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EEG Mind Controlled Smart Prosthetic Arm – A Comprehensive Study

Taha Beyrouthy*, Samer Al Kork, Joe Akl Korbane, Mohamed Abouelela

American University of the Middle East, Egaila, Kuwait

AYCAN BULUCU/15290146
CEREN YAVUZ/15290189
ECE GÖRKEMLİ/15290158
PELİN BÖLÜKBAŞ/15290145

BME 462 RESEARCH TECHNIQUES

Why we chose this article?

- There are some similarities and differences with our research article
- Mechanical hand control with EEG headset
- Arm and wrist movement
- XBee communication
- Smart sensors
- Different EEG type

INTRODUCTION

There are over 10 million amputees worldwide, out of which 30% are arm amputees

The most important purpose of this project is to reassign nerves and allow amputees to control their prosthetic devices by simply thinking about the action they want to perform

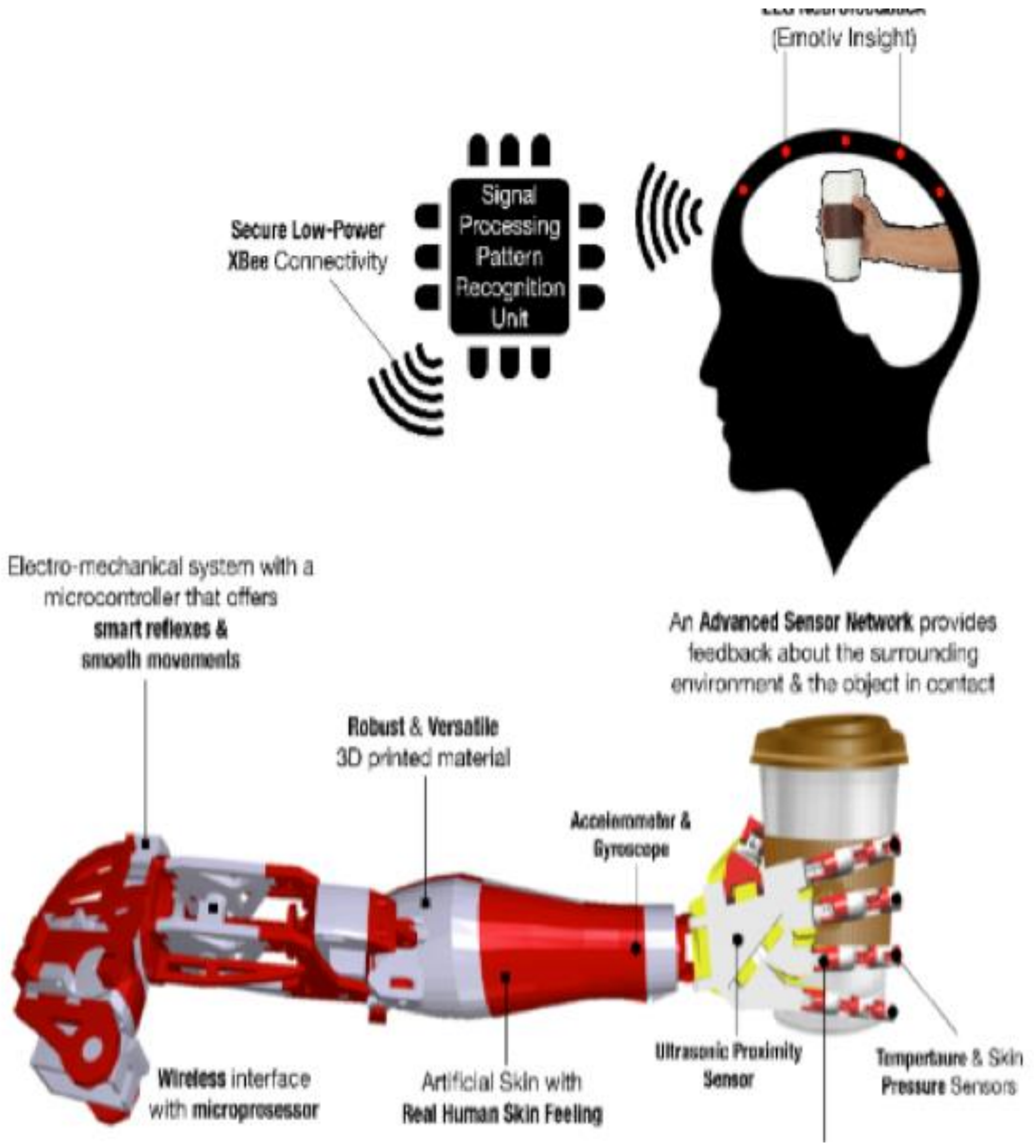
There are three most important methods of controlling robotic arms:

