Underwater Communication Using IR Uplink and NEC Protocol

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Abstract

Due to various phenomena like salinity, temperature and turbidity etc., data transmission in the underwater medium is challenging. Conventionally used underwater communication methods are electromagnetic waves and acoustic waves, which have a huge loss of information and narrow bandwidth, respectively. Since underwater communication has major applications in defence and oceanographic research, there is a need for a method with less loss of information and low latency. Hence Li-Fi can be used as an alternative for acoustic waves.

In this context of our project, we used IR uplink, which is secure and does not interfere with VLC. This does also reduce the effect of absorption and scattering. For the safe transmission of data, NEC protocol is used.

Keywords Li-Fi, Acoustic Waves, VLC, IR Uplink, NEC Protocol.

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INTRODUCTION

Underwater communication is crucial in tactical surveillance, pollution monitoring, defence, oceanographic research etc. Many AUVs are being deployed to ease these applications, resulting in the requirement of high bandwidth and high capacity for data transfer. Conventional acoustic waves have limited bandwidth, which led to the exploration of optical wireless communication and Li-Fi. Nevertheless, the major challenges are due to the basic features of the sea or ocean.

Acoustic Waves for underwater communication have little absorption and large distance coverage. The audio signal was first transmitted underwater in the US using sideband suppressed carrier modulation, which suffered poor quality and distortion upon receiving. Despite technological developments, underwater acoustic communication has many challenges. They suffer high latency, less bandwidth, greater transmission losses etc., which is because of the vivid nature of the aquatic environment.

Research has been done on using RF waves for underwater wireless communication as it provides large bandwidth and fast velocity. However, they need a large antenna and high transmission power to compensate for high antenna losses. They also have high attenuation in seawater.

Hence alternative for underwater communication is optical signals, as they support a good data rate. Despite many challenges for the propagation of optical signals underwater like scattering and absorption, they have a Gbps data rate for a few hundred meters due to a high-frequency carrier. There is evidence of good underwater data transmission over moderate ranges from experimental and theoretical studies. Also, Li-Fi can support multiple access, handover, duplex transmission and many more between the access points and user equipment.

Though absorption and scattering due to disturbance by the sun or suspended particles pose great challenges, underwater optical communication works well for moderate ranges.

Various organic substances like viruses, bacteria, organic detritus, and many inorganic substances cause scattering. There are many studies and evidence of effective wireless underwater optical communication. Like the argon-ion laser experiment over 9m,50Mbps in 1992, 1995's LED-based underwater visual wireless communication over the range of 20m,30m and 10Mbps, 1Mbps, respectively, initiated the interest and research in the field and unwinding its greatest possibilities.

The difference in the attributes of water bodies poses challenges to the optical beam propagation underwater. Characteristics of water bodies vary concerning the geographical location and physio-chemical parameters.

Inherent and apparent optical properties are the optical properties that water poses. Medium and particulate substances present in it affect the inherent properties, whereas medium and the geometrical structure of light affect the apparent properties. Absorption, scattering and attenuation coefficients all come under inherent properties, whereas apparent properties define directional properties of the optical beam.

Sea or ocean are divided into three different zones, namely, euphotic, disphotic, and aphotic, according to which the physical properties vary. As the name suggests, the euphotic zone receives ample sunlight hence having the majority of life; this zone lasts up to 200m in depth, beneath which is the disphotic zone that gets a little sunlight, not supporting much plant growth. The aphotic zone is the zone to which hardly any sunlight reaches. Depending on which absorption, scattering, attenuation, background noise, and other parameters affecting underwater optical communication differ with the increase in salinity and turbidity, attenuation and dispersion of visual signal increases. Hence the bit error rate (BRE) increases with the saltiness and turbidity of seawater. Though visible light communication has more data rate, use of it in uplink not only causes discomfort to the eyes but also can lead to interference in the downlink transmission. Hence by using IR signals, we can overcome these setbacks.

In this paper, an underwater optical wireless communication system using IR uplink is designed and successfully tested. The proposed system has a good data rate and is less affected by absorption and scattering. The data is transmitted safely by using the NEC protocol. Further advancements can be made in the system to best suit the applications. We have demonstrated our output by deploying a robot underwater, giving it instructions via a Li-Fi transmitter and observing the output. The output obtained is quite accurate, and we envision using the proposed technology in UVs being deployed underwater.

COMPONENTS USED

NODEMCU:

NODEMCU ESP8266 is a microcontroller having an operating voltage of 3.3v and seventeen GPIO pins, out of which sixteen are digital, and one is analog; it does also have one Wi-Fi pin along with its small dimensions, making it good for its use in IoT

IR diode:

IR frequency range lies just below the visible light; IR signals are invisible to the naked eye. Hence, they can be transmitted safely by using IR protocols like NEC. IR diode is quite similar to an LED, but the only difference is the light emitted by it is invisible. Hence in our project, we used an IR uplink to transmit data securely.

TSOP 1738:

TSOP 1738 is an IR sensor used to sense the IR signals. It is used at the receiver to sense the transmitted IR signal.

