Temporal Classification of EEG Signals for BCI Using Morse Code (LIS Case)

Haja S. Andriantsilavo[1], Nicolas R. Razafindrakoto[2], and Andriamanga Ratsimbazafy[3]
[1,2,3]Ecole Supérieure Polytechnique d'Antananarivo, Université d'Antananarivo, Madagascar
E-mail: [1]xahajas@yahoo.fr, [2]raft@nic.mg and [3]ndriamanga@gmail.com

Abstract— The lack of means of communication blocks patients with disabilities such as the Locked-In Syndrome (LIS). These persons are able to express their desire in their brain but they are unable to perform it. Here, we propose a method of temporal classification of the EEG (ElectroEncephalogram) signals from scalp of those people and translate them into Morse code. Thus, they have the ability to write a word or, furthermore, an understandable sentence by using a Brain Computer Interface (BCI). The LIS attendant will only see the letters shown on screen, not the inherent manipulations.

Keywords— BCI, EEG signals, EMOTIV INSIGHT, Morse code.

1. ELECTROENCEPHALOGRAM (EEG)

Neurons product two kinds of flow to transmit the information out of the brain. The first is chemical by exchanging ions between the inner and the outer of the cell. The second is electrical due to local current caused by the differences of electrical potential seen on the pyramidal cells.

It can be detected at the head surface after penetrating through skin, skull and several other layers. The amplitude average of this potential is about 50µV peak to peak so the electrical signal on the scalp electrodes has to be massively amplified before treated [1].

Till now, scientists found six types of brainwaves from the frequency of 0 Hz to approximately 40 Hz [1]:

- infra-low (<0.5 Hz),
- delta (0.5 Hz-4 Hz),
- theta (4 Hz-8 Hz),
- alpha (8 Hz-13 Hz),
- beta (13 Hz-38 Hz),
- gamma (38 Hz-42 Hz).

The more frequency is getting high the more people are thinking or calculating, in need of concentration. The alpha waves are predominant in EEG because they separate "eye closing" to "open eye" and concern mental coordination.

In 1958, scientists adopted the "10-20 electrode placement system". It consists on dividing the head onto proportional parts. Their name is in accordance with their place on the brain areas: F (frontal), C (central), T (temporal), P (posterior), and O (occipital).

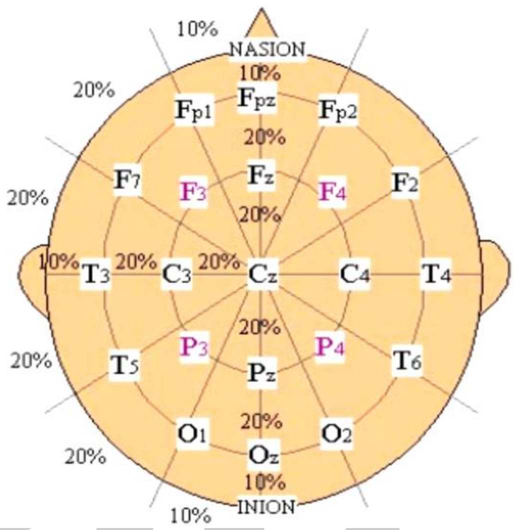

Figure 1: *10-20 electrode placement system [1]*

II. BRAIN COMPUTER INTERFACE

A Brain Computer Interface (BCI) is about all systems that relay the brain to an effector without passing through nerves and muscles [2][3][4][5]. In Jacques Vidal's paper, "Toward direct brain-computer communication", it is said that the EEG is made by signals produced by neurons in the cortex rather than made by shuffle noises [2][3].

There are six steps in formulating a BCI [6][7]:

- Taking measure (EEG)
- Pre-treating and filtering EEG signal
- Taking off its characteristic
- Classifying them
- Translate into a command
- Checking feedback

Nowadays, we only know a bit about how the brain works. However, we can already use his electrical activity to provide people with disabilities a mean to improve their life [8]. The main advantage of BCIs is that they only need cerebral activities without other information [9].

ISSN: 2582-6832

III. TEMPORAL CLASSIFICATION

Two types of phenomenon can be considered with BCI: EEG provoked by stimulations and EEG due to imaginations. We will choose the last one because imagined action has the same signature as the real action: in time, space and frequencies [9]. In this case, we will use a file of EEG signal in. edf format to simulate our program. This file was taken in https://physionet.org/physiobank/database/.

The goal is to classify the electric flow corresponding to the frequency band of beta or gamma waves into Morse code in accordance to the duration of the pulse. If it lasts longer than a threshold time, it will be considered as a dash; otherwise it is translated as a dot. Those Morse code had to be turned to letters to form a word or even a sentence that the LIS attendant can read.

