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ASDTech: AI Techniques for Autism Spectrum Disorder Detection

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Abstract: ***Autism Spectrum Disorder (ASD) affects communication and behavior in children and is being managed through early diagnosis. ASDTech is an AI-based system developed to detect autism using facial images. It combines a ResNet50-based deep learning model with a random forest classifier for accurate classification. The system uses real-time image augmentation, feature extraction, and performance evaluation to ensure reliability. Designed to be portable and scalable, ASDTech offers a fast, accessible, and cost-effective solution for early ASD screening.***

Keywords: autism diagnosis, deep learning, facial image analysis, portable screening system, AI healthcare solutions

1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition that affects communication, behavior, and social interaction in individuals, especially during early childhood [3]. Early diagnosis and intervention are critical, as they significantly improve long-term developmental outcomes [8]. However, traditional diagnostic processes are time-consuming, require expert clinicians, and are not easily accessible in rural or under-resourced regions [4].

With the rapid advancement of artificial intelligence (AI) and machine learning (ML), new possibilities have emerged for automating and enhancing the diagnostic process for ASD. Recent studies have shown that deep learning models, especially Convolutional Neural Networks (CNNs), can extract subtle patterns in facial expressions and behavioral features indicative of ASD, which may not be immediately apparent to human observers [5] [27].

This research presents ASDTech: AI Techniques for Autism Spectrum Disorder Detection, a dual-model intelligent system that leverages the power of deep learning and ensemble machine learning techniques to detect autism in children based on image data. The project employs a fine-tuned ResNet50-based CNN for classification and a Random Forest classifier trained on deep features for robust decision-making. The system incorporates data augmentation, transfer learning, and advanced evaluation metrics to ensure high accuracy and reliability in real-world applications [17].

Recent advancements in Artificial Intelligence (AI) and Deep Learning (DL) have opened new avenues in medical imaging and behavioral pattern recognition [13].

2. Literature Survey

Recent research in the intersection of artificial intelligence and autism spectrum disorder (ASD) detection has highlighted the growing effectiveness of machine learning (ML) and deep learning (DL) models in recognizing behavioral and visual cues associated with ASD [25]. Traditional diagnostic methods, such as clinical observation and questionnaires like the ADOS (Autism Diagnostic Observation Schedule) [15], though reliable, are time-consuming, require expert evaluators, and are often inaccessible in rural or under-resourced settings [6] [12].

Several recent works have explored hybrid models that combine CNN-based feature extraction with traditional ML classifiers to improve robustness and interpretability [2] [26]. Moreover, techniques like data augmentation, transfer learning, and hyperparameter tuning have been crucial in achieving generalization across diverse datasets [7]. While many existing systems focus on behavioral video analysis or audio cues, image-based detection has emerged as a lightweight and scalable alternative [23]. This literature informs the development of ASDTech, which leverages these advanced techniques to build a dual-model system aimed at early ASD detection using facial images and hybrid classification for diverse users.

3. Problem Statement

Children with Autism Spectrum Disorder (ASD) often go undiagnosed or are diagnosed late due to the complex nature of the condition and the limited availability of expert clinical services, especially in low-resource or rural regions [1] [21]. Traditional diagnosis methods rely heavily on time-intensive behavioral assessments and parental interviews, which are not always accurate or accessible [4]. This delay in detection can significantly affect a child's development, as early intervention is critical for improving social, cognitive, and communication outcomes [8] [3].

Additionally, existing technological solutions for ASD screening are often fragmented, require specialized equipment, or are not scalable for wide deployment [28]. There is a pressing need for an intelligent, affordable, and non-invasive tool that can assist in the early screening of

ASD using easily accessible data such as facial images [11].

The challenge lies in developing a system that can automatically learn relevant patterns from visual cues, differentiate between autistic and non-autistic features with high accuracy, and function effectively across varying environments and devices [5]. The goal of this research is to address these limitations through the development of ASDTech, an AI-based system that uses deep learning and machine learning techniques to accurately detect autism in children using facial image data.

