Autism Spectrum Disorder Prediction in Children from Facial Images Using a Novel Xception Network with Dataset Balancing

Mary Sebasti Rubala.S[1], Elamparithi.M[2], Anuratha.V[3]

[1]Research Scholar, Department Of Computer Science, Kamalam College of Arts and Science, Anthiyur, Affiliated to Bharathiar University, Coimbatore, Tamil Nadu, India, Email: ddxavier.prabala@gmail.com
[2]Associate Professor ,Department Of Computer Science, Kamalam College of Arts and Science, Anthiyur, Affiliated to Bharathiar University, Coimbatore, Tamil Nadu, India, Email: profelamparithi@gmail.com
[3]Associate Professor ,Department Of Computer Science, Kamalam College of Arts and Science, Anthiyur, Affiliated to Bharathiar University, Coimbatore, Tamil Nadu, India, Email: profanuratha@gmail.com

Received: 18.04.2024 Revised : 19.05.2024 Accepted: 20.05.2024

ABSTRACT
Autism spectrum ailment as a circumstance has modelled massive initial analysis demanding situations to the scientific and fitness communal for aextendedperiod. The early prognosis of ASD is essential for initialinterference and proper enough organization of the public of affairs. This looks at using the hyperparameter-tuned Xception model to discover autistic children using facial images. This makes use of the three phases for prognosis. It begins with performing dataset balancing by ok-method (KM) clustering set of rules. After that, pre-processing is performed, including noise offers in the facial photos, which are suppressed by bilateral filtering. Additionally, photo augmentation is carried out to enhance the exceptionality of the dataset. Finally, the autistic and non-autistic youngsters are assessed using the Xception version, in which the hyperparameter is optimally decided on via the Gaussian Mutation cantered Dwarf Mongoose Optimization (GMDMO) algorithm. The dataset used to examination these mannersremainedcomposedsince the Kaggle stage and contained of 2,940 expression pics. Fashionable assessment metrics remained used to assess the results of the planned model. Consistent with the findings of the experiments, the proposed device achieves a median accuracy of 99.49% with much less class time of 0.72ms.

Keywords: Autism Spectrum Disorder Classification, Dataset Balancing, Hyperparameter Tuning, Facial Images, and Pre-trained Models

1. INTRODUCTION

Autism Spectrum disease (ASD) is unique of the neural disorders that stands a behavioral bugconsideredthrough way of unfortunatespoken interplay and confined and boring behaviors, with neurodevelopment that leads to enduringdamage [1]. It usually appears throughout early youth and disturbs the kid's reasoningcapability, publicsentiment, physical and motor-poweredoperative, and social communication [2, 3]. It is turning into greater sizable. Initialrecognition of autism range ailment ASD is tremendously helpful to the well-being sustainability of offspring and is a challenging venture also [4]. Recently, there has been a growing hobby in using system learning (ML) to resource inside the prognosis of ASD [5]. Device learning (ML) allows teaching ASD fashions in much less time and with extra accuracy. Diverse category models of ML, which include random forest (RF), choice tree (DT), help vector system (SVM), logistic regression (LR), and many others., may be used for primaryestimate of autism to avoid its extended consequences in grownups as well as children [6]. However, because of the handcrafted capabilities, the ML algorithms are commonly now not sturdy and are computationally intensive due to high dimensions.

Modern studies show that Deep mastering (DL)-primarily based strategies can efficiently differentiateamong ASD and non-ASD kids, assumedadequate well-annotated makeover pictures [7]. Convolutional neural networks (CNNs), a bottomless getting-to-recognize perfect, are typically used designed for studying seen snapshots throughnegligible pre-processing [8]. Even though CNNs are relatively green and accurate, schooling the fashions calls for a tremendous amount of time and computational capitals. Because of this, as an alternative of initialbeginningscrape, it's much additionalsuitable to service pre-skilled models that have formerly been advanced in using processors

