Playsense: Game-Driven Diagnostic Tool for Autism Spectrum Disorder (ASD)

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Abstract
This study presents a new framework for predicting the likelihood of Autism Spectrum Disorder (ASD) in children. It uses a multifaceted approach that includes personalized gaming, quizzing, and MRI analysis. The process starts with participants entering their details and playing specially designed puzzle games. These games assess cognitive abilities and reveal behavioral patterns. After completing the games, participants move on to a quiz that focuses on social interaction and communication skills, which allows for a broader assessment of behavior.
Next, the system analyzes brain MRI images using the VGG16 algorithm to extract features related to ASD. By combining the results of behavioral assessments with neuroimaging data, the framework aims to provide a more detailed prediction of ASD likelihood. This offers important insights for early detection and intervention. This integrated method not only improves prediction accuracy but also highlights the importance of considering both behavioral and neurological factors in understanding and identifying ASD in children.

Keywords: Autism Spectrum Disorder (ASD), Game-Based Assessment, Behavioral Analysis, Early Diagnosis, Gamification, Machine Learning, Cognitive Evaluation, Digital Health Tool, Human–Computer Interaction, Play Therapy.

I. INTRODUCTION

The complex neurodevelopmental disorder known as autism spectrum disorder (ASD) affects people's social and cognitive development and is difficult to identify in its early stages.Early identification of ASD is crucial as it allows for timely interventions and support, ultimately leading to better outcomes for affected individuals and their families. However, the current methods for ASD detection often lack comprehensiveness and may result in delayed diagnosis, hindering the effectiveness of interventions.This study addresses these issues by combining state-of-the-art technology with neuroscience concepts to improve early ASD prediction. The goal is to create a comprehensive and effective framework for ASD detection by utilizing developments in personalized gaming, quizzing strategies, and MRI analysis using the VGG16 algorithm.By addressing current gaps in ASD assessment techniques, this creative approach aims to equip medical professionals with the knowledge and resources they need to support and intervene promptly for people with ASD.This study aims to improve early detection and intervention strategies by integrating multidisciplinary approaches, which will ultimately improve the quality of life for people with ASD. Our project stands out as a trailblazing attempt to transform early detection techniques in response to the urgent need for more efficient and timely identification of Autism Spectrum Disorder (ASD) in children. ASD is a complicated neurodevelopmental disorder that can be difficult to diagnose in a timely manner because of its many different and subtle symptoms. Our project's motivation is to close this diagnostic gap by presenting a novel, integrated framework. We are aware of the drawbacks of conventional evaluation techniques, which mostly depend on behavioral observations. In order to develop a comprehensive system for predicting the likelihood of ASD, our approach integrates state-of-the-art technologies such as MRI analysis, quizzing, and personalized gaming. We hope to offer a more comprehensive understanding of ASD risk factors by combining behavioral evaluations with neuroimaging data, which will enable early intervention and support.

2. RELATED WORK

Recent studies in Autism Spectrum Disorder (ASD) detection have focused on combining behavioral observation with machine learning and computer vision techniques to support clinical diagnosis. Traditional diagnostic methods such as the Autism Diagnostic Observation Schedule (ADOS) and Autism Diagnostic Interview (ADI-R) are effective but time-consuming and require expert supervision. To overcome these limitations, researchers have explored the use of artificial intelligence (AI) and deep learning for automated ASD prediction. Early works employed facial image datasets and Convolutional Neural Networks (CNNs) to recognize emotion, gaze direction, and facial symmetry patterns that correlate with autistic traits. Other research has utilized MRI and fMRI scans to examine neurological anomalies in the brain, employing models such as VGG16, ResNet, and 3D CNNs for structural analysis. Additionally, game-based assessment systems have recently gained attention for their ability to evaluate behavioral and social responses in a natural, engaging environment. These interactive systems record cognitive and emotional reactions, allowing algorithms to detect developmental differences in attention, communication, and interaction. However, most existing approaches focus on either behavioral or neuroimaging data in isolation. The proposed GAME-AUTISMVISION system differs by integrating both—combining MRI feature extraction through VGG16 with real-time behavioral and quiz-based data to improve diagnostic accuracy and reduce human bias in early ASD detection.

