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Refurbished and improvised model using convolution network for autism disorder detection in facial images

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ABSTRACT

The main quality of deep learning over conventional machine learning (ML) techniques empowers firsthand uses in processing of images, speech recognition, medical imaging, machine translation and robotics, computer vision, and numerous other fields. The purpose of this study is to assess algorithms of deep learning for person with the disorder of autism. This disorder is developing disorder that causes significant communicative, social and behavioral difficulties in those who have it. In this research paper, the enhanced version of convolution network is discussed. Visual geometry group (VGG), is one of model of the convolution neural network which has essential features of convolution neural network (CNN). The VGG 16 net is employed to calculate the processes that can be used to classify this disorder with improved accuracy. The preprocessing of the image data is done. The VGG 16 convolution network is used to classify between autism spectrum disorder (ASD) and non-ASD. Finally, the algorithm's efficacy is considered based on its accuracy performance. The VGG 16 net algorithm produces better results with an accuracy of 68.54%, compared with the normal CNN algorithm.

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1. INTRODUCTION

Autism spectrum disorder (ASD) is a neurologic condition that affects children between the ages of 6 and 17, and it causes impairments in communication abilities and social interaction. Autism spectrum disorder causes patients to engage in activities that are repetitive and destroys social bonds as well as communication. According to the World Health Organization (WHO), one in every 160 children has autism spectrum disorder (ASD), and these children usually have other disorders such as depression, anxiety, and attention deficit hyperactivity disorder (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 [1]. 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. 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 [2]:

a) Mental retardation (an issue with learning).
b) Impaired linguistic ability (postpones the acquisition of linguistic skills).
c) Deficiency due to hereditary or lifestyle variables.
d) A neurological, mental, or social disorder.
e) Insomnia (strange motions).

2. AUTISM AND CONVOLUTION NEURAL NETWORK

Because there are no medical tests like sugar tests, blood tests, and so on, it is extremely difficult to diagnose ASD. The diagnosis of ASD is based on the kid's behaviour and the parent's perspective, and if the parent of an autistic child is unable to explain their child's symptoms appropriately, it is extremely difficult for a doctor to determine the correct form of autism. According to medical research, autism has no known cure, although Therapies and treatments are there that can help the patient's behaviour to some extent [3]–[5]. Therapy can also assist to ease some of their symptoms. Convolution neural network (CNN) has received very much interest in the arena of classification in recent years. These are solid classifiers with outstanding precisions in a wide range of applications and a lot of unrestricted parameters. In addition, CNN models have better accuracy when it comes to the extraction of features, and they are able to deal with a high number of uncontrolled parameters, which simply implies a huge quantity of free parameters. The convolution layers, fully connected layers, activation function, and pooling layers are the primary components that make up the CNN model [6].

3. VGGnet AND ITS ARCHITECTURE

Visual geometry group, also known as visual geometry group (VGG), is one of model of the convolution neural network. It is typical deep convolution network where "deep" indicate the number of layers with 16 or 19 convolution layers [7]. The architecture of VGG Architecture is shown in Figure 1. Simonyan and Zisserman from University of Oxford proposed this architecture which is also called as VGGnet. It is really based on CNN's most important features. An input image of 224*224 is used in VGG-based convolution network. The pre-processing stage layer generates an RGB image with pixels varies from 0 to 255 to and deducts the mean of image values determined over detailed imagenet training set [8]–[11].

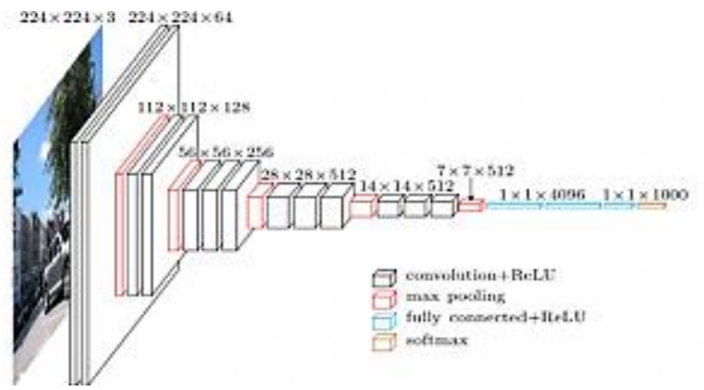

Figure 1. VGG architecture

The input visuals are processed first, then these weighted layers are applied [11], [12]. Convolution layer stack is used to do processing on the pictures that have been trained. There are a total of 13 convolutional layers and three fully linked layers in the VGG 16 architecture. Small filters of 3*3 are employed by VGG 16 to achieve improved depth. The VGGNet variation has a total of 19 weighted layers, including 16 convolutional, fully-connected layers, although it maintains the same maximum pooling of 5 layers. Both versions of the VGGNet include two completely connected layers, each with a total of 4096 channels. These layers are then followed by a further fully connected layer that consists of 1000 channels and is used to categorise 1000 labels [13]–[15]. In the very last completely connected layer, the softmax layer is the one that's employed for classification. VGG Architecture:

a) Input: The VGGNet accepts images with fixed size of 224*224 with three channels (R, G, and B). The preprocessing is done to normalize RGB values for each pixel which is achieved by subtracting mean value from every pixel.
b) Convolution layer: An image is passed through two stacks of convolution layer with size of 3*3. It is followed by rectified linear unit (ReLu) activations. Each layer contains 64 filters. The stride and padding

of convolution layer is fixed at 1 pixel. Stride is the number of the pixels over the input matrix. It is neural network filter which adjust the momentum of picture or the video. The output activation layer is then passed to spatial max pooling with size of 2*2 with stride of 2. Consequently, it reduces the image size from 224 *224*64 to 112*112*64. Later the activation flows though same stack of convolutional layer but with 128 filters instead of 64. Now the size after second stack of convolution layer becomes 56*56*128. Next step is of third stack which of three convolutional layer and max pool layer with 256 filters. It makes the output size of 28*28*256. Lastly two stacks of convolutional layer with filter of 512 each is applied which makes the output size of 7*7*512 [16]–[18]. The detailed depiction convolution neural network configuration of the VGG net is shown in Figure 2 and Figure 3.

c) Hidden layers: ReLu activation function is applied on all hidden layers in VGG network. Full form of the ReLu activation function is rectified linear unit activation function. Basically, it is linear function which will give an output if input given is positive and otherwise it produces zero as output. As mentioned, the convolutional layer's stride is fixed at 1 pixel.

d) Fully-connected layers: There are three fully connected layers in VGG. 7*7*512 is flattened into fully connected layers. There are 4096 channels or neurons in first two layers. Out of the three layers, the first two have 4096 channels each, and the third has 1000 channels, 1 for each class.

It is proposed to use small fields to replace large one. There will be nonlinear rectification layers instead of one single rectification. It will help in reduction of count of parameters in order to achieve better results.