L298 Module:

L298 is a motor driving module; it can drive up to two motors. It consists of four inputs, and it needs a 12V DC power supply to function, which is generally given with the help of the battery. In our project, it is used to drive the motors of the output device.

MOTOR:

A 12-volt 60 rpm motor is used to drive the output device.

SOFTWARE USED

Arduino IDE: Arduino IDE is the Software used to write and load the code to the Arduino. The language used for writing the code is Embedded C which is quite easy to write code in, and the software is user friendly.

SCHEMATIC DIAGRAM

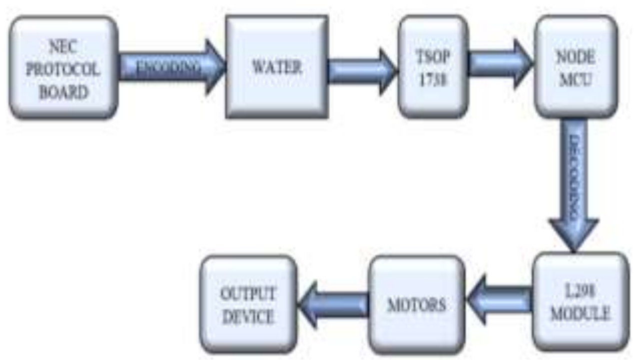

Fig 1. Schematic diagram

EXISTING METHODOLOGY

There are a handful of works done on underwater wireless communication, out of which some concentrate on underwater Li-Fi communication, while others on acoustic communication. The majority of the works using Li-Fi concentrated on the usage of visible light communication, like LED or laser diodes. In most of the systems, there is the usage of Arduino or pic microcontrollers. The data generally transmitted is text, audio, or video signal, and the output is either displayed on the personal computer or LCD board. Some of the systems used Bluetooth and IoT to transmit signals and incorporated GPS for tracking. The LASER systems as a Li-Fi source use 520nm blue-green LASER, using modulation schemes like OFDM, OOK, etc. They use photodetectors to detect the incident light, demodulate it and receive the transmitted signal.

The main problem with the usage of visible light for communication underwater is security, and also using VLC for uplink is not only difficult but also discomforting to the user. These visible-light ranges attract aquatic organisms obstructing the transmission path, addition of noise, distortion of the transmitted signal, absorption, scattering, attenuation etc. Though it has less latency, good bit rate and good propagation distance, these drawbacks make VLC not the best option for communication underwater. Hence, an alternative method that is less explored is proposed and explored in this paper, which uses IR uplink. Though it might have certain disadvantages, it is quite a secure method for data transmission underwater.

PROPOSED METHODOLOGY

6.1 TRANSMITTER:

In this project, we are using IR uplink to transmit data underwater, as primarily we are working on underwater communication using Li-Fi, and also uplink using VLC can also be done but it has certain disadvantages like causing inconvenience to the user's eyes, attracting marine life, being less secure and being visible to everyone which is not preferred in any kind of systems that are to be used in defence or research.

Since using IR for uplink can overcome all these disadvantages and can be transmitted securely by using certain secure protocols like NEC, Sony etc. In our project, we have used the NEC protocol since it is considered to be the most secure protocol and widely used.

In our project at the transmission end we have an NEC protocol board with IR uplink, we even have predefined instructions for four keys and programmed the board in such a way that IR light is emitted only when one of those four keys is pressed and the instruction corresponding to that key is sent via water to the receiver.

The inner mechanism that happens when a key is pressed is, that a certain binary signal is generated which is modulated by the modulator present on the board. This modulated signal is given to the IR LED which converts this electrical modulated signal into light modulated and emits the light accordingly. The carrier frequency here used is 38 kHz. By using NEC protocol each key has a unique hexadecimal code corresponding to them, which is sensed by the receiver, the encoded instruction is decoded and the corresponding function is performed. NEC protocol uses pulse distance encoding to easily differentiate between zeros and ones.

6.2 RECEIVER:

CIRCUIT DIAGRAM:

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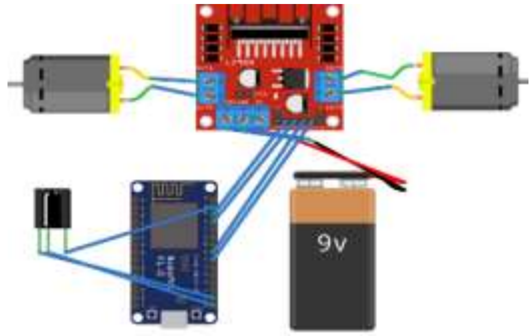

Fig 2. Receiver circuit

From the above circuit diagram, we can observe that at the receiver end we have TSOP 1738 sensor, which is an IR sensor, NODEMCU as the microcontroller, an L298 motor driving unit, and 2 motors and a 12V battery for power supply.

