An approach to emotion recognition in single-channel EEG signals using Discrete Wavelet Transform

Alejandro Gómez, *Student Member, IEEE,*[1] , Lucia Quintero, *Member, IEEE,*[1]
Natalia López, *Member, IEEE,*[2] Jaime Castro,[3] and Luisa F. Villa[4]

[1] Mathematical Modeling Research Group, GRIMMAT, Universidad EAFIT, [2] Medical Technology Laboratory, GATEME, Universidad Nacional de San Juan. [3] Psychology, Education and Culture Research Group, Institución Universitaria Politécnico Grancolombiano , [4] System Engineering Research Group, ARKADIUS, Universidad de Medellín

In this work, we perform an approach to emotion recognition from Electroencephalography (EEG) single channel signals extracted in four (4) mother-child dyads experiment in developmental psychology. Single channel EEG signals are decomposed by several types of wavelets and each subsignal are processed using several window sizes by performing a statistical analysis. Finally, a neural network obtained an average accuracy rate of 98% of classification in two emotional states such as happiness and sadness.

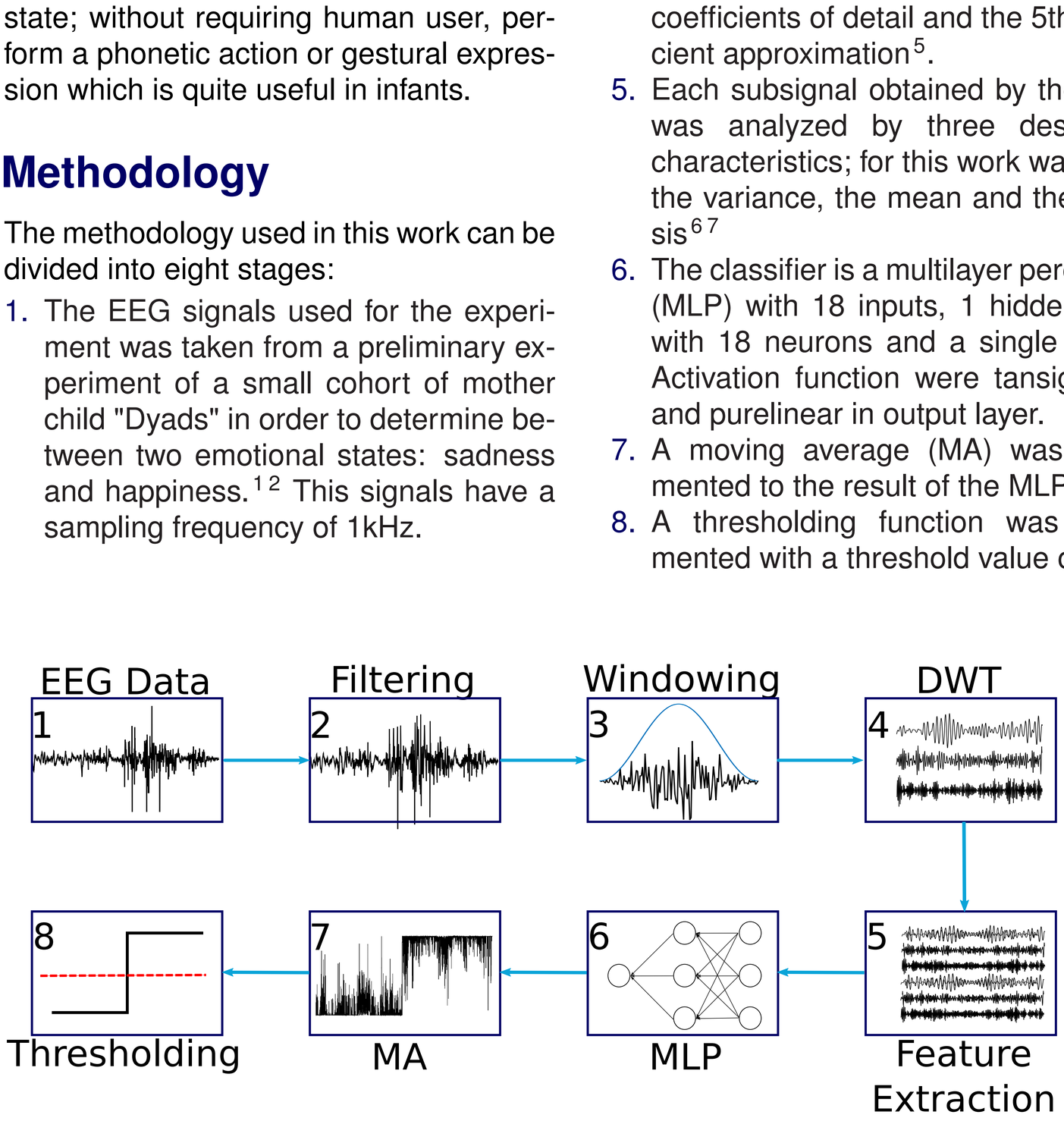
Introduction

A different approach that has been studied in recent years for detection of emotional states is by analyzing the electroencephalographic signals, these signals being the interaction between neurons when an action or a thought happen, in this case when an emotional state is given. Detect emotions using EEG signals is very important, because these signals are directly related to brain activity, allowing a mapping from emotional states to the different areas of neuronal activity. This can allow psychologists validate or determine emotional states, or allowing a system of artificial intelligence that decisions taken in front of a human user's emotional state; without requiring human user, perform a phonetic action or gestural expression which is quite useful in infants.

Methodology

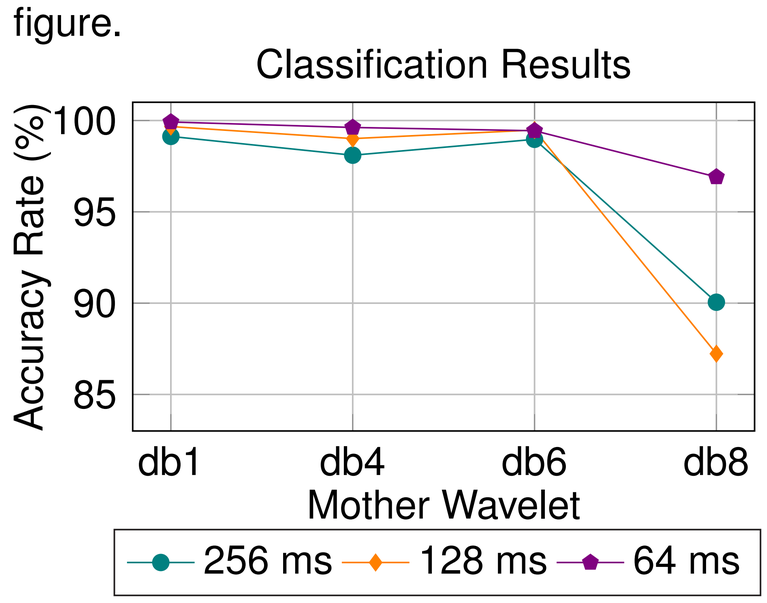
The methodology used in this work can be divided into eight stages:

