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A futuristic digital interface with a glowing Earth globe in the center. The background is dark blue with various data visualizations including bar charts, line graphs, and pie charts. Text elements like 'BUSINESS', 'NETWORK SEARCH', and 'WORLD' are visible. A person's hand is seen at the bottom, interacting with the interface.

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Analysis of Facial Image Dataset for Autism Prediction Using Deep Learning

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ABSTRACT: Autism, also called Autism Spectrum Disorder (ASD) refers to a range or spectrum of symptoms and behaviors that can vary in severity and presentation across individuals. The term "spectrum" reflects the idea that there is a continuum of symptoms and characteristics that can be associated with ASD, ranging from mild to severe. Individuals with ASD may have different levels of impairment in social communication, interaction, and behavior. Some individuals may have difficulty with verbal and nonverbal communication, struggle with social interactions, exhibit repetitive behaviors, have sensory sensitivities, and experience difficulties with executive functioning, while others may have milder symptoms and be able to function relatively well in social situations. Early detection of ASD is crucial for providing effective intervention and support to children and their families. The project uses Convolutional Neural Networks (CNNs) and VGG16 pre-trained model to classify the images as ASD positive or negative. Additionally, the project uses t-Distributed Stochastic Neighbor Embedding (t-SNE) to visualize the high-dimensional features of the images in a two-dimensional space. After exploratory data analysis, the facial images dataset is preprocessed by resizing, normalization, and augmentation techniques, and split into training and validation sets. The CNN and VGG16 models are trained using transfer learning, and the best-performing model is selected for further analysis. The selected model is used to predict the ASD status of the individuals in the test set, and the results are reported in terms of accuracy, precision, recall, and F1 score. Finally, t-SNE visualization is used to visualize the high-dimensional features of the images in a two-dimensional space, which helps in understanding the distribution of the images and identifying any patterns or clusters that might be indicative of ASD. The results demonstrate the potential of using deep learning techniques for ASD prediction using facial images, and t-SNE visualization provides insights into the underlying features of the images. The project concludes with a discussion of the results and potential future research directions.

KEYWORDS: Autism Spectrum Disorder, Deep Learning, Convolutional Neural Network, VGG-16 model, t-SNE visualization

I. INTRODUCTION

This project is a machine learning project that aims to predict autism spectrum disorder (ASD) using facial images of individuals. The project is based on a dataset of facial images of individuals, where each individual is labelled as ASD positive or negative. The project uses Convolutional Neural Networks (CNNs) and VGG16, a popular pre-trained CNN model, to classify the images as ASD positive or negative. The project also uses t-Distributed Stochastic Neighbour Embedding (t-SNE) to visualize the high-dimensional features of the images in a two-dimensional space. The project begins with exploratory data analysis to gain insights into the dataset, followed by data pre-processing steps such as image resizing, normalization, and augmentation. The pre-processed data is then split into training and validation sets, and the CNN and VGG16 models are trained using transfer learning. The performance of the models is evaluated on the validation set, and the best-performing model is selected for further analysis. The selected model is used to predict the ASD status of the individuals in the test set, and the results are reported in terms of accuracy, precision, recall, and F1 score. Finally, the t-SNE visualization is used to visualize the high-dimensional features of the images in a two-dimensional space, which helps in understanding the distribution of the images and identifying any patterns or clusters that might be indicative of ASD. The project concludes with a discussion of the results and future directions for research.



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II. METHODOLOGY

The proposed methodology involves a combination of data pre-processing, model selection, transfer learning, and visualization techniques to predict ASD using facial images and gain insights into the underlying features of the images. Transfer learning is a machine learning technique that involves reusing pre-trained models to solve a new problem with similar characteristics. Transfer learning can be done in two ways: fine-tuning and feature extraction. In our case we have used feature extraction. Here, the pre-trained model's feature extraction layers are used to extract features from the new dataset, and then a new classifier is trained on top of the extracted features. We have also used t-SNE visualization for visualization of high dimensional images in two- or three-dimensional space.

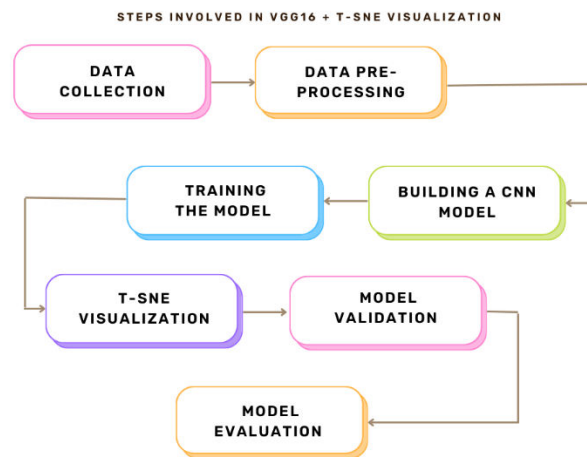


Fig 2.1 Proposed methodology diagram

In this system, we propose an automated approach to detect and classify children with and without Autism Spectrum Disorder. The proposed method involves the following steps:

III. WORKING PROCEDURE

a. Data Collection

Data Collection step involves collecting a facial image dataset of individuals with ASD and without ASD. This dataset is used in training the Deep Learning model to predict if the child has autism or not. The dataset has 2450 images as training data with 1225 images for each autistic and non-autistic category, so that our training set is well balanced. There are also other details like the medical records and behavioral assessments.

