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EDGE AI-BASED BEHAVIOUR ANALYSIS AND ROUTINE SUPPORT FOR AUTISM

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Abstract:

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by challenges in social interaction, communication, and behavioral patterns. Early diagnosis plays a crucial role in providing timely intervention and improving developmental outcomes. This project proposes a software-based intelligent system for early autism detection using facial image analysis and deep learning techniques.

The system utilizes a publicly available facial image dataset containing labeled images of children with and without ASD. Image preprocessing techniques such as resizing, normalization, and face region extraction are applied to improve model performance. A Convolutional Neural Network (CNN) model, implemented using transfer learning with MobileNetV2 architecture, is employed for feature extraction and classification. The model is trained to distinguish between ASD and non-ASD cases based on visual behavioral cues present in facial patterns.

The backend is developed using Python and Flask, while the frontend interface is built using React.js for image upload and result visualization. The trained model outputs a probability score indicating the likelihood of ASD, along with classification results. System performance is evaluated using metrics such as accuracy, precision, recall, F1-score, and confusion matrix analysis. The proposed solution provides a cost-effective, non-invasive, and scalable screening tool that can assist healthcare professionals and parents in early-stage autism risk assessment. This system demonstrates the potential of deep learning in supporting clinical decision-making and advancing intelligent healthcare applications modules.

INTRODUCTION

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental condition characterized by impairments in social communication, restricted interests, and repetitive behaviors. The disorder manifests in early childhood, but its diagnosis is often delayed due to the complexity of symptoms and reliance on behavioral observation. According to global health studies, the prevalence of ASD has increased significantly over the past decade, emphasizing the need for efficient and early diagnostic tools.

Traditional diagnostic methods involve clinical assessments, structured interviews, and behavioral analysis conducted by trained professionals. While these methods are effective, they are time-intensive, subjective, and often inaccessible in rural or under-resourced areas. As a result, many children are diagnosed at a later stage, missing the opportunity for early intervention, which is crucial for improving long-term outcomes.

Recent advancements in Artificial Intelligence (AI),particularly in deep learning, have opened new possibilities for automated medical diagnosis. Deep learning models, especially Convolutional Neural Networks (CNNs), have demonstrated exceptional performance in image classification and pattern recognition tasks. Facial image analysis has gained attention as a promising approach for ASD detection, as subtle facial features and morphological differences can be indicative of the disorder.

The proposed system aims to address the limitations of traditional methods by providing an automated, efficient, and accessible solution for ASD detection. By utilizing a pretrained MobileNetV2 model and integrating it into a web-based platform, the system ensures high accuracy and real-time usability. This approach not only reduces dependency on manual assessments but also enables early screening at a larger scale.

RELATED WORK

The application of machine learning and deep learning techniques in healthcare has grown rapidly, particularly in diagnostic imaging. Several researchers have explored the use of image-based analysis for detecting neurological and developmental disorders. Convolutional Neural Networks (CNNs) have been widely adopted due to their ability to learn hierarchical representations of image data.

Early approaches to ASD detection primarily relied on behavioral data and questionnaire-based analysis. However, these methods lacked objectivity and required expert intervention. With the emergence of deep learning, researchers began exploring facial image datasets to identify phenotypic markers associated with ASD. Studies have shown that children with ASD may exhibit distinct facial characteristics, which can be captured using CNN models.

Transfer learning has proven to be highly effective in medical image classification tasks, especially when datasets are limited. Pretrained models such as MobileNetV2, VGG16, InceptionV3, and ResNet50 have been successfully applied in various healthcare applications. These models leverage knowledge from large-scale datasets, reducing training time and improving performance.

Despite these advancements, many existing systems are limited by their lack of real-time implementation and user accessibility. Some models require high computational resources, making them unsuitable for deployment in real-world environments. The proposed system addresses these challenges by using a

lightweight architecture (MobileNetV2) and integrating it with a web-based interface, ensuring both efficiency and usability.