First of all, we put in a configuration file the values of all thresholds: durations of dashes/dots, duration of separation between codes/letters, amplitude of silence/significant signal. We write the data path of the EEG file to translate. The program checks this file all the time to see if new information arrives to constitute another Morse code and then another letter.

After that, we run “transcription.exe”. Here is an extract from this program:

```
// log of all signals
log_array = [];
// get the value of the signal from the file
signal = get_signal();
binary_signal = 0;
if (signal > VALUE_SIGNAL_MIN)
binary_signal = 1;

// add the value to the log of the signal
log_array.push(binary_signal)

// evaluate list of signals in the log
previousValue = 0; // the value of the previous signal
signalLength = 0; // the time duration of a signal
silenceLength = 0; // the time duration of a silence
loop log_array (signal_value, index) {
    if (signal_value == 1) {
        if (previousValue == 1) {
            signalLength = signalLength + 1;
        } else {
            if (signalLength < separator_duration_min) {
                // considere the signal as a silence if it is too
short
                signalLength = silenceLength + signalLength
                // reset the silenceLength
                silenceLength = 0;
            } else {
                if (signalLength <
point_symbol_duration_min) {
                    silenceLength = silenceLength +
signalLength;
                    // reset the signalLength to 1
                    signalLength = 1;
                } else {
                    currentSymbol = '.';
                    if (signalLength >=
line_symbole_duration_min) {
                        currentSymbol = '_';
                    }
                    // the symbol to list of symbols
                    list_symbols_array.push (currentSymbol);
                    // reset log_array
                    log_array = [];
                }
            }
        }

    }
}

alphabet =
{'A','B','C','D','E','F','G','H','I','J','K','L','M','N','O','P','Q','
R','S','T','U','V','W','X','Y','Z'};
symbols_correspondance = {".-", "-...", "-.-.", "-..", ".",
"..-.", "--.", "....", "..", ".---", "-.-", ".-..", "--", "-.", "---",
".--.", "--.-", ".-.", "...", "-", "..-", "...-", ".--", "-..-", "-.--",
"--.."};
// compare all symbols from the list_symbols_array with
the symbols from the symbols_correspondance

symbols => alphabet
print alphabet
```

Board 1: *Extract from “transcription.exe”*

IV. Results

A. Results using an EEG file

We tried our program on a file named “chb01_01.edf” during one minute. The EEG signal has been high filtered at >15Hz.

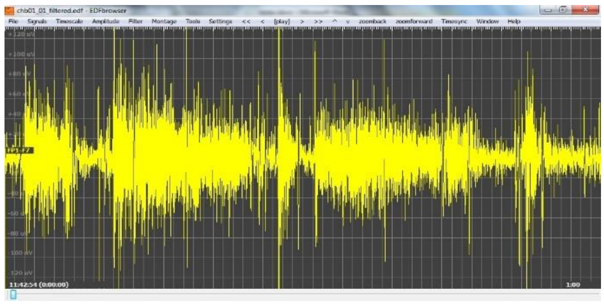

Figure 2: *The waveform of the file “chb01_01.edf”*

We choose:

- 20µV as an amplitude threshold

All rights are reserved by UIJRT.COM.

- 3s as a duration threshold between dash and dot
- and also 3s as a duration threshold between separations of Morse code and letter

The result is "-", "-.-", "." which correspond to "TKE"

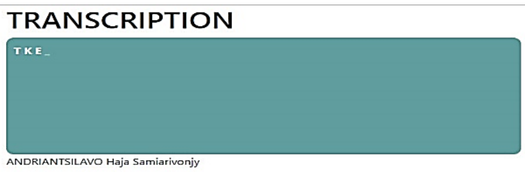

Figure 3: *Transcription of "chb01_01.edf"*

For the file "chb02_01.edf", taken during one minute, we use:

- 40µV for the amplitude threshold
- Less than 10s for dots
- Less than 3s for Morse code separation

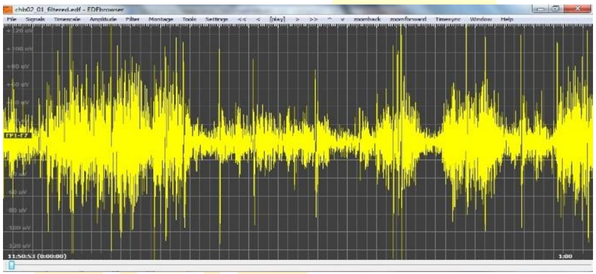

Figure 4: *The waveform of the file "chb02_01.edf"*

The result is "-", "..", ".": corresponding to "TIE"

Figure 5: *Transcription of "chb02_01.edf"*

B. Results using an EEG signal picked up from a real person

Using the EMOTIV INSIGHT device with 5 sensors for our test, we called the interface « WHAT'S ON YOUR MIND » to illustrate that there's no need to interact within other part of the body but just the mind.

