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Design and research of smart boxing trainer based in physical education practice on the sensor

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Abstract. Since the 20th century, boxing has developed rapidly and become popular among people. According to techniques and tactics and training requirements of all kinds of boxing, a smart boxing trainer based on the sensor is designed in the study. The system of the designed smart boxing adopts STC12C5A60S2 processing chip in hardware, including signal collection, deviation compensation, voice announcement and other modules. In terms of software, Keil μVision2 is used to realize the initialization driver to hardware modules, helping collect power signals and eliminate interference and set the time and voice modules. BSDSOI S SD voice chip is combined with Interphonic 5.0 to broadcast results of the training. Finally, the system is tested, the deviation source is analyzed and the deviation is compensated. The experiment shows the training method is effective, that the system is viable, and that the system can be used by coaches to make more targeted training plan for trainees.

Key words. Sensor, boxing training, boxing training, trainer, system calibration.

1. Introduction

Boxing is a valuable event, which can improve the coordination of human body and stabilize the respiratory system [1]. So in order to meet the requirements of training, training devices designed for boxing emerge. In China, training devices are relatively backward, which mainly includes hand target, training bag and simulated target as a result of outdated technology and knowledge. The training devices are too outdated, dull and stereotyped to systematically acquire training data [2]. Therefore, it is difficult for coaches to make horizontal and vertical comparison for trainers, which may affect their improvement. A new type of equipment, which works in collecting data and integrating teaching, training and testing, seems to be very important.

In box training, physical training device are interesting and scientific. At present,

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many types of training devices have produced in China, which can only record one punching position [3–4]. Training devices produced abroad have many positions and complete functions. But these devices are costly, so they cannot be generally used in China [5]. For example, linear displacement sensor of the taekwondo trainer manufactured in South Korea displays in spite of slow force, so the design of the device has weakness in measurement. The cost of the trainer itself is so high that it cannot be used widely in China [6]. Based on the above conditions, the simulated training target of the smart boxing trainer is designed according to techniques and tactics and training requirements. Computer technology is embedded in the device to control it, realizing the digitization of boxing punching information. Sensing technology is also used to exactly measure punching points and momentum and other key moving parameters. Hence, an intelligent man-machine training is realized, which makes it possible for coaches to make better plans for the trainees.

2. Hardware design of the smart boxing trainer

2.1. Realization of simulated system

Basic equipment used in the design is the primitive pile trainer currently existing in the market. And meanwhile, kennel processing control chip is also implanted in the trainer by electronic technology. Hardware function structure of the system is shown in Fig. 1. The flow chart of specific modules is shown in Fig. 2.

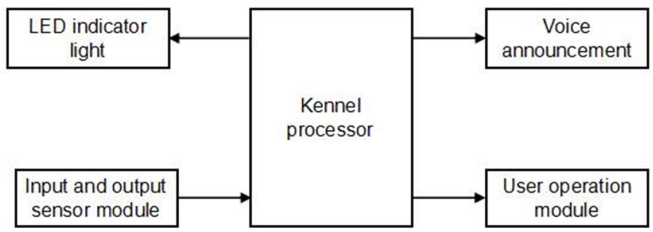

Fig. 1. Hardware function structure of the system

In the designed system, pressure transducer is voltage sensor. Signal acquisition and converter of the system are very important. The pressure sensor can convert power signals of boxing trainees into voltage signals. And these tiny voltage signals are converted into sample signals of A/D converter after amplification and wave filtering. At last, A/D converter converts these simulated voltage signals into digital signals again and send to microprocessor for processing. TH4805 pedal force sensor in the design is adopted as signal acquisition unit.

TH4805 sensor works in a strain mode, and its working principle is shown in Fig. 3.

