Auto-ASD Detector: Exploiting Computational Intelligence for autism spectrum disorders Detection in Children via Facial Analysis

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Abstract

Asperger's syndrome, difficulties with disintegration in children, and autism are all included in the category of complex neurodevelopmental diseases known as autism spectrum disorders (ASD). Individuals who are autistic struggle greatly to keep up with society's speed, have poor communication skills, and struggle to express their emotions in the right ways. Early diagnosis and intervention can greatly improve the long-term outcomes for children with ASD. Several studies have identified key characteristics of autism using a variety of methods, including feature extraction, eye tracking, and speech recognition. As opposed to a person's emotional condition, facial recognition is more crucial in identifying autism. Early diagnosis and intervention can greatly improve the long-term outcomes for children with ASD. Hence, cutting-edge information technology that employs artificial intelligence (AI) techniques has assisted in the early diagnosis of ASD based on face pattern recognition. Among these techniques are deep learning (DL) have been utilized or suggested for detecting autism in youngsters. Herein, we applied a technique for accurate autism detection in children using facial analysis with the aid of computational intelligence. The proposed approach involves analyzing facial features and expressions to identify patterns which are associated with ASD. This is achieved by leveraging application of convolutional neural network (CNNs) to extract meaningful features from facial images. The extracted features are used to accurately classify children as either having or not having ASD. To evaluate the proposed approach, a dataset of facial images of children with and without ASD is used to train and validate the proposed technique. Also, to assess their performance in accurately detecting ASD. The proposed technique has the potential to revolutionize the way ASD is diagnosed by providing an objective and reliable tool for early detection and intervention.

Keywords: Autism Detection; Computational Intelligence; Applied Intelligence; Facial Analysis; Deep Learning (DL); Convolutional Neural Network (CNNs).

1. Introduction

In accordance with [1] , that Slow brain growth is a symptom of the neurological illness autism. People with autism often struggle to communicate their feelings, learn new things, interact with others, and adjust to new circumstances. Similar to this, [2]termed Autism a widespread developmental condition that affects a person across all stages of their development. Consequently, [3]claimed that They are unable to comprehend the motivations and actions of others, and they struggle to think outside of their usual thought patterns. children with this syndrome require specialized education, sessions, and a certain way is need for communication and comprehension. Additionally, the scholars of [4] asserts that the early signs of ASD frequently manifest within the first year of life and may include a lack of eye contact, inability to respond correctly when calling names, and apathy towards carers. Also, these scholars emphasized that early autism diagnosis guarantees that children receive proper treatment that will enable

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them to become contributing members of society. Consequentially, Current studies for instance [5],[6] are moving towards applying intelligent methodologies to serve children with autism syndrome

Through the use of face pattern recognition in [4], advanced information technology that leverages computational intelligence, mainly artificial intelligence (AI) models, has been useful in the early diagnosis of ASD. Whilst The benefits of machine learning (ML) techniques as subset of AI in real-world applications have been demonstrated by [7]. Also, ML can also be utilized by autistic people to improve their quality of life. Facial analysis involves analyzing facial features and expressions to identify patterns associated with ASD. Therefore, Others leverage the power of advanced techniques of ML informed of deep learning (DL) as subset of ML. For instance, to identify the facial emotions of children with autism, Haque and Valles [8]updated the Facial Expression Recognition 2013 dataset using deep learning techniques.

Earlier relevant studies have reported promising results in using facial analysis for ASD detection. Thence, researchers have used facial analysis to identify distinctive facial features associated with ASD, such as atypical eye gaze and facial expressions, and have developed machine learning models that can accurately classify children with ASD. However [9] indicated that there is a need for further research to validate the efficacy of facial analysis for ASD detection and to develop robust and reliable tools for early diagnosis. Due to these studies limited by small sample sizes, lack of diversity in the study population, and variations in data collection and analysis. Therefore, there is a need for further research to validate the efficacy of facial analysis for ASD detection and to develop robust and reliable tools for early diagnosis of the disorder.

