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ISSN: 0193-4120 Page No. 4084 - 4089

Underwater Video Signal Transmission via Laser Beam

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Article Info
Volume 81
Page Number: 4084 – 4089
Publication Issue:
November-December 2019

Article History
Article Received: *5 March 2019*
Revised: *18 May 2019*
Accepted: *24 September 2019*
Publication: *19 December 2019*

Abstract:

Wireless data transmission below the sea has been facing many challenges, and so many solutions have been proposed and implemented. Using wireless optical communication technologies to transmit video signals via laser beam underwater is the aim of our work. In this project, a laser communication system is being designed to transmit video signals from a waterproof camera mounted on an underwater remotely operated vehicle (ROV), to a monitor on the surface. Accordingly, two circuits have been designed and built, one is to encode the video signal, and transmit it via the laser beam from the ROV, another is to receive the light waves using a silicon photo detector, and decode the signal back to its original form to display a live feed from the camera underwater. The system has been tested and adjusted to obtain the most efficient results, aiming to reduce the losses due to the different underwater disturbances including water impurities, the flow of the water, etc. This project presents significant advancement in the underwater explorations and studies, which benefits many universities and big companies such as ARAMCO, as well as adds to the field of optical communication and the uses of laser for underwater communication purposes.

Keywords:- *Wireless; laser; video; underwater*

1. INTRODUCTION

Remote Communication includes the transmission of data over a separation without help of wires, links or some other types of electrical conveyors. The transmitted separation can be anyplace between a couple of meters (for instance, a TV's remote control) and a huge number of kilometers (for instance, radio correspondence) [1]. Current remote innovation offers proficient and reliable correspondence for every mechanical application. It is a perfect arrangement inside and outside, on account of solid transmission, low support, and expanded framework accessibility [2].

Unlike the air medium, it is challenging to transmit the radio waves through the seawater since it is a good conductive material due to its salty nature [3]. Very low frequency radio waves that ranges between 3-30 kilohertz can travel in a shallow underwater depth, around 20 meters [4]. However, it has a very slow data rate and a narrow bandwidth; hence it cannot carry audio signals, only text messages with a rate of 300 bit/s, 35 ASCII character/s or 450 words/minute [5].

Extremely low frequency and super low frequency electromagnetic radio waves that range between 3-30 hertz have the ability to travel up to hundreds meters underwater [6]. But, it needs a huge challenging transmitter with an incredible wavelength, which makes its construction and usage very rare and difficult. Such an underwater communication system has been built only 3 times; by the American navy, Russian navy and Indian navy [4].

As indicated by Ribas, Sura and Stojanovic [7] "With constrained access to remote ocean, the tests were kept to a shallow water channel (which is perhaps harsher than the remote ocean short connection) with the expansion of genuine clamor recorded in the profound waters in the Gulf of Mexico". In like manner, the submerged acoustic correspondence was turned out to be poor since it's impacted by way misfortune, clamor, multi-way, Doppler spread and high factor engendering delay [7].

Laser based underwater Communication wound up a standout amongst the most happening exploration zones these days. As per Kumar and Vikrant [8]: "The submerged laser correspondence framework is fit for transmitting diverse record arrangements of Video, Audio, Image and content document and backings information rates up to 80-100 kbps". With respect to submerged laser correspondence, green and blue lasers are liked to be utilized since they can infiltrate through the ocean because of their low vitality blurring rate of around 0.155~0.5db/m, which diminishes their shot of being consumed by the ocean not at all like alternate hues [8].

The technology that is used nowadays in taking pictures and videos underwater does not satisfy the market needs, where a trained diver cannot dive more than 700 meters under the water surface [9]. Moreover, taking pictures or videos by a diver takes a long time until the data is actually obtained, for they have to wait till the diver is back to the surface to display the videos or pictures [10]. Therefore, using an underwater remotely operated vehicle (ROV) with a wired camera needs a very long cable to reach long distances which is not sufficient [11].

Thus in this work, a laser communication system is being designed to transmit video signals from a waterproof camera mounted on an underwater remotely operated vehicle (ROV), to a monitor on the surface. The development and dissemination of underwater signal transmission and remotely operated underwater vehicles are intended for widespread, where its system has a high level of control over the direction, and a camera for recording underwater videos. Underwater video signal transmission via ROV will be helpful for two groups. Firstly, educational institutions, as deliverables would provide a vehicle to engage in submarine studies and assist in the picture and video improvement.

In the contemporary world of technology, the use of wearable technology is proliferating in every field from medical science to arm forces. Coupling such technology with powerful algorithms and Internet connectivity opens unlimited potentials to develop technologies that overwhelm human capabilities.

