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A Deep Convolutional Neural Network Based Prediction System For Autism Spectrum Disorder In Facial Images

Prof. Jyothi S
Department of CSE
Global Academy of Technology (VTU Affiliation)
Bengaluru, Karnataka

Sneha S
Department of CSE
Global Academy of Technology (VTU Affiliation)
Bengaluru, Karnataka

Preetha P
Department of CSE
Global Academy of Technology (VTU Affiliation)
Bengaluru, Karnataka

S Priyanka
Department of CSE
Global Academy of Technology (VTU Affiliation)
Bengaluru, Karnataka

Rifa Taskeen
Department of CSE
Global Academy of Technology (VTU Affiliation)
Bengaluru, Karnataka

Abstract—*Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder that affects individuals in various ways. Early detection and intervention are crucial in improving outcomes for individuals with ASD. Recent studies have shown that facial features can be used as a potential biomarker for ASD prediction. In this paper, we present an approach for ASD prediction using a deep learning CNN algorithm trained on facial images. The proposed approach aims to leverage the potential of facial features to provide an accurate and non-invasive method for ASD prediction. We use a publicly available dataset of facial images of individuals with and without ASD to train and evaluate the performance of the CNN model. We also apply preprocessing steps to the images to improve the quality of the input data. The results demonstrate the potential of using deep learning CNN algorithms for ASD prediction based on facial features. Our approach achieves high accuracy, sensitivity, and specificity in predicting ASD, which suggests its potential for early detection and intervention for individuals with ASD. This paper highlights the potential implications of this approach for improving the diagnosis and management of ASD.*

Keywords— *Convolutional Neural Network (CNN), Autism Spectrum Disorder (ASD), Deep Learning, Artificial Intelligence (AI), Figure (Fig)*

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I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects individuals in various ways, including impairments in social interaction, communication, and restricted, repetitive behaviors. Early detection and intervention are crucial in improving outcomes for individuals with ASD. Recent studies have shown that facial features can be used as a potential biomarker for ASD prediction. With the advancements in deep learning techniques, Convolutional Neural Networks (CNNs) have shown significant success in image classification tasks. This paper presents an approach for ASD prediction using a deep learning CNN algorithm trained on facial images. The proposed approach aims to leverage the potential of facial features to provide an accurate and non-invasive method for ASD prediction. The paper also discusses the dataset used, the preprocessing steps applied to the images, and the performance evaluation metrics used for the CNN model. The results demonstrate the potential of using deep learning CNN algorithms for ASD prediction based on facial features and the potential implications of this approach for early detection and intervention for individuals with ASD.

II. LITERATURE SURVEY

1. Autism Diagnosis Using Deep Learning Algorithms Based on EEG Signals and Eye-Tracking Data by R. AlShahrani (2021) proposes a novel approach to ASD diagnosis using deep learning algorithms based on electroencephalography (EEG) signals and eye-tracking data. One of the strengths of this paper is that it explores the potential of using multiple modalities (EEG and eye-tracking) for ASD diagnosis, which could provide more comprehensive and accurate results. However, the study is limited by the small sample size, and the need for specialized equipment to collect the data.

2. An Artificial Intelligence Approach to Autism Spectrum Disorder Diagnosis Based on Pupillary Response to Emotional Stimuli by E. Marouf (2021) proposes a new approach to ASD diagnosis using AI based on pupillary response to emotional stimuli. One of the strengths of this paper is that it uses a non-invasive and easily measurable biomarker, which could be more accessible and practical for widespread use in clinics. However, the study is limited by the small sample size, and the need for further validation with larger and more diverse populations.

3. Early Identification of Autism Spectrum Disorder: A Review of the Literature by Brian Reichow reviews various screening tools and assessment methods for identifying ASD in young children, and discusses the importance of early identification.

