

Use of IoT and Wearable Technology Design Fundamentals in Healthcare Industry

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Introduction

Today, IoT and Wearable Technology are among the fastest growing technologies. It can be shown as an innovative feature that allows remote access, processing and control, which can be connected to the Internet. Wearables technologies are used in smart homes, between machines (M2M), transportation between vehicles (V2V), healthcare, electrical networks and many other industrial applications.

The world's population is growing older and older due to low birth rates in many parts of the world and the desire to live longer with advancing technology. It is estimated that from 2025 to 2050, the population over the age of 65 in the world will reach 1.6 billion. With this increase in the elderly population around the world, it is inevitable that problems related to providing various health services (stroke, dementia, heart attack, etc.) will arise. In addition, it has been expanded to cover various health problems (actuators, GPS devices, mobile devices and various sensors, etc.) from all age groups in order to address more objects.

The IoT also has the potential to analyze captured data by accurately tracking people, equipment, assay samples, supplies, and test animals. For example, sensors can detect deficiencies in the patient's exercise activities by comparing excessive cardiological or walking activities with normal walking pace. The data obtained in these two examples can be collected and processed in a center with the help of wired or wireless communication technologies, providing very valuable information to healthcare providers.

In addition, these data can be reviewed by insurance companies, healthcare providers and pharmaceutical companies and used for future studies. In addition, the fitness movements of the person can be detected by sensors and collected with the help of wired or wireless network technologies and analyzed in a center. Thanks to the analyzed data, it can be ensured that the person performs more accurate and regular exercise

movements in order to keep his body fitter in intense work tempo. Diet status can be controlled simultaneously with a wearable or wearable device (glasses, wearable devices placed on the teeth or devices that detect mouth movements, etc.) to be placed on the body while performing the fitness movements of the individual.

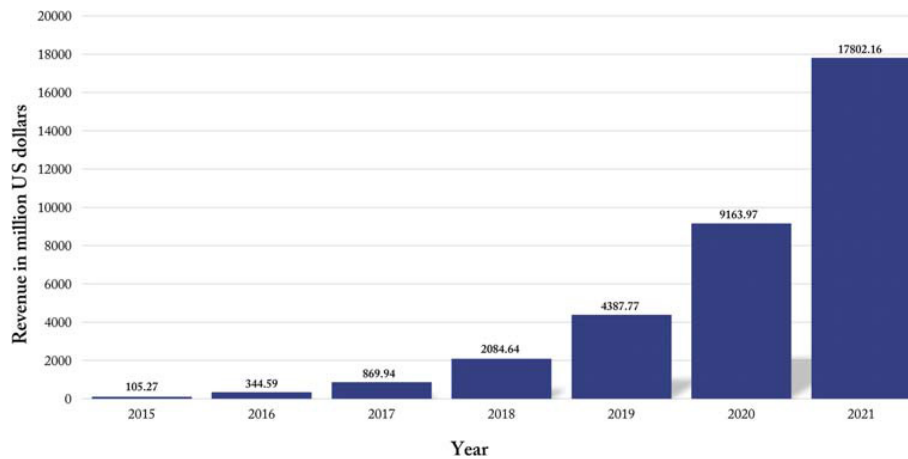


Figure 1. Projected global market size for wearables in healthcare from 2015 to 2021. (Junata,2018)

Wearable technology itself is proliferating in development in both the commercial and research worlds. Figure 1 shows the gradual increase of the projected global market for wearable devices in healthcare from 2015 to 2021. In particular, wearable technology will be a large part of healthcare and has a large market share within the pharmaceutical industry in the future.

With an increasing number of global aging populations, wearable technologies paired with home health and rehabilitation services will be extremely beneficial. We can think of mechanical watches as the ancestor of wearable technologies. Likewise, glasses are examples of wearable technologies. We use crutches for clothes to keep us warm in winter and cold days or to move around when a leg is broken. Humans have a long history of developing technology to extend the functionality of the human body. In recent years, with the development of technology for the defense industry, health services and professional sports, many wearable devices have been developed. Today, our smart watches, smart glasses and different kinds of smart clothes are produced. If we take a brief look at the history of wearable technology in Figure 2;