Wearable technology, wearable gadgets or wearables all refers to a category of technology devices that are incorporated with items that are wearable by human, like clothes or accessories to have a continued access to computational functions incorporated to individuals' daily life. Wearable technology like Google Glass not only has the capability to perform computational tasks such as computers or smart phones, but also has sensing features that are not provided by computers or smartphones (R&D, 2006). These features mainly used to track information related to human health status or to measure some biological or physiological parameters. This project uses Google Glass to provide a solution for visually impaired people using wearable devices coupled with computer vision technology to assist them in dealing with daily life needs. By developing such system visually impaired people can recognize the surrounded objects.

Visual Impairment is a limitation in vision system functionality, which led to not seeing objects as clearly as a healthy vision system. There are many contributing factors that cause visual impairment; some of these factors could be inherited medical conditions like glaucoma, cataracts, and diabetic retinopathy. People with such medical conditions have higher probability to be visually impaired. According to the World Health Organization, almost

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314 million people are visually impaired (2010). Having this huge number of visually impaired people, make it important to provide them with tools that would assist them during their daily life activities, as they face many difficulties in dealing with different life needs and requirements.

To facilitate their everyday activities, visually impaired people need a safe and efficient tool that helps them to navigate, identify and recognize objects around them. This tool must use all the sources of non-visual environmental information that have been considered by their sighted guides. Visually impaired and blind people use different ways to identify objects around them. These methods manly depend on their other senses such as hearing (audioception), taste (gustaception), smell (olfacoception) or touch (tactioception). However, these methods are manual methods and usually require other's assistant. With the absence of using technology to solve this issue, we find a research gap in finding a new technological solution that helps them in identifying objects.

This work is constructed to provide a technological solution for visually impaired people. This solution involves the use of Google Glass and building an application that allows the Glass to capture images of objects and identify them. Then, the identified object will be transferred into an audio message to the visually impaired or blind person.

The objective of this work is to introduce a tool for object identification/ recognition to help visually impaired and blind people in their daily activities. Also, to make it easier to navigate places without the help of sighted guides. The solution aims to send images to a station and get feedback notification about the surrounding object. The resulted information will be transferred as an audio to the user and will display the result on the glass screen.

2. PROTOTYPE DESCRIPTION

The underwater Remotely Operated Vehicle (ROV)'s main function is to host the waterproof camera, which provides a live feed video to the monitor on the surface. The camera is used to discover the underwater life and/or check for faults or leakages in underwater equipment (e.g. drilling pipes). The ROV consists of A polymerizing vinyl chloride (PVC) frame, Submersible pumps, Flotation packs, Controller, Underwater camera, Lights, and battery. The submersible pumps are the ROV's prime motion control; they move it forward, backward, up, and down. In total, there are 6 submersible pumps attached to the ROV where 2 pumps: push forward and backward, 2 pumps: rotate right and left, 2 pumps: move up and down. The submersible pumps are designed to be bidirectional to minimize the cost and weight of the submarine. The ROV is controlled with a joystick that is programmed via Arduino. The system architecture is shown in Figure 1.As observed in Figure 1, the system includes wireless communication in two different mediums; air and underwater. Both of the laser communication system and the free space wireless communication system are used to receive the video feed signal from the camera mounted on the ROV to the monitor on the surface. The laser communication system is used underwater to transmit the video signal taken by the underwater camera to the receiver below the surface. Similarly, the wireless communication system is used to transmit the video signal to the receiver and on to the monitor on the ship or land base. The underwater laser communication technology is chosen in this project to increase the data transmission speed/rate.

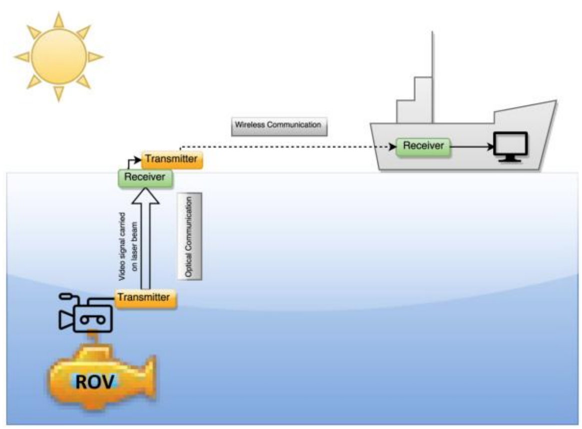

Figure 1: System Architecture

3. DESIGN AND ANALYSIS

3.1 Remotely Operated Vehicle

The ROV will be built in way that it can float. Therefore, large flouting packs are added to the top of the ROV, also weights are added to the bottom of it to provide the necessary buoyancy. The weights and floats are distributed evenly across the ROV to provide the required underwater stability. The battery

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is the heaviest part in the ROV therefore, it will not go down in water with it in order to achieve the required buoyancy and stability, but it will be connected to the ROV through a tether cable. The 1100 GPH pump has been chosen due to its lightweight. To move the ROV in all 6 directions (up, down, right, left, forward and backward), we needed at least 6 of the 1100 GPH pumps. The camera that was found most suitable for the project is the Go Pro HERO4.we chose the Arduino kit to control the ROV pumps' rotation direction. Basically, the pumps are DC motors, and in order to control and drive them, the Arduino Uno's software is used to keep them at their neutral point until it receives a serial communication signal from the PS2 joy stick controller.

