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Designing a Care System based on the Internet of Things for Patients with Multiple Sclerosis

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Abstract: ***Multiple sclerosis (MS) is a neurodegenerative disease that is a major health problem. This issue requires the development of new tools to control patients' activity and reduce care costs. The monitoring system based on the Internet of things is a suitable solution for this concern. In this study, the researchers developed a tool that uses an Arduino board and four accelerometer sensors, heart rate and pulse oximetry sensors, temperature sensors, and Bluetooth modules to monitor the factors related to the health of multiple sclerosis patients. In this method, the information obtained from the sensors connected to the patient's body is placed on the memory board and displayed with the help of an LCD. In the next step, the Bluetooth module transmits the information obtained from these sensors to a mobile application. This application has the ability to share and store information. This information, together with the date display on the LCD, in addition to notifying the person of the resulting changes; it is also sent periodically to the doctor. In general, this tool, together with a mobile device, helps to increase the self-care of patients, increases the interaction between the patient and the doctor, reduces the frequeI. nt visits of patients to care centers, and helps to improve the quality of life of patients..***

Keywords: Internet of Things. Multiple sclerosis, wearable technology, Arduino board, healthcare

I. INTRODUCTION

Multiple sclerosis is a chronic, progressive and common demyelination disease of the central nervous system in young adults. According to the available evidence, currently more than 2.3 million people worldwide are suffering from this disease (1, 2). In the United States, approximately 500,000 people are suffering from multiple sclerosis, and every year about 8,000 new cases are diagnosed. This disease mostly affects people aged 20-40 and is the third leading cause of disability in the United States (3, 4).

In Iran, according to the information of the Multiple Sclerosis Association, there are nearly 50,000 patients with multiple sclerosis and the number is increasing (5). The increasing trend of MS patients increases the need to pay attention to patients' treatment issues and problems (1). The Internet of Things (IoT) is one of the latest applications of information technology in healthcare. The Internet of Things can be defined as a network of smart measuring devices and physical objects that are digitally connected to collect, monitor and control healthcare data (6, 7). The Internet of Things in the health care sector can reduce the unnecessary hospitalization of patients in the hospital while reducing treatment costs and increase the well-being of patients (8, 9). In this project, a portable system was designed with the help of IOT tools, which can continuously measure movement, heart rate, pulse oximetry and body temperature by connecting to the patient's body. This tool displays information on an LCD board without any interruption of time by connecting to the patient's body, and if the information is transferred to a mobile phone, this information can be used in various ways. In this connection, authorized people can connect to the board with a personalized password, which prevents data security from being compromised.

II. PRESENTING THE SYSTEM

Three-axis accelerometer, heart rate, pulse oximetry and temperature sensors are used in this tool. By using the pedometer sensor and the movement of continuous physical activity, the patient increases his efficiency and physical fitness. This action will increase flexibility, improve balance and rehabilitate patients. Adequate sleep is necessary for the proper functioning of the MS disease body. Chronic stress reduces the quality of life of MS patients and aggravates the symptoms of the disease. Stress and sleep patterns are monitored through heart rate sensor and pulse oximetry of body temperature.

The information obtained from these sensors is displayed on the LCD board and transmitted to the mobile via Bluetooth. Bluetooth module is a safe and low-cost technology. Bluetooth is password protected to ensure that the system is secure and not exploited by any intruders. The Bluetooth range is 10 to 100 meters, the bandwidth is 2.4 GHz, and the speed is 3 Mbps. An interactive Python program has been used in the mobile phone to communicate with the board, which has the ability to store information up to infinity and share and transfer information in different networks and programs.

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In this article, an electronic health monitoring system for MS patients, which is very cheap and available, is proposed. This system increases the level of medical services that patients receive with the ability to provide remote services. It helps to improve self-care and increase independence and self-confidence of patients.