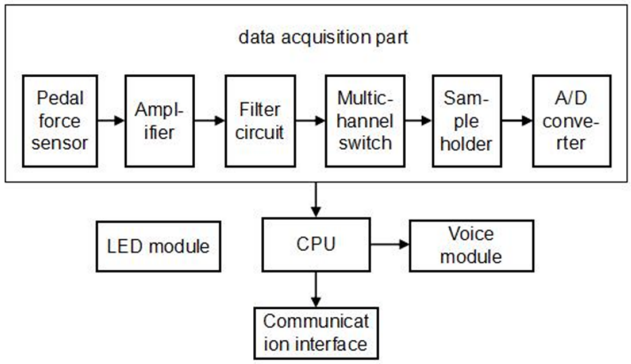

Fig. 2. Flow chart of modules data acquisition part

2.2. Realization of digital system

In designing the power module, voltage regulator in the system is LM317, enlarging the input range of supply voltage. In order to enhance the stability of circuit voltage, TL431L regulator chip is used in the system. 479 μF capacitor and 104 filter capacitor are also used in the input part of the power module so as to reduce interference. Serial communication circuits are added to the power module. Level conversion chip of MAX232 is embedded in the system in the way of RS232 bus. As for voice module, audio playback module BSD5015 SD is used. Therefore, a LM317IC chip converted by a 3.3 V voltage is employed. In terms of MCU processing module, processor chip STC12C5A60S2 is used, which has high speed, lower power consumption and strong ability of anti-interference. STC12C5A60S2 is the main control part of data collection. 8/10 bit resolution through chip integration makes analo-to-digital conversion for dynamic analog signals and sends the collected data to the control memory.

3. Software implementation of the smart boxing trainer

3.1. Power signal acquisition and interference elimination

In the process of power signal acquisition, three threshold values are set as system evaluation limits, whose determination system adopts the training quantification standard of national boxing player. The power signal is amplified 10 times, the acquired signal is sent to MCU, whose voltage signal ranges from 0 to 5 V. As 8 bit binary A/D conversion is applied in the system, the signal precision is $1/(2^8-1)$. When the binary is x after receiving A/D conversion, the corresponding voltage signal value is $5x/(2^8-1)$ and power signal value is about $5x/(2^8-1)\times 1000/5$ N. In the implementation of the program, three graders are set, standing for the grade limit of three voltage signals, namely, 0x30, 0x80and 0xCC, and their corresponding power signals are about 20 kg, 50 kg and 80 kg. The detailed data acquisition flow is shown in Fig. 4.

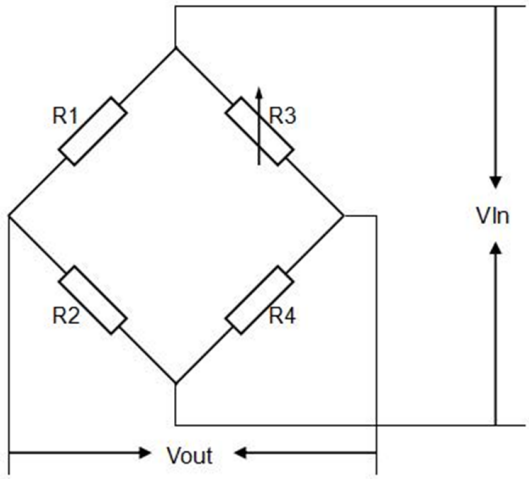

Fig. 3. Working principle of TH4805 sensor

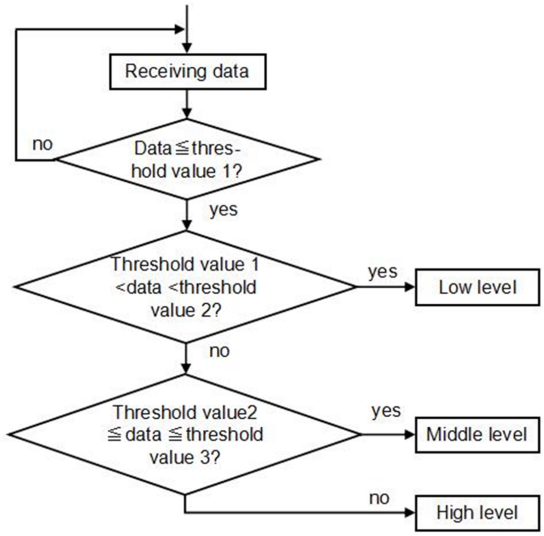

Fig. 4. Process of force data acquisition

When the trainee punches the target, it can be seen from the oscilloscope display: there is a nearly 10 ms interval from the beginning of the wave form to the maximum value. But the the precision the system requires is detecting 4 boxing data in a second (the time to do a boxing is 250 ms or so), so it takes just 200 ms to know the maximum value of voltage change. The system may be affected by glitch signal in acquiring signals, so the time for AD conversion is set 5.5 μs. And 100 conversions takes about 600 μs. The average value of 100 voltage values is taken as a signal acquisition point. It takes 200 ms to acquire 300 average values. By sequencing

these averages, the maximum value is clear so that interference in signal acquisition can be decreased.