and big datasets. Switch studying is an idea that includes consuming the heaviness and strictures of those pre-professional fashions to adjust the very last output consistent with the software of the widespread duties, which ends up in better class or estimate accuracy [9].a number of the popular pre-trained models are visual geometry institution (VGG), residual network (ResNet), AlexNet, DenseNet, Inceptionv3, Xception, MobileNet, etc. [10]. these models have many homes which includes parameter or weight sharing, efficient function gaining knowledge of capability, and many others., making them efficient for ASD class. Among them, the Xception version is one of the efficient techniques for the ASD category, which goes better than the other fashions with wealthy feature illustrations. Still, the random initialization of the hyperparameter influences the type performance and takes more excellent iterations to locate the ideal parameters. This work uses the Xception with superior hyperparameter selection based on the GMDMO rules. The mainbenefaction of the paper are as follows:

- The advanced machine uses the KM clustering set of rules to balance the amassed dataset. This KM set of rules is notably simple to enforce and warranted convergence, and it efficiently balances accuracy and processing time.
- The proposed system uses the Xception model to classify the ASD instructions, wherein the hyperparameter is optimally decided based on the GMDMO set of rules to keep away from overfitting problems and gives top-quality prediction performance.

The relaxation part of the broadside is hooked up as surveys: Phase 2 evaluates the cutting-edge works associated with ASD detection. Section three offers the proposed method. Section four affords the experimental consequences and talk. In the end, segment 5 concludes the proposed paintings with suggestions for destiny.

2. LITERATURE SURVEY

This section covers the recent surveys regarding to ASD classification uing DL representations. Zeyad A. T. Ahmed et al. [11]A facemask capabilities recognition device was provided to recognize kids through ASD based on DL models. To begin, the preprocessing change is done to normalize the dataset. Then, the system used CNN for function extraction, and these capabilities were fed into the Mobile Net, Xception, and InceptionV3 fashions to classify ASD. The facial snapshots had been taken from a public dataset on Kaggle, and the consequences confirmed that the Mobile Net grasped 95% accurateness,Xceptionaccomplished 94%, and InceptionV3 reached 0.89%.

K. K. Mujeeb Rahman and M. Monica Subashini [12]They recognized disablitiy in kids based totally on standingmakeover capabilities and deep neural networks (DNN). To start, the accrued samples were fed into the MobileNet, Xception, EfficientNetB0, EfficientNetB1, and EfficientNetB2 to extract beneficial facial capabilities, and then, the DNN model changed into used to classify autism based totally on the extracted features. The device used a publicly-to-be-had dataset, and the Xceptiontypicaloutstripped the others, through an AUC of 96.63% and a compassion of 88.46%.

Fawaz WaselallahAlsaade and Mohammed Saeed Alzahrani [13]They advised a class and detection of ASD based on DL algorithms. First, the preprocessing turned into finished to extended family and crop the accrued pix. Then, the CNN extracted the facial features from the image. In the end, the Xception, VGG-19, and NASNETMobile become used to classify ASD children. The device used the Kaggle dataset, which includes 2,940 appearancepictures, and the effects confirmed that the Xceptiontypical performed the maximumaccurateness result of 91%.

Hasan Alkahtaniet al. [14]They counselled a DL algorithm to perceive ASD in kids-based facial landmarks. Initially, normalization was done using the gathered snapshots to normalize the dataset. Then, the MobileNetV2 and hybrid VGG19 were used with distinctive ML applications, such as LR, SVM, RF, DT, gradient boosting, and ok-nearest neighbors, to categorize autism and non-autism kids. The 2940 photographs of autistic and non-autistic youngsters's data have been accumulated from the Kaggle. The MobileNetV2 version finished with an accuracy of ninety percent, higher than the other fashions.

Amna Hendr et al. [15]They developed a diagnosis of ASD based on convolutional neural networks (CNN). First, the entered photographs were rescaled, cropped, and minimal, and most pixels were calculated to remove the empty location. After that, CNN models, including GoogleNet, AlexNet, ResNet18, VGG16, and SqueezeNet, were used to classify the autistic youngsters. The system amassed sample data from the Kaggle resources, and the results showed that the gadget completed a higher accuracy of 90.48%.