Although there is no definitive cure for MS, the use of certain drugs can reduce the severity of these symptoms. On the other hand, cognitive disorders affect more than three-quarters of people with MS, which means thinking clearly and quickly. It is harder for them to remember things. Using the present application and the existing smart TV application to display reminders and notifications can be effective in increasing the self-care of patients.

III. PARTS SPECIFICATIONS

A. ADXL335 Accelerometer Sensor

The ADXL335 provides full 3-axis accelerometer measurement. This module measures acceleration in the range of ± 3 g in the x, y and z axis. The output signals of this module are analog voltages that are proportional to the acceleration. This sensor consists of a micro-machined surface polysilicon sensor and signal conditioning circuit. It is small in size (1 inch x 1 inch) and can be used for tilt measurement applications as well as dynamic acceleration due to movement, shock or vibration.



Fig1. ADXL335 accelerometer sensor

B. LM35 Temperature Sensor

LM35 is a temperature measuring device and has an analog output voltage proportional to temperature. This sensor provides the output voltage in Celsius (Celsius). It does not require any external calibration circuit. Its sensitivity is LM35 10mV/°C. As the temperature increases, its output voltage increases. It is a 3-terminal sensor used to measure temperatures from -55°C to 150°C.

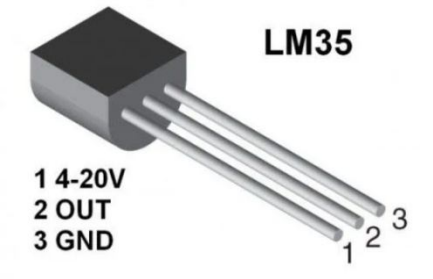


Fig2 LM35 temperature sensor

C. MAX30100 Oximeter

The MAX30100 is an integrated pulse oximetry instrument and heart rate monitor sensor. This instrument contains two LEDs, an optical detector, optimized optics and signal processing. It is a heart rate monitoring sensor along with a pulse oximeter. This sensor includes two light-emitting diodes, an optical detector and a series of low-noise signal processing devices for heart rate detection and pulse oximetry. Low noise log combines pulse oximetry and heart rate signals for diagnosis. This sensor device is placed on a thin part of the patient's body, usually the fingertips and the earlobe, which have a higher blood flow rate than other tissues and facilitate heat transfer.

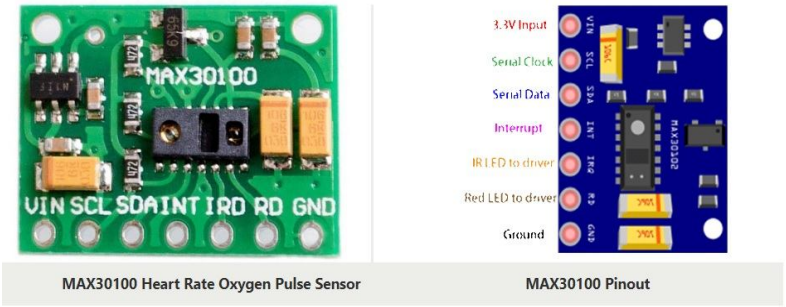


Fig3. MAX30100 Oximeter

D. Bluetooth module HC-05

The HC-06 Bluetooth module is an easy and inexpensive tool designed for wireless serial communication. It is a slave module, which means that it can receive serial data when serial data is sent from a master Bluetooth device (such as a smartphone or PC). When the module receives wireless data, information is sent. No special source code for Bluetooth module is needed in Arduino chip. An app on the phone is used to send input to the module, which receives and then transmits it to the Arduino. The Arduino and the actuators in turn respond according to the specified source code. When the module is not in pairing mode, the LED on the module will flash quickly, and when it is paired with the mobile app, the LED on the module will remain steady red.

