Research on Hardware Circuit design and Positioning Algorithm of Electronic Whiteboard Based on Ultrasonic Infrared

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Abstract. With the development and progress of science and technology, in daily work, we have introduced various computer technology-related algorithms, which makes our work more precise and efficient. This paper mainly studies the hardware circuit design and positioning of the electronic whiteboard using ultrasonic infrared, and it also discusses the system structure and principles.

Keywords: Ultrasonic Infrared, Electronic Whiteboard Positioning, Single Chip Microcomputer Transmitting and Receiving, Circuit

1. Introduction
With the development of technology, the single teaching method is gradually improved. Traditional blackboard writing and multimedia teaching can no longer meet the current teaching needs. However, the interactive whiteboard organically combines multimedia teaching and traditional blackboard writing. It combines the advantages of the above two modes and gradually becomes an indispensable teaching tool. The electronic whiteboard is a high-tech product, which developed by a variety of high-tech methods, such as cutting-edge electronic technology and software technology. It uses wireless positioning, sensing and other technologies, it can achieve paperless office and teaching. This paper focuses on the electronic whiteboard system, which is based on ultrasonic and infrared. It also discussed the design of the transmitting circuit and the plane positioning algorithm [1].

2. System structure and working principle of ultrasonic infrared electronic whiteboard

2.1. Working principle and positioning principle of electronic whiteboard
As shown in Figure 1, in this system, the transmitter pen changes within the plane of the electronic whiteboard and periodically emits infrared and ultrasonic signals. The left and right signal receivers in the signal receiving processor respectively receive infrared and ultrasonic signals and amplify them. After filtering, send them to the signal processor, the signal processor extracts the time difference between the infrared and ultrasonic signals arriving at the left and right signal receivers, and sends them to a PC equipped with special software. The PC calculates the coordinates of the transmitter pen (that is, writing notes). And for display, identification and printing.
Figure 1. Wireless positioning electronic whiteboard based on ultrasound
When the positioning principle is on the surface of the screen, the transmission speed of ultrasonic is used to calculate the distance from the transmitting point to the receiving point according to the time between the transmitting and receiving of ultrasonic waves. The principle of plane positioning is to place two ultrasonic receivers distributed at a fixed distance on one side of the screen. The pen used for positioning is an ultrasonic transmitter [2]. When the pen moves, the ultrasonic waves emitted by the pen are detected by the receiver along the surface of the screen. The distance between the pen and the two receivers can be calculated from the time of receiving the ultrasound. Using the principle of three-point positioning, that is, the principle that the vertex where the pen is located can be determined according to the known three side lengths of a triangle, and the position coordinates of the pen are calculated. This is a ranging positioning mode.

2.2. The overall structure of the electronic whiteboard
The electronic whiteboard system is mainly composed of signal pen, signal receiver and host computer. The system block diagram of the system is shown in Figure 2.

Figure 2. Block diagram of the electronic whiteboard system

3. Design of signal transmitting and receiving circuit

3.1. Block diagram of signal transmission principle
The basic function of the signal pen is that the single-chip microcomputer in the signal pen generates pulse signals, amplified by the drive circuit, and then drives the ultrasonic and infrared sensors on the signal pen to generate ultrasonic and infrared signals. The principle block diagram of the signal pen 3.
3.2. Signal transmitting circuit design
What the one-chip computer chooses in the system is PIC12C508a of Microchip Company to produce the waveform circuit. The waveform circuit mainly sends out pulse signals from the GPO port and GP1 port of the PIC12C508a single-chip microcomputer as the driving signal for the ultrasonic and infrared sensors of the pen tip. The GPO port of the single-chip microcomputer PIC12C508a sends out a pulse signal with a pulse width of 400μS and a period of 10ms as the driving signal of the ultrasonic sensor. No. GP1 port sends out a pulse signal with a pulse width of 200μS and a period of 10ms as the driving signal of the infrared diode. Choose SFH426 as the infrared emitting diode, which has an emission angle of 120°, so use 4 SFH426 to evenly distribute it on a circle of the pen to achieve 360° omnidirectional emission. The ultrasonic sending sensor is US80KT-01, which can realize 360° omnidirectional transmission of ultrasound [3].

