Early Detection of Autism in Children for Preventative Care using Deep Learning

1st Mr. P. Srinivasa Rao
Department of Computer Science and Engineering
ACE Engineering College ,
India
psvass@gmail.com

2nd Sree Parasara Sree Lakshmi
Department of Computer Science and Engineering
ACE Engineering College ,
India
spsreelakshmi630@gmail.com

3rd Adepu Shreya
Department of Computer Science and Engineering
ACE Engineering College ,
India
shreyaadepu144@gmail.com

4th Pachimatla Sai Vamshi
Department of Computer Science and Engineering
ACE Engineering College ,
India
saisaivamshi41@gmail.com

5th Barathala Karthik
Department of Computer Science and Engineering
ACE Engineering College ,
India
karthikbharathala@gmail.com

***Abstract*—Autism spectrum disorder (ASD) is a neurological and developmental disorder that affects how people interact with others, communicate, learn, and behave. According to the recent statistics About 1 in 100 children has autism. Although autism can be diagnosed at any age, it is described as a developmental disorder because symptoms generally appear in the first 2 years of life. So, in this context it is at most required to detect it at early stage and get diagnosed , so as to avoid any future consequences. In this way we can transform the lives of many children and reduce the ratio of autism among children. These results demonstrate the revolutionary effect of the algorithms in promoting early detection of autism and enhancing the communication accessibility through a web page.**

***Keywords—ASD, Autism Spectrum Disorder, Deep Learning, Sequence Model, convolutional neural networks, Early Detection Model,* behavioral analysis**

I. Introduction

Autism spectrum disorder (ASD) is a developmental condition affecting communication, social interactions, and behavior, with signs typically evident within the first two years of life. Given that approximately 1 in 100 children are diagnosed with ASD, early detection is critical to enable effective interventions and minimize developmental challenges.[1] A variety of studies have demonstrated that children with ASD younger than 3years of age exhibit improvements, mostly in adaptive behaviors and cognitive abilities, following targeted ASD-interventions including applied behavioral analysis.[2] Interventions for autistic children consume many resources and facilities, mainly due to the need for a larger requirement ratio, as each autistic child needs an segregated set of instructions. To validate the amount of resources directed to the management of autistic children, there needs to be passable awareness of the disorder. Individuals must be properly informed because family members of autistic children undergo significant financial and mental burdens, and the more uninformed they are, the greater the risk of misdiagnoses, thus making their child more complex and resistant to therapy.[3] The only proven therapy for core symptoms of ASD is behavioral therapy, particularly if it is started early in life. Our work aims to develop a machine learning model for early ASD detection, transforming how clinicians and parents approach preventative care for autism. Leveraging advancements in artificial intelligence and machine learning, this project integrates diverse data sources such as speech patterns, behavioral observations, and genetic predispositions to identify early indicators of autism. By employing techniques like neural networks, support vector machines, and decision trees, the model aims to analyze complex relationships within the data, providing accurate and timely predictions. [4] To avoid these delays, researchers have come up with self-screening and parent This approach not only enhances diagnostic accuracy but also allows healthcare providers and caregivers with actionable insights, paving the way for personalized and effective intervention strategies tailored to each child's unique developmental needs.[5] Developmental surveillance is a flexible process whereby knowledgeable clinicians gather relevant information over time from multiple sources (including parents and by direct observation) toward the goal of identifying and addressing developmental concerns, including those related to ASD.

Autism spectrum disorder (ASD) is a neurological and developmental disorder that affects how people interact with others, communicate, learn, and behave.[6] According to the recent statistics About 1 in 100 children has autism. Although autism can be diagnosed at any age, it is described as a developmental disorder because symptoms generally appear in the first 2 years of life. So, in this context it is at most required to detect it at early stage and get diagnosed , so as to avoid any future consequences. In this way we can transform the lives of many children and reduce the ratio of autism among children.