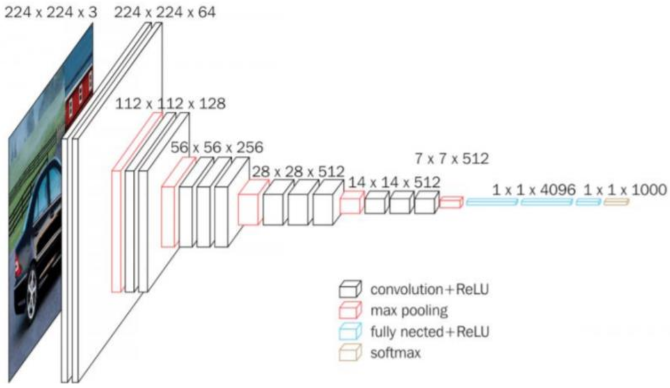

Figure 1. The convolution neural network configuration of the VGG net

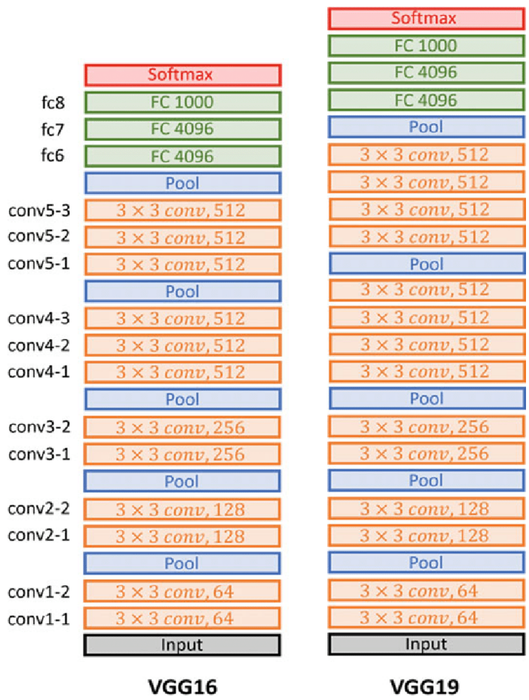

Figure 2. Different versions of VGG convolution network

4. VARIANT OF VGG

VGG is brought into the world to reduce the number of parameters in convolution layer and also helps in improving the training time. Numbers of variants are available for VGGNet like VGG16, and VGG19. that differ in numbers of layers in network. In this study, author has discussed five variants of VGG convolution network as shown in Figure 4. As it can be seen that there are two versions of VGG 16 that is C and D. Not much of a variation among them except that instead of 1*1, filter size of 3*3 is used for some convolution layers [19]–[21]. Parameters are 134 million and 138 million respectively. The major problem of VGG 16 is that it is slow to train and requires lot of space and bandwidth that make it inefficient. VGG 19 convolution network has deep 19 layers where 16 are convolution layers, 3 fully connected layers, 5 max pool and 1 softmax layer [22], [23].

ConvNet Configuration					
A	A-LRN	B	C	D	E
11 weight layers	11 weight layers	13 weight layers	16 weight layers	16 weight layers	19 weight layers
input (224×224 RGB image)					
conv3-64	conv3-64 LRN	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64
maxpool					
conv3-128	conv3-128	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128
maxpool					
conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256 conv1-256	conv3-256 conv3-256 conv3-256	conv3-256 conv3-256 conv3-256 conv3-256
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 conv1-512	conv3-512 conv3-512 conv3-512	conv3-512 conv3-512 conv3-512 conv3-512
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 conv1-512	conv3-512 conv3-512 conv3-512	conv3-512 conv3-512 conv3-512 conv3-512
maxpool					
FC-4096					
FC-4096					
FC-1000					
soft-max					

Figure 3. The convolution neural network configuration of the VGG net [24]

5. RELATED DATA

Facial dataset of autistic children named as autistic children facial dataset is taken from Kaggle data owned by Imran Khan [5], [10], [25], [26]. 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 [26].

6. METHOD

To classify the autistic and non-autistic child, Author has deployed VGG 16 convolution network in this study. The proposed frame work is depicted through Figure 5. It is employed Google Colab 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. Following the completion of the data preparation procedure, the entire dataset is split into an 80:20 proportion, with 80% used as a training set and the remaining 20% preserved for testing. The photos generated from the dataset were all of different sizes. 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, color space conversion was conducted. All of the photographs were converted from the BGR color format to grayscale. After that, the preparation phase was completed by turning all of the photos into arrays for future processing.

