Wearable Technology

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Introduction

Humans have always needed to improve themselves and their environment since the early ages. With this quest and the development of various products, technology has moved to a very important point today. The initial aim was to serve the basic needs of people, but in recent years, increasing the comfort of these basic needs has become a priority. Wearable technology is one of the technologies that has an important place for comfort. Wearable technology generally includes devices that the user can wear for various purposes or place on any object in different ways.

Wearable technology first came into our lives in the 13th century with the glasses invented by Roger Bacon (Rosen, 1956). While these designed glasses are a fact of life today, smart glasses have started to enter our lives now. It can be said that the designed watch in the form of a necklace by Peter Henlein in 1504 is among the first designs used in wearable technology in history (Guler et al., 2016). This pocket watch evolved into different models in the 1900s and became a wrist watch, the most convenient design for users.

With the development of the cinema industry, people began to transfer the products of their dreams to movies. These products of imagination, which only appear in science fiction films, have become commonplace today. For instance, it is seen that the smart glasses used in the movie “Back to the Future”, which was screened in 1987, were produced by Google company, and the self-drying smart jacket used in the same movie was produced by Kickstarter company. The used smart shoes in the movie “Back to the Future” came also into our lives with Nike company.

With the development of wearable technology, products have begun to be developed in many different sectors. In Figure 1, wearable technology products for many needs of users from different sectors are given. They are frequently used in the sports and entertainment sectors, especially in health.

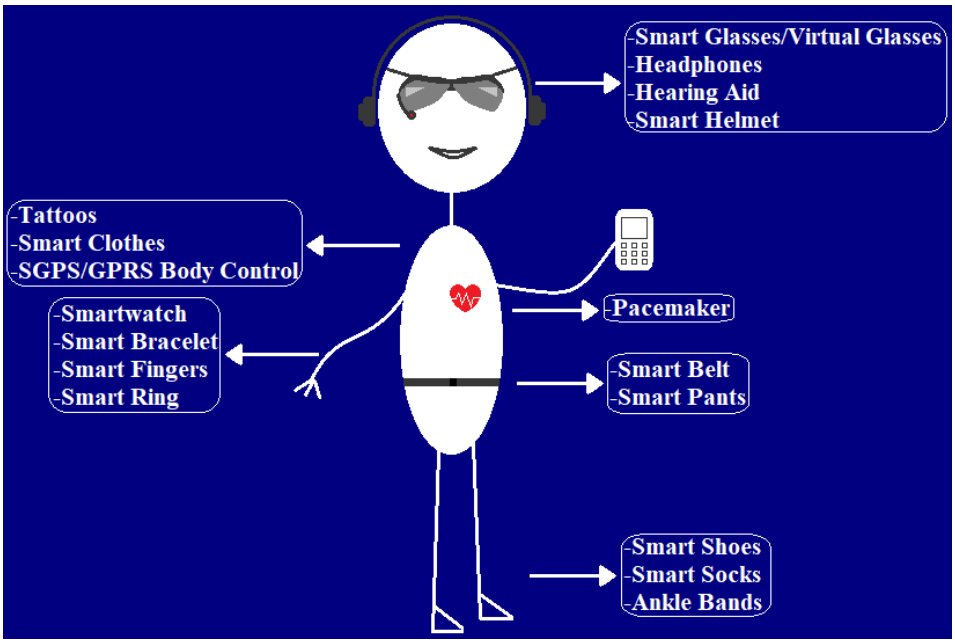

Figure 1. Wearable Technology Devices

Today, studies continue for new wearable technology devices and the development of existing technology devices. For example, in a study that outlines the future, motion recognition was aimed with an accelerometer and microphone placed on the arms of users such as workers (Ward et al., 2016). The health sector has had the biggest share in the growth of wearable technology. The bracelet, which was designed to track the movement of the user in 2008, is one of the essential studies carried out in the field of health (Ananthanarayan et al., 2010). With the progress of these studies, the production of wearable technology devices for more special cases has gained momentum. As an example, in the study carried out in 2021, the used wearable wrist sensor to observe the reach-to-grasp movement of the arms of individuals with stroke and to determine the treatment goals is mentioned (Yang et al., 2021).

