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Model People Auscultation System Based on Capacitive Sensor

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Abstract: The medical teaching needs auscultation training, so a model people auscultation training system was designed based on capacitive sensing principle. The PIC32 CPU with charging time measuring unit was used as the system core. Capacitance sensors were set in different parts of the model, the sampled signal was digitalized and processed, the cancelling jitter algorithm and dynamic average filtering was used for improving signal, and then the simulation audio was played. At the same time, the acquisition data was sent to the workstation through Zigbee RF module for being processed. The experience results showed that the system could simulate the audio signal from the different model parts, and it’s useful for raising the training effect; the algorithms of dynamic average filtering and cancelling dithering played important role for keeping on the system stable.

Keywords: Model People, Auscultation system, Capacitance sensor, Wireless transmission

1. INTRODUCTION
In the medical teaching practice, the human body model (also called model) is often used to develop students’ ability of diagnosing human organs disease, and the auscultation simulation training is taken in different parts of the model, the main simulation content includes intentional, lung, abdominal auscultation and vascular tone, subcutaneous emphysema sound, muscle bundle fibrillation tone, joint activities tone, fracture surface fricative, pulse, etc [1-5]. where exists the main disadvantages: can't simulate difference between different signs and symptoms of the patients auscultation sound; Only teachers can play a auscultation sound, but the auscultation sound can not be automatically and actively adjusted according to the realization of the trainee auscultation operation, etc. This kind of simulation training system is mainly composed of two parts: workstations and model people, and the high price also limit its popularization application. Therefore, using the capacitance sensor for testing the auscultation head position of stethoscope and realizing a model people organ diagnostic instrument, the PIC32 series single chip microcomputer is used as the system control core, so as to improve the students’ ability of auscultation illness in different body parts.

2 SYSTEM SCHEME
The system is mainly composed of the two parts: workstations and man model. In addition, man model used built-in power supply power for each part of the model. The overall diagram of auscultation training simulation system is as shown in figure1.

The single chip processor used in system is PIC32MX120F032D produced by Microchip Company, with 13 ADC channel AN0 - AN13, and most can be connected to the 13 touch sensor. According to the simulation training needs, in auscultation site installed certain number of capacitive touch sensor, and respectively connected to the AN0 - AN13 ports of the single chip microcomputer. CTMU module has a programmable current source used for capacitive touch sensor charging. When pressing sensor, the microcontroller acquisition the corresponding parts touch information data and was transferred to the workstation using the ZigBee 2.4 GHz wireless radio module.
The workstation is used to set a disease, signs, age, and according to the model parameters such as model people feedback information to make judgment, provides specific auscultation sound information for model people. In order to realize the auscultation simulation, many auscultation modules are installed in model parts, such as in the lung, stomach, heart, wrist, and other auscultation parts [3]. The working process of the system is: the workstation software set simulation sickness, human body characteristics (age, gender, etc.), and other conditions in each part, and through the wireless network, the data was sent to the CPU in human body model, after the CPU received the data, the CPU converted the data to audio signal and drove power amplifier, and then play auscultation tone, so the purpose of the training auscultation was achieved.

2.1 Capacitive sensor principle

According to plate capacitor basic structure and its principle, the human body blood iron can produce similar capacitance characteristics, this capacitance attached to the body. As shown in figure 2, when the body (such as finger) contact capacitive touch sensor, will act as another capacitance plate because of its dielectric property [6-8]. This will make the system’s effective capacitance change, which can be used to detect the touch action. At this time the equivalent capacitance sensor is:

\[ C_F + C_P = C_{OUT} \]

The capacity will change with the environment and finger touch. When touching, finger acts as one of the parallel plate, and the other as a parallel plate is connected to the input end of the sensor chip. When the capacitor group close to the conductor, it will produce a capacitance substantially coupled to the ground, in determining the touch it will represent measuring voltage changes. Capacitive touch induction solution may be realized using the voltage change technology; this system uses the charging Time measuring Unit CTMU (Charge Time Measurement Unit) in PIC MCU chip to achieve [3].
2.2 Realizing capacitive touch induction

The PIC32 MCU is specially equipped capacitor charging time measurement module CTMU, which can be combined with a modulus conversion ADC unit and used for accurate measurement the capacitance. It contains a constant current source that connected to the ADC channels, as shown in figure 3. CTMU uses constant current source to calculate the small changes of capacity and time difference between the events [8, 9].

