# Efficient Classification Of Autism in Children based on Resnet-50 and Xception module

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***Abstract*—Children with autism spectrum disorder struggle to process emotions appropriately, which makes it difficult for them to understand facial expressions. It is crucial for autistic children to recognize emotions because emotion is a crucial component of good socialization. In the proposed method, we use the two different CNN architecture which includes Resnet-50 and Xception modules, and designed an app to classify autistic and non-autistic children. The results demonstrated that the accuracy of the Resnet-50 method is better when compared to the existing conventional methods.**

***Index Terms*—Autism, Children, Deep Learning, Convolution Neural Networks, Resnet-50, Xception module.**

## I. Introduction

A developmental and neurological illness called autism spectrum disorder (ASD) encompasses a range of difficulties with speech, nonverbal communication, social interaction, and communication [1]. ASD symptoms commonly appear within the child at ages of first year and may include a lack of eye contact and lack of response to the people when they called [2]. The effective states of an autistic person can be assessed using a variety of invasive and non-invasive techniques, such as blood flow analysis, electro myography, electrothermal activity, and cardiovascular activity. Although these approaches are meant to be non-invasive, however, sensors on the skin can distract the user and alter the emotional state of an autistic youngster. In order to address that issue, another non-invasive and contactless technique called thermal imaging was used. In thermal imaging, a thermal camera can easily record the thermal imprints that make up the human face, which represent variations in blood flow. These thermal imprints have been used to assess how physiological signals and effective states are related. However, accurate predictions are not met because of the wide range of emotions in the recorded data.

Recent developments in machine learning and deep learning algorithms have shown substantial growth in various applications for classification and regression tasks [3]–[5]. In [6], a complex, difficult, and enduring developmental impairment, autism, commonly known as an autism spectrum disorder (ASD), encompasses issues that are defined by repetitious actions, nonverbal communication, and a lack of focus. ASD has been growing more rapidly in recent years, necessitating early diagnosis. Autism detection requires a variety of time and money-consuming screening tools. Predictive analytics, which is another name for a variety of mathematical models, has been increasingly popular in recent years. Machine learning and pattern recognition are two multidisciplinary study fields in medicine that offer efficient methods to detect ASD.

In [7], authors demonstrated about ASD, a neurological disorder, may experience lifelong difficulties with language acquisition, speech, cognition, and social skills. It affects 1 percent of the world's population and typically manifests during the developmental stages, between the first two years of birth. ASD is primarily brought on despite the fact that its symptoms can be reduced by detecting and treating it early, it is caused by heredity or environmental factors. The only procedures utilized to diagnose ASD at this moment are clinically based standardized tests. This results in a lengthy diagnostic process and a sharp rise in medical expenses. Machine learning techniques are being utilized to reduce the time and precision needed for diagnosis.

Further in [8], authors discussed the abnormalities of human growth and behavior. Speech issues, issues interacting with the outside world, and any constrained or repetitious activities in humans will have an impact on health. It also covers brain development disorders, which have an impact on the anatomical and functional skills of the brain. As a result, there is a large body of literature on automatically identifying ASD. They do point out that advances in computer technology and testing standards have made early identification of ASD possible. This study uses machine learning, deep learning, ICT tools, humanoid robots, and VR to offer a thorough assessment on the diagnosis of autism spectrum condition in children.

## II. Related Works

In this section, we provide the existed work on autism detection based on ML and DL techniques.

### A. Review on Autism detection based on ML techniques:

There are various ML algorithms applied for Autism detection in children. In [9], authors analyzed the autism spectrum disorder (ASD) based on various ML techniques which include Support Vector Machines (SVM), Random Forest Classifier (RFC), Naive Bayes (NB), Logistic Regression (LR), and KNN. From their study, results show that Logistic Regression offers the highest degree of accuracy for the data set selected. Later in [10], authors tested autism disorder on four distinct benchmark datasets (QCHAT, AQ-10-child, and AQ-10-adult) and empirically compared the performance of the eight well-known ML algorithms. The performance of ML algorithms is compared and analyzed based on metrics like precision, sensitivity, specificity, and classification accuracy. The test results show that the support vector machine (SVM) based classifier outperforms when compared to the other existing ML algorithms. Regression with multiple variables is currently ranked second. On the other hand, the decision tree-based algorithm yields the worst results. One major limitation of this approach is age constraints.

