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A Survey on Exploring Early Signs of Autism and User Perspectives

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Abstract: Diagnosing Autism Spectrum Disorder (ASD) present challenges due to the absence of specific diagnostic tools fordefinitive identification. ASD is characterized by social communication challenges and restricted or repetitive behaviors, diagnosed based on observed behavior. This survey investigates the landscape of computational models for ASD detection, reviewing methodologies like Naïve Bayes, Support Vector Machine, Logistic Regression, KNN,Neural Network, and Convolutional Neural Network (CNN). The study extends its focus to include the development of an application to identify autism and support for parents. It addresses the increasing role of ML in medical research and aims to comprehensively explore the evolving landscape of ASD detection models. The paperdelves into the intricacies of ASD diagnosis, emphasizing the potential synergies between ML methods and creative applications that enhance recognition and parental involvement.

Keywords: Autism Spectrum Detection (ASD), Machine Learning, Diagnostic Challenges, ML-Based Diagnosis, Supportive App.

I. INTRODUCTION

The introduction establishes Autism Spectrum Disorder as a complex neurodevelopmental condition and emphasizes the critical need for early detection and intervention because of varied and intense symptoms across individuals. It critiques traditional diagnosis methods, primarily reliant on behavioral observation, advocating for objective tools. The exploration of computational models and multimodal data fusion is presented as a potential solution to address the complexity inherent in ASD diagnosis. This research builds upon existing knowledge, incorporating various ML models, ranging from Naïve Bayes to Convolutional Neural Networks (CNN), showcasing a comprehensive analytical approach. The practical dimension is introduced through the development of an application for early autism identification. This application not only serves as a diagnostic tool but also provides support for parents, emphasizing the importance of timely interventions.

The interventions carefully look at how different ways of adjusting features and picking relevant ones affect the performance of a machine learning model. The aim is to make the proposed diagnostic framework more accurate and reliable by paying attention to the details and methods used. The study recognizes age-specific variations in ASD presentation, evaluating datasets representing Toddlers, Children, Adolescents, and Adults, thus ensuring the framework's applicability across diverse populations The comprehensive framework, integrating advanced ML algorithms, multimodal data fusion, and feature optimization techniques, emerges as a promising avenue for achieving early and reliable ASD diagnosis. The final aim is to facilitate to improved outcomes for individuals on the spectrum, reflecting the potential impact of technological advancements in addressing the challenges associated with ASD diagnosis.

This survey introduces an application that develops the application to develop social skills in children diagnosedwith autism. Recognizing the increasing prevalence of ASD and the limitations of existing technology resources, an application has been tailored which indicates the specific needs of children with autism. It focuses on enhancing skills, which are critical for social interaction and empathy. By engaging children in interactive activities and exercises, the application aims to empower them to better understand and interpret the emotions, intentions, and beliefs of others, leading to improved social communication and interaction. This delves further into the methodology of the application's design and details the proposed solution. This work aims to contribute to the advancement of technology-assisted interventions for ASD and empower children with ASD to thrive in their social interactions.

II. RELATED WORK

S. M. Mahedy Hasan, M. P. Uddin, M. A. Mamun, M. I. Sharif, A. Ulhaq and G. Krishnamoorthy's A Machine Learning Framework for Early-Stage Detection of Autism Spectrum Disorders [1] provides framework for evaluating computational learning methods techniques in the early detection of the disorder.

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The method includes the usage of four different Feature Scaling (FS) strategies and eight ML algorithms applied to four standard ASD datasets representing different age groups. Various statistical evaluation measures are employed to identify the best-performing classification methods and effective feature scaling techniques for each age group. This includes risk factor calculation and attribute importance ranking using different Feature Selection Techniques (FSTs). The proposed framework achieves promising results, outperforming existing approaches, and provides detailed insights for healthcare practitioners in screening ASD cases across different age groups.

M. Kohli, A. K. Kar and S. Sinha's The Role of Intelligent Technologies in Early Detection of Autism Spectrum [2] provides a paper that employs a scoping review methodology to assess the part of technologyin detecting autism in children under six years old. The evaluation process involves the Critical Appraisal Skills Programme (CASP) and a set of evidence-based minimum items designed to assist in reporting systematic reviews, commonly referred to as the PRISMA scoping review checklist.