4. Proposed System

The proposed system, ASDTech, is a hybrid diagnostic framework developed to detect Autism Spectrum Disorder (ASD) in children using facial image data. The architecture integrates a deep learning-based Convolutional Neural Network (CNN) using a pre-trained ResNet50 model [31] and a machine learning-based Random Forest classifier [32].

The system begins with image preprocessing using Keras' ImageDataGenerator [33], applying transformations such as rotation, zoom, brightness shifts, and flipping to improve model generalization and performance across diverse data samples.

The backend server is the central processing unit of the Sahana application, built using the Django framework and deployed with an ASGI server (Daphne) to handle asynchronous communication. By leveraging Web-Sockets, the server ensures instant message delivery and real-time updates for all users. This architecture also integrates third-party messages or events during chat sessions. The architecture is also designed to be scalable, ensuring that the system can handle increasing traffic and user interactions without sacrificing performance.

The ResNet50 model, with its top layers removed, functions as both a deep feature extractor and a classifier [31]. For classification, additional dense and dropout layers are added to the network, and the model is trained using the Adam optimizer [34] and sparse categorical crossentropy loss. Alongside, features extracted from the CNN are flattened and normalized using Scikit-learn's StandardScaler [35], then passed to a Random Forest classifier tuned via GridSearchCV. This combination of models enhances prediction accuracy and robustness, especially in complex or imbalanced datasets [2].

Once trained, both models along with the scaler and class label mappings are saved using joblib and json, making them easily deployable in web or mobile applications. Training performance is visualized using accuracy and loss curves plotted with Matplotlib, while classification results are evaluated using accuracy scores and detailed classification reports. By fusing deep feature learning with traditional ensemble methods, ASDTech provides an efficient, scalable, and accessible solution for early ASD screening in clinical and community environments [13] [22].

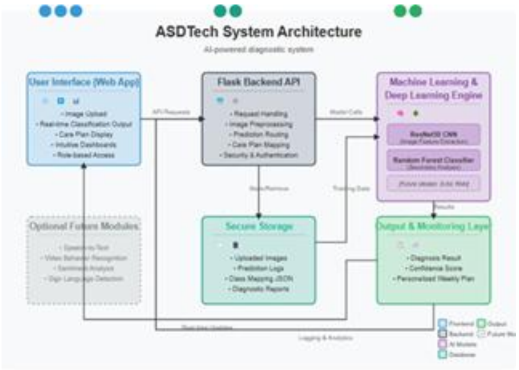

Figure 1: System Design Flowchart

5. Implementation

A. Pseudocode

1) **Start** → Load and preprocess the image dataset using real-time augmentation for both training and validation sets.
2) **Feature Learning** → Initialize and train the CNN model (ResNet50) with additional dense layers to classify images as autistic or non-autistic.
3) **Feature Extraction** → Use the trained CNN to extract deep features from the images and flatten them into vectors.
4) **Ensemble Learning** → Normalize the extracted features and train a Random Forest classifier using optimized hyperparameters.
5) **Evaluation and Save** → Evaluate both models using accuracy and classification reports, then save the trained models, feature scaler, and label mappings for deployment.

B. Important Implementation Tools and Techniques

The ASDTech system leverages a range of powerful tools, libraries, and frameworks to achieve accurate and efficient autism detection. The entire project is developed using Python, due to its strong ecosystem for machine learning and deep learning applications. For the deep learning component, TensorFlow [36] and Keras [33] are used to implement a customized version of the ResNet50 convolutional neural network, which is pre-trained on ImageNet and fine-tuned for ASD classification. Real-time image augmentation and preprocessing are handled using Keras' ImageDataGenerator, which applies transformations like rotation, zooming, bright-ness adjustments, and flipping to increase model generalization [37].