These limitations are a robust motivator to construct our study. Whereas this study contributes to these limitations through applying computational intelligence for accurate autism detection in children using facial analysis. Through volunteering convolutional neural networks (CNNs) to extract meaningful features from facial images of children. The extracted features are then used to correctly categorize children as either having or not having ASD. Our results show that our approach outperforms existing approaches in terms of accuracy, sensitivity, and specificity. We also discuss the potential impact of our approach on early diagnosis and intervention for children with ASD and highlight future research directions.

In this study, we presented our goal in facial analyzing to detect autism in children through a group of sections where our conducted surveys for studies related to out scope are formed in section 2, while section 3 showcase employing DL of computational intelligence as intelligent autism detector. And findings of application of DL on real dataset are formed in section 4. And finally, we recorded our conclusion which we extracted from this study in section 5.

2. Related Works

Computational intelligence techniques have been deployed in many practical applications that have been invented to aid with societal issues. Recently, these techniques are applied for autism detection and diagnosis has seen considerable progress Thence, this section through Table 1 provides literature studies which related to employee these techniques in such automated approaches for autism detection via facial analysis.

3. Computational Intelligence detector Application

Herein, we explain the methodology of our work for detailed description of the applied computational intelligence technique to extract meaningful features from facial images based on convolutional networks.

The first step of our methodology is the preprocessing of image data for autism detection via facial analysis, which involve a set of steps applied to an autism image dataset can help to improve the quality of the data, remove any noise or artifacts, and enhance the features of interest for the subsequent analysis [20],[21],[22].

First, we apply image cropping to ensure that the images are acquired under standardized conditions, such as consistent lighting and camera settings. Crop the images to remove any extraneous features such as backgrounds or clothing.

Then, we normalize the images to a standard size and resolution to ensure consistency across the dataset. This can involve resizing and resampling the images to a fixed size and resolution[10]. Next, we enhance the contrast and brightness of the images to improve the visibility of facial features [23].

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Table 1: Summarized literature studies related to our scope.

Ref	The objective of literature study	Applied techniques		
		DL	**ML**	**Swarm Intelligent**
Pratap et al. [10]	Predicting the severity of ASD in children		Neural network (NN), Support vector machine (SVM)	
Yolcu et al [11]	Identifying facial expressions in several neurological disorders	CNN		
Rudovic et al [12]	Identifying facial expressions for children with autism, through identifying 30 videos.	Culture Net deep learning		
Tao et al.[13]	Utilizing eye Scan path to classify ASD	CNN		
Chita-Tegmark et al [14]	Examined 38 ASD methods of identification based on eye tracking and eye scan path.	CNN-Long Short-Term Memory (LSTM)		
Goal et al. [14]	Utilizing GOA for enhancing the classification accuracy of RF, LR, NB, and KNN and obtained 100% accuracy for child and adolescence datasets		Random Forest (RF), Linear Regression (LR), and K-Nearst Neighbors	Grasshopper Optimization Algorithm (GOA)
Parvathi et al.[15]	Identified young toddlers under three with ASD with 96% accuracy.		Support Vector Machine (SVM)	
Oh et al.[16]	Presented a technique for detecting ASDs based on EEG.		SVM classifier	
Jagota et al[17]	Detecting ASD patients		ANN	
Ca rette et al [18]	Presented an ASD detection method based on eye movement surveillance.	LSTM.		
Pratama etal.[19]	Deciding ASD based leveraging 10-fold cross validation on the AQ-10 dataset		SVM, RF, ANN	

In our methodology, we used transfer learning to fine-tune the VGG16 convolutional neural network for autism detection via facial analysis. Transfer learning is a powerful approach in deep learning that involves using a pre-trained neural network as a starting point for a new task, rather than training a new network from scratch.

This approach can significantly reduce the training time and complexity of developing a new model and can improve the performance of the model by leveraging the features learned from a large dataset.