3.3. Signal launch software design
The main functions realized by the software are: firstly, it sends out pulse signals with a period of 10ms and a pulse width of 400μS and 200μS respectively, which are used as driving signals for ultrasonic and infrared sensors. When the signal pen is working, it sends out the ultrasonic and infrared signals required for system positioning. The second is to wake up or make the microcontroller enter sleep mode by judging the level change of pin 4 of the microcontroller, that is, the GP3 port [4]. Using the pin level change interrupt mode of the microcontroller, when the pin is low, the microcontroller enters the sleep state, and the current at this time is reduced; when the GP3 port becomes high, it will wake up from sleep mode to enter Working status. This is done so that when the pen is lifted, the MCU enters the SLEEP mode and does not send a signal.

3.4. Signal receiving part design
The ultrasonic receiving sensor uses SR80KHZ-01, which is also a piezoelectric film sensor, which has the advantage of receiving a large range of signals. Cylindrical thin film sensors exhibit good directional angle characteristics and a large bandwidth. These characteristics make it play a good role in two-dimensional positioning, digitizer, object detection and ranging, etc., and get better applications. Piezoelectric thin-film ultrasonic sensors also have a very low quality factor, which means that the signal rise and fall times are shorter than ordinary ceramic ultrasonic sensors. These characteristics are ideal for positioning applications.

The infrared receiving sensor adopts ST1838, which is the smallest infrared remote control system receiver. The PIN diode and preamplifier are installed in a welded shell and epoxy material encapsulated. The modulated signal output by the receiver can be directly demodulated by the microprocessor. Its main advantage is that it still has reliability in interference environments. The shell has a shielding effect against electromagnetic interference [5,6].

The one-chip computer uses Microchip's PIC12C508a, which mainly uses its CCP1 and CCP2 modules to capture the time reference signal (infrared signal), the ultrasonic signal channel RI and the ultrasonic signal channel R2 in the capture mode, and the time delay information can be obtained.
4. Research on three-point positioning algorithm of ultrasonic ranging on PC

The positioning methods based on TOA (Time of Arrival) estimation mainly include circular positioning and spherical positioning. This system uses TOA circular positioning, and the circular positioning algorithm based on TOA estimation is shown in Figure 4 [7].

![Figure 4. Schematic diagram of TOA circular positioning algorithm](image)

This method uses two fixed position sensors to locate a source. The two receiving sensors located in a fixed position receive the transmitted signal from the source, and calculate the propagation time of the transmitted signal from the source to the sensor R1, R2: \( \tau_{S,R1} \), \( \tau_{S,R2} \). For the TOA method, the distance of the signal to the receiving sensor can be transmitted by measuring the source signal Time is obtained, an estimated value of distance corresponds to a circle centered on the receiving sensor, and the intersection of the two circles is the position of the source signal, so that the source can be located [8,9]. According to the propagation speed C of the source signal, the length of the two line segments SIR1 and SIR2 can be obtained as formula (1):

\[
\begin{align*}
S_{IR1} &= \tau_{S,R1} \times C \\
S_{IR2} &= \tau_{S,R2} \times C
\end{align*}
\]

According to the Pythagorean theorem of plane geometry, there is formula (2):

\[
\begin{align*}
S_{IR1} &= \sqrt{(x-x_s)^2 + (y-y_s)^2} \\
S_{IR2} &= \sqrt{(x-x_s)^2 + (y-y_s)^2}
\end{align*}
\]

\(Y_a=y_b\) From the formula (1) (2), the coordinate points can be obtained as formula (3):

\[
\begin{align*}
x &= \frac{(x^2 - x_s^2) - (y^2 - y_s^2)}{2(x_s - x)} \\
y &= y_s(1 + \frac{y_s}{x_s}) - \frac{y_s^2}{x_s}
\end{align*}
\]

The key to the positioning algorithm based on TOA estimation is to accurately measure or estimate the propagation time of the source's transmitted signal to the two receiving sensors. The positioning method based on TOA estimation is implemented through a combination of software programming and hardware design [10].

5. Conclusion

The electronic whiteboard is a high-performance electronic product. It not only contains the functions of handwriting input and computer operation, but also has a small size, so it is very easy to carry. This is very suitable for business personnel or academics and other portable use.

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