Ying Li et al. [16]They proffered a face photo type technique of autistic children based totally happening the 2-phase transmission getting to know. First, the face photos had been accrued from autism-associated websites and Facebook pages. Then, the gadget used segmented switch learning of MobileNetV2 and MobileNetV3 fashions, which extracted capabilities from the enter and classified autistic children. The results confirmed that the accuracy of the machine changed to 90.5%, and the AUC is 96.32%.

Taher M. Ghazal et al. [17]They presented an initialrecognition of autism in youngsters founded on switch studying. First, a information set of facephotographs of disablitiy and non-autistic offspring become changed and amassed from the Kaggle. Then, the pre-processing is done to resize the collected snapshots. Then, the system used the AlexNet model to extract features and encounter the autism.The effects showed that the perfectaccomplishedaappreciationaccurateness of 87.7%.

2.1 Research Gap

The above-stated element surveys the latest works using the DL technique to predict autistic children from facial pictures. DL algorithms are powered to research capabilities, putting off t. He wants hand-engineered intervention automatically, and they handle big and complex datasets. Some of the above-referred algorithms use the famous DL approach, namely, the CNN method, which may routinely examine the features from the information; however, it requires a large variety of samples and computational strength to teach, and they're notoriously tricky to optimize. AA has a few works that use switching to gain knowledge for ASD diagnosis. Switch studying wants a minordiversity of examples, and itcontainer switch the model skilled on an extensive range of examplestowardsindividualsresponsibilitiesthrough a minor wide diversity of models and attain a correct version by using retraining to high-quality-tune the model's parameters. However, these works use more than one pre-educated model, which lowers the device's effectiveness. It also calls for much computational power. Also, an imbalance in elegance is demanding while schooling the model using transfer learning. When classifiers are confronted with imbalanced datasets, where the range of negative instances outnumbers the acceptable instances, the overall performance drops considerably.

Similarly, it uses the random hyperparameter to educate the community. The initialization of random hyperparameters reduces the experimental consequences, and overfitting trouble can also occur due to the number of iterations. This painting solves these above-noted problems, and it uses the unconventional hyperparameter-tuned Xception version to classify autistic children with dataset balancing.

3. PROPOSED METHODOLOGY

This paper proposes a pre-skilled Xception version to predict the autism spectrum disease in kids with dataset balancing, shown in Determine 1. It accommodates three phases: dataset balancing, preprocessing, and class. The following subsections explain those phases in brief.

