Deep Learning: An EEG-based Study of Cognitive Functions and Human Emotions

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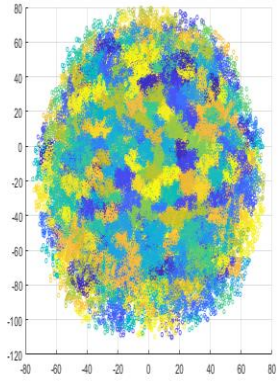
Statement of the problem: Using the Deep Learning (DL) techniques, develop a method of mapping the real-time EEG data onto the clusters of activated cortex neurons – the *DL-EEG tomography.*

The clusters identified as activated, then, can be associated with certain emotions and even meanings of thoughts. Thus, the DL-EEG tomography leads to real time objective discovery of human emotions and cognitive actions. The method of *ad hoc* interpretation of EEG signals is expected to enhance the effectiveness of medical studies and educational technologies.

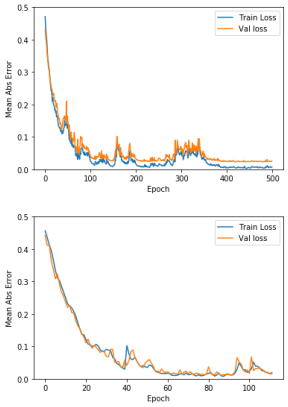


Here is the approach developed in this project: An activation model for a statistical set of neurons and their clusters is assumed. A set of multiple realizations of the activation process is produced and the calculated EEG potentials are collected (a forward model). The collected data now are used to solve the 3D *inverse* problem to find the neuron clusters being most likely activated to produce a given set of EEG data (a backward model).

A model example: A clusterized cortex (100,000 neurons agglomerated into 1024 clusters)

A method of solving large scale 3D inverse problems by using the Deep Learning technique was developed and studied. The method is applied to the cases when the empirical data is absent while some forward-feeding models may exist. These models are used to create an appropriate dataset for training the Deep Artificial Neural Network. Both continuous and discrete (binary value) domains are considered in the ill-posed problem's solution.

The proposed technique is based on regularization using the Hamming norm which leads to a solution presented as the set of clusters. The method was applied to Low Resolution Brain Tomography based on the EEG signals.



Examples of the TensorFlow ANN implementation are given. The numerical experiments with the proposed DL-EEG tomography showed the 90% accuracy of clusters prediction for a given set of the EEG data. The theoretical study has been complemented with other forms of Deep Learning analysis applied to the experimental dataset DEAP.

DL-EEG Training and Validation

Reference

R. Tankelevich (2019) Inverse Problem's Solution Using Deep Learning: An EEG-based Study of Brain Activity. Part 1, Research Gate, Preprint.