Design of Control System of Physical Fitness Treadmill Based on Embedded Technology

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***Abstract*—Treadmill is the commonest method to get a good health, but traditional treadmill has limited functions and low intelligence. While embedded technology implements special function and is controlled by internal computer system. Putting embedded technology into treadmill can enhance the intelligence and add extra functions. In this paper, system structure and work way of treadmill were analyzed scientifically through embedded technology and the design of controlling system. The system hardware structure was analyzed and designed effectively, combined with the application of embedded technology and serial communication technology, realizing the optimization of setting and motion parameters of the treadmill science display. Motion information was recorded, and multimedia entertainment function was also embedded in it. Finally, the system was tested and had a relatively stable and reliable working state. In addition, it also had a beautiful appearance and met the needs of consumers. Therefore, treadmill control system based on embedded technology has the features with cost-effective, low cost and relatively complete fashion and has a good prospect.**

Keywords-embedded technology; control system; sports fitness; treadmill control; system design.

I. INTRODUCTION

The traditional treadmill control system has a single function, which is mainly to set up and display the various state parameters of the treadmill, and the display mode is rare. It usually use the basic LED display, which is increasingly unable to meet the needs of today's consumers. Today, the embedded technology has developed rapidly, and has been widely used in industrial control, communications, information appliances, medical instruments, intelligent instruments and meters, automotive electronics, aerospace and other fields. Therefore, the embedded technology in the treadmill control system can make the control system more stable, the operation more concise and clear, and the additional multimedia functions will also meet the needs of consumers. In this paper, the embedded technology was integrated into the treadmill, and the control system of the treadmill was discussed in detail[1-3].

II. EMBEDDED TECHNOLOGY

Embedded technology pays attention to the reasonable control of the equipment, which realizes the effective monitoring of the equipment, and embodies the management function of the equipment comprehensively. Embedded system is adapted to a special computer system with higher requirements towards reliability, cost, volume and power consumption. It is composed of four parts, that is, embedded microprocessor, peripheral hardware device, embedded operating system and user application program. Usually, it is used to control, monitor and manage other devices, see Fig.1.

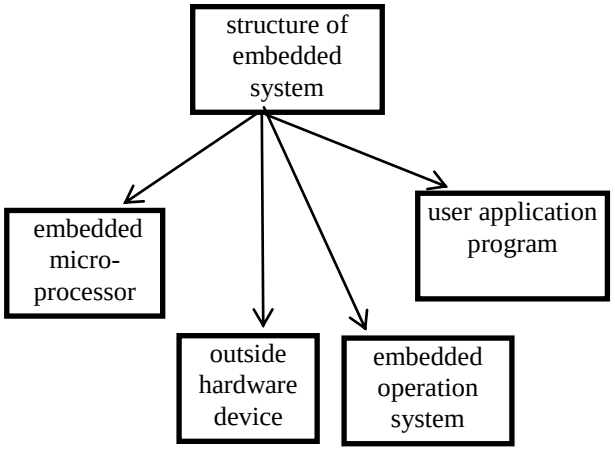

Figure 1. The structure of embedded system

III. STRUCTURE OF TREADMILL CONTROL SYSTEM

A. Hardware Structure

According to market research and user survey, the new control system has three main functions. One is the control function, which is used for a variety of state parameter setting and control of the treadmill. The second is the user motion information recording function, which is used for the historical record and compare the user's motion parameters. The third is the multimedia function for playing a variety of audio and video file. Based on this, the hardware design of the treadmill control system is shown in Fig.2[4-5].

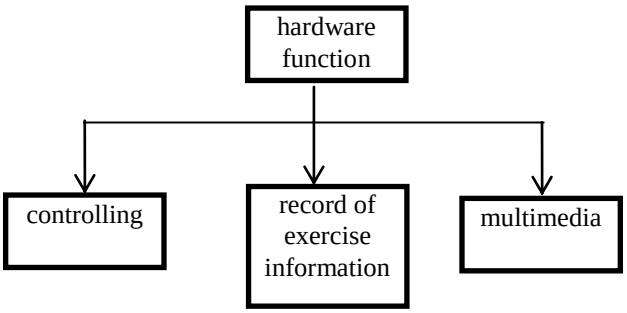

Figure 2. The hardware design of the treadmill control system

Control function is set and controlled based on condition parameter of treadmill. The realization of the user's motion information recording function is always focused on the reasonable settings of the user's historical motion parameters[6]. Multimedia functions are reflected to realize the effectiveness of audio and video files. The hardware structure of the control system is shown in Fig.3.

