Learning to decode human emotions

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Affective Computing (AC) is a research field that aims to automatically detect and quantify human emotions. Mainstream techniques for affect detection are voice or facial expressions, text, body posture or language. Affective Neuroscience is a recent AC approach that attempts to find the neural correlates between human emotions and the brain activity registered by Electroencephalography (EEG). Learning to decode human emotions (Fig.1) across multiple subjects is a challenging problem due to the high EEG variability between individuals.

In the present work we developed a new deep learning algorithm, Echo State Network (ESN) with Intrinsic Plasticity, as a general framework for extracting the most relevant AC discriminative features. ESN belongs to the class of recurrent neural networks where the parameters of the hidden recurrent layer (called reservoir) are generated randomly and only the ESN output parameters (the readout) are trained. This ESN property speeds up the model training however there is a risk to become unstable. We applied the biologically inspired adaptation rule Intrinsic Plasticity (IP) to guarantee the reservoir parameters tend to equilibrium states and observed that these states are concentrated in different regions depending on the inputs. If two input vectors are close in the input space, they will result in close equilibrium points in the reservoir state. These findings defined the feature selection approach: the EEG recordings are mapped into the reservoir equilibrium states. The dominant features are extracted iteratively from low dimensional combinations of these states. The proposed ESN-based software sensor was demonstrated for detecting the positive and negative valence of human emotions across individuals.

AC systems (Fig.2) are useful for brain studies, psychology research and clinical applications as a complement to other statistical methods. This work is part of a joint project that involves researchers from University of Aveiro, Technical University of Sofia and Bulgarian Academy of Sciences.

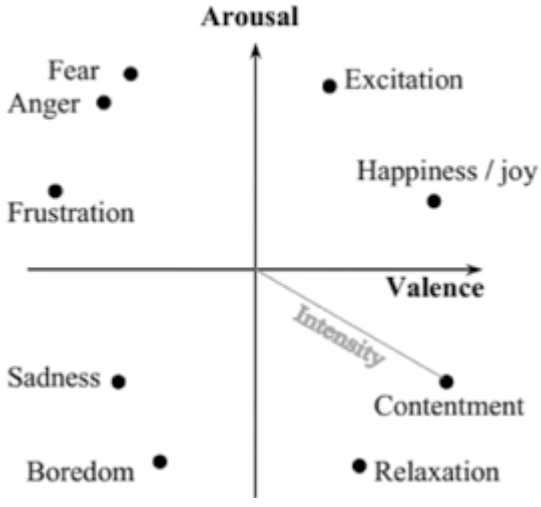

FIGURE 1
Human emotions in valence-arousal space.

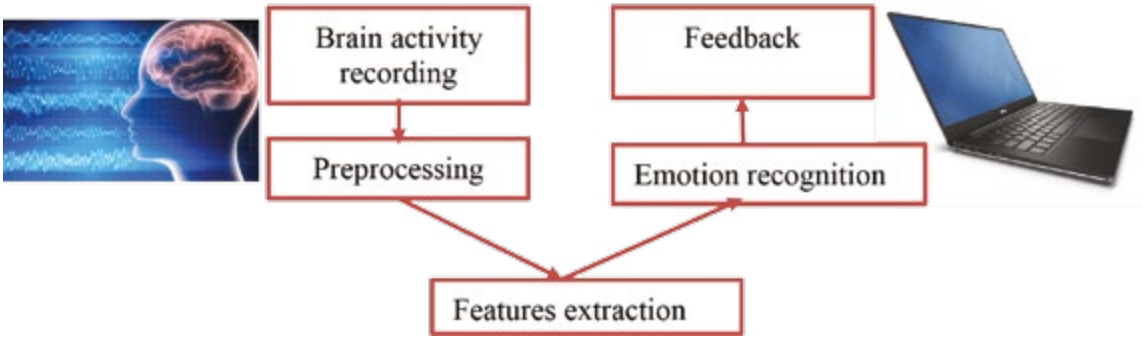

FIGURE 2
Emotion decoding architecture.