An Automated Underwater Wireless Communication System Using Li-Fi with IOT Support and GPS Positioning

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Abstract. The most difficult medium for data communication is the underwater medium. It is due to its characteristics. The various existing mode of the communication in water medium are electromagnetic waves, acoustic waves and optical signal. But all these have its own drawbacks. The loss will be huge for Electro-Magnetic (EM) waves, so it is limited to the short range communication, optical waves has line of sight issues. To overcome these, in this paper, a Li-Fi technique is used for data transmission in water medium. It uses Light Emitting Diode (LED) sources for transmission of data. This will ensure the maximum transmission rate and it is more efficient and cheaper than the other existing methods. In this paper, automation via Bluetooth, IoT and it has GPS tracking capabilities are also incorporated

1. Introduction
Wireless data transmission in water medium has various challenges compared to other mode communication in air medium. To attain desirable data transmission rates for underwater wireless communication, advanced equipment devices are needed. Water medium possess few distinguished features which makes it unique and difficult in data communication compared to other traditional communication methods. Underwater Communications are influenced by several phenomena such as salinity, turbidity, pressure, temperature, amount of light entering the water surface and their effects on waves.

Even though underwater communication faces lot of difficulties and challenges, it plays a vital role in real time application. Few applications where it is useful are surveillance of environmental impact, data communication through Autonomous Underwater Vehicle (AUV) for broadcasting the animal health condition in ocean, exploration of oil and gas monitoring in ocean and coastal security. To carry out the data transmission between the buoy to AUV or from AUV to any external devices, an sophisticated processor board is designed. It consists of transmitter and receiver section for processing the signals. To protect the devices proper insulation is provided and kept inside the floating boat referred as buoy. For application like submarine and military purpose, anchored based sensors with erected processing towers will be employed.
For underwater wireless transmissions to happen there are three technologies available. First one is the radio frequency communication has high data throughput over a short distance and affected by Doppler effects. Second method is optical transmission, it uses 450 to 550 nm wavelength. The disadvantage of this method, it requires line of sight to establish proper communication between the transmitter and receiver. Third technique is acoustic communication. The factors need to be considered are Doppler effects and Inter-symbol interference. Due to low bandwidth and high spatial interference acoustic mode of communication is restricted to one to one user. i.e., multiuser communication and multiplexing of signals are not possible. The advantage of this technique is the process does not affect the life of marine animals in ocean since it uses only low frequency signal.

Since we are in the period of industrial revolution 4.0 and automation getting extensively employed, we are integrating our system with a bit of automation to enhance its capabilities and for better user utilisation.

2. Existing System
For terrestrial application, data must be converted to proper form and it need to sampled in such a way that it has to follow the Nyquist sampling theorem. This requires skilled person and it is tedious work. Acoustic signal can be used as carrier in most application since it has low absorption characteristics. The only drawback is it can be used over large distance communication due to signal deterioration. System which uses EM waves requires high bandwidth and high absorption on the signal transmitted. Inter-symbol interference is another parameter that restrict the use of EM waves in underwater communication.

3. Proposed System
Our main aim is to reduce the complexity and implement an underwater wireless communication in real time. A low cost, automated system for underwater wireless communication to happen with ease. Li-Fi could serve as a best alternative instead of an acoustic modems due to its high speed, highly secured data transfer and energy efficient. Underwater communications can be monitored and analysed. Moreover we could bring up a simple and cheap prototype serving for commercial and real time applications.

4. Literature survey
Different error codes are applied to the modelled underwater channel [1]. The encoding of the data is carried out prior to the modulation scheme. An (63, 53) RS code[2,3] is applied and author obtained an 10-3 as error rate in air medium. Authors also showed that the considerable coding gain was obtained using Trellis Coded Modulation[4] scheme in the underwater communication. Spectral analysis of signals is carried out in[5]. In underwater communication[6] optimal frequency plays a vigorous role in obtained better error rate. In [7], authors obtained an experimental formula for the optimal frequency for a particular distance.

With this predicted frequency, simulation is carried out for the error coding techniques like Turbo codes[8,9], convolution code. The results showed that the convolution code with least hamming distance gives least error. The variation of the guard interval (GI) in the orthogonal frequency division multiplexing is studied in detail[10]. An sample image is first converted into binary format and then it is transmitted to the modelled channel. The authors proved that error free communication was obtained if the GI interval maintained is 25% of the encoded data. The purpose of this technique is to eliminate the Inter-Symbol-Interference[11,12] in the time varying channel like underwater channel.

The study of decision feedback and linear equalizer in the underwater channel is studied in [13]. The authors designed the channel at two different range. One at 100 meters and another one at 1000 meters. A optimal step size obtained for the LMS equalizer is 0.05 to 1. For RLS algorithm[14,15] it lies between 0.02 to 1. The simulation result concluded that the Error Rate of 10-4 is achieved with the signal strength of 24 dB using RLS algorithm. The data communication using Dolphin clicks[16] are carried out by the authors. The proposed algorithm is evaluated by comparing its performance with the
well-known standard techniques OFDM and the Equalizer. The result evident that the dolphin click\cite{17,18} produce an error rate which is one fifth of the error rate generated by the former techniques.