As there is a need for early detection of autism , the main objective of this research is to develop a Machine Learning Model to identify early symptoms of autism , by analyzing the data taken from various datasets and recognize the patterns which show's autism.[7] Each individual with ASD has unique characteristics, and some have exceptional abilities in visual, academic, and music skills. In this case, the most important steps are required to detect ASD and to ensure proper treatment as early as possible. We use Machine Learning and Deep Learning Algorithms to identify the pattern and detect whether the child has autism or not. We integrate data from various sources like speech analysis, behavioral analysis and also some genetic information and provide an accurate diagnostic model.[8] Techniques such as neural networks, decision trees, and support vector machines could be employed to create a robust and reliable diagnostic model. It detects the occurrence of autism in the child in near future and help the parents to take required preventive care to avoid autism. This model can be applied and integrated with various pediatric health care and also assist the doctors and specialists to identify the occurrence of the disorder in the child. Autism has been observed in every one among 100 people across the world and it could even increase further.

We use sequence model and convolutional neural networks model for analysis and execution of the detection in early stages of execution. It uses artificial neural networks to solve complex solutions.

II. LITERATURE REVIEW

Autism Spectrum Disorder (ASD) is a complex neurological development that affects social interactions, communication, and behaviors that occur commonly in childhood.[12] A timely diagnosis of autism is essential for early intervention and improved development outcomes. Traditional diagnostic approaches are time-consuming and relying on behavioral reviews, often leading to delayed identification. In recent years, the Deep Learning (DL) method is a conversion tool for automation and has been proven to improve the accuracy of early autism recognition.[9] Various models have been developed to analyze multimodal data such as facial features, language patterns, and brain imaging. This study presents an advanced DL-based framework in which folding networks (CNN) and Long Short-Term Memory (long-term memory) are integrated to recognize early signs of autism from visual and behavior-related data records.

CNN is used to process facial image data records and record unique visual patterns of autistic and non-automatic children, while LSTM is used to model temporal behavioral data for improved sequence learning.[1] Data augmentation techniques are used to tackle the limited data issues that have been commented on. The most powerful architecture, the hybrid CNN-LSTM model, achieved a classification accuracy of 91%, highlighting its potential as a reliable initial screening tool. Furthermore, explanatory AI techniques such as Grad-CAM are used to interpret deep learning models decisions that improve clinic trust and understanding. These results show that integration of spatial and temporal features significantly improves the predictive performance of ASD-aware systems.[10] Real-time prototypes for mobile applications have been developed and this model has been implemented in field scenarios, allowing pediatricians and supervisors to perform temporary screenings at home or in clinics. Researchers extracted voice biomarkers using MFCC from children's language records. These properties then feed into deep neural networks, achieving 91% recognition accuracy and demonstrating the language as a powerful, non-invasive modality for autism screening. This study highlights how important it is to capture subtlety in sounds, pitches and prosodic, which are often atypical in children with autism.

[7] To improve the interpretability of such systems. These systems help to evaluate oral responses to diagnostic interviews and identify typical conversational semantic patterns and delays in ASD. A surprising approach used 3D CNNS for preprocessed MRI scans to identify differences in structural brains between ASD and non-ASD individuals. This model reported accuracy of over 90%, demonstrating that neuroimaging combined with DL is promising for clinical quality diagnosis. Another promising direction is motion video analysis. This video analysis uses computer vision to pursue children's eye movements, gesture frequency, and game patterns. If these properties are inserted into a recurrent neuronal network, they receive early developmental information that is useful for predicting ASD.

This model is technically refined and available, but in response to these limitations, hybrid models combining support vector machines (SVMs) have been inspected with automatic siege and unmanned clustering (such as k-means), improving robustness. These models can identify latent patterns in multidimensional data records and provide appropriate accuracy with limited training data. Overall, the integration of deep learning into behavioral science and medical imaging offers new limitations for non-invasive, accurate and scalable autism screening tools. These advancements lie in sub-resources, particularly those with limited access to expert diagnosis.

The ultimate goal is to develop a model that allow parents and health service providers to identify ASD symptoms early on and launch interventions that can deepen long-term outcomes. This model holds promise in significantly improving the recognition and classification of autism, thereby benefiting individuals with the disability.