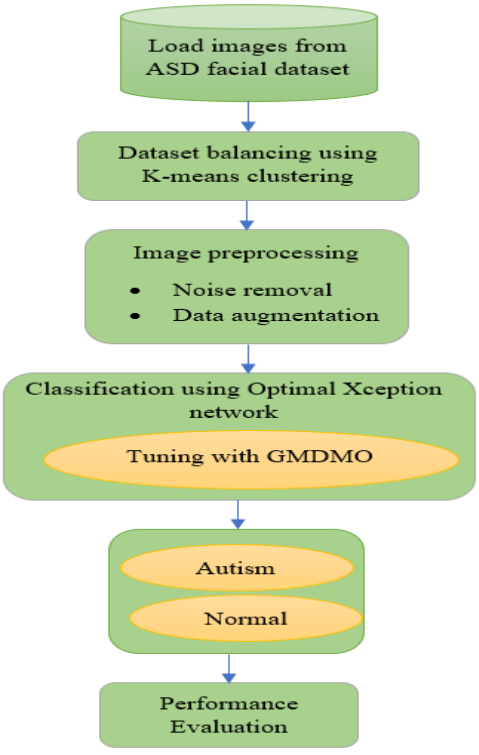

Figure 1. Workflow of the proposed methodology

3.1 Dataset Balancing

To start, the entered snapshots are amassed from the freely to-be-had supply. Typically, those publicly accumulated facts could be more balanced. The imbalanced records manner that the range of facts points in one elegance is notably extra than the quantity of facts factors in some other class. When the magnificence distribution is imbalanced, deep knowledge of algorithms generally tends to move powerfully toward most of the people's class and push aside the minority. Therefore, the accuracy can be excessive. However, the model can't recognize facts times within the minority magnificence to classify them, leading to many misclassifications. Special techniques were proposed to deal with the imbalance problem; however, most methods are complicated and tend to simulate pointless noise. In this paper, we proposed a k-method (KM) clustering set of rules to stabilize the dataset. KM set of regulations is a clustering-primarily based below-sampling technique to triumph over class imbalance with two method techniques: cluster center and nearest buddies from the cluster middle. It's a low-complexity algorithm that specifies the parameter okay-value. Then again, every most effective sample belongs to the cluster with the best similarity after the okay approach. The process concerned within the KM clustering algorithm is given as follows:

First, the clustering quantity okay is determined, and okay preliminary centroids are randomly decided on. After gathering the majority brilliance dataset into k collections, our set of rules calculates the distances between the data within every cluster and the cluster centroids from two viewpoints and selects information based on those distances. Sooner or later, the subset of the mainstream magnificence dataset is blended with the marginal class dataset to generate a new composed dataset.

3.2 Preprocessing

Preprocessing facial pics for the ASD dataset is essential to make the pics more constant and to remove irrelevant facts because snapshots in a dataset comprise irrelevant records, including historical past items or facial hair. It also facilitates improving the performance of ASD detection by lowering the quantity of information that needs to be processed. To begin with, the noise provided within the facial pictures is filtered through the Bilateral filtering technique. A mutual filter-out is a non-linear, part-keeping, and noise-lowering flattening clear-out for snapshots. It substitutes the depth of apiece pixel with a subjective standard depth value from pixels close by.It is well-defined as follows:

$$\vec{N}^{FI}(b)=\frac{1}{\zeta_C}\sum_{b_n\in\phi}\vec{N}(b_n)\,\ddot{E}_k\left(\left\|\vec{N}(b_n)-\vec{N}(b)\right\|\right)\vec{S}_h\left(\|b_n-b\|\right) \qquad (1)$$

Where, $\vec{N}^{FI}$ denotes the noise filtered image, $\vec{N}$ denotes the unique participation image towards remain clean, $b-$ refers the organizes of the present pixel to be filtered, ϕ refers the window cantered in b, so $b_n\in\phi$ is alternative pixel, $\ddot{E}_k$ signifies the variety kernel for smoothing variances in concentrations (this purpose can stand a Gaussian function), $\vec{S}_h$ denotes the spatial (or domain) and ζ_C refers the normalization constant. Once noise wasremoved from the collected image, image augmentation is performed ton improve the quality of the dataset. In this image augmentation, essentially it applies random rotations, shifts, flips, crops, and resize on facial images.

3.3 Classification

Ultimately, the autism and non-autism class is completed in this segment using the Xception network from the preprocessed dataset. The Xception structure is a stack of 36 convolutional layers with linear residual connections except for the first and the final modules. It comprises three flows: access waft, center flow, and exit glide. The entry flow initiates the waft of information and is followed by the center flow, where operations are repeated eight times. The architecture consists of a residual structure to address the vanishing gradient hassle. The exit waft terminates the order of convolutions. Each convolution and separable convolution layer is succeeded by batch normalization. The hyperparameter of the Xception version is optimally selected by way of the Gaussian mutation-targeted Dwarf Mongoose Optimization (GMDMO) algorithm, which reinforces the Xception version's overall performance and avoids randomness.figure 2. Shows that the Xception architecture.