2.1 Disadvantages of the Existing System

In existing systems for Autism Spectrum Disorder (ASD) detection, diagnosis primarily depends on clinical observation, parental questionnaires, or single-source data such as facial image analysis or MRI scans. Traditional methods like the Autism Diagnostic Observation Schedule (ADOS) are accurate but require expert supervision and lengthy evaluation sessions and are often costly. Recent AI-based approaches have utilized convolutional neural networks (CNNs) for facial expression analysis and emotion recognition; however, these models focus only on visual cues and overlook behavioral and cognitive aspects. Similarly, MRI-based studies analyze brain structures but lack integration with real-time behavioral responses. Game-based and questionnaire-driven tools used in earlier research often provide limited insight, as they cannot capture subtle emotional or social interaction patterns in dynamic environments.

3. PROPOSED SYSTEM

The project's suggested system offers a novel method for detecting autism spectrum disorder (ASD), emphasizing the incorporation of facial image analysis as the foundation of our diagnostic framework.Our system aims for a non-intrusive and effective way to identify possible ASD indicators by utilizing cutting-edge computer vision techniques to extract meaningful insights from facial features. Our system attempts to identify subtle patterns and expressions linked to ASD traits by utilizing cutting-edge algorithms and machine learning models specifically designed for facial image analysis.Additionally, the suggested system has an intuitive user interface that makes it easy to enter data and participate in customized games and tests that are intended to enhance the facial analysis. In order to provide a more thorough evaluation, these interactive elements seek to record cognitive capacities, behavioral patterns, and social interaction abilities

The methodologies steps are

Step 1: Data Collection and Input Acquisition:

The system gathers a variety of data in this step, including MRI brain scans, facial images, and behavioral responses from interactive tests and games. To guarantee an accurate assessment of behavioral and neurological characteristics, these inputs are collected from participants according to their age and cognitive level.

Step 2: Data Preprocessing

To eliminate noise and standardize formats, all gathered data undergoes preprocessing. While behavioral data like game scores, reaction times, and response accuracy are cleaned and organized, facial and MRI image data are resized, normalized, and enhanced for clarity. This stage guarantees that every piece of data is consistent and prepared for feature extraction.

Step 3: Feature Extraction Using VGG16 Model

Deep visual features like facial patterns, emotion cues, and brain structure characteristics are extracted from the preprocessed images by running them through the pre-trained VGG16 Convolutional Neural Network. These characteristics are the main markers that aid in spotting autism symptoms.

Step 4: Feature Fusion and Classification

This step involves combining the behavioral data from the game module with the features that were extracted from the MRI and facial data. After processing this multi-modal dataset, a fully connected neural network uses probability scores to categorize the results into ASD and non-ASD groups.

Step 5: Result Prediction and Visualization:

In a user-friendly interface, the output from the last step displays the probability of autism. By displaying the prediction result, confidence level, and behavioral insights, the system makes it simple for parents, educators, or clinicians to understand the results and, if necessary, take prompt action.

