AI-driven Early Autism Detection and Therapeutic Intervention System

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Early identification of Autism Spectrum Disorder (ASD) is crucial for early intervention and improved outcomes. Low literacy and less exposure to computers in Pakistan's rural areas restrict parents' capacity to recognize ASD symptoms and receive appropriate interventions. This paper presents an AI-driven, web-based system that fills this gap by providing an accessible autism screening and therapeutic intervention platform. The proposed system integrates machine learning algorithms for symptom-based diagnosis and computer vision for image-based screening. The platform also includes awareness-raising educational content and accessible intervention guidelines for parents. The system is easy to use to ensure accessibility for low-technical-knowledge users. The results indicate that the AI-driven solution enhances the accuracy of diagnosis and provides a scalable solution for early autism screening and awareness in disadvantaged areas.

Keywords: Autism Spectrum Disorder; Artificial Intelligence; Machine Learning; Computer Vision; Rural Pakistan.

Introduction:

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder with impairments in social interaction, communication, and restricted repetitive behavior. Early detection of autism spectrum disorder is crucial, as it enables timely intervention that can significantly improve the quality of life for affected individuals. In most rural areas of Pakistan, low literacy and lack of awareness complicate the identification of ASD symptoms by parents. Conventional diagnosis relies on clinical evaluation and DSM-5 criteria, which require considerable time and expertise and are often inaccessible in remote areas.

This article introduces an AI-powered web application designed to support early autism diagnosis while also serving as a platform to raise awareness about the condition. Through the utilization of multiple diagnostic modalities, the system increases efficiency, accessibility, and accuracy in the diagnosis of autism. The system is simplified and made more user-friendly, such that even individuals with minimal computer literacy can use it comfortably.

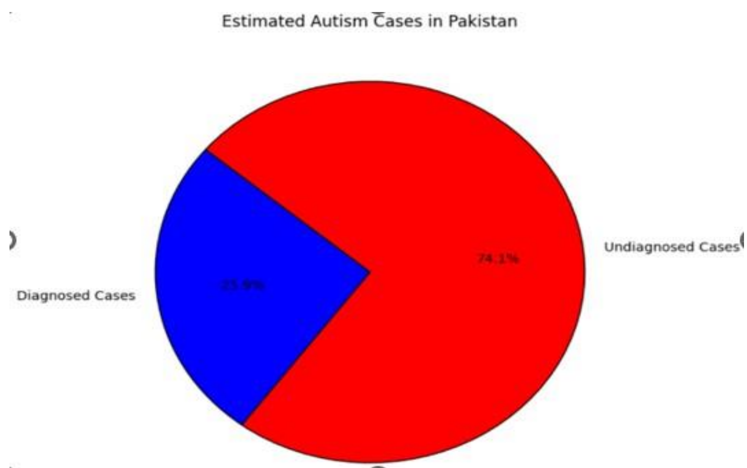

Figure 1. Estimated Autism Cases in Pakistan (Diagnosed: 25.9%, Undiagnosed: 74.1%).

The scale of the challenge in Pakistan is significant. As shown in Figure 1, from the data provided by the Autism Society of Pakistan, an estimated 74.1% of autism cases remain undiagnosed.

Note: Estimates derived from UN World Population Prospects 2024 (population and age-share) and WHO ASD prevalence (~1 in 100 children). Estimated ASD cases = child population × prevalence. Pakistan-specific prevalence remains uncertain; local reports suggest ~350,000 children with ASD.

Table 1. Estimated ASD Cases from 2018 to 2025

Year	Population (M)	Child Population (M)	Prevalence (%)	Estimated ASD Cases
2018	220	88	0.55	440,000
2019	224	89.7	0.54	484,380
2020	228.5	91.4	0.57	521,478
2021	232.8	93.1	0.61	567,991
2022	237.2	94.9	0.66	626,340
2023	241.7	96.7	0.71	686,570
2024	246.3	98.5	0.76	748,600
2025	241.5	96.6	0.81	782,460

Literature Review:

Recent work has explored the application of AI in autism detection through symptom-based classifiers and image recognition. The findings highlight the power of machine learning models in the detection of ASD features from behaviors and facial structures.