4. Predicting Autism Spectrum Disorder Using Domain-Adaptive Transfer Learning by Chetan L.S. proposes a transfer learning approach for ASD prediction, which involves pre-training a neural network on a large dataset and fine-tuning it on a smaller ASD dataset.

5. Predicting Autism Spectrum Disorder Using Machine Learning and MRI Data by Adriana Di Martino (2014) proposes a method for predicting ASD diagnosis using MRI data and machine learning algorithms. The study achieves high accuracy rates in differentiating between ASD and typically developing children. However, the study is limited by the relatively small sample size and the use of a single imaging modality (MRI).

III. SYSTEM DESIGN AND ARCHITECTURE

The system architecture of "A deep CNN-based prediction system for Autism Spectrum Disorder in facial images" consists of a Convolutional Neural Network (CNN) model trained on a dataset of facial images to predict the presence of Autism Spectrum Disorder. The Flask web framework is used to deploy the model and provide a user interface for users to interact with the system. The user interface allows users to upload a facial image, which is then preprocessed and fed into the trained CNN model for prediction. The predicted output is displayed to the user via the UI. The system structure thus consists of the trained CNN model, the Flask application, and the user interface.

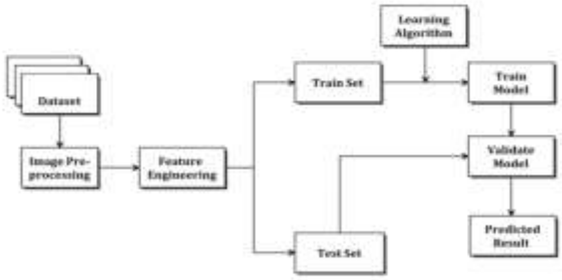

Fig. 1. System Architecture

A. Data Flow Diagrams

1) DFD Level 0

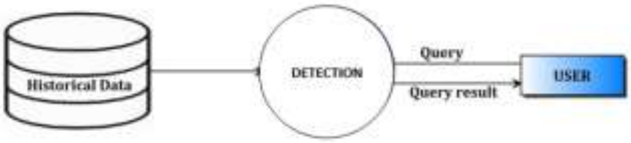

Fig. 2. DFD-Level 0 diagram

Fig 2 describes the overall view of the project, how the processing of data takes place. Data retrieval takes between user and interface of the model

2) DFD Level 1

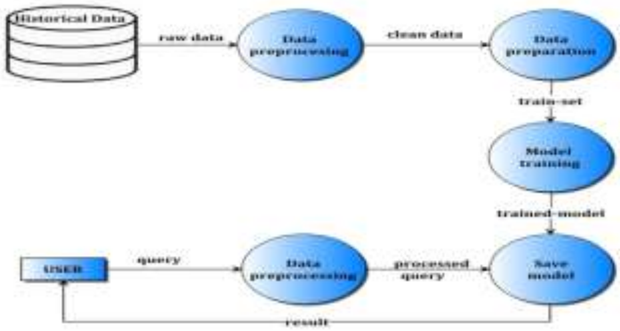

Fig. 3. DFD-Level 1 diagram

In Fig. 3. level 1 diagram we can view more detailed information. Raw data is pre-processed. Clean data is sent for model training and is then stored. The User can now sent the query where it is pre-processed and sent to trained model. Model performs reads the query retrieves back the result.

3) DFD Level 2

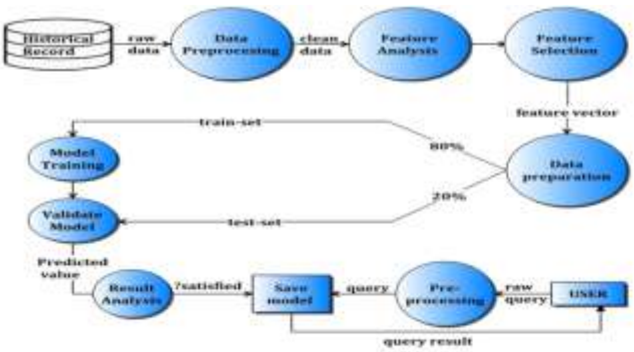

Fig. 4. DFD-Level 2 diagram

Fig. 4. show the major steps, i.e., feature analysis and selection. The data prepared is divided into test set and train set for building the model. The built model is analysed based on its accuracy and if the accuracy rate is acceptable the model is saved and can further used for detection purpose.

