ISSN 2616-5775 Vol. 6, Issue 5: 68-74, DOI: 10.25236/AJCIS.2023.060509

Design and Implementation of Portable Physical Health Indicators Based on FPGA

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Abstract: *Physical health indicators are developing towards miniaturization and diversified functions, and require them to have certain real-time analysis and diagnostic functions. To achieve such a function, it is necessary for the processor to have high performance and powerful algorithm processing capabilities. FPGA is now the ideal choice among mainstream processors and programmable chips. This article first introduces the portable and recognition system framework of FPGA, and then improves the application of signal processing to beneficial detection and diagnosis of various indicators of physical health. Then, in the design of physical health indicators using FPGA, five commonly used standard indicators are introduced first, and then five indicators of physical health are implemented using FPGA. The pressure sensor MS5536 is used to obtain the sampling data of the recognition system. Process the data and ensure that the collected data is valid. At the end of this article, DSP, ARM, and microcontroller are introduced as processors to complete data calculation and control functions, which cannot be well completed. However, various functions of physical health indicators can be achieved in FPGA, and then FPGA chips and signal processing are used the successful resolution rate of the event is higher than that of the other two systems, and the experimental results show that the lowest probability can reach 80.2%.*

Keywords: *Physical Health Indicators; Portable devices with FPGA; Identification System; Signal Processing*

1. Introduction

With the rapid development of medical electronics and modern computer technology, portable devices based on FPGA can identify important indicators of physical health and quality of life, and are also a symbol of a country's social development. The design of physical health indicators is an important means of controlling and improving the overall health level of the people. Therefore, achieving comprehensive, scientific, and reasonable standards for physical health indicators is of great significance for improving the overall health level of the people and improving social structure [1-2]. For the portability of FPGA, the standard for physical health indicators should include objective indicators of health status, such as blood pressure, blood sugar, blood composition, etc., as well as subjective indicators, such as physical activity ability, health status, etc. [3-4]. We will consciously preprocess information to remind the health of various indicators in the body. Secondly, based on the health status of different populations, identification systems should also be established to distinguish different age groups [5].

People have been studying electrocardiogram signals for a long time, and our laboratory has also done a lot of research work in this area and achieved certain research results. Fang Z conducted research on the preprocessing of electrocardiogram signals and the extraction of electrocardiogram feature parameters, and proposed his own algorithm in the denoising of electrocardiogram signals and the detection of electrocardiogram QRS complex [6]. The QRS complex detection algorithm based on maximum point histogram distribution proposed by Shahadi HI has a high detection rate and is suitable for embedded system implementation. In terms of hardware system design, Zhang Yan, Tian Yi, and others designed an electrocardiogram monitoring and alarm system based on MSP430 [7]. Shi P combines the design of the Cortex-M3 ECG monitoring system and the remote ECG monitoring system based on OMAP3530[8].

Portable detection based on FPGA has significant advantages such as non-invasive, easy to operate, high efficiency, low energy consumption, and environmental protection, and is widely used in medical

ISSN 2616-5775 Vol. 6, Issue 5: 68-74, DOI: 10.25236/AJCIS.2023.060509

clinical diagnosis. It can detect, signal process, and recognize the standards of physical health indicators.

2. Related research

2.1 Portable devices with FPGA

FPAG's portable oscilloscope has multiple implementation schemes, with the core components mainly being single chip microcontrollers, signal processing, packaging/semiconductors, integrated circuits, and other individual or combined solutions. Taking into account factors such as the design function of technical indicators for physical health, the complexity and difficulty of its application circuit [9-10] a design scheme based on FPGA is selected. By implanting a Nios embedded soft core processor in FPGA as its control core circuit, and utilizing FPGA internal logic resources to form a functional interface module, various functions of health indicators are achieved, and recognition system control is adopted. It is mainly divided into four main parts, namely the signal front-end conditioning part, the signal acquisition circuit part, the interactive display part, and the power module part[11-12], as shown in Figure 1.

