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Autism Disorder Detection Based on Deep Learning: Deep Analysis

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Abstract

Autism disorder is a neurologic illness which impairs verbal abilities and social interaction in children aged 6 to 17. It can be detected by using facial or biomedical images. As Autistic children has not similar facial features as normal child, Deep learning techniques may be used by extracting some important features. The key purpose of this research paper is to design a system to detect this order using facial features. Predefined models like VGG 16, VGG19, ResNet152V2, EfficientNetV2 and InceptionResNetV2 have been applied on Dataset Autistic Children Facial Dataset is taken from Kaggle data owned by Imran Khan. Different evaluation parameters like accuracy, loss, Confusion matrix are used for the evaluation of these five predefined models. It has been found that ResNet152V2 has achieved higher accuracy on other models.

Keywords: - ASD, Convolution Neural network, Autism, CNN, Deep learning

Introduction

Autism spectrum disorder (ASD) is a neurologic illness that impairs communication abilities and social interaction in children aged 6 to 17. ASD disrupts social connections, communication, and causes sufferers to engage in repetitive activities. [1] As per WHO, one in every 160 children has ASD, and these children frequently have additional illnesses such as melancholy, nervousness, and ADHD. During childhood, early detection is critical for improving communication and social skills in kids with ASD and improving their value of life. An early diagnosis is critical for controlling and treating this condition. Autism is referred to as a "spectrum condition" because of the vast range of indicators that individuals encounter. This ailment is a development and neurologic illness that begins in childhood, develops throughout the first few years of life, and persists throughout one's life. It has an emotional effect on how a person interacts with people, converses, and learns. This condition disrupted the communication and conduct of individual people. Psychologists used the “Diagnostic and Statistical Manual of Mental Disorders (DSM)” published by “The American Psychiatric Association” in order to make a diagnosis for a variety of psychological illnesses[2]. According to the DSM-5, there are five types of ASD, and a person can be diagnosed with one or more of them. In 2016, the “Diagnostic and Statistical Manual of Mental Disorders (DSM)” listed five major types of ASD:

1) Mental retardation (an issue with learning)
2) Impaired linguistic ability (postpones the acquisition of linguistic skills)
3) Deficiency due to hereditary or lifestyle variables
4) A neurological, mental, or social disorder
5) Insomnia (strange motions)

Machine learning in Autism Disorder

ASD is a neurological illness or behavioural ailment that causes a person to have lifelong communication and interaction issues. A person's ASD issue may begin while they are toddlers or young children, and it may persist through adolescence and into adulthood. Although this condition cannot be cured, it can be detected early. The person's treatment may be enhanced with this early detection. Different ML algorithms have been applied to ASD diagnosis. Based on the symptoms, it can be discovered at the early stage of 2 years of age[3]. Finding the best approaches for early ASD prediction is still being researched in the area of medical diagnosis of this disease.

Literature survey

Study	Dataset	Feature Extraction	Classification	Results (%)
(Preethi et al. 2022)[4]	Autism Brain Imaging Data Exchange	AdaDelta optimization algorithm	CNN	74.19
	(KAFD-2020)	the Facial Action Coding Systems (FACS	CNN	67.75
(Saranya and Anandan 2022)[5]	MRI Images from Kaggle	None	CNN	91
	Autism Brain Imaging Data Exchange	None	VGG-16 and ResNet-50	63.4 and 87.0
(Arumugam et al. 2021)[6]	Autism Brain Imaging Data Exchange	None	CNN	97.07
	The AQ-10 from the UCI repository	Bootstrap Gradient Boosting	ensemble ML technique	93.42
(Husna et al. 2021)[7]	Four ASD datasets	`relief F' feature selection technique	SVM	100
	ASD datasets	several feature selection techniques	SVM	99.61
(Saleh and Chern 2021)[8]	neuroimaging dataset	None	VGG16	86
	physiological data	None	naive Bayes algorithm	87
(Arunkumar and Surendran 2022)[9]	ASD dataset	(LBP) and (GLCM) algorithms.	GoogleNet ResNet-18 and (SVM)	95.5 and94.5
	Autism Brain Imaging Data Exchange	Conditional random forest	Random Forest	73.75
(Hossain et al. 2021)[10]	Autism Brain Imaging Data Exchange	Dual regression	3D CNN classifier	77.74

