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Design of a Visible Light Indoor Positioning Device

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Abstract. Under the background of low accuracy of existing indoor positioning technology, serious wireless resource consumption and complex system implementation, this paper studies the indoor positioning technology based on visible light communication and designs a visible light indoor positioning device. The device is a cubic space of 80cm*80cm*80cm, controlled and driven by LED control circuit. Through this design, the effect of improving the positioning accuracy is achieved.

1 Introduction

With the popularization of mobile communication networks and the continuous development of wireless communication technologies, the demand for indoor positioning has become increasingly prominent[1]. However, the current development of indoor positioning technology faces two major challenges: On the one hand, traditional wireless signals are subject to a complex indoor environment, resulting in irregular intensity attenuation, and reliability is greatly reduced; on the other hand, infrared, ultrasonic and other positioning technologies rely on a large number of special equipment[2]. The cost is high and it is difficult to deploy widely. With the advancement of science and technology, LED lighting technology has also been rapidly developed. Compared with traditional lighting sources, this LED semiconductor lighting has the characteristics of long life and low energy consumption. Using this characteristic of LED, it is used as At the same time as lighting, it can also be used as signal modulation for information transmission, thus forming an emerging optical wireless communication technology, see optical communication technology. This kind of technology has very high security; resource-rich, inexhaustible; with high transmit power; no electromagnetic interference. Therefore, the visible light wireless communication technology has a high development prospect and provides an effective solution for indoor positioning technology based on VLC (visible light communication). The VLC technology integrates lighting and communications, and LED (Light Emitting Diode) illumination sources provide communication capabilities. Therefore, if every lighting source emits a unique location beacon externally, the indoor environment will be divided into a more accurate positioning network. Users can determine the location of their own area by using the information provided by the lighting source to achieve indoor positioning.

2. System Overall Design

The positioning system is a 80cm*80cm*80cm fully enclosed wooden cubic space box. The inside bottom is drawn with a coordinate axis, and the other three sides are sprayed with paint to black, so that the white LED lamp is more discriminating in the daytime environment. The three LED lights to be tested are fixed to the top of the positioning space by the isosceles triangle. The point to be measured moves in an isosceles triangle that is mapped vertically to the positioning bottom layer. The height of the positioning space is constant, and only the side to be measured is on the bottom layer. The two-dimensional coordinates can be positioned.

The visible light-based indoor positioning device includes an image acquisition device that obtains an image corresponding to visible light emitted by a light source, wherein the visible light is modulated visible light, the visible light includes identity information of the light source, and the image processing device is connected to the image acquisition device to obtain the visible light[3].

The bright and dark stripes in the image, in which the bright and dark stripes in the image correspond to the identity information of the light source; and a control device connected to the image processing device to identify the light and dark stripes, obtain the identity information of the light source, and find the identity of the light source in the map. The corresponding position of the information, get the current position. The device overlook map is shown in Figure 1.

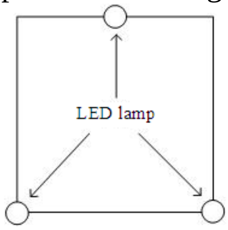

Figure 1. Device overlook map

The system consists of three parts: LED control system, sensor and camera, and display system. The system block diagram is shown in Figure 2.

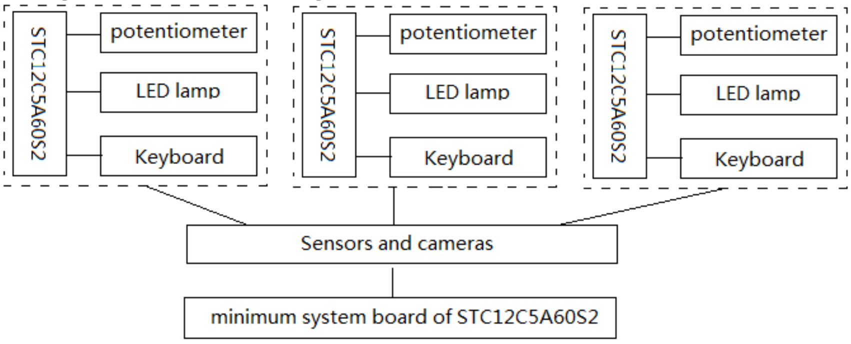

Figure 2. System block diagram

In order to achieve indoor positioning, a VLC-based indoor positioning system design scheme is proposed. The program uses a VLC hardware platform with a single-chip microcomputer as the control core to implement the distribution of location beacon information through time-division multiplexing (TDM) technology. The edge location algorithm estimates the distance between the sender and the receiver, implements the positioning information processing software using Visual C++, and completes the indoor positioning function on the PC terminal.

Due to the mutual interference when sending signals from different senders and the difficulty in recognizing the received signals at the receiving end, the time-division multiplexing technique is used at the sending end to send information. The system measures the level of the electrical signal exchanged by the optical signal at the receiving end, and uses the interpolation method to calculate the distance estimation value. At the receiving end, in order to facilitate the processing of the data by the host computer, we used Visual C++ to compile a positioning information processing software to facilitate the operation of the PC and the information display. At the same time, the position coordinates of the point to be measured can be calculated based on the received data.

Trilateral positioning is a method of locating based on distance information. The basic idea is that the coordinates of the three senders and the distance from the sender to the test point are known, and the coordinates of the test point can be uniquely determined.

