A Literature Review On Autism Spectrum Disorder (Asd) Detecton Using Machine Learning

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***Abstract*—** Autism Spectrum Disorder (ASD) is a developmental disorder that influences a person's communication, behavior, and social interaction. Some of the common symptoms are problems with eye contact, delayed language development, restricted use of gestures, and difficulties with playing or engaging in common social interactions. ASD children could have problems with understanding social cues or sustaining a conversation. These communication challenges are usually evident during early childhood and vary in intensity, ranging from mild to extreme. While some children might say very little or nothing at all, others might say words in unique ways, for instance**,** by repeating words or talking in a flat tone.

In addition to the problems of communication, kids with ASD tend to exhibit stereotypical behaviors and limited interests. This can range from hand-flapping, routine repetitions, having an unusual attachment to specific items, or showing intense interest in specific topics. Others also show peculiar response to senses, such as over responding to sound, lights or texture. Since these symptoms begin to appear at a very tender age making them mild to severe, early detection is desirable. Early detection treatment via speech therapy, behavioral support, and educational interventions can markedly enhance the development and well-being of a child.

Keywords— Autism Spectrum Disorder (ASD); Machine Learning (ML); Early and automated Diagnosis; Predictive Modeling; Behavioral Analysis; Support Vector Machine (SVM); Decision Tree; Random Forest; Deep Learning.

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder of complex nature that affects the communication, social interactions, and ability to adapt to variation in daily routines of an individual. The prevalence of ASD globally has increased manifold over the past decades and is now estimated to occur at a rate of approximately 1 in 100 children, varying regionally and population-wise. The issue of early and proper diagnosis of ASD is critical in order to implement early treatment that stands high chances of promoting the cognitive, behavioral, and social performance of the individuals affected by the condition.

Despite the importance of early detection, current diagnostic approaches for ASD—such as behavioral rating, parent report, and clinician judgment—are typically time-consuming, subjective, and require highly trained professionals. These constraints present substantial challenges, especially in low- resource or rural settings where the location of special services is limited. Moreover, process can take several months to years, leading to delays in receiving therapeutic treatments.

Given these challenges, the diagnosis based on a ML method of the approach can become a good solution. ML models can implicitly discover patterns in unstructured data that would be difficult to to identify otherwise and use them to derive predictions based on features presented as inputs. In the proposed project, we would propose to create an ASD early diagnosis machine learning-based system with a variety of input variables that would include behavioral indicators, demographic variables, and psychological assessment.

Certain ML models, such as Decision Trees, Support Vector Machines (SVM), Random Forests, and Deep Learning models, will be tested and trained on public ASD data sets. The goal will be identifying the most predictive performance accurate model(s), sensitivity, specificity and computational complexity.

Finally, the system to be proposed should be an assisting diagnostic tool that contributes to clinical decision support, hastens the diagnostic process, and ensures wider access to early screening, especially in remote areas.

II. COMMON SIGNS AND SYMPTOMS

Autism Spectrum Disorder (ASD) is one of the development disorders that affect how persons communicate, interact with others and the world around them. Though both persons with ASD are atypical, the commonalities which are present are:

A. Social Communication Challenges

- Trouble keeping eye contact or using facial expressions
- Development of slow speech or little gesturing
- Difficulty with common back and forth conversations/play
- Unnatural speech rhythm, e.g. repeating words or speaking in a monotonous, robotic style.
- Difficulty comprehending social cues, sarcasm, or nonverbal communication

B. Repetitive Behaviors & Unique Sensory

- Repetition movements for example hand-flapping, rocking and spinning.
- Strong attachment to routines—changes can be very distressing
- Intense, highly focused interests in specific topics.
- Atypical sensory sensitivities (e.g., dislike of loud sounds or particular textures, or bright light)

Since signs of ASD often appear in early childhood, timely identification opens doors to targeted support—like speech therapy, social skills training, and personalized education plans. Early intervention can make a profound difference, helping children build communication skills, adapt to sensory needs, and thrive in their daily lives.

While ASD presents challenges, it also brings unique strengths. Many individuals with autism have remarkable attention to detail, deep knowledge in areas of passion, and honest, straightforward perspectives. With understanding and the right support, people with ASD can lead fulfilling, meaningful lives.