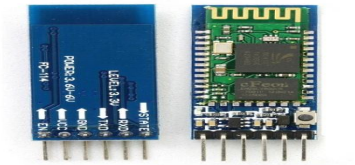


Fig4. Bluetooth module HC-05

E. Arduino UNO

Arduino Uno is a microcontroller board based on ATmega328 (datasheet). It has 14 digital I/O pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connector, a power jack, an ICSP header, and a reset button. . It can be powered by a USB cable connected to a computer or by an AC-to-DC adapter or battery. The Uno differs from all previous boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it has an Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.



Fig5. Arduino UNO

F. Description of Serial Bluetooth

Terminal application 'Serial Bluetooth Terminal' is a line-oriented terminal / console application for microcontrollers, arduinos and other devices with a serial / UART interface that connects to your Android device via Bluetooth to serial conversion. This application supports different versions and different Bluetooth devices, this application also has the ability to share, transfer and store data. Also, the ability to display the date and time next to each data provides the ability to have a detailed medical history.

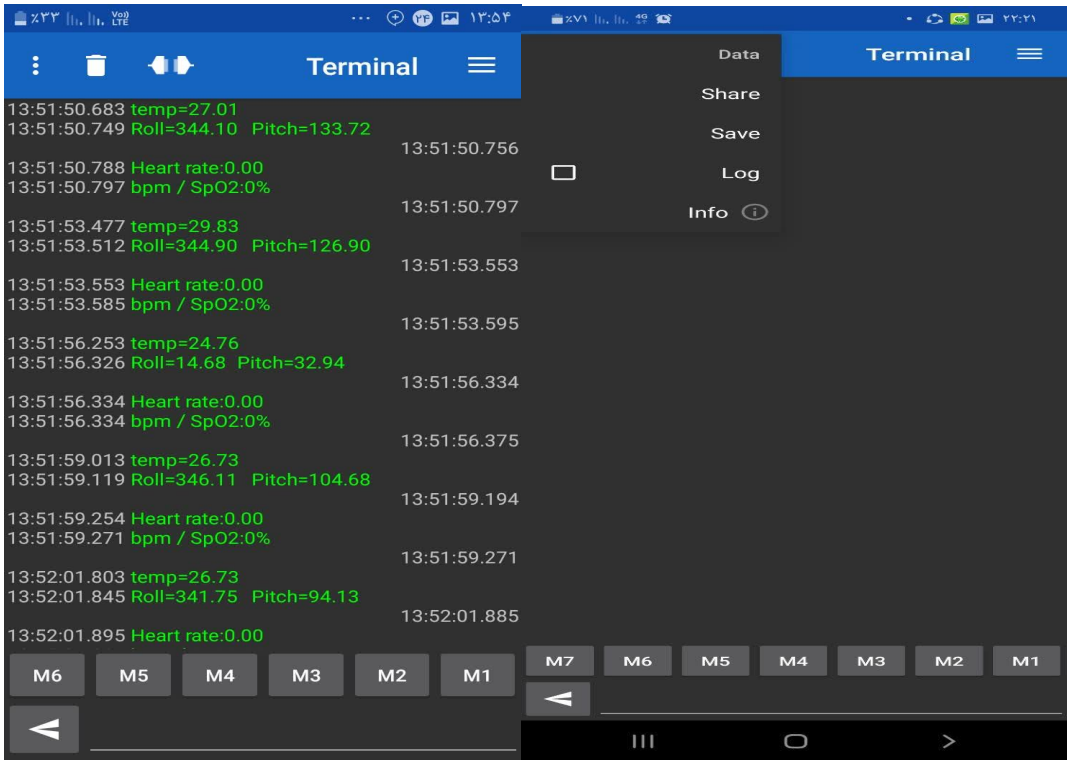


Fig6. Display of heartbeat and blood oxygen and temperature and mobility reading on the Serial Bluetooth Terminal

G. Block Diagram

Accelerometer and temperature sensor, oximetry and bluetooth HC05, power supply are connected to Arduino UNO. The accelerometer sensor measures the patient's mobility and the temperature sensor measures the body temperature. When the oximetry sensor is in contact with the patient's hand, it measures the pulse rate and the oximeter measures the blood oxygen level. The Arduino will process the code and display the patient data on the LCD screen. The HC05 Bluetooth module provides connectivity through which the data appears on the mobile app. Therefore, the patient can access the data using this application and provide it to his doctor or health care providers periodically or online. Therefore, the patient's health data is recorded and remotely controlled and processed, and the necessary measures are taken accordingly.