3.2. Setting of time and voice system

It is concluded and found from the researches and experiments: in high state of rapid boxing, the high-quality boxing of common training people is mainly in the preceding 50 times. Therefore, in designing the system, 10 s is set as the round time to evaluate the performance of users. Timer 0 working mode of MCU is applied in designing the program. The crystal oscillator of MCU is 12 MHz, and its mechanical period is 50 ms, hence, the time of 200 exactly corresponds to 10 seconds. Meanwhile, voice announcement module is added in the system to report the training results of trainees. BSD5015 SD card audio playback module used in the design combines Interphonic 5 speech synthesis system made by Iflytek.

4. System detection of the smart boxing trainer

4.1. System calibration

The designed system in the study is calibrated statically and dynamically. The process of static calibration is: within the 1000 N measurement, as the amplified sensor signal is converted to 0–5 V voltage signal by AD, the correspondent pressure of each 1 V voltage signal is 200 N or so. In addition, the calibration also includes voltage detection by the potentiometer, which directly chooses the output voltage (5 V) of the chip. When it is rotated to the maximum, PI.0 port voltage of 60S2 is 4.99 V and meanwhile the power of voice announce is 996 N. The specific static calibration results are shown in Table 1.

Table 1. Static calibration

Voltage (V)	Standard pressure (kN)					
	0	c	c	c	c	c
Stroke	(1)	(2)	(3)	(4)	(5)	(6)
Forward stroke (1)	0.000	1.002	2.006	3.008	4.006	5.007
Reverse stroke (1)	0.001	1.004	2.007	3.009	4.004	
Forward stroke (2)	–0.003	1.005	2.010	3.003	4.007	5.003
Reverse stroke (2)	–0.004	0.998	2.005	3.006	4.009	
Forward stroke (3)	–0.002	1.007	2.009	3.011	4.012	5.012
Reverse stroke (3)	0.003	1.007	2.008	3.007	4.005	
Average value	–0.0012	1.004	2.007	3.007	4.007	5.008

Besides, when dynamic measurement calibration is carried on, as the human target face is installed with cushion and spring device, the deviation is higher than that of the static calibration. The whole dynamic measurement calibration work

is done according to law of conservation of momentum, and the specific method is: swing balls are placed in the same height. They are free to fall successively. The force of punching area of human target and impact force induction balance after these balls fall is collected. By comparing several experiments, it can be found that the force collected dynamically is by 30–40 N smaller than that of the standard strength under rigidity. Different trainees are in different states, the training target had better be more flexible. Under this circumstance, some deviations in dynamic state can be ignored compared with the overall effect of the system.

4.2. Deviation compensation

The sensor in the system is relatively sensitive. In real-time detection, the system automatically enters to the working statement in power-on condition and produces deviation of measurement data because the sensor is embedded inside the human target and creates mechanical pressure in fixing with the target. In order to solve the above problems, the dial switch is connected in the system to set lower threshold value under detection. The dial switch with 8 bit binary can be set to 255 to the maximum. After debugging, the compensation of 0x10 is made in the system. It is about 60 N, namely, FR (R means real value) = FA (A means acquisition) – FC (C means compensation).

5. Conclusion

After investigating the current situation and needs of boxing market at home and abroad, the creation of the study and viability are approved, which means modern electronic technology and boxing training are combined in an effective way of designing a smart boxing trainer based on the sensor. Hardware circuit module plan as well as hardware circuit controlling works of each module (acquisition module, power module and voice module) are designed, thus making it possible to acquire signal, eliminate interference and set time and voice module. In the latter stage of circuit debugging, the system is calibrated statically and dynamically, which verifies the viability of the system.

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