K. D. Bartl-Pokorny et al's Robot-Based Intervention for Children with Autism Spectrum Disorder [5] provides an examination of robot-based immersions for children with autism, focusing on emotion-related skills. Notably, Nao and ZECA have frequently used robots. The most trained skills were basic emotion recognition and interaction, while happiness, sadness, fear, and anger were the most frequently addressed emotions. Challenges in robot-based interventions included limitations for specific ASD subgroups, security concerns, and efforts to automatically recognize children's emotional states by robotic systems. The review concludes with summarized recommendations for applying robot-based interventions in ASD.

M. A. Rashidan et al's Technology-Assisted Emotion Recognition for Autism Spectrum Disorder Children [4] provides a systematic review approach with evidence-based minimum items designed to assist in reporting on technology-assisted methods for recognizing affective states in individuals with autism. Despite methodological variations, the review synthesized data narratively, presenting research methods, systems, equipment, and models addressing technology-assisted and affective states-related issues. This concluded that technology-assisted emotion recognition could enhance therapy sessions between therapists and individuals with ASD. The review aims to serve as a concise reference for practitioners and researchers seeking insights into the current state-of-the-art studies in this area.

J. Han, G. Jiang, G. Ouyang and X. Li's A Multimodal Approach for Identifying Autism Spectrum Disorders in Children [3] provides the challenge of identifying autism in children by proposing a novel multimodal diagnosis framework. The procedure involves combining electroencephalogram (EEG) and eye-tracking (ET) data to capture both internal neurophysiological and external behavioral perspectives. The approach follows a two-step process utilizing Stacked Denoising Auto Encoders (SDAE). In the first step, individual SDAE models are employed to extract features from the EEG and ET modalities. Moving to the second step, a third SDAE model comes into play, tasked with integrating and fusing the features acquired from both EEG and ET modalities, thus creating a holistic representation. This multimodal identification model automatically captures correlations and complementarity between modalities in a latent feature space, resulting in informative representations with enhanced discriminability. Evaluation on a dataset of 40 ASD children and 50 typically developing (TD) children demonstrates superior performance compared to unimodal and simple fusion methods. The proposed framework holds promising potential for providing objective and accurate ASD diagnosis to assist clinicians.

F. Ke, S. Choi, Y. H. Kang, K. -A. Cheon and S. W. Lee's Exploring the Structural and Strategic Bases of Autism Spectrum Disorders with Deep Learning [6] provide utilization of 14 different deep learning models, including convolutional and recurrent neural networks, to diagnose autism based on neurobiological evidence. The study employs an open-source autism dataset with over 1000 MRI scan images and a high-resolution structural MRI dataset. This involves training 3D convolutional neural networks to visualize combinations of brain regions and recurrent neural networks to efficiently classify the sequence of brain regions. The findings highlight emphatic structural and strategic evidence, particularly associated with subcortical structures like the basal ganglia. It identifies the distinct brain structures characterizing ASD, aiming to streamline deductive reasoning for clinicians and provide an economical and time-efficient diagnosis process.

N. Rusli, S. N. Sidek, H. M. Yusof, N. I. Ishak, M. Khalid and A. A. A. Dzulkarnain's Implementation of Wavelet Analysis on Thermal Images for Affective States Recognition of Children with Autism Spectrum [7] tackles the difficulties in psychosocial engagements for children with autism by introducing a non-invasive method using thermal imaging to identify affective states. The theory was grounded on dermal temperature changes associated with pulsating blood flow in the frontal face area. This method includes a structured experimental setup inducing affective state expressions, a wavelet-based pattern detection technique for thermal imaging data analysis, and evaluation against a

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baseline model for typical developing children aged 5 to 9. The results showed an 88% classification accuracy in identifying affective states in autistic children, suggesting the potential for more effective responses to improve social-emotional interaction in this population.

K. Khowaja et al's Augmented Reality for Learning of Children and Adolescents with Autism Spectrum Disorder [8] outlines distinct research inquiries on learning abilities, applicants, augmented reality, study plan, methods of data collection, environments, criteria for evaluation, outcomes of intervention, simplification, and sustainability. Commonly used technologies include computers, smartphones, and smart glasses. The predominant study plan involved an initial assessment and a follow-up assessment, with observation as the primary data collection method. Most evaluations occurred in classroom or controlled research environments, utilizing human-assisted parameters. Results indicate positive benefits of AR on learning skills for children with ASD, with favorable outcomes in maintenance tests. However, because of thevariety of capabilities addressed and participant heterogeneity, a conclusive statement on AR's overall effectiveness in ASD education is deemed premature. It suggests a study arrangement for ASD and promoters for upcoming studies to explore AR effectiveness across varied applicants, machinery, overview, maintenance, and inclusive classroom settings.