	Autism Brain Imaging Data Exchange	An AE-based feature	DNN classifier	79.2
(Bala et al. 2022)[11]	Autism Brain Imaging Data Exchange	Conditional random forest	Random forest	62.5
	Autism Brain Imaging Data Exchange	None	The proposed multichannel DANN	73.2
(Sharif and Khan 2022)[12]	Autism Brain Imaging Data Exchange	Extra-tree	SVM	72.2
	Autism Brain Imaging Data Exchange	None	CNN classifier	70.22
(Liao, Duan, and Wang 2022)[13]	Autism Brain Imaging Data Exchange	None	3D CNN classifier	64
	Autism Brain Imaging Data Exchange	None	DNN classifier	74
(Ahmed et al. 2022)[14]	Autism Brain Imaging Data Exchange	A two-sample t-test and LASSO	SVM	83
	Autism Brain Imaging Data Exchange	Graph-based feature-select ion method	DBN classifier"	76.4
(Reiter et al. 2021)	Autism Brain Imaging Data Exchange	PCA	A multilayer perceptron	64.4

Materials and methods

This research paper proposes the Deep learning models like VGG 16, VGG19, ResNet152V2, EfficientNetV2 and InceptionResNetV2 to detect the autism using facial features of the children. These facial features can be utilized to determine whether child has autism or not.

Method:

Firstly, the framework of predefined machine learning models for classification process is shown in Figure 1. Initially, the dataset suggested in above mentioned module is loaded. The photos generated from the dataset were all of different sizes shown in Figure 2. We used Python Open CV's resize function to resize all of the photographs to the same size. After bringing all of the photos to a standard size, colour space conversion was conducted. All of the photographs were converted from the BGR colour format to grayscale. After that, the preparation phase was completed by turning all of the photos into arrays for future processing. The data set is divided into three subparts i.e., Training, validation and test Dataset. The feature extraction is actually done on train data. To classify the autistic and non-autistic child, Author has deployed different predefined deep learning models in this study. It is employed Google Collab as an environment

which is Google's cloud-based service and for programming language; we have used Python 3 in this study. The Virtual Tensor Processing Unit (TPU) from Google Colab was utilized to speed up the execution of classification algorithms.

