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The description of the development of the photoelectric sensors in detecting heart sound lesions

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Abstract:
Cutting-edge developments in medicine require more precise medical equipment and more effective methods. In response to the current societal challenges of an ageing population and the prevalence of coronary heart disease, I propose a photoelectric stethoscope in this study to enhance the diagnostic capabilities of existing medical equipment and reduce the barrier to using traditional stethoscopes. This photoelectric stethoscope, firstly, by pressing its metallic inner chamber closely to the chest, detects heart vibrations and converts them into optical signals with a phase difference using a built-in LED. Secondly, it employs photoelectric conversion to transform the optical signals to electronic signals, which is then filtered and amplified to output the human heart sound signals. Finally, those signals will be collected in large quantities and used for training heart sound models, enabling the photoelectric stethoscope to have the capability to distinguish heart murmurs and pathological sounds among heart sound, which can effectively avoid the drawbacks of using traditional stethoscopes.

Keywords: Optical-to-electrical Conversion, Stethoscopes, Applications, Directions for development

1. INTRODUCTION

At present, the global population shows a trend of continuous growth and ageing, and the problems of co-morbidities and chronic diseases are gradually becoming more prominent. According to statistics, the proportion of coexisting diseases in the global elderly population is as high as 55-98 per cent, of which the prevalence of co-morbidities in the elderly population over the age of 65 reaches more than 60 per cent. With the continuous improvement of health consciousness and medical service level, health care equipment is developing at a very fast speed. In recent years, the emergence of a variety of high-tech multidisciplinary integration of health care products has greatly improved the lives of people around the world, slowing down the aging process. The current context of ageing diseases is placing higher demands on medical technology. The initial detection of heart diseases such as coronary artery disease is now highly dependent on the patient's self-reporting of symp-

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toms and initial diagnosis with a stethoscope. In order to improve the accuracy of the initial diagnosis of heart diseases such as coronary heart disease, it is necessary to improve the accuracy and usefulness of the stethoscope. The use of photoelectric sensors, which are highly utilised in the field of medical equipment, can effectively reduce the pressure on medical resources and improve the accuracy of the initial diagnosis of heart diseases by taking advantage of their high convenience and accuracy.

2. INTRODUCTION TO PHOTO-ELECTRONIC SENSORS

Photoelectric sensor is a device that converts optical signals into electrical signals. With the development of science and technology, photoelectric sensors play an increasingly important role in modern science and technology and industrial fields.

The core working principle of photoelectric sensors is based on the photoelectric effect, i.e., light irradiated to certain substances in society can cause the release of electrons within the substance, thus generating an electric current. According to the different changes in the state of electrical properties, the photoelectric effect can be divided into four kinds of external photoelectric effect, photo-conductivity effect, photovoltaic effect, pyroelectric phenomenon[1] Photoelectric sensors are usually composed of three parts: transmitter, receiver, and detection circuit. Among them, the transmitter is responsible for transmitting the light beam; the receiver is responsible for receiving the reflected or transmitted light; the detection circuit converts the received light signal into an electrical signal for subsequent processing. Photoelectric sensors are divided into six types, namely the convective type, reflective plate type, diffuse reflection type, focusing type, fixed-area type, adjustable-area type. Contrast photoelectric sensors can penetrate dust and smoke, long-distance detection, and is not affected by the detection of the background and the colour of the object to be measured. Reflective plate photoelectric sensors require only one end of the power supply, saving installation space. The diffuse reflection method is less reliable and is easily affected by the colour, reflectivity and size of the object. Focused photoelectric sensors have a small spot size and are effective for colour-coded detection or small object detection. Fixed-area photoelectric sensors are not sensitive to changes in the colour of the object to be measured, but sensitive to changes in distance. Adjustable-area photoelectric sensor measurement of the detection distance can be adjusted, the position of the shut-off point can be adjusted.

With the continuous progress of science and technology and the advancement of industrial automation, the photoelectric sensor market is growing and has a good market prospect. In the automation and intelligence of traditional industry, photoelectric sensors are mostly used for object positioning, technology, colour recognition, etc., effectively improving the level of automation of industrial production lines; in health care, blood oxygen measurement, heart rate monitoring, biological parameter detection and other aspects of the wide range of applications of photoelectric sensors; in environmental monitoring, photoelectric sensors are used for the detection of atmospheric pollutants, water quality, soil humidity, etc.; in the Traffic management, photoelectric sensors for traffic signal control, automatic parking and so on. Not only that, the emerging field, the Internet of things, automatic driving, smart wearable devices and other happy product development is also inseparable from the application of photoelectric sensors.