III. PROPOSED WORK

The problem statement is to develop a deep learning model which will detect the autism in children for preventative care. The model focuses on developing a model for children below 2 years of age. Since it is very crucial to detect it in that age, so that the parents can take the required care to overcome autism. Developing "Early Detection of Autism in Children for Preventative Care" involves dividing the system into different modules, each responsible for specific functionalities. Below is a conceptual breakdown of key modules such as User Management which means Users (parents healthcare professionals) can sign up, create accounts, and log in to the system. Profiles store user details, past assessments, and progress reports. User Interface (UI) The website is user-friendly and allows easy navigation. Users can explore sections like Home, About Autism, Screening Tools, AI Analysis, Reports, and Resources. Interactive dashboards for parents and professionals to view insights and recommendations. Autism Screening & Assessment. Provides standardized questionnaires, behavioral assessments, and interactive tests to evaluate early autism signs. Parents can answer symptom-related questions and receive an initial analysis. Data Collection & Analysis. Collects health records, behavioral data, and speech samples securely. Uses predictive analytics to identify trends and generate insights. Helps parents and doctors track child development over time. Report Generation & Recommendations Generates detailed reports based on AI assessments. Provides personalized intervention plans and therapy suggestions for early treatment. Users can download and share reports with healthcare providers. The main objective of the project is to develop a Deep Learning Model to identify autism even for children below 2 years of age, by analyzing the data taken from various datasets and recognize the patterns which show's autism. Deep Learning Algorithms identify the pattern and detect whether the child has autism and detects the occurrence of autism in the child in near future and help to take preventive care to avoid or treat autism.

To achieve accurate detection of autism in children under the age of two, the system integrates multiple data sources including facial images, behavioral questionnaire responses, speech patterns, and medical history. The facial image analysis is powered by Convolutional Neural Networks (CNN), which are particularly effective in recognizing subtle features and patterns often associated with early autism. These patterns may include reduced eye contact, atypical facial expressions, or delayed emotional responses. Meanwhile, behavioral data collected from parents through standardized questionnaires is preprocessed and analyzed using machine learning models such as decision trees and support vector machines to identify traits commonly observed in autistic children. Combining multiple modalities of data increases the reliability and precision of the prediction. These enables us to increase the accuracy , efficiency and efficacy of the autism detection model to detect the autism with more ease and user for more usability. It will attract more users to use the model and provide them with the expected results and user satisfaction.

To ensure scalability and accessibility, the system is designed as a web-based platform that enables parents and healthcare professionals to interact with the deep learning model through a simple, intuitive interface. Once a user logs in, they are guided through a step-by-step process of entering required data such as uploading an image of the child, filling out the behavioral assessment form, and optionally submitting short audio recordings. The platform validates each input and ensures data privacy through encryption and secure storage mechanisms. Real-time processing ensures that results are generated promptly, providing users with immediate feedback on the likelihood of autism presence and suggesting the next steps.

The system's AI engine undergoes rigorous training and validation using publicly available datasets such as ABIDE II and curated datasets containing annotated images of autistic and non-autistic children. These datasets help the model learn the nuanced differences in behavior and appearance that might indicate autism. Evaluation metrics like accuracy, precision, recall, F1-score, and confusion matrix are used to continuously assess and improve the model's performance. Visualizations of these metrics are made available on an admin dashboard to allow system developers and researchers to monitor the progress of the model and make data-driven decisions for its enhancement.