ASD is a *spectrum*, meaning no two people experience it the same way. Some may need significant support, while others may develop coping strategies that make their differences less noticeable. The key is recognizing individual needs and strengths.

III. EXISTING SYSTEM

Conventional ASD detection by machine learning methods has focused mainly on structured data from clinical assessment tests, behaviour questionnaires and demographic data. These methods often employ a supervised algorithm to classify between ASD and non-ASD groups based on a labelled sample. Standard examples for these are the Autistic Diagnostic Observation Schedule (ADOS) and the Social Responsiveness Scale (SRS) which provide quantifiable behavioral indicators.

Machine learning and artificial intelligence algorithms such as SVM, decision trees, random forests, naïve Bayes, k-NN, and logistic regression have been most commonly used. Therefore, the models presented here are chosen due to their robustness for handling small, structured data, and due to them being interpretable in the clinical context. Feature selection is vital, involving frequently behavioral characteristics, response styles, and so developmental history.

Moreover, classical machine learning has allowed researchers to find systematic patterns in patterns of behavior that might not be immediately visible by hand. These models enable prompt screening by revealing subtle signs of ASD, as it is often the case in primary care or educational practice where restricted diagnostic tools are available. In addition, low computational cost of these guys allows them to be utilized in resource-constrained areas.

These models are measured using quality controls such as accuracy, precision, recall and AUC (area under ROC curve). We apply cross-validation in order to enhance generalizability. However, there are limitations due to data scarcity, unbalanced classes, and heterogeneity of ASD problems. Nevertheless, classical machine learning methods have paved the way for advanced methods, such as deep learning and multimodal data fusion in the context of current ASD research team to take corrective measures.

IV. PROPOSED SYSTEM

Detecting autism spectrum disorder (ASD) early can make a huge difference—but it’s not always easy. That’s why we’ve developed a hybrid AI system that combines multiple data sources and advanced machine learning techniques for more accurate and reliable detection.

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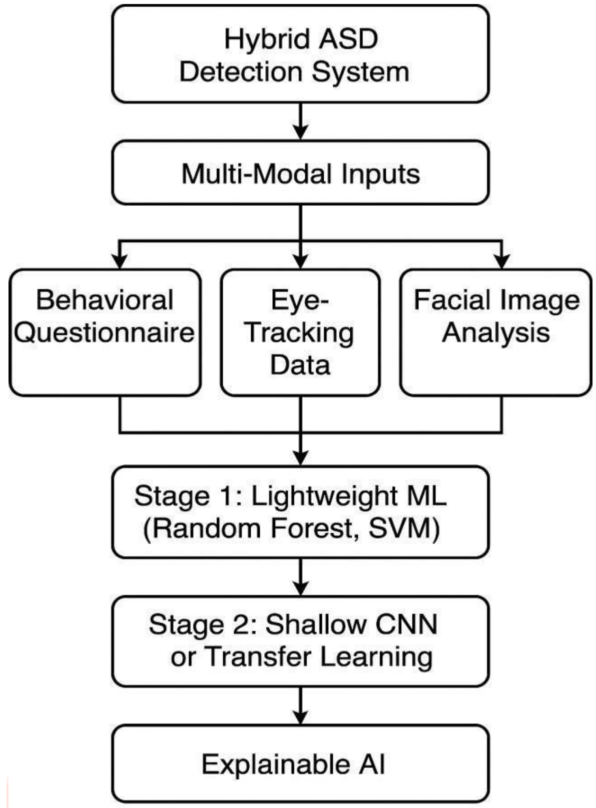

Figure 1: Proposed Multimodal ASD Detection Framework.

A. Gathering Different Types of Data

Instead of relying on just one method, our system analyzes multiple inputs to get a fuller picture:

- **Behavioral Questionnaires** – Parents, caregivers, or individuals fill out structured forms that track social interactions, reactions to stimuli, and other behavioral patterns.
- **Eye-Tracking Data** – By measuring where a person looks, how long they focus, and how their gaze shifts, we can spot potential ASD-related differences.
- **Facial Expression Analysis** – Using images or video, we examine subtle facial cues, micro-expressions, and emotional responses that might indicate ASD.