3. CURRENT STATUS OF TRADITIONAL STETHOSCROPES IN MEDICAL APPLICATIONS

3.1 Application of traditional stethoscopes

The traditional stethoscope, as one of the important tools for doctors to make preliminary diagnosis, can detect abnormal sounds in the patient's heart, lungs and other organs through auscultation, providing direction and clues for further examination and treatment. According to the survey, 74.6% of clinicians use stethoscopes during outpatient clinics, and 70.6% of them use stethoscopes more than five times a week. These data show that traditional stethoscopes still play a central role in daily medical work. The stethoscopes currently used on the market mainly sample membrane vibrations. This structure in the collection of signals can not effectively filter low-frequency signals, listening to high-frequency signals, diagnostic noise is larger, the accuracy of the diagnosis is lower.

3.2 Analysis of the disadvantages of traditional stethoscopes

Although the traditional stethoscope is widely used, but there are still a lot of disadvantages.1, the use of traditional stethoscopes rely on the doctor's subjective judgement, stethoscopes come back to the heart sounds need to be through the doctor's experience and knowledge of the patient's disease and the degree of illness.2, traditional stethoscopes on the environment requires high. Hospitals, clinics and other places where there is the patient's voice, the patient's family communication, electronic voice broadcast and so on will affect the doctor's hearing to a certain extent. External noise and the stethoscope to collect the patient's heart sound confused with each other, will interfere with the doctor's judgement. 3, the traditional stethoscope has certain limitations. Doctors must communicate with patients face-to-face, listening to grasp the patient's physical condition, such a distance limitation is not conducive to modern medical equipment home.4, as a user of the stethoscope, doctors need to wear a stethoscope for a long time during the work period, which will cause ear discomfort or fatigue.5, traditional stethoscopes can not record heart sound information. Patients do not have the support of accurate and trustworthy preliminary diagnostic data in the case of long-term treatment, which can lead to the wrong direction of bias in the subsequent treatment plan.

3.3 Advantageous analysis of photoelectric stethoscope

Compared with the above-mentioned disadvantages of traditional stethoscopes, photoelectric stethoscopes have obvious advantages. Photoelectric stethoscope can digitally record the heart sound heart sound, easy data storage and remote transmission; photoelectric stethoscope with visualisation function, can be collected to the heart sound waveform real-time display, assisting the doctor to diagnose; photoelectric stethoscope can be used, such as high-frequency ultra-sensitive sensing technology and the environment of the sound reduction noise reduction technology active noise reduction, reduce the impact of the murmur; photoelectric stethoscope has a higher than the traditional stethoscope sensitivity and Accuracy, can capture the heart sound content in the weaker part of the physiological signals; photoelectric stethoscope can be equipped with intelligent analysis functions through machine learning, models, etc., the collected heart sound data for sorting and classification, to provide a certain diagnostic reference; photoelectric stethoscope is lightweight, easy to carry, and suitable for a variety of medical environments in the rapid initial diagnosis; photoelectric stethoscope can be integrated with the storage of the heart sound, replay and other multi-functional, to improve the credibility of the diagnosis. The photoelectric stethoscope can integrate heart sound storage, playback and other multi-functions to improve the credibility of diagnosis.

4. PHOTOELECTRIC SENSORS IN THE MEDICAL FIELD

Photoelectric sensors are widely used in the medical field[2][3] In diagnostics and monitoring, photoelectric sensors can be used to monitor and diagnose a wide range of physiological parameters, such as heart rate, blood pressure, blood oxygen saturation[4][5] In imaging technology applied to medical imaging technology, such as optical coherence tomography (OCT)[6] , photoelectric sensors have the advantage of high resolution and high imaging speed. In minimally invasive surgery, photoelectric sensors play an important role, such as precise pressure monitoring and temperature control by photoelectric sensors[7] In biomedical sensing, fibre optic sensors in biomedicine[8[9]] can be used to measure physiological parameters such as body temperature, blood pressure, muscle displacement, etc.[10] Optical sensors can also be used to measure human pulse signals to analyse human health[11]-[15] Photoelectric sensors can also be used in smart medical devices, where the integrated and intelligent design of photoelectric sensors makes medical devices more accurate and user-friendly. When used in drug delivery systems, photoelectric sensors ensure accurate and safe drug delivery. In remote monitoring applications, photoelectric sensors help to realise remote health monitoring[16][17] , which is particularly important for patients with chronic diseases, reducing the number of hospital visits and improving the convenience of treatment. During surgery, photoelectric sensors can provide precise navigation and help doctors perform accurate surgical operations. The use of photoelectric sensors can improve the safety and effectiveness of surgery and reduce complications during surgery. These applications of photoelectric sensors not only improve the efficiency of medical diagnosis and treatment, but also bring patients a more comfortable and convenient medical experience. With the advancement of technology, the application of photoelectric sensors in the medical field will be more extensive in the future, bringing more innovations and breakthroughs in the field of healthcare.