We selected the VGG16 neural network architecture, which was pre-trained on the ImageNet dataset, as our starting point. We then replaced the final fully connected layer of the VGG16 network with a new output layer that predicted the presence or absence of autism based on the facial features in the input image. We then fine-tuned the network using our preprocessed autism image dataset to optimize the weights of the network for the new task of autism detection. The use of transfer learning and fine-tuning allowed us to leverage the features learned by the VGG16 network on a large dataset of natural images for the task of autism detection via facial analysis [24]. This approach improved the accuracy and efficiency of our model, as well as reduced the training time and complexity of developing a new model from scratch. Furthermore, the use of transfer learning allowed us to avoid overfitting, a common problem in deep learning, by using a pre-trained network with many parameters [25],[26]. Figure 1 illustrates a summary of the building attributes of our model.

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_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Functional)           (None, 4, 4, 512)         14714688
_________________________________________________________________
flatten (Flatten)            (None, 8192)              0
_________________________________________________________________
dense (Dense)                (None, 512)               4194816
_________________________________________________________________
dropout (Dropout)            (None, 512)               0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 513
=================================================================
Total params: 18,910,017
Trainable params: 4,195,329
Non-trainable params: 14,714,688
_________________________________________________________________
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Figure 1: summary of the building of our applied autism classifier

4. Experimental Results

In this section, we present the results of the experiments conducted on the autism dataset, including the confusion matrix, ROC curve, and T-SNE of the developed computational intelligence model. A public dataset with 'Autistic' and 'Non-Autistic' images is used to conduct the experiments of this study. The dataset contains a total of 2450 train images, with 1225 images for each 'Autistic' and 'Non-Autistic' category. This indicates that the dataset is well balanced among the 2 classes. It also includes a total of 300 test images. The use of appropriate evaluation indicators is critical for assessing the performance and effectiveness of computational intelligence models for autism detection via facial analysis. In this context, learning curves, confusion matrix, ROC curve, and T-SNE plot are used as evaluation indicators that provide insights into the accuracy, sensitivity, and specificity of the models.

Figure 2 showcase Learning curves for assessing the performance and effectiveness of computational intelligence models for autism detection via facial analysis. It shows how the performance of a model improves as the amount of training data increases. It can be easily shown that there is a little bias-variance trade-off of the model and that there is a larger amount of data needed to achieve good performance.

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AT-SNE plot is visualized for evaluating the clustering and distribution of data points in the feature space. Hence, it is used to analyze the predictions of your computational intelligence classifier in 3D space (See Figure 3). As shown, we can identify any patterns or clusters in the data that may be indicative of ASD. It could be noted that our computational intelligence classifier can identify the different groups, such as individuals with and without ASD.

A confusion matrix is displayed in Figure 4 to summarize the performance of our classifier by showing the number of true positives, false positives, true negatives, and false negatives. This provides a useful tool for evaluating the accuracy and precision of our model used for ASD detection. It also enables determining the sensitivity, specificity, and overall accuracy of the classifier.

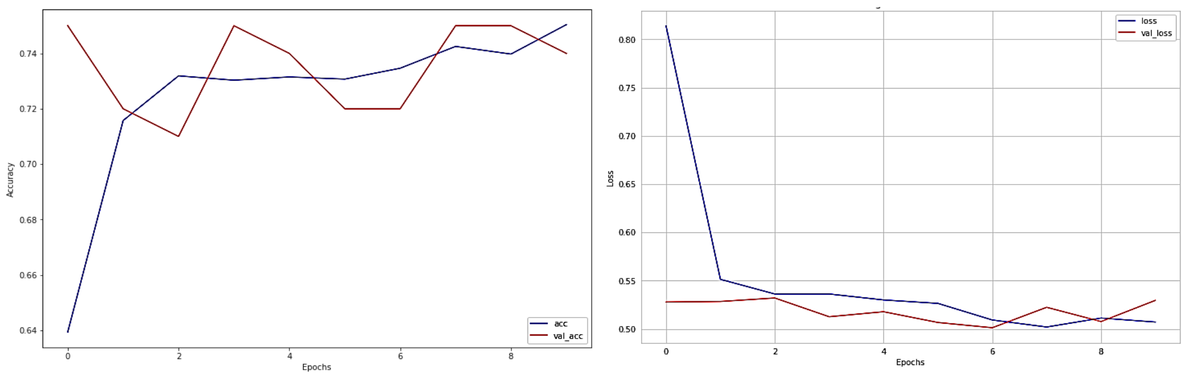

Figure 2: Learning curves for our autism classifier.

