The comparison of parameters between optical, acoustic, optoacoustic, and AI-based optoacoustic modems. Table 1 shows the above-said comparison of parameters.

II. LITERATURE SURVEY

With the great advancement in mechanization in science, the upgradation in artificial intelligence is a key part in various areas such as public areas communicating space, submerged, and earth-situated language. The ease of computerized reasoning is based on the understanding of the automation of human ideas. The objective of this paper is to provide a better way of approach to making an underwater communication modem for AI-based applications. The uniqueness of man-made thought is the capacity in justifying and deciding the right moves in accomplishing a particular task. The possibility of the human made consciousness is based on the human idea. This work throws more light on making a new path for the underwater communication modems with AI applications and to develop insights on what really a “responsible AI” means. This work proposes a hybrid solution to overcome the bandwidth limitation in optical and acoustic communication with the help of acoustic-assisted aligned channel between the optical transceivers.

Underwater robots need to tackle numerous challenges. Some of the naturally occurring disturbing are underwater currents, marine life, unexpected vegetation, unmanned vehicles, etc., and restricted possibilities and reduced vision are some of the technical barriers. Hence the robots are need to design to manage all such barriers on its own without any external support. Hence, machine learning based modern technology and AI is now being adopted for designing a robot such that they operate autonomously in tackling the challenges they undergo. Before we decide to choose a robot for an environmentally safe activities for underwater communication, they should be made such that we can rely on them for the sole purpose. The robots should be capable of working on their own on worst situation for accomplishing the missions safely and in a better way by making the right decisions. They should get back to its base stations for charging before it is out of power.

III. OPTO-ACOUSTIC AI MODE

The idea for implementing the opto-acoustic modem with AI is made with the face growing pace of AI in real time applications and its diversity. The proposed modem is based on both the optical and acoustic signal calculator. The new of modem is saving the data about the unknown entry in ocean body, study of underwater creatures, natural disaster, any unusual disturbances at the backend. The proposed hybrid modem for both opticl and acoustic signals adds as advantage for implementing the AI technology into the system. Overcoming the long multipath spreading in underwater communication is well tackled by OFDM, hence it is more preferred for UWA channels. Figure 1 shows some of the real time applications of AI.

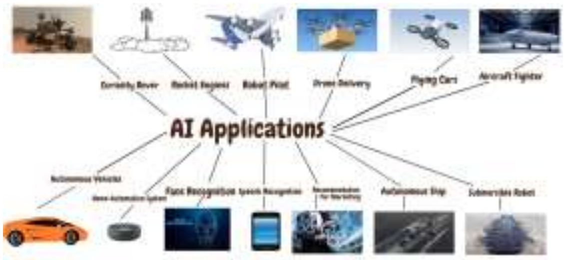

Figure 1 AI Applications

The need for interfacing with high level programming making the analysts free from details an generating models of high level leading to the increase in the productivity and improved reliability and quality analysis. AI with knowledge based systems provide an opportunity to meet the need.

The mathematical model processing for an AI system is shown in figure 2.

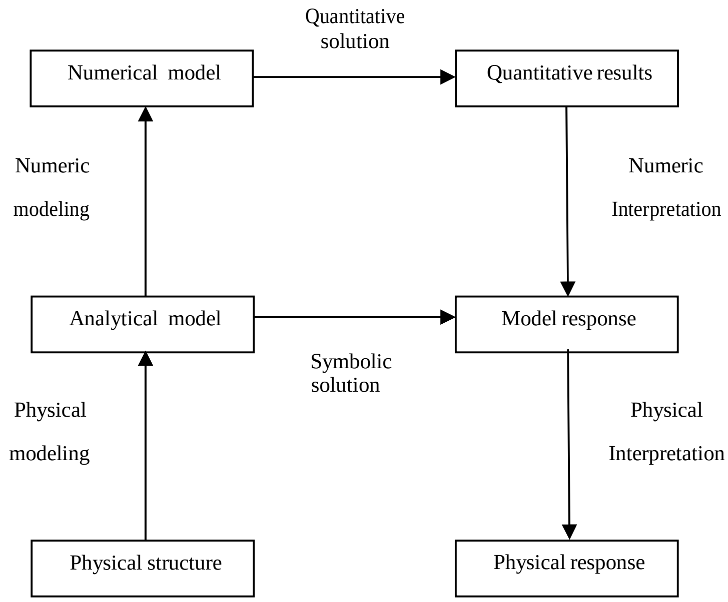

Figure 2 Mathematical model processing of an AI system

The factors influencing the oceanic environment and the need of AI system to monitor an assess the health an alert if there is need.