1. EEG device that records brain waves
2. Surgical implantation
3. Sensors to be attached to the robotic arm

COMPARISONS

Table 1. Arm Types comparison

Arm Type	Usage	Flexibility	Potential
Robotic	Using mounts	Depends on the motors, material and design	Big potential with the rise of 3D printers
Surgical	Surgically Implanted	Depends on the training and the physiotherapy	Very high especially for the war victims
Bionic	Very effective for everyday usage	Depends on how well can the processor analyze the surroundings	Good potential, especially with the microprocessor revolution
Prosthetic	Similar to the surgical limbs, but less medical attention	Very high flexibility (custom made for each person using exact measurements)	Overshadowed by the surgical and the robotic limbs
Static	No mechanical use	Not flexible	No potential



System Architecture

The proposed system is divided into 4 major units:

- 1-The Input Unit - EEG sensors
- 2- The Processing Unit - Pattern recognition
- 3- The Electro-Mechanical Unit - The arm
- 4- The Interface Unit - Smart sensor network

1. Processing Unit

The processing activity consists of two main parts:

- Pattern recognition
- Command part

2. Input Unit

In this unit, brain signals were captured by an array of advanced EEG sensors communicating with a Signal Processing Unit via Bluetooth technology

3. Electro-mechanical Unit

Every mind state was captured and encoded to represent a set of desired tasks to be performed by the arm

Due to the diversity and the complexity of brain wave activities among different humans, machine-learning techniques were required

4. Interface Unit – Smart Sensor Network

This unit is composed of a network of smart sensors, including temperature, skin pressure and ultrasonic proximity sensors etc.

The main features of this unit allow the arm to interact with and adapt to the surrounding environment

Technical Specifications

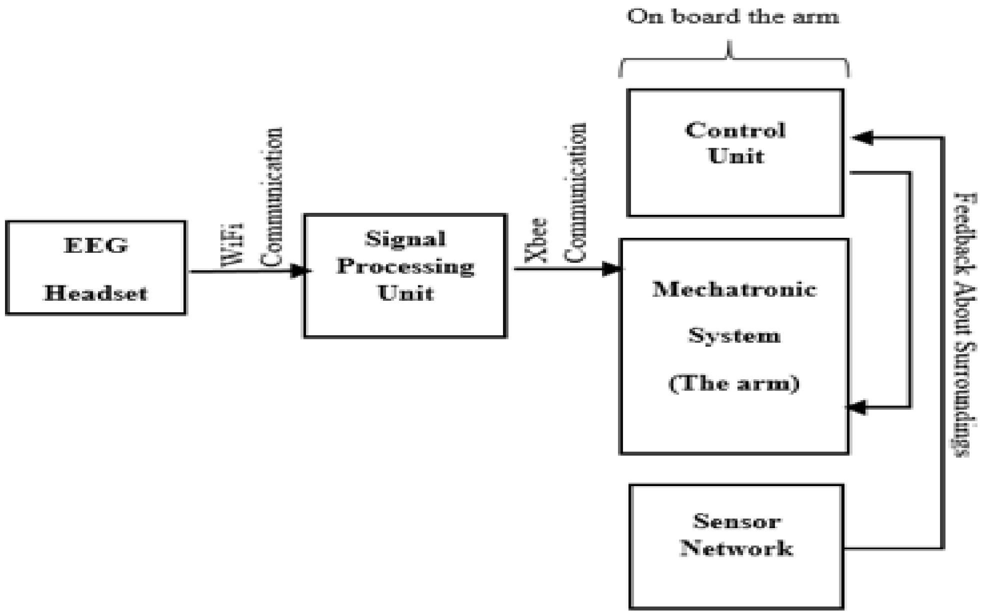


Figure 3. System overview – block diagram

- The 3D hand model was created using a material called EcoPLA
- Material can change color when exposed to heat
- One of the main features of this arm is its affordability
- The Smart Prosthetic Arm architecture was based on an electro-mechanical system controlled by EEG

The sensors included in the proposed solution can be classified in two categories:

- User-end sensors
- Environment-end sensors

Sensors providing intelligent feedback about critical condition, such as high temperature or pressure, etc.

