

Preliminary Design and Research of Wearable Devices for Parkinson 's Disease

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Abstract. A typical neurodegenerative condition is Parkinson's disease. Since no medication therapy will halt the progression of the disease, patients will eventually lose the ability to function and live a normal life. Generally, the diagnosis of Parkinson's disease mainly depends on the patient's Electroencephalogram(EEG) combined with Magnetic resonance imaging (MRI) and Computed Tomography(CT) images. The disadvantage is that the cost of monitoring and maintenance of testing equipment is relatively high. And large, expensive equipment such as MRI and CT cannot be transported over long distances. Now with the development of wearable technology, portable wearable helmets can be used to diagnose and monitor Parkinson's disease. In this paper, by combining the existing research results of microwave scanning and wireless sensor networks, the preliminary design and research on this wearable device that may appear in the future have been carried out. This device can meet the needs of Parkinson 's disease diagnosis in areas where medical equipment is underdeveloped, and can also meet the needs of daily monitoring of Parkinson 's patients.

Keywords: Parkinson's Disease; Wearable Devices; Diagnosis; Monitoring.

1. Introduction

Parkinson's disease is a common neurological condition that affects older people more frequently. An estimated 60 years old is the typical age of onset. It is uncommon for young adults under 40 to get Parkinson's disease. After Alzheimer's disease, Parkinson's disease is the second most prevalent neurological condition. With the aging of the population worldwide, the number of Parkinson 's patients will continue to grow. There are estimates that by 2030, the number of Parkinson 's patients in China alone will surge to 5 million. The large number of Parkinson 's patients is a very big challenge for diagnosis and subsequent monitoring equipment. The diagnosis and monitoring of Parkinson's disease is complex. Parkinson's diagnosis depends not only on some of Parkinson's unique clinical motor symptoms, but also on the patient's medical history and signs. It can also be diagnosed by PET imaging to show the synthesis of dopamine transmitters in patients. However, the inspection cost of this project is relatively expensive. MRI or CT scan images are also very important tools in PD research[1]. However, the use and transportation of these tools require high costs, so it is important to diagnose conveniently for areas with less abundant medical resources. The same is true for the daily monitoring of patients. In addition to Parkinson 's diagnosis, follow-up monitoring of patients is also important. Early Parkinson 's patients can achieve good results through drug therapy. However, due to the late motor complications and the patient 's body stiffness caused by life cannot take care of themselves is the biggest problem.

In this context, it is necessary to develop a device that can accurately diagnose and monitor Parkinson 's disease while achieving low cost and easy to use.

In the Mobile Health (mHealth) industry, wearable technology has been crucial for the diagnosis, treatment, and rehabilitation of many diseases and disorders[2]. A novel approach to Parkinson's disease diagnosis and monitoring is offered through wearable technology. For Parkinson's movement symptoms, there are currently a lot of wearable monitoring devices available. These gadgets can detect PD motor symptoms in real-time and create multiple data models by using particular motion algorithms. As a result, medical professionals may instantly and precisely assess the patient's mobility

state[3]. If a head-mounted device equipped with a microwave and electrode sensor is designed, the expected results can be achieved while monitoring. It can also be equipped with wireless sensor networks for more convenient monitoring and processing.

2. Related Works

The research on related work has covered the past five years, 2017-2022. The results of various studies in the past five years are summarized and compared.

The author in [1] proposed a low-cost microwave brain scanner. The scanner's imaging system consists of an RF transmitter/receiver module and a digital image processor. The scanner's images can show the brain activity of Parkinson's patients and meet the needs of medical personnel for the diagnosis and monitoring of Parkinson's disease.

Article [3] is a review article published in 2020. The current application of wearable sensor devices for Parkinson's disease is mainly focused on monitoring the motor symptoms of Parkinson's patients such as bradykinesia, tremor, gait, myotonia and non-motor symptoms such as rapid eye movement, depression, etc. At the end of the article, the author said that wearable devices have significant advantages, especially in the years of the global COVID-19 outbreak.

The article [4] introduces the development of a radar-based microwave head imaging algorithm, which is used to detect strokes, tumors and other abnormalities formed in the brain. This improved MIST algorithm lays the foundation for us to build a complete Parkinson's portable monitoring system.

