

Research on monitoring system of physiological index of intelligent treadmill based on sensor

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Abstract. Based on the study of fitness system monitoring, we have established a treadmill system through Bluetooth communication. By collecting and recording physiological parameters and motion data, we analyze the data, and use the results of the analysis to give a scientific evaluation of physical condition, fitness effect and fitness program quantification. For a single exercise, according to people's dynamic physiological parameters and exercise data, we give the fitness effect of exercise and physical reserve evaluation parameters, so as to help people to better understand their physical condition and exercise fitness effect. Therefore, people can get more scientific exercise, to prevent excessive exercise or lack of exercise and other issues, and improve fitness efficiency.

Key words. Heart rate monitoring, control system, physiological parameters.

1. Introduction

Running exercise is one of the most important activities for people to carry out physical exercise and is one of the most popular fitness activities in the world [1]. It has a high rating in the medical profession and sports field, and it is also the most effective way of exercise [2]. Running can effectively strengthen the function of limb muscles, bone exclusion, heart and lung, and it has the obvious curative effect for losing weight [3]. Due to some objective factors, such as: climate, environment, venues, etc., people are increasingly concerned about the indoor exercise, so treadmill fitness has become the preferred way of people to exercise [4].

The basic physiological parameters of the human body include blood pressure, pulse and body temperature, which are closely related to vital signs, and we can use these physiological parameters to determine the health of the human body [5]. At present, the most commonly used indoor fitness equipment is electric treadmill, and it enjoys features of small footprint, easy speed regulation and simple operations [6]. Some treadmills also support audio and video playback, with a simple heart rate

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measurement function, different environments and venues experience function, but these treadmills in the human nature has not fully reflected [7]. From the point of view of fitness, it did not achieve the best fitness effect. In view of the above situation, we combine treadmill fitness with sports health monitoring, collect and store the physiological parameters during people running. In addition, through a certain analysis and processing, we present the people's physical and sports situation in time, so people can view their current health indicators in real time, and understand their own exercise situation. Therefore, it has great application prospect and research value to record and analyze motion data for a long time.

2. The basic structure of the system

2.1. Treadmill system requirements

1) Collect and record the physiological parameters (heart rate) and motion data (velocity, distance, slope, time) for a long period of time.

2) Based on the statistical analysis of the data, we give a quantitative evaluation of the physical condition, fitness effect and fitness program.

3) Based on the statistical analysis of the data, we give guidance to people's later fitness training programs.

4) For a single movement, according to people's dynamic physiological parameters and motion data, the system can adjust the exercise intensity and exercise time in real time.

2.2. The hardware requirements of treadmill system

In hardware, the system consists of seven parts, namely treadmill hardware, frequency converter, host computer board, heart rate meter, display, keyboard and mobile phone side.

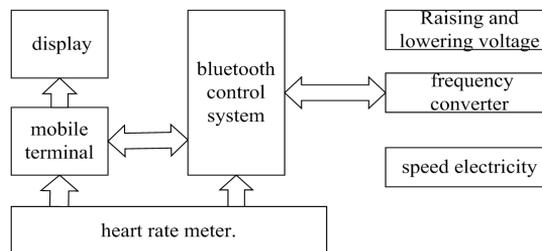


Fig. 1. System hardware requirements analysis chart

(1) Treadmill

Treadmill hardware is provided by Rizhao Kangli, mainly composed of motor, running belt and metal frame. Model: AC9000.

(2) Frequency converter

The main task of the inverter is to control the speed of the treadmill motor speed

and the size of the ramp motor, this part is the purchase of the sea frequency of the inverter, the relevant agreement has been written.

(3) Host computer

In order to communicate with iPhone and iPad, here we adopt the Bluetooth 4 communication scheme to realize wireless transmission. On the one hand, Apple released restrictions on the Bluetooth protocol, allowing programmers to add their own protocol. On the other hand, Bluetooth 4 has been popular in the new Apple and Android phones, so here we choose the CC2540 chip.

(4) Heart rate meter

Heart rate is an important feedback signal for human health. In the process of rational control of fitness, heart rate is an important part of scientific fitness. Heart rate is a relatively simple measurement of a physiological parameter, heart rate changes can directly reflect the body's exercise intensity, energy consumption, breathing and physical condition. At present, the fitness industry is using hand-held heart rate sensor and wireless heart rate chest.

(5) Mobile terminal

Here, we use the Bluetooth 4.0 low-power protocol to achieve the control and display of the above functions. This can directly be arranged through the Bluetooth 4.0 to obtain the value of wireless heart rate chest, and then directly display it. Due to the hardware limitations of Bluetooth 4, the support of system iOS7 is used.

3. Selection of heart rate sensor

3.1. Heart rate

Heart rate is an important indicator of human health feedback. In the process of exercise, the reasonable control of heart rate is an important way of scientific fitness. With the development of the heart rate measurement system, it has become an important part of fitness equipment, so the purchase of electronic control equipment is also an important reference for this. Heart rate is an important physiological parameter in the human body, heart rate changes can directly reflect the body's breathing, energy consumption, physical condition and exercise intensity.

3.2. Heart rate sensor

The principle of the heart rate sensor: the heart is like a power supply, the reason why the blood can continue to circulate in the body. As it is dependent on the rhythm of the heartbeat, people can maintain normal life activities. Electrocardiogram (ECG) signal is an important physiological signal of the human body, it contains rich physiological information, which can reflect the function of the heart system, and among them, the heart rate is an important one. Place two electrodes at any two points in the human body, we can collect the body of the weak ECG signal.