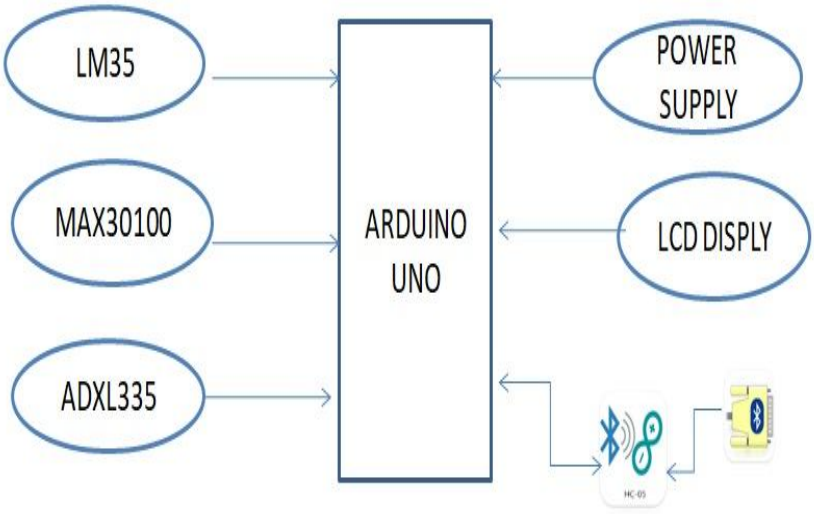


Fig 7. Block diagram

H. Hardware Design

A remote health monitoring system using IOT is proposed where a person can receive, store and send data. The motion sensor can show the patient's mobility. The LM35 temperature sensor is a precision integrated circuit temperature device with linear output voltage proportional to Celsius temperature and has advantages over linear temperature sensors calibrated in Kelvin. MAX30100 is also a multipurpose sensor that displays heart rate along with pulse oximeter. Bluetooth HC05 is commonly used to connect small devices such as mobile phones using a short-range wireless connection for file exchange. Arduino UNO board is based on ATMega328P (receive datasheet). This board has 14 digital input and output (I/O) pins. The speed of data transfer in this board can vary up to 1 megabit per second and is within 10 meters. This board uses the 2.45 GHz frequency band. The Arduino processes the code and displays the patient data on the LCD screen. The HC05 Bluetooth module provides the connection through which the communication with the mobile application is established and the data appears on the mobile screen. By storing, sharing and transferring information, any disturbances in vital parameters and changes in life patterns are diagnosed by remote doctors.

IV. METHOD

The motion sensor and the temperature sensor display the body temperature; the oximeter sensor measures the heart rate and blood oxygen level when the patient is in contact with the sensors. The Arduino processes the code and displays the patient data on the LCD screen. The HC05 Bluetooth module provides the connection through which data is displayed and monitored on the application. Therefore, the patient and other relatives connect to the board through the application, and the doctors and relatives of the patient can access the data. As a result, this method causes self-care and better control of the patient's health level.

A. Experimental Results Related to Hardware

When the device is connected to the patient's body, the body temperature is measured by the LM35 temperature sensor, the acceleration and mobility by the ADXL335 accelerometer sensor, and the oxygen level and heart rate by the MAX30100. These measured values are also displayed on the LCD screen. When the device is connected with the mobile application by Bluetooth sensor, the measured values are displayed on the mobile phone. An example of these items is shown in the pictures below.

