Brainiac's Arm—Robotic Arm Controlled by Human Brain

Dalibor Đumić(✉), Mehmed Đug, and Jasmin Kevrić

International Burch University, Francuske Revolucije bb, Splitska 53, 71210 Ilidza, Sarajevo, Bosnia and Herzegovina
{dalibor.djumic,mehmed.dug}@stu.ibu.edu.ba, jkevric@ibu.edu.ba

Abstract. This paper shows electroencephalograph (EEG) controlled robotic arm based on Brain–computer interfaces (BCI). BCIs are systems that enable bypassing conventional methods of communication (i.e., muscles and thoughts) and provide direct communication and control between the human brain and physical devices using the power of the human brain. The main goal of the project work is to develop a robotic arm that can assist the disabled people in their daily life and by it make their work independent on others.

Keywords: Robotic arm · BCI · Human brain · Disabled people

1 Introduction

Robotics is the science of robots, their design, development and implementation. It covers the fields of informatics (especially artificial intelligence), Electrical and Mechanical Engineering. These advancements manage robotized machines (robots for short) that can replace people in hazardous situations or assembling forms, or look like people in appearance, conduct, as well as discernment.

A considerable lot of today's robots are propelled by nature, adding to the field of bio-enlivened mechanical autonomy. The idea of making machines that can work self-sufficiently goes back to established times, however examine into the usefulness and potential employments of robots did not become considerably until the twentieth century. Throughout history, it has been habitually expected that robots will one day have the capacity to copy human conduct and oversee undertakings in a human-like style.

Today, robotics is a quickly developing field, as mechanical advances keep; inquiring about, planning, and building new robots fill different useful needs, whether locally, monetarily, or militarily.

Numerous robots are worked to do tasks that are perilous to individuals, for example, defusing bombs, discovering survivors in shaky destroys, and investigating mines and wrecks. Mechanical technology is likewise utilized as a part of STEM (Science, Technology, Engineering, and Mathematics) as an educating help.

M. Hadžikadić and S. Avdaković (eds.), *Advanced Technologies, Systems, and Applications II*, Lecture Notes in Networks and Systems 28,
https://doi.org/10.1007/978-3-319-71321-2_73

2 Literature Overview

The most information is collected from the Internet because it's the biggest source of the available knowledge for students and young professionals. All references except [1–5] are from the Internet and they are used in research in order to develop and make Braniac's arm, whereas literatures [6–10] provide necessary information related to servo motors, robotics and biomedical signals. The robotic hand was built from InMoov 3D printed parts [11] which will be explained in in coming sections.

Sections 3–6 are focused on giving details about research and making of the Brainiac's arm. Section 7 contains results obtained with the Brainiac's arm. Also, Sect. 8 provides conclusion.

3 Design of Brainiac's Arm

Robotic arms are new innovations in technology and they are used to perform different tasks in industry, military, space exploration and so on. Robotic arm is a mechanical arm that has similar functions as human arm and it is usually programmed.

The 3D printed robotic parts are taken from the InMoov project, which are open source parts designed by Gael Langevin [11].

In this paper is shown how 3D printed robotic arm can be programmed for brain controlling. The robotic arm in this project is in normal size and it is built for interaction with users (Fig. 1).

Fig. 1. 3D design of robotic arm [1]

Braniac's arm is constructed of several parts such as:

- 3D printed parts of fingers,
- a pipe and
- a bed with servo motors (Fig. 2).