5. STRUCTURAL DESIGN OF OPTICAL STETHOSCOPE

5.1 Structural Analysis of Traditional Stethoscopes

The principle of operation of conventional stethoscopes is mainly based on acoustic transducers and the phenomenon of resonance. Stethoscopes usually contain a circular resonance chamber in which a back membrane is mounted. When the stethoscope is placed over the patient's body, the back membrane senses the acoustic vibrations of the internal organs. The resonance chamber of the stethoscope is an air cavity with an inherent resonant frequency. The resonance phenomenon occurs when the sound waves coming from the organs in the body match the resonance frequency of the resonance cavity, which means that the resonance cavity will amplify and convert the sound sig-

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nals more efficiently, enabling the doctor to hear and recognise the sound of the organs in the body more clearly. The core device of the stethoscope consists of four main parts: the pickup, amplification and filtering circuits, the processing chip and the Bluetooth module. The main role of the pickup is to collect the sound of the diagnosis, the function is equivalent to "microphone". The amplifier and filter are the "speakers" that amplify the sound. The processing chip is used to reduce the interference of noises and ensure that the sound data is obtained in an ideal way. Finally, the Bluetooth module transmits the sound signals to a computer for storage. In the principle of membrane vibration, the chest piece of the stethoscope (the stethoscope head) is the key part, which is divided into two main parts: the diaphragm and the copper bell. The diaphragm is a membrane, usually made of polyvinyl chloride or rubber, which is responsible for picking up sounds from inside the body. The copper bell body is a hollow copper part that directs sound to the hearing bones. The tube of the stethoscope is an important part that transmits the vibrations to the hearing bones, it is a flexible tube usually made of rubber or silicone. One end of the tube is connected to the hearing head and the other to the auditory bone, and its function is to transmit the sound of the diaphragm vibrations to the auditory bone so that the doctor can hear the sounds of the internal organs.

