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Implementation and Application of the Upper Limb Home Exercise Tracking Device

Çağatay Ersin[1*]

[1]Vocational School, Electronics and Automation Department, Çankırı, Turkey

Abstract: Cerebrovascular and neuromuscular disorders are increasing in parallel with the increasing average age in the world. Home exercises become very important for the physiotherapy of patients who have lost upper limb motor skills due to these disorders. In this study, an upper limb exercise tracking device was implemented. Individuals with upper limb discomfort can regain their lost motor skills by taking physical therapy. But physical therapy is a holistic treatment method. Individuals who lose their motor skills can improve their motor skills with home exercises. The physical therapist gives home exercises to the person with discomfort according to his / her illness. However, it is not possible to monitor whether these exercises are done correctly. This device has been developed for the follow-up of home exercises by a physical therapist. The implemented device was created on the basis of IoT (Internet of Things) and the esp8266 microcontroller wifi module was used. In the home environment where internet access is available, the device attached to the upper limb has been sent to the thingspeak IoT platform with a three-axis accelerometer (accelerometer). The physical therapist will be able to track the position of the upper limb and how many degrees it can perform in three axes (x, y, z) while the user is doing home exercises.

Keywords: Accelerometer, IoT, Physical Therapy, Esp8266.

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Üst Uzuv Ev Egzersiz Takip Cihazının Gerçekleştirilmesi ve Uygulanması

Özet: Dünyada artmakta olan yaş ortalaması ile paralel olarak serebrovasküler ve nöromasküler rahatsızlıklar artmaktadır. Bu rahatsızlıklardan dolayı üst uzuv motor becerilerini kaybeden hastaların fizyoterapisi için ev egzersizleri oldukça önem kazanmaktadır. Yapılan bu çalışmada üst uzuv egzersiz takip cihazı gerçekleştirilmiştir. Üst uzvunda rahatsızlık yaşayan bireyler fizik tedavi alarak kaybettikleri motor becerilerini geri kazanabilmektedirler. Fakat fizik tedavi bütüncül bir tedavi yöntemidir. Motor becerilerini kaybeden birey ev egzersizleri ile de motor becerilerini geliştirebilmektedir. Fizik tedavi uzmanı rahatsızlık sahibi kişiye rahatsızlığına göre ev egzersizleri vermektedir. Fakat bu egzersizlerin doğru yapıldığının takibi yapılamamaktadır. Yapılan bu cihaz ev egzersizlerinin fizik tedavi uzmanı tarafından takibi için gerçekleştirilmiştir. Gerçekleştirilen cihaz IoT (Nesnelerin İnterneti) tabanlı oluşturulmuş ve esp8266 mikodenetleyici wifi modülü kullanılmıştır. İnternet erişimin olduğu ev ortamında üst uzva takılan cihaz üç eksenli accelerometre (ivmeölçer) ile üst uzvun konumunu thingspeak IoT platformuna gönderilmiştir. Fizik tedavi uzmanı, kullanıcı ev egzersizleri yaparken üst uzvun konumunu ve üç eksende (x,y,z) kaç derece yapabildiğini takip edebilecektir.

Anahtar Kelimeler: İvme Ölçer, IoT, Fizik Tedavi, Esp8266.

1. Introductıon

Biomechatronics is a new field in the world, the scope of which has started to be determined especially in the last 10 years. There are a limited number of studies and researchers in this field in our country. Biomechatronic studies are currently used for the treatment, detection, and follow-up of diseases. Since the use of upper limbs in the human body is very intense in daily life, when any discomfort occurs in this area, the quality of life of people is more affected [1]. The person minimizes these ailments by taking physical therapy. Physical therapy forms are a method used to reduce symptoms for a short time. These forms of treatment can be ice massage,

Corresponding author;Çağatay Ersin Tel.:,0(506)2921703 cagatayersin@karatekin.edu.tr.

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hot pack, diathermy, ultrasound, and transcutaneous electrical nerve stimulation (TENS). Physical therapy is needed not only for muscular ailments but also for diseases called stroke. Stroke, which is one of the most common diseases in middle-aged and older people, is a disease experienced by approximately 15 million people every year worldwide. About 9 million of these people survive and are in need of rehabilitation [2]. One of the major problems encountered after a stroke is the loss of movement and sensation in a certain half of the body. Successful results are obtained in stroke rehabilitation by using different methods in treatment centers and patients are able to make the movements they need during their daily work. [3].