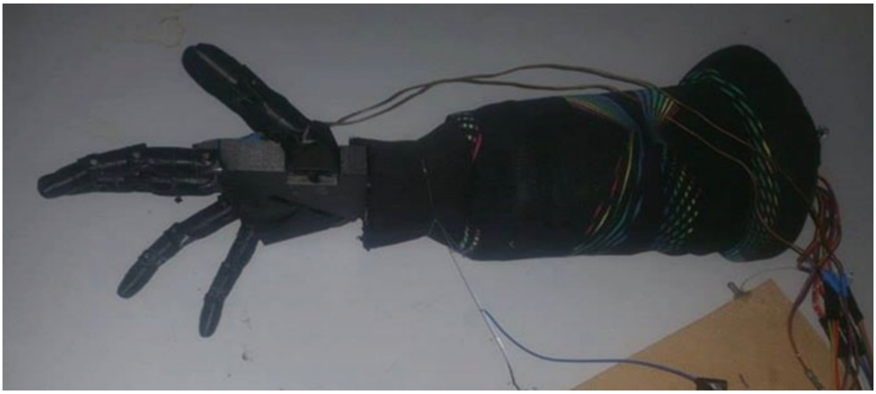

Fig. 2. Brainiac's arm

A fist of Brainiac's arm is consisting of the 3D printed finger which are together assembled. The fist is then connected to a pipe, then the pipe will be connected to the bed for servo motors (Fig. 3).

Fig. 3. A fist of Brainiac's arm

Servo motors will be connected with fingers by simple strings and they will move according to the desired direction. The bed is consisted of six servo motors where five of them will move the fingers and one servo motor will move arm up and down (Fig. 4).

Fig. 4. Positions of servo motors in the bed of Braniac's arm

4 Biomedical Signals

Biomedical signals are phenomenon that carries information relative to one or more biological systems involved. Obviously, biomedical signals can be found at different observation scales: as an example, at the level of a functional organ (heart, brain, liver, kidneys, etc.), at a system level (cardiovascular, central nervous, endocrine-metabolic systems, etc.), but also at the level of the cell or even at a subcellular level, as indicated in the previous section, as well as in higher dimension systems, as in the case of the quantitative study of morbidity, mortality, and the mechanisms of propagation of an epidemic disease inside a certain population [6].

4.1 Electroencephalograph (EEG)

An electroencephalograph (EEG) is the recorded electrical activity generated by the brain. In general, EEG is obtained using electrodes placed on the scalp with a conductive gel. In the brain, there are millions of neurons, each of which generates small electric voltage fields. The aggregate of these electric voltage fields creates an electrical reading which electrodes on the scalp are able detect and record. Therefore, EEG is the superposition of many simpler signals. The amplitude of an EEG signal typically ranges from about 1–100 uV in a normal adult, and it is approximately 10–20 mV when measured with subdural electrodes such as needle electrodes [7].

4.2 NeuroSky Mindwave Headset

NeuroSky has developed a dry sensor system for consumer applications of EEG technology. The NeuroSky system consists of dry electrodes and a specially designed electronic circuit for the dry electrodes (Fig. 5).

The Attention Meter algorithm indicates the intensity of mental "focus" or "attention". The value ranges from 0 to 100. The attention level increases when a user focuses on a single thought or an external object, and decreases when distracted. Users can observe their ability to concentrate using the algorithm [2].

Fig. 5. NeuroSky mindwave headset [8]

5 Proposed Methodology of Brainiac's Arm

The proposed hardware mechanic system consists of four modules:

- 3D printed model of Brainiac's arm
- Arduino Uno microcontroller
- Servo motors
- Bluetooth module

5.1 3D Printed Model of Brainiac's Arm

This Brainiac's arm is made almost entirely of 3D printed parts that are snapped together. The fist of Braniac's arm is assembled from the 3D printed parts. There are five fingers and each of them has six parts. Also there is a palm which is constructed of three parts by two bolts. A fishing line is pulled through these parts and the ends of these lines are connected to five servo motors whose will pull or stretch the fingers.

The index and middle finger are connected to the main part of palm; the thumb is connected to the main part of palm with a bolt. The two other parts of palm (green and purple part in Fig. 6) are connected to the main part of palm with a bolt. Then the little finger and the ring finger are connected to the other parts of palm (Fig. 7).