The use of three-sided positioning algorithm to achieve positioning, first of all need to estimate the actual distance between the receiving and sending ends based on the received short signal strength. This scheme does not directly measure the light intensity at the receiving end. Instead, it adopts a simple and easy method, that is, it reflects the strength of the received signal through the level of the receiving end, and uses the interpolation method to realize the distance estimation at both ends of the sending and receiving. The system adopts the pulse position modulation (PPM) signal provided by the VLC hardware platform. The receiving end should accurately determine the start and end moments of the square wave pulse signal during demodulation. Therefore, when the data demodulation is performed at the receiving end, a level is defined to define the square. Wave range. When the distance between the transmitter and the receiver is close, the attenuation of the optical signal in the space is small, the amplitude of the received square wave is larger, and the level is larger;

conversely, when the distance between the transmitter and the receiver is far, the level is relatively small. In practice, there is no functional relationship between the transmission distance and the level. Therefore, an interpolation method is used to achieve distance estimation at both ends of the transmission and reception.

For the three-sided positioning method, the equations have unique solutions as long as the three LEDs are not on the same line. Transceiver ends are placed on the same horizontal line and there is no external interference in the space, the straight line distance between the two starts from 30cm, every 2cm measurement level, each measurement of 80 to 100 sets of data to average and record . Take the actual distance of the transceiver as the abscissa and the value level as the ordinate to fit the relationship between the two. In order to reduce the distance error, the system screens the level of the receiving point, takes the average of the first 10 levels as the reference value, and compares it with the reference value from the 11th level received. When the difference is greater than 30, the data is discarded; when it is less than 30, the cumulative summation is averaged to avoid the occurrence of serious deviations that interfere with the average of the value levels. The LED lamp has a slight difference and the measured level is different. Therefore, three LED lamps need to be measured separately. When the distance estimation is performed, as long as the measurement level is determined between those two levels, interpolation can be used. The estimation of the distance between the two ends of the transceiver can be calculated by the interpolation method.

3. Hardware System Design

We chose the stc12c5a60s2 microcontroller as the master core, which is 12 times faster than the stc89c52. Three single-chip microcomputers are used to control each of the three LED lights, and the 51 smallest system board is created by the user. The volume is small and the downloading procedure is convenient, and does not occupy too much space. Input different numbers on the keyboard, and then the STC12C5A60S2 MCU gives the LED lights different frequencies. The measurement circuit judges the position of the sensors according to the signals detected by the sensors, and displays the specific coordinates on the other display. For this system we use the 1602 display to meet the display requirements.

4. Program Design

4.1 Program function description and design idea. According to the requirement of the software, the keyboard is mainly set up and displayed.

1) Keyboard realization function: setting frequency value, frequency band, voltage value, and setting out type of output signal.

2) Display part: display voltage value, frequency band, step value, signal type, frequency.

4.2 Main program flow chart. The main program flow chart is shown in Figure 3. Description: initialize serial communication at 9600 bits per second; Convert the analog reading (which goes from 0 - 1023) to a voltage (0 - 5V).

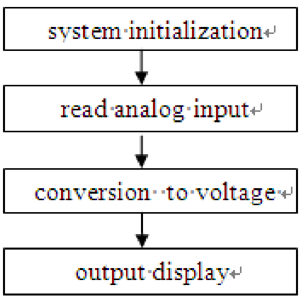

Figure 3. Main program flow chart

5 Test Results and Analysis

In order to verify the feasibility and effectiveness of the scheme, simulation experiments and actual tests were performed on the positioning system. At the same time, the same positioning scene is tested using the implemented positioning system. The test is divided into two phases. Firstly, the random distribution of the positioning section is tested to verify the feasibility of the solution. Secondly, a fixed-position positioning node is selected for testing to evaluate the positioning performance of the solution.

5.1 Test result (data).

Table. Ⅰ 2V signal test results

Signal value/V	0.2050	0.2100	0.2045	0.4026	1.007	1.542	1.669	1.999
Display/V	0.2051	0.2100	0.2044	0.4026	1.006	1.542	1.669	1.999

5.2 Test analysis and conclusion. Based on the above test data, the following conclusions can be drawn:

1. In the 80cm*80cm*80cm space, when the receiving end is located at the edge of the triangle, the distance from the three sending end to the receiving end is always far.

2. In the actual system + test, the average positioning error of 3.2cm was obtained, which improved the positioning accuracy compared to the first experiment. This is because the first random test of the 10 points was tested once and not for each point. The test is averaged several times, so the positioning error is large.

In summary, this design meets the design requirements.

6 Conclusions

This paper proposes a visible light localization method that estimates the distance from the positioning node to the LED using the luminous intensity of the indoor lighting LED, and uses the three-sided positioning to obtain the position information. The test results show that the system performs simulations and actual tests at 80cm*80cm*80cm and 31 points respectively. In the actual system test, the average positioning error of 3.2cm is obtained. Compared with the first experiment, the positioning accuracy is improved. Because the 10 points of the first random test were tested once and no average was taken for each point multiple times, the positioning error was large. The deviation of the positioning results at the center of the triangle was small, and the positioning error at the edge of the triangle was small. Large. This is because the value of the received value at the center of the triangle at the receiving end is relatively accurate, the distance estimation is quite accurate, and the positioning error is low. When the receiving end is located on the edge of the triangle, the distance from the three sending end to the receiving end is always far. Therefore, the received value has a large level error and the distance estimation is inaccurate, resulting in a large positioning error. In the 80cm space, the bit error is 3.2cm, which verifies the feasibility of the system to achieve indoor positioning based on the three-side positioning method.

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