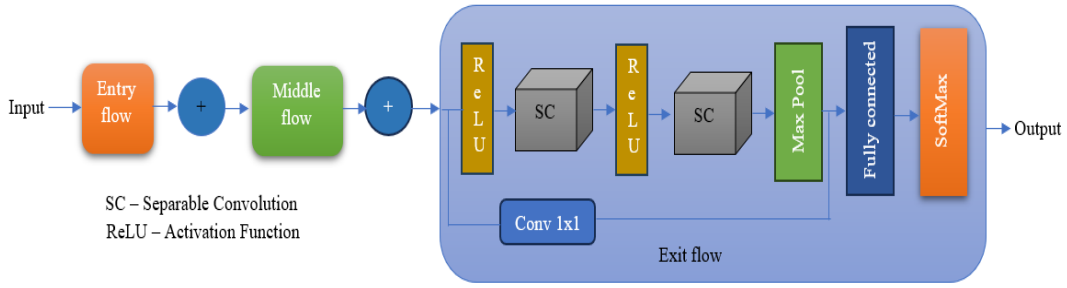

Figure 2. Xception architecture

Figure 2 comprises three flows, namely, entry flow, middle flow, and exit flow. These flows are briefly explained as follows:

a) Entry flow

Initially, the pix in the training set is forwarded to the get entry and go with the float, which generates the characteristic maps. It accepts the contributiondepiction of size 299 × 299 × 3. This entry follows the movementthen incorporates four modules with a convolutional layer. The convolutional layer is an essential issue that uses the convolutional operators to extract features from the entered data. Within the initialcomponent, convolution is carried out through 32 and 64strainers with a 3x3 clear-out length. Inside this waft's three modules, separable difficulty is appreciated with 128, 256, and 728 filters in a 3x3 filter length. Ultimately, it makes a 19x19x728 length function chart at the production.

b) Middle flow

The center drift is occasionally called the middle shape component, and it accommodates a nine-layer shape that repeats eight times. Within the nine-layer shape, there are three layers of ReLU, separable Conv, and batch normalization. A rectified linear unit (ReLU) is an activation characteristic that introduces the belongings of non-linearity to the Xception model and solves the vanishing gradients' trouble.It is mathematically defined as follows:

$$f\left(\tilde{P}_I\right) = \max\left(0, \tilde{P}_I\right) \quad (2)$$

Where, $\tilde{P}_I$ refers the input preprocessed image. After it passes via the separable convolutional layer, three distinguishable convolution procedures with 728 filters in 3x3 length are frequent in eight instances, creating a 19x19x728 function plot at the production. Herein, the setstandardization layer is also used to make the system's education quicker and more solid by normalizing the layers' inputs by re-centering and re-scaling the records.

c) Exit flow

The obtained feature maps from the center flow are then exceeded to the existing drift. It has modules. Within the initialcomponent, distinguishable convolution is done with 728 and 1024 filters in 3x3 sizes, and inside the ultimate element, it's carried out with 1536 and 2048 filters. Afterward, the structure is finished with the totaling of completely connected layers. The ultimately linked layer uses SoftMax characteristics to categorize the output. The SoftMax classifier becomes the limitationson or after the related sheet and computes the belongings to expect the production. In a SoftMax production of zero methods, the picture fit in to elegance zero, and in a SoftMax output of one approach, the image belongs to magnificence 1; herein, class zero is the autism magnificence and class 1 is the everyday class.

Moreover, the Xception network's hyperparameter is optimally tuned via the Gaussian mutation-centered Dwarf Mongoose Optimization (GMDMO) set of rules. The DMO is a swarm intelligence-based technique that is stimulated by animal behavior to find answers to optimal global troubles. It replicates dwarf mongoose behavioral responses. Even though the fundamental DMO plays very well in solving optimization problems, it still needs to improve the shortcomings of slow convergence rate and nearby most excellent stagnation whilst fixing complex optimization tasks. therefore, this have a look at introduces a modified version named GMDMO. The proposed GMDMO uses this method to avoid the problems of nearby optima and improve global search ability. It starts with the population of the dwarf mongoose, which is generated randomly. After that, each character's health is computed using the equation (3).To lower the classifier mistakes, it is taken as health.