Fig. 6. 3D design of Brainiac's arm [3]

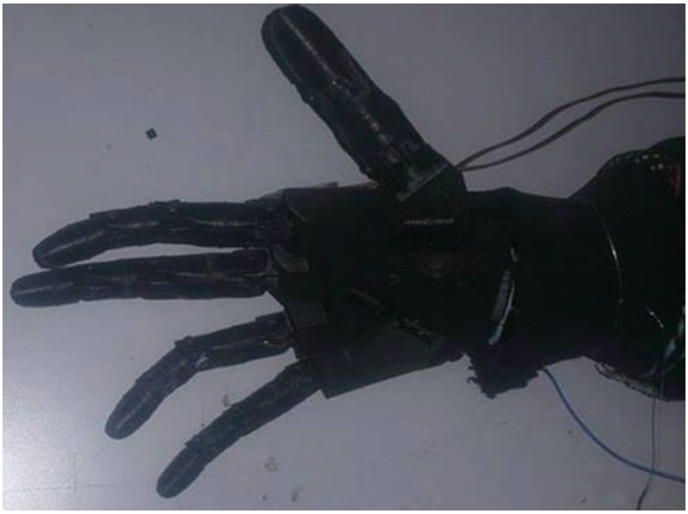

Fig. 7. 3D printed Brainiac's arm

5.2 Arduino Uno Microcontroller

Arduino is an open source microcontroller development board based on easy to use hardware and software. The Arduino Uno is a microcontroller that works on the ATmega328. The ATmega328 has 32 KB and it has 2 KB of SRAM and 1 KB of EEPROM. Arduino Uno has 14 digital input/output pins 6 of them are PWM outputs (Pulse Width Modulation, or PWM, is a way of getting analog results with digital means), 6 analog inputs, a power jack, a USB connection, a 16 MHz crystal oscillator, an ICSP header, and a reset button [4] (Fig. 8).

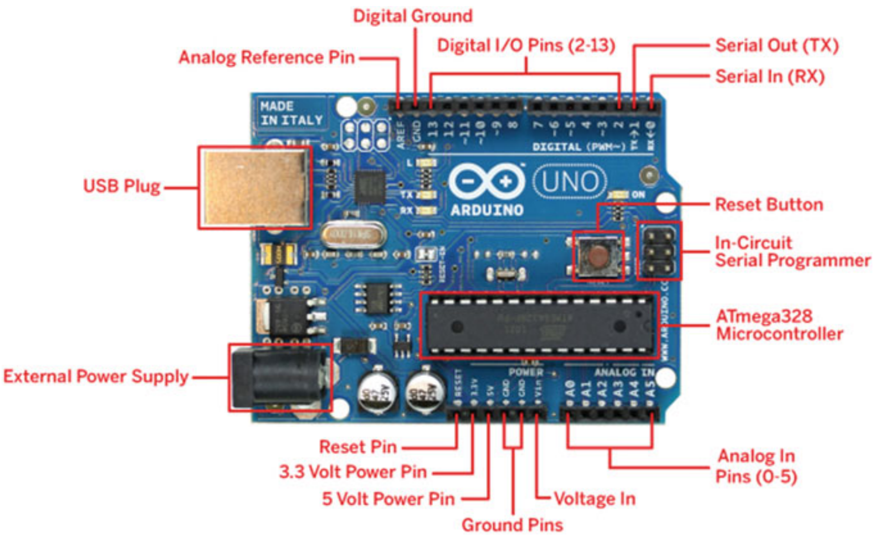

Fig. 8. Arduino uno microcontroller and its parts [5]

5.3 Servo Motors

Servo motors are not something new in technology they have been around for a long time and they are used in many applications. They are very energy efficient and they are small in size that is why they are used in many applications. They are also used to operate remote-controlled or radio-controlled an example of that are toy cars, robots and airplanes. Because of their properties servo motors are used in industrial applications, robotics, in-line manufacturing, pharmaceutics and food services [12] (Fig. 9).

5.4 Bluetooth Module

In the project Bluetooth module is used to connect with NeuroSky Mindwave headset. HC-05 is used as Bluetooth module and it's based on the Cambridge Silicon Radio BC417 2.4 GHz Bluetooth Radio chip. This is a complex chip which uses an external 8 Mbit flash memory [13] (Fig. 10).