EXISTING SYSTEM

Existing systems for Autism Spectrum Disorder (ASD) detection primarily rely on traditional clinical and behavioral assessment methods conducted by trained healthcare professionals. These methods include observational analysis, structured interviews, and standardized diagnostic tools such as the Autism Diagnostic Observation Schedule (ADOS) and Autism Diagnostic Interview-Revised (ADI-R). While these approaches are considered reliable, they are time-consuming, require expert involvement, and are often subjective in nature. As a result, early diagnosis is frequently delayed, especially in regions with limited access to specialized medical facilities.

In recent years, machine learning-based approaches have been introduced to improve the efficiency of ASD detection. These systems utilize questionnaire data, behavioral patterns, and basic image analysis techniques to classify individuals. However, many of these models depend heavily on handcrafted features and lack the ability to automatically learn complex patterns from data. Additionally, several existing image-based systems use traditional algorithms that are not robust enough to capture subtle facial variations associated with ASD.

Some advanced systems have incorporated deep learning models such as Convolutional Neural Networks (CNNs) for facial image classification. Although these methods have shown improved

PROPOSED SYSTEM

The proposed system is designed as an end-to-end framework for detecting Autism Spectrum Disorder (ASD) using facial image analysis and deep learning techniques. The system architecture consists of multiple stages, including image acquisition, preprocessing, feature extraction, classification, and result visualization. Each stage plays a crucial role in ensuring the accuracy, efficiency, and reliability of the overall prediction process.

The process begins with the image acquisition stage, where users upload facial images through a web-based interface. These images are transmitted to the backend server for further processing. In the preprocessing stage, the input images are resized to a standard resolution of 224 × 224 pixels to match the input requirements of the deep learning model. Pixel values are normalized to ensure consistency across inputs, and face detection techniques are applied to extract the region of interest. Additionally, data augmentation techniques such as rotation, flipping, and zooming are employed during the training phase to enhance the model's generalization capability and reduce overfitting.

Feature extraction is performed using the MobileNetV2 architecture, a lightweight Convolutional Neural Network (CNN) optimized for efficient computation in mobile and embedded environments. The model is pretrained on a large-scale dataset and fine-tuned using transfer learning to adapt it for ASD classification. This approach enables the system to effectively capture complex facial patterns and discriminative features while maintaining low computational cost.

Following feature extraction, the classification stage is carried out using fully connected layers, where the extracted features are mapped to output classes, namely ASD and Non-ASD. A sigmoid activation function is used to generate a probability score representing the likelihood of ASD. This probability is further interpreted as a risk percentage to provide meaningful insights to the user.

Finally, the result visualization stage presents the classification outcome along with the corresponding probability score through a user-friendly web interface. The integration of a Flask-based backend and a React.js frontend ensures real-time processing, efficient communication, and ease of use. This makes the proposed system suitable for practical deployment and early-stage autism screening.

The frontend of the system is developed using React.js, which provides a dynamic and responsive user interface. React.js enables the creation of reusable components, improving maintainability and scalability of the application. The user interface allows users to upload facial images, view prediction results, and visualize risk assessments in an intuitive manner. Additional features such as loading indicators, error handling, and result visualization components enhance the overall user experience. The frontend communicates with the backend using HTTP requests, ensuring real-time interaction between the user and the system.

The core of the system lies in the deep learning model, which is implemented using TensorFlow and Keras libraries. These frameworks provide powerful tools for designing, training, and deploying Convolutional Neural Networks (CNNs). The MobileNetV2 architecture is selected due to its lightweight nature and high efficiency, making it suitable for real-time applications and deployment on resource-constrained systems. The model is trained using a labeled dataset of facial images, where each image is associated with a corresponding class label indicating ASD or non-ASD. During training, the images are passed through multiple convolutional layers that automatically extract hierarchical features such as edges, textures, and facial structures.

ARCHITECTURE DIAGRAM

SYSTEM MODULES

The proposed system is divided into multiple functional modules, each responsible for a specific task in the autism detection pipeline. These modules ensure efficient processing, accurate prediction, and user-friendly interaction.

1. Image Acquisition Module

This module enables users, including parents and healthcare professionals, to upload facial images through a web-based interface. The frontend is developed using React.js, which securely transfers the input image to the backend server via API calls.