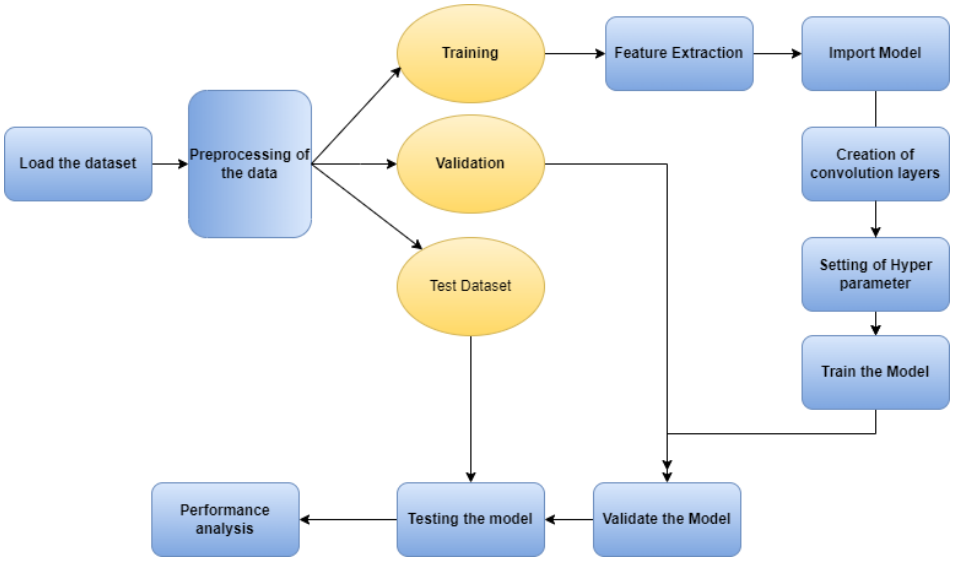

Figure 3: *Framework of Predefined machine learning models*

Materials

Facial Dataset of Autistic Children named as Autistic Children Facial Dataset is taken from Kaggle data owned by Imran Khan[15]. In present work, authors have used Autistic children Data set, which we obtained from Kaggle Repository. The dataset contains 2940 photos of children's faces, with subfolders of autistic and non-autistic images which are distributed evenly. There is collection of photos of youngsters aged 2 to 8 years old. The male female ratio in autistic class is 3:1 and it is 1:1 in the non-autistic class. As the Autistic Children Facial Dataset has ample number of images, so dataset was split into 1000 images for training, 50 for validation as depicted in Figure 4.