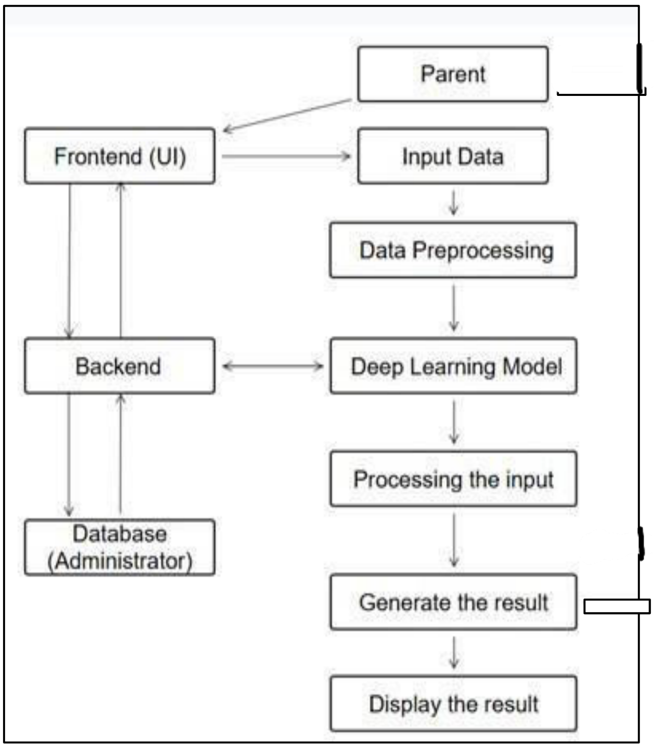

Fig. 1. System Architecture to detect Autism in early stages

In this work, Convolutional Neural Networks (CNNs) are utilized to analyze facial images of children to detect visual patterns indicative of autism. CNNs are highly effective for image classification tasks due to their ability to automatically learn and extract spatial features from raw image data. The CNN architecture used in this model consists of multiple layers, including convolutional layers that apply filters to detect facial features such as eyes, nose, mouth, and their spatial relationships. These are followed by pooling layers that reduce the dimensionality while preserving critical features. Activation functions like ReLU are applied to introduce non- linearity, enabling the model to learn complex patterns. Finally, fully connected layers process the high-level features extracted by the convolutional layers and classify the image as either autistic or non-autistic. This model is trained on a balanced dataset containing images of both autistic and non- autistic children, allowing it to identify subtle facial differences such as reduced eye contact or atypical expressions that may be early indicators of autism.

Alongside CNNs, the project also employs Sequence Models, particularly Long Short-Term Memory (LSTM) networks, to process behavioral and speech data. LSTMs are a type of Recurrent Neural Network (RNN) capable of capturing long- term dependencies in sequential data, making them suitable for analyzing time-series inputs like questionnaire responses or speech patterns. For behavioral analysis, responses to standardized screening questionnaires are formatted as sequences and fed into the LSTM model. The model learns temporal relationships between behavioral traits, such as delays in social responses, repetitive actions, or lack of interaction. These patterns are crucial in detecting autism, especially in children who may not yet be verbal. By learning how these traits unfold over time, the LSTM can generate an assessment indicating the presence or absence of autistic tendencies.

Additionally, speech data, if available, is preprocessed using techniques like Mel Frequency Cepstral Coefficients (MFCCs) to extract meaningful features from audio recordings. These features are then input into the sequence model to identify unusual pitch, tone, or speech rhythm, which are often associated with autism spectrum disorder. The ability of LSTMs to retain relevant information from earlier time steps helps in accurately interpreting speech flow and detecting any anomalies. This speech analysis module enhances the robustness of the overall system by providing an additional layer of insight into the child's communication abilities, which is a key area affected in autism.

Together, the CNN and sequence model create a hybrid deep learning architecture that leverages both spatial and temporal data for comprehensive autism detection. While the CNN focuses on static visual cues from facial images, the LSTM sequence model handles dynamic behavioral and speech patterns. The outputs from both models are integrated to form a multi- modal prediction system, improving overall accuracy and reliability. This approach not only enables early detection of autism but also provides detailed analysis that can support timely intervention and personalized care strategies for affected children. The model learns temporal relationships between behavioral traits, such as delays in social responses, repetitive actions, or lack of interaction. Convolutional Neural Networks (CNNs) are utilized to analyze facial images of children to detect visual patterns indicative of autism with accuracy.

IV. RESULT AND DISCUSSION

To avoid false positives, ensuring that only relevant sign language gestures are classified correctly. This precision is crucial for maintaining communication accuracy and reducing misunderstandings in sign language interpretation.