2. Image Preprocessing Module

This module prepares the input image before it is fed into the deep learning model. The preprocessing steps include image resizing to 224 × 224 pixels, pixel normalization, and face region detection using OpenCV. Data augmentation techniques such as rotation, flipping, and zooming are applied during the training phase to improve model generalization. These steps ensure uniform input size and enhance model performance.

3. Feature Extraction Module

Feature extraction is performed using a pretrained Convolutional Neural Network based on the MobileNetV2 architecture. Transfer learning is employed to extract high-level features automatically. The pretrained layers capture spatial patterns and visual behavioural cues relevant to ASD detection.

4. Classification Module

The extracted features are passed through fully connected layers for binary classification into ASD and Non-ASD categories. A sigmoid or SoftMax activation function is used to generate the classification output.

5. Probability and Risk Assessment Module

This module computes the probability score indicating the likelihood of Autism Spectrum Disorder. The probability value is converted into a user-friendly risk percentage for better interpretation.

6. Database Management Module

All user inputs, prediction results, timestamps, and probability scores are stored in a structured database such as MySQL or MongoDB. This facilitates record management and future analysis.

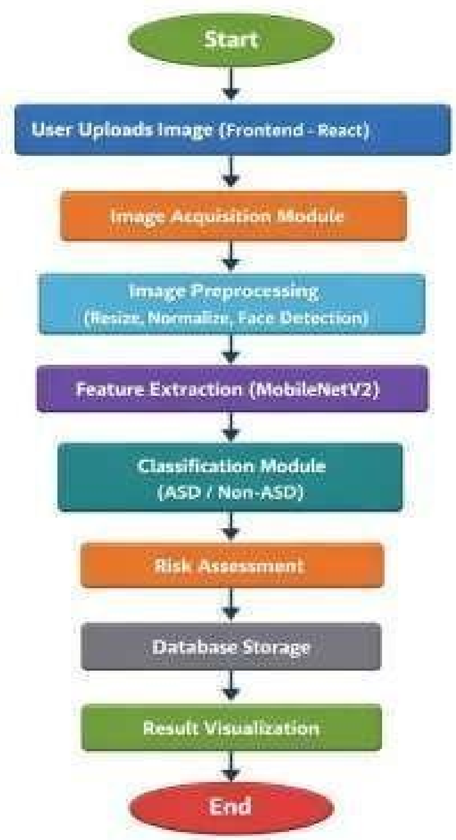
7. Result Visualization Module

This module presents the output to the user in an intuitive format. It displays the classification result (ASD or Non-ASD), the corresponding risk percentage, and graphical representations such as bar charts or gauge indicators. The dashboard ensures easy understanding of the prediction results.

8. Model Evaluation Module

During the training phase, the performance of the model is evaluated using standard metrics such as accuracy, precision, recall, F1-score, and confusion matrix. These metrics help in assessing the reliability and effectiveness of the model.

FLOW CHART



The flowchart represents the overall working process of the proposed ASD detection system. It begins with the user uploading a facial image, followed by preprocessing steps such as resizing, normalization, and face detection. The processed image is then passed to the MobileNetV2 model for feature extraction and classification. Based on the prediction, the system calculates the risk probability and stores the result in the database. Finally, the output is displayed to the user through a dashboard interface.

Following classification, the system calculates the probability score to estimate the risk level associated with ASD. The prediction results, along with the probability values, are stored in the database for record maintenance and further analysis. Finally, the result visualization module displays the classification outcome and risk percentage through a user-friendly dashboard interface.

SYSTEM IMPLEMENTATION AND RESULTS

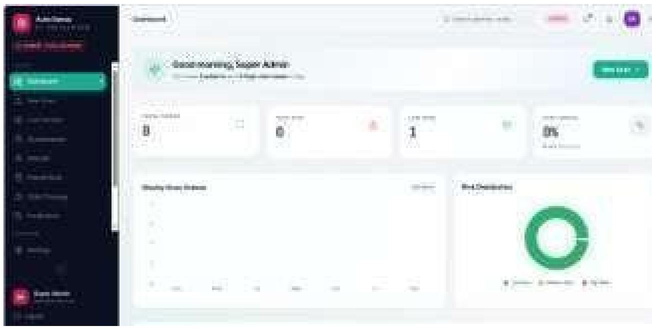


Fig.1. Main Administrator Dashboard Displays the high-level overview of total scans, risk metrics, and weekly volume trends within the Aura Sense ecosystem.

