Wearable Devices and The Energy Supply of It

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Abstract. This paper mainly focuses on two perspectives. The first part is about the principle of some popular optical biosensors (oximeter and heart rate sensor). Next part is about the possible solution for wearable devices' energy supply. In today's era, wearable devices already have many very perfect functions, such as a series of health detection such as heart rate detection. However, due to the limited size, the power supply of wearable devices has been a problem. The reasons why I come up with this device is that wearable devices are attached to our body, like smart watches. Every time when I start walking or doing the sports, I feel like my body is burning. This may be exaggerated, but this feeling is true. The human body is a wonderful structure that has a microelectronic system within it. So far, there are several devices that can extract excess energy from the body and convert it into thermoelectricity.

Keywords: principle, energy supply, heat, resistance.

1. Introduction

Nowadays, the wearable devices are very popular among hospitals and people's daily life, for example, the smart watch has some biosensors like heart rate sensor and oximeter. The market for wearable sensors is predicted to grow to $5.5 billion by 2025, impacting global health in unprecedented ways [1]. Wearables have been gradually integrated into people's lives, but some research shows that wearables can boost worker productivity several notches, as well as monitor the physical and mental health of employees [2]. Although the volume of the device is very small, the function and accuracy is undoubtable as the technology is advanced. But it still has problems. The most obvious problem is the energy supply of the devices. For example, the apple watch is one of the most popular smart watch around the globe. But a lot of consumers reflect that they need to charge it frequently. It is quite inconvenient. Therefore, in the future, we hope to develop a technique to increase the continues of the wearable device [1]. The new developed technology has a great potential in wearable devices' energy supply work [2]. The aim of this Systematic Literature Review is to provide a heuristic overview on the recent trends of wearable technology and to assess their potential in workplaces. The research shows that even the generate of electricity rely on the temperature difference and other factors, but they do not directly proportional to the metabolic reate [3]. authors talk about the principle of Oximeters [4, 5]. The article talks about a sample machine on heart rate monitor [6]. creating electric power by harvesting the waste heat from the human body is one of the effective solutions in this way. For this reason, the development and improvement of the technology of wearable thermoelectric generators have received much attention recently [7]. In this article, the author talks about the energy supply of wearable devices, and describe the actuation function which caused by self powered system [8]. it talks about the possible method to convert human energy into electricity [9]. variations in body temperature activate these thermoreceptors, which inform the preoptic area of the hypothalamus. This area then activates heat regulation mechanisms to increase or decrease body temperature and return it to baseline [10]. overview of anatomy and physiology and a preview of the body regions and functions. It then covers the characteristics of life and how the body works to maintain stable conditions.

2. Method

2.1. The principles of the example wearable devices

2.1.1. The Oximeter

By driving a red LED(660nm) and an infrared LED(910nm) in turn, the blue line indicates the response curve of the receiving tube to reduced hemoglobin when hemoglobin does not contain oxygen molecule 100. It can be seen from the graph that the absorption length of reduced hemoglobin for 660nm red light is relatively strong, while that for 910nm infrared light is relatively weak. The red line indicates the response curve of the receiving tube to oxygenated hemoglobin when hemoglobin and red blood cells with oxygen molecules are present. In the spectrum, red light at 910 nm has a stronger energy absorption or color absorption effect than red light at 660 nm. In blood oxygen testing, blood oxygen data can be obtained by comparing and calculating the difference between the reflected waves absorbed by the two kinds of light. This is the basic principle of blood oxygen detection.

2.1.2. The heart rate sensor

It's a photoplethysmograph. Principle goes like this: Our blood appears red because it reflects red light and absorbs green light. The Apple Watch uses green LED lights with light-sensitive photodiodes, monitor blood flow through the wrist at any point in time. When the heart beats, the blood flow through the wrist increases, so does the absorption of green light; decreases during heartbeat intervals. So the watch can count people's heart beats per minute. Also, The algorithm allows us to demodulate this signal and then calculate the pulse rate, which is equal to the heart rate.

2.2. The energy supply solution

The above passage are two typical wearable sensors. We can see that even the devices are very small (most of them can put into a watch), they still have very complete working rules. But those wearable devices have a lot of problems too. The most obvious one is the energy supply. Due to the small volume of the wearable devices, they cannot have very big batteries like other electric devices. So they cannot work for a long time. Harvesting energy has a great role and significance in the medical field. Many medical testing devices require long-term and continuous data, so the issue of power supply is critical. In wearable devices, a device that can be durable can make the detection data more durable and persuasive. Therefore, thermoelectric generators are a good choice. Because it operates independently of optical conditions or the movement of the wearer [5]. The following passage I will mainly focus on thermoelectric generator.

A thermoelectric generator is a device that converts heat transmission or the temperature difference between two hot and cold surfaces directly into electrical energy. As iot technology advances, the issue of providing sustainable power is one of the major challenges on the road to the development of these tools.

The reasons why I come up with this device is that wearable devices are attached to our body, like smart watches. Every time when I start walking or doing the sports, I feel like my body is burning. This may be exaggerated, but this feeling is true. The human body is a wonderful structure that has a microelectronic system within it. So far, there are several devices that can extract excess energy from the body and convert it into thermoelectricity. But these energies cannot be used directly, they still need to be adjusted before they can be used. The average human, at rest, produces around 100 watts of power [7]. Some humans can output over 2,000 watts [7]. The energy mentioned above is needed for vital functions like heartbeat and muscles, but some of it is lost as heat. It is possible to extract this energy and convert it into heat and electricity [8]. Scientists have been study converting human's power into electricity for a long time. For example, the system of using consumer's heat energy to provide hot water in Stockholm Central Station is very successful.

