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Human Motion Data Acquisition System of Intelligent Motion Bracelet Based on Human-Computer Interaction

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Abstract. In order to improve the accuracy of human motion data acquisition and reduce the time-consuming of data acquisition, an intelligent motion Bracelet human motion data acquisition system based on human-computer interaction is proposed and designed. Firstly, the overall architecture of the system is designed, mainly including application layer, transmission layer and perception layer. Secondly, the system hardware is designed, mainly including the motion data acquisition module, temperature acquisition module and ZigBee wireless transmission module of human-computer interaction intelligent sports bracelet, so as to ensure the realization of the system function. Finally, in the part of system software design, wavelet transform is used to discretize the collected human motion data and divide the attributes, so as to improve the availability of the data. The experimental results show that compared with the traditional motion data acquisition system, the designed system has higher acquisition accuracy and shorter time-consuming.

Keywords. Human computer interaction; Smart sports bracelet; Human motion data; acquisition system

1. Introduction

Under the background of the stable development of social and economic level, people's material living standard has been greatly improved. With the gradual enrichment of material conditions, people began to gradually pursue the level of physical health. Under the background of modern society, proper exercise is an essential way to improve the level of physical health, but once there is excessive exercise or incorrect exercise mode, it will do some harm to the body [1-3]. Therefore, in order to avoid this problem, human motion data acquisition system came into being. Human motion data acquisition is mainly divided into two ways: wearable and non wearable. Wearable is to collect motion data by contacting the human body in the process of motion, while non wearable is the acquisition method without contacting the human body [4]. Compared with non wearable, wearable acquisition technology has the characteristics of higher accuracy. For example, it can accurately collect human motion data through sports bracelet.

Reference [5] proposes a human motion data acquisition system based on shimmer wireless wearable sensor device. Firstly, the system constructs a multi-sensor node model and uses the median filtering algorithm to filter the motion signal collected by

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the sensor. According to the filtered data, the sliding window technology is used for data segmentation. Finally, the feature extraction method is used to extract the features contained in the data, so as to complete the collection of motion data. However, the operation process of this method is long, resulting in a long time for the overall data acquisition. Reference [6] proposes a human motion data acquisition system based on MEMS sensor. The system uses the combination of FPGA and arm to design the system. After the signal of human motion data is collected by the sensor, the data is stored by FPGA and transmitted to arm for storage and processing. Kalman filter is used to denoise the collected motion data signal to eliminate the data error. Although the system denoises the data, the accuracy of the data collected by the system is insufficient. Reference [7] proposes a human motion data acquisition system based on wireless transmission protocol. The system is based on the core single chip microcomputer and obtains human motion data through multiple measuring points. The collected human motion data is transmitted to the host computer through wireless transmission protocol, and the reliable transmission is realized by time division multiple access multiplexing technology. However, the accuracy of human motion data acquisition of the system still needs to be further improved.

In order to solve the problems of low data acquisition accuracy and long time-consuming in the above traditional system, an intelligent motion Bracelet human motion data acquisition system based on human-computer interaction is proposed in this paper.

2. Human motion data acquisition system of intelligent motion bracelet based on human-computer interaction

2.1 Overall system architecture design

The human motion data acquisition system of intelligent motion Bracelet based on human-computer interaction is mainly composed of three levels: application layer, transmission layer and perception layer. The overall structure of the system is shown in Figure 1.

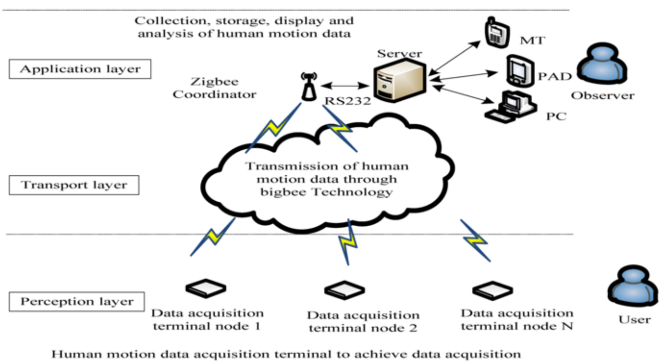

Figure 1. Human motion data acquisition system architecture of intelligent sports Bracelet

It can be seen from the structure of the human motion data acquisition system of the intelligent motion Bracelet shown in Figure 1 that the perception layer of the system is mainly responsible for the acquisition of human motion data through the terminal node, while the transmission layer is mainly responsible for the transmission of human motion data through bigbee technology, and the application layer is responsible for the processing and storage of human motion data and the display of the collected human motion data through intelligent terminals such as computers, for users to use and analyze.

2.2 System hardware

(1) Motion data acquisition module of intelligent motion Bracelet

In order to improve the collection accuracy of human motion data of intelligent sports bracelet, the human-computer interaction module of human body and intelligent sports bracelet is used to collect motion data. The human motion data is collected through the sensor in the intelligent motion bracelet, and the human motion data is collected through ZigBee wireless transmission technology and transmitted to the PC [8]. The working principle of the motion data acquisition module of the intelligent motion Bracelet under human-computer interaction is shown in Figure 2.