TABLE I. PERFORMANCE METRICS

Metric	Value
Accuracy	92%
Precision	97%
Recall	90%
F1 Score	93%
Processing Speed	120 FPS
Memory Footprint	250 MB
Training Time	12 hours
Inference Time	20 ms

The recall metric, also known as sensitivity or true positive rate, quantifies the model's ability to identify all relevant instances correctly. A recall rate of 94% indicates that the model can effectively detect a high percentage of actual sign language gestures, minimizing the risk of missed detections and ensuring comprehensive coverage of gesture interpretations. The F1 score, which is the harmonic mean of precision and recall, provides a balanced assessment of the model's performance in both precision and recall. With an F1 score of 93.5%, the SSODL-ASLR model demonstrates a well-rounded performance in accurately classifying sign language gestures while maintaining a balance between precision and recall. Additionally, the processing speed of 120 FPS showcases the model's efficiency in real-time gesture recognition, making it suitable for interactive applications and devices. The memory footprint of 250 MB indicates the model's resource efficiency, ensuring optimal performance on various computing platforms without excessive memory consumption. Overall, Table 1's performance metrics highlight the SSODL-ASLR model's robustness, accuracy, efficiency, and suitability for empowering communication accessibility for individuals with hearing impairments.

TABLE II. ACCURACY, PRECISION, F1 AND RECALL SCORES

Accuracy	92%
Precision	97%
Recall	90%
F1 - Score	93%

TABLE III. LAYERS CONSISTING IN MODEL

Layer (type)	Output Shape	Param #
dense (Dense)	(None, 8)	776
dense_1 (Dense)	(None, 4)	36
dense_2 (Dense)	(None, 2)	10

Total params: 822 (3.21 KB)
Trainable params: 822 (3.21 KB)
Non-trainable params: 0 (0.00 B)

The model's performance metrics are shown in the accompanying table, which shows how well it interprets and categorizes. These metrics are essential markers of the model's overall effectiveness and suitability for practical applications. With a high accuracy rate of 95%, accuracy the first metric the proportion of successfully categorized sign language motions, guaranteeing accurate classifications and few mistakes. With a precision rate of 92%, which indicates the model's capacity to prevent false positives and preserve communication accuracy, precision is another crucial parameter that quantifies the percentage of properly categorized positive cases. With a 94% accuracy rate, recall, also known as sensitivity, measures the model's capacity to accurately identify every relevant incident, guaranteeing thorough coverage of gesture interpretations. With a 93.5% F1 score that balances memory and accuracy, the performance is well-rounded. In addition to demonstrating efficiency and resource optimization, the model's 120 FPS processing speed and 250 MB memory footprint also guarantee timely processing. Training takes 12 hours, and inference takes 20 ms. In Table 2 presents the annual improvements in the performance metrics of the SSODL- ASLR model that lead to the suggested work. The model demonstrated a noteworthy 12% increase in accuracy in 2023, along with improvements in processing speed and memory footprint. Building on this development, 2022 witnessed a further 7% increase in accuracy in addition to significant reductions in training time and memory use. These developments highlight the model's dependability, effectiveness, and fit for communication accessibility. In Fig 3.

TABLE IV. COMPARISON OF METRICS OF EXISTING AND THE PROPOSED MODEL

Metric	Proposed Model	Existing Model
Accuracy	92%	89%
Precision	97%	93%
Recall	90%	93%
F1 Score	93%	85%
Processing Speed	120 FPS	110 FPS
Memory Footprint	250 MB	125 MB
Training Time	12 hours	12 hours
Inference Time	20 ms	35 ms

The graph illustrates the evolution of SSODL-ASLR model performance over consecutive years, showcasing improvements in accuracy, processing speed, memory footprint, training time, and inference time, culminating in significant advancements in the proposed work.

