Radiomic analysis of brain MRI: A case study in Autism Spectrum Disorder

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Introduction

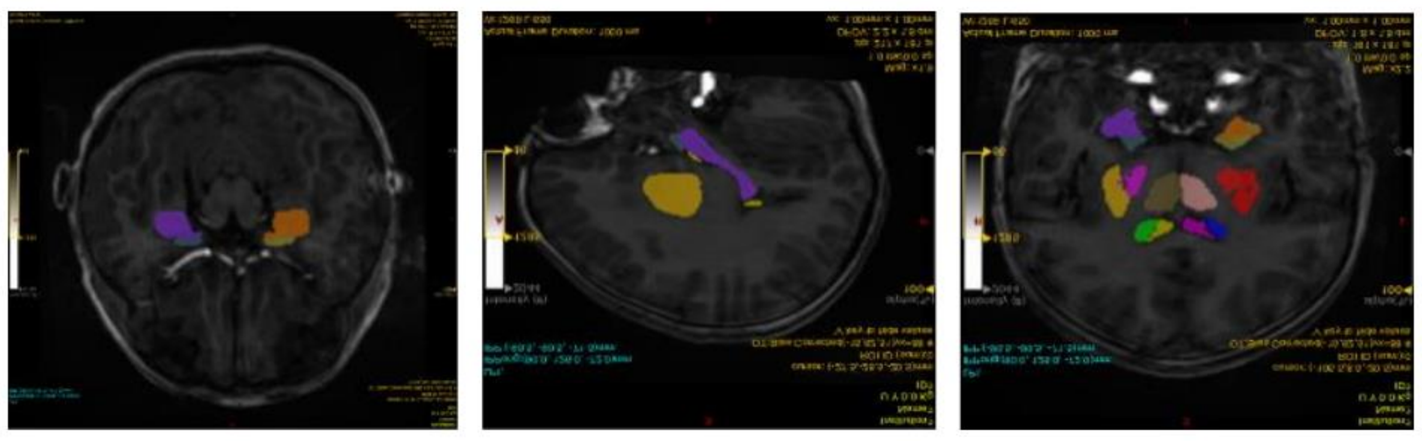
Autism Spectrum Disorder (ASD) is a disease that develops in children, being characterized by motor, cognitive and emotional difficulties. The causes of this disease are not yet fully understood, which has led to an increase in the study of this disorder. Recent studies indicated that the development of autism can cause structural and functional changes in the amygdala and the hippocampus, which are brain structures that are responsible for controlling some emotional and cognitive behaviors. For this reason, an effort has been made to understand the changes in those structures with the development of autism [1, 2]. Magnetic Resonance Imaging (MRI) is an imaging approach capable of visualize those changes, enabling the acquisition of 3D brain images where a Radiomic Analysis can be performed through the extraction of features and their posterior analysis [1, 3]. This is the goal of the present work, aiming to find features with potential to be biomarkers in the diagnosis of ASD. Two analysis approaches were followed: a general exploratory one, using the mean values of the features and a second one through classification based on a similar study performed by Chaddad *et al.* [1].

Methods

The data used consisted in MRI images obtained from ABIDE I [4] database. A sample of 48 patients was used for this study, in which 24 patients had no autism, being used as control and 24 patients were diagnosed with autism. In what concerns the age, only 10 had less than 15 years in which 5 had autism. Regarding the gender, 37 patients were male and 11 female. The procedure was divided in three steps:

1) Brain Images Segmentation

This procedure was carried out in the VolBrain online segmentation workflow [5].



Left hippocampus | Left amygdala | Right hippocampus | Right amygdala

2) Feature Extraction

This procedure was carried out in the LifeX software [6].

- Morphological → Volume
- Textural
  - GLCM → Energy, Entropy, Contrast, Correlation, Homogeneity, Dissimilarity
  - HISTOGRAM → Skewness, Kurtosis, Entropy, Energy

3) Feature Analysis

i) General Exploratory Approach

- Has the goal to have a first look on the behaviour of the features;
- Quantitative analysis of the same features between cases and controls and also between age groups;
- Exploration of the mean values of the features extracted.

ii) Radiomic Analysis of Classification

- Radiomics analysis of classification;
- Case classification using features was performed with three different models:
  - Support vector machine (SVM) *
  - Neural networks (NN) *
  - Random forest (RF)
- Model's performance was evaluated by their accuracy;
- The classification was performed in three different types of data:
  - Features from the hippocampus
  - Features from the amygdala
  - Features from amygdala and hippocampus.
- A TOP features was obtained through the RF model, after 15 runs.

* Data needed to be separated into training and testing with Leave One Out (LOO) and k-fold methods

Results and Discussion

i) General Exploratory Approach

Morphological features

- Patients under 15 years: patients with autism presented lower volume of both structures;
- Patients over 15 years: patients with autism presented lower volume of the hippocampus and higher volume of the amygdala;

Textural features

GLCM:

- Hippocampus: patients with autism presented lower homogeneity, energy, contrast, correlation and dissimilarity and higher entropy;
- Amygdala: patients with autism presented higher homogeneity, correlation, entropy and dissimilarity and lower energy and contrast;

HISTOGRAM:

- Hippocampus: patients with autism presented higher values of skewness, kurtosis and entropy and lower energy;
- Amygdala: patients with autism presented lower values of skewness and kurtosis and higher values of entropy and energy;

→ It was not found a general rule to the behaviour of the features between age groups.

ii) Radiomic Analysis of Classification

Accuracy values of each model used to classify the data used, for both LOO and k-fold split methods.

	Hippocampus		Amygdala		Hippocampus + amygdala	
	LOO	kf	LOO	kf	LOO	kf
SVM linear	0.500	0.575	0.625	0.575	0.625	0.642
SVM non linear	0.500	0.592	0.563	0.625	0.500	0.500
NN	0.604	0.592	0.500	0.567	0.688	0.633
RF	0.958		0.958		0.980	

- A greater accuracy was obtained with the RF model in all the data used, both with the LOO method and with the k-fold;
- The dataset containing features of the amygdala and hippocampus had better results compared to the data containing only features of the amygdala or the hippocampus;
- TOP features (after 15 runs): volume of the amygdala, entropy, homogeneity and dissimilarity.

Conclusion

This work intended to analyze MRI brain images, in particular the hippocampus and amygdala structures, in order to contribute to the diagnosis and understanding of the ASD. The first approach allowed the general understanding of the behaviour of the features and the second one allowed us to achieve the features that presented more potential to become biomarkers in the diagnosis of ASD. In order to achieve this in the second approach, several feature classification models were used and evaluated through their accuracy, where the RF model presented better results in classifying the patients in cases or controls. It was also with this model, that was possible to obtain the potential biomarkers for the diagnosis of ASD.

References

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