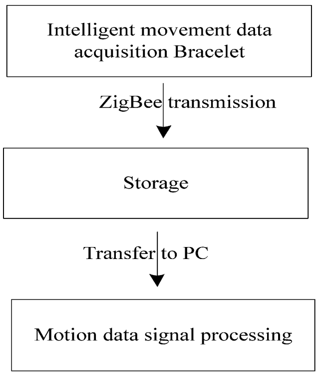

Figure 2. Motion data acquisition module

(2) Human body temperature data acquisition module

When the human body is moving, the temperature change is the most obvious. Therefore, the temperature sensor module is designed to collect the temperature data when the human body is moving. The temperature sensor is mainly composed of microprocessor, power circuit and keys. The structure of the temperature sensor module is shown in Figure 3.

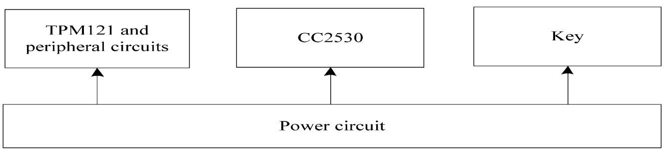

Figure 3. Composition of temperature sensor module

(3) ZigBee wireless transmission module

In order to transmit the collected human motion data safely and effectively, ZigBee wireless transmission module is designed in the system. ZigBee wireless transmission module includes CC2530 chip, peripheral circuit, power module and display module, which can transmit a number of collected data in the process of human motion. Structure of ZigBee wireless transmission module is shown in Figure 4.

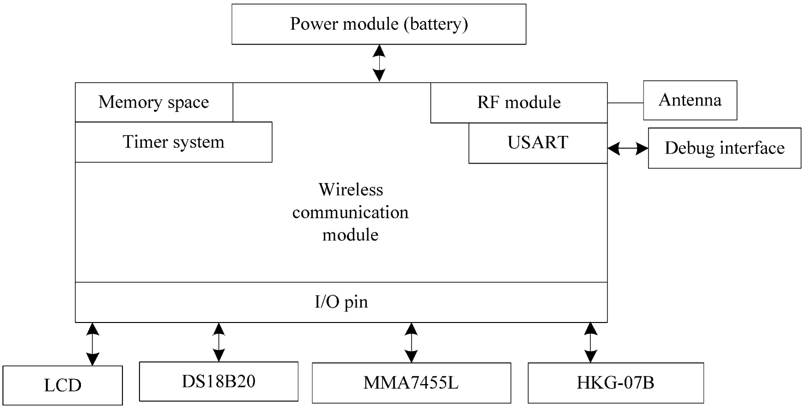

Figure 4. ZigBee wireless transmission module

2.3 System software

Assuming that there is one-dimensional human motion data acquisition signal, the expression is:

$$f(t) = s(t) + n(t) \tag{1}$$

In the formula, $s(t)$ represents the original human motion data signal, and $n(t)$ represents white noise [9-10].

The human motion data signal shown in formula (1) is discretized [11], and the discrete signal $f(n)$ is obtained. The wavelet transform expression of the discrete signal is:

$$W(i,j) = 2^{-\frac{1}{2}} \sum_{n=0}^{N-1} f(n) f(t)(2^{-j} - k) \tag{2}$$

In the formula, $W(i,j)$ represents the coefficient of wavelet transform, j represents the calculation constant, and k represents the wave number calculated by wavelet. In order to simplify the calculation [12], the wavelet transform expression shown in formula (2) is expressed recursively:

$$S(j+1,k) = S(j,k)h \tag{3}$$

$$W(j+1,k) = W(j,k)g \tag{4}$$

In the above formula, h and g represent the filtering parameters of scale function and wavelet function respectively [13-14], and $S(j,k)$ represents the scale transformation coefficient. The calculation formula of human motion data signal reconstruction is:

$$S(j-1,k) = S(j+1,k)\overline{h} + W(j+1,k)\overline{g} \tag{5}$$

In the formula, $\overline{h}$ and $\overline{g}$ respectively represent the mean value of the filtering parameters. The noise elimination of the data signal is completed through the reconstruction processing of human motion data. After the noise elimination, the attributes of the same type of human motion data are divided, so as to improve the analyzability of human motion data [15].

Calculate the principal component similarity factor of two human motion data:

$$S_p = \frac{M'T'}{L'k'} S(j-1,k) \tag{6}$$

In the formula, k' represents the number of principal components in the human motion data set. Compare the similarity factor calculated in formula (6) with the similarity threshold η_1. If it exists, calculate the distance similarity factor between the data $S_p > \eta_1$, otherwise eliminate the data. The calculation formula of distance similarity factor between human motion data is:

$$S_d = \sqrt{\frac{2}{\pi}} \int_1^{\infty} S_p e^{z^2} dz \tag{7}$$

In the formula, e represents the discrete parameter of data noise, and z represents the window smoothing parameter of data. Compare the calculation result of formula (7) with the threshold η_2. If $S_d > \eta_2$ exists, it is considered that the two data belong to the same type of data.