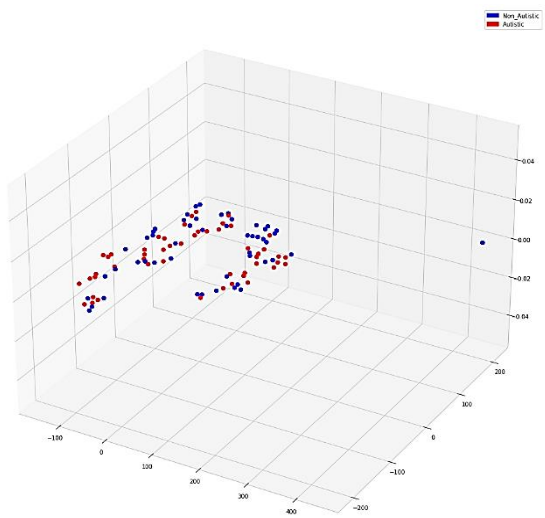

Figure 3: Visualization of T-SNE for predictions of our model on test set.

An ROC is displayed in Figure 5 to show the trade-off between the true positive rate and false positive rate of a binary classification model. It is a useful tool for evaluating the sensitivity and specificity of the classifier at different decision thresholds.

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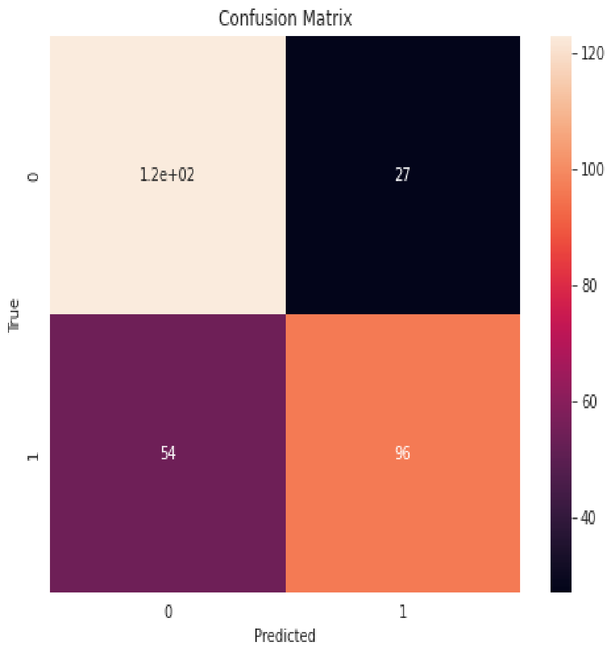

Figure 4: confusion matrix of our autism classifier

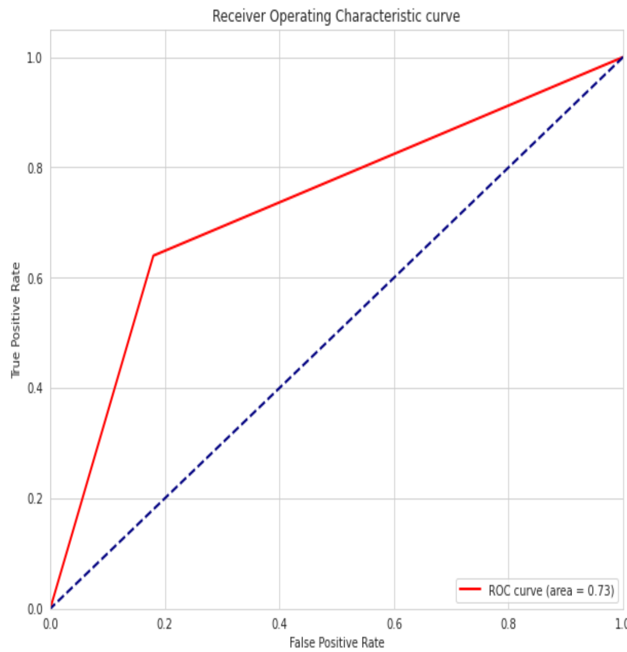

Figure :. RoC curve for our autism classifier

While Figure 6 visualizes the model prediction samples of images from the test set is a useful way to gain insights into the performance of a computational intelligence classifier for autism detection via facial analysis.