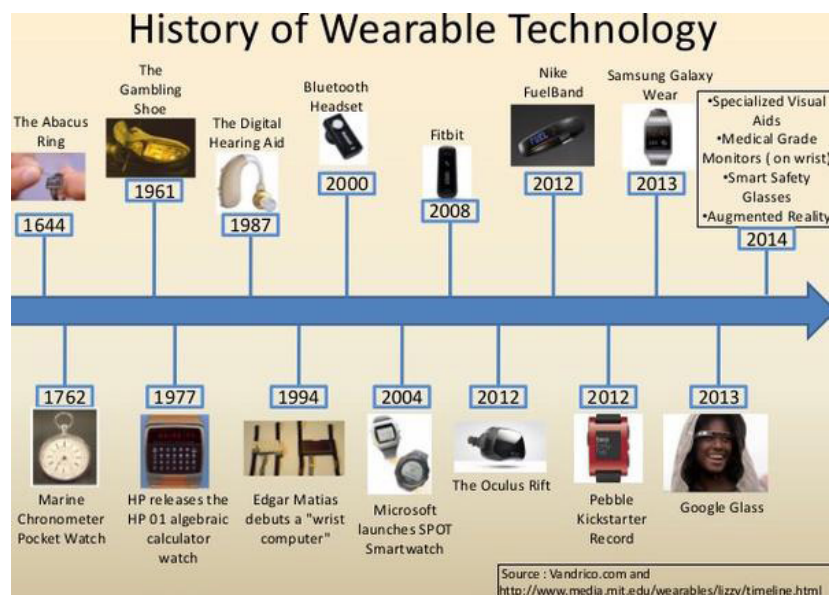


Figure 2. A Brief Look into the History of Wearable Technology (URL 1,2016)

The first wearable computer was invented in the 1960s by mathematics professor Edward Created by Thorp.

The first algebraic calculator wristwatch went public in 1977. The Sony Walkman was released four years later. In the 1987s, digital hearing aids, which are the ancestors of today, were introduced.

Steve Mann, a Canadian researcher, invented the wearable wireless webcam in the 1990s. In 1994, the wrist computer was developed. Such devices have made it easier to use future IoT technologies. Fairs and academic studies on wearable technology gained popularity in the 90s. Wearable technology gained popularity in 2000 with Bluetooth headphones.

In 2011, wearable technology gained a lot of attention when Google developed the first prototype of smart glasses, today called Google Glass.

In the 2020s, the use of AR and VR glasses, especially in game software on computers and smartphones, has increased a great interest in wearable technologies.

It offers various health-related areas such as patient disease symptom monitoring for guidance and rehabilitation monitoring in patients' daily activities and operating rooms. Smart healthcare has spurred the development of smart wearable mobile devices. Some of the smart wearable mobile devices are smart phones, smart watches, etc. to monitor the heart rate, sleep status, blood pressure and other activities. This opens new facets in the medical field by sensing data with wearable devices to analyze patients' health, behavior and recommendations to further improve health. It also helps patients to be controlled by doctors remotely and in real time. Wearable smart devices should be convenient, cost-effective, safer and easily usable by the user. In the future, cloud computing can be further enhanced with big data and deep neural networks.

Wearable technologies provide continuous monitoring of physiological and biochemical

What Is The Internet of Things (IoT) and How Does It Work?

Figure 3 shows a picture of all devices connected to the internet through databases, data aggregators or relays, display services or other devices.

IOT devices send the sensor data they collect to the cloud for analysis and share it with the desired devices when necessary. Sometimes these devices communicate with other related devices and can make decisions based on this information. The best example of an advanced IoT device is the human body. It stores data from our sense organs and can mimic most sensory abilities when needed. With IoT we can use it to draw conclusions about analog or digital values from sensors.



For example; With the smart watch on your wrist, we can monitor all the activities of the day, the distance you have covered, the steps you take and how your heart beats. This

data collected here is analyzed and we can reach important information about our health.

Basic structure of IoT solutions

An IoT solution consists of many layers, from a physical device to the end user, by combining many different technologies into a single product. These layers;

- Device hardware: Every IoT project usually includes hardware including Microcontroller Unit (MCU) and sensors/actuators. It is also very important to choose the most suitable communication medium for the IoT device.
- Device firmware: According to the content of the project, it is necessary to write the device firmware to run on the MCU. This is where we collect data and transfer it to other components as needed.
- Communication: There should be a common language for obtaining and sharing data from the physical environment. The protocols that provide the connection between these devices enable the communication of data both to the physical environment and to the application layer.
- Backend system: In this part, all data is collected in the back-end system and the management, monitoring and integration of the product is provided. Depending on the project requirements, data can be sent to cloud providers. In addition, big data analytics can be applied on the data from the Sensors or artificial intelligence algorithms can be used when necessary.
- End-user applications: In this part, a modern interface can be designed to control and monitor the necessary information.

