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Well-Designed wearable devices in healthcare

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Abstract. In recent years, wearable devices have gradually become a hot topic in the society. Due to their advantages such as ease to carry, ease to operate and diverse functions, the scientific community and businesspeople are developing them. Numerous new products, such as smartwatch eyes, have entered the market, which reflects the huge demand for wearable devices in today's society. Wearable devices in medicine and health monitoring have played a vital role in such aspects, such as early detection of diseases and low-cost medical services. But distance wearable devices into everyone's life is still a long way to go. This paper studies the current wearable devices' problems, such as privacy leak risk and poor battery life, and wearable devices' potential development direction in the future. It is concluded that wearable devices have achieved good development results in medical treatment. Wearable devices come in various forms and have unlimited development potential in the future. Its importance to the intelligent era is undeniable. Wearable devices have put forward solutions to solve the problem of insufficient social resources.

Keywords: Wearable Devices, Healthcare, Sensor.

1. Introduction

Wearable devices have recently been a hot topic in the technology market. More wearable devices have been gradually put into the market, but there is currently no unified definition and classification standard for wearable devices. Based on current research results, the wearable device is a portable smart mobile device directly worn on the body or integrated into the user's clothes or accessories. Based on the human body's natural ability, it uses science and technology to realize the corresponding information intelligent interaction function through the built-in sensor. With its unique advantages, wearable devices affect people's behavior patterns, improve work efficiency and change our lives. With the development of science and technology, wearable devices with different forms and functions appear, which facilitate people's life in different aspects such as medical health, travel and leisure, such as health monitoring equipment and safety positioning system. In 1975 Hamilton watch published the Pulsar calculator watch. 1977 a wearable device for the blind was developed by CC Collins that uses a head-mounted camera to convert images into a tactile grid on a vest.

In 1979, Sony rolled out Walkman Cassette Walkman. In 1984, Casio developed Casio Databank CD-40. It is one of the world's first digital watches to store information. 1993, researchers at Columbia University developed an augmented reality system, KARMA, which includes a head-mounted display, Private Eye, which Reflection Technology developed in 1989. In 1999, RIM published the first product - the RIM850 two-way pager. In 2000, the world's first Bluetooth headset shipped. 2006, Nike's Apple

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team developed a device that tracks distance and speed and works with an iPod Nano. In 2011, Jawbone launched a fitness band that tracks sleep, exercise, diet, and links it to your smartphone for $130. 2012, SONY is offering a Smartwatch that uses Bluetooth to connect to an Android smartphone, costing $150. 2013, Google is rolling out a beta version of Google Glass to select users. Google Glass is an optical head-mounted display that attaches to glasses, can be controlled by voice, and can use Wi-Fi to surf the Internet. Wearable devices are easy to carry, easy to control, convenient and fast, and user-friendly equipment. These advantages are why wearable devices have been out of development for decades. In the future, the development prospect of wearable devices will be very broad. For all of us, lower bondage wearables are the way to go, enhancing functionality while striving for comfort and beauty. At the same time, wearable devices can also be designed for special occupational groups according to their needs, such as doctors, firefighters, police, etc. Wearable devices have come a long way, but there is still much room to grow. With the advent of the intelligent era, people's demand for wearable devices will gradually increase, which is its rapid development.

2. The distinctive superiorities of biosensors in wearable devices

There are a variety of wearable devices on the market, all based on rapidly evolving sensing technology. With the arrival of the intelligent era, the booming development of sensing technology makes increased sensors of different forms and functions appear on the market. Sensing data is the main input of wearable devices and the basis for subsequent computation, analysis and services. Wearable devices use various types of sensors to obtain information from different sources such as the environment and the human body for storage, analysis and calculation and then support upper-layer application services and interaction behaviors. For example, motion sensors include pressure sensors, gyroscopes, accelerometers, etc. Motion sensors can record human movement, such as the number of steps taken, distance run, heart rate during exercise, calories burned, etc. Some sports bracelets on the market now use this technology. There are also biosensors. Biosensors include blood glucose, ECG, EMG, body temperature, brain waves, etc.

