Deep learning for neurological disorders prediction

Djelikh Soumia
LESIA Laboratory
Mohamed Khider University of Biskra

Saouli Rachida
LINFI Laboratory
Mohamed Khider University of Biskra

The brain is a highly complex organ that serves as the command center for the body, controlling various functions and interpreting external stimuli. Several neurological pathologies can affect the brain as well as the nerves and the spinal cord. These disorders encompass structural, biochemical or electrical abnormalities within the nervous system. According to the World Health Organization, conditions such as epilepsy, Alzheimer disease, stroke, learning disabilities, Autism Spectrum Disorder (ASD), and brain tumors fall within the realm of more than 600 neurological disorders that strike millions yearly affecting their mental and physical well-being, impeding daily tasks, work, and social interactions.

In this work, we are interested in ASD, which is considered one of the most relevant neurological disorders affecting children in recent years. In addition, the etiology of ASD is still unclear and not well understood. ASD is defined as a complex brain developmental disorder that affects brain function, leading to social-communication impairments with restricted stereotyped behavior. It is often accompanied by sensory sensitivities and medical issues such as gastrointestinal disorders, seizures or sleep disorders, as well as mental health challenges such as anxiety, depression and attention issues. [1]

Currently, there is no cure for ASD, but it is possible to significantly mitigate its impact and slow its progression through the implementation of comprehensive early interventions. There is convincing evidence that an early ASD diagnosis is very important, leading to timely interventions that can improve learning, communication, social skills, and underlying brain development. Younger children tend to acquire the necessary skills faster, and some of the symptoms seen in ASD will be controlled at an earlier stage through the early implementation of tailored education. In this way, the differences between children with autism and their peers can be reduced over time. [2]-[7].

Extracting knowledge from the brain detecting neurological disorders is a crucial and wide research area in the field of biomedical science. The information regarding the neurological disorders can only be evaluated by extracting the functional condition of the brain. Different techniques are available for studying the functional states of the brain, such as MRI, Functional MRI (fMRI), positron emission tomography (PET), and electroencephalography (EEG). [8]-[11]

In our research, our attention is directed towards the use of EEG signals for ASD diagnosis, as they exhibit distinctive patterns that differentiate autistic from normal EEG signals. In addition, EEG is a widely used technique for capturing brain signals due to its excellent temporal resolution, non-invasiveness, usability, and low setup costs. It provides a significant amount of multi-channel signals, which neurologists typically examine visually to identify and understand neurological abnormalities. However, relying on the visual inspection of EEG signals is not a reliable procedure for assessment due to the lack of standardized criteria. It is time-consuming, error-prone, laborious, and requires the services of an expert. [12]-[14]

As a result, researchers have turned their attention to more advanced techniques such as machine and deep learning to analyze brain and behavioral data objectively. These automated systems can assist neurologists in performing brain/behavioral-based diagnosis of disorders like ASD without the need for a multidisciplinary team. These advanced techniques offer more efficient and accurate results and can lead to better diagnosis and treatment plans for patients.

In recent years, there has been significant progress in the field of ASD detection using EEG signals, driven by the need to overcome the limitations of visual analysis. In [15], Tawhid et al. presented a method converting EEG signals into time-frequency spectrogram images, subsequently classified using a combination of Local Ternary Pattern and Census Transformed Histogram with SVM. In a related study [16], Baygin et al. proposed a hybrid deep lightweight feature extraction method for EEG signals. They used one-dimensional Local Binary Pattern and Short Time Fourier Transform to generate spectrogram images, followed by deep feature extraction and selection using pre-trained models. In[17], Ari et al. developed an automated ASD detection method based on deep learning. They employed the Douglas-Peucker algorithm, sparse coding, and Extreme Learning Machine-Autoencoder, demonstrated the potential for highly efficient CNN-based models in ASD diagnosis. The existing automated state of the art approaches have a major limitation of being specific to the EEG and have not been tasted on EEG datasets with varying metadata. In this context, Wadhera et al. recently created a generalized framework for ASD classification based on EEG data, emphasizing flexibility in processing EEG data from various sources and devices [18].

Within the scope of this thesis, we are interested in technological advancements in the field of Artificial Intelligence, Machine Learning, and Deep Learning to develop a robust and efficient early prediction system for ASD based on EEG data. Our goal is to further enhance the quality and speed of ASD diagnosis, ultimately leading to right and timely interventions that significantly improve the lives of children affected by this condition, as well as their families and caregivers.

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