In addition to the use of wearable devices combined with microwave brain scanning for Parkinson's disease detection, the next section is about EEG detection using wearable devices.

The reason why collecting daily EEG signals is challenging is mainly because the requirements for the required acquisition system and signal processing system are relatively high. The author of article [5] designed and developed a wearable acquisition system for EEG recording. The electronic device used is a small-size low-power electronic system and is easy to integrate into wearable systems.

The article [6] describes a new way of EEG signal acquisition. This in-ear EEG measurement has great development space in the future. In the article [6], the author created a simulation model of the ear, and selected two most advanced electrode materials to confirm the credibility of using the ear electrode to collect EEG signals.

Special mention is made here to the article [7], whose authors proposed a combination of wireless sensor networks for non-invasive detection of patients with Alzheimer's disease. So, for patients with Parkinson's disease similar to Alzheimer's disease, better monitoring can also be achieved by connecting wearable devices to wireless sensor networks.

By analyzing the above existing work, we can conclude that the combination of microwave scanning technology and EEG signal acquisition technology can design a portable wearable device for the diagnosis of Parkinson's disease. This equipment is good for medical personnel and medical technology is not developed areas.

3. Discussion

3.1 Overall Idea

The wearable device envisaged in this paper needs to combine three different technologies to meet the needs of a full range of more accurate and more convenient monitoring and diagnosis. The most basic design concept of this device is based on the low-cost microwave brain scanner proposed in Reference [1]. The 3D model of this device is shown in Figure 1. (The modeling software used in Figure 1 is Solidworks) In appearance, this helmet is not very different from the helmet used in daily cycling. Because this helmet is equipped with a microwave scanning system and an EEG monitoring system, it needs to be connected to a power supply for use. A power port and a data port are retained at the rear end of the helmet. The role of the data port is to back up the data collected by the patient.

Next, the realization of different functions of the helmet will be introduced. They are EEG monitoring, microwave monitoring and wireless sensor network.

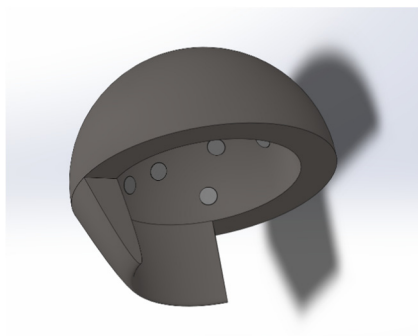


Fig 1. The overall look of the device

3.1.1 Detection of EEG

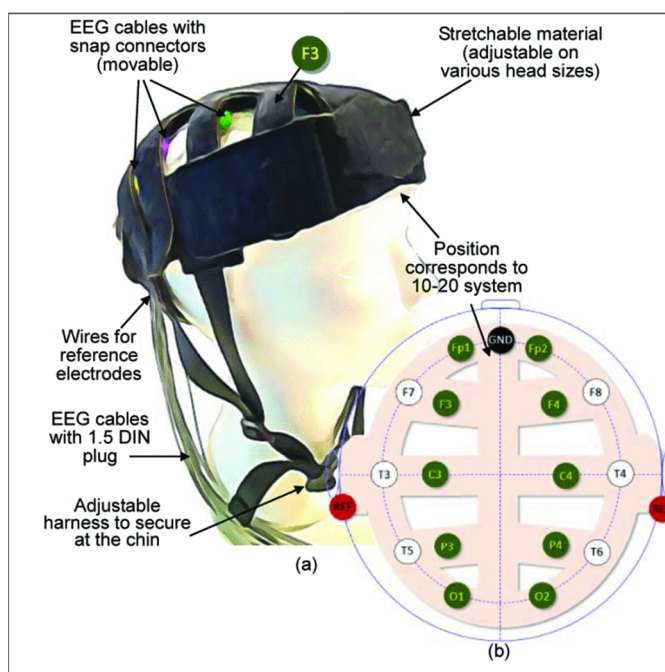


Fig 2. Dry EEG Electrode and Dry EEG Head Cover[8]

Different from the traditional EEG signal acquisition, the equipment envisaged in this paper uses dry electrodes. Since wet electrodes also need to be applied in patients with conductive paste to reduce the impedance of the electrode. Considering the speed of patient monitoring and the convenience of equipment use, this monitoring helmet is designed to use dry electrodes to monitor patient EEG signals. Figure 2 shows a packaging design for a dry EEG head cap taken from a reference[8]. The worldwide 10-20 system is used in this design. The 10-20 system is a widely accepted technique for applying electrodes to the scalp during EEG monitoring[8].