Bi-directional communication channel setup offered the arm the ability to have smart reflexes

NUMBER	COMPONENTS
1	Processing unit
2	Emotive EEG headset
3	Embedded sensors
4	Control unit (Arduino based)
5	XBee driver

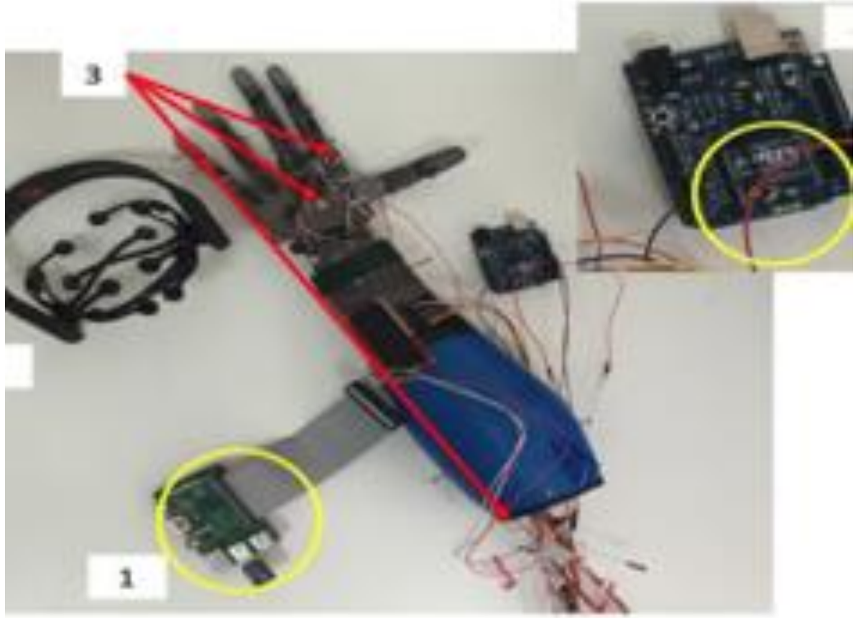


Figure 4. System overview – photo of the actual component

Testing and Results

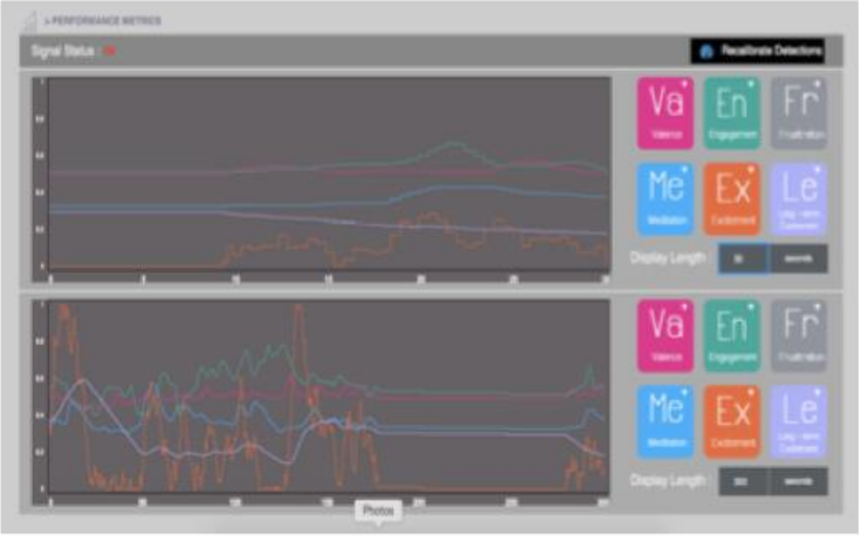


Figure 6. Different signals detected by the Emotiv headset

During the training session performed, the signals corresponding to valence, engagement, frustration, meditation, short and long-term excitement detected by the Emotiv EPOC headset for 30 and 300 seconds

A 3D cube was displayed, and a training session was available in order to guide the user to move the object

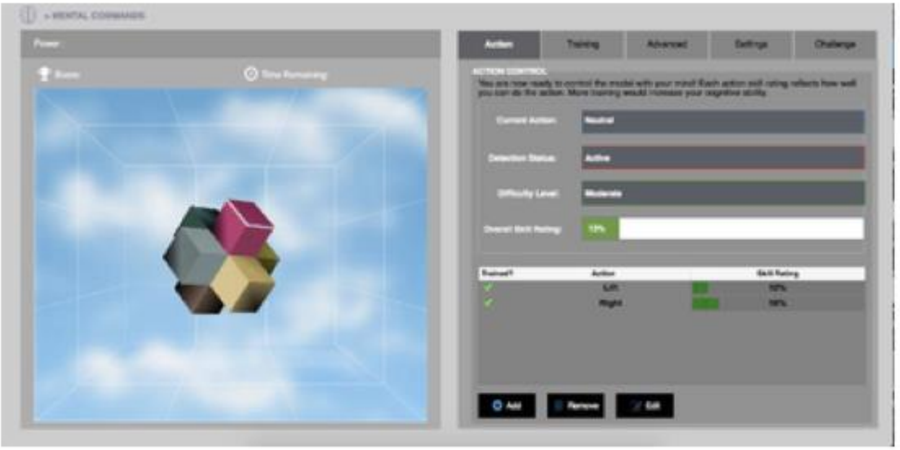


Figure 7. Training session with the 3D cube

The actions simply define the smart reflexes of the arm which can protect the user from the surrounding environment