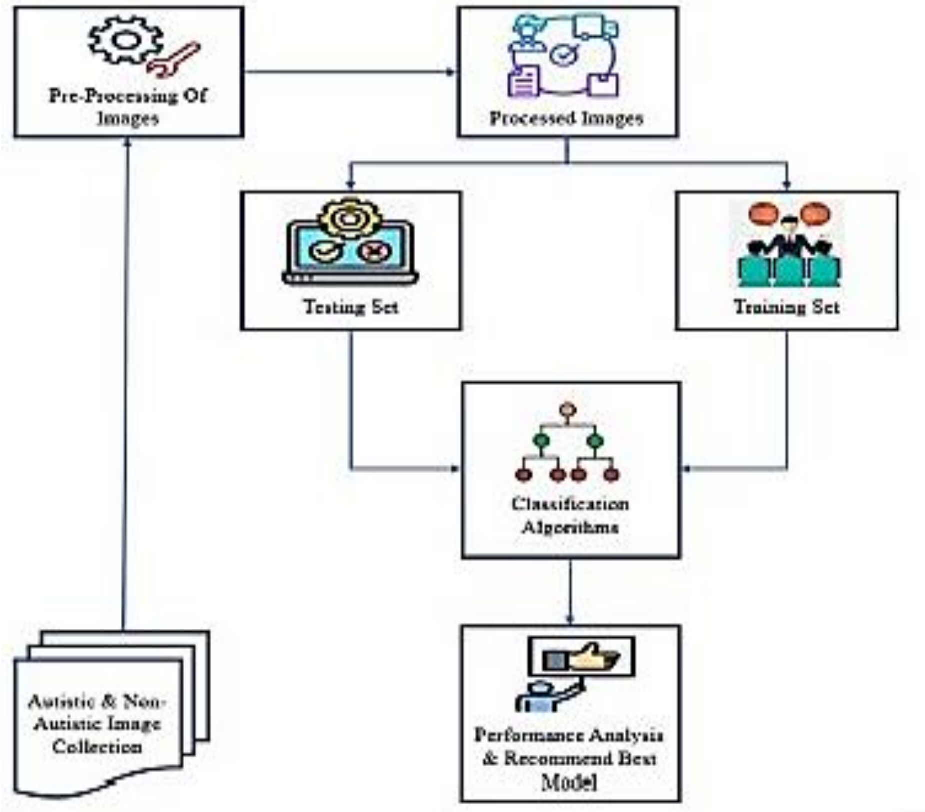

Figure 4. Proposed work flow of method

7. RESULTS AND DISCUSSION

In this day and age, for the classification of data set, there is wide use of CNN. In the proposed paper, authors used facial dataset of children with autistic named as autistic children facial dataset which is taken from Kaggle data owned by Imran Khan. It consists of 5874 images of children with subdirectory of autism and non-autism. During the training process, the learning rate was adjusted to 0.005, the batch size was set to 32, and the number of epochs was 5. The input image of 224*224 matrixes was given to network. The time of execution of this work was about 8 hrs and 30 minutes using the Google Colab TPU. We have attained 70.22% of accuracy. It is observed that better accuracy will be achieved after increasing number of epochs. In Figure 6, the intersection between training and validation accuracy is shown. Model loss and model accuracy is shown in Figure 7 and Figure 8 respectively. When applying simply the batch normalization or heavy dropout option to the extremely deep model, we discovered that the model gained accuracy; nevertheless, this accuracy was not very high.

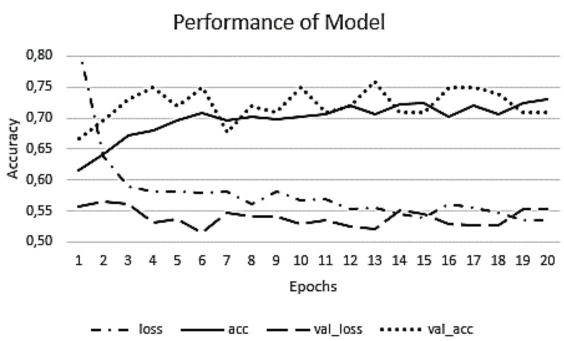

Figure 6. Validation accuracy and training accuracy

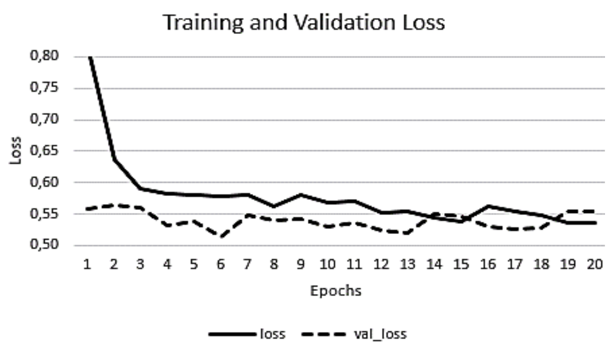

Figure 7. Depiction of model loss

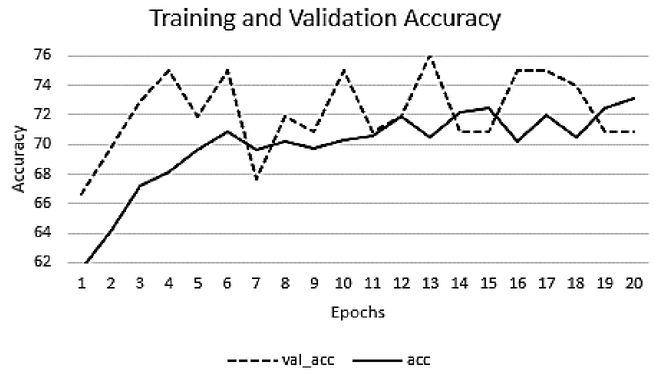

Figure 8. Model accuracy

8. CONCLUSION

In this work, we developed a CNN model to distinguish ASD from control participants. Our suggested CNN architecture can provide improved classification performance with fewer parameters, reducing training time. As a result, our suggested model is less complicated and quicker than existing similar models. To classify autistic and non-autistic child, VGG net convolution network is applied on dataset of images. It has been demonstrated that the suggested model performs effectively, particularly with fewer pictures. It is also specified how the accuracy is affected by the number of epochs. It has been discovered that 25 epochs are adequate for an effective training of a purposed model.

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