We proceeded as follows:

- With the CORTEX software that comes with the helmet, we measured the maximum length of concentration of a person, to automatically parameterize the duration of the dots and dashes
- After having obtained this parameter, the user interface subdivides this duration into 4 parts. A gauge will evolve along the bar measuring the concentration of the individual
- The first part (in blue) is not significant, made for passing reflections that are not necessarily to formulate any word
- The second part (in green) represents an initialization of the writing intention, if the user's concentration time does not exceed the limit of this bar, a dot will be displayed in the results space
- The third part (in yellow) will be translated as a dash, i.e. if the concentration is long enough to reach this bar, it is as if the user had wanted to write a dash
- The last part (in red) is dedicated to the delete function, if it is just reached, the last symbol is deleted, if it is maintained until the end the last letter will be deleted
- Each symbol will be displayed after returning to the blue area and the symbols will be transcribed into letters as soon as the gauge no longer detects concentration activity.

If the compound symbols do not correspond to any letter, a star will appear in the result area.

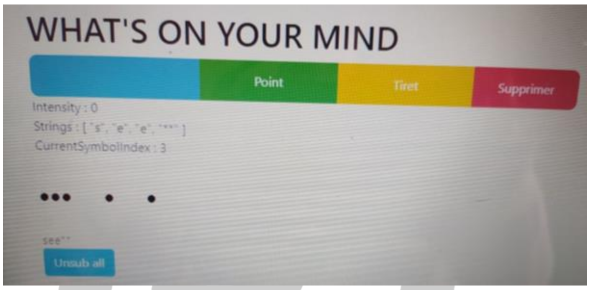

Figure 6: *writing "see"*

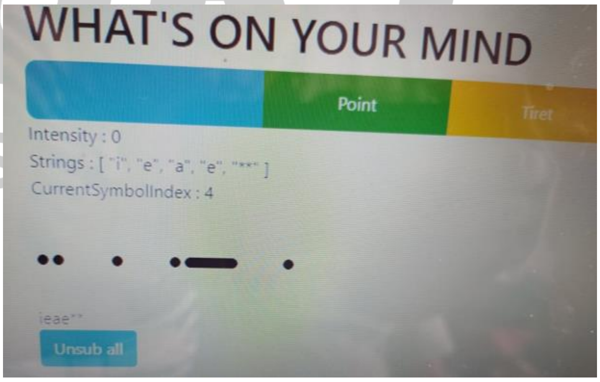

Figure 7: *writing some vowels*

V. CONCLUSION

In this paper we took any file to illustrate the fact that we can classify the EEG signal within his temporal wave and we tried it on an EEG signal picked up from a person willing to write and having the instructions made for it (in our case it's a Morse code). Configurations are adapted during the learning phase so that transcription passes easily. The acquisition phase is done by INSIGHT cask. We notice that fatigue occurs after a few attempts, which is why it is best to limit the number of words to be written at first and to add more little by little. We can foresee a proposal of usual words by intelligent completion to familiarize the user with the process.

All rights are reserved by **UIJRT.COM.**

REFERENCES

[1] M. Teplan, “Fundamentals of eeg measurement”, MEASUREMENT SCIENCE REVIEW, Volume 2, Section 2, 2002

[2] A. Barachant, “Commande robuste d’un effecteur par une interface cerveau-machine EEG asynchrone”, thesis, march 28th 2012, Université de Grenoble.

[3] “L’interface cerveau-machine ou "agir par la pensée"”, INSERM.

[4] J. Fruitet, “Interfaces Cerveau-Machines basées sur l'imagination de mouvements brefs : vers des boutons contrôlés par la pensée”, thesis, july 4th 2012, Université de Nice.

[5] F. Lotte, “Les Interfaces Cerveau-Ordinateur : Conception et Utilisation en Réalité Virtuelle”, Revue Technique et Science Informatiques, Hermes, 2012.

[6] A. Lécuyer, C.Blonz, “OpenViBE : un logiciel pour les interfaces cerveau-ordinateur”, Interstices, may 13th 2009.

[7] A. Lécuyer, “Commander “par la pensée” avec les interfaces cerveau-ordinateur?”

[8] J. Dumoulin, “GERBIL Gesture Recognition using a Brain Lightweight Headset”, thesis, February 11th 2011, Hochschule für technick und Architektur Freiburg.

[9] M. Congedo, C. Jutten, “Quand le cerveau parle aux machines”, DocSciences n°13 Informatique et médecine, INRIA, july 4th 2011.

UIJRT
ISSN: 2582-6832