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Underwater Robot with Wireless Communication Module (Through Zigbee)

Neelam R. Sattur, Parina K. N, Pushpanjali S.

Abstract— Development of an Underwater Robot which focuses on two main functions: the movement of the robot and image capture of the surroundings and transmission to the base station. Software written in Embedded C monitors functions of the underwater robot, communicating through Zigbee, ensuring controlled movement in all directions. For capturing and transmitting the images, a micro-controller board namely Raspberry Pi, is used which communicates with the computer through Wi-Fi. Image capture is through an underwater camera.

Index Terms— Communication, Embedded C Software, Remotely operated vehicles, Underwater Robot, Wi-Fi, Zigbee.

1 Introduction

THE intent is to develop a robot that is compatible for underwater research, navigation species identification, archaeological survey and communication from underwater to the base station on the surface and vice versa. The proposed model will have a communication range of 300 meters. This survey paper is a precursor to the building of a working model of an underwater robot, with wireless communication, which is a student project in part completion of Bachelor's Engineering Degree (Electronics and Communication Engineering) as per norms of Visvesvaraya Technological University, Belgaum, India.

A robot is a machine that can be programmed by a workstation and is capable of carrying out a complex series of actions automatically. They can be of two types: autonomous and semi-autonomous.

Robotics is a techonolgy used for designing machines which can be used to replace human beings in harmful conditions and locations.

The use of underwater robots is helpful to explore and study the ecosystems in the oceans and seas all over the world, 75% of the earth is cover with water.

The exploration of oceans and seas is helpful for scientific research of ecosystems, identification of shipwrecks or airplane crashes and mining for rare minerals underwater.

The major obstacle that humans face is to survive the conditions underwater for longer a period of time. As the water pressure on the divers increase with the increase in depth, the dissolved gases in the human blood increases rapidly and can be fatal to the divers, through a phenomenon called "Decomposition Sickness (DCB)" or "Aerobullosis" also popularly known as "Bends".

Humans are unable to work underwater at depths more than a few meters for long duration and to acquire the data which help in mining or surveys. Underwater robots can easily take over this task and are most useful here. It is very difficult and expensive to design and develop a system for humans, which can sustain the conditions and challenges encountered in deep sea underwater exploration. However an underwater robot can be designed with comparatively low cost and which can undertake all tasks. The Underwater robot would incorporate a suitable communication channel, controllers and processors and other components required.

2 RELATED WORK

2.1 Wireless RF Camera Monitoring for Underwater Co-operative Robotic Archaeological Applications.

Authors: Diego Centelles, Eduardo M. Rubino, Jorge Sales, José V. Martí, Raúl Marín, Pedro J. Sanz.

In this paper they have developed an underwater robot for archaeological operation. There are many applications of underwater robot one of them is archaeological survey. The word "archeology" stands for revisiting the history and study of ancient ruins of structures or ships further research. This task involves deep sea explorations. It requires expensive diving equipment and poses a great danger for the divers due to the unknown conditions underwater. Sometimes the shipwrecks are found at the seabed which are scattered with thermal vents, abyss and underwater volcanoes that are dangerous for divers.

Remotely Operated Vehicles (ROVs) can be the solution but they are very expensive. They have proposed a semi-autonomous robot that can help with the task. This robot can move underwater depending on the command given by the user and gives feedback through images captures by the on-board camera. Communications is a major part of any robotic application which involves user interacting with the robot. This system is cheap and overcomes the previous problems involved in deep sea exploration and will be able to conduct archaeological survey in a safe and efficient manner.

2.2 Wireless Underwater Metal Detector Robot.

Authors: Suraj Namdeo Rathod, Dagade Megha T, Nakhate

Mayur V, Lokare Supriya.
This paper develops an underwater robot used for metal detection. The deep sea has on its seabed many precious metals such as Silver, Gold, Copper, Manganese, Cobalt, available for extraction. The advancement of technology enables people to use ROVs for detection the presence of metals. They have used Zigbee in order to command to the ARM controller for movement of the robot in all directions. Zigbee module is used for communication from and to the ROV as it is less expensive.

2.3 A Compact Acoustic Communication Module for Remote Control Underwater.

Authors: Joseph DelPreto, Robert Katzschmann, Robert MacCurdy, Daniela Rus.