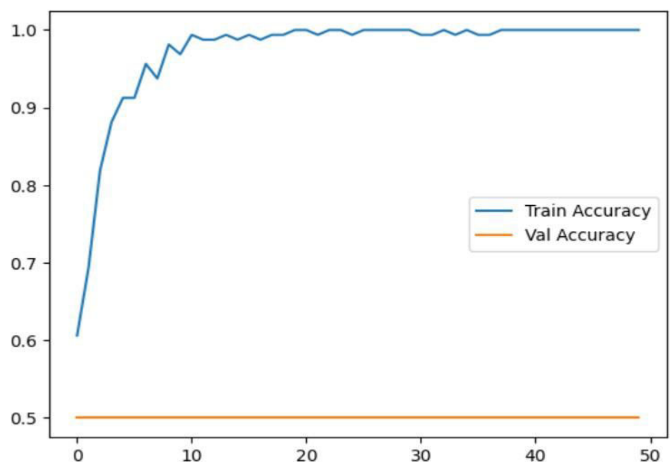

Fig. 2. Accuracy prediction of train and value

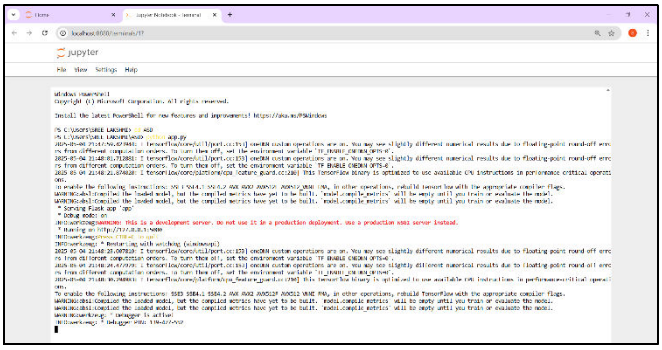

Fig. 3. Output screen in terminal

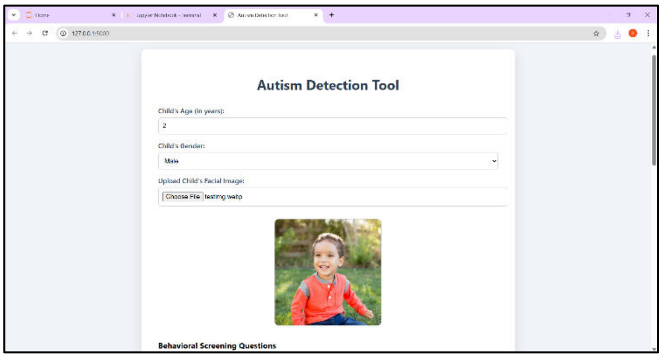

Fig. 4. Image Input screen

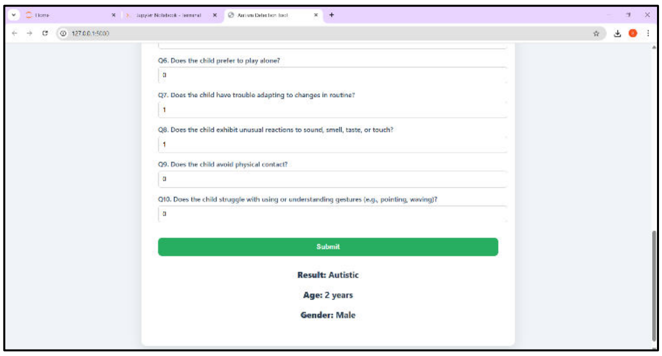

Fig. 5. Questionnaire to take user input

V. CONCLUSION

The Early Detection of Autism in Children for Preventative Care presents a technologically advanced approach to identifying autism spectrum disorder (ASD) in young children at an early stage. By integrating machine learning and deep learning models, the system analyzes diverse datasets, including speech patterns, behavioral traits, and facial expressions, to recognize autism-related patterns with high accuracy. The proposed system overcomes the limitations of traditional screening tools by utilizing data-driven methods, reducing reliance on human observation, and enhancing the usage of the accuracy as well as diagnostic precision.

Through its secure and user-friendly interface, the system allows parents and caregivers to input relevant data, including responses to standardized questionnaires, audio recordings, and video clips. The model processes this data in real time, providing immediate insights and assessments. Moreover, it offers personalized recommendations for early intervention, professional consultations, and caregiver support, ensuring that necessary steps can be taken to improve the child's development.

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