B. Stage 1: Fast & Efficient Machine Learning

First, we use lightweight machine learning models to process structured data (like questionnaires and eye-tracking numbers). These include:

- **Random Forest –** A powerful algorithm which utilises numerous decision trees to make an accurate classification..
- **Support Vector Machines (SVM)** – Fits well- handling of high dimensional and complex data.
- **Particle Swarm Optimization (PSO) –**It is a metaheuristic population optimisation algorithm that is based on bird and fish behaviours in the society where it involves particles that fly through the solution space to discover the best solution sharing the information regarding the best location as a fish**.**

These models are quick and efficient, making them ideal for initial screening.

C. Stage 2: Deep Learning for Complex Patterns

For image-based data (like facial expressions), we turn to deep learning:

- **Shallow CNN** – A streamlined version of a convolutional neural network (CNN) that detects visual patterns without heavy computation.
- **Transfer Learning** – We fine-tune pre-trained models (like VGG or ResNet) that already understand general facial features, adapting them specifically for ASD detection.

This step helps catch subtle, hard-to-spot behaviors that simpler models might miss.

D. Explainable AI: Clear & Trustworthy Results

AI shouldn't be a "black box"—especially in healthcare. That's why we use Explainable AI (XAI) to:

- Show why the system made a particular diagnosis.
- Highlight which factors (e.g., eye movement, facial expressions, or questionnaire answers) had the biggest impact.

This transparency helps doctors and families trust and understand the results, making AI a true partner in early ASD detection.

With the combination of various sources of data, powerful machine learning and deep learning, we develop a system which is accurate, flexible, and reliable, compared to single-mode methods. Not to mention that under transparent descriptions of each of the decisions, physicians and families will be able to make more informed decisions-leading to earlier interventions and better outcomes.

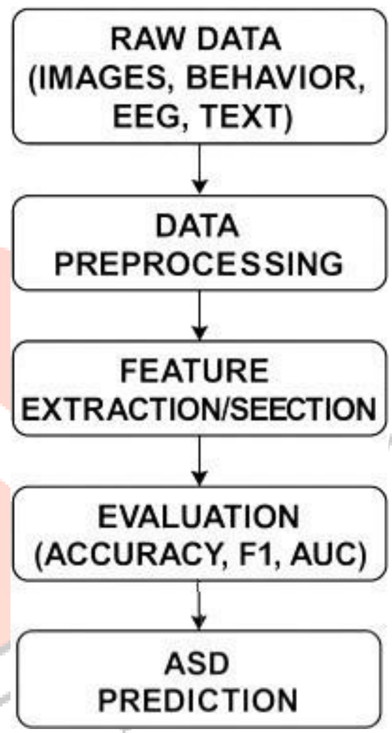

Figure 2: Machine Learning Pipeline for ASD Detection.

V. CONCLUSION

The research highlights the efficiency of the use of machine learning methods in identifying Autism Spectrum Disorder (ASD), a discovery offering great hope of early detection and treatment.. Random Forests, Neural Networks models, and Support Vector Machines were also observed to be very accurate with the use of screening and behavioral data. These observations usher in growing potential for AI-based tools to aid doctors with more effective decisions.

Notably, such success also indicates the worth of embedding AI in clinical workflows to provide quicker and more precise detection. As these technologies continue to develop, the position of explainable and trustworthy AI systems will grow exponentially more important in establishing trust between healthcare providers and patients alike. Ultimately, such developments seek to enhance the early identification of ASD with increased prospects for improved outcomes for individuals and families touched by the condition.

VI. FUTURE WORK

Future research must target some important areas to make successful the transition of AI-driven tools to actual clinical environments:

A. Utilization of Multimodal Data:

Next-generation models should make use of heterogeneous data types including facial expressions, speech properties, and neuroimages to enhance further prediction performance. Multimodal fusion of the data is what could be used to allow a more accurate interpretation of ASD description and better model performance on detection.

B. Expansion of Datasets:

To reinforce model robustness and generalizability, it is essential to widen datasets across different populations, particularly under-represented groups. This will minimize potential biases and ensure the models are applicable to diverse real-world settings.