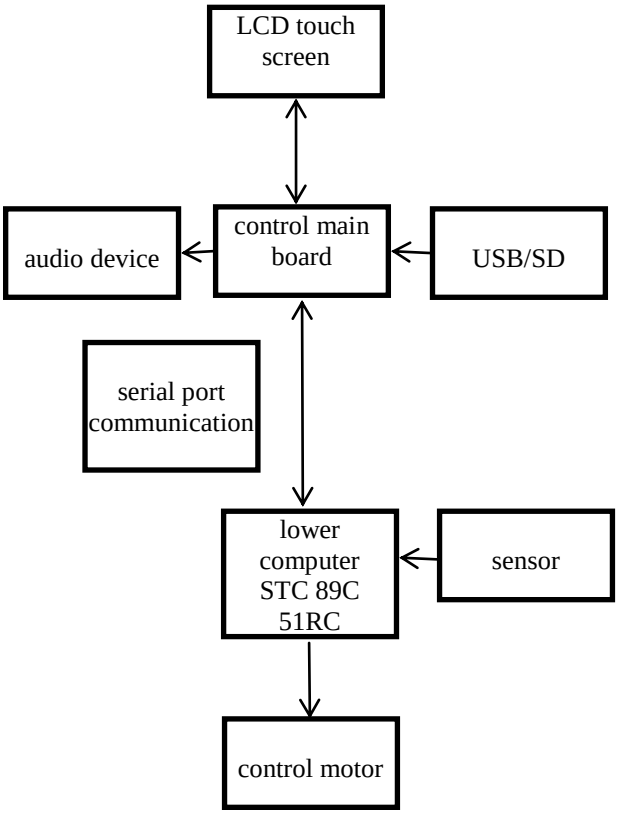

Figure 3. The hardware structure of the control system

LCD touch screen is mainly a link of man-machine interface. It will gradually realize information interaction between control system and user, and touch screen with the size of 4 inch is provided to get more wide field of vision. In addition, the control board is the core part of the host computer control system, which is based on the Samsung Corp ARM 926EJ embedded CPU as the core to expand the peripheral interface. Touch screen is the main part of man-machine interface, which realizes the information interaction between user and control system, and SHARP10.4 Inch Touch screen is adopted. The large screen not only brings wider vision, but also facilitates the operation of the user. Moreover, USB/SD interface is mainly used to connect external memory, such as USB device, SD card and so on[7].

The storage space available on the motherboard is very limited, and the addition of external storage devices is cheaper than of the motherboard, so external storage devices are a sure choice. An audio device is used for outputting sound, and audio interface is on the main board, which can play stereo. STC 89C 51RC is subordinate to the system's lower computer. It takes the chip STC, 89C, 51RC as the control core to realize the pulse signal reception and control of the motor, and use the serial port and the host computer control system for communication. Because positive logic is used in the upper and lower computer control circuit, TTL level communication mode is adopted in serial communication[8].

B. Software Structure

The system software mainly implements data processing, data communication, data display and man-machine graphic interface operation. The main process of the upper computer control system realizes the communication through the mechanism of shared memory, and the program reads the control information to the memory sharing area and completes the corresponding operation. The hardware system extends the external memory of 128M, the purpose of which is to store user data and software data, so as to facilitate the expansion of later functions. Finally, Windows CE 5.0 embedded operating system is selected as operating system[9].

As for the design of software system, the process of data processing and data communication is often paid attention to, and the data display function is provided to realize the man-machine graphical interface operation, as shown in Fig 4.

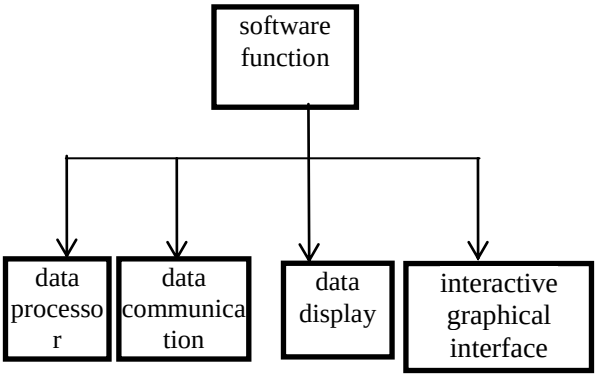

Figure 4. The function of software system

Process of data processing is to achieve the initial data and data processing optimization, as well as to achieve data communication and reasonable display of data. For the basic structure of the control system software, as shown in Fig.5.With regard to the software control process of the upper computer, combining the basic mechanism of memory, the communication process is realized gradually, and the corresponding operation is completed. The design of the hardware system pays more attention to the rational analysis of external memory, realizing the storage of user data, reasonable application of software data, and the expansion of function.