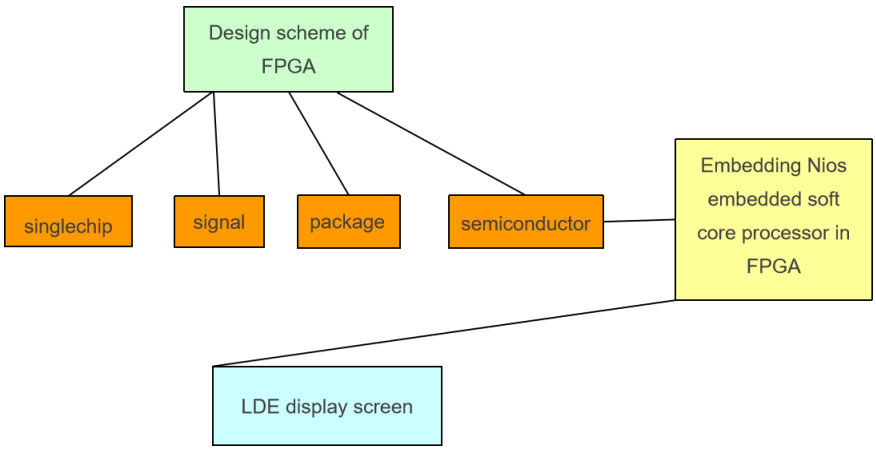

Figure 1: FPGA class diagram

As shown in Figure 1, the signal processing process is as follows: first, the signal to be tested is processed through the front-end conditioning section to ensure that the voltage range of the processed waveform meets the health indicator design function. The required voltage range is used, and then the waveform is sampled using a dual channel analog-to-digital converter AD9288. Through AD conversion, the converted digital signal is sent to the FPGA, which then undergoes necessary operational processing, The processed data is stored in the dual port RAM5 and ultimately output to the LCD screen to display the health indicators and coefficients of each part of the body[13-14].

2.2 Identification system

The recognition system is a device that can monitor various indicators of the patient's body in real time, including temperature, blood pressure, heart rate, respiratory rate, etc. These indicators are key indicators for evaluating a person's physical health and important reminders for many diseases. The telemetry medical system transmits this data to the cloud through wireless communication technology, and analyzes and calculates it through professional software to generate visualized reports, allowing doctors to timely grasp the patient's physical condition and provide more accurate diagnosis and treatment plans.

The advantage of the recognition system lies not only in its real-time monitoring function, but also in its ability to prevent further deterioration of the condition. We know that some diseases require a long treatment process, such as hypertension, diabetes and other chronic diseases. Many patients often relax their vigilance and ignore the use of drugs and the health management in daily life after the condition is effectively controlled at the initial stage of treatment. This can easily lead to the recurrence or worsening of the condition, making treatment more difficult.

The recognition system monitors the changes in data, sends timely alerts to doctors, reminds them to pay attention to changes in patient conditions, and adjusts treatment plans in a timely manner. At the

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same time, the telemetry medical system can also set up automatic treatment functions. For example, for patients with diabetes, the system can automatically adjust the insulin dose according to the patient's blood sugar changes to improve the treatment effect[15].

2.3 Signal processing

Signal processing is a general term for the processing of various types of electrical signals according to various expected purposes and requirements. The processing of analog signals is called analog signal processing, while the processing of digital signals is called digital signal processing. The so-called "signal processing" refers to the process of processing signals recorded on a certain medium in order to extract useful information. It is a general term for the process of signal extraction, transformation, analysis, synthesis, and other processing. In order to utilize signals in various indicators of physical health, people need to process them and describe them using formula methods to explain:

To ensure the calculation effect, the continuous power flow method is generally used for calculation. The following is the calculation process:

Splitting is the process of splitting a signal: x (n) (n=0,1,2. - N-1) into two disjoint subsets, typically dividing a sequence into even sequence x (2n) and odd sequence x (2n+1):

$$\text{Split} = \{x(2n), x(2n+1) \tag{1}$$

Prediction is aimed at the correlation between data, using x (2n) and a prediction operator P independent of the dataset structure to predict x (2n+1), and then replacing x (2n+1) with the difference between the predicted value and x (2n+1), namely:

$$d(n) = x(2n+1) - P(x(2n)) \tag{2}$$

d(n)= x(2n+1)- P(x(2n)) ; In order to maintain the invariance of scale features, an update process is required, with the aim of generating a better sub dataset c (n) through the update operator U, which preserves some of the characteristics of the original dataset x (n), namely:

$$c(n) = x(2n) + U(d(n)) \tag{3}$$

3. Design and implementation of physical health indicators

3.1. Introduction

With the development of society, people's living standards are constantly improving, and the requirements for quality of life are also increasing. The importance of physical health and routine indicator examinations is also increasing. However, going to the hospital for a physical examination not only wastes a lot of time, but also is expensive. Therefore, we provide Portable devices with FPGA for people to conduct various indicators of physical health checks. Then explain the five common indicators of physical health. The following are 5 indicators that meet the requirements of physical health:

3.1.1. Normal heart rate: 60-80 beats/minute

The heart rate range of a healthy adult is 60-100 beats per minute, with most people ranging from 60-80 beats per minute. Children's heart rate is faster than that of adults, and children under the age of 3 often have a heart rate of over 100 beats per minute. Hypertensive patients require heart rate management when they exceed 80 beats per minute.

3.1.2. Body mass index

The lighter the weight, the better. Here is a formula for you to calculate what your normal weight should be. Recommended calculation method by the World Health Organization: Male: (height cm-80) × 70%=standard body weight; Female: (height cm-70) × 60%=standard body weight. If in a short period of time, weight loss is too fast and people are obviously thin, this situation is more common in diabetes, hyperthyroidism, malignant tumors, gastrointestinal system and other diseases; If the weight increases rapidly in a short period of time, on the one hand, it is related to your unhealthy diet, on the other hand, it may also be related to hyperlipidemia, hypothyroidism, and diabetes. A large number of studies at home and abroad show that about 60% - 80% of adult diabetes patients are overweight before onset.

ISSN 2616-5775 Vol. 6, Issue 5: 68-74, DOI: 10.25236/AJCIS.2023.060509

3.1.3. Body temperature indicators

A normal person's body temperature should be between 36 ℃ and 37 ℃, and fever can be diagnosed if it exceeds 37 ℃. In addition to fever, there is also a situation where the body temperature is below normal, known as "hypothermia". Low body temperature often occurs in elderly people, patients with long-term malnutrition, and patients with hypothyroidism or frequent shock.

3.1.4. Pulse index (heartbeat index)

The standard pulse for adults should be 60-100 beats per minute (note: athletes' pulse may be lower than this standard). If there is a pulse that is too fast, too slow, intermittent, weak, fast and slow, it indicates that there may be a heart problem and prompt medical attention is needed. The heartbeat of elderly people is generally slightly lower than the standard number, but as long as it can be maintained at no less than 55 beats per minute, it is considered normal. If the heart rate is usually slow and suddenly increases to 80-90 beats per minute, it is necessary to consider whether you have a potential disease and seek medical examination immediately.

3.1.5. Respiratory indicators

Healthy individuals should breathe steadily and regularly. Approximately 16-18 times per minute. If there is shortness of breath, gasping heavily, or insufficient breath, the symptoms of fast and slow breathing, chest tightness, and suffocation are all abnormal manifestations. Shortness of breath and breathlessness are commonly seen in asthma diseases; Chest tightness and suffocation are more common in heart diseases. For elderly people, their heart and lung function may weaken, and they may also experience symptoms of palpitations and shortness of breath after exercise. However, if the symptoms are relieved after rest, it is normal and not a manifestation of the disease. Finally, the Portable devices with FPGA is used to achieve the standards for five indicators of physical health. By simulating whether the body is healthy through the recognition system, the most direct signal processing judgment is to use various common body indicators.