To address the above-mentioned limitation, in [11] authors aimed to create a mobile application for the prediction of ASD in individuals of any age and proposed a successful prediction model based on the combined ML-based approach. The combined approach includes Random Forest-CART (Classification and Regression Trees) and Random Forest-ID3 (Iterative Dichotomiser 3). The obtained results of this approach demonstrated that the prediction model performs better for two different types of data sets in terms of accuracy, specificity, sensitivity, precision, and false positive rate (FPR).

Thereafter, in [12], behavioral based ML method was proposed for infants of age between 6 and 36 months. In the behavioral-based approach, videos of infants with abnormal behavioral conditions are spotted. Most behavioral abnormalities include directed gaze towards people or items of interest, positive affect, and vocalization. In this behavioral-based ML method, authors collected the data set with 2000 videos in which each video has a span of 3 minutes. Then, a feature selection process was employed for the most important statistical behavioral features. In addition, an over and under sampling process was applied to balance out the class imbalance and attained an accuracy of 82% .

Later in [13], the effectiveness of various ML algorithms are tested on early-detected transformed ASD data sets for infants, kids, teens, and adults. The transformed data sets used a variety of feature transformation techniques, such as log, Z-score, and sine functions. The effectiveness of various classification methods was then tested using these modified ASD data sets. We found that SVM performed best on the data set for toddlers, while Ada-boost performed best on the dataset for kids and adults. Where as Glmboost performed best on the dataset for teens. However, the best classification results for toddler datasets came from feature transformations using sine function and Z-score. The outcomes of these analytical methods show that machine learning techniques can produce accurate forecasts of ASD status when properly optimised. This implies that it might be feasible to use these models for the detection of ASD in its early stages.

However, all the above-mentioned ML algorithms have limitations which include less accuracy and low efficiency.

### B. Review on Autism detection based on DL techniques:

In this section, we provided the related work done by the researchers based on deep learning techniques. In [14], authors proposed a fundamental Convolutional Neural Network's architecture for ASD detection based on facial expression recognition. However the majority of ASD patients lack the ability to recognise facial expressions. The results of facial expressions recognition has shown better recognising emotions in children at formative years.

Later in [15] biological imagery and data from social media are used to identify autism spectrum disorder (ASD), a type of mental illness. The neurological ailment known as autism spectrum disorder (ASD) is connected to brain development and has an aesthetic impact on the face. The facial landmarks of children with ASD are significantly different from those of children who are developing normally (TD). The development of a system based on facial recognition and The novel aspect of the study is the identification of autism spectrum disorders via social media. Deep learning approaches may be used to recognise these landmarks, but they demand precise technology for extracting and creating the right patterns from the face data. Further in [16], authors discussed about a developmental brain condition that impairs cognitive, linguistic, social, and communication abilities. Authors used the CNN architecture in this study using two datasets of adult ASD screening data. The performance of the CNN model in the diagnosis of ASD in terms of classification accuracy is studied.

In [17], authors used a simple online application to built a deep learning system, specifically a convolutional neural network with transfer learning and the flask framework. The designed transfer learning framework help communities and psychiatrists to empirically detect the autism based on facial traits. The models that were employed for the classification challenge were Xception, Visual Geometry Group Network (VGG19), and NASNET Mobile.

Later in [18], authors proposed a deep learning algorithm for automatic detection based on thermal images which are feeded as training data. However, the limitation in the existed work is need of thermal images as a data set. In our proposed method, we use the two different CNN architectures to get the improved accuracy with normal images as training data set.