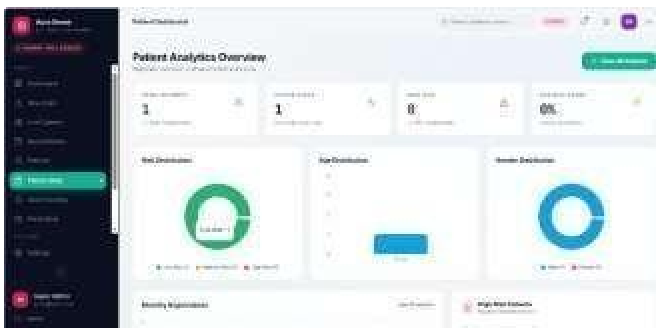


Fig.2. Patient Analytics and Demographic Overview Visualizes aggregate data including age and gender distribution, risk classification ratios, and monthly registration trends.

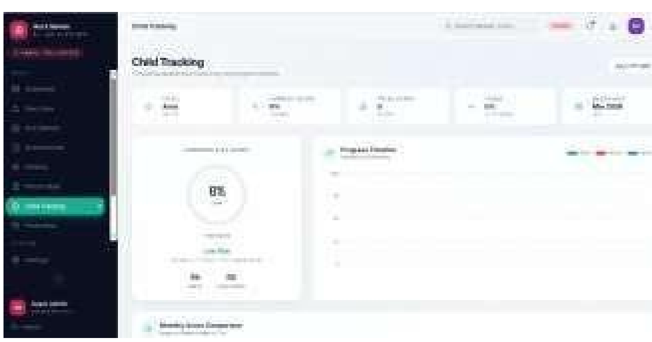


Fig.3. Longitudinal Child Tracking and Progress Analysis Illustrates the multi-modal risk score calculation based on image and questionnaire data over a defined timeline.

Fig.4. Digital Twin 3D Facial Mapping Interface Shows the 3D mesh generation with AI attention heatmaps and neural pattern matching scores for ASD risk assessment.

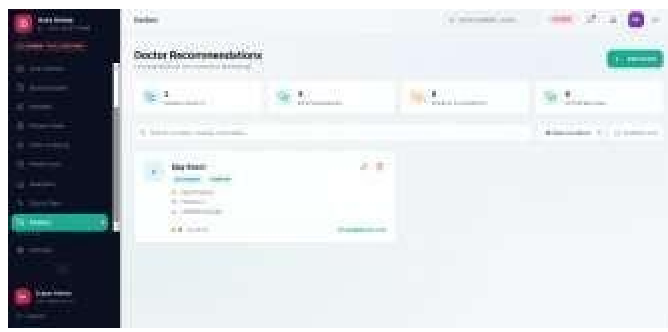


Fig.5. Integrated Specialist Referral and Doctor Directory The module interface for connecting users with verified neurologists and pediatricians based on diagnostic results.

CONCLUSION AND FUTURE WORK

The proposed system presents an efficient AI-based solution for the early detection of Autism Spectrum Disorder (ASD) using facial image analysis. By leveraging the MobileNetV2 deep learning model with transfer learning, the system is capable of accurately classifying ASD and Non-ASD cases. The integration of image preprocessing, feature extraction, and classification ensures reliable and consistent performance. Furthermore, the implementation of a web-based interface enables real-time prediction and user-friendly interaction. The system also provides a probability-based risk assessment, making the output more interpretable and useful for early screening. Overall, the proposed solution is cost-effective, scalable, and contributes to the advancement of intelligent healthcare systems.

Future work can focus on improving the system by incorporating a larger and more diverse dataset to enhance accuracy and generalization. The development of a mobile application can further increase accessibility and usability. Additionally, integrating video-based behavioural analysis and multimodal data can improve the reliability of ASD detection. Advanced deep learning architectures and AI-based recommendation systems can also be included to support therapy planning and decision-making. These enhancements will make the system more robust and suitable for real-world healthcare applications.

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