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Implementation of existing model for Autism Spectrum Disorder detection in fMRI scans from ABIDE dataset

Purpose of this project

With the development of digital health technologies, artificial intelligence is being applied in diagnostic processes of various medical conditions. Most popular would be applying machine learning models to detect cancer or COVID-19, but there are psychological or psychiatric disorders diagnosis of which could also benefit from emerging technologies. This research is about building deep learning models to assist professionals in the process of diagnosing Autism Spectrum Disorder (ASD).

Autism is a developmental disorder characterised by difficulties with social interaction and communication, and by restricted and repetitive behavior. Diagnostic process in ASD is currently entirely based on behavioural observations and psychological and psychiatric interviews. This makes it prone to being undiagnosed or misdiagnosed and people would receive support and treatment unfitted to their condition.

This project utilizes concepts from Yang, T, & Zhang: *A Deep Neural Network Study of the ABIDE Repository on Autism Spectrum Classification*. [1] They propose a network which reaches around 70% of accuracy, this is the average maximum result obtained by most researchers trying to apply deep learning on the ABIDE dataset. I will try to reproduce given accuracy with a use of different ROI atlas and a different correlation measure.

Neurocognitive basis

There are known differences in brain activity between autistic and neurotypical (non-autistic) subjects. These differences present themselves during the so-called resting state - in laboratory environment - resting state fMRI, that is when the study participant has a task of doing nothing, thinking about nothing or thinking freely. Functional connectivity is calculated by measuring the co-activation level of rs-fMRI time-series between anatomically separated brain regions.

[1] Yang, Xin & T., Paul & Zhang, Ning. (2020). A Deep Neural Network Study of the ABIDE Repository on Autism Spectrum Classification. International Journal of Advanced Computer Science and Applications. 11. 10.14569/IJACSA.2020.0110401.

Dataset

Brain scans and time series acquired during this resting state make up the dataset used in training this deep learning model. It consists of brain scans from both autistic and neurotypical subjects. The preprocessed dataset is available to download using the *nilearn* library[2]. It contains data for 871 participants. This is a very small amount for a deep learning model, but standard data augmentation methods may fail to enhance the model's ability to detect autism. More data needs to be collected from real-life fMRI study participants. Surprisingly, the dataset weighs over 200 gigabytes.

Data format is *.nii,* which is a standard data format for neuroimaging scans.

Implementation

Due to hardware limitations in the *colab* environment (not possible to download 200GB of data and have it stored there), the project was implemented and trained locally. This makes for the neural net to be more simple than it would be on a machine with lots of computational power.

A very important part of implementing the model is data preprocessing. The way it is done here is slightly different from what is proposed in the aforementioned paper. Data preparation step consists of: calculating ROIs (regions of interests) using BASC atlas, applying brain connectivity correlation measure and then conducting Principal Component Analysis (PCA) on features with 99% variance. This makes for the model input (X). The output (y) is a boolean value marking whether the participant is autistic or not.

The neural net architecture is relatively simple - input of 571 size, two hidden layers (128 x 64 and 64 x 2), with ReLU activation function on each layer. Data has been divided into train and test sets, with the test set being 30% of the dataset.

Results

The implemented neural net reaches an accuracy of around 29%, which is way below desired result for any deep learning model.

Results from the given paper could not be reproduced using a different ROI atlas and different correlation measures. This proves that in this case data preprocessing and neuroimaging knowledge is key to obtaining satisfactory results, even using neural networks with a straightforward architecture. A set of data augmentation techniques, increasing the number of participants or using a different machine learning concept could improve learning performance on the given dataset. A direction worth exploring would be use of SVM after a thorough data preparation.

[2] https://nilearn.github.io