1. The EEG signals used for the experiment was taken from a preliminary experiment of a small cohort of mother child "Dyads" in order to determine between two emotional states: sadness and happiness.[1 2] This signals have a sampling frequency of 1kHz.
2. Several studies report a range for the detection of emotions in EEG signals in the range of 0.5Hz to 70Hz[3 4],therefore a filtering process was implemented, three IIR filters of 10^{th} order with a Butterworth response: a high pass at 0.5Hz, a low pass at 70Hz and a notch 60Hz.
3. A windowing process is implemented with a Hanning window, an overlap of 50% was done, and three window sizes: 254ms, 128ms and 64ms.
4. Each fragment of the signal was decomposed using the Discrete Wavelet Transform (DWT) with the wavelet db1, db4, db6 and db8 at 5 levels with the 5 coefficients of detail and the 5th coefficient approximation[5].
5. Each subsignal obtained by the DWT, was analyzed by three descriptive characteristics; for this work was taken the variance, the mean and the kurtosis[6 7]
6. The classifier is a multilayer perceptron (MLP) with 18 inputs, 1 hidden layer, with 18 neurons and a single output. Activation function were tansigmoidal and purelinear in output layer.
7. A moving average (MA) was implemented to the result of the MLP.
8. A thresholding function was implemented with a threshold value of 0.5.



Results

The emotion detection of sadness and happiness was performed with 3 different sizes of windows and 4 different wavelet decomposition types, the results for the classifying process are in the following figure.



It may be noted that in general a bigger sizes of windows the percentage of accuracy is smaller, and the worst result correspond to the Wavelet db8.

Conclusion

The detection between the happiness and sadness emotional state, is possible through an analysis of a single channel of EEG. The effect of window size was evaluated, indicating that it is important but stable. Allowing the selection of larger window sizes to reduce computational costs. This analysis can be used to study the mental mappings during the mother-child dyads interactions.

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