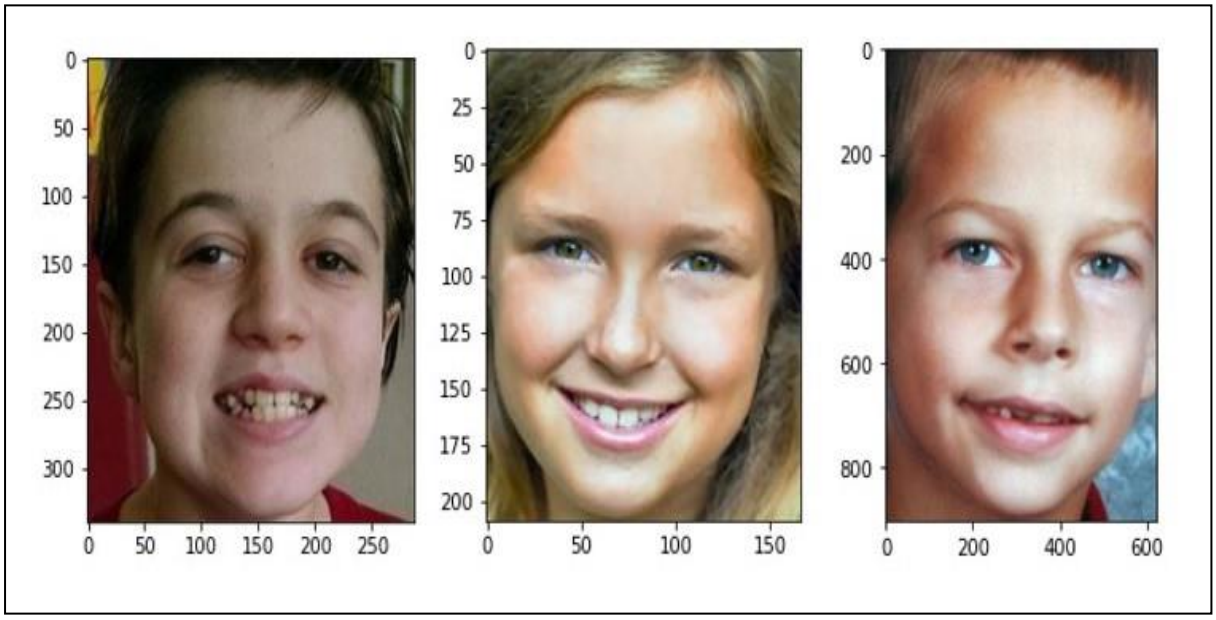

Figure 5: *Some images from dataset with different sizes*

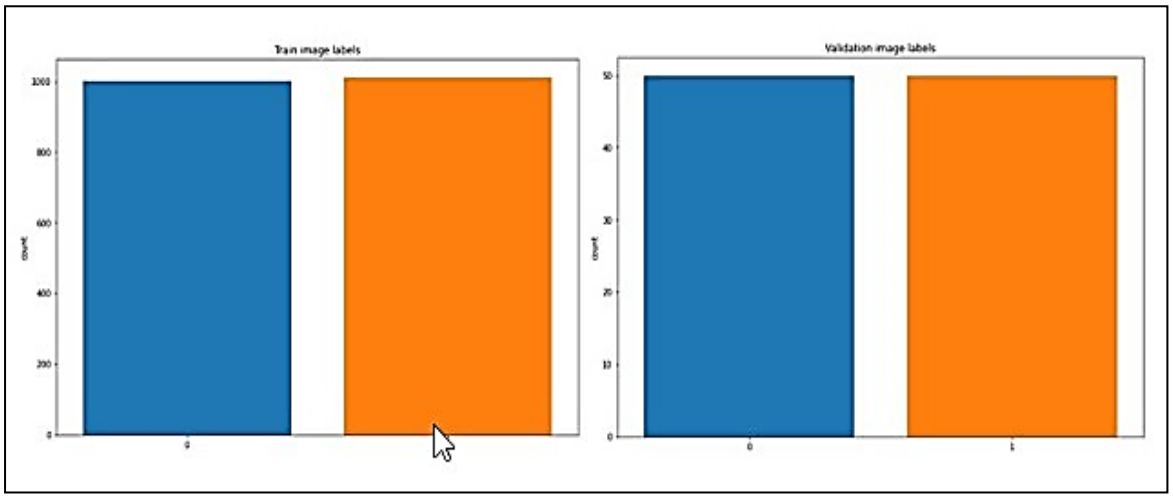

Figure 6: *Splitting of dataset*

Predefined Models

This research paper proposes the Deep learning models like VGG 16, VGG19, ResNet152V2, EfficientNetV2 and InceptionResNetV2 to detect the autism using facial features of the children. The Parameters of predefined Learning models are shown in Table 1. This table depicts the number of parameters (in Millions), complexity, speed and features of respective models.

Table 2: *Parameters used in the pretrained deep learning models.*

Model	No. of Parameters (in million)	Complexity	Speed	Special Feature
VGG16	138	High	Low	detect generic visual features
VGG19	143	Low	High	Replace large filters with small
ResNet152V2	84	Low	High	Depth wise convolution followed by point wise convolution
EfficientNetV2	24	High	Low	Uses small size of kernels
InceptionResNetV2	56	Low	High	Identify mapping based on skip connections

Analysis and Results

This section basically presents the results of experiments conducted to detect autism. Table 3 provides the summary of five predefined deep learning models which is VGG 16, VGG19, ResNet152V2, EfficientNetV2 and InceptionResNetV2. Each model is trained and tested to extract the features which is used to classify the children as autistic or non-autistic on the basis of facial features. Figure 7 shows accuracy achieved by five deep learning models.

This figure shows that ResNet152V2model had the highest accuracy of 71 % as comparative to other models and EfficientNetV2 has performed low with the accuracy of 48%.

