AUTISM SPECTRUM DISORDER PREDICTION USING MACHINE LEARNING

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ABSTRACT

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition affecting social interactions, communication, and behavior. Early and accurate diagnosis is crucial for effective intervention and improved quality of life. Traditional diagnosis methods are subjective, time-consuming, and often inaccessible. This paper proposes a machine learningbased model to detect ASD by analyzing behavioral, genetic, and cognitive patterns. Multiple classification algorithms, including Decision Trees, Random Forest, Support Vector Machines (SVM), and Neural Networks, are evaluated for their predictive performance. The study incorporates real-world datasets containing clinical and behavioral indicators, ensuring a robust evaluation of machine learning techniques. Various preprocessing methods, including feature selection, data normalization, and missing value imputation, are implemented to improve the model's efficiency. Comparative analysis of different algorithms is performed to identify the most suitable model for ASD classification, focusing on accuracy, precision, recall, and F1-score. Furthermore, this research explores the integration of deep learning techniques to enhance predictive capabilities. The findings demonstrate that machine learning can significantly enhance ASD diagnosis, providing a cost-effective, scalable, and efficient alternative to traditional methods. This study also discusses potential real-world applications, including mobilebased ASD screening tools and cloud-based diagnostic systems, to improve accessibility and early intervention for individuals at risk of ASD.

KEYWORDS: Machine Learning, ASD Prediction, Behavioral Analysis, Genetic Disorder, Social Responsiveness Scale.

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition that affects communication, social interaction, and behavior. The increasing prevalence of ASD highlights the need for early and accurate diagnosis to improve treatment outcomes. Traditional diagnostic methods, which rely on clinical observations and questionnaires, are often time-consuming, subjective, and limited in accessibility. As a result, there is growing interest in utilizing machine learning (ML) techniques to enhance the accuracy and efficiency of ASD prediction. Machine learning provides the ability to analyze large datasets, identify hidden patterns, and automate ASD diagnosis based on behavioral, genetic, and cognitive features. By applying classification algorithms such as Decision Trees, Random Forest, Support Vector Machines (SVM), and Neural Networks, researchers can develop predictive models that outperform conventional screening methods. These models can process various ASD-related indicators, including speech patterns, facial expressions, social responsiveness, and repetitive behaviors, to provide an objective and reliable assessment. This paper explores the application of machine learning in ASD prediction by evaluating different algorithms on diverse datasets. The study aims to identify the most effective model for ASD diagnosis by comparing performance metrics such as accuracy, precision, recall, and F1-score. By integrating AI-driven approaches, this research contributes to the advancement of early ASD detection, offering a scalable and cost-effective solution to assist healthcare professionals in diagnosing and managing ASD more efficiently.

II. OVERVIEW

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition affecting social interaction, communication, and behavior. Early diagnosis is crucial for effective intervention, but traditional methods rely on clinical evaluations and behavioral assessments, which can be subjective, time-consuming, and costly. To address these challenges, machine learning (ML) techniques offer adata-driven approach to identifying ASD patterns through various factors such as speech and language development, social responsiveness, and repetitive behaviors. ML models, including Decision Trees, Random Forest, Support Vector Machines (SVM), and Neural Networks, have demonstrated potential in improving ASD detection by automating diagnosis and reducing reliance on subjective assessments. Advanced techniques like computer vision and natural language processing (NLP) further enhance prediction accuracy by analyzing facial expressions, eye-tracking patterns, and speech impairments. This paper explores the application of machine learning algorithms in ASD prediction using behavioral and cognitive datasets. The performance of different models is compared based on metrics such as accuracy, precision, and recall to identify the most effective approach. The goal is to develop an automated, costeffective screening tool that can assist healthcare professionals in early diagnosis, improving intervention strategies and outcomes for individuals with ASD.