5.2 Structural Framework of the Photoelectric Stethoscope

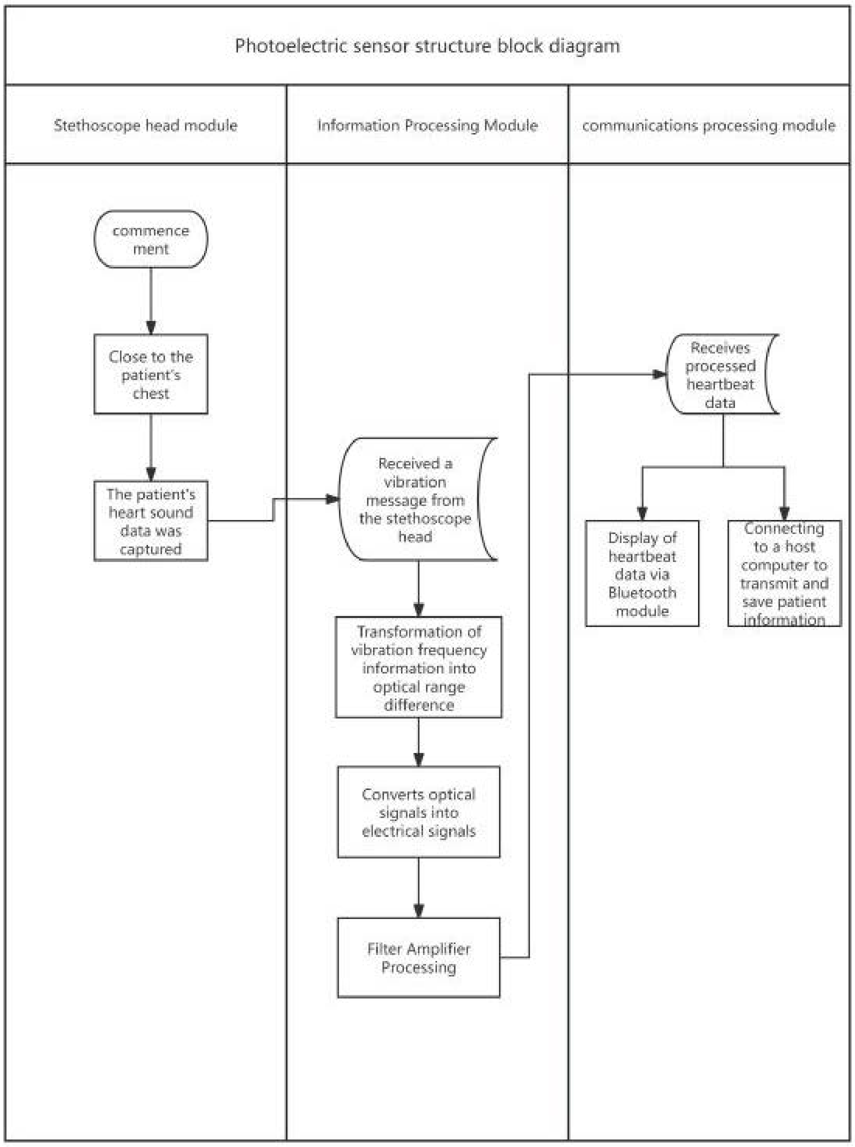

Figure 1 Structural framework of an photoelectric stethoscope

Electronic stethoscopes mostly adopt "Y" type structure[18] The main structure of the photoelectric stethoscope designed in this study is divided into three modules: the auscultation probe, information processing and communication processing. Firstly, the probe is close to the patient's chest cavity, and then the stethoscope head collects the heart sound data and transmits it to the information processing module. In the information processing module, it is divided into three parts. The first part is used to convert the acoustic signal into an optical signal; the second part is used to convert the optical signal into an electrical signal for heart sound data; the third part is the filtering and amplification module, which is to filter out the noise from the electrical signal for heart sound data and amplify the required heart sound data, so as to make the collected heart sound data clearer and more accurate.

5.3 Structural Design of Photoelectric Stethoscopes

Inside the photoelectric stethoscope, an LED light source that can continuously emit a steady beam of light is set to irradiate the outer membrane, and the light passes through the outer membrane and is reflected back to the silicon photocell inside the photoelectric stethoscope. The photoelectric stethoscope is attached to the heart of the left chest cavity of the human body to detect the vibration of the human heart. The vibration of the human heart will drive the vibration of the outer membrane of the photoelectric stethoscope. This leads to changes in the light reflected back from the light beam irradiated to the outer membrane, i.e., generating a reflected light range difference. And then use the photoelectric effect of the silicon photocell to reflect the intensity of light size, to obtain the size of the photocurrent, and ultimately the optical signal into an electrical signal. After amplification and filtering, the monitored heart sound signal is output.

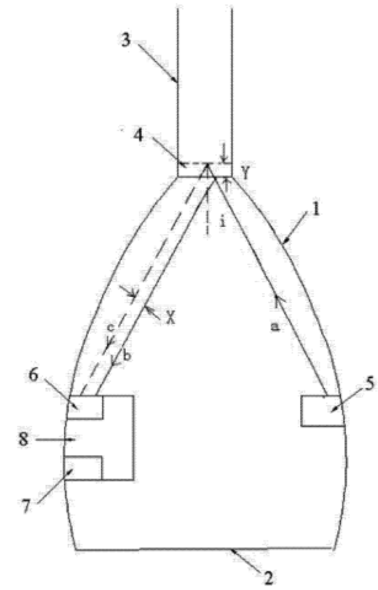

Figure 2 Design of the stethoscope head

5.4 Photoelectric Stethoscope Amplifier Circuit Design

The amplifier circuit designed in this study is to convert the signal into a voltage quantity, which is amplified by a negative feedback circuit consisting of an integrated amplifier, which employs switches to select different amplification levels. The power supply of the integrated op-amp in the circuit, added resistance and capacitance, the role of the power supply filtering, making the power supply more stable. The dual-source complementary power amplifier circuit is constructed at the back using discrete components to increase the output power of the output circuit.