![Figure 3. The built-in CTMU module of PIC microcontroller](image)

CTMU can provide fast response speed, at the same time, it has a number of current source in different range, making it charging at faster speed for analog channel, thus to improve the response time of the capacitive touch induction system. The basic formula of these CTMU peripherals for capacitive touch induction application is:

\[ I \times T = Q = C \times V \]

where, for CMTU, \( I \) is the constant current source, \( T \) is capacitive touch sensor charging fixed cycle, \( C \) is capacitive touch sensor capacitance, \( V \) is capacitive touch sensor voltage value (be read through the ADC). This formula in rearranged, then can detect the capacitance relative change by observing the voltage change [10].

According to the front formula, it can be concluded the testing steps for the touch process: first, the capacitive touch sensor (as a capacitance) is connected to a multiplex channel for CTMU peripherals and ADC; Then, the constant current source charges the touch sensor in a fixed period of time (\( T \)), and the sensor voltage (\( V \)) is measured through the ADC; When the capacitance produced by touch sensor welding plate doesn’t change, in continuous charge measuring, voltage will not change. The voltage will change when the diagnosis device touch capacitance sensor effectively.

As shown in figure 4.

Due to the CTMU has persistence current source, and may be combined with multichannel ADC, so it provides effective resources for capacitive touch sensor application. CTMU peripherals will be connected directly to the ADC input pins, make it be connected to any pin through the multichannel analog switch. This configuration makes the measurement sensor number of single CTMU is equal to that of ADC channel. It’s convenient for measurement calibration because of the fine position control related to the current source, also can reduce the external interference and transmission loss.
3 SOFTWARE FILTERING ALGORITHM FOR INTERFERING

The many kinds of factors, such as the temperature and humidity, touch degree and pollutants and EMI/EMC interference will lead to sensor capacitance wavering, thus affecting touch induction performance of the system capacitance.

In order to deal with these effects, the dynamic average detection algorithm of software filter is used to eliminate the residual noise on sensor pad, and software dithering algorithm to distinguish the two states between touch and not touch.

The algorithm can also test multiple touch state, in order to distinguish the touch by means or not. And then, to detect touch through the calibration software so that the system is more robust even the capacitance touch pad has a thick covering layer [11], the dynamic average detection algorithm thought is: take N continuous sampling value as a queue, The fixed queue length is N. The new collected data each time is placed in the rear, and discard the first data (FIFO principle: First in First Out) in the original team. The N data in the queue was made in arithmetic average operation, and obtained a new filter data. This method can effectively filter the general random interference noise, so that the signal swings around a mean value [12, 13].

The dithering algorithm are: set a filter counter; Every time the sampling value is compared with the current value: (1) if the sampling value is equal to the current value, the counter is reset; (2) if the sampling value is not equal to the current value, the counter + 1, and judge whether the counter is equal or greater than the upper limit N (overflow); If the counter overflow, will replace the current value with this value and clear counter. Therefore, this method has good filtering effect for measured parameters changing slowly so it can prevent numerical jitter nearby the critical value.

4 CONCLUSIONS

The human diagnosis model system based on the capacitive touch sensor provided a good training means for medical students' auscultation human illness training, the experiences showed that: the system simulation training effect is clear, and the system can save data workstation and processing through the wireless way. In system realization the problems needed to be pay attention are: (1) the distance influence between the near sensors should be considered; (2) in order to reduce parasitic capacitance and increase finger capacitance, it's should be fully considered for the influence capacitive touch induction effect factors, such as sensor pad size, the stethoscope size of the commonly used should be close to the ideal value as far as possible; (3) the conductance line length may influence the line impedance and sensitivity, so the appropriate line length between sensors and single chip microcomputer should be selected well, etc.
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