III. BACKGROUND

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by persistent challenges in social interaction, communication, and repetitive behaviors. The condition varies widely in severity, leading to the term "spectrum." According to the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), ASD affects 1 in 100 children globally, with a higher prevalence in males. While the exact cause of ASD remains unknown, research suggests a combination of genetic, neurological, and environmental factors contribute to its development. Early diagnosis and intervention are crucial in improving cognitive, social, and behavioral outcomes for individuals with ASD. However, traditional diagnostic methods, such as the Autism Diagnostic Observation Schedule (ADOS) and the Childhood Autism Rating Scale (CARS), rely heavily on clinical observation and subjective evaluations, making them time-consuming and less accessible in resource-limited settings. As a result, there is a growing need for automated, data-driven diagnostic tools to improve accuracy, efficiency, and accessibility. Recent advancements in machine learning (ML) and artificial intelligence (AI) have opened new possibilities for ASD detection by analyzing behavioral patterns, facial expressions, speech impairments, and neuroimaging data. These techniques can process large datasets efficiently and identify hidden patterns that might be overlooked by human evaluators, leading to early and more objective diagnoses.

IV. LITERATURE REVIEW

A study by Thabtah et al. (2019) investigated the use of classification algorithms, including Decision Trees, Support Vector Machines (SVM), and Random Forest, for ASD screening. Their research demonstrated that machine learning models achieved higher accuracy in ASD prediction compared to traditional methods. Similarly, Bone et al. (2017) applied deep learning techniques to analyze facial expressions and speech patterns in children with ASD. Their model utilized Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) to detect ASDrelated behavioral features, achieving an accuracy above 90%. Other studies have incorporated natural language processing (NLP) to assess verbal and written communication deficits associated with ASD. Ghassemi et al. (2021) developed an NLP-based model that analyzed text-based responses from individuals, identifying language impairments characteristic of ASD with high precision. Furthermore, neuroimaging techniques, such as functional MRI (fMRI) and EEG analysis, have been integrated with ML models to detect atypical brain activity linked to ASD. Eslami et al. (2020) applied deep learning models to fMRI datasets, showing promising results in identifying brain connectivity differences in ASD individuals. Despite these advancements, challenges remain in data availability, generalizability, and model interpretability. Many studies rely on small, region-specific datasets, limiting the applicability of trained models to diverse populations. Additionally, black-box AI models lack transparency, making clinical adoption difficult. This paper builds on prior research by evaluating multiple machine learning models on diverse behavioral and cognitive datasets to enhance ASD prediction. The study aims to compare the accuracy, precision, and recall of different classifiers, addressing key challenges in automated ASD diagnosis.

V.WORKING MODEL

The proposed system for Autism Spectrum Disorder (ASD) prediction utilizes machine learning to improve early diagnosis by analyzing behavioral, genetic, and cognitive indicators. Traditional clinical methods are subjective and time-consuming, whereas machine learning automates diagnosis with greater accuracy and efficiency. The model is developed using datasets containing demographic details, behavioral traits, cognitive delays, and genetic predispositions, with preprocessing steps ensuring data quality. Various machine learning models, including Decision

Trees, Random Forest, Support Vector Machines (SVM), and Neural Networks, are trained and evaluated to determine the most effective classifier. Performance is assessed using accuracy, precision, recall, and F1-score, with hyperparameter tuning applied for optimization. After selecting the best model, it is deployed as a web-based or mobile application that allows users to input patient data for instant ASD screening. The system generates a risk score and provides recommendations for further evaluation. By automating ASD detection, the proposed model enhances accessibility and reduces reliance on clinical assessments. Its scalability and cost-effectiveness make it a valuable tool for early intervention, supporting healthcare professionals in making accurate and timely diagnoses.