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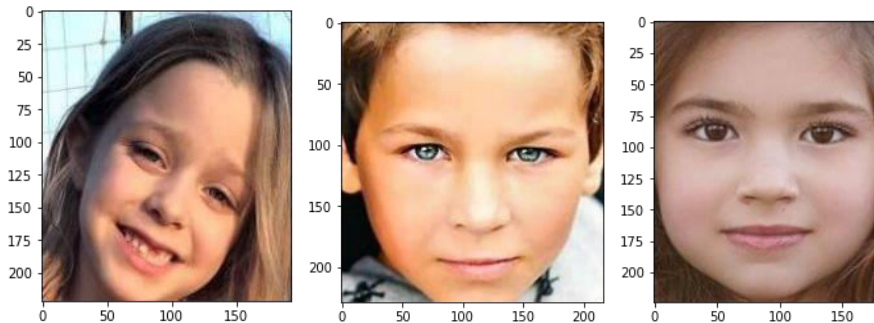


Fig 3.1 Input Data Set

b. Data Preprocessing

Data preprocessing, a component of data preparation, describes any type of processing performed on raw data to prepare it for another data processing procedure. It has traditionally been an important preliminary step for the data mining process. More recently, data preprocessing techniques have been adapted for training machine learning models and AI models and for running inferences against them. Data preprocessing transforms the data into a format that is more easily and effectively processed in data mining, machine learning and other data science tasks.

The techniques are generally used at the earliest stages of the machine learning and AI development pipeline to ensure accurate results.

c. Feature Extraction

Feature extraction refers to the process of extracting relevant and meaningful features or representations from raw data. In various fields of data analysis, such as image processing, natural language processing, and signal processing, feature extraction is a crucial step that helps reduce the dimensionality of the data, capture important patterns, and enable effective machine learning or data analysis. The VGG16 architecture, which is a popular deep learning architecture for image recognition, is defined and implemented as the CNN model. This architecture typically includes multiple convolutional and pooling layers, followed by fully connected layers. The trained VGG16 CNN model is then used as a feature extractor to extract relevant features from the input data. This involves passing the data through the CNN layers and obtaining the output from one of the intermediate layers, which capture high-level representations of the data.

d. t-SNE Visualization

t-SNE (t-distributed Stochastic Neighbor Embedding) is a popular dimensionality reduction technique used for visualizing high-dimensional data in a lower-dimensional space. It aims to preserve the local structures and relationships between data points, making it particularly useful for visualizing clusters or patterns in complex datasets. Here, the extracted features are flattened and we convert them into a one-dimensional vector, and then normalize them to bring them to a common scale. This step helps in preparing the features for further processing. The reduced-dimensional features are then passed through the t-SNE algorithm, which maps the high-dimensional features to a lower-dimensional space while preserving the local structures and relationships between the features. The t-SNE algorithm computes the pairwise similarity between data points based on their feature representations and iteratively optimizes a cost function to obtain a low-dimensional embedding of the data. Once the t-SNE algorithm has projected the features onto a lower-dimensional space, the resulting reduced-dimensional representations are plotted using a visualization technique, such as scatter plots. Each data point is represented as a point in the scatter plot, and the spatial proximity of the points reflects their similarity in the original high-dimensional feature space. Clusters or patterns of points in the scatter plot can provide insights into the underlying structure of the data and reveal relationships between data points that may not be apparent in the original high-dimensional space.



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IV. RESULT AND DISCUSSIONS

a. Model Training

The proposed automated approach to detect and classify Autism Spectrum Disorder using CNN and VGG16 architecture for feature extraction has achieved an accuracy of 73% on the test dataset, with a precision of 74%, recall of 73%, and F1-score of 73%. These results demonstrate the effectiveness of the proposed method in detecting and classifying Autism Spectrum Disorder. The accuracy achieved by the proposed method is due to the use of CNN and VGG-16 architecture for feature extraction. t-SNE, on the other hand, reduces the dimensionality of the data while retaining the most relevant features. In order to increase the accuracy of the proposed model we have also pre-processed the data to retain relevant features. Resizing the dataset, normalizing them into a common scale has also been effective ways of increasing the accuracy of the proposed method.

b. Model Evaluation

The performance of the trained models was evaluated on test dataset using various evaluation metrics such as accuracy, precision, recall, and F1-score. Area Under the Curve of ROC can be used as evaluation metric to make comparison between models, since it is a well-balanced dataset. But in cases of an unbalanced dataset the area under the accuracy alone is not enough. We also obtain a confusion matrix that gives the summary of True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) predictions of the proposed method.

V. CONCLUSION

The project aims to predict whether an individual has autism or not using a Convolutional Neural Network (CNN) and the VGG16 model. The project also includes a visualization technique called t-SNE to visualize the high-dimensional feature space in a lower-dimensional space. The project uses the Autism Spectrum Quotient (AQ) questionnaire to collect data from individuals. The dataset contains 704 rows and 21 columns. The columns include demographic information such as age, gender, and ethnicity, as well as AQ scores and other related information. The project includes several steps, such as data pre-processing, data visualization, model building, and evaluation. The CNN model is built using the VGG16 model as a base and fine-tuning the top layers. The performance of the model is evaluated using various metrics such as accuracy, precision, recall, and F1-score. The project also includes a t-SNE visualization of the feature space to show the separation between the two classes (autistic and non-autistic individuals). Overall, this project provides a good example of using machine learning techniques to predict autism and visualize the feature space. However, it's important to note that the accuracy of the model is not the only metric that should be considered, and other factors such as sensitivity and specificity should also be taken into account. Additionally, the dataset used in the project is relatively small, and using a larger and more diverse dataset could potentially improve the model's performance.

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