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Positioning Techniques for Underwater Visible Light Communications

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Abstract

In this paper, a positioning scheme for Underwater Visible Light Communications (UVLC) is proposed. Using buoys as UVLC transmitters on the sea surface and any photodetector based receiver underwater, the position of the receiver is estimated using multilateration method based on received signal strength within the transmitter coverage. A numerical evaluation was carried out, which shows that the proposed positioning scheme has a high level of accuracy, compared with other underwater positioning schemes. It can further be extended that Global Positioning System assisted intelligent buoys can be developed for UVLC positioning.

I. Introduction

Underwater optical wireless communication system has become an interesting research area to explore [1]. Global Positioning System (GPS) suffers from a poor performance in certain areas, especially underwater. Therefore, we cannot use GPS for an accurate underwater positioning [2]. Studies on visible light communication (VLC) have recently demonstrated promising applications on indoor localization and positioning, which can offer an accuracy of up to millimeter scale[3].

The present work investigates an Underwater VLC (UVLC) positioning scheme employing several buoys floating on the sea that transmit LED ID as position data to a receiver under clear ocean water. The receiver device equipped with a photodetector receives optical power signals from several LEDs to estimate its position based on a multilateration method.

The rest of this paper is organized as follows. Section II describes the system configuration. Section III presents the results and finally, conclusions are drawn in Section IV.

II. System Configuration

Figure 1 shows the system configuration. A simulation for the transmission was carried out employing four buoys transmitting LED IDs through blue LED with a defined angle of divergence of 60° through OOK modulation. Each transmitter consists of 140 W LED bulbs. The illuminance distribution pattern of the blue LEDs at a certain depth, which represents a coverage area of the reception, was fed directly into the photodiode receiver in line-of-sight (LOS) links without any obstruction. The buoys were assumed to be static on the sea surface unaffected by environment condition such as winds or sea waves that will make spatial interferences. We also assumed that the sunlight exposure did not penetrate through sea surface that can add noises to the signals reception. We defined an investigation area of 20 m x 20 m x 30 m for ease of analysis of the position accuracies.

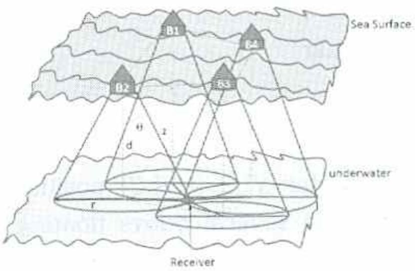

Figure 1. Receiver positioning system for underwater VLC using 4 buoys

III. Results

A simulation was carried out based on the aforementioned assumptions. The receiver will get the signals from the transmitter with losses due to clear water channel in LOS link with received power distribution.

The results show that we can estimate the position of any receiver with an accuracy of 10 cm using multilateral method (Fig. 2). It should be noted that in this simulation we use a linear least square calculation to compute the estimated distance of true position based on the received signal strength. Since the position was estimated in terms of coordinate from four sources, we could obtain a better accuracy compared with the estimation from fewer sources.

IV. Conclusion

The proposed positioning scheme for UVLC has been simulated using four buoys placed on sea surface and one underwater receiver. Multilateration method and linear least square estimation were used to estimate the real position of the receiver. The proposed scheme shows an accuracy of 10 cm under predefined conditions. For future work, we need to consider simulation employing real

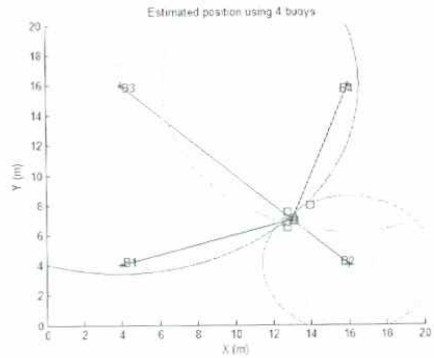

Figure 2. Simulation results: An estimated position for receiver at a coordinate of (13, 7) meter.

practical environment parameters such as sea surface movement or wind direction and sunlight exposure on several type of sea waters.

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