6. Result Analysis

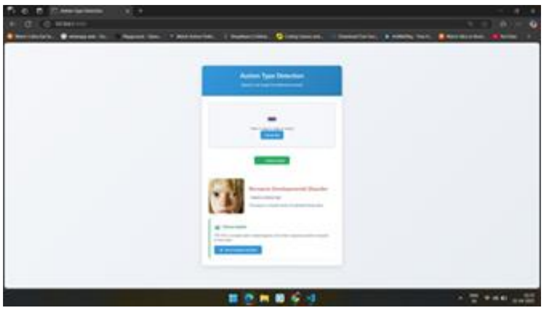

Figure 2: Autism Type Detection

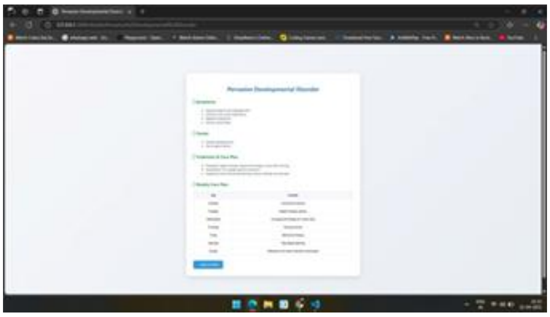

Figure 3: Treatment & Care Plan

7. Limitations and Discussion

While the proposed ASDTech system demonstrates high performance and usability in controlled environments, several real-world limitations persist:

- **Dataset Diversity**: The current system relies on curated facial image datasets that may not fully represent di-verse ethnic, cultural, and demographic characteristics, potentially affecting detection accuracy across different populations [4] [1].
- **Connectivity Constraints**: Rural and remote regions in India-often with highest needs for diagnostic sup-port-may suffer from weak or unreliable internet access, limiting deployment of cloud-based models and affecting real-time processing capabilities [9] [6].
- **Classification Ambiguity**: The dual-model approach, while robust, may occasionally produce conflicting results in borderline cases, and cannot detect the full spectrum of autism presentations, particularly those with minimal visual manifestations [27] [30].
- Despite these constraints, the system lays a strong foundation for technology-assisted screening in resource-limited settings and provides valuable support to healthcare professionals in preliminary ASD assessment.
- Future Work
- Several advancements are planned to enhance both the technological and societal impact of the ASDTech system:
- **Multimodal Integration**: Expand the system to incorporate additional data modalities such as voice patterns, movement analysis, and eye-tracking information to improve detection sensitivity and specificity [13] [23].
- **Longitudinal Assessment**: Develop functionality for tracking developmental changes over time, allowing for monitoring of intervention effectiveness and develop-mental trajectories [8] [30].
- **AI-Driven Intervention Planning**: Incorporate recommendation algorithms that suggest personalized intervention strategies based on the specific pattern of features identified during screening [11] [29].
- **Inclusive Design**: Add multilingual support and simplified user interfaces to improve accessibility for non-technical users, parents, and educators in diverse socioeconomic settings [28] [21].

8. Conclusion

ASDTech represents a significant step forward in leveraging artificial intelligence for the early detection of Autism Spectrum Disorder in children [30]. By combining the power of deep learning through a ResNet50-based convolutional neural network with the interpretability and robustness of a Random Forest classifier, the system provides a reliable, efficient, and accessible solution for preliminary autism screening [2] [22]. The hybrid architecture allows for both high-accuracy classification and feature-based decision making, making it suitable for use in both clinical and non-clinical environments. Real-time image augmentation, advanced training techniques, and thoughtful model evaluation further enhance the system's adaptability and generalization capabilities [37].

The project demonstrates that facial image data, when processed using modern AI techniques, can serve as a valuable tool for recognizing behavioral patterns associated with ASD [27] [18]. Moreover, by saving trained models and tools in portable formats, ASDTech can be seamlessly integrated into mobile health apps, school health programs, or telemedicine platforms, extending its reach to underserved regions [29] [28]. In future work, the system can be expanded with additional data modalities such as video, audio, or behavioral assessments, and improved using real-time feedback from therapists and caregivers [13]. Ultimately, ASDTech stands as a promising, technology-driven support system for enabling early diagnosis and fostering inclusive developmental care.

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