III. LITERATURE SURVEY

S. No	Year of Publication	Project Title	Description
1.	2023[1]	A Machine Learning Framework for Early-Stage Detection of Autism Spectrum Disorders	The paper proposes a comprehensive framework for evaluating ML techniques in the early detection of autism. The methodology involves the approach of four different Feature Scaling (FS) strategies and eight ML algorithms applied to four standard ASD datasets representing different age groups. Various statistical evaluation measures are employed to identify the best-performing classification methods and effective feature scaling techniques for each age group. The study includes risk factor calculation and attribute importance ranking using different Feature Selection Techniques (FSTs). The proposed framework achieves promising results, outperforming existing approaches, and provides detailed insights for healthcare practitioners in screening ASD cases across different age groups.
2.	2022[1]	A Multimodal Approach for Identifying Autism Spectrum Disorders in Children	This paper addresses the challenge of identifying Developmental Diversity in children by proposing a novel multimodal diagnosis framework. The methodology involves combining electroencephalogram (EEG) and eye-tracking (ET) data to capture bothinternal neurophysiological and external behavioral perspectives. The approach employs a two-step process with stacked denoising autoencoders (SDAE): first, separate (Stacked Denoising Auto Encoders) SDAE models learn features from EEG and ET modalities, and then a third SDAE model fuses these learned features. This multimodal identification model automatically captures correlations and complementarity between modalities in a latent feature space, resulting in informative representations with enhanced discriminability. Evaluation on a dataset of 40 ASD children and 50 typically developing (TD) children demonstrates superior performance compared to unimodal and simple fusion methods.

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			The proposed framework holds promising potential for providing objective and accurate ASD diagnosis toassist clinicians.
3.	2022[2]	The Role of Intelligent Technologies in Early Detection of Autism Spectrum Disorder	The paper employs a scoping review methodology to assess the role of technology in detecting autism in children under six years old. The study spans from January 2011 to December 2021 and includes 35 selected studies from PUBMED, SCOPUS, and IEEE Xplore databases. The evaluation process involves the Critical Appraisal Skills Programmer (CASP) and the PRISMA scoping review checklist.
4.	2021[1]	Implementation of Wavelet Analysis on Thermal Images for Affective States Recognition of Children with Autism Spectrum Disorder:	The study aimed to address challenges in socio-emotional engagement strategies designed for children on the Autism Spectrum by introducing a non-invasive method using thermal imaging to identify affective states. The hypothesis was based on cutaneous temperature changes associated with pulsating blood flow in the Frontal face area. The methodology included a structured experimental setup inducing affective state expressions, a wavelet-based pattern detection technique for thermal imaging data analysis, and evaluation against a baseline model for typical developing children aged 5 to 9. The results showed an 88% classification accuracy in identifying affective states in autistic children, suggesting the potential for more effective responses to improvesocial-emotional interaction in thispopulation.
5.	2021[2]	Technology-Assisted Emotion Recognition for Autism Spectrum Disorder (ASD) Children	The study conducted a systematicreview using the Preferred Guidelines for In-Depth syntheses and Meta-syntheses approach to investigate technology-assisted methods for recognizing affective states in people with autism. Despite methodological variations, the review synthesized data narratively, presenting research methods, systems, equipment, and models addressing technology-assisted and affective states-related issues. This concluded that technology-assisted emotion recognition could enhance therapy sessions between therapists and individuals with ASD. The review aims to serve as a concise reference for practitioners and researchers seeking insights into the current state-of-the-art studies in this area.