Initially, the arm automatically checks the three sensors (pressure, IR temperature, and proximity)

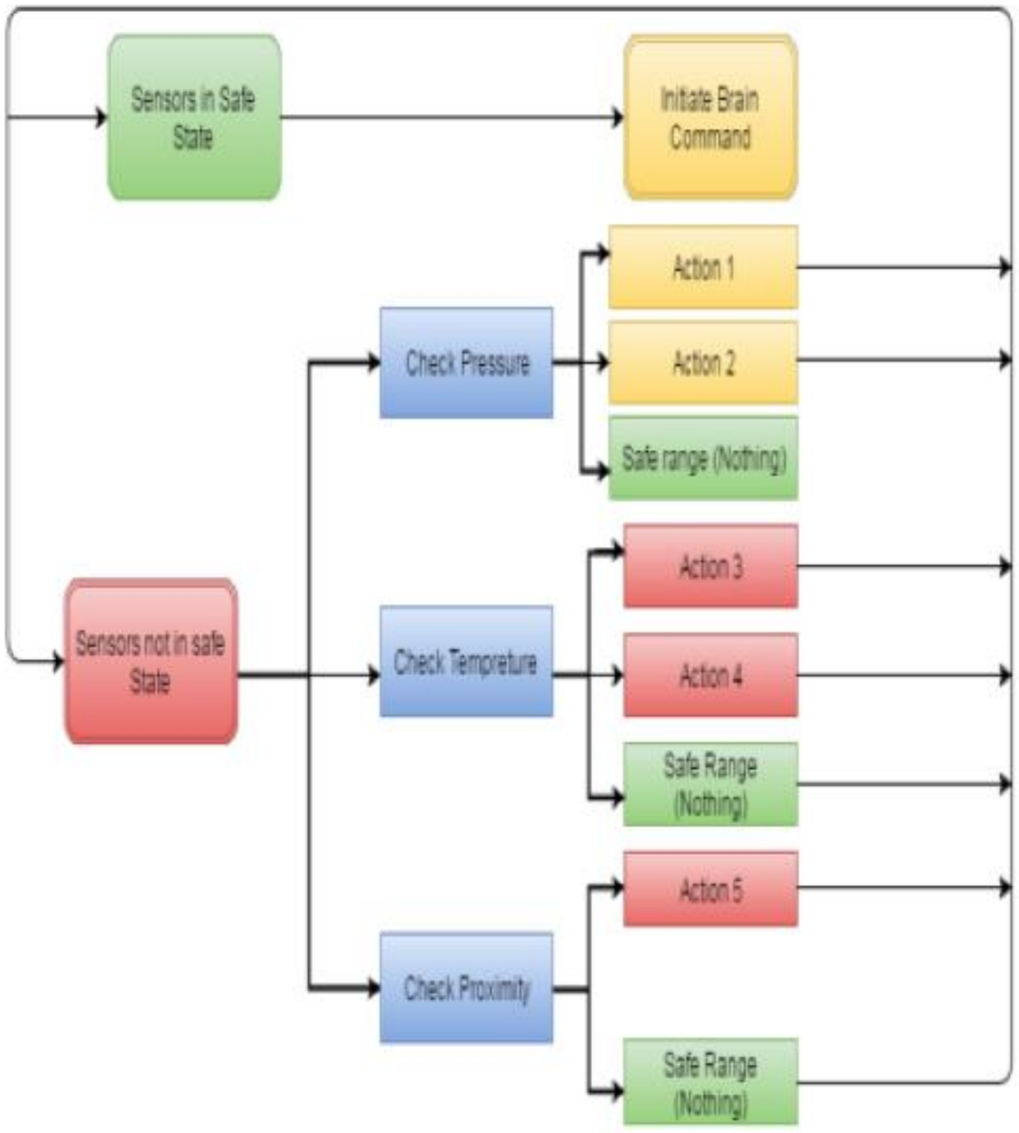


Figure 10. Flowchart of the algorithm

Conclusion

Comprehensive studies and researches emphasize the preferability of the EEG mind controlled arm in terms of cost and ease of use in the health and other fields

Based on a specific application, this smart arm can be programmed to execute a series of predefined actions, and customized with dedicated sensors, actuators and customized algorithms

Future Prospects

Patients can feel and control objects more easily with the development of prosthesis that are more suitable for social and sports activities

THANK YOU