C. Model Interpretability and Transparency:

Work needs to go towards making machine learning models more transparent and interpretable. This is essential in achieving trust in clinical settings, where doctors need to know how a model reaches a conclusion.

D. Accessible Diagnostic Tools:

Creating accessible diagnostic tools that operate online or on mobile phones can greatly improve early and easy access to screening services, particularly in remote or underserved communities.

E. Clinical Collaboration and Iterative Testing:

Strong clinician and healthcare provider partnerships are needed for effective implementation of AI systems. Continuous, real-world testing and feedback will be essential to optimize these tools and establish their real-world effectiveness.

VII. RELATED WORKS

Here, we analyze and discuss several machine learning (ML) and deep learning (DL) methods applied in recent studies for the detection and evaluation of Autism Spectrum Disorder (ASD). The literature reviewed encompasses various data types, modeling methods, and evaluation approaches aimed at improved diagnosis accuracy and consistency.

Most of the research employed supervised learning methods. Hybrid models, for example, RF-SVM, were applied to preprocessed autism screening data with chosen features, and performance was verified through methods such as 10-fold cross- validation. SVMs were often employed as baseline classifiers and at times in conjunction with eye- tracking programs like Viola-Jones, showcasing decent accuracy upon application to visual behavior data.

Deep learning methodologies dominated, particularly within investigations utilizing neuroimaging data (e.g., fMRI, sMRI, EEG, PET) or facial image datasets. Models based on CNNs, such as architectures ResNet and Xception, were used to perform feature extraction and classification, with high accuracy being obtained. Ensemble models sometimes integrated CNNs with standard classifiers like Random Forest and logistic regression, or utilized transfer learning with pretrained models like EfficientNet and MobileNet, enhancing generalization across datasets.

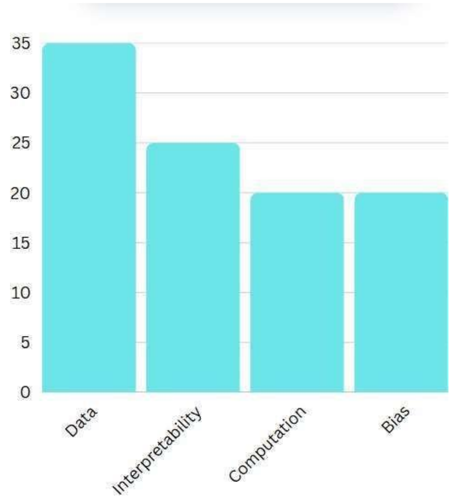

Figure 3: ASD Research Challenges Distribution.

In systematic studies on well-organized datasets such as Autism Quotient (AQ) scores and demographic profiles, conventional ML models—logistic regression, Naive Bayes, decision trees, and K- nearest neighbors (k-NN)—were compared. Interventions in preprocessing were most commonly missing value imputation, feature encoding, scaling, and feature selection. A few of them utilized ensemble learning strategies, where ensembles of multiple classifiers were combined by soft voting methods, which consistently performed better for prediction.

Other approaches focused on EEG signal processing, behavioral and genetic feature mapping, as well as semantic data profiling. Such types of methods had involved intricate use of feature engineering and data augmentation to enhance learning and the adaptability of the models.

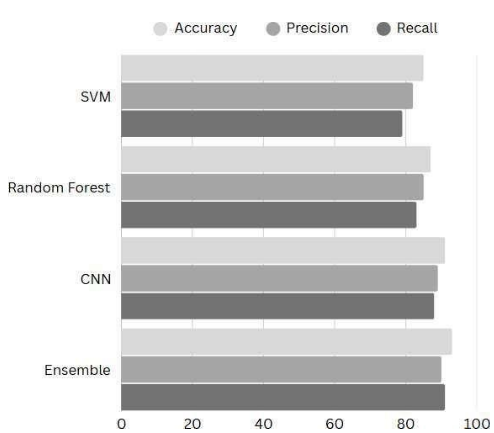

Figure 4: Performance Comparison of ASD Detection Models.

Broadly, the surveyed methodologies reflect increased usage of multimodal data integration, use of ensemble and hybrid methods, and deep architectures. Even with considerable advances, issues like interpretability of models, computation expense, and availability of high-quality, diverse datasets are still open research directions.

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