3.2 Optical Communication System

An optical communication system is used to transmit the video feed to the monitor on the surface. Figure 2 shows the communication system.

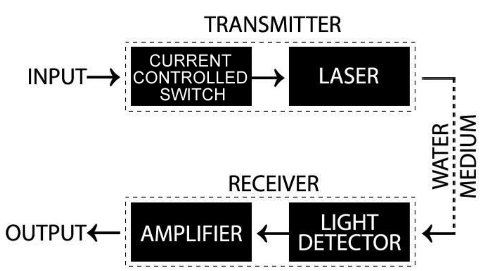

Figure 2:Laser Communication System Diagram

The laser beam is used to carry the data from the ROV, traveling in seawater. This system creates a new form of point-to-point optical communication link to the industry. The system consists of two parts; the transmitter, where the laser is controlled to carry the signal, and the receiver, where a photodiode detects the laser beam and outputs the signal into the monitor. The laser was controlled by controlling control the intensity of the laser beam to match the analog signal spectrum. In the transmitter unit, the electrical signal comes from a GO-PRO camera through a coaxial cable. A video amplifier that offers an adjustable gain from 400 to 0 is used to amplify the video signal. The video signal amplitude is then modulated before it goes to the current controlled switch. The laser driver is, in the most ideal form, a constant current source. The light from a laser contains exactly one color or wavelength. The optical source used in this project is a laser diode that emits an optical radiation at 650 nm. As the maximum current that passes through the laser diode is 120 mA, two transistor switches have been placed in parallel. After the optical signal passes through the water, it travels towards the optical receiver. The Receiver Telescope comprises of a focal point used to collimate the laser bar into the optical identifier. The Optical Receiver, which is in charge of changing over these optical heartbeats into electrical proportional heartbeats and evacuating the impacts of the distinctive commotion current sources through transmission and getting a correct reproduction of the transmitted flag, contains a photograph identifier, a video flag enhancer which is acclimated to open up the flag 10 times, a demodulator and a projector or a TV screen.

4. RESULT AND DISCUSSION

4.1 ROV

The Controller Software was utilized to drive the ROV, over a Wire connect, with PS2 joystick readings being surveyed continually. A factor that must be tried was the correct development of the ROV from the four pumps. Designing them and testing their points of confinement by utilizing the joysticks was accomplished effectively. The most critical test for the ROV was putting the entire development into its condition. Subsequent to running this test check of the primary extent of developments was accomplished, for example, advancing, in reverse, turning left and ideal, and in addition climbing and down.

4.2 Optical Communication System

The optical communication system was tested and a good quality result was successfully achieved in mediums, free space (air medium) and underwater medium. The results are taken from the projector connected to the receiver circuit. The filters and amplifiers have been adjusted many times to obtain the best results. However, the values of those amplifies, filters and other circuit components need to be changed when the environment is changed, since the light in the surrounding area affects the signal transmission.

The transmitted video signal via laser beam has been captured on a projector. However, the colors quality

Published by: The Mattingley Publishing Co., Inc.

was slightly reduced due to the channel, while the signal attenuation causes further quality reduction as well. Even though the colors are not as accurate, the underwater environment our project is designed to help in, oil pipes inspection is not a colorful environment, and the results we obtained would be sufficient enough for that purpose. The pictures below show the comparison between the original video signal, and the video signal that has been transmitted via laser beam in free-space (air medium) and in water medium. Figure 3 shows Original and Free-Space Transmitted Video Signals. Figure 4 shows Original and Underwater Transmitted Video Signals.

Figure 3:Original and Free-Space Transmitted Video Signals

Figure 4:Original and Underwater Transmitted Video Signals

5. CONCLUSION

The aim of this work was to develop an optical communication system that transmits a video signal from an underwater source to a monitor in the surface. Thus, it was achieved by building an underwater remotely operated vehicle that would carry a waterproof camera, and building an optical communication system that would transmit the analog video signal, via a laser diode, to the receiver on the surface and then converts the signal back to its original form to display the video on a monitor. This work succeeded in designing the optical communication system. The point-to-point communication system has proved to be efficient in the calm pure water, however it gets more challenging and the losses increase as the movement and impurities increase. For developing the project further, new methods could be looked into to increase the efficiency of receiving the light signal and directing it to the photo detector to obtain a better link. As the submarine moves underwater, the light signal moves as well, and may go astray from the original path and the point-to-point link will be lost. Using fiber optics is also a suggestion that proposes promising results, it would maintain the same speed rate while illuminating the signal attenuations caused by the signal scattering and water impurities as well.

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