Factors for a AI system to have a healthy ocean

- Marine litter prediction.
- Real time monitoring of pollution levels.
- Over fishing & protection.
- Automated fish catch threshold.
- Aquaculture monitoring & illegal fishing.
- Real time monitoring of oceanic temp. & PH, phytoplankton, oceanic currents, coral reef ecosystem.
- Monitoring marine habits, coral reef mapping, AUV deep sea assessment, quantities of oceanic species & location.

IV. MIMO OFDM based underwater opto-acoustic AI modem

One of the best approach to overcome the bandwidth limitation in opto-acoustic communication channel is using Multiple Input Multiple Output (MIMO) technology. Multiple transmitting elements simultaneously transmit the independent information streams in the same bandwidth using AI. Thus bandwidth requirement is significantly reduced. The great advantage of MIMO is brought out by studying the shallow water channel using AI. Channels for submerged acoustic communication are very limited and also reverberant. Numerous high recurrence tests are conducted in shallow water. An investigation under different circumstances on drift information collected in shallow water has been carried out in this work to study the delineation of sea conditions (arbitrary sea medium, surface waves) influencing the sign properties. Differences at various stages, fleeting clarity of individual waves, spatial intelligence of multipath waves at different time scales are incorporated in channel properties. limited bandwidth, rapid time variation, fading, refractive properties of communication medium, limited bandwidth and Doppler shifts. Numerous multipath exists in shallow water due to water surface proximity and interfaces at the bottom level resulting in longer delay spread. This is considered to be the most challenge in configuring the underwater acoustic communication.In the opto-acoustic modem architecture of the system controls an underwater robot through an optical link. The system comprises of three high level components. The input for the system is fed from two optical and sound sources. After receiving the input, an encoder control gadget in the movement controlled framework to and electrical sign which can be pursued by the movement controlled framework. The channel for the opto-acoustic system reaches MUX with the use of a multiplexer. The design of the proposed opto-acoustic AI modem for underwater communication is shown below

The concatenated signal is then divided into two separate signals at the MUX as OP and AC signals. All the signals are collected by the MUX and then forwarded into OFDM transmitter. The figure 3 shows the OFDM part permitting the high effectiveness as its regulation plan and transporter power can be controlled independently by every transporter. QPSK is first applied on the information in the QPSK side and then it is exposed to create and the received OFDM signal is examined. The fundamental concept of OFDM is breaking down the high rate information signal into numerous low rate streams. All these broken low rate data streams are simultaneously sent over subcarriers. The received signals are processed in the MIMO OFDM block. The output is then processed as OP and AC.

For instance, consider that two modems are used for Underwater communication say modem1 and modem2. Modem 1 is fitted on land and modem 2 is installed at aquatic area with both light and sound sensors being installed in it. These sensors will generate a data connection web system which transfers the signal back and forth between a mode. With the implementation of AI technology, these data is stored and the installed modem is made to learn to generate the feedback for vibration and signals received. These stored data have various uses as discussed in the earlier part.

- **Proposed OFDM Transmitter**

As signals are transmits the signals, sampling is one which breaks own the continuous signals into discrete time signal. The MIMO block of the transmitter multiplies the capacity and then the signal is forwarded to AI block. Raspberry pi is used for integrating the system which greatly reduces the cost of the entire system. AI block transforms the signal into computerize code and it is resent to FFT for further transmission. Finally the signal is sent to MUX. Figure 3 shows the block diagram of the proposed OFDM transmitter.