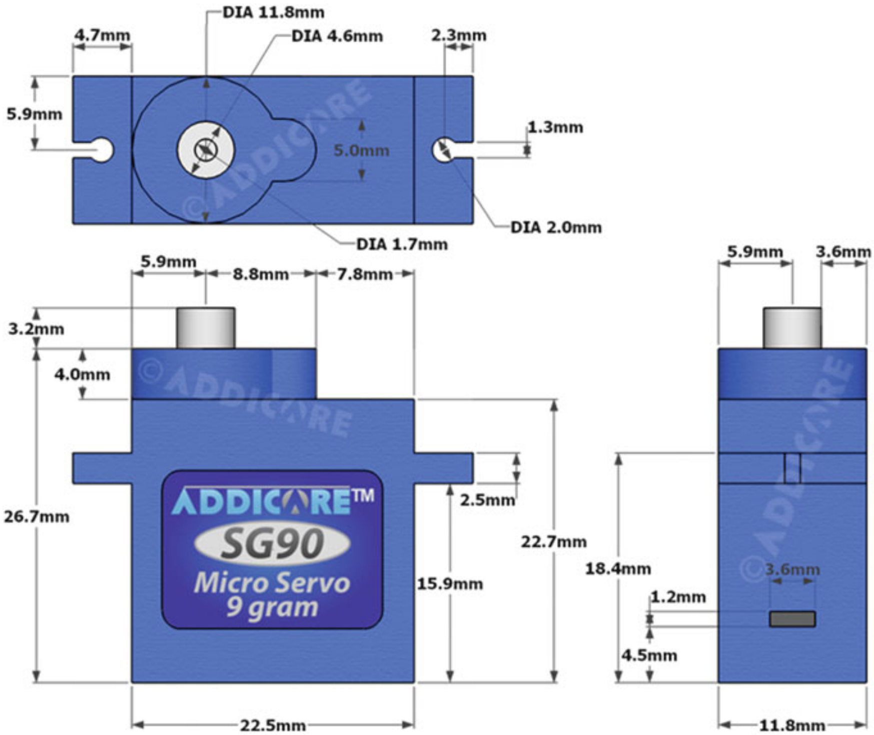

Fig. 9. MicroServo 90 servo motor and its dimensions [14]

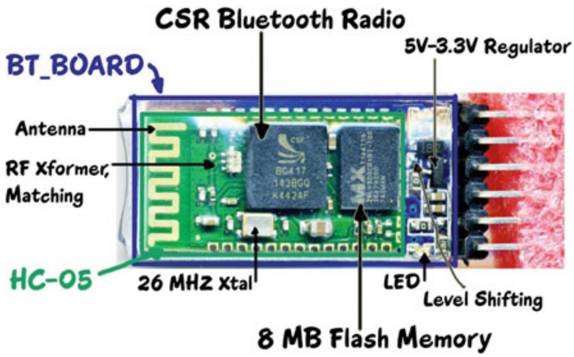

Fig. 10. HC-05 bluetooth module [15]

6 Pseudo Code and Design Flow of Braniac's Arm

6.1 Pseudo Code

Pseudo code for using robotic arm as a grabber:

```
checkBluetoothConnection();

if (connection == true)
{
        Serial.print("Connected")
        curAttention = readAttenetion();
        switch(curAttention) {
        case stage1:
                quarterCloseFist();
                break;
        case stage2:
                halfCloseFist();
                break;
        case stage3:
                threeQuartersCloseFist();
        case stage4:
                fullCloseFist();
                break;
        default:
                openFist();
                break;
        }

}
else
{
        Serial.print("Connection failed..")
        connectAgain();
}
```

6.2 Design Flow

Figure 11 describes the design flow of the Brainiac's arm. It shows a loop which shows how the fist of the arm is closing according to the measured concentration of a human brain and it never stops to work until a user turns off it.

