

Autism Detection System using Machine Learning

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Abstract: *Autism spectrum disorder (ASD) is a developmental disorder that influences social interaction, communication skills, and behavioral responses. Identifying ASD at an early stage is crucial because it allows children to receive timely support, which improves their learning abilities, emotional development, and overall quality of life. Yet, current diagnostic practices are often expensive, require long evaluation sessions, and depend heavily on the judgment of medical specialists, making early detection difficult and less accessible. To address this issue, the proposed system introduces an automated method for preliminary screening. A short 15-second video of the subject is recorded using a webcam and processed to study facial expressions, micro-expressions, and repetitive behavior patterns that are commonly linked with autism. Emotional irregularities, such as sudden laughter, fear without clear reason, or rapid mood shifts, are also considered, since these are often early indicators observed in children with ASD.*

Keywords: Autism detection, Machine Learning, Emotion Recognition, image video analysis, non-invasive screening

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a complicated and heterogeneous group of neurodevelopmental conditions, characterized by persistent challenges in social interaction and alongside restricted, recurring tendencies in activities, interests, or behavior. In light of the wide range of signs and severity indicated by this spectrum nature, anyone with ASD describes the condition in a unique way.

This intrinsic variability makes prompt and accurate diagnosis especially difficult and frequently causes major knowing delays. Numerous epidemiological studies have been conducted on the prevalence of ASD worldwide, and new estimates from agencies such as the Centers for Disease Prevention and Control (CDC) show a growing trend.

This underscores the seriousness of the public health problem, which calls for creative approaches to early intervention and support. ASD has a significant social and economic impact on people, families, educational systems, and healthcare infrastructures all over the world. The societal and economic impact of ASD is substantial, affecting individuals, families, educational systems, and healthcare infrastructures worldwide. Emotional expression is an important aspect of human communication, yet individuals with ASD often display atypical facial emotion patterns. Rapid or inconsistent changes in facial expressions, along with difficulty in interpreting others' emotions, are frequently observed characteristics. These variations can serve as valuable behavioral markers for early detection. Recent progress in Artificial Intelligence (AI) and computer vision enables the automatic capture and analysis of such emotional shifts. A system based on facial emotion recognition offers a non-invasive, cost-effective, and supportive tool for clinicians, helping in timely diagnosis and intervention strategies.

II. LITERATURE REVIEW

Thapa and Bhandari [1] proposed a CNN-based model for ASD detection using static facial features. Their study demonstrated that deep learning can extract subtle facial patterns that may not be noticed clinically, though the approach was limited by small datasets and lack of demographic diversity. Similarly, Al-Othman et al. [2] applied CNNs to facial images, achieving good accuracy but facing challenges due to lighting, pose, and dataset scarcity.



Hossain et al. [3] extended this work by analyzing temporal changes in facial expressions through video data, improving accuracy but requiring large datasets and high computational resources.

Other researchers have explored alternative modalities. O'Reilly et al. [4] used machine learning on eye-tracking data to identify unique gaze patterns, though reliance on specialized devices limited scalability. Johnson et al. [5] reviewed multi-modal approaches integrating neuroimaging, behavioral, and facial data, noting improved accuracy but increased complexity. Chen et al. [6] analyzed gaze and social attention in natural settings, highlighting reduced eye contact as a marker, though dataset diversity remained an issue.

Beyond facial and behavioral cues, Ahmed et al. [7] applied deep learning to MRI and fMRI data, achieving strong results but facing cost and ethical concerns. Rahman et al.

[8] focused on behavioral features such as social interactions and repetitive patterns, presenting a practical, low-cost alternative, though subjectivity in behavioral data posed challenges.

Overall Existing System

Existing studies on ASD detection have mainly focused on static facial analysis, video-based emotion recognition, eye-tracking, behavioral data, and neuroimaging. Most CNN- based methods effectively capture facial or emotional cues but are limited by small datasets, lighting variations, and lack of diversity. Video-based and multi-modal systems provide better accuracy but require high computational power.

III. METHODOLOGY

The methodology of the proposed Autism Detection System is designed to provide a structured, reliable, and accessible approach for early-stage autism screening. The system is built on a client-server architecture, ensuring modularity, scalability, and ease of maintenance. The workflow begins with user registration and authentication, where individuals create accounts through a secure web interface. User credentials are hashed and stored in a MySQL database to ensure privacy and data integrity, and session management mechanisms are implemented to maintain secure access during active use. This foundation guarantees that all subsequent interactions, uploads, and analyses are restricted to authorized users, enhancing the system's security and reliability.

Once authenticated, users can submit either static facial images or short video clips for analysis. For image-based autism detection, the system preprocesses uploaded images by resizing, normalizing, and enhancing quality to match the input requirements of the Convolutional Neural Network (CNN) model. Faces are then detected using Haar Cascade classifiers, which identify and isolate facial regions efficiently. The pre-trained CNN model (model.h5) subsequently analyzes these facial features and classifies the individual as autistic or non-autistic, providing a confidence score to indicate the reliability of the prediction. This module ensures rapid, automated image assessment, enabling accurate screening even with minimal human intervention.