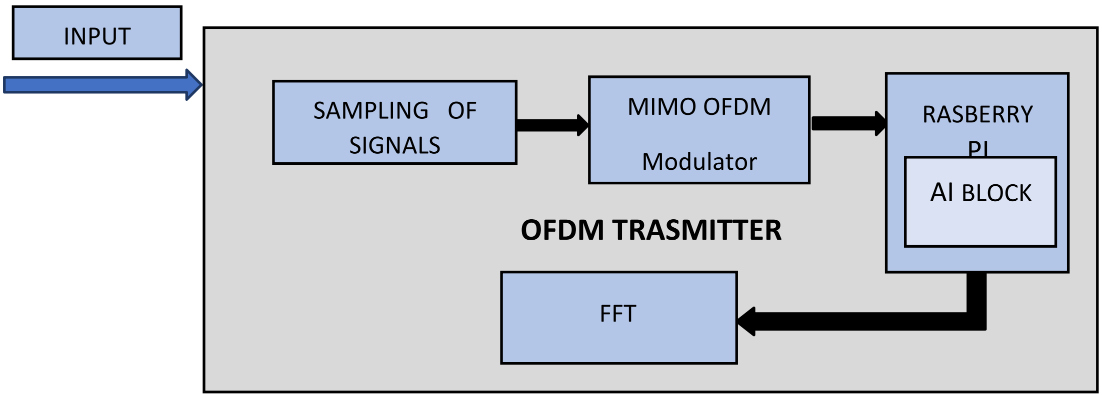

Figure 3 OFDM transmitter

- **Proposed OFDM receiver**

The OFDM receiver receives the signals where the frequency domain signal samples are converted into time domain signals. The samples received by MIMO OFDM demodulator recovers the information from the modulator carrier wave. From here the sampling signals undergo discrete time signalling. Raspberry pi is used to integrate the signals for generating continuous high bandwidth with high data rate signals of OP and AC outputs form the opto-acoustic AI modem. Figure 4 shows the block diagram of proposed OFDM receiver.

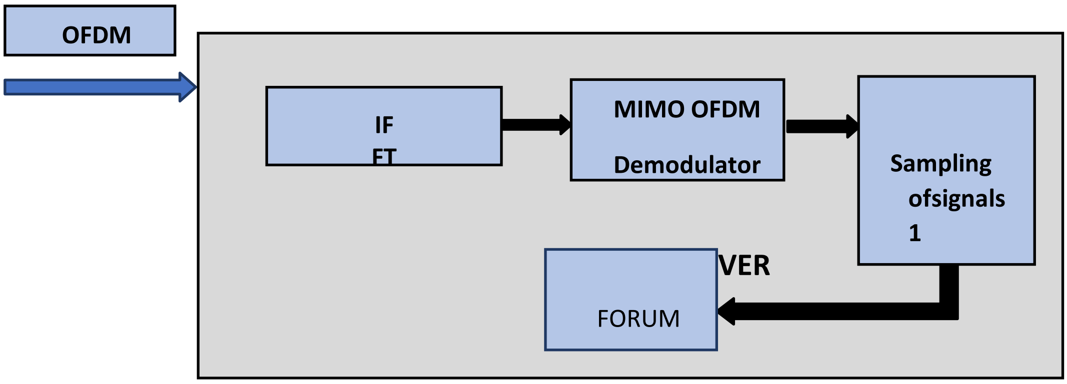

Figure 4 Proposed OFDM transmitter

- **SENSE -PROCESS -ACT- LEARN**

The loop system of Sense-process-act-learn of learning is followed and is shown in figure 5. The signals are first sensed by the underwater robots. Both the optical and sound signals are processed by the robots which act on the target venue to evaluate the data set by recording various acquittal activities and itself self-using Artificial intelligence as how to respond back to the system. Again the entire paradigm is followed. It turns into a channel associated with a criticism regulator. While considered beneath the degree of man-made reasoning, channels and regulators for detecting and acting are a fundamental fixing. Inertial route frameworks are channels giving solid and evaluated assessments to specialist states, both surface and subsea. Moreover, powerful control frameworks regularly balance out directionally unsteady ships and submarines. The inertial route framework (INS)- to direction regulator sense-act circle depicts numerous independent marine robots: ready to execute a mission script however unfit to comprehend to respond shrewdly to the climate. Figure 5 Sense-process-act-learn. Figure 5 shows the process of Sense-process-act-learn.

