Research on a novel gesture recognition device

Jian Huang
Xijing University, Xi'an, China

Abstract. In order to effectively detect the input gesture information, a new type of capacitive sensing technology, which is of a low power consumption, low cost but high resolution non-contact sensing technology, is adopted. When our finger gets close to the metal plate, it will cause the change of the capacitance value of the metal plate to the ground. That value can be converted into 28-bit binary data for output. The microprocessor is equipped with the IIC interface for acquisition and processing of the output data. Because a variety of gestures produce different capacitance values, their output varies. After many times of training and machine learning, different gestures can be identified. The test results show the rate of different gestures recognition is over 99%, which can be applicable in human-computer interaction equipment.

1. Introduction
Gesture recognition is one of the important research directions in human-computer interaction technology. It can be used in virtual reality, sign language recognition, games and other fields. In recent years, gesture recognition has received extensive attention and research. In reference [1], monocular camera was used to collect gesture information, and gesture contour was combined with image matching algorithm to identify it. In reference [2], a convolutional neural network gesture recognition method based on multi-dimensional parameters of FMCW radar is proposed, which can recognize gesture by analyzing and processing radar wave signal. In reference [3], the depth image was segmented and gesture recognition was performed by training random forest classifier.

The above methods are basically based on graphics and image processing and pattern recognition technology, which need to process a large amount of data, with high algorithm complexity and low recognition rate [4-7].

In order to avoid these shortcomings, this paper proposes a new gesture recognition method, which uses a new digital capacitance sensor fdc2214 to detect gesture, and based on non-contact capacitive sensing technology. Fdc2214 has four channels, each of which can sense the small change of capacitance and convert it into 28 bit binary output. In the experiment, two channels are used to connect a 20cm * 30cm double-sided copper clad laminate. When different gestures approach the copper clad laminate, parasitic capacitance will be generated and different digital values will be obtained. Through multiple machine learning, different gestures can be recognized.

2. System structure
The system block diagram is shown in Figure 1. In the figure, channel 2 and channel 3 of fdc2214 are used to connect the two ends of 20cm * 30cm double-sided copper clad laminate to sense the change
of copper clad laminate capacitance. Channel 0 and channel 1 are exposed in the air, sensing the capacitance in the current environment as a reference value. The capacitance values of the four channels sensed are converted into digital quantities, and connected to the master control stm32f103zet6 through IIC interface for software processing, and relevant data are sent to the display for display [8]. The power supply unit provides 3.3V DC.

3. Main working principle and technology

3.1. Principle of fdc2214

The structure block diagram of fdc2214 is shown in Figure. 2. In order to improve the data acquisition rate, it is necessary to connect an external 40MHz active crystal oscillator [9]. The schematic diagram of channel 0 and channel 3 is drawn in the figure. For channel 0, pins in0a and in0b connect inductance L and capacitance C to form an oscillation circuit. Cx0 in the figure is an external variable capacitor, which can be any metal or conductor. Together with L and C, it forms an oscillation circuit with variable oscillation frequency.

The working principle of channel 0 to channel 3 is the same. Taking channel 0 as an example, its equivalent circuit is shown in Figure 3. In the figure, the sensing plate 1 and the sensing plate 2 constitute the target detection sensor. In the test, the sensing plate 1 is a 20 cm * 30 cm double-sided copper clad plate. Perceptron 2 is a different gesture. Their capacitance values are CX1 and CX2, where CX2 is variable. They are connected in series with L and C to form an oscillation circuit. The oscillation frequency FS is calculated by formula (1) and (2). Formula (3) calculates the reference frequency fr, and formula (4) finally obtains the digital quantity up to 28 bits after conversion.
In formula (1), $f_s = \frac{1}{2\pi \sqrt{L(c + c_s)}}$

$$f_s = \frac{1}{2\pi \sqrt{L(c + c_s)}}$$

In formula (2), $C_X$ is the equivalent capacitance of $C_{X1}$ and $C_{X2}$ in series.

$$C_X = \frac{1}{C_{X1}} + \frac{1}{C_{X2}}$$

In formula (3), $F_R$ is the reference frequency, $f_{clk}$ is the input frequency of fdc2214, which is 40MHz. ch0_SEL is realized by setting the fdc2214 internal register 0x14 by software to realize the frequency division of $f_{clk}$. When testing, it is set to two frequency division.

$$f_r = \frac{f_{clk}}{ch0\_sel}$$

3.2. Connection between fdc2214 and stm32

The connection diagram of fdc2214 and STM32 is shown in Figure 4. In the figure, they are grounded together, and 3.3V power supply is adopted. The data line SDA in IIC interface of fdc2214 is connected with pb10 of STM32. Clock line SCL of IIC interface is connected with pb11 of STM32.

$$DATA_0 = \frac{f_r}{f_s} \times 2^{28}$$

4. Software flow chart and main technology

The software flow chart is shown in Figure 5. Firstly, the serial port, SPI, IIC and timer are initialized. Judge whether the training mode, if yes, enter the training mode, collect a gesture for many times; then transfer to the next group, re-collect multiple times; after all the training, classify and store different gestures. After the training mode, enter the recognition mode, collect gesture information, conduct pattern matching, judge and recognize [10]. The information can be sent to computer through serial port or displayed on LCD.
4.1. **IIC sequence diagram**

The read and write data of STM32 and fdc2214 are carried out through IIC interface, and the reading and writing sequence is shown in Figure 6. The IIC interface can be simulated by pb10 and pb11 of STM32.