3.2. Analysis and result experiment

The above introduces the five common indicators of physical health, and then analyzes how to design and implement the standards for the five indicators of physical health in FPGA portability, identify whether the body is healthy, and signal processing judgment for each indicator index. He mainly uses the portable oscilloscope design of FPGA to measure: normal heart rate, body weight indicators, body temperature indicators, pulse indicators, and respiratory indicators. Firstly, the sampling data of the recognition system needs to be obtained by calibrating the pressure sensor MS5536 through five steps. Before processing data, it is necessary to ensure that the collected data is effective, which is the prerequisite and foundation of data processing. Secondly, when collecting data, signal processing should be carried out first, and invalid data should be discarded. The program has been improved and improved time and time again, and finally, the data of our five indicators is shown in Figure 2:

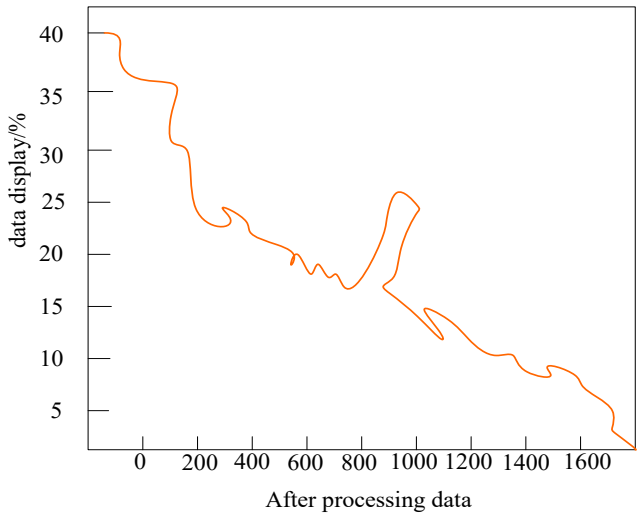

Figure 2: After data completion

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As shown in Figure 2, after processing the five commonly used indicators, the main data collected after data processing is effective, and all five indicators are relatively normal.

After obtaining data from five detections, a basic processing algorithm was used in applications such as image processing, software radio, communication, pattern recognition, and spectral analysis. Digital filtering includes linear filtering and nonlinear filtering. Only by transmitting it to the Portable devices with FPGA can various indicators of physical health be achieved. As shown in Table 1:

Table 1: Data Table of Various Indicators of FPGA

Amplitude/NV	Test value/nv	Error/nv	Error rate/%
100	100.049	0.049	0.049
200	200.725	0.725	0.362
500	501.039	1.935	0.387
1000	1002.92	2.92	0.292

As shown in Table 1, it can be seen that in the various indicator data tables of FPGA, their error rates and test values are relatively small compared to the error. The main digital filtering methods used include linear filtering and nonlinear filtering, which are then transmitted to the FPGA to achieve the relevant data of various indicators in physical health.

4. Portable design of FPGA and implementation of physical health indicators

4..1 Introduction

At present, the mainstream physical health indicators in the market mainly use DSP, ARM, and microcontroller as processors to complete data processing and control functions. DSP is a chip designed specifically for processing digital signal algorithms, with a structure that separates instructions and programs. It integrates multipliers and adders internally, and supports parallel operations with fast computation speed. It is a processor with a reduced instruction set architecture that supports 16 bit/32 bit dual instruction sets and is compatible with 8 bit/16 bit devices. Compared to DSP, it has weaker digital computing power, but its control performance is better. Microcontrollers are usually 8-bit or 16-bit, which is cheap, but compared to the first two types, they have weaker performance in both computation and control. Like the development process of other electronic devices, physical health indicators have also gone through a process of development from single functionality to functional diversity. At present, physical health indicators are not only indicators for detecting and displaying processing results, but also for simple analysis of physical health signals. They can also measure and analyze various parameters such as blood oxygen, body temperature, pulse, etc. They can monitor, analyze, and diagnose physical health indicators in real-time, and have certain automatic analysis and diagnostic capabilities. To achieve such functions, it is necessary for the processor to have high performance and powerful algorithm processing capabilities, while DSP, ARM, and microcontroller cannot perform these functions well.

4.2. Develop functional design and completion

With the development of integrated circuits and chip manufacturing technology, the number of logic gate circuits integrated in FPGA is increasing, but the cost and power consumption are becoming lower and lower. Currently, FPGA has been widely used in the field of digital signal processing, replacing most systems that use DSP as a processor. Due to FPGA being hardware programmable, it allows designers to flexibly configure according to their own design needs, fully leveraging its performance. Nowadays, FPGA is developing towards integration, with ARM, DSP, hardware IP cores, etc. integrated on one chip with FPGA. Replacing ARM, DSP, microcontroller, etc. with FPGA has become a development trend in the future. In addition, the powerful parallel computing ability and design flexibility of FPGA are very advantageous for physical health indicator devices, fully meeting the requirements of real-time processing of a large amount of indicator data. Moreover, FPGA products have strong upgrade capabilities in both hardware circuits and software programs, which coincide with the requirements of portable physical health indicator devices. Therefore, in the main design, we choose FPGA as a portable device, I believe that in the near future, FPGA will also become the mainstream portable indicator of physical health.

