# ROBOTIC ARM CONTROL USING THE BRAIN WAVES

A. Karakoc, D. Dogan, and T.C. Akinci

***Abstract*—** Although the human brain has not solved the mystery in full, significant progress has been made as a result of scientific studies on the brain. Through the electrodes connected to the human brain, the EEG signs of our thoughts can give information about the current intellectual and physical state of the human. With the signals from the brain through the EEG biosensors, we can measure the motivation level of our brain. Depending on our state of thought or motivation, changing signs can be used to control a system. This study consists of four stages. Robotic-hand design was made in the first stage. Plastic parts in robotic-hand design are drawn by CAD (Solid) program and produced by 3D printer. In the second stage, the servomotor and the necessary mechanisms are placed into the plastic model and the joints are moved by the motors that pull the lines of the line for the correct movement of the fingers. The third stage is the software phase that will control the movement of the servo-motors in the bionic hand. Software codes have been created for the Arduino card to control the system. In the fourth and final stage, the study was carried out by practicing on how the individual would be motivated by the use of the bionic hand sensor with the brain waves sensor.

***Keywords*—** *EEG sensors, Brain Wave control, Robotic Arm.*

## I. INTRODUCTION

AS is known, one of the most important diseases limiting human movements is paralysis and loss of limb. Genetic reasons, accidental or various diseases may have caused these losses. These losses can cause neurological disorders. These patients come to this level, especially as a result of some scans. These patients may not be able to perform their own care because of their illness or they may experience communication difficulties. The use of brain signals can help these patients communicate with other people. Systems that detect EEG signals and convert them to control signals can be designed. These systems transform people's thoughts into signs that control mechanisms by means of software [1].

Thanks to the latest technological advances, EEG sensors and other intelligent sensor groups have been developed, which can be controlled by the patient's brain commands. *Beyrouthy* et al created a hand model with 3D printer by friends. Servomotors provide the movements of this prosthetic model. This model shows the ability to make movements that are suitable for many scenarios. These scenarios are selected from real human movements. Computer algorithms generate all these movements.

Experimental results show that; EEG thought / motivation studies are promising and alternative for solutions requiring surgical interventions [2].

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Manuscript received July 18, 2017; accepted Aug 18, 2017.
Digital Object Identifier:

Researchers have recently proposed new scientific methods to restore the function of lost abilities for patients with neuro-motor disorder. One of these methods is to provide a new non-muscle communication and control channel to the brain, ie a direct Brain-Machine Interface (BMI). A study by Howida et al. presents a BMI system using brain EEG signals associated with movement of the arm to control a robotic arm [3]. In the literature, many studies have been performed using brain waves (sensors / vibrations) [4-7]. The CBI (Brain Computer Interface) makes it possible for people to use a computer, an electromechanical arm, or a variety of neuro-prostheses without using the motor nerve systems. In particular, these systems are of paramount importance to improve the quality of life of patients with paralysis and Amyotrophic Lateral Sclerosis (ALS). The brain computer interface is a new technology that allows people to communicate with electronic devices such as computers, where they use brain waves called electroencephalogram (EEG).

The aim of this study is to facilitate the lives of patients who cannot use their fingers or their hands with the EEG biosensor. In addition, patients with paralysis or ALS should develop a model that is closest to the human hand so that they can live their lives better, and that this model is used by the patient with an EEG sensor. Moreover, because this model is an electromechanical model, it may be possible to evaluate it as an engineering design and application.

## II. BRAIN, STRUCTURE AND FUNCTIONING

The brain is a complex organ that forms part of our Central Nervous System (CNS) and is the largest part of our encephalon. It is located in the anterior and upper part of the skull cavity and is present in all vertebrates. Inside the brain skull is located in a transparent fluid called spinal fluid, which maintains it both physically and immunologically [8]. The function of the brain as part of the Central Nervous System is to regulate the majority of body and mind functions. Respiration, heart rate regulation, thinking, talking, etc. all life functions are the task of the CNS.

Although the brain is composed of three main parts: the forebrain, midbrain and posterior brain, the brain has a much more complex structure [9]. This complex structure consists of various regions. These regions undertake different tasks. Seeing, hearing, tasting, motion controls, perception and speech are controlled from different parts of the brain [9].

The cerebellum is located at the back of our heads. The cerebellum helps keep our body in balance. In addition, the muscles are compatible with each other. The most basic task of the cerebellum is to provide balance and to evaluate the warnings from the eye [9].

The spinal cord is the posterior brain portion located between the spinal cord and the pons. The spinal cord on the dandruff, just like in the cerebellum and spinal cord substances are available. The motor nerves in the brain are also distributed diagonally across the spinal cord. The most important tasks of spinal cord bulb; Digestive, respiratory, circulatory and excretory systems to ensure the operation. In addition, controlling and regulating the blood sugar of the liver controls vital reflexes such as swallowing, sneezing, coughing and vomiting [9].