Feature selection and representation play a vital role in ML and DL algorithms for effective autism classification. However,

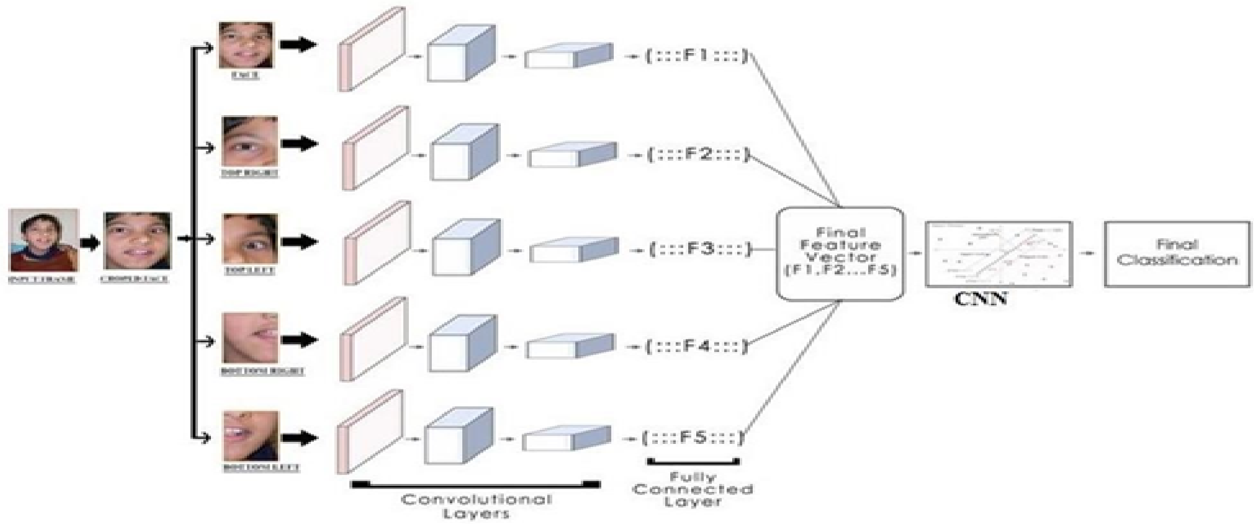


Fig. 1. CNN architecture for Autism classification in child

extracting informative features from complex multidimensional data, like neuroimaging or behavioral data, remains challenging. The identification of the most relevant features is not always straightforward, and existing feature selection and extraction techniques may not fully capture the complete range of pertinent information. As a result, the performance of classification models can be limited by the inability to adequately represent the data's intricacies.

## III. Methodology

In the proposed work, we solve the autism detection problem using transfer learning approach, which makes use of the architecture and trained biases and weights of an existing model. As a result, our task is more computationally efficient, and we get better results with a smaller amount of data. In the proposed work, we used the two deep CNN architectures namely Resnet-50 and xception algorithms for efficient classification of autism. The CNN architecture for autism classification in child is shown in Fig.1. The design methodology for the implementation of autism detection is shown in Fig.2. Each step of our proposed methodology is discussed as follows:

### *A. Upload the dataset*

In this step, we uploaded the data set containing 412 images where the application used 329 images for training and 83 for testing. In the proposed work, we applied the data set to two different CNN Algorithms which includes Resnet50 and Xception algorithm with transfer learning techniques to train Autism detection model. The selected data set consists of two different classes such as 'Autistic' and 'Non-Autistic.