With developing technology, rehabilitation robots have become widespread in the field of physical therapy. The use of robotic systems in physical therapy and rehabilitation is important not only to reduce the therapists' workload but also to make this long, laborious, and costly process easier for patients. Rehabilitation robots can provide the patients with only the amount of movement support they need in order to actively participate in the therapy while ensuring that the necessary exercise movements are performed in a repeatable, followable, and easily adjustable manner [1]. Although successful results are obtained with treatment methods applied in centers providing services for rehabilitation purposes, there are some limitations and disadvantages in the processes here. These; Dependence on a particular center and specialists, a limited number of people benefiting from rehabilitation services, relatively high costs in the rehabilitation process, and difficulties in accessing rehabilitation services. Such problems require the development of practices for rehabilitation in the home environment [3]. Physical exercise increases the rate of energy consumption. The resting metabolic rate can increase 20 times, cardiac output can increase 6 times, depending on the intensity of the exertion of the body, the cardiovascular system, the endocrine system, the neuro-motor system, the thermoregulatory system rapidly respond to this demand and sudden changes ocur. Physical exercise; Any activity that occurs in the body where there is muscle activity. Exercise, on the other hand, is physical activities that are planned in accordance with a purpose and include repetitions. It may include the whole body or some related parts. The main purpose of physical activity/exercise is to increase physical fitness. The value of energy expended by physical exercise; Body position varies according to sitting, standing, walking, climbing uphill, and muscle strength / physical capacity of the person. Exercise test findings, climate, environmental conditions, intellectual demands, food intake, and emotional status should be taken into account when recommending exercise to the person. Factors such as the age, gender, posture of the individual, the percentage of total muscle mass involved in an exercise, environmental conditions, temperature, and height change the energy requirement of the muscles contracted during exercise [4].

The IoT (Internet of Things) concept allows physical objects/devices to communicate in order to share information and make decisions. The Internet of Things is the transformation of traditional objects into smart ones using basic technologies such as embedded devices, communication protocols, sensor networks, internet protocol, and applications [5]. The Internet of Things (IoT) is a communication network that includes devices, software, and access services that enable us to control and analyze physical events around us. These physical events, production processes, energy networks, patient tracking systems, recycling processes, transportation, smart buildings, shopping, etc. There may be measurable quantities or control systems in areas such as [6]. The concept of the Internet of Things has attracted all the attention as a new development in the field of informatics in recent years. Connecting physical objects to the internet makes it possible to access remote sensor data and control the physical world remotely. The merging of received data from other sources with data found on the Web creates new synergistic services that go beyond the services that can be provided by an isolated embedded system. Especially, with the increase of WiFi and mobile wireless internet access, it has started to evolve towards ubiquitous

information and communication networks. The spread of the Internet to this extent leads to the emergence of new formations [7].

The Internet of Things consists of three main parts: objects, communication networks that connect objects with each other, and computer systems using data transferred between objects. Although there is currently no common protocol for all objects to use the same language, many objects can be connected to the internet and the number of objects and application areas that can be connected to the internet is rapidly increasing [8].

2. Material and Method

With the rapidly increasing population worldwide and the increase in the average age, muscle disorders are also increasing in parallel. An intense pace in the business world also affects muscle ailments. In this study, a tracking device was developed for home exercises after physical therapy. In cases where the individual with arm muscle discomfort needs to do home exercises after receiving physical therapy, it should be followed by a physical therapist. The user will attach this device to the upper limb where exercise is required and perform the exercises given by the physical therapy specialist. With the accelerometer on the device, the movement angles of the arm in 3 axes were measured. When the user puts on the device and exercises, the physiotherapist will be able to follow the exercises correctly on the thingspeak channels with the esp 8266 wifi module and internet connection on the device. A microcontroller is used to control the system and receive sensor data. When the user moves the upper limb horizontally on the x-axis, vertically on the y-axis and z-axis, the date and arm angle can be seen in the x, y, z-axis channels. In this way, it can be seen through the channel whether the user doing the exercise does the exercises correctly or not and how long he did it on which days and hours. The blog diagram of the created system is shown in figure 1.