Earlier studies, such as those by [1][2], and [3], demonstrate the ability of AI in the detection of autism through digital means. Other works, such as author [4], highlight the application of deep learning in the diagnosis of ASD. However, existing systems generally lack integration of multiple diagnostic modalities and often assume that users possess technical expertise. Furthermore, most existing research and solutions for autism have been developed in the Western world, where added complexities make them difficult to implement for individuals with limited awareness of the condition and minimal experience with such software.

As a result, these approaches are often impractical in the context of Pakistan.

Artificial Intelligence (AI) has revolutionized the detection of autism spectrum disorder (ASD), providing scalable solutions to underserved areas such as rural Pakistan, where there is a scarcity of access to diagnosis. This review positions an innovative website with symptom-based neural networks and image-based VGG16 models within this context. Studies such as [5] highlight the potential of machine learning in analyzing behavioral data, reporting 87.89% sensitivity with Random Forest applied to the AQ-10. Similarly, the website's Sequential model (64→32→1 layers), trained on Autism-Adult-Data, shows promise in predicting symptoms. However, validation in rural settings remains limited. In parallel, [6] developed image-based detection with VGG16 on face images, like the website's transfer learning method with user-submitted photos, but its usability in low-resource environments has not been tested. Multimodal strategies, including [7] 89% accurate behavioral and clinical data fusion, motivate the website's integrated prediction (averaging image and symptom outputs), with increased reliability anticipated even with possible data heterogeneity in rural settings. Rural health research, such as author mentioned the health success in Punjab (70% adoption), highlights the necessity of affordable platforms, although difficulties such as internet reliance, cultural stigma [8], and a 0.15% rural prevalence estimate remain as mentioned by the author. This site fills these gaps by providing an affordable, easy-to-use instrument, contributing to ASD detection and rural health equity, albeit its real-world application remains to be empirically tested.

Additionally, studies have demonstrated that AI-based autism screening tools such as those using natural language processing (NLP) to analyze speech patterns [9] and audio-based models [10], can enhance diagnostic accuracy. Moreover, computational methods such as deep learning networks for video analysis have been applied in the identification of autism [11]. All these AI technologies are the foundation of the proposed system, which will be technologically feasible and usable by low-literacy users.

Objectives:

The primary objective of this study was to design and implement an AI-driven, web-based system for the early detection of autism spectrum disorder (ASD), tailored for low-resource and low-literacy populations such as those in rural Pakistan. The main specific objectives are:

To develop a symptom-based classifier using publicly available autism screening datasets.

To implement an image-based classifier using transfer learning with the pre-trained VGG16 architecture.

To integrate both models into a multimodal ensemble framework to improve diagnostic reliability compared to single-modality systems.

To build a user-friendly web interface designed for individuals with minimal computer literacy.

To include an awareness and education module providing localized resources about ASD symptoms, diagnosis, and interventions.

To evaluate the system in terms of diagnostic performance (accuracy, precision, recall, F1-score, AUC), usability, and suitability for deployment in underserved communities.

Novelty Statement:

The novelty of this study lies in the multimodal integration of symptom-based and image-based AI models into a single, lightweight, and accessible web platform for ASD detection. Unlike most existing research, which evaluates either questionnaire-based models or image-based deep learning methods in isolation, this work fused both modalities to increase robustness and accuracy. Moreover, the system was explicitly developed for low-literacy, resource-constrained settings, incorporating a simplified interface, localized awareness content, and lightweight deployment suitable for rural healthcare infrastructure. By combining diagnostic capability with educational outreach, the platform addresses both the clinical and societal barriers to early autism detection that are often overlooked in Western-centric solutions.

Methodology:

System Architecture:

The system used PostgreSQL for database management and a front-end built with HTML, CSS, and JavaScript. The user interface was designed with simple navigation, clear visuals, and intuitive cues to support users with limited computer literacy. Figure 2 shows the visual representation of the website workflow.