Figure 3 shows the electrode distribution inside the helmet designed by the author. Based on the design of many different EEG head covers and dry electrodes, the 10-20 system is also used in the design of EEG monitoring module. A rigid metal snap connector, a polymer-based sensor structure, and silver-silver chloride(Ag-AgCl)are further components of hybrid packaging[8], Parylene C based flexible electrodes[5] can be selected for electrode selection. Because Parkinson 's patients are mostly adults, standardized designs are used in size.

At the same time, considering the development of ear-entry EEG in the future, the ear part (as shown in Fig.1) is specially reserved when designing the helmet and the ear-entry electrode

acquisition module is designed. It can provide doctors with EEG signals collected by two different acquisition methods so that doctors and systems can summarize more accurate judgments for patients.

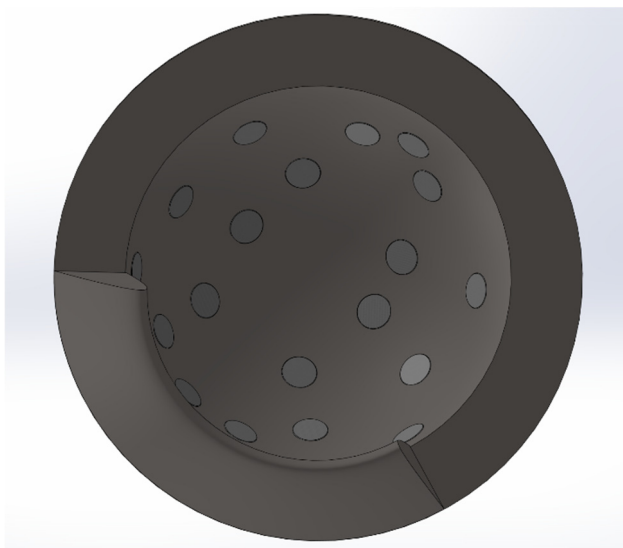


Fig 3. The electrodes in the devices

3.1.2 Microwave Detection

In order to obtain a more complete brain scan image, this wearable device must cover the patient's brain part completely. As shown in Figure 1, most of the patient's head is covered by the helmet. Compared to previous technologies, this one offers the advantages of being inexpensive, lightweight, and non-ionizing [4].

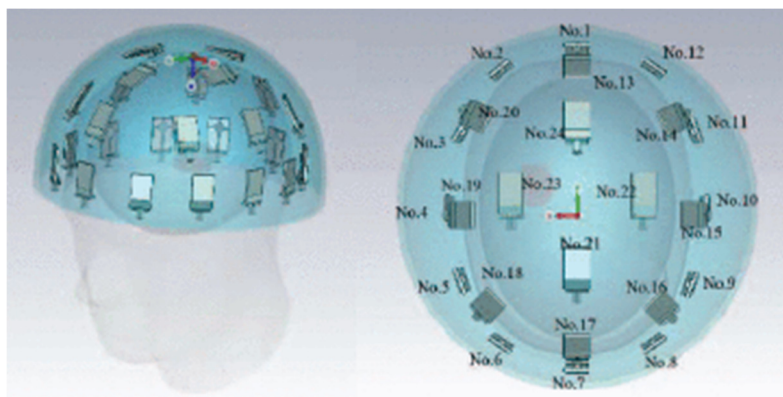


Fig 4. Geometry of the Helmet Scanner[9]

According to previous studies, the effect of microwave scanning has a great relationship with the antenna array. So, when designing this helmet chose a full-coverage antenna array. Figure 4 shows an antenna array of a more maturely designed helmet-mounted scanner. However, for the helmet proposed in this paper, because there are still electrodes for monitoring the EEG module, the position of the antenna array needs to be modified to avoid the influence of the electrodes on the microwave scanning results.