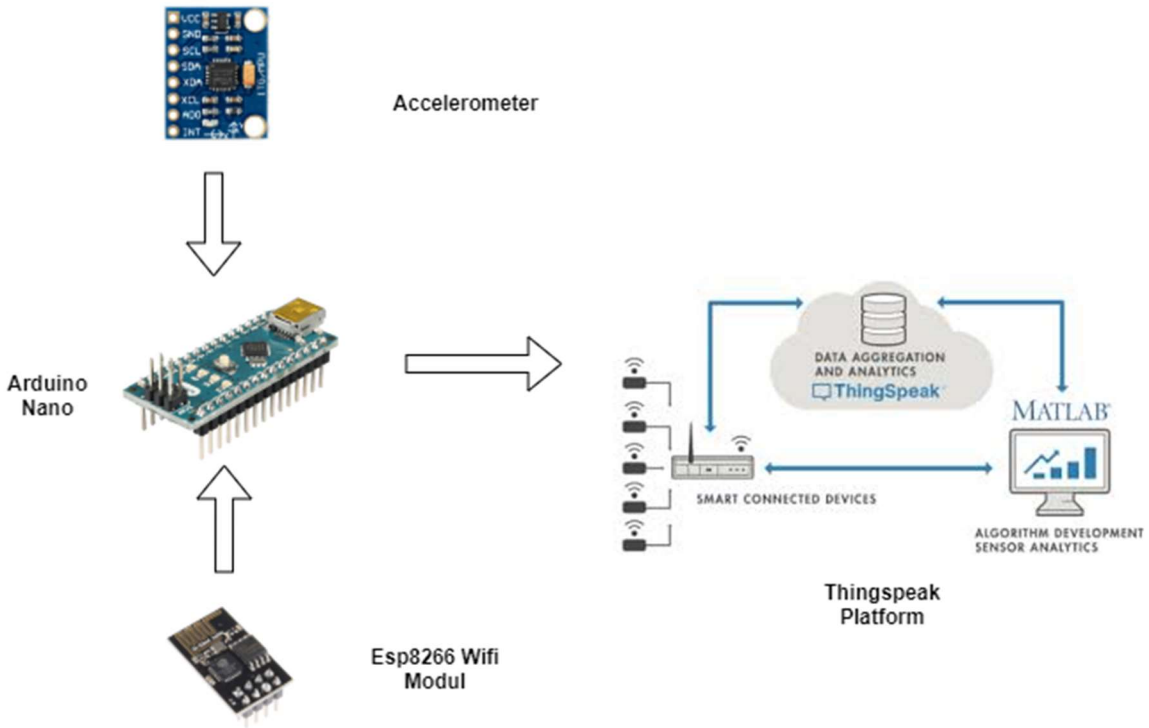

Figure 1. Blog diagram of the system

2.1. Internet of Things

The industrial revolution and technological developments are making great progress today. With developing technology, existing businesses are looking for ways to use their technology better and more efficiently. The concept we encounter as an integral part of technology is the internet. Internet of Things is a popular and widely used concept today [9]. The Internet of Things (IoT) is a network of devices, software, and access services that you can use to control and monitor physical events around us. These physical events include production processes, energy networks, patient tracking systems, recycling processes, transportation, smart buildings, smart shopping, etc. It can be measurable dimensions such as a or control systems [10]. "Internet of Things" is required in a presentation listing the benefits of using RFID (Radio Frequency Identification) technology and recommending it for use [11]. Typical Internet of Things architecture consists of 5 basic layers. Detection layer OSI fast response code reader etc. can be used in places. It takes certain information about any sensor in these layers and makes a definition. The collected information includes location, wind speed, vibration, degree of belonging, humidity, temperature, dust content in the air, etc. The resulting options are then transferred to the upper layer, the network layer [12]. Identification and tracking technologies, wired and wireless sensor and actuator networks, advanced communication protocols, and distributed information systems for smart objects are the best known IoT practices. As a result of activities carried out in different information fields such as social sciences, electronics, informatics, and telecommunications, significant contributions are made to the advancement of IoT [13]. Intelligent connectivity and computing using existing networks and network resources are an essential part of IoT. With the increasing availability of WiFi and 4G-LTE wireless internet access, there is an evolution towards ubiquitous information and communication networks. However, for the vision of the Internet of Things to emerge successfully, the computing paradigm will have to go beyond traditional mobile computing scenarios using smartphones and portable devices and evolve into combining everyday objects and placing intelligence in our environment [14]. Globalization, intense competition, and technological developments shape the activities of companies. Internet of Things is emerging as a new concept. With this concept, it is stated that the internet, which is a global communication network, receives information not only from people but also from objects, and thus interprets the information it collects and transmits it to other objects and people. Today, almost all information entries on the internet are a human resource. With the concept of the Internet of Things that has emerged very recently, it is expected that the internet will lead to a more important and greater change than the global impact created by the internet by communicating not only with people but also with objects. As a result of the establishment of a global neural network in the near future; everyone and everything is expected to be connected. The cloud technology used today can be counted among the steps of this process. Since the Internet of Things is a part of the daily lives of companies and people, data security is brought to the fore. Data security can have different meanings for individuals and companies. A significant loss or loss of reputation for individuals and companies due to voluntarily shared information does not appear to be a priority [15]. With new developments in technology, many sensor devices can be integrated into the Internet environment via WSN (Wireless Sensor Networks) systems [16]. The Internet of Things provides a worldwide widespread network of uniquely addressable objects in that network to communicate with each other through a specific protocol. The Internet of Things is referred to as the next industrial revolution or the next evolution of the internet. IoT can be defined as an advanced and effective solution for connecting objects to the Internet and collecting data from objects over a network. It will determine how businesses, governments, and consumers interact with the physical world through sensors, cameras, phones, smartphones, and other smart IoT devices connected to the internet. IoT is a technological paradigm that aims to increase the connectivity of everyday