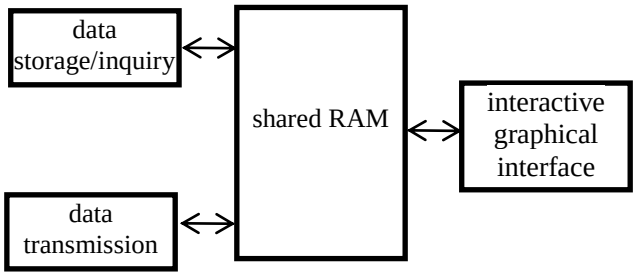

Figure 5. The basic structure of the control system software

IV. CONTROL SYSTEM DESIGN OF SPORTS FITNESS TREADMILL

A. *Hardware Design*

The hardware design of the control system of sports fitness treadmill is to choose a suitable chip according to a processor form on the motherboard, and focus on a variety of resources application interface controller to realize LCD controller module. For the application of the built-in hardware interface, wireless base band chip connection is implemented to realize other functional modules, and achieve stable and reliable system control, as well as provide powerful multimedia functions. With the participation of the system function module, the reasonable control of the LCD touch screen bus interface is needed, and the design of the power management module is effective. Z228 chip, developed by Shanghai Huarun electronics company, is selected as processor on the motherboard.The internal chip integrates the ARM 926EJ kernel, MPEG-4 hardware coder and a variety of controller and interface resources. Without the support of the peripheral chip, the system can achieve a variety of required functions. Among them, the built-in LCD controller can support up to XGA resolution true color liquid crystal display. A variety of built-in hardware interface can be easily connected to a wireless base band chip, memory expansion card, computer and other functional modules, and HDK, BSP and SDK of WinCE and Linux two versions are also provided. The application of Z228 chip in the control system of treadmill can not only realize stable and reliable control system, but also can provide powerful multimedia function. According to the functions needed by the system, LCD touch screen, bus interface, USB SD interface, UART interface, power management module and audio interface are extended in peripheral hardware devices..

B. *Software Design*

Main hardware structure of the system should be considered with regard to the realization of software design and gradual generation of the embedded operating system. Effective download on target board combined with the development process of main software in the system can achieve the system application in the platform. For the customization process of system platform, host computer control system adopts Windows CE 5.0 operating system to realize multiple thread task scheduling. The system has good tailoring and portability, and supports a variety of mainstream CPU, such as ARM, MIPS, X 86, SuperH. It has real-time functions on most occasions, rich API, friendly user interface, and rich application software. Moreover, it occupies a large proportion in today's consumer electronic products. According to the composition of system hardware, corresponding embedded operating system is generated by cutting the BSP provided by Z228. This system will be downloaded to the target board, and export specific software development kit SDK, which is used to compile applications that will run on the platform, as shown in Fig.6.

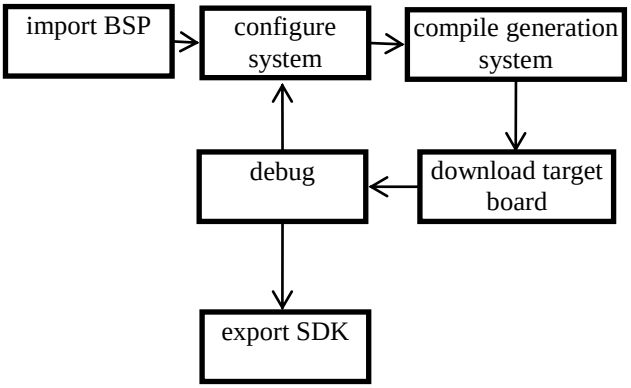

Figure 6. The customization of system platform

The application design process, combined with MPC multiple thread programming mechanism control, completes the design of multimedia function module and treadmill control module, and realizes the design of user information storage module and data communication module. The basic design of treadmill control module, combined with the application of motion parameters, pays attention to the direct monitoring of the movement state, and then realizes the effectiveness monitoring of the status thread. For the basic application of data communication module, it directly realizes data transmission of lower and upper computer, and focus on the special communication protocol, data communication and gradually realize the receiving and recognition of data communication. The design of multimedia function module pays more attention to the effective play of video files, and meets the needs of users gradually. The comprehensive application of the user

information storage module achieve programming and analysis through storage of effective record of the historical movement, and programming and analysis of the database, in order to get the effective and recycling use of space.

The data of sports fitness treadmill can be seen as table 1.

TABLE I. THE DATA OF SPORTS FITNESS TREADMILL

Parameter	Value		
	Data set 1	*Data set 2*	*Data set 3*
Time(s)	100	200	300
Distance(m)	10	40	90
Speed(m/s)	0.1	0.2	0.3
Heart rate(bpm)	70	90	120

V. WORK WAY OF TREADMILL

Once the system is in the state of power, automatic operation must be completed, main control interface is gradually opened, the reasonable application of LCD touch screen is realized, and reasonable motion parameters on the treadmill should be set. The application of motion module needs to combine the basic movement process of the subordinate computer feedback, which focus on the main interface screen and simulate the reasonable analysis of the user. In the actual movement stage, users can also enjoy the full enjoyment of the multimedia function. When the multimedia button is clicked, the multimedia player interface is opened.