Using biosensors to collect human signals, signal processing to obtain information, health monitoring, and disease detection, with the help of these medical devices, can collect more body data to facilitate treatment. Low-cost health monitoring has also been achieved, allowing more people to access medical services. Finally, the environmental sensor is also a widely used sensor, such as humidity sensor, ultraviolet sensor, pH sensor and so on, through environmental testing data to complete environmental monitoring, health prediction and so on. Environmental sensors can be used to manufacture PM2.5 portable detectors and personal comprehensive environmental monitoring terminal equipment. At present, environmental pollution in society is very serious. Air pollution, land, and water pollution will lead to many chronic diseases and bodily damage function. Environmental sensors can be used to solve these problems. In addition, flexible sensors are made of flexible materials with very strong environmental adaptability. With the development of the Internet of Things and artificial intelligence, many flexible sensors have the characteristics of high integration and intelligence. As time goes on, different substances are used to make new sensors. The flexible substrate materials are very limited, and the successful one is polydimethylsiloxane (PDMS). There are still many materials to be excavated in the future. For example, some research institutions have found that carbon materials can make flexible sensors but need graphene materials to cooperate. Flexible sensors play an indispensable role in wearable devices because they have very good flexibility to make wearable devices fitter for the surface of the human body. These sensors have different advantages and functions, are easy to wear, have simple operations, and are diverse so that wearable devices glow with different luster, which has become an important part of life.

3. Recent progress of biosensors in wearable devices

With the continuous development and innovative integration of mobile communication, image technology, artificial intelligence and other technologies, driven by global applications and experiential

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consumption, wearable devices have developed rapidly and become one of the fastest growing high-tech markets in the world. There are increasingly different kinds of wearable devices on the market.

3.1. Respiratory sensing device

Wearable devices are important in medical treatment, such as respiratory diseases. Chronic obstructive pulmonary disease, bronchial asthma and other diseases, these common diseases to public health, caused a great threat but also brought a heavy medical burden. Wearable devices have already made preliminary progress in treating these diseases. For example, wearable devices play an important role in monitoring human health. For COPD patients, decreased activity is a risk factor for hospitalization and death. Wearable devices can monitor and intervene in patients' daily activities. Improve physical activity levels and quality of life by monitoring detailed characteristics of daily activities. For patients with bronchial asthma, wearable devices have completely different effects. Wheezing is a typical sign of asthma attacks, and monitoring daily breath sounds may help diagnose, warn of acute attacks, and evaluate disease activity. There are already wearable acoustic sensors that can monitor asthma attacks in patients. At the same time, detecting biomarkers in exhaled breath condensation can help monitor the degree of asthma disease activity and guide the treatment and management. For example, exhaled NO, as an inflammatory biomarker of asthma, can assist in the diagnosis, but frequent detection is needed to prevent it effectively [1].



Figure 1. A wearable device for lung health monitoring [2].

3.2. Temperature sensing device

Temperature sensing devices are also an important class of applications. The wearable temperature monitoring device has flexible wearable characteristics, which can monitor real-time temperature and record for a long time. The temperature data will automatically issue a warning when it exceeds the set value. The temperature sensor plays an important role in this. The temperature sensor system is a system that senses, processes and transmits the collected human temperature signal and is the core component of wearable devices. Thermosensitive temperature sensors are commonly used. The resistivity of a thermistor varies markedly with temperature. It is divided into a positive temperature coefficient thermistor and a negative temperature coefficient thermistor. Presently, a negative temperature coefficient thermistor is widely used, with the advantages of high measurement accuracy and good reliability. Flexible sensors appear with the development of flexible matrix materials, further promoting intelligent wearable devices' development and improving their wearable comfort. The Life Shirt, developed by Vivo Metrics company in the United States, can monitor more than 30 human physiological indicators such as respiratory rate, heart rate and body temperature by putting sensors into the clothing. It can conduct a preliminary analysis of the monitoring data and submit the analysis report to the doctor. In China, wearable temperature monitoring products are relatively mature, including the intelligent children's electronic thermometer developed by Beijing Ruiren Technology Medical Co.,

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LTD. The device can collect temperature data every second and has an alarm function. When the collected temperature data is abnormal, it can alarm and remind the wearer to take medicine [3].



Figure 2. IFever Smart Children's Thermometer [3].