devices. Therefore, the growth and use of this type of technology will increase exponentially in the coming years due to its application in multiple fields [17].

2.2. Thingspeak IoT Platform

Thingspeak is a free data platform for the Internet of Things (IoT), which remains popular today [18]. Thingspeak is also a web-based open API IoT-based information platform that converts external components used for IoT into its own data and is used to store sensor data [19]. Thingspeak communicates as a 'data packet' carrier between the internet connection and the cloud and retrieves the detected graphic from the connected sensor to the main microcontroller, saves, analyzes, observes, and operates. The main feature of the Thingspeak function is the data area which is the status area, location area, and channel area. Thingspeak can process, visualize purposes. Data can be processed with MATLAB, ThingTweet and other applications on the platform. There are also applications for thingspeak analysis and prediction. It helps to use graphical visualization processes for sensors / actuators and graphically for objects. It allows communication with objects. Thingspeak provides access to real device, graphic visualization and plugins to collaborate with web services, social networks or API. Thingspeak's main feature is the Thingspeak Channel. Programs loaded into the microcontroller perform within 15 seconds to transmit sensor data to the Thingspeak channel [11]. As Internet of Things technology develops, it becomes available for wireless networking [20]. This study was instantly monitored according to the triaxial acceleration sensor upper extremity movement. Three channels were created in the Thingspeak data platform: x-axis, y-axis and zeni. Esp 8266 was sent to Thingspeak channels opened with the wifi module. Instant data is graphed on Thingspeak channels. The graphical view of Thingspeak channels is shown in figure 2.