The Figure 4 diagram below shows the general structure of IoT solutions:

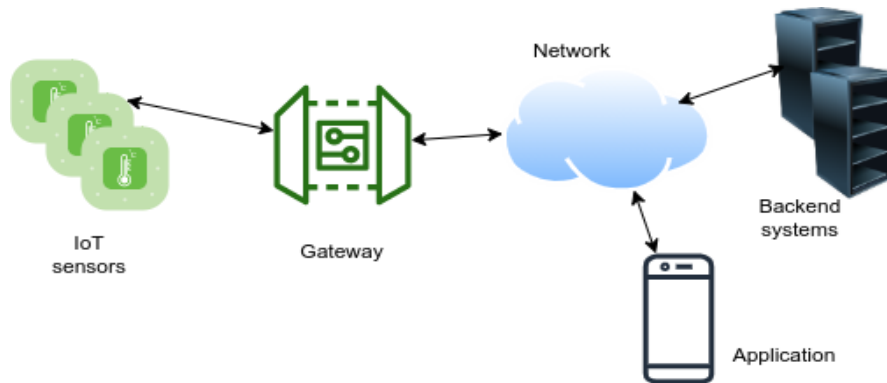


Figure 4. General structure of IoT solutions (URL 3,2021)

The Wearable is based on 3 layers: First Layer, this layer is sensors. The sensors are placed closest to the body. Sensors monitor items such as temperature, movement, and heart rate. Layer Two, this layer is the link and control layer. The Bluetooth Low Energy (BLE) protocol is the most widely used protocol for connecting wearable devices to a smartphone or home network. Layer Three, this layer is the cloud from which the wearable provides and reads data.

Different Types of Wearable Technology

Different types of wearable technology, commonly known as wearable technologies, refer to smart electronic devices that can be incorporated into clothing or attached to the body as implants or accessories. Smart watches, fitness trackers, shiny jewellery, smart clothing, body wearables, and head-worn displays are examples of standard wearables in Figure 5.

Wearables have gained great momentum with customers over the past decade. Smartwatches are probably the best-known wearables. In addition, products such as glasses, head-mounted displays (HMDs), Socks and gloves are examples of modern wearable technology on the market.



Figure 5. Different types of wearable technologies (URL 4,2022)

Since these devices are in contact with the user's body, they offer services such as calorie tracking and sleep monitoring thanks to embedded systems.

Some of the different types of wearable technology include;

1. Smart Watches

Smart Watches can easily access the desired information both on their own screen and by connecting to the smart phone. It allows to take EKG heart rhythm, SpO2 or body temperature through sensors on the watch.

2. Audible

Hearing aids allow you to hear what is happening around you. It also has audio input and output. The earbuds are specially designed to hear ambient noise. These devices have microphones on them.

3. Fitness Tracker

With fitness trackers, heart rate, SpO2, steps taken, calories burned and other fitness indicators are all tracked. Fitness-oriented products can also send notifications and alert messages to smartphones when necessary.

4. Smart Shoes

Smart Shoes have also gained importance in recent years. With these devices, the number of steps and speed and step length, distance, walking time and other data are

collected with smart shoes.

5. Smart Clothing

Smart suits can provide deeper insights than other examples of modern wearable technology, as they come into contact with a more important part of the body, enabling advanced monitoring for medical care and lifestyle improvement.



Figure 6. Smart sock (URL 5,2022)

Each smart sock is infused with three thin, soft textile pressure sensors. Attached to each smart sock, a magnetic Bluetooth smart electronic anklet collects data and transmits it wirelessly to Sensoria's mobile app and web dashboard to provide runners with real-time visual and audio feedback, as well as post-workout analysis.

It includes sensor calibration and motion capture algorithms with smart pants and combines it with e-skin smart clothes that can be used in daily life. This allows for a variety of applications in rehabilitation, sports, occupational safety and wherever detailed and robust motion capture is required.

6. Smart Glasses

Smart glasses record what the user sees and send the data to a cloud system when necessary. These glasses can do anything like our smartphones and tablets. They have internal and external sensors that can collect data from computers, smartphones and other electronic devices.

7. Wearable Cameras

Wearable cameras capture images from a first-person perspective. They are often attached to clothing such as shirts, hats or helmets. In addition, wearable cameras capture events such as daily life, parties, performances, sports and other events.