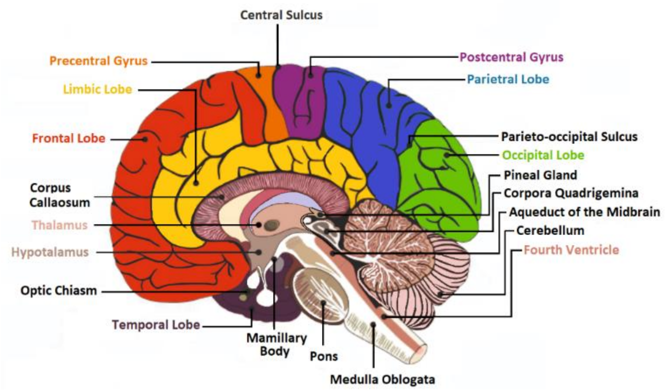


Fig.1 Internal parts of the brain [9].

Brain in humans is one of the most advanced and complex among all animal species. It is not only bigger but also twisted and folded, creating grooves and layers in itself, which gives it a wrinkled appearance. The human brain weighs about 1.5 kilos. The weight of the brain constitutes 2% of the weight of human weight. It has excellent cell management. It has approximately 86 billion nerve cells. The human brain is approximately 1.4-1.5 kilos (3.3 lbs), and its volume is approximately 1130 cc in women and 1260 cc in men. The majority are composed of glial cells and neurons [8].

These nerve cells, *ie*, neurons, are connected to each other by trillions of neural networks (neurons). Neurons are specialized cells that receive, process and transmit information at the intracellular and intracellular levels. This is done through electrochemical signals (neural hills) called action potentials. Neurons consist of three parts: cell body, axons and dendrites. One of the most important cells to perform cellular nervous system functions is Glia Cells. These cells provide structural support to neurons, covering axons with axons for better synaptic transmission. Neuroglia (Glia) Cells, Schwann cells are classified as Oligodendrocytes, Astrocytes, Ependymal cells and Microglia cells [10].

The development of the human brain begins at the embryo stage and ends in youth. Four weeks after falling into the mother's womb, the brain begins to form a neural tube from which the brain stem comes. Then, the process of proliferation, migration and cell decomposition, in which the formation and development of the brain takes place, begins. Neurons are produced in the neural tube and then transported to form important parts of the brain. Finally, they will be separated and specialized according to the function they will have.

## III. BRAIN WAVE SENSOR (EEG SENSOR)

Defining and grouping activities in the brain was quite difficult in the past years. However, as a result of studies conducted by Hans Berger, an electroencephalogram was invented. Berger is considered the founder of EEG. Berger also attracted attention by putting different diagnoses on his work. Berger preferred different diagnosis and treatment methods for individuals who had a tumor in his brain. Berger has been successful in using therapies to diagnose the signals he has recorded from the electrodes he has worn on the non-invasive scalp [12].

Electroencephalogram; EEG is the measurement of electrical impulses of neurons. Therefore, it helps to investigate the cognitive activities of human beings. The processing and interpretation of EEG signals by using signal-processing techniques is based on different approach algorithms. EEG-based technology is more preferred in clinical neurology than other radiological imaging methods. EEG-based technology is not only medically limited, but a lot of research is being carried out due to the analysis and interpretation of brain waves.

The brain computer interface (BCI) is one of the communication channels developed to interact between the human brain and the digital environment to control / operate external devices. When designing this interface, it is aimed to increase the living standards of disabled and old people by considering the medical interests. The system aims to control the devices by interpreting the brain wave frequencies in the mind. Many studies have been done for this.

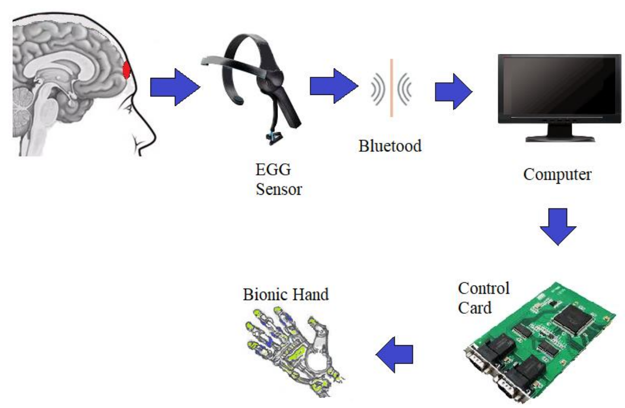


Fig.2. Brain Computer Interface and measurement systems.