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6.	2021[3]	Robot-Based Intervention for Children with Autism Spectrum Disorder	The review examines robot-based approaches for supportingchildren diagnosed with autism, focusing on emotion-related skills. The methodology follows the PRISMA guidelines, systematically searching databases for articles until May 2021. The review encompasses 892 participants, with 570 being children with ASD. Notably, Nao and ZECA have frequently used robots. The most trained skills were basic emotion recognition and interaction, while happiness, sadness, fear, andanger were the most frequently addressed emotions. Challenges in robot-based interventions included limitations for specific ASD subgroups, security concerns, and efforts to automatically recognize children's emotional states by robotic systems. The review concludes withsummarized recommendations for the application of robot-based interventions in ASD.
7.	2020[1]	Exploring the Structural and Strategic Bases of Autism Spectrum Disorders with Deep Learning	This paper utilizes 14 different deep learning models, including convolutional and recurrent neural networks, to diagnose autism based on neurobiological evidence. The paper identifies an open-source autism dataset with over 1000 MRI scan images and a high-resolution structural MRI dataset. The methodology involves training 3D convolutional neural networks to visualize combinations of brain regions and recurrent neural networks to efficiently classify the sequence of brain regions. The findingshighlight emphatic structural and strategic evidence, particularly associated with subcortical structures like the basal ganglia.The paper identifies distinct brain structures characterizing ASD, aiming to streamline deductive reasoning for clinicians and provide an economical and time-efficient diagnosis process.
8.	2020[2]	Implementation of Wavelet Analysis on Thermal Images for Affective States Recognition of Children with Autism Spectrum Disorder	The objective of the research was to address challenges in socio-emotional communication for children diagnosed with autism by introducing a non-invasive method using thermal imaging to identify affective states. The hypothesis was based on cutaneous temperature changes associated with pulsating blood flow in the frontal face area. The methodology included a structured experimental setup inducing affective state expressions, a wavelet-based pattern detection technique for thermal imaging data analysis, and evaluation against a baseline model for typical developing children aged 5 to 9.
9.	2020[3]	Augmented Reality for Learning of Children and Adolescents with Autism Spectrum Disorder	This paper conducts a systematic review to explore the use ofaugmented reality (AR) in improving skills for individuals diagnosed with autism during childhood and adolescence. The review addresses specific research questions related to learning abilities, members, augmented reality, study design, data collection techniques, context, criteria for evaluation, program effects, transferability, and sustainment. Social communication proficiencies were frequently focused on,and individuals with autism

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			were involved in all studies. Commonly Used technologies include computers, smartphones, and smart glasses. The predominant study employed a initial assessment and a follow-up assessment study framework, with observation as the primary data collection method.
10.	2019[1]	The Genetic-Evolutionary Random Support Vector Machine Cluster Analysisin Autism Spectrum Disorder	The study introduces a genetic-evolutionary random SVM cluster framework for in-depth exploration of neuroimaging data in Autism Spectrum patients. The methodology involves the randomformation of a starting grouping of SVMs, followed by a genetic evolution process of genetic exchange and genetic alteration to optimize classification accuracy. These recommended techniques achieve a notable 96.8% accuracy when evaluated on resting-state fMRI data from 103 people found to have a disorder and 106 were healthy. This framework not only identifies abnormal neural organ parts connected with the disorder but also suggests a perspective on the disorder's pathogenesis. The study underscores the potential ofthe proposed method as a valuable tool for diagnosingpotential ASD patients.
11.	2019[2]	Diagnosis of Autism Spectrum DisorderBased on Eigenvalues of Brain Networks	The study proposes a method for diagnosing Autism Spectrum Disorder (ASD) by creating brain network-based features using functional magnetic resonance imaging (fMRI). The process involves segmenting the brain into regions, constructing functional connectivity, and extracting features based on the eigenvaluesof the Laplacian matrix. Additional features are derived from networkcentralities, and a feature selection algorithm is applied to obtain discriminative features. Machine learning models, including linear discriminant analysis (LDA), are trained on the ABIDE dataset. The LDA model achieves a classification accuracy of 77.7%, outperforming state-of-the-art results. Overall, the study integrates neuroimaging and machine learning for promising ASD diagnosis.
12.	2018[1]	Developing a Software That Supports theImprovement of the Theory of Mind in Children with Autism Spectrum Disorder	The study aimed to address thechallenges in supporting children diagnosed with Autism Spectrum Disorder (ASD) by developing a mobile application targeting empathy skills based on mind theory. Theme theology identifies gaps in existing applications, leading to the creation of a tailored mobile app. Usability tests with experts ensured the application's content and usability adequacy. Validation tests with both experts and end-users demonstrated promising results, indicating the application's potential effectiveness. Iterative improvements were made based on feedback, resulting in a refined application poised to support professionals working with children diagnosed with autism.