Bluetooth 4.0 technology is the rise of a wireless transmission technology in recent years. This program requires Bluetooth 4. G lungs without traffic, which has the advantages of the small interference, low power consumption and no external power

supply. It can develop their own communication protocol, and the communication can be more flexible, as well as it can communicate with iPhone and other mobile terminals, so as to save the treadmill computer research and development work. To have an integrative consideration, we give up the noise of the larger common wireless heart rate chest, and select the hand-held and Bluetooth 4.0 chest strap compatible program.

3.3. Heart rate data filtering

Heart rate is an important feedback signal for human health. In the process of reasonable control of fitness, heart rate is an important part of scientific fitness. Heart rate measurement system as an important part of improving the value-added fitness equipment, fitness equipment has gradually become an important criterion.

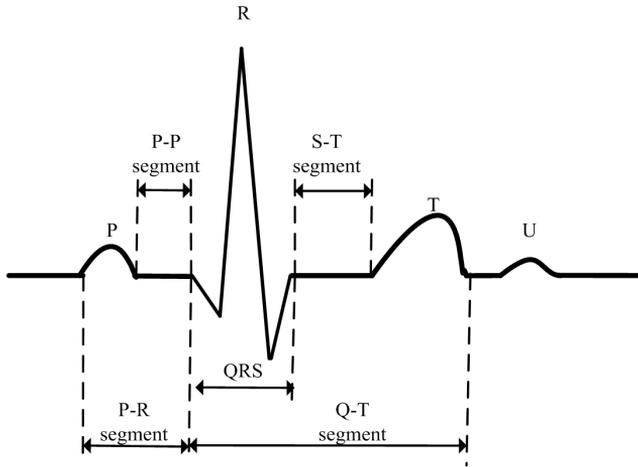


Fig. 2. Standard electrocardiogram

The standard human ECG signal waveform is shown in Fig. 3. The signal acquisition process is shown in Fig. 4.

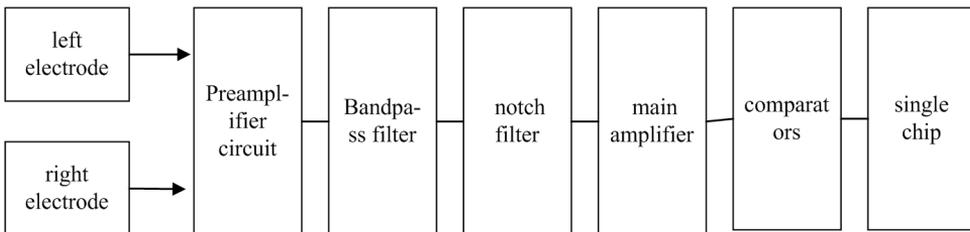


Fig. 3. Flow chart of ECG signal acquisition

The heart rate filtering algorithm: suppose that we need to find the value of a_5 , where we select the filter window 9. The collected raw data by the time is in order: $a_1 \cdots \cdots a_9$. First, find the average of these nine values: $\bar{a} = 1/9 \sum_{n=1}^9 a_n$.

Then, calculate the absolute value of the difference between the average of each value: $k_n = |a_n - \bar{a}|$. The bigger the k_n , the greater the difference between the point and the 8 points around it. We need to reduce the weight of this point, where $1/k_n$ is the weight of this point. And then calculate the normalization constant. The formula is $1/\alpha = \sum_{n=1}^9 1/k_n$. We can calculate the value of the point: $\alpha' = \alpha \sum_{n=1}^9 \alpha_n/k_n$. Therefore, when we calculate the average, it can effectively remove the effect of noise on the mean.

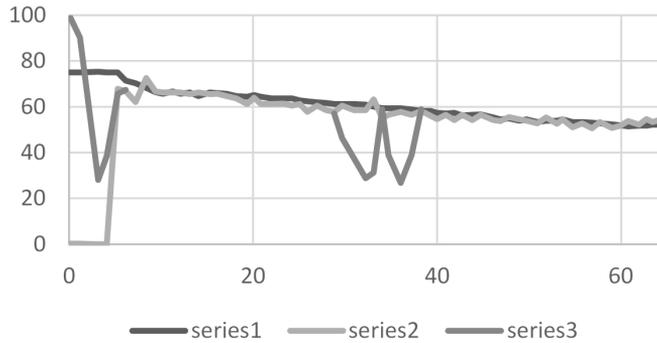


Fig. 4. Mean filtering data processing

Series 3 is the original data, series 1 is the data after the difference operation, and series 2 is the mean filtered data. The results show that the method can not only effectively filter out the noise, but also can retain the accuracy of the values.

4. Conclusion

According to the traditional treadmill industry hardware and communication methods, we design a hardware device that can control the treadmill, and it can communicate with Apple's Bluetooth 4.0 low-power transmission hardware device. This paper analyzes the characteristics of various heart rate acquisition sensors, and gives a heart rate acquisition scheme compatible with hand-held heart rate sensor and Bluetooth 4.0 wireless heart rate chest. This study improves the heart rate filtering algorithm, summarizes the predecessors' algorithms and puts forward our own algorithms.

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