8. Implantable body sensors

They are implantable, communicating from the inside with the wearer's body rather than the skin. Some of such wearables are available both in fitness monitoring units and medically, such as blood glucose, blood pressure, electrocardiography, pulse rate, respiratory rate, body temperature, etc. It is intended to measure body information such as (Figure 7).

Pill-like sensors have been produced that can monitor blood pressure. After swallowing such drugs, the user can easily monitor the data collected from the body.

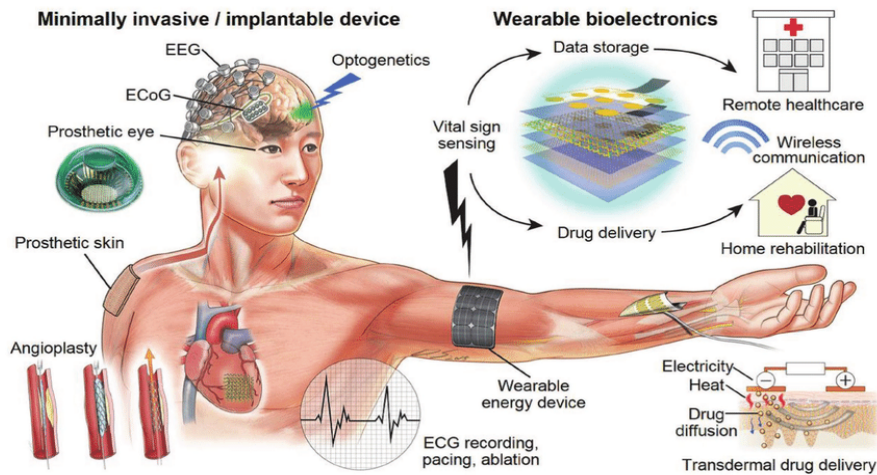


Figure 7. Body sensors (URL 6,2022)

Body sensors can be implanted on or inside the skin's surface. They move with the skin, collecting data and transmitting it to computers or mobile phones connected to them. Electrocardiogram (ECG) and electroencephalogram (EEG) readings can be made with body sensors, and also when the patient takes the sensor pill can be checked. In addition, body sensors monitor physical activity and sleep patterns.

9. Life Belt

The Life Belt is a transkarin wearable device that monitors the physical health of pregnant women. Obstetricians and doctors do not want the patient to visit them often. Thus, they monitor their health remotely using a life belt. It sends alerts to patients and authorities if any complications occur. So they can take quick action to save both the mother and the fetus.

10. Head Mounted Displays

Head-mounted display (HMD) is a device that provides virtual reality and augmented reality for the user. It is worn on the head or as part of a helmet.[1] In front of it is a small screen optics (monocular or binocular HMD). There is also an optical head mounted display (OHMD) type. This can mirror the projected images and allow the user to see it. A typical HMD has one or two small screens, lenses and translucent mirrors built into the glasses. It is used as augmented reality (AR) virtual reality (VR) glasses with HMDs.

11. Smart Jewelry

Another product used in monitoring health data is smart jewelry. These smart jewels can be in the form of necklaces, bracelets, watches and rings. They can track your heart rate, sleep, stress and advise you on how to stay healthy.

12. Location Tracker

With Location Tracker, it usually receives GPS data and sends the location of the product to the connected device. GPS trackers for kids are extremely useful. Especially parents can use such devices to find out what is going on around their children and their location.

13. Exoskeletons

It uses a combination of electric motors, pneumatics, levers, hydraulics and tentacles on

exoskeletons, also known as outer suits.

Also, Active and passive exoskeletons are the two main types of exoskeletons. The user's movements are strengthened by actuators on active exoskeletons. They can be used especially in medical, military and civil settings.

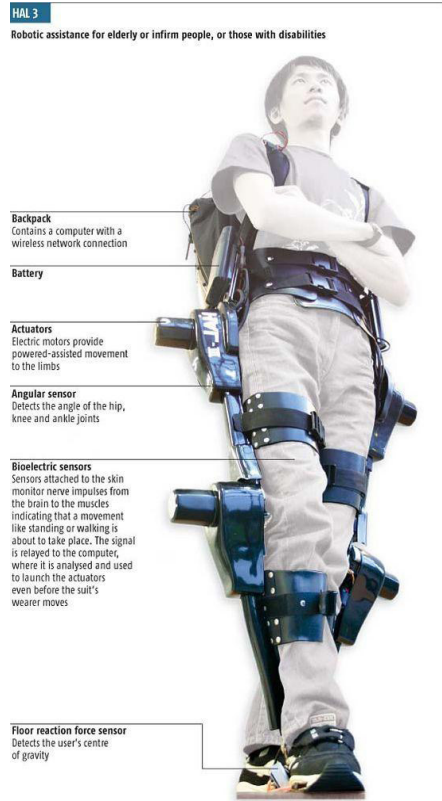


Figure 8. Robot assistance for elderly or infirm people (URL 7,2022)