Electroencephalogram (EEG) markings are low-amplitude (1-400 μV to top hill) bioelectric signs measured from electrodes on the brain surface or through the person's scalp. Research has revealed that a large amount of neurological information is stored in these signs. In the last 15 years, the examination of EEG signals has been accelerated, with the use of these markers to develop patient treatment methods and to establish a BCI by means of these signals to communicate with electronic devices.

The first observed by Hans Berger is the 8-12 Hz alpha waves. Hans Berger; In this frequency range, fixed waves appeared but disappeared with opened eyes. When the formation of alpha rhythm is examined, it is proved that it is observed clearly in the records taken from the occipital lobe. In order for alpha activity to be achieved, a person must be in a closed, stagnant physiology. Beta rhythm is the activity with a frequency range of 12-38 Hz in the brain. When the person is awake and fit, the brain performs beta release. The amplitude is usually below 30μV. This brain wave has a logical thinking phase and is largely involved in one's daily life. In case of excitement, the frequency of the beta wave increases at the moment of focus. However, when the brain releases beta waves in continuous and high doses, behavior disorders, addictions, nerves and neurosis are experienced.

Delta activity is the electrical activity with the slowest frequency range (0.5-3 Hz) secreted by the brain. The delta wave appears in deep meditation or deep sleep. Theta waves are low oscillatory waves with a frequency of 5-8 Hz. It is just before the person falls asleep. This frequency plays a role in remembering long forgotten information. Gamma waves have a frequency greater than 30 Hz. Gamma waves play an important role in determining the effect of the external world on neural structure. This rhythm state of depression that spread even spent an adult becomes apparent as soon as possible seizures [13-17].

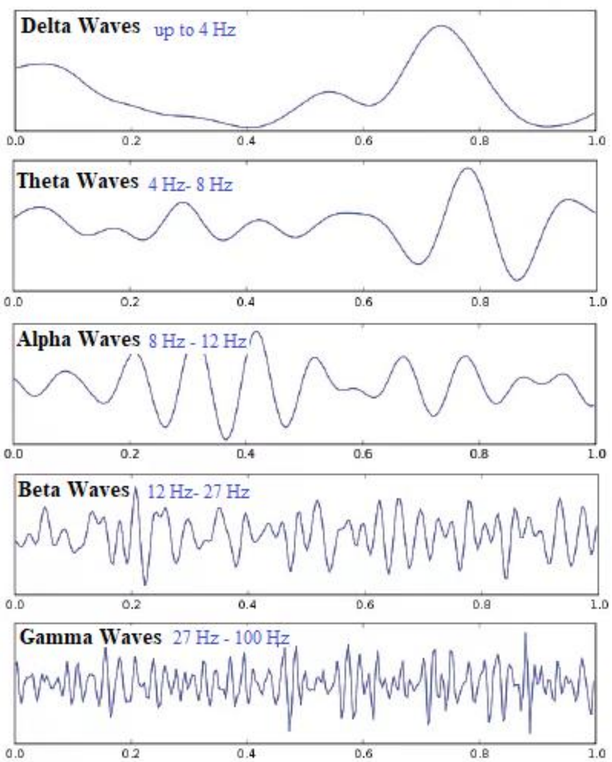


Fig.3. Frequency range of the brain wave [18].

Although the medical standards recommended using the 10-20 electrode system, which is accepted for EEG measurement, recent developments, have shown that high efficiency can be obtained from single channel studies [18]. In this study, EEG biosensor of single channel Neurosky company © was used. This EEG Biosensor can determine the user's mental fatigue, brainwaves, and winks. This product includes a ThinkGear chip that provides the interface between the user's brain and the robot systems. The sensor that contacts the contact and reference points on the forehead and ear, transmits all measured data to the digital form software and applications. The sensor has a sensing range of 10 meters and uses the TGAM1 Bluetooth v2.1 Class 2 module. The frequency used is 12 MHz. The required power is 9-12V. The LPC2148 processor form is used to control these types of devices.

Since the amplitudes of the EEG signals are very low, a variety of noises can be easily confused. It is affected by external factors such as the presence of electrically operated devices in the measurement room, the light being turned on or off, and the presence of devices that can emit electromagnetic waves in the environment. In addition, during the measurement of the person's eye blinking, moving the arm, such as physical activities can be very affected. Various signal processing methods are used in the literature to remove the noise from EEG signals. In this study, signal processing is not mentioned. In the literature, the noise source that is tried to be removed is the noise caused by blink. This noise is particularly confined to the signs in the electrodes located near the eye and in the occipital regions [19, 20].

## IV. BIONIC HAND (ROBOTIC ARM) DESIGN

EEG controlled robot arm consists of 61 parts and the required models are printed from 3D printer. Then the joints are connected to the pins. MG-996R type servomotor is used for the movement of the fingers. Arduino provides the control of the motors. Bluetooth 4.0 is used to transfer the signals received from the EEG biosensor to the card.