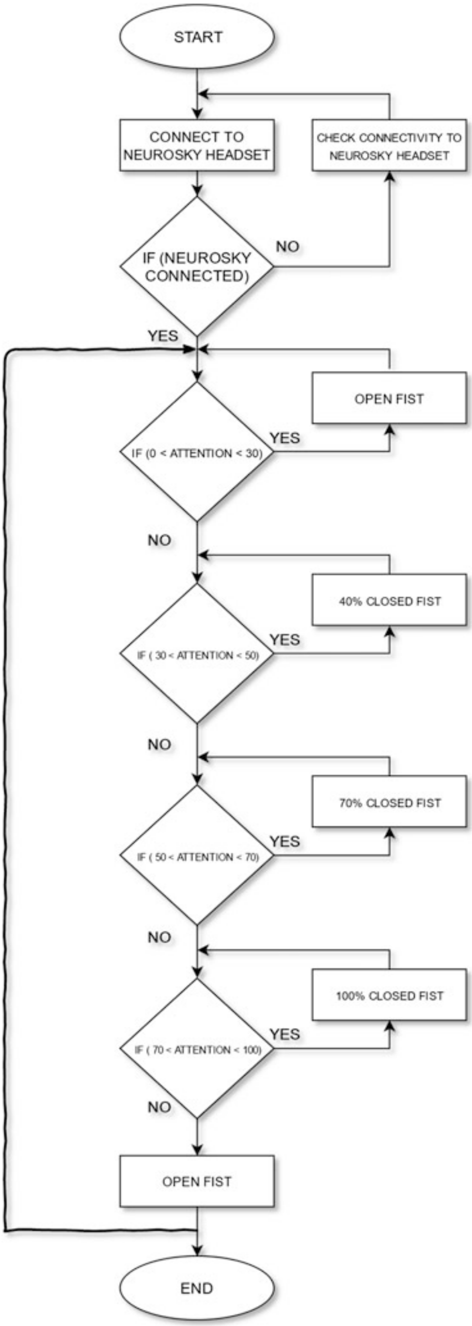

Fig. 11. NeuroSky mindwave headset

7 Results

The result is the Braniac's arm which can be controlled using brain signals in other words reading the attention of a human brain in order to move fingers of the Brainiac's arm.

As attention increases, fingers form a fist. There are four levels of attention and every level has set angles for each servo motor. The attention is measured from 0 to 100 and the angles of rotation are different for every finger which is connected on each servo motor. Index finger of Brainiac's arm will be took as an example, where the difference between stretched and bent finger is 120°.

Every level of attention has its desired position. The starting position of servo motor that is connected to index finger is 30° and when the attention is grater then 30 (it moves into second level of attention) the motor moves to 60° that is desired position for the second level of attention. For every finger, it is different so there was a need calculate the rotation of the servo motor and match the right angle with the right level of attention.

8 Conclusions

The interesting thing about Brainiac's arm is that it can be used in different fields. First of all, it can be used by people with disabilities, people who are lacking a physical body. Using brain, they can control their missing part of body [9, 10]. The advantage is that they will train their brain and attention. Similar work has been done in [9, 10] where authors used EEG signals for controlling the arm. In [9] was developed a Java Application for tracking the signals and there was given visual feedback to user. Also in the [9] force sensors are used with the arm, in our work we didn't implement force sensors. Our next stage will be the implementation of force sensors which will give us much more control of the robotic arm. The difference between our work and [9, 10] is that we used much cheaper equipment for performance of similar task. In [10] two software framework were presented in order to control a 5 degree of freedom robotic and prosthetic hand. In this paper we developed our software for the control of robotic arm. In [9, 10] EPOC headset was used for tracking brain signals, which is much better equipment than our Neurosky because it has more electrodes which means it can measure brain activity in several points whereas ours is focused on one point of human's head. If we compare our solution with the [9, 10] solutions, they have more precise results but we have simpler and cheaper solution.

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