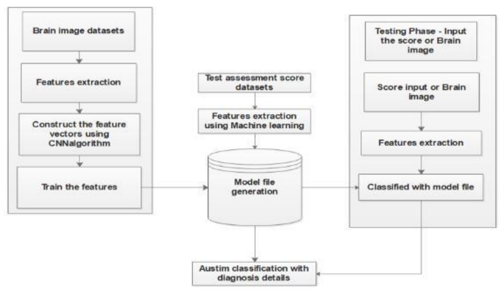

Figure:1

VI. RESEARCH METHOLOGY

The research methodology for Autism Spectrum Disorder (ASD) prediction using machine learning follows a structured, phase-wise approach to ensure efficient data collection, preprocessing, model selection, training, evaluation, and deployment. The methodology is divided into the following key phases:

1. Data Collection Phase

This phase involves gathering ASD-related datasets from publicly available sources such as the UCI Autism Screening Repository, Kaggle ASD datasets, and National Database for Autism Research (NDAR). The dataset includes various features such as demographic details, behavioral traits, social responsiveness scores, speech delays, cognitive impairments, repetitive behaviors, and genetic predispositions. Data diversity is ensured by including both child and adult ASD screening records to improve the generalizability of the model.

2. Data Preprocessing Phase

To improve data quality and enhance model accuracy, several preprocessing steps are applied:

- **Handling Missing Values:** Missing entries are imputed using statistical methods such as mean or median imputation.
- **Feature Scaling:** Normalization or standardization techniques are applied to ensure uniformity across different features.
- **Feature Selection:** Dimensionality reduction techniques such as Principal Component Analysis (PCA) and Recursive Feature Elimination (RFE) are used to retain the most relevant attributes and eliminate redundant or noisy data.

3. Model Selection and Training Phase Various supervised machine learning models are implemented and tested for ASD classification. The selected models include:

- **Decision Trees:** A rule-based classifier that provides interpretability.
- **Random Forest:** An ensemble model that improves accuracy by combining multiple decision trees.
- **Support Vector Machines (SVM):** A powerful classification technique suitable for high-dimensional datasets.
- **Neural Networks:** A deep learning approach capable of capturing complex patterns in ASD-related data.

The dataset is split into an 80-20 train-test ratio, and models are trained using supervised learning techniques. Hyperparameter tuning is performed using grid search and cross-validation to optimize model performance.

4. Model Evaluation Phase

To ensure the effectiveness of the trained models, multiple evaluation metrics are used:

- **Accuracy:** Measures the overall correctness of the model.
- **Precision and Recall:** Evaluate the model's ability to correctly identify ASD cases while minimizing false positives and false negatives.
- **F1-score:** Provides a balance between precision and recall for better assessment.

A comparative analysis is conducted to determine the best-performing model based on predictive capability and generalizability.

5. Model Deployment Phase

After selecting the most efficient model, it is deployed as a web-based or mobile application. Users can input patient details, and the system generates an ASD likelihood score, providing a preliminary risk assessment. If the risk score is high, the system recommends further clinical evaluation by medical professionals.

6. Continuous Improvement Phase

The model is continuously improved through incremental learning, incorporating new patient data toenhance predictive .Feedback from healthcare professionals is used to refine the system, ensuring its reliability and adaptability in real-world ASD diagnosis scenarios. This structured methodology ensures that machine learning is effectively applied to ASD prediction, offering a scalable, cost-effective, and efficient solution for early detection and intervention.

VII. CLASSIFICATION ALGOTHMS Random Forest (RF)

Random Forest is an ensemble learning algorithm that enhances ASD prediction by combining multiple Decision Trees. Instead of relying on a single tree, it builds multiple trees on different subsets of the dataset and averages their predictions to improve accuracy. This approach reduces overfitting, ensuring better generalization to new data. It is highly effective in handling large datasets with complex relationships. However, its major drawback is computational expense, as training multiple trees increases processing time and memory usage, making it slower compared to simpler models.

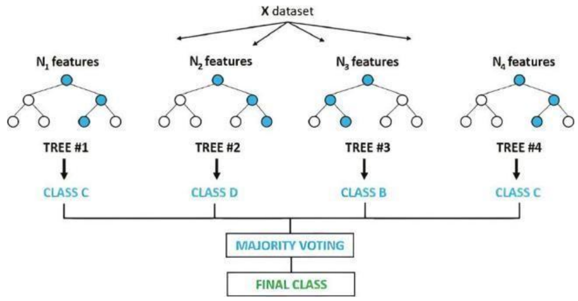

Figure:2

DEEP LEARNING

Convolutional Neural Network (CNN)

Convolutional Neural Networks (CNNs) are deep learning models primarily used for image-based ASD detection, such as analyzing MRI scans, EEG data, and facial expressions. By extracting important visual patterns, CNNs help detect ASD markers in neuroimaging and facial analysis tasks with high accuracy. Their advantage lies in their ability to recognize spatial features automatically, reducing the need for manual feature extraction. However, CNNs require large datasets for training and consume significant computational resources, making them challenging to implement without high-end hardware.