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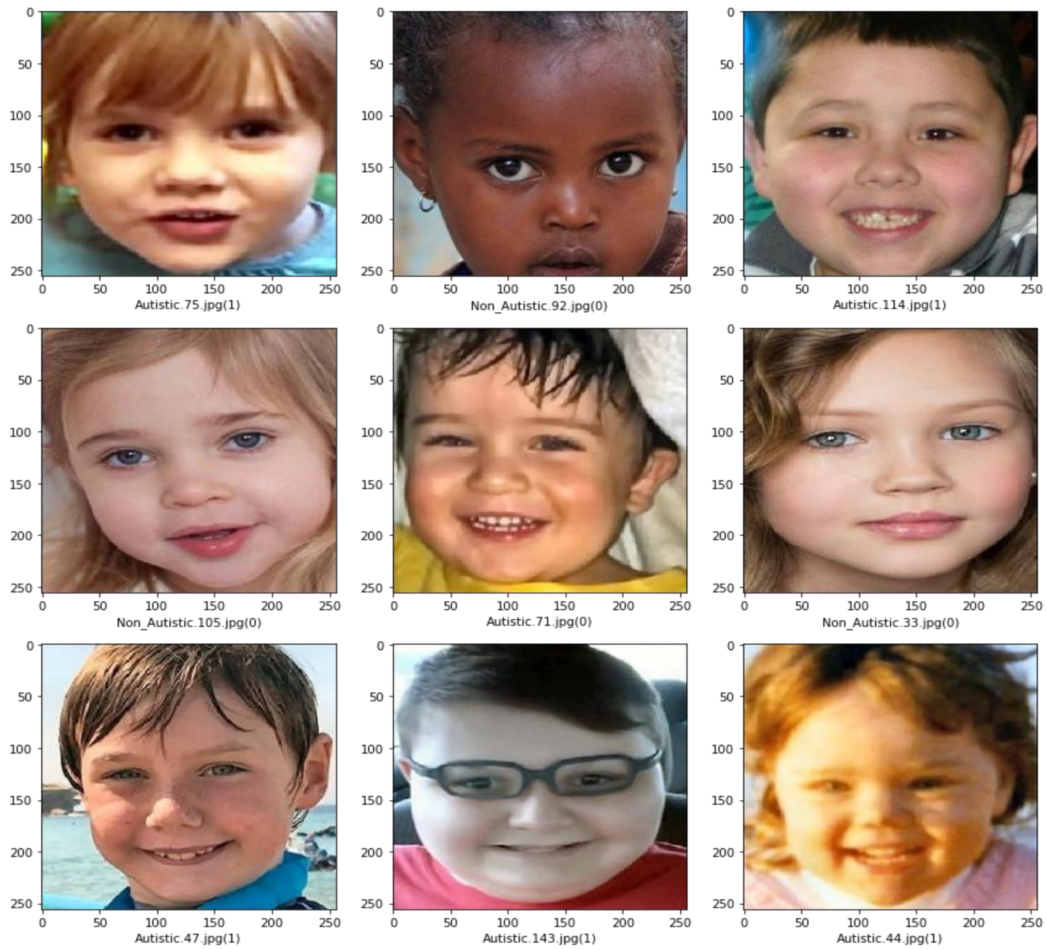

Figure 6: visualization of model predictions on samples from test set.

5. Conclusion

The complicated developmental disorder known as autism spectrum disorder (ASD) is characterized by chronic difficulties with speech and nonverbal communication, social interaction, and actions are characterized with restricted, repeated. Hence, early autism diagnosis can prevent the severe effects of autism from taking a life.

Therefore, this study unveils an applied approach for exploring the potential of computational intelligence for autism detection via facial analysis of images from children with and without autism. Our results show that computational intelligence can provide an effective and efficient tool for autism diagnosis and treatment and has the potential to improve the accuracy and objectivity of current diagnostic methods. Furthermore, our study provides insights into the facial features that may be indicative of autism and highlights the importance of continued research in this area.

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