### *B. Data Preprocessing*

In the data pre-processing step, we perform resizing and normalization on the uploaded data set. Then we split the data set into train and test where the application used 80 percent images for training and 20 percent for testing. Along with resizing and normalization, image enhancement and denoising were also performed to make the data set of good quality.
Image enhancement is one of the important pre-processing steps to highlight the details in an image and for good visual perception.
In general, noise is added to the data due to the sources like sensors, environmental conditions and noisy channels, etc. Hence, along with image enhancement, de-noising is also

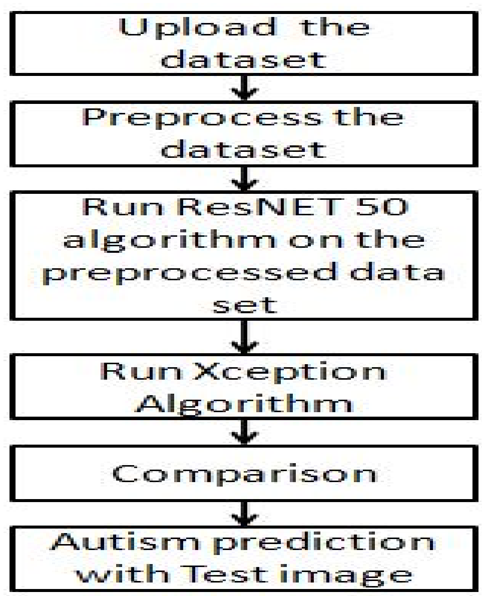


Fig. 2. Design Methodology

performed on the data set for quality improvement in the data with a high signal-to-noise ratio.

### C. Resnet-50

ResNet50 is a popular convolutional neural network (CNN) architecture for deep learning, which was introduced by Microsoft Research in 2015. It is designed to enable very deep networks with hundreds of layers to be trained effectively while mitigating the vanishing gradient problem that can arise in such deep networks. The architecture of ResNet50 consists of 50 layers, including convolutional layers, pooling layers, and fully connected layers. The core building block of the network is the residual block, which enables information to be passed forward through the network more easily. A residual block is made up of two convolutional layers, each followed by batch normalization and Rectified Linear Unit (ReLU)activation. The output of the second convolutional layer is added to the input of the block before the ReLU activation, effectively creating a shortcut connection that skips over the convolutional layers. This helps to preserve the gradient signal, preventing it from vanishing as it passes through many layers. ResNet50 also uses a technique called global average pooling, which replaces the traditional fully connected layers at the end of the network. Instead of flattening the output of the last convolutional layer and passing it through a series of fully connected layers, global average pooling computes the average of the activations of each feature map in the last convolutional layer. This produces a one-dimensional vector, which is then passed through a single fully connected layer to produce the final output. The output of ResNet50 is a probability distribution over the classes in the training set, and it can be used for tasks such as image classification and object detection. ResNet-50 has achieved state-of-the-art performance on various benchmark data sets and has become a popular choice for many computer vision tasks.

### D. Xception algorithm

Xception is a convolutional neural network (CNN) architecture that is designed to improve the efficiency of the network by reducing the number of parameters and computations required. The name ”Xception” is a combination of ”Extreme Inception” and ”Exceptional Network”. The architecture of Xception is based on a series of depthwise separable convolutions, which are a combination of depthwise convolutions and pointwise convolutions. In traditional convolutional layers, the same set of filters is applied to the entire input volume, resulting in a large number of parameters. In contrast, depthwise convolutions apply a single filter to each input channel separately, reducing the number of parameters required. Pointwise convolutions then combine the outputs of the depthwise convolutions, applying a set of filters to each pixel of the output. The Xception architecture uses a series of these depthwise separable convolutions, which reduces the number of parameters by up to an order of magnitude compared to traditional convolutional layers. This allows for deeper networks to be trained more efficiently, with fewer computations and less overfitting. Xception has achieved state-of-the-art performance on various benchmark datasets for image classification, object detection, and semantic segmentation tasks. It has become a popular choice for many computer vision applications, particularly those with limited computational resources.