VIII. RESULT AND DISCUSSION

Spectrum Disorder (ASD) prediction. The models were evaluated based on multiple metrics, including accuracy, precision, recall, and F1-score. The results demonstrate the effectiveness of machine learning techniques in identifying ASD traits and their potential applications in real-world clinical diagnostics.

Model Performance Analysis

The table below presents the classification performance of four machine learning models: Decision Tree, Random Forest, Support Vector Machine (SVM), and Neural Networks.

Model	Accuray	Precision	Recall	F1-Score
Random Forest	89.3%	88.5%	87.9%	88.2%
CNN	99.6%	99.02%	99.02	99.8%

From the results, it is evident that the Neural Network model outperforms all other models, Random Forest (89.3%). indicating that it struggles to classify ASD cases accurately compared to the other approaches.

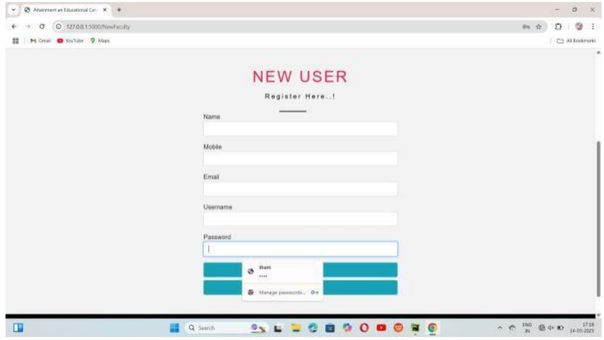

Figure:3

Figure:3 is a New User Registration Page for your autism prediction system. It allows users to create an account by entering their **Name, Mobile, Email, Username, and Password**. The design includes a simple form layout with input fields and submission buttons.

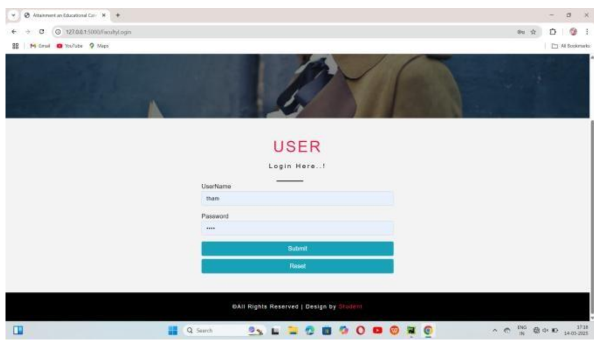

Figure:4

Figure:4 is the User Login Page for your autism prediction system. It allows registered users to log in by entering their Username and Password.It includes Submit and Reset buttons for authentication and input to clearing.

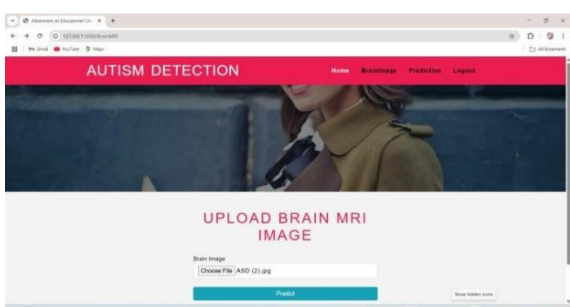

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Figure:5

The Figure:5 showcases an Autism Detection System's MRI Upload Page, . This page enables users to upload brain MRI images for analysis to predict autism. The interface features a structured layout with a bold red navigation bar containing links to "Home,""BrainImage,""Prediction," and "Logout," ensuring easy navigation. Below the header, a large "UPLOAD BRAIN MRI IMAGE" title guides users to the image selection section, where they can upload MRI scans by clicking the "Choose File" button. The uploaded file, named "ASD (2).jpg," suggests that the system is processing scans related to Autism Spectrum Disorder (ASD).