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4.3. Comparison of implementation results

In order to study the effectiveness of FPGA in achieving physical health indicators, an FPGA chip processor was used to analyze and implement various indicators of physical health, which can fully meet the requirements of real-time processing of a large amount of indicator data. Then, a comparative analysis was conducted with the indicators of DSP and ARM chip processors, and the results are shown in Figure 3:

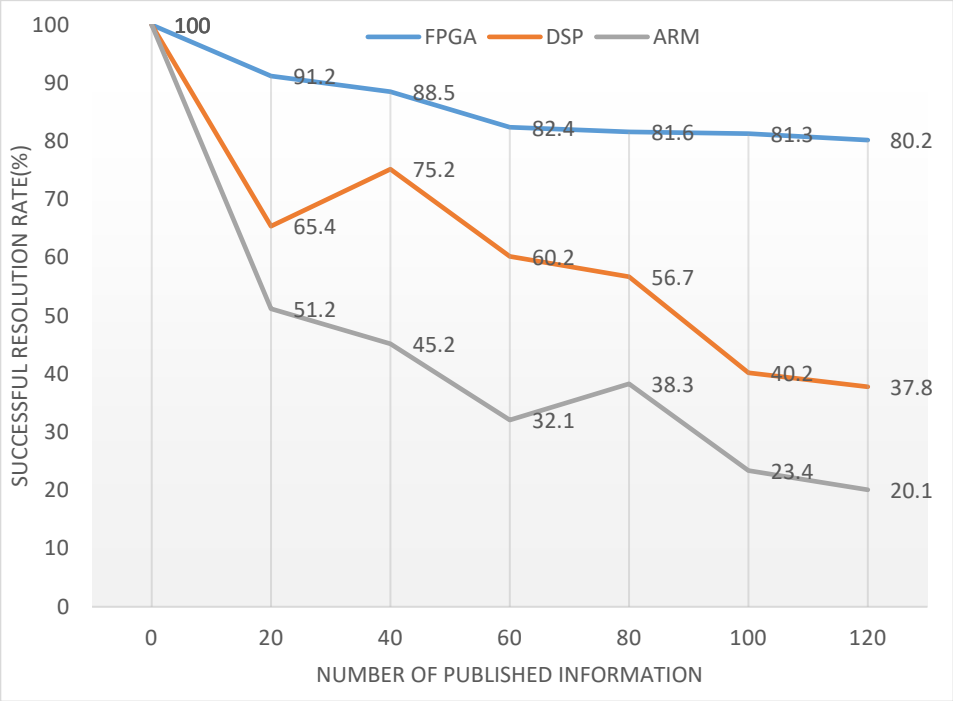

Figure 3: Chip processor test results

From Figure 3, it can be seen that under the premise of gradually increasing the number of signal processing on chip processors, the successful resolution rates of events on all three chip processors have shown a downward trend to some extent, but the reduction degree of chip processors in this article is the smallest. When the number of signal processing is large, the FPGA still has a high success rate.

5. Conclusion

In the design and implementation of physical health indicators, the portable method using FPGA can not only compensate for the shortcomings of DSP and ARM microcontrollers in various indicator functions, but also ensure parallel computing ability and design flexibility, improve the real-time and safety of physical health indicators, improve the efficiency of portable processing, and improve the overall performance of chip processors. Among various indicators of health, signal processing methods have certain promotion and application value. Finally, the overall design was tested and analyzed to verify the effectiveness of the algorithm and the rationality of the system scheme. Secondly, comparative analysis was conducted on three signal processors to minimize the reduction in FPGA. In the future, the portable design of FPGA for physical health indicators has certain prospects and development, but its shortcomings lie in the weak computing power of microcontroller chips.

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