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ScienceDirect

Procedia Computer Science 110 (2017) 304–311

Procedia Computer Science

www.elsevier.com/locate/procedia

The 12th International Conference on Future Networks and Communications (FNC 2017)

Integrating Correlation Acquisition with Location Optimization for Accurate Indoor Lightwave Robot Positioning

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Abstract

In this paper, we proposed an indoor lightwave positioning system contains correlation operations with genetic algorithms. The implemented CDMA signaling system by spread spectrum (SS) codes can locate the position of the robot receiver as against noise interference. In the allocated LED transmitters, each channel of the transmitted signals is modulated into a series of maximal-length sequence code (M-sequence code) by LED light blinking. In the robot receiver, correlation peaks detection between received summed signal and each local replica signal is based to estimate the distance from each transmitter to the robot. We choose three transmitters among five to closest to the robot for more reliable positioning information. The robot positioning is first estimated by time difference of arrival (TDOA) and then genetic algorithm (GA) optimization is applied for more accurate robot location. We finally simulate out the TDOA result and analyze the accuracy of the robot position.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: Visible Lightwave Communication (VLC); Spread Spectrum (SS); Maximal-Length Sequence (M-sequence) Code; Time difference of Arrival (TDOA); Genetic Algorithm (GA).

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1877-0509
Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2017.06.099

1. Introduction

In today's advanced technology, the robots are widely used in variety kinds of area. Like cleaning machine in the house, the assembler arms in the factory and others based on the indoor environment. The positioning methods are important issues for locating the robot. The designer of indoor positioning system must know the distance between the receiver and the facility of transmitters. Further, we must to estimate the accurate coordinate of the location of the robot receiver.

There are many advantages by using white LEDs such as the benefit of long life expectancy, high luminance, no ultraviolet spectrum, and environmental protection, etc. These devices are considered common lighting systems and kinds of green energy. Moreover, they are not merely lighting devices but also applied for indoor light positioning. Factories, shopping malls and supermarkets are highly interested in indoor positioning, because demanders should find items quickly. Hence, visible light communication (VLC)[1, 2] has become an attractive way for indoor lightwave positioning.

To capture object distance over VLC scheme, correlation acquisition among orthogonal code sequences is one of the proper techniques. There are several digital coding sequences can be applied on VLC, like maximal-length sequence (M-sequence) codes[3], Gold sequences[4], and Walsh-Hadamard codes[5]. In this paper, we introduce an orthogonal codes based on their orthogonal correlation characteristics. By performing correlation acquisitions on coding lightwave signals with local code signal in the robot receiver, we can estimate the position of the robot receiver.

Gregary B. Prince[6] present a two-phase hybrid algorithm to determine the receiver's location. First procedure is called coarse phase using receive signal strength (RSS)[7] and second procedure is called the fine phase using angle of arrival (AoA)[8]. RSS is used LED anchors to transmit power of illuminant to determine. AoA improves RSS estimation by the azimuth and elevation direct the angle to the transmitter. The result show the VLC is feasible way for indoor communication.

The positioning is very important for a robot and a person to navigate their destinations. When robots and persons who are outdoors, the GPS can give the directions. However, the positioning system cannot be used in indoor, because indoor positioning environment is quite complicated. Therefore, a lot of positioning systems have been investigated such as ultrasonic [9], RFID[10], Wi-Fi, iBeacon and so on.

An overview on this paper is as follows. For orthogonal coding transmission through optical wireless channel, we introduce correlation detection techniques of M-sequence coding to estimate robot location. In Section 2, we illustrate the whole 3D environment and the characteristics of orthogonal codes. It is important for us to obtain the time of flight between visible lightwave transmitters and the robot receiver. These flight time are deeply connected with signals coding and acquisition techniques. Section 3 presents theoretical analysis and coordinates optimization of the robot receiver. Positioning algorithm of Time-Difference of Arrival (TDOA) is executed to make an initial estimation on the location of robot receiver. Simulation and estimation results for robot positioning accuracy are investigated in Section 4. Finally, concluding remarks and future research works are outlined in Section 5.

2. Architecture of Indoor Positioning System

An indoor positioning system using LED lightwave for estimating the position of the robot receiver and the configuration of the system is depicted in 3-D environment in Figure 1. There are five LED transmitters in the system, except the central LED transmitter, which is placed at the middle of the room, other LEDs are installed at the corner of the ceiling. To generate five M-sequence codes by chips cyclic in the same code family and assign to different transmitters, each transmitter is connected to a central controller. The transmission signals are modulated by M-sequence codes and LED light wave carrier. The indoor positioning system is setting up in the room and the room size is 10 meters in length, 10 meters in width and 3 meters in height.