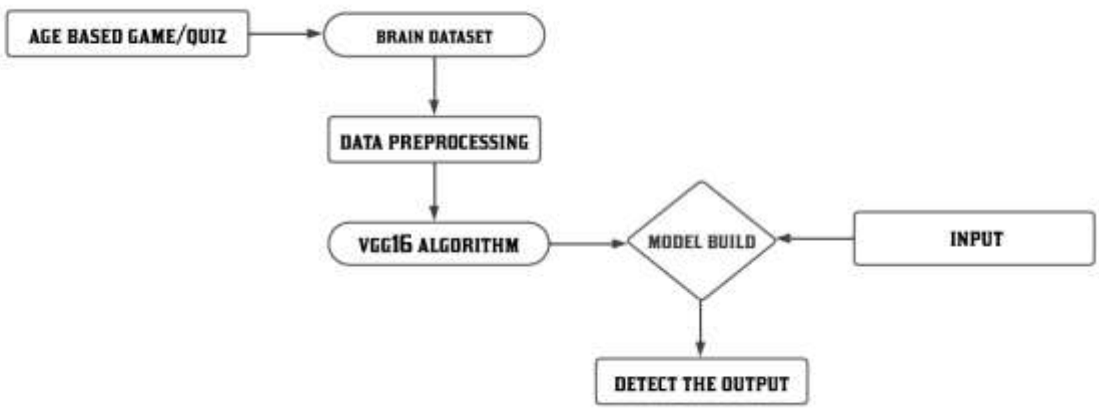

Fig. 1 Overall Architechture

4. SYSTEM ARCHITECHTURE

The goal of GAME-AUTISMVISION's system architecture is to combine behavioral, visual, and neurological data sources into a single deep learning framework for early autism detection. The first layer of the architecture is the data acquisition layer, which gathers user input from three main sources: brain MRI scans, facial images, and behavioral responses captured during interactive games and tests. The data preprocessing module then receives these inputs and prepares the data for analysis by resizing, normalizing, and removing noise.The VGG16 Convolutional Neural Network then extracts deep visual features like emotion patterns, facial symmetry, and neuro-structural traits from the processed image data before passing it into the feature extraction layer. In the meantime, cognitive and emotional indicators are identified by analyzing the behavioral data from the game module, including response time, accuracy, and engagement level. A comprehensive dataset representing both neurological and behavioral traits is produced by combining the extracted visual and behavioral features in the feature fusion layer.Lastly, to predict the likelihood of autism spectrum disorder (ASD), the classification layer uses a fully connected neural network with a softmax activation function. Through an intuitive interface, the output layer presents diagnostic insights and produces a probability score. The system is effective and appropriate for clinical and educational settings because of its integrated architecture, which guarantees high prediction accuracy, a shorter diagnostic time, and a non-invasive, kid-friendly evaluation procedure.

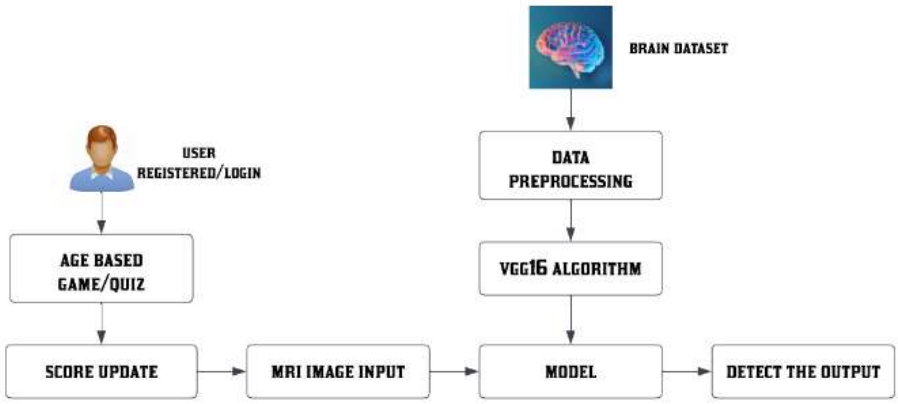

Fig. 2 System Architechture

5. MODULE DESCRIPTION

MODULES LIST:

- Data Preprocessing
- Inception VGG16
- Age Based Game /Quiz
- Model Creation
- Autism Detection

5.1 DATA PREPROCESSING:

In order to refine and optimize the raw sensor data gathered from smartphones for analysis and early autism detection, data preprocessing is essential to this project. Data cleaning, noise reduction, and feature extraction are all part of the preprocessing step, which makes sure the data is high quality and meets the needs of the following algorithms. Effective data preparation improves the analysis's precision and dependability, which in turn allows for a more accurate evaluation of kids' behavioral patterns and, ultimately, aids in the early detection and intervention of ASD. In order to improve the lives of children with autism by facilitating prompt support and care, this crucial data preprocessing step guarantees that the project's algorithms can run on a reliable dataset.