Humans are warm-blooded creatures. Therefore, when the outside temperature is very different from its own temperature, people will maintain their body temperature within a constant range

through their own thermoregulation to ensure that the heat will not be lost in large amounts. In the process of ATP production by cells throughout the body, approximately 60 percent of the energy produced is in the form of heat used to maintain body temperature [9]. Thermal neutrality means that the body does not need to consume or release heat to maintain its own thermostatic system. Our bodies lose heat in four ways: by conduction, convection, radiation and evaporation. These modes of heat transfer all follow the same principle: flow from high concentration to low concentration in the fluid. As a result, the efficiency of these heat transfer methods can change depending on the environment.

Heat conduction is a mode of heat transfer, which can occur in both solid, liquid and gas. The heat transfer is most obvious in solids. Some molecules in the solid will vibrate at a high frequency in place after receiving heat (the vibration frequency depends on the heat collection), which will cause nearby molecules to vibrate at the same frequency. Over time, the vibrations travel farther and farther, so that the energy is successfully transferred to other molecules.

Convection is the transfer of heat to the air around the skin. Warm air rises from the body and is replaced by cold air that is later heated. Convection can also occur in water. When the water temperature is below body temperature, the body dissipates heat by heating the water closest to the skin, which is replaced by cooler water.

Thermal radiation is the transmission of electromagnetic waves caused by thermal energy. When the microscopic particles inside the object begin to move, or the state of motion changes, electromagnetic radiation is excited. Among them, infrared has significant thermal effect on human body. When the temperature is low, it mainly radiates with invisible infrared light, and when the temperature is 300 ° C, the strongest wavelength of thermal radiation is in the infrared region. Evaporation is a physical change caused by the irregular movement of water molecules in a liquid into a gas state. Evaporation can occur at any temperature, and the higher the temperature, the faster the evaporation rate. It is different from vitalization. Volatilization is also a physical change, is the free emission of material molecules, free movement, not affected by temperature, it can be liquid, can be solid. Volatilization generally refers to organic matter, such as alcohol, gasoline, camphor essence.

Due to those ways of transferring energy from our body, we can see that huge amount of energy is lost from our body everyday. So if we can collect those energy and transfer them into wearable devices, the devices can run continuously. The harvesting of energy by the human body is usually divided into active and passive according to the way it works. Active methods usually generate electricity through physical movement in everyday activities, such as running and walking. The passive approach, on the other hand, is to collect the body's own dissipated energy. Active energy harvesters are defined as systems that require external mechanical stimulation to generate electricity. [6].

A healthy person's body temperature is usually kept constant through thermoregulation mechanisms. Therefore, the excess energy or heat generated in the human body is usually transmitted to the outside through the skin, and the main latent heat is emitted to the outside. Table 1 shows the amount of energy lost by the human body during different activities.

Table 1. the contribution of each mechanism to the total heat loss from the body during different activities

Activity	Sensible (W)	Latent (W)	Total (W)
Seated at rest	60	45	100
Sedentary work	65	55	120

There is a temperature difference between the human body and the external environment. Based on the Seebeck effect, using temperature differences to generate electricity is the most efficient way to harvest wearable heat energy. The thermoelectric generator is arranged in series and parallel on the flexible circuit board to form the thermoelectric module, the thermoelectric module is arranged on the front of the sports tights to make the thermoelectric clothes, and when the thermoelectric generator is in close contact with the human skin, the energy is effectively collected and converted.

Current circuit boards have evolved into highly miniaturized products. However, rigid substrate materials lead to limitations in existing wearable electronics, which cannot be conformal integration with the soft curved human body. The ideal wearable sensor needs to maintain good sensing performance despite severe deformation such as bending, stretching or twisting. Conductors such as liquid metals and ionic liquids can also be used as electrode materials for new wearable devices. For example, liquid metals have good electrical conductivity and fluidity at room temperature and are ideal materials for preparing stretchable electrodes. The liquid metal conductive fiber prepared by the injection method has a tensile property of up to 700%, while maintaining the continuity of metal conduction. The unique fluid characteristics and metal characteristics make liquid metal greatly attract people's attention in the field of wearable materials.

3. Result

Up to now, people's research has mainly focused on the choose of the material and structure of hot thermal electricity generator, two decisive factors that can directly lead to the efficiency of the generator's energy collection. During the power generation process, the wearable thermoelectric generator may have the problem of uneven power generation, which may be caused by the temperature difference between the two ends of the generator. Generators, on the other hand, require energy to operate. Therefore, the initial operation of the thermoelectric generator requires additional energy or emf stored inside it. Some DC-DC converters cannot adapt to the input load of the connected thermoelectric generator, resulting in a decrease in the energy conversion coefficient and the thermoelectric generator out of optimal working condition. Therefore, in view of the impact of this type of DC-DC converter on WTEG, it is essential to establish a resistor match [11-13]. Also, thermoelectric generator has a lot of advantages: relatively small temperature differences can obtain energy, as long as there is a temperature difference of tens of degrees can generate electricity. Long life, no mechanical driving part, not easy to occur the loss and deterioration of each part [14-16].

4. Conclusion

Thermoelectric generators do have many advantages, and have gradually developed into the public field of vision and into practical applications. But there are still a number of issues that need to be resolved with regard to the functionality of wearable devices, as shown in the figure 1 below.



Fig 1. The list of current problems

At present, self-powered devices for wearable devices are still in the laboratory stage and have not been mass-produced. Most wearable devices are made of flexible materials, so there is bound to be a problem of performance degradation after long-term use. Therefore, the future direction of our research should be to discover new materials and structures to help mitigate the performance degradation caused by long-term use while maintaining easy to wear. The results of this study can provide some targeted and more realistic thinking for the power supply of wearable devices.

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