In a different study using wearable technology devices, smart collars used to track the activities of dogs are mentioned (Yashari et al., 2015). With this study, it clearly shows that wearable technology is used in other living things besides humans and that the point it has reached today is very comprehensive. The improvement of wearable technology in many areas will increase its effects on our lives and will continue to change our lives.

Data Process of Wearable Technology

The data collection and processing process in wearable technologies generally has the same logic. Figure 2 shows the data process of wearable technology schematically. There are 5 data process steps, namely data collection, preprocessing data transfer, computation, data processing and data storage, respectively.

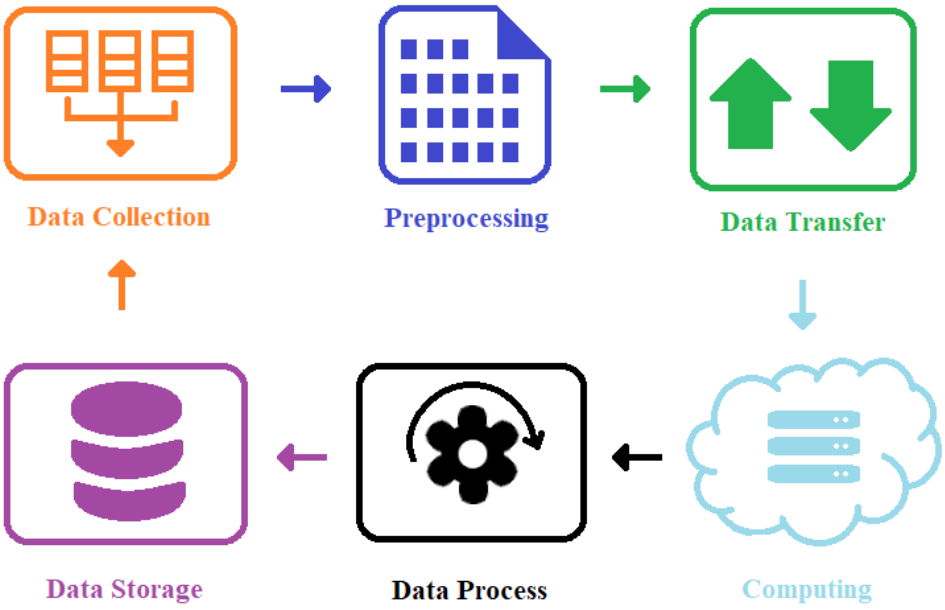

Figure 2. Data Process of Wearable Technology

Data Collection

User data is collected and processed on wearable technology devices. Crowdsourcing is used in collaborative retrieval of collected data, depending on its size. Crowdsourcing of data collected from wearable technology devices, in other words, crowdsensing, is used to activate the regular collection of data. Crowdsensing is carried out in forms such as participatory (active) sensing, where users actively report their movements or observations voluntarily, and opportunistic (passive) based on the automatic sensing, collection and sharing of data with certain applications running in the background. User involvement is almost nonexistent in opportunistic sensing (Delmastro et al., 2016).

Preprocessing

In wearable devices, as in many technologies (Crone et al., 2006), there is a data preprocessing. Unnecessary or bad data is passed through important stages such as filtering, structured, cleaning and validation so that the storage resource is not sufficient or the raw data is in an understandable format. It is aimed to improve the performance of wearable technology devices by improving the collected data as a result of these stages. In addition, in the preprocessing step, data is compressed to reduce the amount of consumed power during data transmission.

Data Transfer

One of the most significant steps in data process of wearable technology is the data

transfer between the device and the network. Considering various parameters such as distance, transmission rate and consumption of power for wearable devices, various technologies are used in data transfer. Various cellular networking such as Bluetooth Low Energy (BLE) (Bluetooth 4.0BLE), Wi-Fi and Zigbee can be given as examples of technologies that are widely used in wearable devices. These networking have advantages and disadvantages among themselves in terms of transmission distance, transmission rate, power consumption and security. It is possible to achieve a range of up to one hundred meters in all three networking. While the transmission rate is higher in Wi-Fi technology than others, consumption of power is higher than other technologies. Wi-Fi technology also has a wide range of application area. It is also known that BLE and Zigbee technologies have higher security compared to Wi-Fi technology. BLE technology has a small size and uses in many applications, but has limited capacity. Zigbee technology is a newer, low-cost wireless mesh network technology with features such as self-healing of the network structure compared to other technologies (Li et al., 2019). The fact that Zigbee is newer limits its application area. Each of these networking depending on the mentioned features has advantages and disadvantages compared to the other. In this context, the technology to be used will vary according to the priority of features such as transmission rate, security and power consumption, depending on the device and application.