IR light after travelling through the water gets incident on TSOP 1738 sensor which senses it, this sensor senses being an IR sensor senses all the IR frequencies that are present near it but only allows the frequencies in the range of 38 kHz as it has a bandpass filter in it. It converts the light signal into an electrical signal and passes it through the preamplifier present, it amplifies and gives it to the microcontroller. The microcontroller upon receiving the signal from the sensor checks it with the hexadecimal code and the instruction to be performed on receiving it and instructs input to the motor driving module. The motor driving module upon receiving the instruction from NODEMCU rotates the motors according to the instruction given. These motors have wheels attached to them and they move according to the movement of the motors, hence moving the output device according to the instructions given upon pressing those preprogrammed keys.

OUTPUT DEVICE

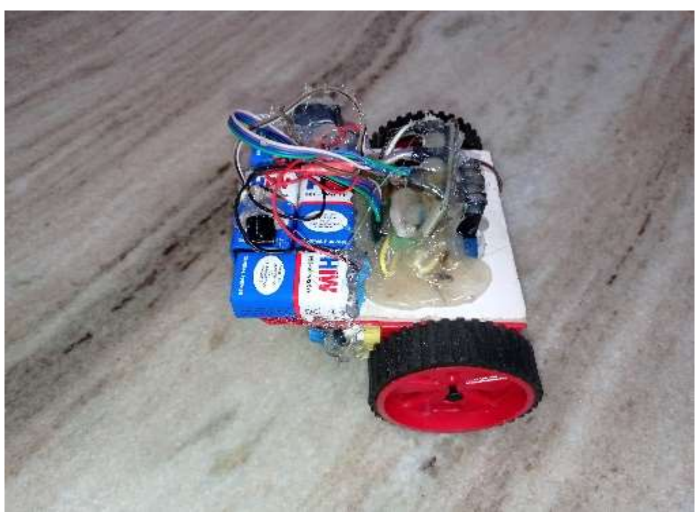

Fig 3. Output device

Fig 4. Output device with transmitting remote.

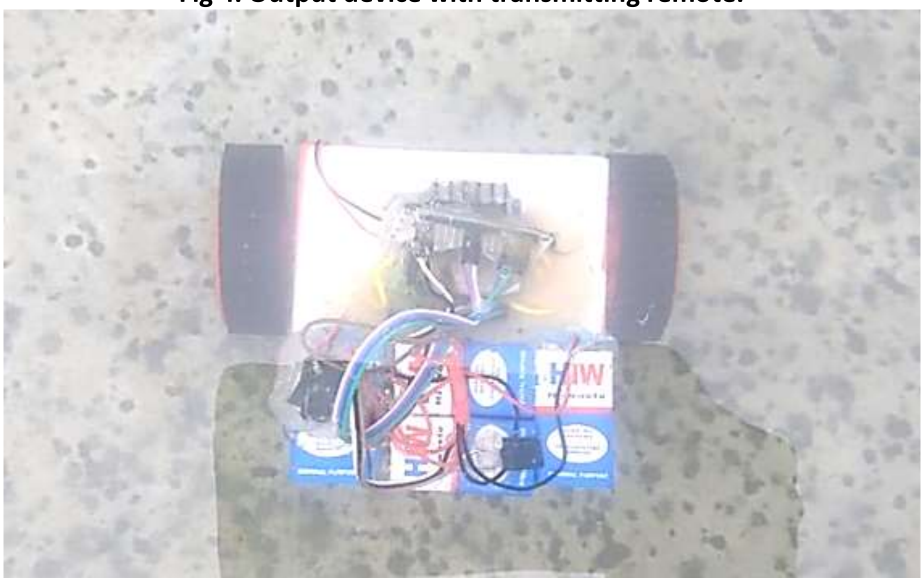

Fig 5. Output device in water

ADVANTAGES

Efficiency:

The proposed system is quite efficient in transmitting data with minimum losses in the underwater medium as it uses IR uplink.

Security:

The proposed system is highly secure as it uses NEC protocol for data transmission and also IR light. Since IR light is invisible to the naked eye, unlike laser and VLC, it is easy to uplink. It is secure and user-friendly as it does not attract any marine life, causing obstacles and hence data loss. It is very undesirable to use laser or VLC in underwater communication, especially defence use.

Cost:

The proposed system is cost-effective and uses Li-Fi, i.e.IR doesn’t require any frequency allocation. And also, all the components used in the above project are quite cost-effective, easily available, easy to use, and the system is easy to implement, which makes it efficient and user friendly.

Speed:

Speed of the system is desirable; it has less latency and a good bit rate.

APPLICATIONS

Underwater communication using Li-Fi has many applications, major of which are its use in defence, especially the proposed system with suitable modifications can be used in submarine-to-submarine communication, ship-to-ship communication etc., it can be used exploring of ocean and monitoring of marine life, petroleum and natural gas extraction, for communication between AUV's and many more.

CONCLUSION

The proposed system is very cost-effective, efficient and secure. This data can be transmitted securely by IR uplink and NEC protocol for data transmission. This system has less latency, loss of information, and reduced effect of noise due to the use of NEC protocol and IR uplink. The output is very accurate, and the system is very user-friendly. This system has reduced latency and increased the accuracy of systems using LASER and VLC. Pressing keys on the remote, which are instructions to the output device, makes it move according to the given instruction.

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