A PORTABLE DEVICE FOR ALERTNESS DETECTION

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Abstract –**Our aim is to conceive a tool that permits to characterize the levels of vigilance of vehicle drivers by recording in real time the physiological signal variation. The adopted way consists in developing a portable device composed of two parts: the first is analogical for signal shaping and the second is a numerical part. The latter is built up around a DSP (TMS320C31) which ensures signal acquisition from analogue/digital converters, storage, real time treatment and display decision. In this support we implemented an algorithms that permits the treatment and the hypovigilance detection. We are currently studying the implementation of a decision algorithm, according to a data base of 12 files of 24 hour- EEG registered in volunteers. We are studying variations of alpha, beta, theta and delta waves of the EEG in order to define decision levels about transitions of a vigilance state to another.**

I. INTRODUCTION

Our research has as objective to take a correlation between the state of vigilance and variations of the EEG signal. This information must be extracted with minimum data to be able to use it in the realisation of a portable hypovigilance detection tools for drivers.

The first stage in our approach, consisted in extracting this correlation based on 24 hours EEG recorded by 4 derivations on volunteers and scores of the vigilance level defined by the subject himself.

The second stage consisted in developing an algorithm, based on these data, to detect vigilance level. On the third stage, our goal consists in implementing the algorithm of classification on a programmable support, in our case we choose to work with a DSP TMS 320C31 of the family Texas Instrument with floating point

II. MATERIALS AND METHODS

A. The electroencephalogram: EEG

The EEG signal is characterised by a weak amplitude (some micro-volts). It is the extra-cellular current created by the cerebral electric activity.

For the electroencephalogram record, we use surface electrodes placed in the very definite places of the scalp, one usually uses some bipolar installations in transverse or longitudinal disposition. The amplitude of the signal varies between 10 μV and 100 μV and the top frequency of the signal is about 40 Hz.

In practice, four bands of frequency for the spontaneous activity are distinguished:

- The delta wave (0,5 Hz to 4 Hz).
- The têta wave (4 Hz to 8 Hz).
- The alpha wave (8 Hz to 12 Hz).
- The bêta wave (12 Hz to 25 Hz).

This distinction of the four waves frequency forming the EEG signal, leads us to use a spectral analysis for alertness detection.

B. The data base:

It is formed by 12 files of EEG recorded on 5 subjects (Every subject has at least corresponding 2 files). The acquisition of the EEG has been made by a holter on the magnetic cassettes in the same conditions. The EEG signals are recorded during 24 hours with a frequency of sampling of 128 Hz for every way.

C. The treatment algorithms:

For a better follow-up and a good analysis of the variation of the different components of the EEG signal, we start with a spectral analysis of this physiological signal using a Fast Fourier Transformation (FFT) on 512 points filtered with a hamming window to eliminate the side effects. This implies a 4 seconds maximal width of the EEG signal sampling (512 samples/128 Hz). We used a Short Time of Fourier Transformation (STFT)[1]to remedy to the limitations of FFT and to introduce a dependence of the spectre related to the time. STFT is based on pondering the signal by a window localised around one instant t, then to analyze it by FFT. The result is a representation of the local spectral content of the EEG signal

$$STFT_x(t,f)=\int x(s)\, h_{t,f}^*(s)ds$$
$$=\int x(s)\, h^*(s-t)\, e^{-j2\Pi fs}ds$$

$h_{t,f}(s)$ is called atom time-frequency, it is equal to :

$$h(s-t)\, e^{-j2\Pi fs}$$

Atoms time-frequency $h_{t,f}(s)$ are all derived of window h(t) by the temporal and frequencies translation. In our case h(t) is a hamming window.

The temporal and frequencies resolutions of the STFT depend on the size of window. For a chosen window, the resolution is constant for all frequencies and all time. For a possible resolution improvement, a reduction of the size of the window is necessary, this is consequently going to degrade frequencies resolution and vice versa.

The second part of our algorithm consists of eliminating the fluctuations of the basis line. In the third part, in order to quantify the vigilance states, we conceive an algorithm of self-organisation based on Kohonen model [2]. This model, inspired by the cortical vertebrate organisation, have been proposed in the 70's, by Sieve Der Malsburg and than by Kohonen.

This model of self-organisation have as objective to present some complex data with a great component of noise in a discreet space with 1, 2 or 3 topology dimensions. It belongs to the class of competitive networks.

Every neurone of the output layer is activated for an entrance data. This competition between neurones is achieved by the inhibitory lateral connections.

In this work we describe two dimensions network. Every N_k neurone is connected to n entrances through n plastic connections with a respective weight w_s. Also lateral exciter connections exist, with a weak weight in a near neighbourhood.

For this network type, it is necessary to apply a rule of training, that treats modifications of external connection weights. The rule proposed by Kohonen is achieved in two stages:

- Selection of the neurone that will correspond to a type of entrance data signal.
- Increase of this neurone activation and that of the neighbourhood neurones, when this signal of entrance is presented. That leads to increase the correspondence between the neurone selected and its neighbourhood with the signal of entrance considered.

For our application, we used a model including 4 entrances that correspond to the percentage of the spectral amplitudes of the 4 bands of frequency that forms the EEG signal: [% = (the spectral amplitude of a band * 100)/(The sum of all the spectral amplitudes)].

The output of the network is formed by a number of neurones that spread between 4 and 6 in order to be able to estimate the performances and the reliability of results.

D. Material implementation

The system is structured around a DSP TMS 320C31 of the family Texas Instrument, this system is interfaced with a PC compatible IBM through ISA Bus via the FIFO's memory (4 KS * 9bits). The latter's are used to transfer data of the PC toward DSP and from the DSP toward the PC in the fastest way (Fig. 5.)