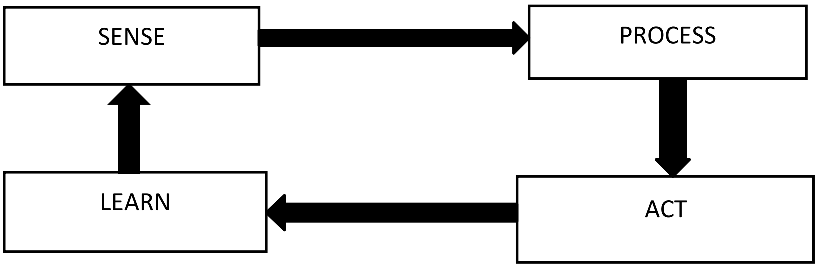

Figure 5 Sense-process-act-learn

V. RESULTS AND DISCUSSION

Comparison of various parameters of optical, acoustic, opto-acoustic modem and AI-based opto-acoustic modem are compared and shown in table 2.

Implementation of raspberry pi using python is used for developing a new generation of Opto-acoustic AI modem having higher bandwidth, greater transmission speed, higher power with great technology is required in developing such a modem with the use of artificial technology. It is carried over with the help of the Underwater system and implementation of the higher categorized simulation part of the opto-acoustic modem in the AI system. Figure 6 shows the sample Database collection of optical signal attenuation under various oceanic conditions through AI implementation. Base on the signal level received under water condition, the system will automatically calculate the level of attenuation that can occur through the database of the signals and its corresponding level of attenuation already attained. So the system automatically generates the messages about the signals based on the previous experience.

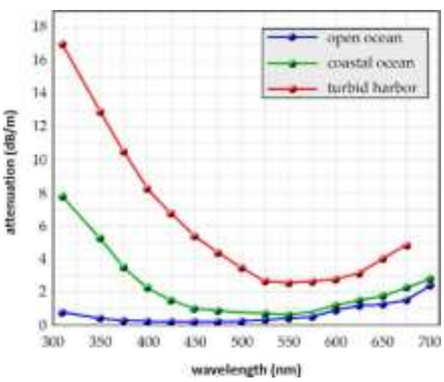

Figure 6 Database of attenuation of optical signals under different oceanic condition

Figure 7 shows a study sample of percentage of level of disturbances observed in the modem implanted oceanic area. All these types of observations are carried out by the AI part of the communication system. Hence under the intruding of any new signals will also be stored in the database and if it is observed in future, the messages will be automatically sent to the nearby or base station for the necessary action. If the received signals are already in the stored database then it will not be stored once again but the response will be automatically performed from the system as the previous response. If the signals are new, it will be stored and will be indicated to the nearby station for action. Thus, AI proves its need in alerting system.