3.3. Graphene flexible sensor

Flexible sensors made from graphene have been a hot topic recently. Graphene is a two-dimensional honeycomb crystal formed by hybridizing C atoms with SP2 electron orbitals, which have excellent electrical and mechanical properties. Single carbon conductive composites are difficult to give the complete performance of sensors, so composites have become the key to the development. For example, carbon materials are used in carbon-based flexible piezoresistive pressure sensors, mainly including CB, CNT, GO, rGO, carbon fiber (CF), and the composite carbon materials between them. For example, the carbon black-based flexible piezoresistive pressure sensor, CB, is the pyrolysis product of organic matter, which has low price, easy mixing, stable conductivity, etc., so it is the most successful conductive filler applied at present. The content, particle size, surface characteristics and dispersion state of CB have important effects, but the uniform dispersion state of CB particles is the key. In addition to CB, there are also carbon nanotubes-based flexible piezoresistive pressure sensors. Carbon nanotubes (CNT) are one-dimensional carbon materials with excellent electrical conductivity and mechanical properties. They all belong to carbon-based flexible piezoresistive pressure sensors. In addition, graphene-based flexible piezoresistive pressure sensors have been used. Many attempts have been made in the scientific community. For example, Yan et al. combined G and nanocellulose to obtain a flexible nanopaper through vacuum filtration and then embedded the nanopaper into the PDMS matrix to prepare a high elasticity (shape variable up to 100%) piezoresistive strain sensor. It is worth mentioning that composite carbon-based flexible piezoresistive pressure sensor, relative to the single carbon materials, with two or more two kinds of carbon materials in building an effective conductive network, has an obvious advantage, can effectively improve the pressure-sensitive performance of conductive composites, lower percolation of more than, at the same time improve the mechanical properties of conductive composites [4-6].

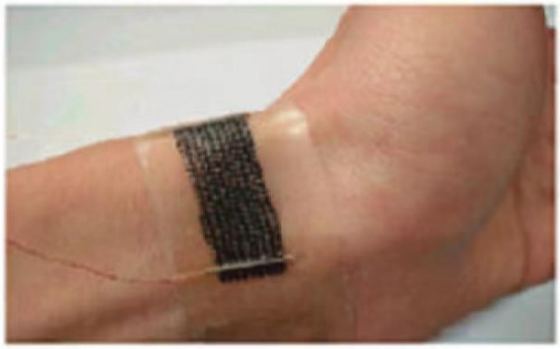

Figure 3. Flexible graphene sensors monitor movement signals [5].

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4. The application of wearable devices in different fields

At present, wearable devices play an important role in various fields of society. Firstly, medical treatment is the most widely used aspect. The mobile medical treatment gradually shows its market potential with the continuous formation of mobile Internet ecology and the popularization of mobile terminal devices. The arrival of wearable devices will accelerate the development of mobile health care. In terms of fitness, wearable devices have the largest consumer group among fitness enthusiasts, and the more consumers are interested in the device, the more conducive it is to expand the market acceptance. Make full use of the application of the Internet of things in smart wearable products so that smart products play a greater role in people's life. In addition, in terms of entertainment, wearable devices are the most widely used in the medical field, followed by entertainment. When wearable devices meet the mobile Internet, people who are good at entertainment will usher in a happy change. Finally, on the military side, wearable devices have begun to appear as increasingly new inventions in the industrial and military fields, and these devices can help people in these two industries to improve their work efficiency to a certain extent.

4.1. Health monitoring

In terms of health monitoring, smart wearable devices can be used for real-time monitoring of body temperature, dynamic ECG, pulse wave, blood pressure, blood oxygen, blood glucose, sleep status and other human health indicators. For example, remote ECG monitoring systems can collect ECG data, analyze signal quality, and screen for symptoms such as arrhythmias. The wearable respiratory sensing system can record the respiratory wave data of the human chest and abdomen in the sleep state, analyze the sleep state, and judge the sleep quality. The patch thermometer can monitor body temperature in real time and provide technical support for large-scale body temperature screening in the stage of epidemic prevention and control. As the aging population becomes increasingly serious, many countries in the world are in urgent need of a low-cost health monitoring method that can monitor the physical data of the elderly and patients with chronic diseases remotely and in real-time through technology and be able to deal with the danger or accident when it happens. For example, for patients with chronic diseases such as diabetes, who need to control their diet and monitor their blood glucose, the wearable device can record their blood glucose at any time and alert them when their blood glucose is too high or too low. For diseases with high recurrence probability, such as heart disease, patients need to monitor heart rate changes in time to avoid disease mutation, notify patients by an alarm when abnormal heart rate is detected, or patients' family members need to seek medical treatment in time [7, 8]. For ordinary people who pursue health, it is also a good habit to pay attention to their health status anytime and anywhere. People can record the exercise time, and energy consumed every day. In addition, if an elderly person has a sudden accident, the wearable device can send a warning message to the emergency center through the wireless network, locate the elderly person who has fallen and give immediate treatment.