The controller of the DMA channel of the DSP is a programmable peripheral, that permits a blocks transfer of data in any site in the memory without resorting the CPU operations.

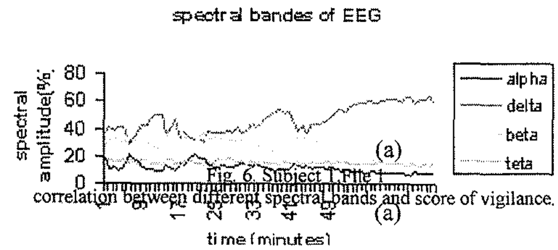
III RESULTS

We used our system for characterisation of the different state of vigilance in each 24 hours EEG recorded. We worked with portions that correspond to states of transitions awakening - sleep. These portions are fixed from scores of subjective vigilance of the subject and that correspond to 30 minutes before the sleep and 30 minutes after the sleep.

Figures 1 and 2 show the results obtained with two acquisitions for the same volunteer. The output layer of the network is formed by 4 neurones. Figures 3 and 6 presents results, with the same two files, with 6 output neurones.

IV. DISCUSSION AND PERSPECTIVES:

We have developed, implemented and tested an algorithm based on Kohonen artificial neural networks. The first results show the reliability of our device. The algorithm developed leads us to have an idea about the correlation between the score of vigilance and the percentage of the different spectral band. There is a negative correlation between scores of vigilance and the percentage of the delta band and a positive correlation between scores of vigilance and the others percentage of the



score of vigilance (transition awakening - sleep) for 6 output neurones.

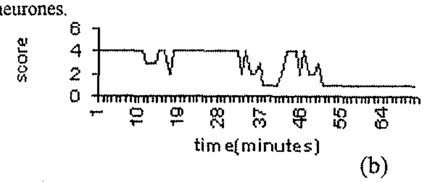


Fig. 1. Subject 1,File 1

(a) The percentage of the spectral bands of EEG signal (transition awakening - sleep).
(b) score of vigilance (transition awakening - sleep) for 4 output neurones.

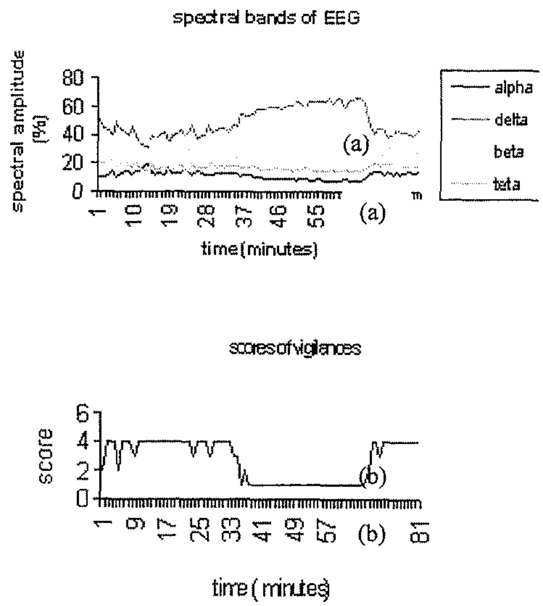


Fig. 2. Subject 1,File 2

(a) The percentage of the spectral bands of EEG signal (transition awakening - sleep).
(b) score of vigilance (transition awakening - sleep) for 4 output neurones.

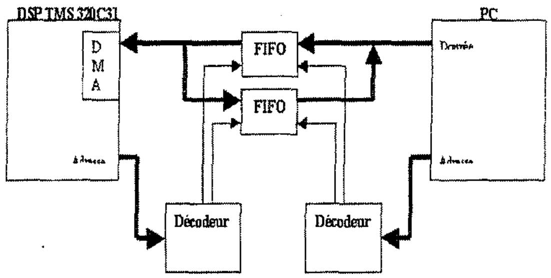


Fig. 5. Block diagram of hardware

spectral bands of the EEG signal (theta, alpha and beta) Fig.6. These encouraging results urge us to ameliorate the algorithm and to improve our device in order to obtain a portable system for a real time hypovigilance detection.

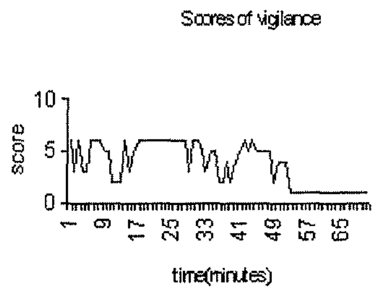


Fig. 3. Subject 1,File 1

score of vigilance (transition awakening - sleep) for 6 output neurones.

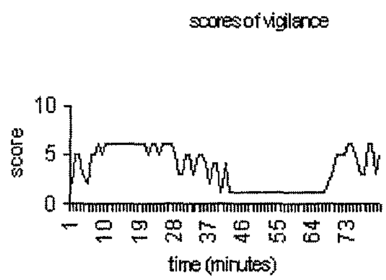


Fig. 4. Subject 1,File 2

score of vigilance (transition awakening - sleep) for 6 output neurones.

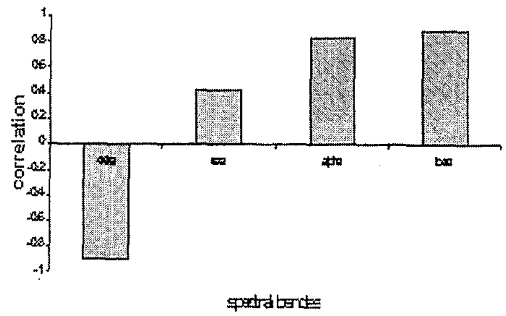


Fig. 6. Subject 1,File 1
correlation between different spectral bands and score of vigilance.

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