Through the combination judgment of principal component similarity factor and distance similarity factor, the accurate attribute division of human motion data is carried out to improve the availability of data.

3. Experimental verification

In order to verify the practical application performance of the proposed human motion data acquisition system of intelligent motion Bracelet based on human-computer interaction, the experiment of system performance verification is carried out under system operation parameters shown Table 1.

Table 1. System operation parameters

Project	Parameter
Operating system	Windows 7
Processor	Inter Core-i5
Hard disk	2TB, 128MB cache
Digit	64 bit
Memory	6GB DDR3 200MHz

Based on the above set system operating environment parameters, simulation comparison and verification are carried out. The experiment selects 20 college students for research. Each college student wears Huawei 4e intelligent sports bracelet, carries out sports for college students three times a week, and collects the sports data of each college student. The data collection cycle is 28 days, so as to fully collect the sports data.

Based on the above data, set the experimental scheme: take the human motion data acquisition accuracy and acquisition time as the experimental comparison index, and compare and verify the system with reference [6] and reference [7].

Human motion data acquisition accuracy: human motion data acquisition accuracy refers to the consistency between the data acquisition results of different systems and the actual data. The higher the human motion data acquisition accuracy, the stronger the performance of the system.

Human motion data acquisition time-consuming: human motion data acquisition time-consuming refers to the time-consuming for different systems to complete all data acquisition under the condition of the same amount of data. The shorter the time-consuming, the higher the acquisition efficiency of the system.

3.1 Human motion data acquisition accuracy

The fundamental purpose of designing the human motion data acquisition system of intelligent motion bracelet is to collect accurate motion data. Therefore, verify the acquisition accuracy of the human motion data acquisition system, and compare this system with the traditional reference [6] and reference [7] systems under the same experimental environment. The comparison results of human motion data acquisition accuracy of the three systems are shown in Figure 5.

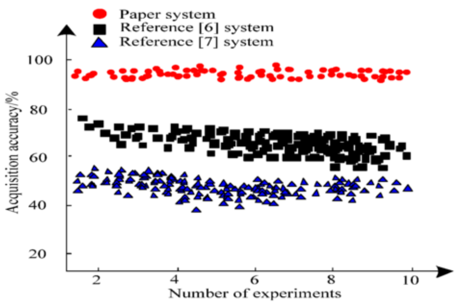

Figure 5. Comparison results of human motion data acquisition accuracy

From the human motion data acquisition accuracy results shown in Figure 5, it is not difficult to see that the acquisition accuracy of the system in this paper is high, and the concentration of the result points is high, which shows that the system in this paper can realize the high-precision centralized acquisition of human motion data. The data acquisition accuracy of the two literature comparison systems is not more than 80%, and presents a relatively decentralized state. Therefore, it shows that the designed system can realize the high-precision acquisition of human motion data.

3.2 Human motion data acquisition time-consuming

Due to the high timeliness of human motion data, the acquisition time of human motion data acquisition system is required to be high. Taking the time of human motion data acquisition as the performance evaluation index, a variety of systems are compared. The time-consuming comparison results of human motion data acquisition of the three systems are shown in Figure 6.

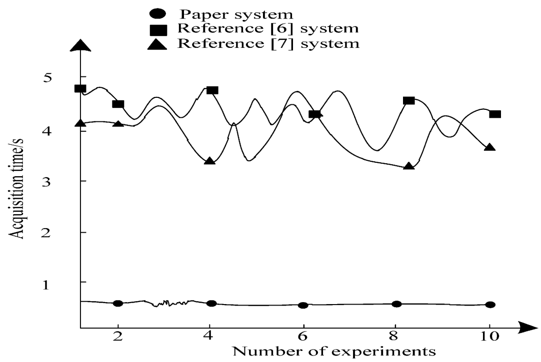

Figure. 6 Comparison results of human motion data acquisition time

From the comparison results of human motion data acquisition time shown in Figure 6, it can be seen that the data acquisition time of the text system is much lower than that of the two literature comparison methods. The maximum acquisition time of the system in this paper is about 0.5s, which shows that the system in this paper can effectively ensure the timeliness of human motion data acquisition.

4. Conclusion

In order to improve the accuracy and efficiency of human motion data acquisition, an intelligent Bracelet human motion data acquisition system based on human-computer interaction is proposed, and the performance of the system is verified from both theoretical and experimental aspects. The system has higher acquisition accuracy and lower acquisition time when collecting human motion data of intelligent bracelet. Compared with the acquisition system based on MEMS sensor, the data acquisition accuracy of the system in this paper is significantly improved; Compared with the acquisition system based on wireless transmission protocol, the data acquisition time of this system is shorter, only about 0.5s. Therefore, it fully shows that the proposed data acquisition system based on human-computer interaction can better meet the requirements of human motion data acquisition of intelligent bracelet.

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