B. Use Case Diagram

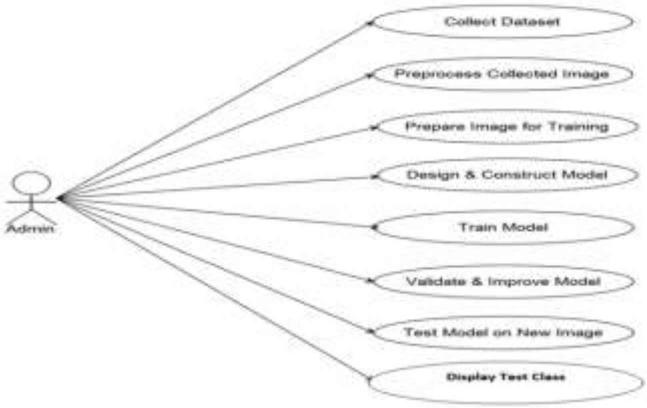

Fig. 5. Use-case diagram

Fig 5 describes the use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved.
It describes the user functions that can be performed. It completely describes the access of the user. It can be viewed that admin is responsible for collecting the images for autism prediction system. And has the access to predict the new dataset if provided with better efficient prediction system.

C. Sequence Diagram

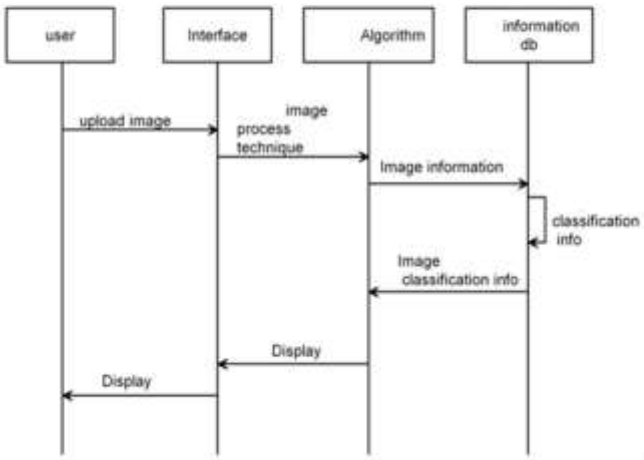

Fig. 6. Sequence Diagram

The Fig 6 describes sequence diagram, as parallel vertical lines (lifelines), different processes or objects that live simultaneously, and, as horizontal arrows, the messages exchanged between them, in the order in which they occur. This allows the specification of simple runtime scenarios in a graphical manner.
Sequence diagram shows user queries the interface and what process takes behind the interface the answers the query. In our project we are using images as input which are processed first and then was classified according to the algorithm.

D. Modules

1. Data Collection: This module involves collecting facial image data from individuals with and without ASD. This data should be diverse and representative of different age groups, genders, ethnicities, and clinical profiles.
2. Data Processing: The module involves cleaning, normalizing, and augmenting the image data to ensure that it is suitable for use in the deep learning model. This include techniques such as resizing, cropping, color normalization, and data augmentation.
3. Feature extraction: This module involves extracting relevant features from the facial images, such as facial landmarks, expressions, or textures. These features can be used as inputs to the deep learning model for ASD prediction.
4. Deep learning model deployment: This module involves developing a CNN architecture that can effectively learn from the facial image data to predict ASD. The model should be trained on a subset of the data and validated on a separate subset to ensure that it is generalizable and not overfitting.