## IV. Results

We have used the data sets from Kaggle with different emotions on faces. We randomly selected one image from the data set and tested the autism using Resnet-50 and Xception modules.
The first step of our designed method is shown in fig.3 where we uploaded the dataset from a folder.

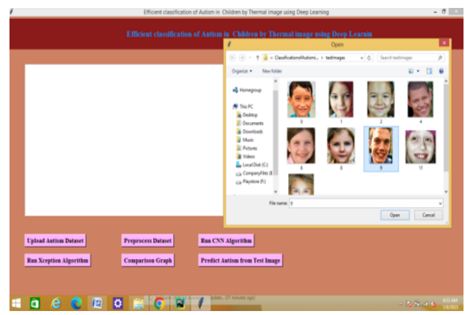


Fig. 3. Dataset upload

The next step shows whether the selected person in the data set has Autism or not after processing through Resnet-50 and Xception algorithms.

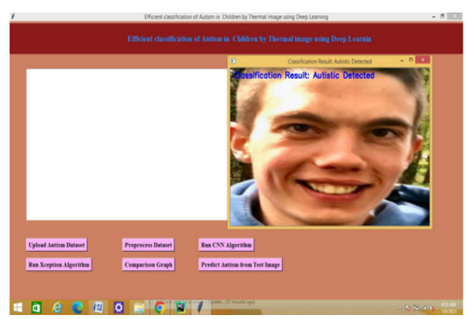


Fig. 4. First Test image Result

From the predicted output, the selected image is detected as Autistic. Again select another image from the data set for detection. The selected data set shows that the person doesn’t have Autism.
The comparative results of Resnet-50 and Xception algorithms in terms of accuracy, precision, Recall and F1 score are tabulated in TABLE I. From the TABLE I, we observed that Resnet-50 has shown the better results when compared to Xception algorithm.

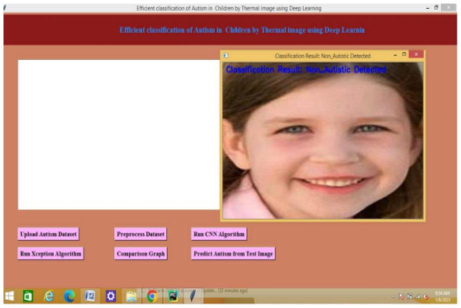


Fig. 5. Second test image result

TABLE I
COMPARISON OF RESNET-50 AND XCEPTION ALGORITHM

| Algorithm | Accuracy | precision | Recall | F1 score |
|---|---|---|---|---|
| Resnet-50 | 96.38 | 96.34 | 96.66 | 96.37 |
| Xception algorithm | 84.33 | 87.25 | 85.55 | 84.25 |

## V. CONCLUSION

We propose an autism prediction method based on deep CNN architectures (Resnet-50 & xception- module). From the study, we observed that deep CNN architectures with transfer learning play a vital role for autism detection. The results of the proposed method demonstrated that the transfer learning approach with Resnet-50 improves the classification accuracy when compared to the existing deep learning techniques without transfer learning approaches. However, the limitation lies in generalization ability of the proposed model. To overcome that limitation, future research would be carried on federated learning. In addition, we further tuned the hyperparameters such as number of epochs, type of activation functions, loss functions, and attention modules, to improve the accuracy and computational efficiency.

## REFERENCES


[1] H. Faras, N. Al Ateeqi, and L. Tidmarsh, "Autism spectrum disorders," *Annals of Saudi medicine*, vol. 30, no. 4, pp. 295–300, 2010.

[2] R. Carette, F. Cilia, G. Dequen, J. Bosche, J.-L. Guerin, and L. Vandromme, "Automatic autism spectrum disorder detection thanks to eye-tracking and neural network-based approach," in *Internet of Things (IoT) Technologies for HealthCare: 4th International Conference, HealthyIoT 2017, Angers, France, October 24-25, 2017, Proceedings 4*. Springer, 2018, pp. 75–81.