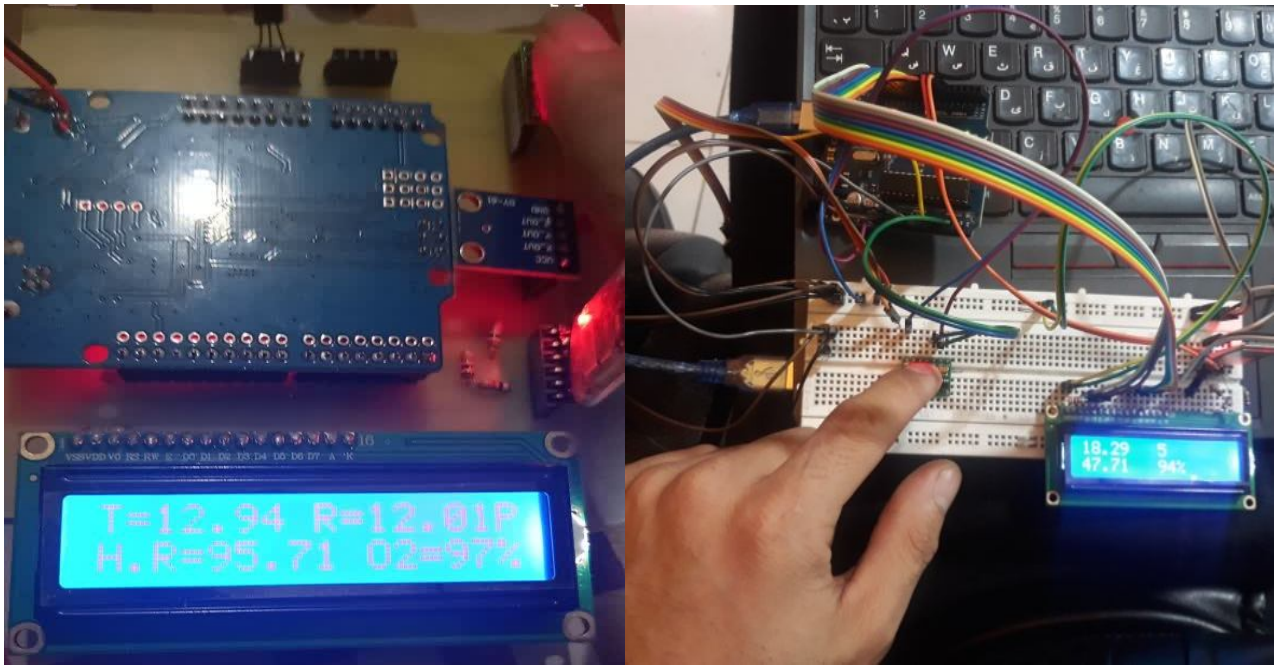


Fig 8. Hardware Display of heartbeat and blood oxygen and temperature and mobility