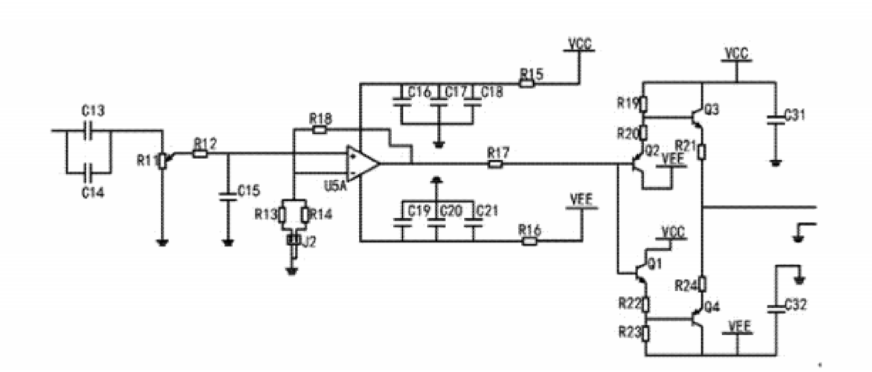

Figure 3. Amplifier circuit design

The resultant photoelectric stethoscope has some functions that traditional stethoscopes do not have. Specifically manifested as: 1, digital recording, photoelectric stethoscope can digitally record heart sound data, easy to store and remote transmission. 2, data visualisation, this photoelectric stethoscope has the function of visualisation, re-

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al-time display of heart sound waveforms, easy to observe the patient's condition. 3, environmental active noise reduction, photoelectric stethoscope information processing part of the addition of high-frequency sensing technology and ambient noise reduction technology can be improved in the complex environment of listening signal-to-noise ratio, improve the credibility of heart sound data. 4, high sensitivity and accuracy, through photoelectric 4, high sensitivity and accuracy, through the photoelectric conversion, can more accurately present the characteristics of the heart sound waveform, easy for doctors to analyse the patient's condition.

6. SHORT

This study discusses the future prospects of stethoscopes using photoelectric sensors in the field of medicine and feasible solutions to achieve their functions. Photoelectric stethoscopes have a huge market potential and a broad development prospect in the medical field, especially for heart sound detection. This study first analyses the global trend of population aging and the high incidence of chronic diseases, and points out the necessity of improving the detection means of medical equipment, especially emphasizing the dependence on stethoscopes for the diagnosis of coronary heart disease and other cardiac diseases, and the importance of improving the accuracy and usefulness of stethoscopes for detection. Secondly, this study analyses the great prospects of photoelectric stethoscopes in the medical field, which can effectively reduce the pressure on medical resources and improve the accuracy of the initial diagnosis of heart diseases, and shows the potential for expansion of photoelectric sensors in the application of industrial automation, health care, environmental monitoring, traffic management and other fields. Aiming at the limitations of traditional stethoscopes, this study discusses three modules, namely, structural design, information processing, and communication processing, and proposes a stethoscope using photoelectric conversion that can effectively avoid the drawbacks of traditional stethoscopes.

7. FUTURE EXPECTATION

In the future, with the development of the intelligent field, the photoelectric stethoscope is expected to integrate more functions to achieve more accurate recognition of heart murmurs and breathing sounds and other functions. In the future development of photoelectric stethoscopes, first, photoelectric stethoscopes can continue to improve diagnostic accuracy, through its high-precision photoelectric conversion and intelligent analysis functions significantly improve the acquisition and analysis of heart sound signals for treatment, thus helping doctors to more accurately diagnose cardiac diseases. With the continuous optimisation of the deep learning model and the accumulation of training data, the diagnostic accuracy before the rolling bar is expected to gradually improve and reduce misdiagnosis. Secondly, the photoelectric stethoscope can better record and analyse individual heart sound data in future development, provide customised diagnosis and treatment plans for each patient, and enable doctors to more accurately understand patients' heart health and adjust treatment plans in a timely manner through long-term heart sound monitoring and analysis. Moreover, the photoelectric stethoscope can be combined with telemedicine technology to enable patients to conduct heart sound testing at home and transmit the data to the doctor in real time, so as to reduce the inconvenience of patients travelling to and from the hospital. Further, the photoelectric stethoscope can be integrated with more functions in the future, from the stethoscope to achieve a multi-functional portable medical device with heart rate monitoring, blood pressure monitoring, respiratory rate monitoring and other functions of the leap, to provide doctors with more comprehensive information about the patient's physical condition. Finally, with the progress of technology and the completion of the scale of the industrial chain, the cost of photoelectric stethoscope will be gradually reduced, and even to the traditional stethoscope close, so that more areas with limited resources or limited economic level of the population can also be widely used in this type of medical equipment, to achieve the home teletherapy, to improve the global level of cardiovascular disease diagnosis and treatment.

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