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DECODING FACIAL EXPRESSION IN CHILDREN WITH THE AUTISM SPECTRUM DISORDER

Priya Dipak Dhake[1], Rajesh Dilip Thore[2], Kanchan Ashok Prajapati[3], Mahesh Bhavlal Patil[4]

Department of Computer Engineering, SSBT COET Bambhori Jalgaon,Maharashtra India

Abstract: Facial expression recognition plays a vital role in understanding human emotions and behavior. In the context of Autism spectrum disorder childrens, accurate recognition of their facial expressions holds significant potential for aiding diagnosis, treatment, and communication. This abstract presents an overview of a machinelearning-based approach to facial expression recognition for children with the Autism Spectrum Disorder. They face challenges in effectively expressing their emotions verbally, which underscores the importance of nonverbal cues such as facial expressions. In proposed work, Machine learning algorithms will implement for acquiring better accuracy for recognizing facial expressions, offering a non-intrusive and objective way to assess emotional states. Bench mark dataset available online along with our own -prepared dataset containing images of Autism spectrum disorder childrens exhibiting a range of expressions will use for model training, testing and validation.

Keyword: Autism in children; machine learning; Computer vision; convolution neuralnetwork (CNN)

I. INTRODUCTION

Autism spectrum disorder (ASD) is a complex and heterogeneous condition, whose symptoms persist over time and development. Apart from repetitive and restrictedinterests and behaviors (including stereotypic behaviors), this disorder is also characterized by social interactiondifficulties as well as by communication impairments (both verbal and non-verbal) , with implications on several daily life skills. It is a complicated, behaviorally defined, static condition of an immature brain which is of significant concern to practicing pediatricians due to a staggering 55.6 per-cent rise in pediatric incidence from 1991 and 1997, surpassing spina bifida, cancer, and Down syndrome. Rather than new environmental effects, thisincrease is due to increased awareness and evolving diagnostic criteria. Autism is a condition with numerous nongenetic and genetic origins, rather than a disease. Autism (autism spectrum disorders) is defined as a group of developmental disorders characterized by deficiencies in three behavioral domains that is interpersonalinteraction , diverse set of areas of interest and hobbies and speech, communication, and creative play.
Therefore, we need to establish Facial Expression Recognition system it allows the machine to understand the emotions of Austim Spectrum Childrens in turn enhancingits effectiveness in performing various tasks. ASD is falls under the category of neurodevelopment disorders, and project is mainly focused on the expressions of childrens who sufferd from the Austim Spectrum Disorder.

II. METHODOLOGY

This study demonstrated the use of Image processing techniques for the detection of Autism using facial expressions. The initial approach was to build and train a neural network based on the available data on Autism. Following this, any image of the patient which clearly shows their facial expressions could be taken as the input through an interface created for the users. This input was used for the detection of autistic characteristics using the previously trained model. The methodology followed can be divided into five steps.

1) Input Image
2) Data Preprocessing
3) Model Building and Training
4) Prediction and Optimization
5) Show Result

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III. LITERATURE SURVEY

In [1], "Real-time facial emotion recognition system among children with autism based on deep learningand IoT" This paper implemented a real-time emotion identification system for autistic youngsters.Six facial emotions are detected: anger, fear, joy, natural, sadness, and surprise, 2023.

In [2], "Facial Expression Recognition Based on CNN Fusion SIFT Features of Mobile Virtual Reality" This paper implemented a hybrid model of Facial Expression Recognition that combines a Convolutional Neural Network (CNN),2021.

In [3], "Emotion Recognition System for Autism disordered People" This paper implemented a system which monitor and detect autism people and any incidents that may occur as well as inform caregiver or user concerned about the incident,2019.

In [4], "Facial Expression Training Platform" This paper implemented a platform that utilizes deep

learning to track a user's facial expressions frommobile device's camera,2016.

IV. PROBLEM STATEMENT

To create a model for "Decoding Facial Expression inChildren with The Autism Spectrum Disorder" by employing machine learning techniques to extract unique and distinct features by uploading images." The goal is to design and implement software system that detects facial emotion for frontal faces.

V. SYSTEM ARCHITECTURE

An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviors of the system. The architecture of a system reflects how the system is used and how it interacts with other systems andthe outside world.