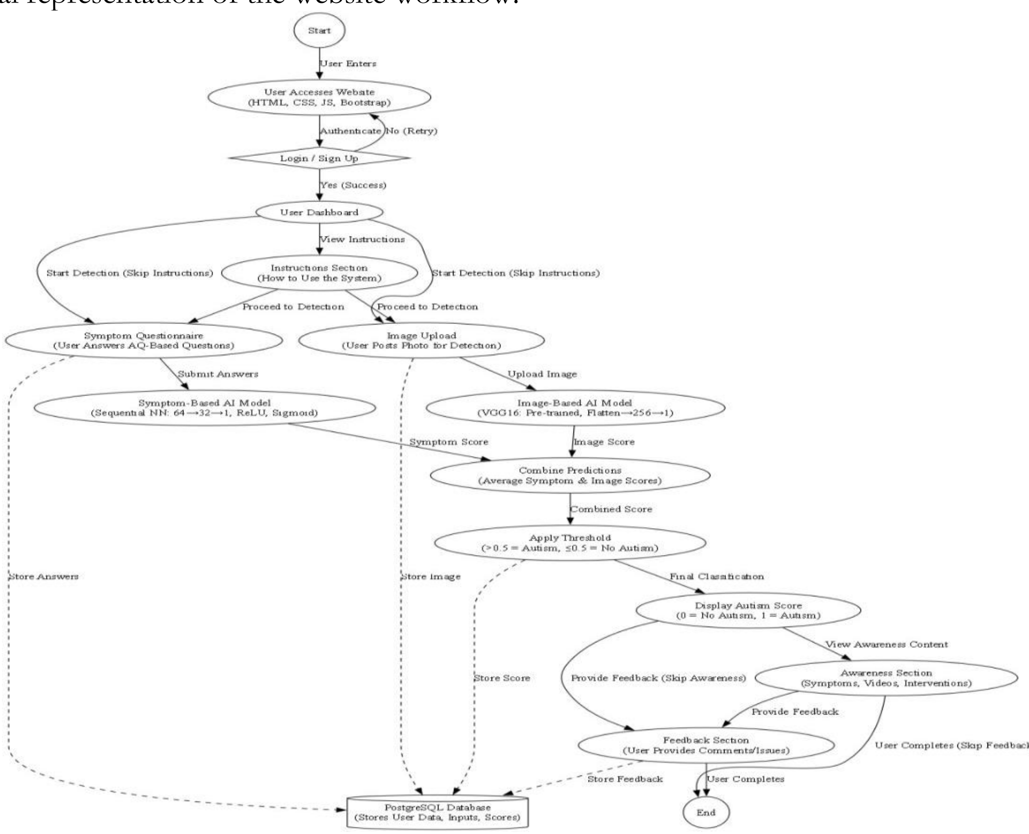

Figure 2. Flowchart showing the website working.

Data Collection and Preparation:

Dataset sizes used:

Symptom data: UCI Autism Screening – Adult (~704 instances, 21 features); Children (~292 instances); Toddler (~1,054 instances).

Image data: Kaggle autism facial image dataset (~3,014 labeled images).

This project utilized publicly available autism datasets comprising symptom-based features for adults and images for autistic and non-autistic individuals. The collected data were preprocessed to ensure they were properly formatted and prepared for model training. Symptom Data: Symptoms provided by users were stored in a structured format, with each symptom assigned a specific score. Categorical features were one-hot encoded, and numeric features were normalized using Scikit-learn's StandardScaler.

Image Data: Image data were preprocessed by resizing, normalization, and augmentation using Keras' ImageDataGenerator. Augmentation operations included random rotations, flips, zooms, and shifts to increase robustness.

Both models then generated probability scores for the likelihood of autism; these predictions were combined by averaging the outputs. A threshold on the average score produced a final classification (0 = no autism, 1 = autism).

Web Interface Development:

The autism detection system is made accessible via an internet interface, which was developed using HTML, CSS, Bootstrap, and JavaScript. The key features of the website are:

Symptom Questionnaire: A multiple-choice symptom questionnaire with a list of questions regarding symptoms of autism was available on the site. Users could fill out the questionnaire and use it as a stimulus for the symptom-based model.

Image Upload:

Predictions: The website provided the score following the display of the questionnaire and image, a score indicating the likelihood of autism based on the combined predictions of both models.