Computing

The workload has increased as the user needs of wearable technology devices. Performing computations on these devices faster and more effectively has been a significant part of the process. Especially in the early development stages of wearable technology, it was necessary to collect data about the used devices and then transfer the data from these devices with a computer connection. With the development of technology, computing began to be carried out not locally, but by moving them to a closed network device. In this context, Multi-Access Edge Computing (MEC) was introduced (Ometov et al., 2021). MEC is a system that allows computing to be returned to the device after being made quickly and effectively.

Nowadays, cloud, edge and fog are the first computing that come to mind in wearable technology devices. Computing, storage and networking are aimed as a result of filling the gap between end-to-end devices in cloud computing. Edge computing is a more comprehensive version of cloud computing, but user data may be at risk. By removing a disk driver from the edge source or copying collected data from a memory stick in cloud computing, important information of user can be compromised. In edge computing, the data of the edge node that is in the nearest network is processed. In fog computing, this network is wider. But fog computing is a technology with a lack of knowledge. Therefore, it has not yet become a frequently used technology in wearable devices. In addition to

these technologies, computing such as mist, mobile, mobile cloud, and cloudlet are also included in the literature (Dolui et al., 2017).

Data Process

Various methods are used to obtain understandable results from data inputs of wearable devices that serve certain purposes. Machine learning techniques such as clustering, classification, and regression are among the commonly used techniques (Lown et al., 2020).

Time series of data are generally used for analysis in wearable technology devices (Sprint et al., 2017). These time series, which are recorded depending on the need, provide a pattern in which physical changes such as behaviors belong to the individual and deterioration of health can be observed in line with the purpose of use. In addition to machine learning, preprocessing steps such as Convolutional Neural Network (CNN), Multilayer Perceptron (MLP), Long Short-Term Memory (LSTM), Physical Activity Change Detection (PACD) are used to obtain the most efficient and accurate results (Janković et al., 2018). The obtained data as a result of the process is presented in formats such as reports and images in a way that is clearer for users.

Data Storage

After data process, the data is stored for later analysis. This process is crucial for the secure recording of personal data. Therefore, it can be necessary to use complex systems in the data storage. Besides, the fast performance and low energy consumption of equipment used for storage are important for devices such as used cell phones for communication. The energy efficiency of the equipment will decrease the workload on the cell phone, which is used for different purposes in daily life (Huang et al., 2015).

Wearable Technology Application Areas

The desire of people to access information quickly and reliably is increasing day by day. Various technologies are being developed for this purpose. Wearable devices are one of these technologies. In this section, the rapidly developing wearable technology sector is covered together with its application areas.

Use in Daily Life

Wearable technology is actively used in many areas of our lives. Smart watches, glasses, headphones, rings and wristbands are just a few of them. In this section, a few wearable technology products used in daily life are discussed.

Now, smart watches reach a wide range of users around the world as they accelerate

access to information, appeal to fashion and are one of the most affordable wearable technologies. The market share of smart watches produced by many companies in the sector is quite large. This technology, which is far beyond any watch, has many features such as measuring the oxygen level in the blood, heart rate monitoring, stress measurement, pedometer, calling for help in the event of a fall, wristband alarm, inactivity alerts, remote connection with mobile phones, making calls, etc. As seen in the image of Apple smart watches in Figure 3, these watches, which have very stylish designs in terms of compliance with fashion, also have models that offer the option to choose a compatible watch dial by taking a picture of the clothes worn (Turakhia et al., 2019).