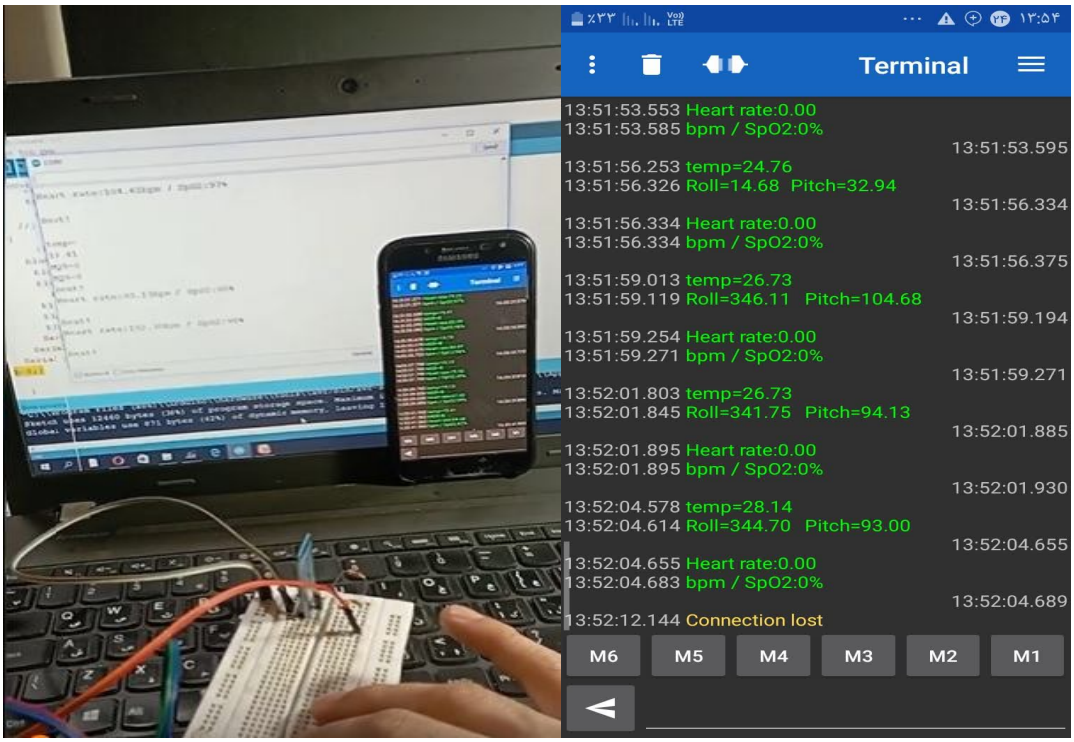


Fig9. Display of heartbeat and blood oxygen and temperature and mobility reading on the Serial Bluetooth Terminal