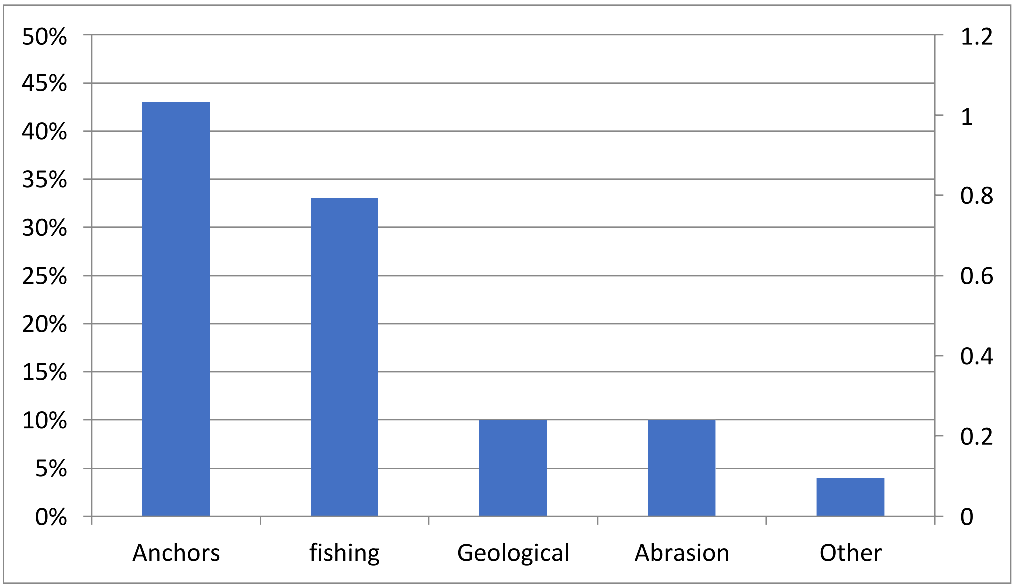

Figure 7 survey based on AI system of observation in underwater prevailing conditions

The observed acoustic signal speed achieved at different oceanic depths by the AI system with reference to the prevailing conditions of temperature and pressure in the implanted oceanic area. Based on the database of acoustic wave speed, the alert will be made by the AI system for the prevailing oceanic conditions like temperature, pressure, turbidity and living organisms which will greatly affect the communication of acoustic signals, alerts will be made for the transmitter in advance.

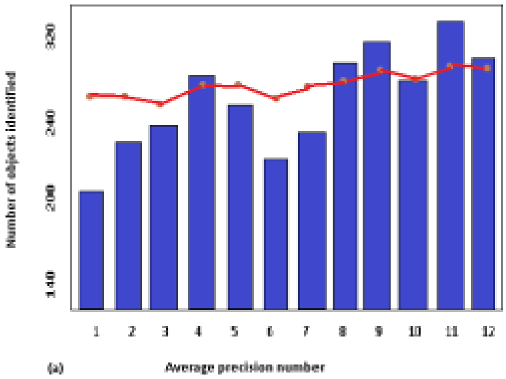

Figure 8 Response of AI system in object identified under different turbidity conditions of water condition

Monitoring the underwater environment impact is an important application of AI which helps it more scalable an automated. The AI system is ingested with an underwater data centre which is nothing but the sample or reference data for the AI system. Based on the level of distraction in the received signal, it is analyzed and response is made by the AI system. Figure 8 shows the detection of received signals with respect to direction and object distraction in the path of signal transmission and reception. The trajectory is framed by the AI system based on the signal communication level through dynamic model simulation. Observations on three sequential scenarios are made with trail planned to make the waypoint in real time scenario. Figure 9 shows the simulation of analysis of AI system over the trajectory of the signal.

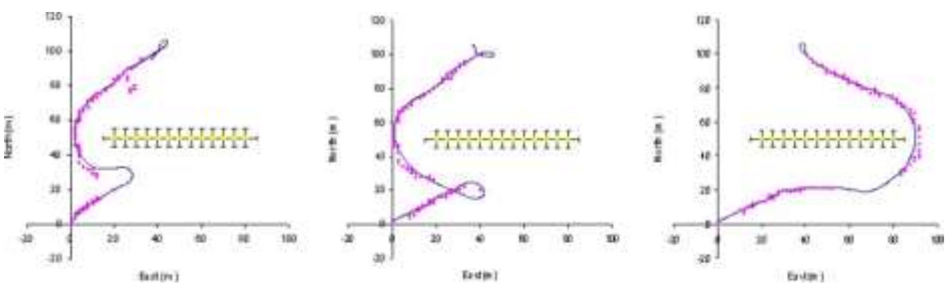

Figure 9 Simulationofavoidingtrajectoryanalyzedby AIsystem

Autonomous Target Recognition is made to find the unmanned underwater vehicles in the path of communication. This survey is analyzed by the AI system to make a response for a successful communication.