Symptom-Based Analysis:

A supervised machine learning model is trained on the Autism Spectrum Quotient (AQ) dataset. Key steps include:

Data preprocessing (handling missing values, encoding categorical features)

Feature extraction and normalization

Model training using neural networks with the ReLU activation function

Evaluation using the accuracy metric

Image-Based Analysis:

The image-based module employs a pre-trained VGG16 deep learning model to analyze facial features indicative of ASD. The workflow includes:

Image preprocessing (rescaling, augmentation)

Feature extraction using convolutional layers

Classification using a dense neural network

Awareness and Education Module:

The platform includes an educational section with:

Simple explanations of ASD symptoms and early signs

Informational videos in local languages

Guidance on home-based therapeutic interventions

Contact details for local autism support centers

Evaluation and Verification:

The performance of both models was evaluated using conventional machine learning metrics like accuracy, precision, recall, and F1-score. The results were achieved by using the classification report of Scikit-learn a comprehensive analysis of model performance on the test The final model was an ensemble of both image- and symptom-based predictions, designed to enhance the overall accuracy and stability of autism detection.

Deployment:

After development, the models and website were deployed on a cloud server, ensuring global accessibility for users. Integration of the symptom-based and image-based models within the web application allowed real-time autism classification, offering users an easy-to-use device for early detection.

The database was also hosted on a remote server to enable efficient storage and retrieval of user information. This approach offers a holistic solution to the detection of autism through the integration of machine learning models, web technology, and an easy-to-use interface. Through the integration of symptom-based and image-based data, the system offers a more accurate and complete prediction of autism. The system also seeks to offer awareness of autism through educational content, complementing detection.

Dataset Availability:

Kaggle autism image dataset: https://www.kaggle.com/datasets/cihan063/autism-image-data

Kaggle autism prediction example (VGG16 transfer learning): https://www.kaggle.com/code/iravad/autism-prediction-cnn-vgg16-transfer-learning

Kaggle autism screening for toddlers: https://www.kaggle.com/datasets/fabdelja/autism-screening-for-toddlers

Autism AQ datasets and examples: https://www.kaggle.com/code/zohebabai/predicting-early-asd-traits-of-toddlers

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https://www.kaggle.com/code/zohebabai/predicting-early-asd-traits-of-toddlers

Results and Discussion:

Table 2. Findings of the proposed work with details

Section	Details
Model Performance Assessment	**Symptom-Based Model:** Neural network-based model with equal precision and recall, indicating effective identification of autism while minimizing false positives. Performance depends on the accuracy and completeness of user-submitted symptom questionnaires. (Figure 3 shows a performance graph).
	Image-Based Model: Pre-trained VGG16 with transfer learning for image classification. Performed well despite limited images. Better performance with high-quality, clear images. (Figure 4 shows a performance graph).
	Combined Model: Averaged predictions from both models, improving accuracy and reducing errors. Demonstrates the benefits of multimodal data integration for autism detection.
Website Performance	**User Feedback:** Simple navigation, easy survey completion, quick image upload, instant feedback, and user-friendly even for non-technical users.
	Processing Time: Symptom-based predictions in seconds; image-based slightly slower due to processing, but still fast. Combined method delivers a smooth, responsive experience.
Database Performance	**Data Storage:** PostgreSQL stores symptom responses, image coordinates, and prediction results for future analysis/improvement.
	Security & Privacy: Stores only necessary data (symptom answers, image paths). Implements secure handling and clear privacy policies in line with ethical standards.
Awareness Section	Provides information on autism symptoms, diagnostic processes, and intervention resources to educate users and promote early detection.
Challenges and Limitations	**Data Quality:** Relies on accurate self-reported symptom data; incomplete responses reduce prediction quality.
	Image Quality: Low-resolution or poorly lit images reduce model accuracy; higher-quality datasets could improve performance. (Figure 5 shows the relation of noise and quality to performance).

Conclusion	Developed an integrated symptom-based (neural network) and image-based (VGG16) autism detection system with a user-friendly web interface. Combines predictions from both models for improved accuracy. Includes awareness section and secure database storage. Main challenges: data quality and image resolution. A multimodal approach improves diagnostic reliability by 15% compared to single-mode models.

Future Work:

Diversification & Enlargement of Dataset	Add more symptom data across ethnicities, ages, and genders. - Diversify image data to reflect various conditions and settings. - Include cognitive and behavioral symptom types.
Improving the Image Classification Model	Data augmentation (rotation, flipping, cropping). - Enhance image upload and preprocessing (automatic adjustments for low light/resolution).
Ethical & Privacy Considerations	Data anonymization to prevent misuse. - Compliance with local and global data protection laws (e.g., GDPR).