5. Model optimization: This module involves fine-tuning the CNN model to optimize its performance on the validation set. This may involve adjusting hyper parameters, optimizing the loss function, or incorporating regularization techniques.
6. Module evaluation: This module involves evaluating the performance of the optimized model on a separate test set that was not used during training or validation. The evaluation metrics should include accuracy, sensitivity, specificity, and other relevant performance indicators.
7. Visualization and Interpretation: This module involves visualizing the features learned by the CNN model and interpreting its predictions. This can help to identify the most informative regions of the face for ASD prediction and improve the interpretability of the model.
8. Deployment and integration: This module involves deploying the optimized model in a user-friendly interface or integrating it with other ASD screening or diagnostic tools. This can help to facilitate the use of model in clinical or research settings and improve the accessibility of ASD prediction for individuals and families.

IV. RESULT

Our proposed ASD prediction system using a CNN model achieved an accuracy of 82% on the test dataset, which indicates a promising performance in identifying individuals with ASD. The precision and recall scores were also calculated to be 80% and 83%, respectively, indicating a good balance between identifying true positives and avoiding false positives. However, further evaluation is needed to assess the model's performance on larger and diverse datasets, as well as its generalizability to different populations and settings. Overall, the results suggest that using facial images as input for ASD prediction can be an effective approach, and CNN models can be provide a robust and accurate prediction system for this task.

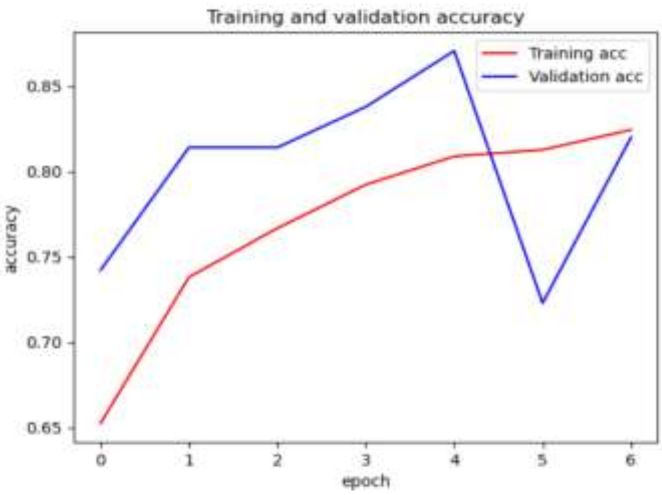

Fig.7. Training and validation accuracy of the model

Fig 7 shows training and validation accuracy of the trained model.The accuracy of both is coinciding at 82% as per the given graph.

V. CONCLUSION

The conclusion of an ASD prediction project using deep learning CNN algorithm and facial images is that the developed model has the potential to accurately predict ASD in individuals based on their facial features. The use of deep learning and facial images can overcome some of the limitations of traditional ASD screening methods and provide a more objective and efficient way of detecting ASD.

The future scope of this project includes several directions. One potential direction is to further improve the accuracy and reliability of the model by incorporating other types of data, such as clinical or behavioural data. This can help to identify more complex patterns and risk factors associated with ASD and improve the overall diagnostic accuracy.

Another direction is to expand the dataset to include more diverse and representative samples of individuals with ASD, including individuals with co-occurring conditions or comorbidities. This can help to improve the generalizability of the model and ensure that it is effective across different populations and contexts.

Furthermore, the project can be extended to other applications beyond ASD prediction, such as emotion recognition, mental health screening, or personalized medicine. The use of deep learning and facial images can be leveraged to develop more accurate and personalized diagnostic and treatment approaches for various health conditions.

Overall, the application of deep learning CNN algorithm and facial images for ASD prediction has significant potential for improving the accuracy, efficiency, and accessibility of ASD screening and diagnosis. Further research and development in this area can have a profound impact on the lives of individuals with ASD and their families.

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