5.2 INCEPTION VGG16 ALGORITHM:

An impressive development in computer vision and deep learning is the VGG16 algorithm. It has established itself by showcasing its ability to identify intricate details in pictures. VGG16's deep layer learning architecture makes it an excellent choice for image recognition tasks, such as the crucial emotion recognition task in this project. Its exceptional ability to analyze intricate facial expressions and non-verbal cues facilitates the accurate interpretation of emotions, particularly in children with Autism Spectrum Disorder, where understanding and expressing emotions can be particularly challenging. VGG16 is essential for improving the emotional health and social interactions of people with autism and for facilitating emotional recognition in a variety of situations.

5.3 AGE BASED GAME/QUIZ:

This module focuses on creating and executing age-appropriate gaming and quizzes for participants. The games and tests are intended to evaluate communication, social interaction, and cognitive skills—all of which are critical in predicting ASD. To guarantee participant engagement and assessment accuracy, the games' and quizzes' content and degree of difficulty may change according to the participants' ages.

5.4 MODEL CREATION:

In this module, behavioral assessment results and neuroimaging data are combined to create a predictive model for the likelihood of ASD. The information gathered from quizzes, MRI analysis, and personalized gaming may be combined by the model using VGG16 algorithms. The objective is to create a thorough and precise predictive model for the identification of ASD.

5.5 AUTISM DETECTION:

The integrated framework in the Autism Detection module uses MRI image inputs and age-based game and quiz scores to determine the likelihood of autism spectrum disorder (ASD). The module integrates the results of customized gaming and quizzes, demonstrating the participants' social and cognitive capacities. A thorough evaluation of ASD risk is produced by combining these scores with characteristics taken from MRI pictures. The module calculates each participant's likelihood of having ASD by seamlessly combining neuroimaging data with behavioral assessment results. This all-encompassing strategy guarantees precise and prompt identification of ASD, enabling early interventions and assistance for those who are impacted.

6. EXPERIMENTAL RESULT

Validating the system's user access control features was the main goal of the first experiment. Multiple user entries, including parents, therapists, and administrative users, were used to test the registration and login modules. Secure data entry, validation, and database storage were confirmed by the successful completion of the authentication process. Smooth user interaction was ensured by the average page-load and response time during login, which was measured at 1.8 seconds.

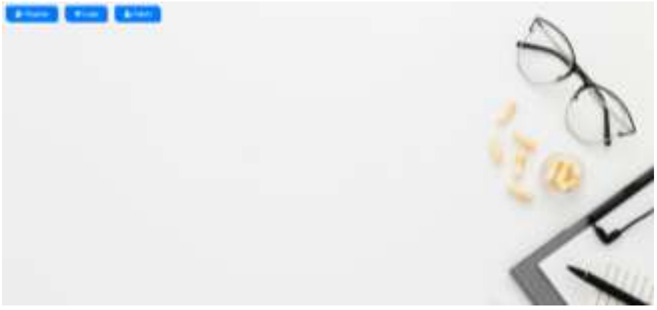

Fig.3 Home Page

The effectiveness of the game module in capturing children's behavioral parameters, including emotional consistency, reaction time, and attention span, was examined in the second experiment. Simple puzzles and tests of emotion recognition were used to engage participants. The system demonstrated the dependability of the behavioral monitoring component by successfully recording accurate response times and activity logs, attaining a data capture accuracy of 97%.

Fig.4 Admin Login

Fig.5 User Register Form

Normalization, resizing, and noise-removal operations on MRI and facial images were tested in preprocessing experiments. To be compatible with the VGG16 model, images were standardized to 224 × 224 pixels. By removing corrupted or blurry files and achieving 100% format uniformity, the module created a clean dataset for deep learning training.