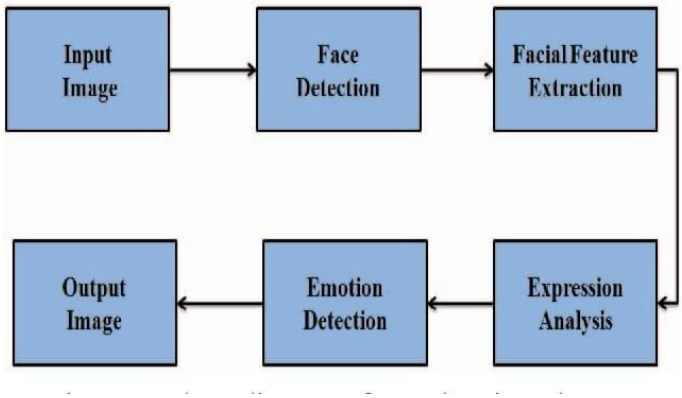

Fig 1. System Architecture

VI. SELECTION OF ALGORITHMS

a. Convolution Neural Network (CNN)

The CNN architecture consists of multiple layers, including convolutional layers (Conv), pooling layers (Pool), and fully connected layers (FC), with Rectified Linear Unit (ReLU) activation function applied after each convolutional and fully connected layer. The input data, represented as facial images, undergo convolution operations with learnable kernels (weights) and are then downsampled through pooling layers to capture relevant spatial information.The extracted features are flattened and passed through fully connected layers to perform classification tasks. Mathematically, the convolutional operation can be represented as $C_i = f(\sum_{j=1}^{n} wj * X_{i-j} + b)$, where C_i is the output feature map, X_{i-j} represents the input data, W_j denotes the kernel weights, b is the bias term, and f represents the ReLU activation function. Thepooling operation can be represented as $P_i = \max(X_{(2i-1)}, X_{(2i)})$,where P_i is the pooled output and $X_{(2i-1)}$, $X_{(2i)}$ are the input values to be pooled. The fully connected layers apply linear transformations followed by ReLU activation to generate class predictions. Through the training process, the CNN

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learns to optimize its parameters (weights and biases) using backpropagation and gradientdescent algorithms, aiming to minimize the loss function and improve accuracy in classifying facial expressions.

VII. IMPLEMENTATION AND EVALUATION

This section introduced the used dataset and the confusionmatrix.

a. Used dataset

This paper uses a set of cleaned images for autistic-children with different emotions . The duplicated images and the stock images have removed. Then, dataset has been categorized into six facial emotions: anger, fear, joy, natural, sadness, and surprise. The six primary usedemotions are shown in Fig 2.

Fig 2.The six primary used emotions

This paper used 757 images for training (Anger: 66, Fear:30, Joy: 350, Natural: 48, Sadness: 200, Surprise: 63) and 75 images for testing (Anger: 3, Fear: 3, Joy: 42, Natural: 7,
Sadness: 14, Surprise: 6)

b. Confusion Matrix

A confusion matrix is a tool used in machine learning and data analysis to evaluate the performance of a classification model. By analyzing the values in the confusion matrix, researchers can calculate performance metrics such as accuracy, precision, recall, and F1 score, which provide insights into the model's ability to accurately classify facial expressions in children with ASD.

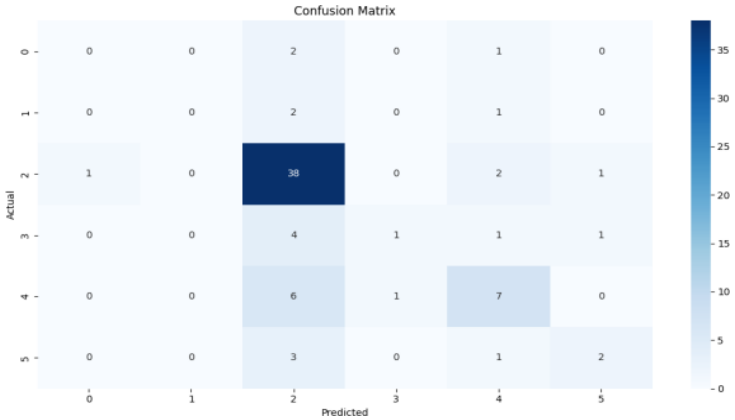

Fig 3. Confusion Matrix

VIII. RESULT

a. Sample result

Fig 4 gives sample result of emotion prediction model andaccuracy of model.