14. Smart Jacket

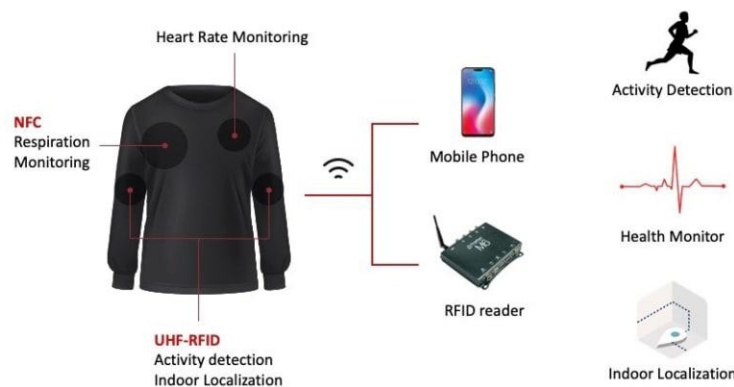


Figure 9. Smart jacket (URL 8,2022)

This Smart jacket can collect information with human health and identify where people are in Figure 9. It can wirelessly transmit the data on the sensors on the jacket to the cloud. At the same time, the jacket can harvest energy to provide a self-contained power source. The life jacket is one of the most widely used wearable devices in the medical field. Thanks to these devices, we can control a person's heart rate or blood pressure.

When necessary, this information can be transferred to the hospital environment.

Results And Discussion

The environment in which doctors or other healthcare professionals can best monitor the patient for chronically ongoing diseases is the patient's natural life. Therefore, various portable monitoring devices are needed to monitor patients in their natural life. These devices can send the data they receive from the patients to the relevant health service providers (hospitals, insurance companies, etc.), enabling them to take various decisions more efficiently for that person and for the future in health services.

Today, wearable health products come up with devices with much more advanced capabilities. For example, it is used to collect vital values such as heart rate with sensors attached to the skin surface and to transfer data to doctors on their devices. With portable Holter-like devices, the patient's electrocardiogram can be recorded and monitored when necessary. This is done via a wireless electrode that must be in contact with the patient. It is usually affixed to the patient's finger or chest. Smart gloves are designed for patients who cannot control their hand movements. The device helps the patient regain hand movement with repetitive arm and hand movements. In the academic community, many articles and projects have been made in the field of wearable technologies in the Health sector.

Modern smartwatches help detect cardiovascular diseases by capturing systolic and diastolic pressure. It also offers advice on oxygen and blood pressure levels, sleep patterns, diet and activity levels.

The Future of Wearable Technology in Healthcare

Many health-related reasons will affect wearable technology. First, technological advances make it easier to design and build non-intrusive technologies that monitor a person's health. Second, technological evolution will solve some pressing technical challenges, such as the short battery life and size of these devices. Implantable devices, which already have an important role in the field of health (pacemakers), will come to the fore with the miniaturization of this technology. Wearable health monitoring devices and any technology with similar monitoring functions will be easy to install, use and manage, effectively improving quality of life and health delivery.

Technology has helped make significant advances in both patients and healthcare. Thanks to its telehealth solutions, patients can now consult digitally and take the necessary medicines on time instead of going to hospitals for consultation.

The increase in the use of smart devices has made people want to follow all kinds of data on these devices. Businesses in the competitive market, on the other hand, have taken technology to different dimensions by not ignoring this desire. One of these dimensions and a technology that has attracted attention with its usage rate in recent days has been smart products. With this technology, people can keep track of their daily activities

and evaluate their statistical results. Human beings can obtain and record many data in different ways, but wearable products help in interpreting this data. These products, which can be used for all animate and inanimate beings apart from being used only for humans, have now become a necessity. The rapid progress of technology makes human life much easier, and it can also reveal some vital problems. Before having a technology, it is necessary to know the most effective use and protection methods.

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Kocer S., Ocal H., & Dundar H. B., (2022). Use of IoT and Wearable Technology Design Fundamentals in Healthcare Industry, In S. Kocer, O. Dundar (Eds.), *Current Studies in Basic Sciences Engineering and Technology* (pp. 168–182). ISRES Publishing.