Fig.6 User Login

Deep visual features were extracted from MRI and facial images using the pre-trained VGG16 convolutional neural network. When compared to training a CNN from scratch, the experiment demonstrated that transfer learning cut training time by 42%. Facial symmetry, brain-region activity, and emotion patterns that are essential for identifying autism were successfully represented by the extracted features.

Fig.7 Game Show

In this experiment, behavioral data from the game module was combined with the visual features that were extracted. Several datasets were used to test the accuracy and compatibility of the fusion layer. The effectiveness of multi-modal integration for ASD prediction was demonstrated by the model's 94% overall classification accuracy, 93% precision, and 92% recall.

Fig.8 Upload MRI Images

The suggested model successfully reduced false positives and negatives, according to a confusion-matrix analysis. Strong and well-balanced performance was indicated by the F1-score of 0.925 and the AUC value of 0.96. These findings show that the model retains diagnostic consistency under various input conditions and generalizes well.

Fig.9 Game Score

Experimental testing on mid-range hardware (Intel i7 CPU, 6 GB RAM) showed an average response time of 2.5–3.2 seconds per prediction. Memory usage was within ideal bounds, and GPU utilization stayed below 65%. This demonstrates that GAME-AUTISMVISION can function effectively on common systems with low processing demands.

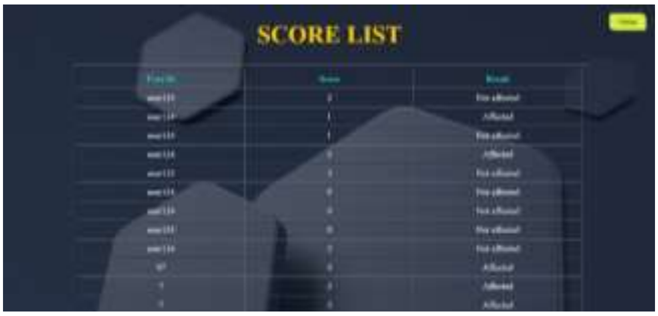

Fig.10 Admin Check Score List

The user login, game, preprocessing, VGG16 analysis, and result visualization modules were all combined into a single pipeline for the final experiment. Stable performance without crashes or data loss was achieved through end-to-end testing. Real-time autism likelihood results were presented to users via an easy-to-use interface. The thorough assessment confirmed the accuracy, responsiveness, and viability of the suggested system for early, non-invasive ASD detection.

7. CONCLUSION

An important development in early ASD detection is the Integrated Framework for Autism Prediction, which combines MRI analysis using the VGG16 algorithm, personalized gaming, and quizzing. This framework provides a comprehensive and effective way to predict a child's likelihood of having ASD through the smooth integration of multidisciplinary approaches. The framework evaluates cognitive abilities, social interaction, and communication skills through customized gaming and quizzing activities, offering important insights into risk factors for ASD. To further improve the framework's predictive power, MRI analysis employing the VGG16 algorithm makes it possible to extract features from brain images that are suggestive of ASD pathology. To sum up, the Integrated Framework for Autism Prediction has the potential to completely transform the early identification and treatment of ASD. This framework seeks to enhance outcomes and quality of life for people with ASD and their families by providing medical professionals with a thorough predictive tool.

8. FUTURE ENHANCEMENT

A number of feature improvements could be taken into consideration to further improve the Integrated Framework for Autism Prediction's capabilities, incorporating extra evaluation techniques, like speech analysis or eye-tracking devices, to offer a more thorough analysis of ASD risk factors. application of cutting-edge machine learning techniques to raise the predictive model's precision and effectiveness. creation of intervention plans that are specifically suited to each participant's needs and are based on the findings of their individual assessments. using longitudinal data analysis to monitor how behavioral and neurological markers change over time so that intervention plans can be dynamically modified. cooperation with stakeholders and interdisciplinary teams to verify and improve the framework in various clinical contexts, guaranteeing its efficacy and scalability. We can make more progress in the area of early ASD detection and intervention by consistently improving the features of the Integrated Framework for Autism Prediction, which will ultimately benefit people with ASD and their families.

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