3.1.3 Wireless Sensor Networks

An overview of the patient monitoring system built using wireless sensors is shown in Figure 5. Whether the helmet is used in a hospital or in the patient's own home, the data collected by the device is transmitted to the database through different gateway servers. Doctors can diagnose and monitor patients through data in the database. The patient's family can also monitor the patient's condition via mobile devices. Doctors can also adjust the threshold of different devices depending on the patient's, when the collected data signal exceeds the threshold of the device, it means that the patient has a

special case. High availability and low cost binary sensors [10] can also be used to determine the patient 's location in real time, preventing the patient from leaving a safe place without escort. This provides convenient monitoring equipment for doctors and families.

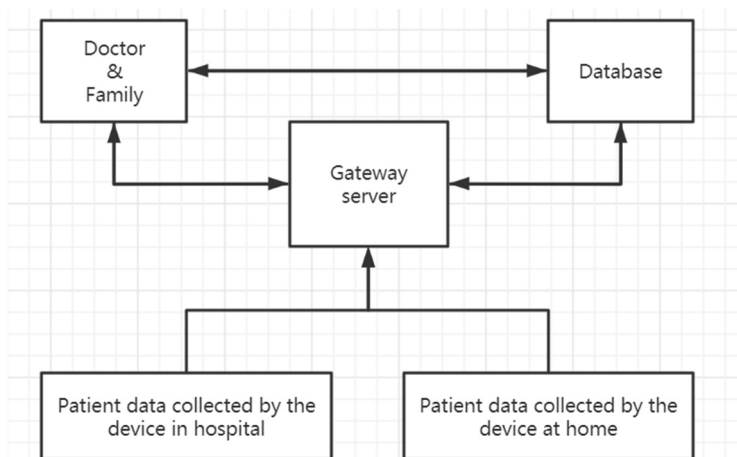


Fig 5. The System of Wireless Sensor Networks

3.2 Research Direction

At the current stage, rapid diagnosis and monitoring of Parkinson 's patients are problems that need to be solved. The purpose of designing and researching this helmet is to solve this problem. Based on the comparative analysis of several technologies mentioned above, the technology suitable for application in helmet design can be chosen. According to the existing research literature, low-cost helmets for Parkinson 's diagnosis have been proposed [1]. The helmet proposed in this paper is optimized on this basis. A module for monitoring patient EEG and a wireless sensor network module is combined. The task of subsequent research is still relatively heavy. In addition to the need to modify the antenna array to achieve the two main monitoring modules do not interfere with each other, but also to the helmet performance testing and comparison to ensure the accuracy of diagnosis and monitoring. At the same time, for EEG module and microwave scanning module need to apply better algorithms to improve accuracy. These are the future research directions.

In terms of feasibility, according to the current mentioned and read the literature, both in terms of EEG or microwave scanners have been relatively perfect design and research. There are also studies on these portable devices for monitoring. So, the feasibility of this helmet is relatively high.

4. Conclusion

In this paper, by combining the relevant research before 2022, a wearable device with strong feasibility is proposed for how to diagnose and monitor Parkinson 's disease conveniently and accurately, and the basic design of this device is carried out. In recent years, with the continuous advancement of technology, wearable devices equipped with high-performance sensors have continued to develop. Parkinson 's diagnosis and monitoring can also rely on wearable devices. The majority of recent research has concentrated on patients with primary PD, typical Parkinson's syndrome, and the primary motor symptoms of PD through reading and examining related literature. The difference is that the device proposed in this paper targets at the non-motor symptoms of PD, and realizes the diagnosis and daily monitoring of PD through the combination of three technologies. This device can be used in areas with insufficient medical resources, and can also be provided to patients for use at home after guidance. Combined with wireless sensor networks, the patient 's data monitored at home can also be transmitted back to the doctor in real time for diagnosis, and can also be sent to the patient's family's mobile phone to solve the situation that the patient 's family cannot know when an emergency occurs. The equipment envisaged in this article will give patients great convenience.

However, there are still many shortcomings in this paper. Due to the lack of manufacturing equipment, there is no way to manufacture this helmet and carry out subsequent experiments. There are many problems and challenges in the manufacture of helmets. Such as which material of helmet will be the most suitable and how to adjust the size for different patients. How to maintain patient data will also be a major challenge. In response to this series of problems and challenges, future research will focus on the production of such wearable devices and the realization of various functions. And will look for hospitals to cooperate to adjust the equipment.

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