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13.	2018[2]	Developing Computational Thinking Skills in Adolescents with Autism Spectrum Disorder Through Digital Game Programming	The study presents a Game Building Workshop designed for youth with autism spectrum to develop Computational Thinking (CT) skills through digital game programming. This includes defining workshop activities with consideration for the unique characteristics of individuals with ASD. Assessment involves classroom observation and artifact analysis, revealing thatparticipants with ASD acquired high-level CT skills related to programming. The collaborative nature of the activities is emphasized, creating a stimulatingand welcoming environment for individuals with ASD. Overall, the adapted workshop proves effective in fostering CT skills in this specific demographic.
14.	2018[3]	Developing a Software That Supports theImprovement of the Theory of Mind in Children with Autism Spectrum Disorder	The study involves the development of a mobile application targeting professionals working with children diagnosed with Autism Spectrum Disorder (ASD). The application focuses on enhancing empathy-related skills based on the mind theory. Usability testing with experts indicates successful task completion with minor time differences. Validation tests with both experts and end-users (children with ASD) yield promising results, affirming the application's effectiveness. The methodology emphasizes seamless integration into professional activities and ensures user comfort, ultimately providing a valuable tool for improving social skills in individuals with ASD.
15.	2018[4]	Computer Vision Analysis for Quantification of Autism Risk Behaviors	The study introduces a self-contained mobile application designed for observational behavior analysis, specifically focusing on assessing risk markers for autism spectrum disorder (ASD) in toddlers. The methodology involves developing the application with engaging stimuli, recording toddlers' responses using a mobile device camera, and employing computer vision algorithms for automatic analysis. The system is validated for measuring engagement, name-call responses, and emotional responses in toddlers in the presence and absence of disorder. The proposed frameworkenables fine-grained quantification of behaviors,supporting risk marker research. The results indicate the potential of this objective and automatic method for scalable behavioral analysis in future studies.

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16.	2017[1]	Multimedia Social Greetings Interventionfor Children with Autism Spectrum Disorders	The narration. The positive reinforcement practice session prompts greetings to cartoon characters,with depth-based tracking recognizing proper behaviors and providing immediate reinforcement. Computational multimedia tools are proposed to streamline VSM content creation. Preliminary results from a pilot study suggest the potential effectiveness of MEBook in teaching greeting behaviors to individuals with autism.
17.	2017[2]	A Feasibility Study of Autism BehavioralMarkers in Spontaneous Facial, Visual, and Hand Movement Response Data	The study proposes a novel methodology for non-intrusive sensing and analysis of behavioral markers in Autism Spectrum Disorder. The pilot study, approved by an institutional review board, involves two groups (ASD and Control) engaging in tasks related to visualization, recognition, and manipulation. Facial expression analysis, utilizing the Facial Action Coding System (FACS), reveals significantly higher prevalence of spontaneous smiles in the ASD group, indicating impairments in reciprocal social communication, such as social smiling. Visual scanning patterns show averted gazes from faces in Visual stimuli. Eye-hand coordination analysis indicates poor correlation in ASD subjects, suggesting deficits in motor coordination during dynamic tasks. The proposed multimodal approach aims to provide quantitative insights into ASD for early symptom detection and effective intervention planning.
18.	2017[3]	Automatic detection and labeling of self-stimulatory behavioral patterns in children with Autism Spectrum Disorder	The study introduces an infrastructure for recording, detecting, and labeling behavioral patterns in children with autism. The methodology employs two sensor platforms, wearable and static. Wearable sensors use accelerometers to detect behavioral patterns, while static sensors include microphones and cameras that capture sounds, images, and videos in a room. Video data serves as ground truth for analyzing wearable sensor data. Upon detecting autistic behavior, the system labels video segments, storing the time of detection. Time-frequency methods extract features, and Hidden Markov Models analyze accelerometer signals, achieving a 91.5% classification rate for the studied behavioral patterns. This enables effective labeling and data storage.

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19.	2016[1]	A Computational Study of Expressive Facial Dynamics in Children with Autism	The study employs a computational approach to analyze facial expressions in children with high-functioning autism in comparison to neurotypical children. The approach involves collecting Motion capture data while individuals produce different facial expressions. Computational analysis focuses on examining overall and local facial dynamics to uncover characteristics not easily detectable visually. The major finding is a reduced complexity in the dynamic facial behavior of the HFA group, particularly in the eye region. The study aims to understand the underlying mechanisms and distinct features of facial expression deficits in children with HFA.

IV. CONCLUSION

The study employs a comprehensive approach to autism detection, integrating various machine learning models for predictive analysis. The core methodology involves the development of an inclusive mobile application tailored for parents. This application serves as a practical tool for autism detection in children, leveraging the predictive capabilities of machine learning algorithms.

The holistic framework not only demonstrates the feasibility of utilizing advanced technologies for early ASD detection but also emphasizes the significance of involving parents in the process. By providing an accessible and user-friendly mobile application, the study aims to empower parents with a valuable tool for potential ASD identification in their children.

In conclusion, the integration of machine learning models with a user-centric mobile application offers a promising avenue for early ASD detection. This approach aligns with the broader goal of enhancing accessibility and inclusivity in autism detection methodologies, ultimately contributing to more effective intervention and support for affected children.

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