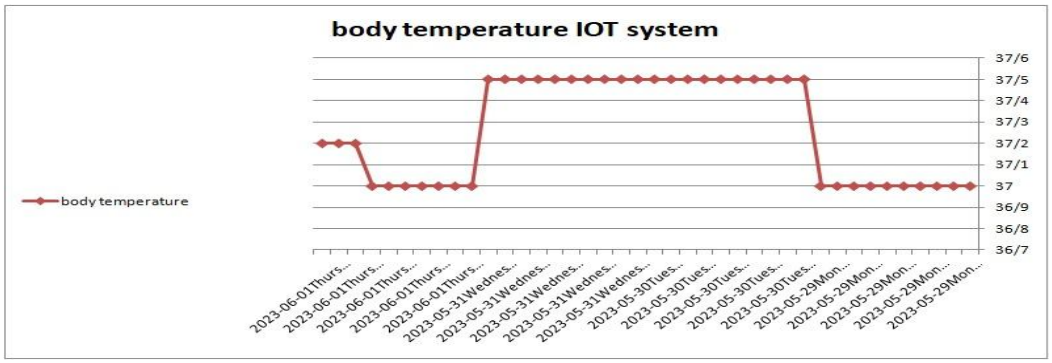


Fig10.Display reading of body temperature parameter in Excel

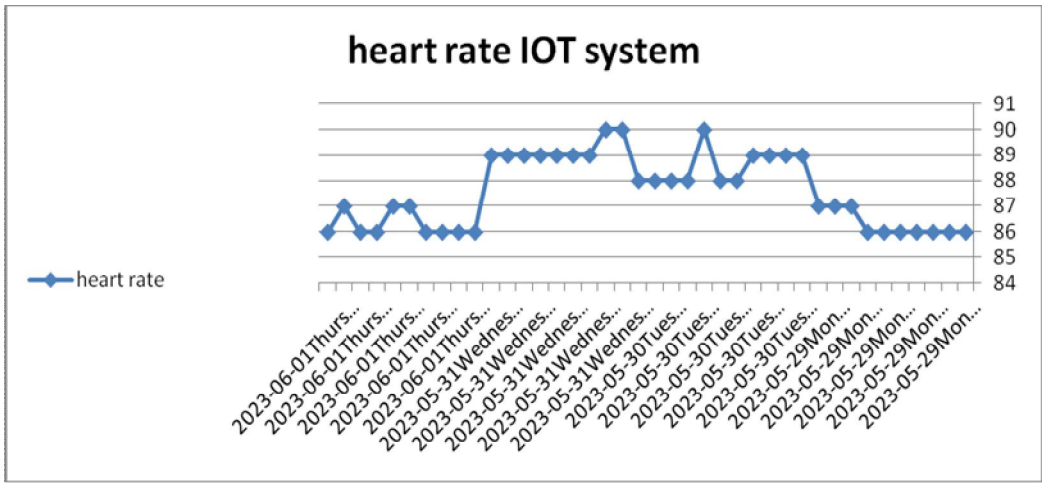


Fig11.Display the heart rate parameter reading in Excel

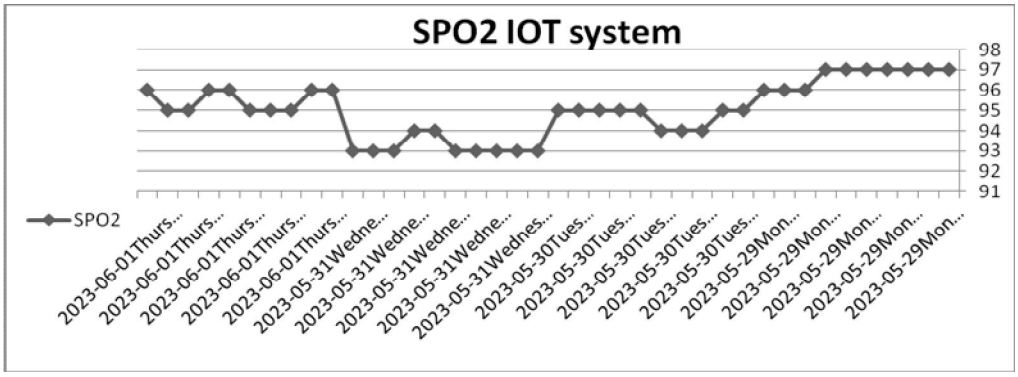


Fig12. Display the spo2 parameter reading in Excel

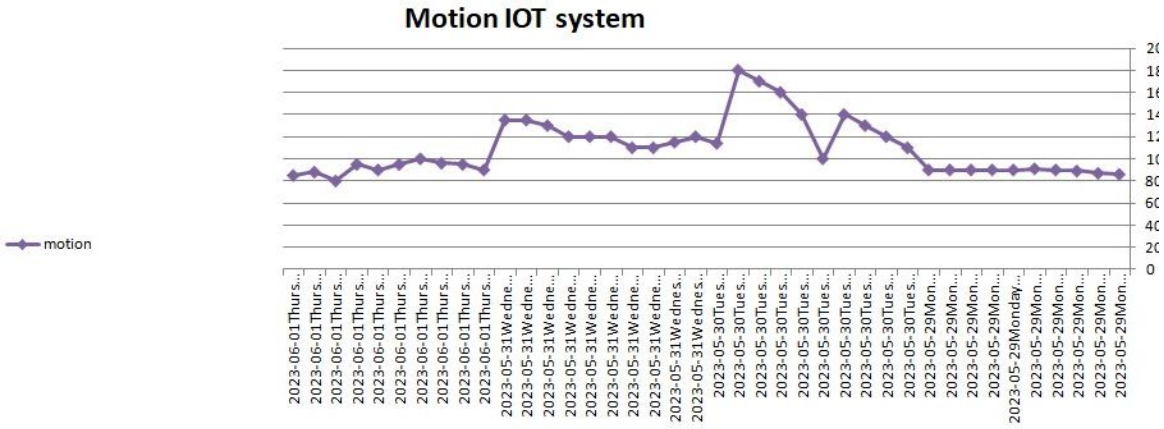


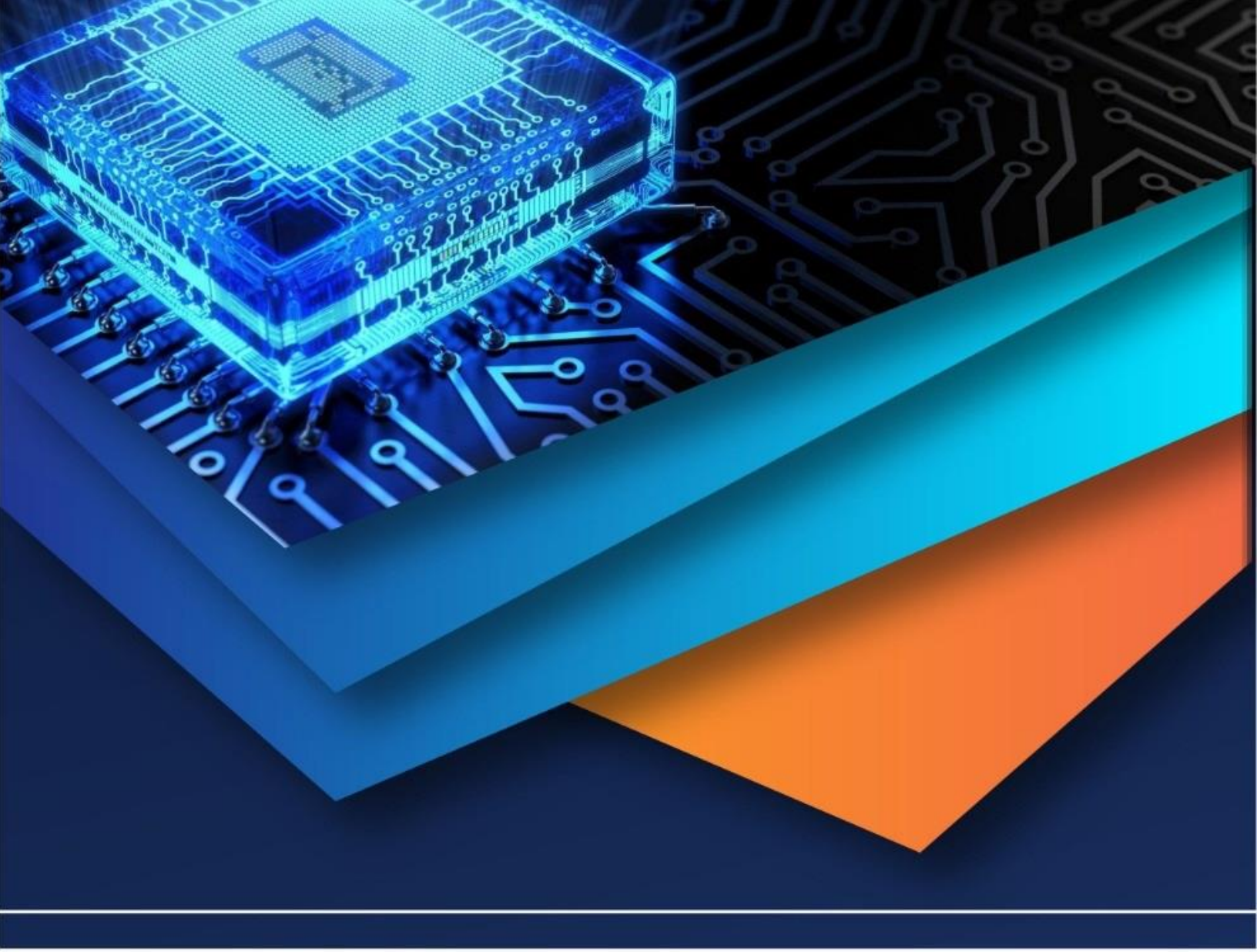
Fig13. Display the reading motion changes in Excel

V. CONCLUSION

In this article, a device is proposed to monitor the health of MS patients. This device is affordable and practical. Since no similar system has been designed for the monitoring and care of MS patients, this system can be used for self-care and remote monitoring of MS patients.

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