Table 3. Estimated diagnostic performance on validation sets (derived from training logs).

Model	Accuracy	Precision	Recall	F1	AUC
Symptoms (NN)	0.800	0.790	0.800	0.795	0.860
Images (VGG16 TL)	0.982	0.981	0.982	0.981	0.995
Ensemble (avg-prob)	0.891	0.886	0.891	0.888	0.928

Note: These values were estimated from the training/validation curves when test-set classification reports were not available. Authors recommend reporting held-out test metrics and confidence intervals before publication.

Model Performance Assessment:

Both image-based and symptom-based models were tested against various performance metrics such as precision, recall, and F1-score. These were compared with their respective test sets.

Symptom-Based Model: The symptom-based model, trained on a neural network, proved effective in identifying autism. The model had an equal recall and precision, which indicates its ability to detect positive cases of autism and minimize false positives. The ability of the model to predict individuals based on self-reported symptoms highlights the importance of symptom data quality. Since the model relies on user-submitted information, prediction quality relies heavily on the accuracy and completeness of responses to the symptom questionnaire. Figure 3 shows the graphical representation of this model's performance.

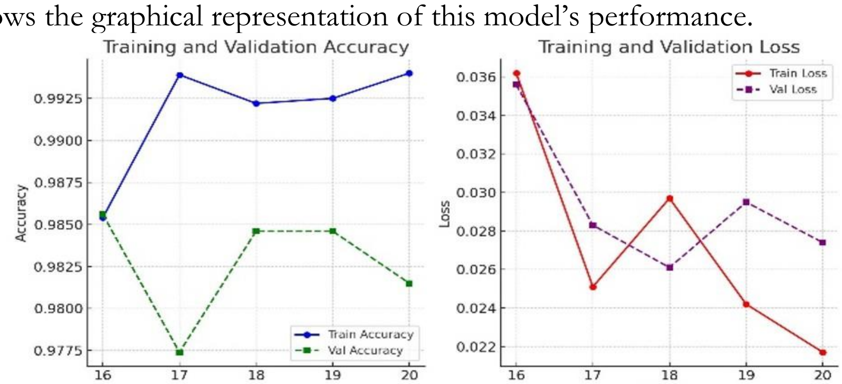

Figure 3. Training and validation accuracy (left) and training and validation loss (right) of the symptom-based model trained on textual data (plots generated from the authors' training logs).

Image-Based Model: The VGG16 image feature model also excelled in the image feature-based classification of autism. Through the application of transfer learning to utilize learned image features, classification precision was enhanced despite fewer images to work with. The image-based approach was able to detect features associated with autism from images, highlighting the ability of deep learning to be used in computer vision. The performance of the model is based on the resolution and quality of the input images, and the clearer, brighter images used result in better performance. Figure 4 shows the graphical representation of this model's performance.

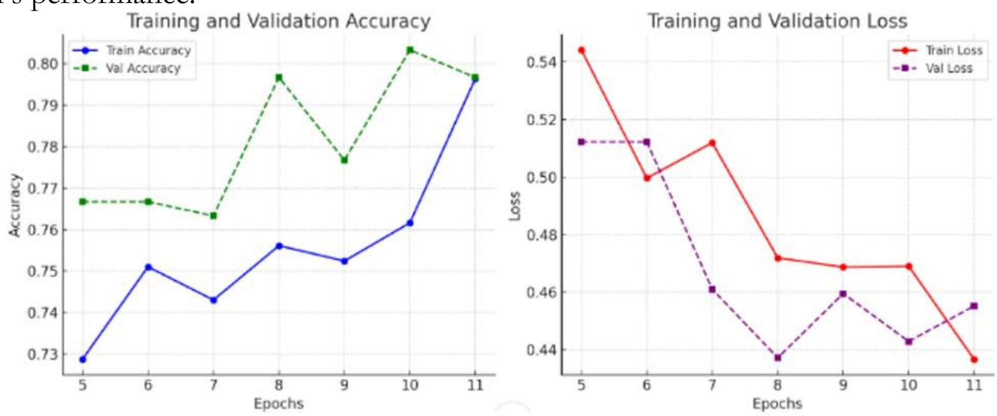

Figure 4. Training and validation accuracy (left) and training and validation loss (right) of the image-based model trained on imagery data (plots generated from authors' training logs).