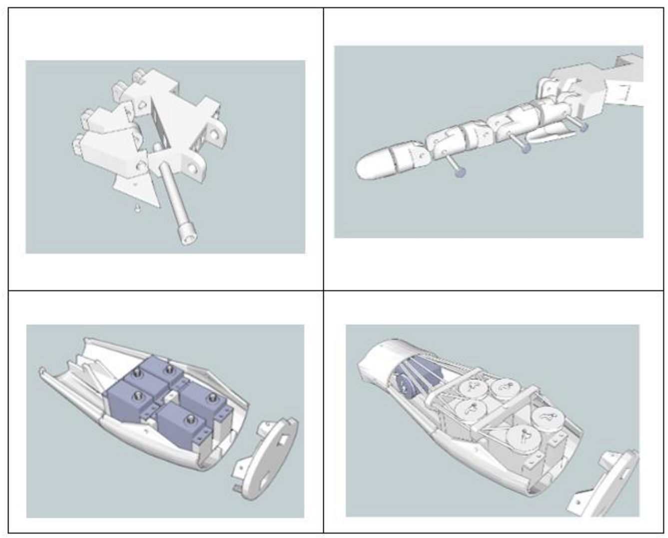

Fig.4. The stages of combining robot arm parts.

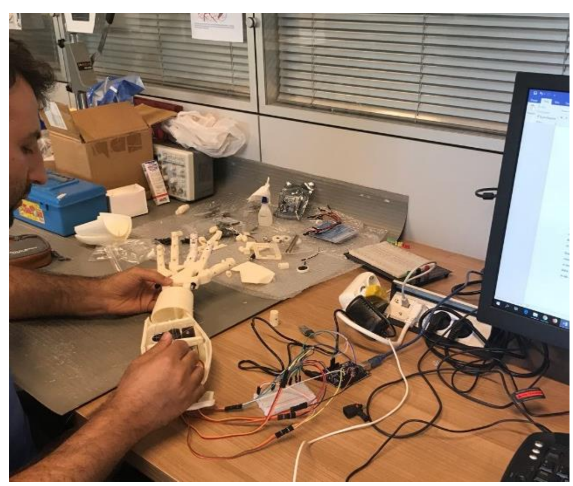

Fig.5. Design and installation of the bionic hand.

To control the bionic hand, the signals from the brainwave sensor are transferred via Bluetooth to the Arduino control card

©. The control card controls the servomotors that control the fingers.

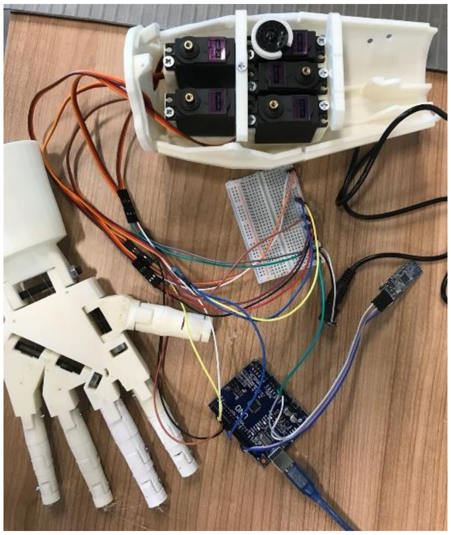

Fig.6. Control of Bionic Hand.

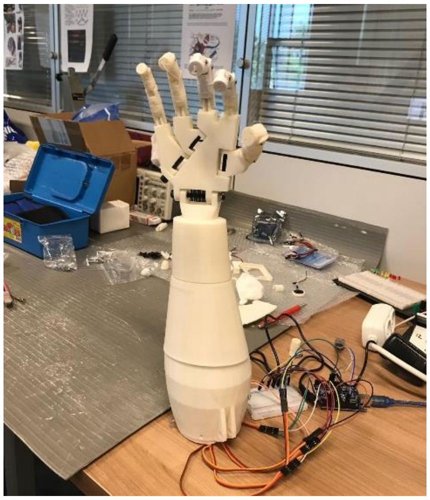

Fig.7. The implementation of the bionic hand..

Figure 4 shows the 3D design of the hand. Figures 5 and 6 show the application of the robotic arm. The procedure is given in Figure 7. Here, modelling and control of the arm is seen.

## V. CONCLUSIONS

In this practical study, which was performed for prototyping, it was ensured that the sub-prosthesis was controlled using brain signals. This work can be called bionic-hand or robot arm. In the study, firstly a model close to the human hand was created and modeled with 3D printer, then engines were installed to control this model and control of the motors was made by means of EEG sensor. It consists of working stages, model extraction, control of motors, software and control of the model with EEG brain-sensor. In this application, EEG can open and close the fingers of the model by means of the brainwave sensor. This switch-off has been achieved successfully with the motivation of the person using the EEG sensor.

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