The polynomial in the convolution code was modified and its performance was evaluated in the underwater communication for different code-rate\cite{19}. As the code rate increases the error rate decreases gradually and the time consuming algorithm of the LDPC code can be simplified by splitting the longer code rate of the convolution code into series of smaller code rate. This ensured the same error rate produced by the LDPC code\cite{20,21} in the underwater communication. statistical analysis\cite{22} of signals and classification of non stationary signals\cite{23} are analysed using signal processing toolbox. In\cite{24}, author effectively communicated in the sea floor between the underwater vehicles using optical signals. This enhanced the researcher to carry out their work in the field of the underwater communication. A high speed optical communication at speed of 10 Mbps was demonstrated in \cite{25} over a short range of 20 meters.

5. Methodology

The proposed system comprises of a transmitting section with automation and a receiving section with GPS tracking and GPRS-IOT support. The construction and working of the system is shown in the Figure 1. The system can be visualized in short with the below block diagram shown in Fig.1.Here the water channel is the medium through which communication takes place.

![Fig.1: Block diagram of the system](image)

5.1 Transmitting section

The transmitting section primarily consists of a PIC-Micro controller equipped with a power supply unit, a Li-Fi transmitter (LED), a 1x5 push button Keypad and a Bluetooth module for better user interface. With the integration of Bluetooth module and keypad, we have developed two modes of operation (i.e.) manual mode and Bluetooth mode. The users can select any one of these modes for operation such that it meets their needs and requirements. The transmitting section block diagram is shown in Fig.2.

![Fig.2: Block diagram of Transmitting Section](image)

The power supply unit is meant for providing the required voltage for the microcontroller unit (9-12v). The keypad unit is programmed for sending predefined data and in mode selection (i.e.) between
manual mode and Bluetooth mode. For manual mode, the messages or data is sent through keypad whereas in Bluetooth mode, the messages and data are sent via Bluetooth through PC or mobile phones.

The li-fi transmitter comprises of a white LED packed up in a converging beam case for higher intensity and accuracy. Light is used as source in Li-Fi technology. In the transmitter section, an LED is switched on and off depending upon the arrival of binary data. Through the photo detector in the receiving section, the data will be decoded. The various advantages of Li-Fi are implementation is simple since it uses only LED and photo detector. It provides high security over the data as it can’t penetrate through any metallic blocks or walls. Multiple devices can be accessed at any instant and result in no overloading of networks.

5.2 Receiving Section
The receiving section primarily comprises of a photo detector (photodiode) coupled with a PIC microcontroller, a GPRS/GSM - IOT modem and a GPS module for positioning. The block diagram of receiving section is shown in Fig.3

![Block diagram of Receiving Section](image)

The photo detector is used to detect the arriving signal and the signal is processed at the microcontroller. A GPS module is meant for GPS tracking and positioning that can used for future reference and in real time applications. The received information along with the GPS-location is then send to cloud via GPRS/GSM - IOT modem where the information is received with date and time of the arrival and it can be used for further processing analyzing and monitoring purposes.

6. Result and Discussion
The Li-Fi transmitter comprises of a white LED packed up in a converging beam case for higher intensity and accuracy. Underwater channel is modelled using ray tracing method. Ambient Noise, Multipath effects and Absorption loss are determined for a short distance of 1 meter. The data is modelled using Binary phase shift Keying modulation, the modulated data is allowed to pass through the LED. In the receiving section, the incoming data is demodulated using BPSK demodulator and data is retrieved back properly using photo detector. The simulation of both transmitter and receiver are carried out using MP-Lab and it is shown in the Figure 4 and 6. The hardware implementation is done using PIC microcontroller for process data, 50 Watts bulb and Olud speaker are used as transmitter and receiver. The audio signal is allowed to pass through the bulb and the same is heard through the speaker without any noise. The hardware implementation of the proposed transmitter and receiver section is shown in the figure 5 and 7.
Figure 4: A Schematic diagram of the transmitting section

Figure 5: Our prototype of the transmitting section.

Figure 6: Schematic diagram of receiving section

Figure 7: Our prototype of the receiving section
The receiving section primarily comprises of a photo detector (photodiode) coupled with a PIC micro controller, a GPRS-IOT module and a GPS module for positioning and it is shown in the Figure 3. The purpose of the photo detector is to measure the incoming signal and it is processed at the microcontroller. A GPS module is meant for GPS tracking and positioning. The received information along with the GPS-location is then send to cloud via GPRS-IOT module where the information is received with date and time of the arrival and it can be used for further processing, analysing and monitoring purposes.

The simulation of receiver section using MP-LaB is shown in the Figure 6 and the real time implemented hardware is shown in the Figure 7. High power LED lights can be turned on and off quickly because the reaction time is less than one microsecond. The change from on state to off state in high frequencies enable the data transmission. The schematic diagram of the proposed system using MP-LaB is shown in the Figure 8 and the simulated result is shown in the Figure 9.
7. Conclusion
Proposed system is user friendly an cost effective compared to other techniques such as Ultrasonic wave communication and Acoustic mode of communication. The various other application in which our proposed system will be applicable are Rescue operation in Sea, Fisherman Security and Submarine patrolling. It is not harmful to any living organism like Fish, Dolphins and Whales in the ocean. The security aspects and robustness of the proposed system is much better than the existing methodology.

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