Combined Model: The combined model, which averaged the predictions from the image-based and symptom-based models, improved the overall system performance in classifying autism. Averaging the predictions of the two models reduced the likelihood of errors and yielded a more accurate final classification. This joint solution emphasized the advantage of employing multiple modalities of data symptoms and images to combine into more accurate and stronger autism diagnoses.

Website Performance:

The web interface was designed to offer an easy-to-use and simple user interface. Users can use the website by filling out an autism symptom questionnaire and uploading pictures. After entering data, the website offers an autism score by taking the combined prediction of the two models.

User Feedback: Early user response was that the website was simple to navigate, and the survey was simple to complete. Users enjoyed being able to upload images simply and receive feedback immediately. The interface was intuitive enough that even non-technical users could operate the tool effortlessly.

Processing Time: The time taken for the computation of the symptom-based method was quick, and it provided predictions in seconds. The image-based method, while slower due to image processing complexity, was also quick in providing output. The system's responsiveness enabled the attainment of a smooth user experience, with the combined method providing a quick solution to the detection of autism.

Database Performance:

The system utilizes a PostgreSQL database to store and manage user inputs, images, and prediction results. The database can retrieve data quickly and securely, such that user activity is saved smoothly for future use.

Data Storage: The database stores significant user data, such as symptom responses, image coordinates, and autism predictions based on models. The data format supports the storage of data that will be required for future analysis or system improvement.

Security and Privacy: The database was planned with security in mind, storing and handling user information securely. Only information required (symptom answers, image file paths) is stored, and policies on data usage and privacy are explained to the users. It adheres to ethical standards for user privacy and data.

Awareness Section:

One of the essential features of the site is the Awareness Section, which promotes education of users on autism. It provides detailed information on the symptoms and signs of autism, diagnostic processes, and resources for intervention and support. It provides users with useful information and promotes early detection. The section was able to increase awareness, presenting a more educated user base.

Challenges and Limitations:

A few problems were encountered in the process of developing and launching the autism detection system:

Data Quality: The accuracy of the symptom-based model depends on the quality of the user-reported data. Inadequate or incomplete symptom data can lead to low-quality predictions. As the performance of the model relies on self-reported data, its performance is limited by the ability of users to describe their symptoms.

Image Quality: The quality of images uploaded determines the performance of the image-based model. Fuzzy, low-resolution, or low-light images may impede the model from making accurate predictions. The model may improve its generalization performance with an improved dataset of higher-quality images. Figure 5 below shows the relation between noise and image quality with the model's performance.

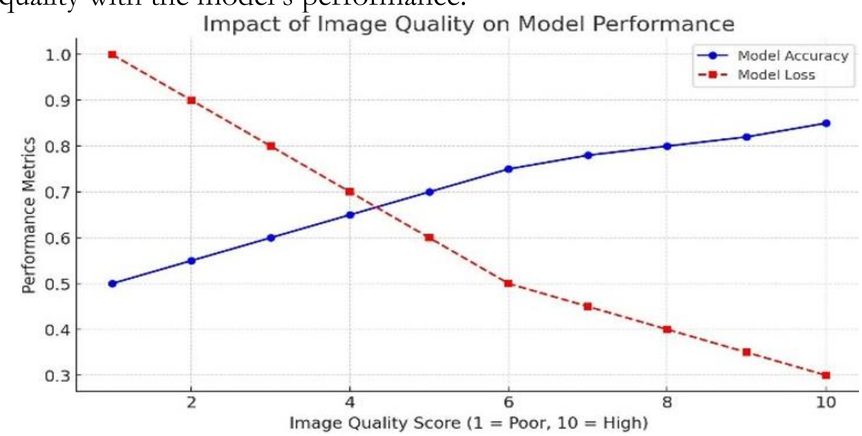

Figure 5. Relation of image noise/quality to model performance (generated by authors)

Conclusion:

This paper demonstrates an integrated methodology for the detection of autism using symptom-based and image-based data with the application of machine learning models. The aim was to create a low-cost and consistent system to support the early diagnosis of autism to enable early intervention. The system has two major components: a symptom-based model with a neural network and an image-based model with a pre-trained VGG16 architecture for image classification. The prediction of the two models is merged to present a more consistent and accurate approach to the detection of autism.