$$fitness = Min\left(Error\ Rate\right) \quad (3)$$

$$Error\,Rate = \frac{No\ of\ \ misclassified\ samples}{Total\ no\ of\ \ samples} * 100 \qquad (4)$$

Then, GMDMOs generate an ability to position food. The mongooses are acknowledged to avoid frequent to the precedingslumbering mound, so the detectives search aimed at the followingunique to safeguardexamination. The scout mongoose is simulated using the equation. (5).

$$\ddot{Z}_d\ (m+1) = \begin{cases} \ddot{Z}_d\ (m) - \ddot{F}_{ST} * Rand\,(0,1) \times \left(\ddot{Z}_d\ (m) - \ddot{v}_d\right), & if\ \varphi_{m+1} > \varphi_m \\ \ddot{Z}_d\ (m) + \ddot{F}_{ST} * Rand\,(0,1) \times \left(\ddot{Z}_d\ (m) - \ddot{v}_d\right), & Else \end{cases} \qquad (5)$$

Where, φ refers the normalworth of the slumbering mound, $\ddot{v}_d$ refers a vector that decides the mongoose's migration to the next sleeping mound and $\ddot{F}_{ST}$ indicates a Gaussian mutation.Gaussian mutation comprises random disturbances generated via Gaussian distribution based on the unique person. Its miles are formulated as follows:

$$\ddot{F}_{ST} = \frac{1}{\sqrt{2\pi\sigma}} \exp\left(\frac{\left(\ddot{Z} - \mu\right)}{2\sigma^2}\right) \qquad (6)$$

Where, μ indicates the anticipation of Gaussian distribution and σ refers defined as the normal deviation of the Gaussian circulationpending the process terminates when it reaches the optimal solution (i.e., optimal hyperparameters).

4. RESULTS AND DISCUSSION

In this phase, the performance of the future autism spectrum sickness prediction in kids from facia snapshots and using a singular Xception community with dataset balancing is analyzed with the present methods in phrases of a few basic evaluation metrics. The proposed version is implemented within the Python running platform with the gadget configurations of processors with middle 17 and 8GB RAM.

4.1 Dataset Descriptions

This look at examined facemask pictures of autistic children and ordinary kids found beginning the Kaggle stage, which is freelyavailableconnectedoverhttps://www.kaggle.com/datasets/cihan063/autism-photo-facts. The information set consisted of 2940 face pictures. From that, 1470 photographs are autistic, and 1470 are non-autistic youngsters. The autistic kidsappearance snapshots are amassed from connectedfoundations associated with autism complaint, in addition the non-autistic kids expressionphotographs are arbitrarily amassed beginning the internet.

4.2 Performance Analysis

This phase covers the results of the proposed Xception version with the present pre-educated fashions, including ResNet, VGG, MobileNet, and CNN fashions. This assessment is performed with the basic evaluation metrics inclusive of accuracy, precision, bear in mind, f-degree, are beneath the curve (AUC), fake astounding rate (FPR), fake insufficient charge (FNR), and category time, respectively. These evaluations are shown in the following figures and tables.

