Tuina Force Acquisition System of Finger Pressing Therapy

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Abstract. A Tuina force acquisition system of finger pressing therapy is discussed. Based on STC12C5A60S2, a display platform for Tuina force acquisition is designed. The hardware of the system is mainly composed of minimum system module, signal acquisition module, amplification and filtering circuit, sound and light alarm module and display module. The system is initialized at startup and adjusted to data acquisition state. When the doctor starts to massage, the measured data by sensor is transmitted to data acquisition system, then transmitted to host computer after processed by single-chip module. The data is displayed real-timely and dynamically on host computer and judged whether or not to generate alarm according to the preset threshold. When the sensor prober is placed on his upper arm, and mechanical stimulation is performed using finger-pressing therapy, the system can collect and display finger-pressing massage force accurately in real time. Experiments show that the system can collect massage force quickly and effectively in real time.

Keywords. Acquisition system; Finger pressing therapy; Tuina force.

1. Introduction
Tuina therapy is a sort of traditional medical treatment which is widely used and has effective clinical curative effect [1]. Relative researches have shown that certain mechanical stimulation on the human body surface can cause changes in various physiological parameters of the human body [2–4]. Although the efficacy of Tuina has attracted the attention of many domestic and foreign researchers, the current theoretical research on massage therapy is still lagging behind [5]. This is due to the lack of effective Tuina force acquisition and quantification approach. In this paper, a Tuina force acquisition system of finger pressing method is designed based on FSR film sensor. This system can not only real-timely measure and collect the Tuina force of finger-pressing method, but also display it real-timely on the host computer in the form of images. In addition, it also has an alarm function. If the Tuina force exceeds the threshold set by the system, it will automatically alarm using sound and light.

2. System Design
Firstly, by using the FSR film sensor, the Tuina force of finger-pressing method on human body surface is converted to voltage signal. Secondly, the voltage signal is transformed to stable sampled voltage value through the amplification and filtering module. Lastly, the sampled value is converted to digital signal, sent to host computer STC12C5A60S2 and displayed in the real time. The overall structure of the system is shown in figure 1.
2.1. Hardware Design

The hardware of the system is mainly composed of minimum system module, signal acquisition module, amplification and filtering circuit, sound and light alarm module and LCD12864 display module. The real system is shown in figure 2.

![Figure 1. Block diagram of the system.](image1)

![Figure 2. The real system.](image2)

2.1.1. Signal Acquisition Circuit Design. The signal acquisition circuit uses +5V voltage as input and generates an analog signal according to the variation of the sensor resistance and the feedback resistance. Then the analog signal is AD converted to digital signal through single-chip module. The schematic diagram of the signal acquisition circuit is shown in figure 3. According to analysis, the output voltage $V_{out}$ can be expressed as below:

$$V_{out} = \frac{R_1}{(R_1 + R_{FSR})}$$

(1)

2.1.2. Amplification Module. This module is based on dual operational amplifier LM358, its circuit schematic is shown in figure 4. According to our analysis, the voltage-gain of this module is expressed as $A_v = 1 + R_{v1}/R_{v2}$, and the output voltage is $V_{out} = (1 + R_{v1}/R_{v2})V_{int}$.

![Figure 3. Schematic diagram of the signal acquisition circuit.](image3)

![Figure 4. Signal amplification circuit.](image4)

2.1.3. Filter Module. This module is based on second-order filter circuit, and an operational amplifier is added to improve the stopband rejection ratio and passband of the circuit. The schematic diagram of the low-pass filter circuit is shown in figure 5.

2.1.4. Alarm Module. The maximum pressure range of finger-pressing therapy Tuina force is 243.994 mmHg-244.169 mmHg [5], which is 32.53 kPa-32.55 kPa after unit conversion. According to the active area of the sensor, the input alarm threshold of the system is set to 5.4 N. The sound and light alarm will be trigger when the intensity of the finger-pressing force exceeds this threshold. The circuit of sound and light module is shown in figure 6.
2.2. Software Design

2.2.1. Main Program Design of the System. Firstly, the system is initialized at startup and adjusted to data acquisition state. When the doctor starts to massage, the measured data by sensor is transmitted to data acquisition system, then transmitted to host computer after processed by single-chip module [6]. The data is displayed real-timely and dynamically on host computer and judged whether or not to generate alarm according to the preset threshold. With the above, the Tuina force is collected accurately and real-timely, and the safety of massage operation can be improved. The flow of the system software main program is shown in figure 7.

2.2.2. Display Module. The data collected by sensor is sent to MCU through serial port, after processed, the value of Tuina force is displayed by LCD12864 module.

Firstly, open the serial port channel of MATLAB to receive data, and create a drawing window. Secondly, determine whether the monitoring window is closed through the window handle, and terminate the loop if the monitoring window is closed. Lastly, read pressure data through serial port and update the drawing in real time, then end the loop and clock serial channel. The real-time monitoring window is shown in figure 8.
3. System Test

3.1. System Calibration
The system is calibrated using weight. Compared to the finger-pressing, the contacting area of weight and the film sensor is different, which causes some measurement error. To reduce the error as much as possible, the calibration data is measured multiply and averaged. The pressure calibration diagram is shown in figure 9, and the relationship between weight and voltage is shown in figure 10.

By the fitting curve of figure 10, we can get the data fitting formula is:

\[ f(x) = -6.917 \times 10^{-6} x^2 + 0.01099x - 0.009762 \]  

Figure 8. The real-time monitoring window.

Figure 9. System calibration diagram.

Figure 10. Experimental result for calibration of the system (a) and fitting curve of the system (b).
3.2. System Test
A healthy male is choose as the testee, the sensor prober is placed on his upper arm, and mechanical stimulation is performed using finger-pressing therapy [7]. During the experiment, the operator repeatedly performs finger-pressing stimulation on the contact position, and the force information is collected by the system, transmitted to host computer and displayed dynamically. The result is shown in figure 11.

![Figure 11. The real-time pressure of repeated finger-pressing.](image)

Flexiforce sensor prober is placed at the force position, where it takes several cycles of vertical mechanical stimulation. Then the force information is sampled by the force measurement system and transferred to computer.

During the experiment, the performer stimulates at the force point repeatedly and samples the force information using force measurement system. Take the first experiment as example, the force signal sampled is shown in figure 12.

![Figure 12. The real-time pressure variation chart on host computer.](image)

To ease observation, the pressure is multiplied 10 times in the program. According to the trend in the figure, when the pressure on the sensor increases, the output of this system increases as well. There
will be a little jitter at first, but it will soon stabilize.

4. Analysis and Conclusion
This system uses FSR film sensor as the sensitive component, the sensor is placed under the fingertip to measure the Tuina force of finger-pressing therapy. The real-time monitoring and displaying of finger-pressing therapy is accomplished through three steps. Firstly, the sensor output resistance variation is converted to voltage signal through acquisition circuit. Secondly, the voltage signal is transformed to digital signal through single-chip module after it’s amplified and filtered. Lastly, the digital signal is sent to host computer and displayed real-timely. The system debugging result indicates that the system designed in this paper is able to acquire the Tuina force of finger-pressing therapy real-timely and monitor whether the applied force is too big. It is expected to be applied to the teaching and mechanism research of massage therapy.

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