TEMPORAL CLASSIFICATION OF EEG SIGNALS FOR BCI USE

Haja Samiarivonjy Andriantsilavo[1], Nicolas Raft Razafindrakoto[2], Andriamanga Ratsimbazafy[3], Tahina Ezéchiel Rakotondraina[4]

[1] Assistant lecturer, Ecole Doctorale Modélisation-Informatique (EDMI), University of Fianarantsoa, Fianarantsoa, Madagascar
[2] Professor, Ecole Doctorale Modélisation-Informatique (EDMI), University of Fianarantsoa, Fianarantsoa, Madagascar
[3] PhD University Lecturer, Ecole Doctorale Modélisation-Informatique (EDMI), University of Fianarantsoa, Fianarantsoa, Madagascar
[4] PhD University Lecturer, Ecole Supérieure Polytechnique d'Antananarivo (ESPA), University of Antananarivo, Antananarivo, Madagascar

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 EEG signals must be pre-processed and filtered: only frequency band corresponding to brain activity will be retained. The LIS attendant will only see the letters shown on screen, not the inherent manipulations.

Keyword: *- BCI, EEG signals, Morse code, algorithm.*

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).

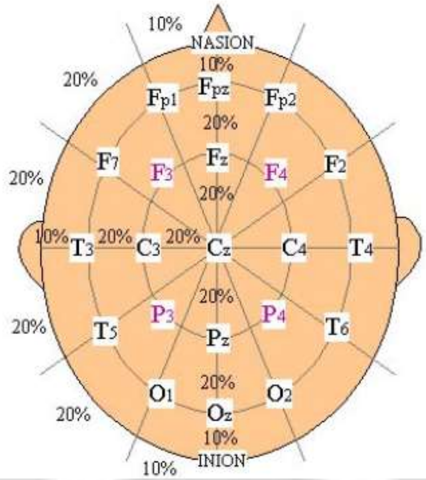

Fig -1: 10-20 electrode placement system.

2. 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].

3. 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].

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.

Here is an extract from the 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
```

Fig -2: Extract of the transcription program.

4. RESULTS AND DISCUSSIONS

We tried our program on a signal during one minute. The EEG signal has been high filtered at >15Hz.

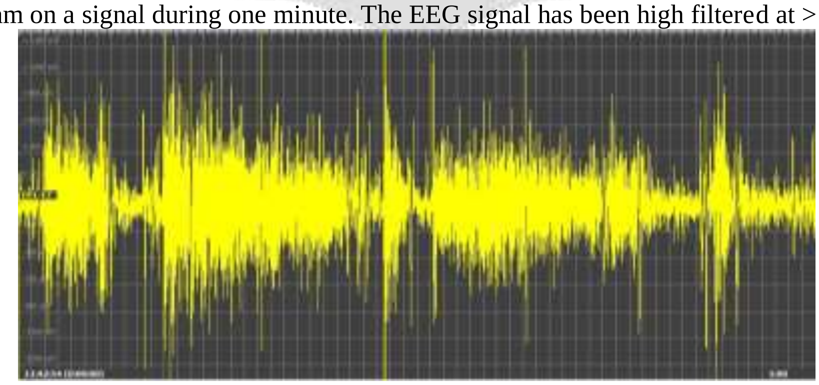

Fig -3: The waveform of the signal from the EEG.

We choose:

- 20µV as an amplitude threshold because significant signals are almost less than 40µV as we see on the waveform
- 3s as a duration threshold between dashes and dots (a dot for less than 3s, a dash for more than 3s of signal coded "1")
- and also 3s as a duration threshold between separations of Morse code and letter (separation between Morse symbols if less than 3s, separation of characters if more than 3s)

With that signal we get "-", "-.-", "." which correspond to "TKE"

Fig -4: Transcription of the signal.

For the second test taken during one minute too, we use:

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

Fig -5: The waveform of the second test.

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

Fig -6: Transcription of the signal for the second test.

Threshold for amplitude depends on the concentration of the person who's testing the transcription. The duration of dots and dash, separation and silence must be readjusted from the experience.
For further research, it is possible to filter the signal so as to avoid noises caused by sampling errors

5. CONCLUSIONS

In this paper we took any EEG signal to illustrate the fact that we can classify them within their temporal wave. By using an EEG signal, picked up from a person willing to write and having the instructions made for it, configurations will be adapted during the learning phase so that transcription passes easily. The acquisition phase is here, done by EPOC cask. This step of the study consists on testing on a person and making him learn how to manipulate the program to write and then communicate with only his mind.

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