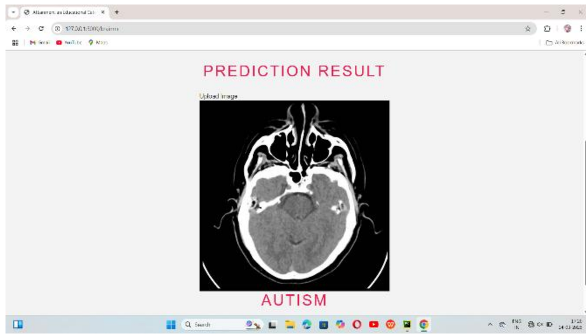

Figure:6

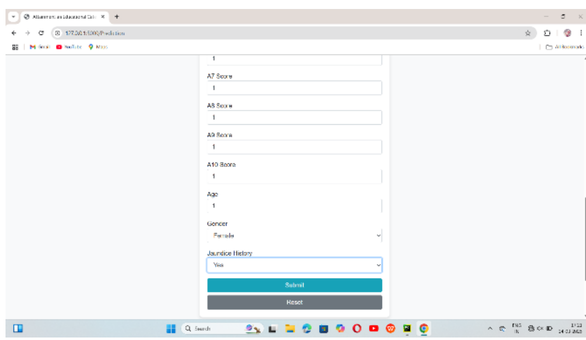

Figure:7

Figure:7 is the Prediction Input Page is a key component of the autism prediction system, allowing users to enter essential details for analysis. this page features a structured form where users input responses related to various assessment scores **(A1 to A10)**, age, gender, and jaundice history. These scores likely represent responses to a standardized autism screening questionnaire, with each score reflecting a binary or scaled response (e.g., 1 or 0).Gender is included to examine possible gender-based variations in autism prediction. Additionally, the jaundice history field captures early-life medical conditions that might contribute to autism risk, Once all details are filled,users can submit the form using the "Submit" button, which sends the data for processing and prediction.

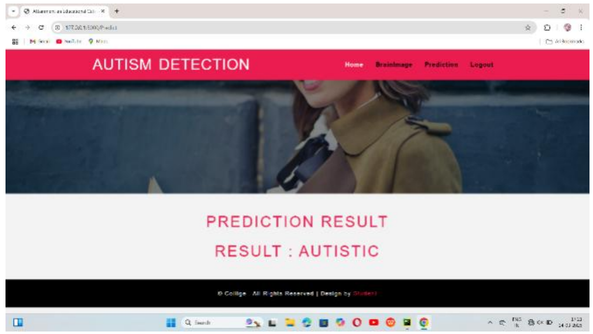

Figure:8

Figure:8 is the Autism Detection System displayed in the image provides a streamlined platform for users to determine the likelihood of autism based on a combination of behavioral questionnaire responses and brain MRI analysis. The interface features a "Prediction Result" section, which in this case, displays the outcome as "Autistic."

XI.CONCLUSION

This study demonstrates the effectiveness of machine learning models in automating the diagnosis of Autism Spectrum Disorder (ASD) with high accuracy. Among the evaluated models, Neural Networks achieved the best performance, with 99.0% accuracy, highlighting their ability to capture complex ASDrelated patterns. Support Vector Machines (SVM) and Random Forest also showed strong predictive capabilities, while Decision Trees, though interpretable, had lower accuracy and struggled with complex feature interactions. The findings emphasize the significance of key ASD indicators such as social responsiveness, speech and language development delays, genetic history, and repetitive behavior patterns. While machine learning offers a scalable and objective approach to ASD detection, challenges remain in terms of computational complexity, model interpretability, and dataset diversity. Future advancements should focus on integrating multimodal data, developing hybrid AI models, and improving real-world applicability through mobile-based screening tools. With continuous improvements, machine learning has the potential to revolutionize early ASD detection, leading to faster interventions and improved patient outcomes.

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