First stage belt drive calculation is as follows.According to the calculation of power and speed, check the mechanical design manual and select the type of conveyor belt.Determine the diameter of the belt pulley and check the belt speed

The diameter of primary small round benchmark is $d_{d1} = 126mm$ and check the belt speed formula as

$$\upsilon = \frac{\pi d_{d1} n_1}{60 \times 1000} = \frac{126\pi \times 2600}{60 \times 1000} \tag{1}$$

The reference diameter of the large pulley d_{d2} can be calculate as formula(2)

$$d_{d2} = i_1 \cdot d_{d1} \tag{2}$$

The center distance a and reference length L_d of the belt are determined.When the initial center distance $a_0 = 900mm$ the required base length can be calculated as formula(3)

$$L_{d0} \approx 2a_0 + \frac{\pi}{2}(d_{d1} + d_{d2}) + \frac{(d_{d2} - d_{d1})^2}{4a_0} \tag{3}$$

Actual center distance a is calculated as formula

$$a \approx a_0 + \frac{(L_d - L_{d0})}{2} \tag{4}$$

$$a_{\min} = a - 0.015L_d$$
$$a_{\max} = a + 0.03L_d$$

The small wheel on the corner α_1 is checked as formula(5)

$$\alpha_1 \approx 180^0 - (d_{d2} - d_{d1})\frac{57.3^0}{a} \tag{5}$$

The minimum value $(F_0)_{\min}$ of the initial tension of a single V belt is calculated

$$(F_0)_{\min} = 886\frac{(2.5 - k_a)p_{ca}}{k_a z v} + qv^2 \tag{6}$$

Controlling of main interface of control system refers to effective observation of movement system with the help of U disk, and rationally use external memory. In addition, external storage space should be supported, and motion records should be reasonably selected. The system finally passed the test, and proved the design of control system of sports fitness treadmill based on the embedded technology not only has a relatively stable reliability, but also has a beautiful appearance, and will fully meet the needs of consumers.

VI. CONCLUSION

In a word, control system design of treadmill based on the embedded technology is different from the traditional treadmill control system. It not only improved the functional performance of the system, but also improved the appearance of the situation, and fully achieved the operation of touch screen. It gradually achieved user needs, and effectively recorded multiple information. Applications of embedded equipment has the features of cost-effective, low cost, relatively complete fashion, which meet the requirements of consumers. In this paper, design of embedded technology based sports treadmill control system provides a certain guiding significance in this field.

REFERENCES

[1] Eunsook Sung, "The effect of treadmill-based and track-based walking training on physical fitness in ankle-sprain experienced young people," Journal of Exercise Rehabilitation, vol. 13, pp. 84–88, Feb. 2017.

[2] CM Fairman,KL Kendall,BS Harris,KJ Crandall and M Jim, "Utilization of an anti-gravity treadmill in a physical activity program with female breast cancer survivors: a pilot study,"International Journal of Exercise Science, vol. 9, pp.101–109,January,2016.

[3] Pei Wang, "A software design of college students' physical fitness test based on mobile phone," Electronic Design Engineering, vol. 20, pp. 61–70, Nov. 2016.

[4] Mei Hong and Shen Junrong, "Software architecture research progress," Journal of software, vol. 12, pp. 1257-1275, Dec. 2015.

[5] Chu Wenkui and Zhang Fengming, "Based on the military software security problems of the COTS study, " Journal of Systems Engineering and Electronics,vol. 3, pp. 2166-2170, Aug. 2014.

[6] MK Edwards and PD Loprinzi, "Sedentary behavior, physical activity and cardiorespiratory fitness on leukocyte telomere length," Health Promotion Perspectives, vol.7, pp.22–27, August 2017.

[7] Han Lihong, "The embedded real-time operating system performance testing method," Journal of Command and Control and Simulation, vol.21, pp.98-101, Apr. 2015.

[8] Chen Zhuo, Wang Tian and Liang Xinyuan,The Embedded System Development. Beijing: Electronic Industry Press, 2015.

[9] Wang Jingang and Yang Ximai,The Vx Works BSP Developers Guide. Beijing: Tsinghua University Press, 2014.

[10] Tu Gang, zhang bo and Yang Fumin, "The research of embedded operating system transplant technology," Computer Application Research, vol. 56, pp. 83-85, Dec. 2014.