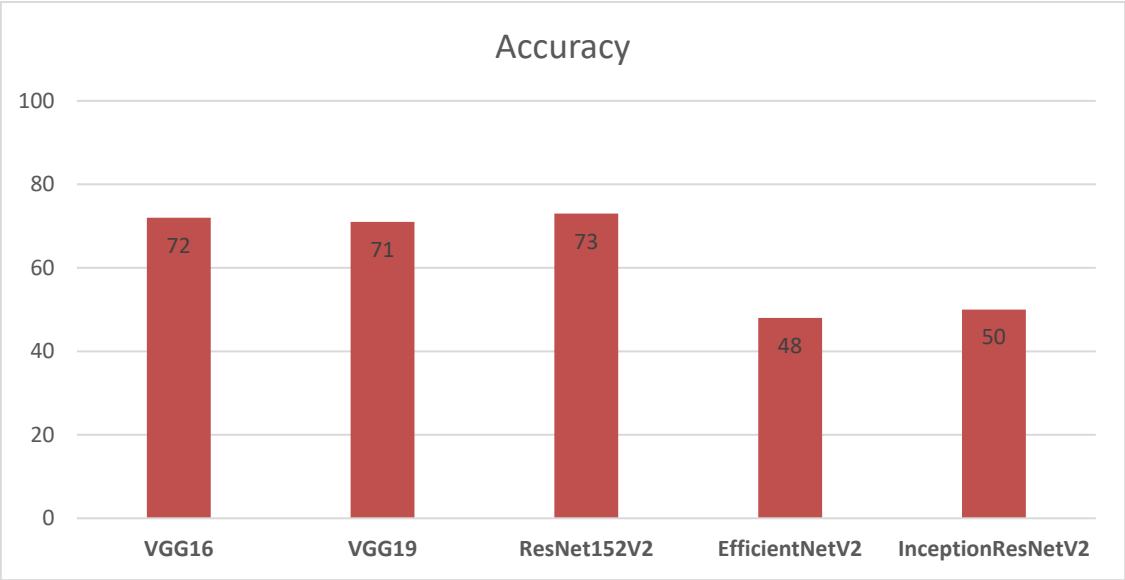

Figure 8: *Accuracy achieved by five deep learning models*

Table 4: *Accuracy and loss at every epoch of deep learning models*

	VGG16		VGG19		ResNet152V2		EfficientNetV2		InceptionResNetV2	
No. of Epochs	Accuracy	Loss	Accuracy	Loss	Accuracy	Loss	Accuracy	Loss	Accuracy	Loss
1	60.3	0.889	61.5	0.817	72.5	0.530	51.2	5.725	56.1	3.630
2	66.7	0.602	64.2	0.637	72.8	0.529	51.6	0.718	62.3	0.649
3	68.2	0.587	67.2	0.589	71.4	0.554	52.2	0.695	63.0	0.636
4	69.0	0.575	68.1	0.582	73.0	0.538	51.4	0.694	65.8	0.621
5	70.9	0.563	69.7	0.581	72.9	0.526	50.1	0.693	64.7	0.619
6	69.1	0.579	70.8	0.578	73.4	0.530	49.9	0.701	65.3	0.621
7	69.8	0.567	69.7	0.581	74.0	0.536	51.8	0.693	64.5	0.630
8	71.0	0.558	70.2	0.562	71.3	0.540	51.3	0.693	68.5	0.599
9	73.0	0.527	69.7	0.580	73.8	0.519	50.6	0.693	66.3	0.603
10	72.6	0.536	70.3	0.567	72.8	0.530	51.2	0.694	67.7	0.601
11	73.0	0.532	70.6	0.570	73.3	0.542	49.4	0.693	67.8	0.602
12	71.9	0.530	71.9	0.553	73.0	0.546	49.8	0.693	66.0	0.608
13	73.9	0.530	70.5	0.555	71.3	0.538	50.2	0.693	68.5	0.590
14	73.6	0.534	72.2	0.545	72.3	0.530	50.3	0.693	67.5	0.614
15	71.1	0.536	72.5	0.538	72.6	0.533	50.1	0.692	67.4	0.591
16	73.3	0.537	70.2	0.561	73.8	0.522	50.2	0.694	69.0	0.588
17	72.4	0.541	72.0	0.554	72.8	0.521	47.3	0.693	68.8	0.584
18	72.4	0.528	70.5	0.548	73.9	0.526	51.0	0.694	68.0	0.588
19	73.9	0.520	72.4	0.536	72.4	0.513	50.4	0.693	68.6	0.591
20	74.2	0.508	73.1	0.536	73.2	0.525	50.4	0.693	67.4	0.591

Conclusion

Due to enhancement in research capacities of health issues, the interest in autism detection in children has increased. Academician and researchers have shown keen interest and

shown their much efforts to find out the cause of this disorder and try to detect in early ages of the life. This paper evaluated the predefined models of deep learning like VGG 16, VGG19, ResNet152V2, EfficientNetV2 and InceptionResNetV2 to detect the autism disorder using some facial features. Publicly available data named as Autistic Children Facial Dataset is used to train the models. Best results in terms of accuracy are achieved by ResNet152V2. Results of different models has showed us possibility in diagnosing autism using deep learning models. It helps in reduction of time as well as efforts for autism diagnosis.

Declarations

The author confirms that there is no conflict of interest and there are no financial funds.

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