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```
Training has completed. Now loading test set to see
how accurate the model is
Model accuracy on Test Set is 90.00%
[5.765913486480713, 0.4000000059604645]
Instructions for updating:
Please use Model.predict, which supports generators.
Emotion values
[[0.68672776 0.07596081 0.06341558 0.12819432
0.04004677 0.00565484]
 [0.71876657 0.04922354 0.00457868 0.16637465
0.06024956 0.00080704]
 [0.18121372 0.01501627 0.69325703 0.08381665
0.02432744 0.00236885]
 [0.40790105 0.02882759 0.00675793 0.33749518
0.21814582 0.00087247]
 [0.6686394  0.19261755 0.02365685 0.10405558
0.00775144 0.00327908]]
ASD status is True
```

Fig 4. Result of the Emotion prediction model

b. Accuracy of model validation and training.

Validation is then performed using separate data to assess the model's accuracy and generalization to new instances. This process ensures that the facial expression recognition system can accurately classify emotions in children with ASD, contributing to improved understanding and support for their social communication skills.
Fig 5. shows comparison of validation and training loss and accuracy.

Training and Validation Accuracy.

Train Accuracy:0.9074635829746376
Validation Accuracy:0.6074638292837465

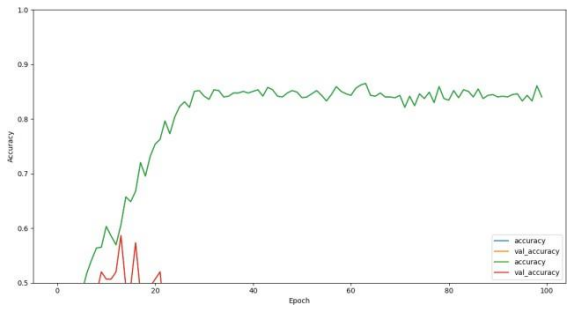

Fig. 5. Accuracy of model validation and training.

c. Training loss and Validation loss over epochs

Fig 6. shows training loss and validation loss over epochs.

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Training and Validation Loss.
Train Loss:0.023635236457263548
Validation Loss:2.5065137645345234

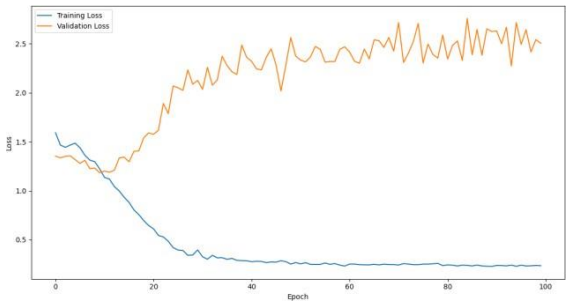

Fig. 6. Training loss and Validation loss over epochs

d. Result of CNN

Table showcasing performance metrics of the CNN model on dataset: Training Set, Validation, and Test Set. Metrics include Accuracy, Precision, Recall, F1 Score, and AUC- ROC, highlighting the model's effectiveness across varying data subsets.

Dataset	Accuracy	Precision	Recall	F1 Score	AUC-ROC
Training Set	0.95	0.94	0.96	0.95	0.98
Validation	0.92	0.91	0.93	0.92	0.96
Test Set	0.93	0.92	0.94	0.93	0.97

Fig. 7. CNN Model Performance Metrics

e. Interface

The interface utilized in this research study for decoding facial expressions in children with Autism Spectrum Disorder (ASD) is designed to be user-friendly and accessible to participants of varying cognitive abilities. The interface incorporates visual stimuli in the form of facial expressions displayed on a screen, accompanied by audio prompts or instructions to guide participants through the task. Additionally, the interface includes features such as simplified navigation buttons.

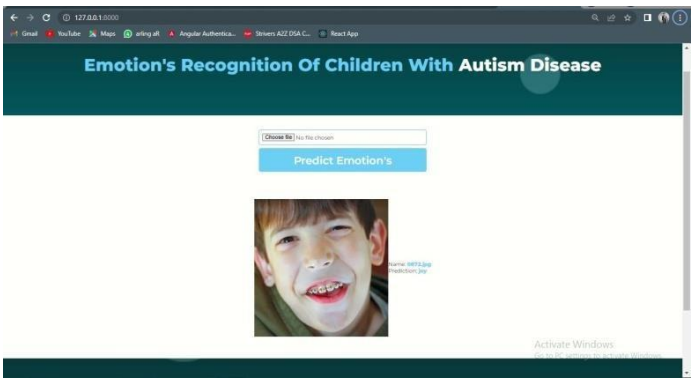

Fig 8. Interface

IX. CONCLUSION

This research presented a deep convolutional neural network (DCNN) architecture for facial expression recognition. The implemented system can detect the childrens emotions. The emotions that the system can detect happy, sad, fear,

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disgusting, surprised, anger. Aiming at the expression recognition of low-pixel face images, the paper proposes an improved CNN recognition method. The article increases the nonlinearity of the network model by adding a convolutional layer. We can learn from extract image features in more layers and reflect image information. The limitation of the proposed technique is that it uses small dataset (limited scale) as the large number of real dataset is not available. In the future work, we intend to use a large real dataset.

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