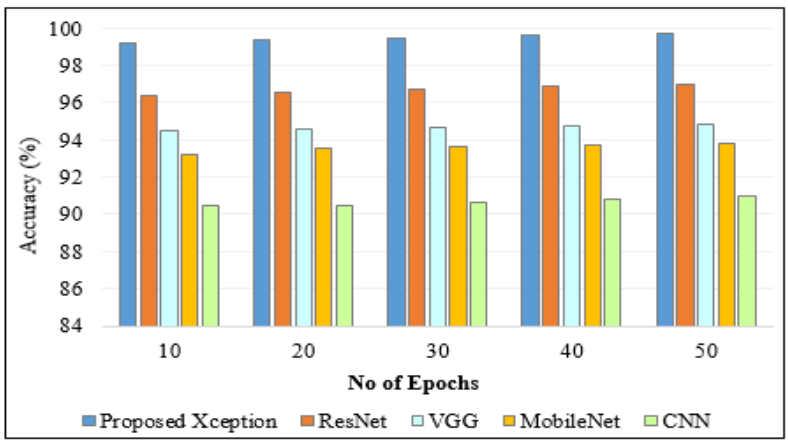

Figure 3. Accuracy versus Epochs graph analysis

Table 1. Results analysis of the proposed model

Metrics	Proposed	ResNet	VGG	MobileNet	CNN
Precision (%)	99.55	96.74	94.75	93.71	90.76
Recall (%)	99.36	96.58	94.58	93.54	90.61
F-Measure (%)	99.51	96.74	94.71	93.65	90.72
AUC (%)	99.43	96.64	94.62	93.54	90.61
FPR (%)	0.016	0.074	0.099	0.182	0.256
FNR (%)	0.057	0.145	0.194	0.252	0.364
classification time (min)	0.72	0.98	1.25	1.86	2.54

DISCUSSION

The overall performance of the proposed and the prevailing methods in terms of accuracy metric is shown in discern three. The evaluation is finished using various epochs from 10 to 50. Accuracy is the ratio of accurately expected predictions using the model to all varieties of completed predictions in the ASD class. In this comparison, the proposed one achieves an accuracy of 99.23% for ten epochs, which is 2.89%, 4. seventy-six, 6%, and eight— events, which is eight higher than the existing techniques. Also, while the epochs grow from 20 to 50, the proposed one maintains accuracy above 99%.For this reason, the findings show that, in comparison with preceding strategies, the proposed method improves percent accuracy in ASD analysis. Able 1 illustrates the consequences of the proposed method with the prevailing approach in terms of precision, remember, f-degree, AUC, FPR, FNR, and classification time metrics. At this desk, the present CNN fashions proffer much fewer results than the alternative existing methods and the proposed one because the CNN method consumed more significant assets, became expensive to assemble, and required a more excellent computational time to attain a higher prediction fee. Different present pre-skilled fashions together with ResNet, VGG, and MobileNet work higher, but they produce slightly lower performance than the proposed one. The purpose is that the proposed one, timely, uses any uncooked facts from the assets. t starts with executed dataset balancing based on the KM clustering technique, which avoids overfitting problems and produces a balanced accuracy rate. After that, the machine performs preprocessing to simplify the dataset and provides apparent effects.Additionally, the classification is accomplished using the Xception version, which saves time throughout education and takes zero 72 minutes for the category. In addition to developing the proposed Xception model accuracy and addressing the overfitting difficulty, the proposed gadget carried out hyperparameter tuning the usage of the GMDMO algorithm, considerably increasing the prediction price and decreasing the overall computational complexity. According to them, the enhancements included in our works boost the model's performance and help it acquire fantastic outcomes.

CONCLUSION

This paper proposes an autism spectrum disease prediction in children from facia images using a novel Xception network with dataset balancing. This paper evaluated the generalpresentation of the plannedclassical against the prevailing models, including ResNet, VGG, MobileNet, and CNN fashions. Each model was turned into skilled on a publicly available ASD facial photograph dataset on the net. This evaluation uses accuracy and precision, considering f-degree, AUC, FPR, FNR, and type time metrics. From the experimental consequences, the proposed one outperformed other model with average accuracy of 99.49%, in conjunction with 99.55% precision, 99.36% consider, 99.51% f-degree, 99.40 percent AUC, 0.016% FPR, 0.057% FNR and 0.72 minutes to classify the ASD training.Consequently, it indicates the model's effectiveness. Furthermore, the model classification results confirmed the opportunity of using such fashions based totally on switching to computerized equipment for professionals and households as it should be and extra speedy autism diagnosis. In destiny, this work could be prolonged by applying the meta-heuristic rules to choose the most fulfilling capabilities to enhance accuracy and reduce prediction time.