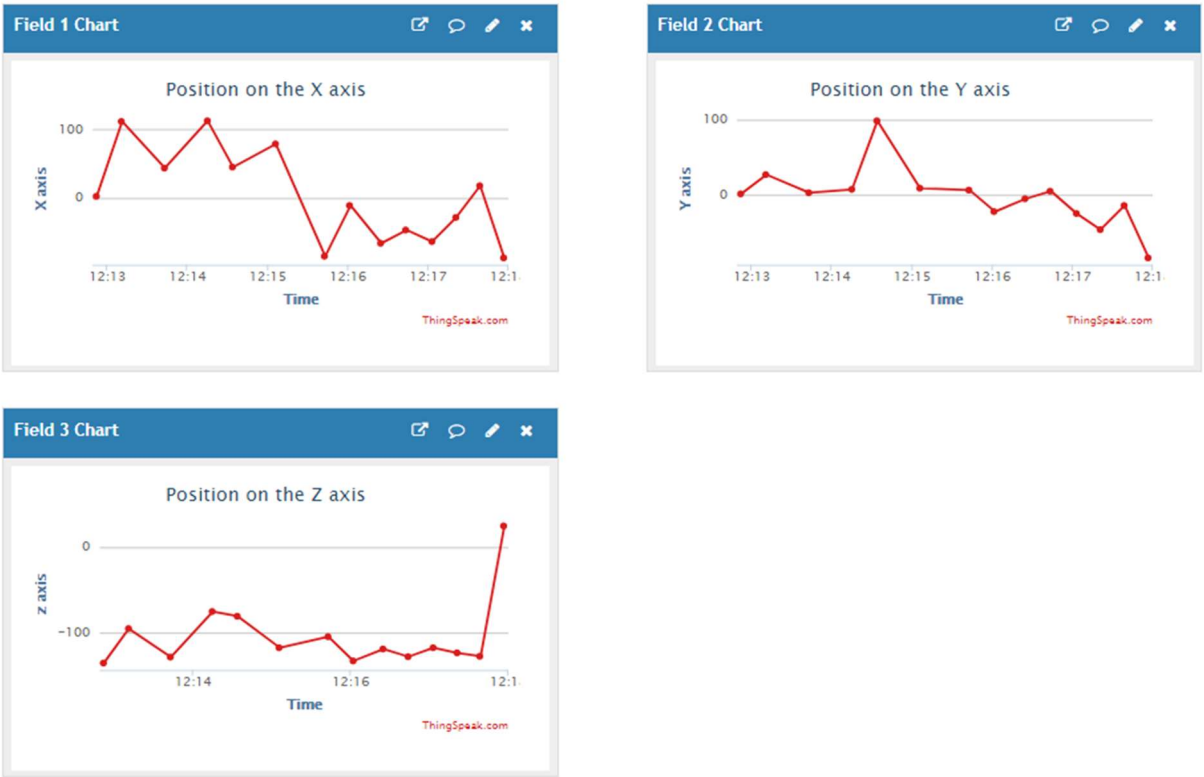

Figure 2. View of Thingspeak channels

2.3. Triaxial Accelerometer

The acceleration sensor is one of the sensors that has become very important due to the development of MEMS (Micro electrical-mechanical systems) technology. The acceleration sensor is an element that detects and measures acceleration and generates an electrical (analog or digital) output voltage proportional to the value of the acceleration. Acceleration occurs when there is a change in the velocity of the object or the direction in which the velocity is directed. In addition to acceleration, an accelerometer is used to measure variable states such as impact, vibration, rotation, and tilt [21].

There are two types of acceleration sensors, analog and digital. There are types of analog acceleration sensors that work according to very different principles. The most common are sensors with capacitance sensitive and piezoelectric effect detection. Acceleration sensors with analog output generate a constantly changing voltage depending on the applied acceleration. In digital output acceleration sensors, a variable frequency square wave is known as PWM (pulse width modulation) is produced as the output signal. The value of the acceleration is directly proportional to the duty period of the PWM signal. There are also digital acceleration sensors that support I2C, SPI, UART [22]. Acceleration sensors are capable of measuring in one, two, and three axes separately or together. The most used type is the biaxial ones. However, triaxial acceleration sensors are becoming more common and cheaper. If the acceleration sensor is used as a tilt sensor to measure gravitational acceleration, it is sufficient that the output range is around ± 1.5g. If used as a crash sensor, ± 5g is sufficient. The acceleration measurement process has a wide variety of uses. It can be used to measure the acceleration of velocity, position, impact, vibration, or gravity [23].

ADXL345 (Analog Devices), which is a kind of accelerometer sensor and used as such, is the sensor of the 'Three Axis Accelerometer, a small, thin, 3-axis accelerometer with low power consumption. ADXL345 is an advanced version of ADXL335 integration. Communication capability can be introduced with digital output that can be given information in order to reduce the code load to be written. Triaxial Accelerometer ADXL345, signal conditional voltage output is provided. ADXL345 is a well-established and proven analog sensor series. In addition, the integration has a very low noise ratio and power consumption (23uA). There is no regulator circuit on the Triaxial Accelerometer ADXL345 and the voltage supplied to this panel should be 2 V dc to 3.6 V dc. I^2C and SPI communication can be used in digital data transmission. The operating modes of the Triaxial Accelerometer ADXL345 are 'low power', 'standby' and 'auto sleep mode'. [24]. The triaxial accelerometer used in this study is shown in figure 3.

Figure 3. ADXL 345 triaxial accelerometer

3. Conclusion

Today, muscle disorders have increased significantly due to the increasing pace of work and increasing age. Difficult working conditions, traffic accidents, stab injuries, and muscle disorders have increased. In this study, a home exercise tracker was designed for individuals with upper extremity muscular disorders. The device was attached to the patient's arm and determined the position and angle in 3 axes (x, y, z) with the ADXL345 accelerometer. The position information in the determined three axes was controlled by Arduino Nano and sent to the THINGSPEAK IoT data platform with the esp8266 wifi module. Three channels were opened on the Thingspeak data platform. Locations are formulated in the Arduino IDE program and sent to the IoT platform as data. The designed device has been converted into an internet-based device with an esp8266 Wifi Server. While the user is doing home exercises, the physical therapist will be able to follow the exercise instantly thanks to the designed device. In addition, it will be possible to remotely monitor the days and hours of the person with the discomfort and whether the exercise is right or wrong. The device is designed as a biomedical device and its cost is very low. It has a structure open to device development. In addition, with the MATLAB interface on the thingspeak IoT platform in the development of the device, data can be processed in future studies.

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