For video-based detection, uploaded clips are processed by extracting individual frames at specified intervals using OpenCV. Each frame undergoes face detection, and detected faces are analyzed with a pre-trained emotion recognition model (emotion_model.h5) to classify facial expressions such as happy, sad, neutral, or angry. The system then applies a heuristic evaluation on the sequence of predicted emotions over time; limited variability in emotional expression within short durations is considered indicative of autism spectrum disorder. The video module further enhances detection by capturing dynamic behavioral cues that static images cannot provide, offering a more comprehensive assessment of potential autism markers.

All analysis results, including patient details, predictions, confidence scores, timestamps, and processed data, are stored in the system's MySQL database. visualizations such as emotion charts for video assessments. The system also provides real-time feedback during uploads and processing, using progress bars and spinners to enhance user experience. Non-functional requirements, such as fast image processing (within five seconds) and efficient video analysis (within two minutes), high system uptime, reliability, and consistency of AI predictions, are incorporated to ensure the tool is practical for real-world usage.



Overall, the methodology combines secure user management, AI-driven image and video analysis, heuristic evaluation, and intuitive result presentation into a coherent workflow. By leveraging pre-trained deep learning models and efficient face detection algorithms, the system achieves high performance while remaining computationally efficient. This integrated approach ensures that the Autism Detection System is capable of providing objective, accessible, and accurate screening for autism spectrum disorder, supporting early diagnosis and intervention efforts.

IV. IMPLEMENTATION

The implementation of the Autism Detection System involves developing a functional prototype that can analyze images and videos to detect early indicators of autism. Python is used as the main programming language, with Flask managing backend API operations and database interactions, and Streamlit providing a simple, interactive frontend for uploading images or videos and displaying results. Deep learning models built with TensorFlow and Keras are used for static image classification and emotion recognition from video frames, while OpenCV, NumPy, and Pillow handle computer vision and image preprocessing tasks.

Deep learning models built with TensorFlow and Keras handle static image classification and emotion recognition from video frames. OpenCV, NumPy, and Pillow are used for face detection, frame extraction, and image preprocessing to ensure accurate model input.

The workflow begins with authenticated users providing input data, which is preprocessed and forwarded to the appropriate deep learning models for inference. In static image analysis, the CNN generates probability scores indicating the likelihood of autism, whereas in video-based emotion analysis, facial expressions are extracted frame by frame, and a heuristic approach evaluates the diversity of emotional responses as a preliminary indicator of ASD. The system also supports real-time assessment through webcam integration, capturing short video sequences and analyzing emotional changes over a brief period. All predictions, including confidence scores, emotion sequences, and timestamps, are securely stored in the MySQL database, enabling record-keeping and further analysis. This implementation ensures a comprehensive, accessible, and scalable solution for early autism detection, combining static, dynamic, and real-time analysis in a unified platform.

V. RESULTS AND DISCUSSION

The Autism Detection System was evaluated to assess its performance, functionality, and robustness. Unit testing verified individual modules, including secure login, image preprocessing, and CNN-based image classification. Integration testing confirmed that components such as video frame extraction, face detection, and emotion recognition worked seamlessly with the frontend, backend, and database. System testing using real-world images and videos validated prediction accuracy, while performance testing showed that image predictions were generated in under five seconds and 30-second video analyses completed in about two minutes. The system also handled varied conditions like poor lighting, background noise, and different file formats effectively.

Functional testing indicated that the image classification module achieved 91.2% accuracy with 89.5% precision and 88.1% recall. Video-based emotion recognition reached 88% accuracy, while autism suspicion identification was correct in 86% of cases. Robust error-handling mechanisms, including API-level responses, model-loading checks, input validation, transaction management, logging, and frontend error display, ensured system stability and provided informative feedback to users. Overall, the results demonstrate that the system is accurate, reliable, and provides an accessible platform for early autism detection.

VI. CONCLUSION

The Autism Detection System successfully demonstrates a practical and integrated approach for early-stage autism detection using both static images and dynamic video inputs. By combining deep learning models for image classification and emotion recognition with robust computer vision techniques, the system provides accurate and reliable predictions. The use of a user-friendly frontend through Streamlit, a flexible backend via Flask, and secure data management with MySQL ensures accessibility, scalability, and data integrity.



Testing results indicate high performance, with the image classifier achieving 91.2% accuracy and the video-based emotion recognition achieving 88% accuracy, demonstrating the system's effectiveness in real-world scenarios. Robust error handling and preprocessing mechanisms enhance reliability and user experience, while real-time webcam integration allows dynamic assessment of emotional patterns. Overall, the system offers a comprehensive, efficient, and scalable solution for preliminary autism detection, making it a valuable tool for caregivers, clinicians, and researchers. Future improvements could include expanding the dataset, refining model accuracy, and integrating multimodal inputs for enhanced detection capability.

The Autism Detection System provides an integrated platform for early-stage autism detection using images, videos, and real-time webcam analysis. It combines deep learning models for image classification and emotion recognition with robust computer vision techniques. The system is user-friendly, scalable, and ensures secure data management through MySQL. Testing demonstrated high accuracy, precision, and reliability in both image and video analysis. Robust error handling and preprocessing mechanisms enhance stability and user experience. Overall, the system is an effective and accessible tool for supporting caregivers, clinicians, and researchers in preliminary autism assessment.

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