VI. Conclusion and Future Scope

In this paper, an Opto-acoustic AI modem basic architecture for submerged correspondence has been proposed and illustrated. From the reproduction results acquired, with the utilization of the proposed hybrid modem a strong association is attained between the earthbound and submerged world. This will trade signals and store all information involving light and sound sensors as hotspots for energy utilized for recording different submerged exercises. The modem advances by carrying out AI and creating feedback mechanism. The collection of both optical and sound signs through a solitary modem demonstrates the outcome of the proposed Opto-acoustic AI modem. Basically, the proposed modem additionally remains a straightforward answer for more prominent information rate and bandwidth for the impending age of fast submerged optical/acoustic correspondence. The future start of a submerged flagged world with incredible communication can be achieved by some modifications in a couple of more OFDM methods. We can carry out the modem utilizing Machine learning with a high-level Algorithm which will start the future framework headway. In this paper, a comprehensive survey of the issues in implementing artificial intelligence in underwater communication by underwater opto-acoustic modem and the significant challenges posed by them for a successful communication is surveyed. A review on the research and the development of artificial intelligence in underwater communications has been addressed and Response of a AI system in signal distraction due to object identified under different turbidity condition of water condition is shown .Also Simulation of avoiding trajectory analyzed by AI system was briefed .Based on the summary of the research developments, the challenges of AI in underwater communication are types of algorithms and different types of data manipulation for synchronizing ,designing of a predictor model and the basic challenges like noise and attenuation, absorption and scattering, multi path, path loss etc. Here we are enabling MIMO - OFDM (multiple input multiple output) in receiver and transmitter side with best sampling system theorems or mathematical calculations. We also code an AI for making the modem to sense the water quality and salinity etc. This modem also enables to study regarding the light and sound system. And also the placement of transmitter and receiver for a proper flow process in AI is also to be found.

REFERENCES

1. I. F. Akyildiz, D. Pompili and T. Melodia, 2005, “Underwater acoustic sensor networks: research challenges,” Ad Hoc Networks. Vol. 3, no. 3, pp. 257–279
2. G. Baiden, Y. Bissiri and A. Masoti, 2009, “Paving the way for a future underwater omni-directional wireless optical communication systems,” Ocean Engineering. Vol. 36, pp. 633–640
3. C. Gabriel, M. A. Khalighi, S. Bourennane, P. Léon, and V. Rigaud, 2013, “Monte-Carlo-based channel characterization for underwater optical communication systems,” IEEE Journal of Optical Communication Networks, Vol.5, no. 1, pp. 1-12
4. A. Munafò, E. Simetti, A. Turetta, A. Caiti, and G. Casalino, 2011, “Autonomous underwater vehicle teams for adaptive ocean sampling: a data-driven approach,” Ocean Dynamics, Vol. 61, no. 11, pp. 1981-1994
5. W. Cox and J. Muth, 22014, “Simulating channel losses in an underwater optical communication system,” Journal of Optical Society in America, Vol. 31, no.5, pp.920-934
6. P. Lacovara, 2008,“High-bandwidth underwater communications,” Marine Technology Society Journal. Vol. 42, no.1, pp. 93-102
7. S. Arnon, 2010, “Underwater optical wireless communication network”, Optical Engineering, Vol. 49, no. 1
8. J. Heidemann, M. Stojanovic, and M. Zorzi, 2012, “Underwater sensor networks: applications, advances and challenges,” Philoshopical Transactions of the Royal Society, Vol. 358, pp. 158–175
9. S. Tang, Y. Dong, and X. Zhang, 2014, “Impulse response modeling for underwater wireless optical communication links,” IEEE Transactions in Communications, Vol. 62, no. 1, pp. 224-236
10. B. M. Cochenour and L. J. Mullen, 2012, “Free-space optical communications underwater,” in Advanced Optical Wireless Communication System, Cambridge University Press, pp. 201–239
11. F. Hanson and S. Radic, 2008, “High bandwidth underwater optical communication,” Application in Opticals, Vol. 47, no.2, pp.277–283
12. K. Nakamura, I. Mizukoshi and M. Hanawa, 2-15, “Optical wireless transmission of 405 nm, 1.45 Gbit/s optical IM/DD-OFDM signals through a 4.8 m underwater channel,” Optical Expressions, Vol. 23, no.2, pp. 1558-1556