![IIC Read and Write Sequence Diagram](image)

**Figure 6.** IIC read and write sequence diagram.

4.2. **Training classification and pattern matching algorithm**

In training, for each gesture, due to the existence of interference, the data will change in a larger range. Therefore, the data must be intercepted. For 28 bit data, the fourth bit is removed. As shown in Figure 7, the effective data b4-b27 is obtained, and then processed by Kalman filter, the regular data can be obtained and classified.

In pattern matching, the gesture information is read many times, then the mean value is taken to judge which category it is in, and then the recognition information is given.
5. Test
According to the above design hardware circuit and program. Make the test sample, as shown in Figure 8. In the figure, STM32 module is in the upper left corner, fdc2214 module and tft1.44 inch display are in the lower left corner, and a 20cm * 30cm copper clad plate is on the right, which is connected to channel 3 of fdc2214 with a wire.

When testing, different gestures can be used to approach or place on the CCL to get the test value. The gestures "1", "2", "3", "4", "5", "stone", "scissors" and "cloth" are given respectively. Channel 3 is used to test different gestures, and channel 0 is used to test the current environment value. As a reference, the following set of test data is obtained.

| Gesture | CH3 Measured value | CH0 Measured value |
|---------|--------------------|--------------------|
| 1       | 5810-5830          | 7081               |
| 2       | 5630-5650          | 7081               |
| 3       | 5530-5550          | 7081               |
| 4       | 5460-5490          | 7081               |
| 5       | 5360-5390          | 7081               |
| stone   | 5310-5340          | 7081               |
| scissors| 5250-5290          | 7081               |
| cloth   | 5140-5180          | 7081               |

From the above three tables, we can see that the use of data interception method and effective filtering algorithm can effectively identify different gestures, and can classify them clearly.

After learning, the group data will be saved. When different gesture recognition is carried out, the corresponding gesture can be judged by collecting the gesture, obtaining its conversion value, matching, and judging its corresponding gesture. After many experiments, the success rate of different gesture recognition is obtained, as shown in Table 2.
Table 2. Success rate of different gesture recognition.

| Gesture  | Recognition success rate |
|----------|-------------------------|
| 1        | 99.9%                   |
| 2        | 99.8%                   |
| 3        | 99.9%                   |
| 4        | 99.9%                   |
| 5        | 99.9%                   |
| stone    | 99.9%                   |
| scissors | 99.6%                   |
| cloth    | 99.8%                   |

As can be seen from table 2, due to the high accuracy of fdc2214, the recognition success rate of each gesture is very high, reaching more than 99%.

6. Conclusions
In this paper, a new gesture recognition method is proposed. Based on the capacitance sensing technology, the corresponding hardware circuit is designed, the software is programmed and with the sample produced. The test results are as good as possible to be able to effectively identify different gestures. Compared with graphics and image processing technology, this technology has the advantages of simple hardware circuit, strong anti-interference ability and high recognition rate, thus can be used in human-computer interaction equipment.

References
[1] Wang Yanquan, sun Bowen. 3D dynamic gesture interaction based on monocular camera [J]. Computer engineering and science, 2018, 40 (9): 11662-1669.
[2] Wang Yong, Wu Jinjun, Tian zengshan, Zhou mu, Wang Shasha. Multi dimensional parameter gesture recognition algorithm for FMCW radar [J]. Journal of electronics and information, 2018,40:1-8.
[3] Hua xufen, sun Jun. research on gesture recognition algorithm based on depth information [J]. Sensors and Microsystems, 017,36 (12): 122-125.
[4] Du Jingyi, Guo Jinhao, Zhang Bo. Ultra low power gesture recognition contactless switch based on STM32 [J]. Coal technology, 2018.37 (8): 208-209.
[5] Si Yang, Xiao Qin Kun. Gesture tracking algorithm based on interactive multiple model Kalman filter [J]. Science and technology and engineering, 2018:18 (22): 229-236.
[6] Wei Qingli, Xiao Wei, Liang Weiqiang, sun Zhenchao, Zhang Li. PNN based gesture recognition [J]. Sensors and Microsystems, 2018,37 (8): 16-18.
[7] Shi Xiangjun, Wang Xingyao. Dynamic gesture recognition based on infrared sensor and hidden Markov model [J]. Electronic devices, 2018, 41 (5): 1286-1290.
[8] Wang Haipeng, Gong Yan, Liu Wu, Li Ze, Zhang Simei. Research on a spatiotemporal multi-scale adaptive gesture recognition method [J]. Computer science, 2017,44 (12): 287-291.
[9] Yu Hailong, fan Xueli, Gong Hailan, Xie le.Research on gesture recognition method of sEMG signal [J]. Journal of Jiangxi Normal University (NATURAL SCIENCE EDITION), 2018,42 (5): 512-517.
[10] Wang Min, Shi Xinyuan, Wang Zhihui, Li Zeyang. Motion gesture tracking algorithm based on vibe and spatiotemporal context [J]. Acta electronica Sinica, 2018,33 (1): 92-98.