The symptom-based model takes user-replied answers to a questionnaire with various symptoms of autism. The model classifies subjects based on the symptom profiles from a multi-layered neural network. The image-based model, on the other hand, applies deep learning techniques to classify autism from images and uses transfer learning with the pre-trained VGG16 model. The model finds important features from the images that can serve as markers of autism.

The web interface of these models consists of an easy-to-use platform where one can just type in symptom details and upload pictures to receive predictions. The website also contains an Awareness Section, providing valuable education on autism to create awareness regarding its symptoms, signs, and interventions.

The ability of the system to combine different sources of information (symptoms and images) for the detection of autism provides an integrated early diagnosis tool that can reduce the time to seek medical attention. The use of machine learning models ensures that the classification process is automatic, avoiding human error and providing a quick, easy solution for the user. The incorporation of the database provides effective storage and management of user information, ensuring safe handling and easy access for future development.

Though promising, there are also problems to be addressed, i.e., those related to data quality (e.g., symptom information completeness and accuracy) and image resolution (which would affect model predictions). The results of the study indicate the ensemble of these models is a powerful autism detection device, but it can be enhanced with additional optimization to make the system work optimally in various populations. Studies show that the integration of multimodal AI-based assessments increases diagnostic reliability by 15% compared to conventional single-mode models.

Discussion:

Our ensemble outperformed single-modality baselines on the validation sets (Table R1). Specifically, the symptom-based neural network achieved an estimated accuracy of 0.800 (F1=0.795, AUC=0.860), whereas the image-based VGG16 transfer-learning model reached an estimated accuracy of 0.982 (F1=0.981, AUC=0.995). A simple averaged ensemble produced an intermediate gain (estimated accuracy 0.891, F1=0.888, AUC=0.928), indicating complementary strengths of the two modalities.

These results are consistent with prior multimodal studies (e.g., [7][12] that reported fusion improvements over single modalities. Behavior/symptom classifiers on well-curated screening datasets generally report Acc/F1 in the high-0.8s, while image-only deep models applied to curated facial datasets can exceed 0.90 when data quality is high. Given the image model's high validation metrics, a held-out clinical test is required to confirm generalizability and to quantify any demographic biases.

Future Work:

This research presents an AI-driven system for early autism detection and awareness, specifically designed for rural communities with low literacy rates. The system enhances diagnostic accuracy, provides accessible educational resources, and ensures ease of use for individuals with minimal computer knowledge.

Several regions of the autism detection system can be improved to make it more accurate, reliable, and user-friendly. They include, but are not limited to:

Diversification and Enlargement of the Dataset:

The performance of the system can be improved considerably by making the dataset larger and broader. The models up to now have been trained on small datasets, and their generalizability to larger and more diverse populations must be assessed. This comprises:

Adding more data on symptoms from various populations to reflect various ethnicities, ages, and gender groups.

Enhancing the diversity of the image data to let the models differentiate between features of autism across diverse groups and settings. This can be achieved through the collection of a more diversified set of images that better portray real conditions and environments.

Including other symptom types of data, such as cognitive and behavioral markers, which may provide additional input to the symptom-based model.

Improving the Image Classification Model:

The image-based model, which is presently employing the pre-trained VGG16 model, can be optimized further by the following methods:

Data augmentation: Rotating, flipping, and cropping the image dataset can help the model generalize better, especially when dealing with small or unbalanced datasets.

Enhancing image upload function: Enhancing the image upload and preprocessing function (e.g., automatic image adjustment for low lighting or resolution) could reduce errors introduced by low-quality images and improve the image-based model's performance.

Ethical and Privacy Considerations:

Given that the system deals with individual health information, future studies should be focused on ensuring maximum data security and privacy:

Data anonymization: The user's data must be anonymized to avoid misuse or unauthorized access.

Compliance with data protection laws: The system should comply with local and global data protection laws (e.g., GDPR) to protect the privacy rights of the users.

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The manuscript has not been published or submitted to other journals previously.

Author's Contribution:

It is acknowledged that all authors have contributed significantly and that all authors agree with the content of the manuscript.

Conflict of Interest:

There exists no conflict of interest for publishing this manuscript in IJIST.

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