In this paper, the authors have proposed a system for development of a robotic vehicle which is capable of providing end to end communication for underwater operations. The system developed was able to support 2048 commands and packaged with user interface for controlling the underwater robot. They have successfully developed a model and demonstrated the operation in a pool and in the open ocean. The main purpose of the system is to replace the human factor, configure sensor networks and to establish communication with the base station on land.

2.4 Re-Evaluation of RF Electromagnetic Communication in Underwater Sensor Networks.

Authors: Xianhui Che, Ian Wells, Gordon Dickers, Paul Kear, and Xiaochun Gong.

The authors propose the development of a robot/vehicle which makes use of acoustic waves as the medium for transmission for underwater wireless networks. Acoustic modems are at the peak of their performance at the moment but the chances of getting much more out of them are very remote.
The use of optical links for underwater applications are impractical.
With the emergence of digital communications technology, this article is motivated by the limitations of present and established wireless underwater communication techniques and the potential applications of electromagnetic waves for underwater applications.
A comparison of the three major underwater technologies (radio, acoustic and optical) indicate the potential of underwater Electromagnetic (EM) waves. EM Signalling coupled with digital technology and signal compression techniques have many advantages which make it useful for underwater applications. EM communication in underwater environments is both feasible and effective for a specific set of applications.

2.5 Underwater robotic vehicles: Latest development trends and potential challenges.

Author: Ahmad Mahmood Tahir.

This paper gives the latest development trends in the underwater robotic technologies.
The underwater working environment requires state of the art operational technology. Innovation in this field of technology needs to have a reliable, flexible, productive and reconfigurable machine called as Remotely Operated Vehicle (ROV) that can work in ever-increasing depths following an optimized strategy. ROVs may be equipped with accessories such as a manipulator arm, SONARs, magnetometers and other instruments for measuring temperature, light and water parameters. Their tasks include operations structure inspection, repair and placement of underwater manifolds and other applications under the water. This paper gives an intensive study of high tech ROV systems, and supporting tools for this technology.
The key challenge in developing ROVs is exploration of underwater environment in a safe and productive manner.
Another important concern is to provide cost effective ROV solutions as the development of cheap yet high quality underwater imaging technology, better power management techniques, improved tethering techniques for power supply and signal transformation. The applications will replace human divers and manned vehicles.
The future direction is to develop hybrid underwater vehicles. The difficulty for development of hybrid structures is to ensure robustness and stability at the same time. A further move is to transfer from ROVs to AUGs. The most prominent advantage will be to have vehicles that are independent thus making them more dynamic. Improvement in the quality of associated technologies and their readily availability will further widen their application domains.

3 RESEARCH GAPS

Paper 1: Limitations of this paper is the use a Wi-Fi a single channel for both providing the command to the robot and also to obtain the captured images as mentioned in 2.1 above. Therefore, the use of a single channel for both the purposes causes a delay in either transmission of the captured images or in the movement of the robots.

Paper 2: Limitation in this paper is that the application is limited i.e., it is used only for the metal detection as mentioned in 2.2 above.

Paper 3: Limitation in this paper was processing power at the receiver and limited data rate. they have suggested to make changes in the microcontroller (smaller in size) to obtain an implementation of different modulation protocol. Other limitations are failure to establish control of multiple devices simultaneously as mentioned in 2.3 above.

Paper 4: Limitation in this paper is the use of RF-EM technology for underwater applications have certain unique challenges:
RF is susceptible to Electromagnetic Interference (EMI). The available data rate is proportional the available bandwidth and can be affected by the signal to noise ratio.

The data rates for underwater RF communication systems are frequency dependent i.e., the attenuation of an EM signal increases significantly with increases in frequency and distance as mentioned in 2.4 above.
A half-duplex antenna is a realistic solution for RF-EM technology.
When RF technology is used for underwater communication, there has to be a unique balance between the parameters such as antenna design and size, transmitting power, duty cycle, data bandwidth and local noise sources for an optimized solution for a specific application.

CONCLUSION

The focus is to achieve further improvement of underwater communications and to make it cost effective for deep sea exploration at a larger scale. It is still very dangerous for humans to explore the deep-sea beyond certain depth. Humans have to depend on advanced and efficient robotic vehicles for exploration, extraction of archaeological artefacts and precious minerals. There is an urgent necessity for development of ROVs specifically for deep-sea conditions. This calls for a dynamic and innovative design and development for such ROVs.

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