REFERENCES

[1] Ashraf, A., Zhao, Q., Bangyal, W. H., & Iqbal, M. (2023). Analysis of Brain Imaging Data for the Detection of Early Age Autism Spectrum Disorder Using Transfer Learning Approaches for Internet of Things. IEEE Transactions on Consumer Electronics.

[2] Benabdallah, F. Z., Drissi El Maliani, A., Lotfi, D., & El Hassouni, M. (2023). A Convolutional Neural Network-Based Connectivity Enhancement Approach for Autism Spectrum Disorder Detection. Journal of Imaging, 9(6), 110.

[3] Han, J., Jiang, G., Ouyang, G., & Li, X. (2022). A multimodal approach for identifying autism spectrum disorders in children. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 30, 2003-2011.
[4] Liao, M., Duan, H., & Wang, G. (2022). Application of machine learning techniques to detect the children with autism spectrum disorder. Journal of Healthcare Engineering, 2022.
[5] El Mouatasim, A., &Ikermane, M. (2023). Control learning rate for autism facial detection via deep transfer learning. Signal, Image and Video Processing, 1-8.
[6] Farooq, M. S., Tehseen, R., Sabir, M., & Atal, Z. (2023). Detection of autism spectrum disorder (ASD) in children and adults using machine learning. Scientific Reports, 13(1), 9605.
[7] Cao, X., Ye, W., Sizikova, E., Bai, X., Coffee, M., Zeng, H., & Cao, J. (2023, June). Vitasd: Robust Vision Transformer Baselines for Autism Spectrum Disorder Facial Diagnosis. In ICASSP 2023-2023 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 1-5). IEEE.
[8] Almars, A. M., Badawy, M., &Elhosseini, M. A. (2023). ASD2-TL∗ GTO: Autism spectrum disorders detection via transfer learning with gorilla troops optimizer framework. Heliyon, 9(11).
[9] Alam, M. S., Rashid, M. M., Roy, R., Faizabadi, A. R., Gupta, K. D., & Ahsan, M. M. (2022). Empirical study of autism spectrum disorder diagnosis using facial images by improved transfer learning approach. Bioengineering, 9(11), 710.
[10] Shapna Akter, M., Shahriar, H., &Cuzzocrea, A. (2023). Autism Disease Detection Using Transfer Learning Techniques: Performance Comparison Between Central Processing Unit vs Graphics Processing Unit Functions for Neural Networks. arXiv e-prints, arXiv-2306.
[11] Ahmed, Z. A., Aldhyani, T. H., Jadhav, M. E., Alzahrani, M. Y., Alzahrani, M. E., Althobaiti, M. M., ... & Al-Madani, A. M. (2022). Facial features detection system to identify children with autism spectrum disorder: deep learning models. Computational and Mathematical Methods in Medicine, 2022.
[12] Mujeeb Rahman, K. K., & Subashini, M. M. (2022). Identification of autism in children using static facial features and deep neural networks. Brain Sciences, 12(1), 94.
[13] Alsaade, F. W., & Alzahrani, M. S. (2022). Classification and detection of autism spectrum disorder based on deep learning algorithms. Computational Intelligence and Neuroscience, 2022.
[14] Alkahtani, H., Aldhyani, T. H., & Alzahrani, M. Y. (2023). Deep Learning Algorithms to Identify Autism Spectrum Disorder in Children-Based Facial Landmarks. Applied Sciences, 13(8), 4855.
[15] Hendr, A., Ozgunalp, U., &Erbilek Kaya, M. (2023). Diagnosis of Autism Spectrum Disorder Using Convolutional Neural Networks. Electronics, 12(3), 612.
[16] Li, Y., Huang, W. C., & Song, P. H. (2023). A face image classification method of autistic children based on the two-phase transfer learning. Frontiers in Psychology, 14.
[17] Ghazal, T. M., Munir, S., Abbas, S., Athar, A., Alrababah, H., & Khan, M. A. (2023). Early Detection of Autism in Children Using Transfer Learning. Intelligent Automation And Soft Computing, 36(1), 11-22.