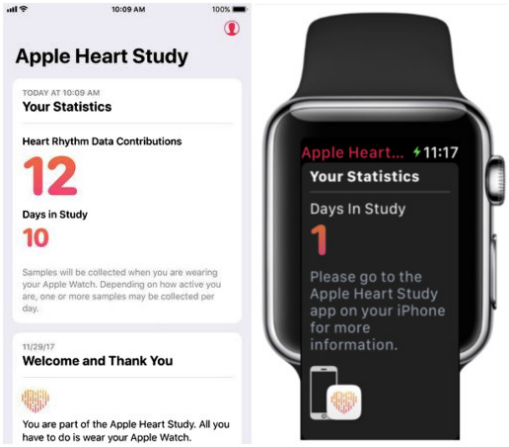

Figure 3. The Photograph of the Apple Application (left) and Smart Watch (right) (Turakhia et al., 2019)

One of the most used accessories in daily life is rings. These smart rings provide some of the key features that smart watches offer. These are basic features such as heart rate tracking, pedometer, remote connection with mobile phones, sleep tracking. As it is known, among the people, the ring is seen as a symbol of love rather than a jewelry. Based on this perception, the manufacturers added the feature of sending the heart rhythms of the couples to each other via radio frequencies. These rings, which are made in collaboration with Oura Health organization and Rezai, photographed in Figure 4, and attracting attention with their stylish designs, are expected to be as popular as smart watches in the future (Poongodi et al., 2021).

Figure 4. The Image of a Smart Ring (Poongodi et al., 2021)

Smart glasses, another wearable technology that is thought to be used frequently in the future, have many features such as recording videos, taking photos, making phone calls, sending messages, and searching on the internet. These glasses support the Global Positioning System (GPS), Wi-Fi and Bluetooth. In addition, some of them also include a face recognition system (Schweizer, 2014). Figure 5 shows the smart glasses produced by Google (Erbas & Demirer, 2014).

Figure 5. Google Glass (Erbas & Demirer, 2014)

Besides smart glasses, there are also glasses such as virtual reality and augmented reality. These glasses, seen in Figure 6, allow people to feel like they are in a virtual environment with their features such as high resolution, eye tracking sensors and game controllers (Ferhat, 2016). Thanks to these glasses, the doors of the virtual world are opened to the users. It is now mostly used in the game and entertainment industry.

Figure 6. Virtual Reality Glasses (Ferhat, 2016)

Bluetooth headphones, which are also wearable technology products, have a growth rate that will remove wired headphones from production and have reached a very wide audience in a very short time. These headphones, which eliminate the cable problem, provide the opportunity to access data remotely with the help of bluetooth feature. For example, it provides you with the ability to answer calls by connecting with your phone. It can also be connected to other devices such as computers and tablets. Bluetooth headphones released by Samsung in Figure 7 can be given as an example to these

headphones. These headphones are one step ahead in the industry by providing freedom of movement to the user and being more aesthetic (Yoo & Ju, 2018).

Figure 7. Released Headphones by Samsung (Yoo & Ju, 2018)

Smart clothes can be given as an example as another wearable technology product that is not used very often yet. Smart clothes, by connecting to mobile phone via bluetooth; with the help of motion sensors, accelerometers and gyroscopes, it provides ease of life for the user by following the movement during the day. Some clothes follow human health with features such as giving a postural warning, monitoring heart rhythm and helping to maintain body temperature. Other smart clothing, on the other hand, appeals to the daily life and entertainment industry and offers features that give a warning when away from the phone, prevent the phone from being lost, and allow instant status updates on social media.

Use in Sports

Smart shoes used today are generally described as computerized sports shoes. These shoes can collect statistics by tracking the sports activities of the wearer. In addition, there are smart shoe models that can automatically adjust the tightness of the shoe according to the foot of the wearer for those who are uncomfortable with the loosening of the shoelaces while doing sports.

Since smart watches can easily replace smart wristbands, smart wristbands are more commonly used during sports activities. These wristbands have features such as heart rate measurement, step counting, calorie calculation, sleep tracking, vibration alarm, reminder, phone notifications and distance measurement.

Golf gloves with motion sensors, produced for golf enthusiasts, offer the opportunity to follow the statistics of the angle and intensity of the athlete's stroke, how many points she/he has collected, from a smartphone.