Figure 4. Apple health bracelet [9].

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4.2. Disease control

Wearable devices also play a non-negligible role in the early detection of diseases. It is a simple, fast and low-cost method to apply wearable devices to early disease screening. Like the sensors mentioned above, they can be used for respiratory diseases. Much screening for chronic obstructive pulmonary disease (COPD) is done in this field by measuring the composition of exhaled breath to determine the presence of disease. I have learned in high school textbooks that the symptoms of COPD are mainly dyspnea, cough, and sputum. Wearable devices can collect data and detect the progress of the disease in time. Wearables can also be used to detect early dementia.

Dementia is a chronic acquired progressive mental retardation syndrome. Clinically, it is characterized by a slow onset of mental decline and a series of cognitive impairments. Accompanied by varying degrees of personality change. It is a group of clinical syndromes rather than an independent disease. Sensors can monitor the quality and duration of a patient's sleep. Compared with normal people to determine whether there is abnormal. And cardiovascular disease, which is more prevalent in the elderly. Because of the secrecy and unpredictability of cardiovascular diseases, the incidence and mortality of cardiovascular diseases are very high, which brings a great medical burden to society. Therefore, routine medical monitoring can play an important role in the timely detection of cardiovascular diseases. Wearable devices can obtain human health data anytime and anywhere, which is very important for judging the existence of diseases. Wearables also have applications in diabetes, a metabolic disease that involves problems with blood sugar control caused by insufficient insulin production or decreased sensitivity. Once you have diabetes, you must monitor and control blood glucose anytime and anywhere. Wearable devices can record food calories and the nutrient ratio of the body anytime and anywhere to judge the fluctuation of blood glucose and give an alarm in time if the blood glucose is too high [10-12]. Compared with traditional blood collection to obtain blood glucose values, especially for diabetic patients who need frequent blood collection, wearable devices are very convenient. In a word, wearable devices can reduce medical expenses by reducing personnel costs and hospital burdens. This is exactly in line with the future market demand. Although there are still many things to be improved in wearable devices, such as information, privacy and security, it is undeniable that the development of wearable electronic devices can make everyone enjoy low-cost medical security, which is necessary for solving social problems [13, 14].



Figure 5. Blood glucose monitor [12].

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5. Conclusion

In the past few years, wearable products have seen a spurt of development, with many products such as wristbands, watches, heart rate bands, smart glasses, etc., and various R&D manufacturers have invested a lot in this aspect. With the increase of products, wearable products also have a few difficulties developing. Many people for wearable products gradually lost their original interest, mainly because of wearable devices. There are many problems, such as uneven product quality and high prices. The professionalism will be questioned, and the recognition will decline. At the same time, there are also security risks. For example, many businesses claim that the bracelet can achieve many health or medical parameters and functions, but it needs to meet medical standards. First of all, what we need to do most is to reduce the price of wearable devices so that wearable devices can enter more people's lives. Samsung currently makes several smart bands that cost more than 1,000 yuan, and Google Glass costs as much as $1,500. This is a very expensive price for the general public. Therefore, if people want to expand the market share of wearable devices and make them affordable for everyone, we should carry out large-scale production and reduce the cost to reduce the selling price or produce products with different prices for the public. For example, high-income people, electronic product lovers or technology talents with high requirements for wearable devices can make products with high configuration and complete functions. Lower-priced products can be produced for the public because their life or career requirements do not require all functions of wearable devices, but only some basic functions. For them, it is a waste of money to buy high-configuration wearable devices at a high price, so to fully meet the needs of different people, they can produce devices at different price points to increase the market share. Privacy is also one of the hot topics that the public cares about. Data privacy and security protection are the future's main directions for wearable devices. Because wearable devices can record the user's body data, behavior habits and other information, the more these data are prone to security problems and hidden dangers. Once leaked, it will harm society greatly. In addition, the development of batteries and chips is a big obstacle to developing wearable devices. In the futubre, wearable devices with low energy consumption and are more comfortable and beautiful will be favored by the public. In a word, there is still a long way to go for the development of wearable devices, which needs the government's encouragement and support and the people's supervision. Future wearable devices' features, such as miniaturization, could revolutionize people's lives.

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