[3] V. C. Dodda, L. Kuruguntla, A. K. Mandpura, and K. Elumalai, "Simultaneous seismic data denoising and reconstruction with attention-based wavelet-convolutional neural network," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 61, pp. 1–14, 2023.

[4] I. H. Sarker, "Deep learning: a comprehensive overview on techniques, taxonomy, applications and research directions," *SN Computer Science*, vol. 2, no. 6, p. 420, 2021.

[5] V. C. Dodda, L. Kuruguntla, K. Elumalai, S. Chinnadurai, J. T. Sheridan, and I. Muniraj, "A denoising framework for 3d and 2d imaging techniques based on photon detection statistics," *Scientific Reports*, vol. 13, no. 1, p. 1365, 2023.

[6] F. Thabtah and D. Peebles, "Early autism screening: a comprehensive review," *International journal of environmental research and public health*, vol. 16, no. 18, p. 3502, 2019.

[7] S. Camarata, "Early identification and early intervention in autism spectrum disorders: Accurate and effective?" *International Journal of Speech-Language Pathology*, vol. 16, no. 1, pp. 1–10, 2014.

[8] W. Jones and A. Klin, "Attention to eyes is present but in decline in 2–6-month-old infants later diagnosed with autism," *Nature*, vol. 504, no. 7480, pp. 427–431, 2013.

[9] K. Vakadkar, D. Purkayastha, and D. Krishnan, "Detection of autism spectrum disorder in children using machine learning techniques," *SN Computer Science*, vol. 2, pp. 1–9, 2021.

[10] H. Takçı and S. Yeşilyurt, "Diagnosing autism spectrum disorder using machine learning techniques," in *2021 6th international conference on computer science and engineering (ubmk)*. IEEE, 2021, pp. 276–280.

[11] K. S. Omar, P. Mondal, N. S. Khan, M. R. K. Rizvi, and M. N. Islam, "A machine learning approach to predict autism spectrum disorder," in *2019 International conference on electrical, computer and communication engineering (ECCE)*. IEEE, 2019, pp. 1–6.

[12] C. Wu, S. Liaqat, H. Helvaci, S.-c. S. Chcung, C.-N. Chuah, S. Ozonoff, and G. Young, "Machine learning based autism spectrum disorder detection from videos," in *2020 IEEE International Conference on E-health Networking, Application & Services (HEALTHCOM)*. IEEE, 2021, pp. 1–6.

[13] T. Akter, M. S. Satu, M. I. Khan, M. H. Ali, S. Uddin, P. Lio, J. M. Quinn, and M. A. Moni, "Machine learning-based models for early stage detection of autism spectrum disorders," *IEEE Access*, vol. 7, pp. 166 509–166 527, 2019.

[14] L. Ronconi, M. Devita, M. Molteni, S. Gori, and A. Facoetti, "Brief report: When large becomes slow: Zooming-out visual attention is associated to orienting deficits in autism," *Journal of autism and developmental disorders*, vol. 48, pp. 2577–2584, 2018.

[15] A. S. Heinsfeld, A. R. Franco, R. C. Craddock, A. Buchweitz, and F. Meneguzzi, "Identification of autism spectrum disorder using deep learning and the abide dataset," *NeuroImage: Clinical*, vol. 17, pp. 16–23, 2018.

[16] I. M. Nasser, M. O. Al-Shawwa, and S. S. Abu-Naser, "Artificial neural network for diagnose autism spectrum disorder," 2019.

[17] F. W. Alsaade and M. S. Alzahrani, "Classification and detection of autism spectrum disorder based on deep learning algorithms," *Computational Intelligence and Neuroscience*, vol. 2022, 2022.

[18] K. Ganesh, S. Umapathy, and P. Thanaraj Krishnan, "Deep learning techniques for automated detection of autism spectrum disorder based on thermal imaging," *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine*, vol. 235, no. 10, pp. 1113–1127, 2021.