A company that produces warm trousers for athletes aimed to use less energy to warm up the athletes by providing the ideal heat for the leg muscles in cold weather. Another

company measures distance, pelvic rotation, jump, step and rhythm with the sports shorts it produces and transmits the data it collects to the smartphone via bluetooth.

Use in Healthcare

The new generation wearable devices used in the healthcare field allow the monitoring of the patient's condition and the remote notification to the doctor, thanks to the sensors and communication devices integrated into the suit. This technology provides great convenience for elderly or disabled citizens who have difficult access to the hospital, as well as for patients living in rural areas where there is no hospital.

Hearing aids are the most basic wearable technology product used in the field of health since ancient times. These devices amplify the sounds coming from the outside and send them to the ear of the hard-of-hearing patients in the form of vibration. In this way, the hearing problem of these patients is eliminated.

Sleep tracking devices used for patients with sleep problems are another product discussed in this field. This product analyzes a person's sleep quality, breathing patterns and sleep hours. In this way, the person can easily decide whether or not to go to the doctor.

Wearable electrocardiogram (ECG) monitors measure heart electro diagrams with the same precision as large hospital ECG devices. In this way, it can predict the risk of heart attack according to the heart rhythm and instantly transmit the data it receives from the patient to the doctor when necessary.

Military Use

Wearable technology appears in the military field, which is especially important in terms of security. As seen in Figure 8, there are many wearable technologies on the vests and helmets of the soldiers (Karamak, 2018).

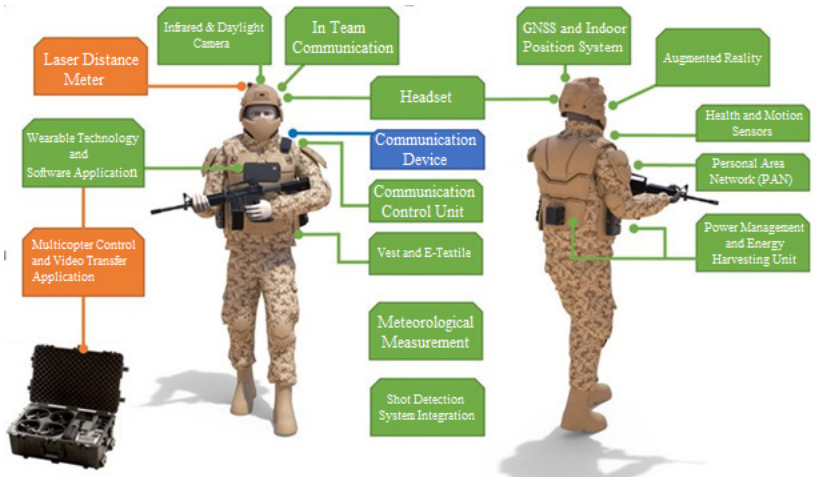

Figure 8. A Sample of Used Wearable Technology in the Military Applications (Karamak, 2018)

There is a military computer on each soldier as seen in Figure 8. Thanks to this computer, commanders and other soldiers can see each other's positions and health status. There are health and motion sensors on each team member. There are two cameras on the helmets which are infrared and daylight cameras. These cameras have the features of recording for educational purposes and monitoring the operation directly. If desired, the images obtained from the cameras can be transmitted to the higher command centers. There are also Global Navigation Satellite System (GNSS) and indoor positioning systems on the back of the helmets. Other technologies on the soldiers are laser distance meter, communication device, shot detection system integration, power management and energy harvesting units. By means of all these technologies, the soldiers can be in continuous contact with each other and with the command centers during the operation and increase their power in the battlefield.

Use for Animals

Smart collars designed for pets track the location and activity of animals and report the information they collect to our smartphones, thanks to their GPS features. This device, seen in Figure 9, is a beautiful wearable technology product against the risk of losing pet (Sagbas et al., 2016).

Figure 9. Smart Collar for Pets (Sağbaş et al., 2016)

In addition to pets, wearable technology devices are also used for cattle. An example of this is smart necklaces produced for cows. These necklaces can monitor cows' temperature, pulse, oxygen needs, birth and hunger times.

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