ARTIFICIAL INTELLIGENCE FOR AUTISM SPECTRUM DISORDER

Zsalzsa Puspa Alivia[1], Jaja Kustija[1], Lala Septem Riza[1], Anne Hafina[2], Ade Gafar Abdullah[1] and Isma Widiaty[1]

[1]Technology And Vocational Education, Indonesia University of Education, Indonesia
[2]Guidance and Counseling Department Program, Indonesia University of Education, Indonesia

Zsalzsa@upi.edu[1]
jajakustija@upi.edu[1]
lala.s.riza@upi.edu[1]
annehafina@upi.edu[2]
ade_gaffar@upi.edu[1]
isma@upi.edu[1]

ABSTRACT: Scoping Reviews (SR) are used in this study to investigate how AI can be used to diagnose and treat autism spectrum disorder (ASD). By examining 55 papers released between 2020 and 2024, the study sheds light on the field's developments, difficulties, and possible prospects. AI-based models, including Convolutional Neural Networks (CNNs), ResNet-18, and hybrid approaches such as GoogleNet combined with Support Vector Machines (SVM), demonstrate high diagnostic accuracy, effectively addressing limitations of traditional methods. Additionally, multimodal frameworks integrating visual, auditory, and textual data show significant promise in providing comprehensive insights into the complexities of ASD. The study also emphasizes the impact of AI in personalized interventions through technologies like Virtual Reality (VR) platforms, telehealth systems, and IoT-based monitoring devices, which improve social skills, communication, and engagement among individuals with ASD. However, notable challenges persist, such as limited access to AI technologies in resource-constrained regions, ethical concerns related to data privacy and algorithm transparency, and a lack of research focusing on adult populations with ASD. Furthermore, the absence of longitudinal studies limits the understanding of the sustained impacts of AI-driven interventions over time. This review underscores AI's transformative potential in ASD care while advocating for inclusive, ethical, and accessible solutions. Future research should focus on expanding multimodal approaches, addressing underserved populations, and validating AI applications in diverse real-world settings to enhance their impact and reach.

Keywords: Autism Spectrum Disorder, Artificial Intelligence, Diagnosis, Interventions, Systematic Literature Review.

1. Introduction

Autism spectrum disorder (ASD) is a condition characterized by impairments in communication, social interaction, repetitive behaviors, and restricted interests, which can impact the surrounding environment (American Psychiatric Association, 2013; Khoirunnisa et al., 2023, 2024; Pandya et al., 2024). ASD symptoms and cognitive abilities vary widely, ranging from high to low levels, and it is often accompanied by other conditions such as ADHD, anxiety, depression, and epilepsy (Lord et al., 2006; RISI et al., 2006). The term ASD was initially categorized under *pervasive developmental disorders* (PDD) in DSM-III (1980) to describe a broader spectrum of social communication deficits. However, it was later simplified in DSM-5 and ICD-11 with additional clinical specifiers for clarity (Lord et al., 2020). ASD prevalence continues to rise, with approximately 1 in 100 children diagnosed globally each year (Wankhede et al., 2024). While initial symptoms are typically observed by 12 months of age, many cases are diagnosed between 48 and 60 months, delaying early intervention services (Manohar et al., 2019; Lord et al., 2020).

Early diagnosis is crucial, as the high neuroplasticity of the brain during early childhood can enhance a child's IQ by 10–15 points. Therefore, diagnosing ASD before 36 months is strongly recommended to improve long-term outcomes (Grzadzinski et al., 2021; Klintwall & Eikeseth, 2014). To facilitate early detection, diagnostic tools such as the *Autism Diagnostic Observation Schedule (ADOS-2)* and the *Autism Diagnostic Interview-Revised (ADI-R)* have been developed (Lord et al., 1994, 2000). The integration of artificial intelligence (AI) represents a groundbreaking advancement in ASD diagnosis and management. AI enables the rapid and accurate analysis of behavioral, neuroimaging, and genetic data, aiding psychologists and psychiatrists in making more informed decisions (Pandya et al., 2024; Joudar et al., 2023). With capabilities such as pattern recognition, decision-making, and data processing, AI offers revolutionary solutions to improve the quality of life for individuals with ASD (Langer & Landers, 2021; Zhang & Lu, 2021).

1.2 Research Gaps

Even though the amount of research on ASD is growing, there are still a lot of important gaps in the area. Methodological flaws and a dependence on subjective evaluations frequently hinder diagnostic procedures, creating variability that makes the development of standardized intervention protocols more difficult (Okoye, 2023; Pardeshi, 2024). Furthermore, despite the consensus that early intervention is crucial, there are not enough long-term studies assessing the viability and efficacy of different strategies over time (Pizur-Barnekow et al., 2020; "Transforming the future of nursing care," 2024).

With little exploration into how it can be utilized in clinical and lacking in resources settings, the integration artificial intelligence in autism research is still in its infancy (Bhatt, 2024; Sassu & Volkmar, 2022). This disparity is more noticeable in areas with limited access to specialized care, underscoring the need for creative, inclusive solutions that use artificial intelligence to improve diagnosis and intervention techniques (Wieckowski et al., 2022; Sumiła, 2022).

1.3 Objectives

By defining the key ideas, theories, and sources of evidence to direct and assess the implementation of new techniques, scoping reviews are a descriptive technique that facilitates the analysis of complex or diverse research initiatives. The results of scoping reviews can identify gaps in the existing literature and indicate areas with limited evidence to merit additional studies or a systematic review.

This study aims to answer the following questions: What are the potential benefits of artificial intelligence (AI) for people with Autism Spectrum Disorder in the field of computer science?

2. Literature Review

A systematic review analyzing 55 scholarly articles published between 2020 and 2024 demonstrates a significant upward trend in research output regarding Autism Spectrum Disorder (ASD) over the past five years. This surge reflects the increasing acknowledgment of ASD's complexity and the pressing need for innovative solutions in diagnosis and intervention. The majority of these studies were conducted in high-income countries such as the United States, the United Kingdom, and Australia, revealing a notable disparity in global autism research. This geographic concentration highlights potential gaps in funding and attention to ASD-related challenges in low- and middle-income countries (Oliveira et al., 2022; Faraji et al., 2022).

The literature review identified key focus areas, including advancements in diagnostic tools, innovative intervention strategies, and the growing role of technology in addressing ASD-related needs. Technological innovations are being increasingly explored to enhance diagnostic accuracy and intervention effectiveness, contributing to improved outcomes for individuals with ASD (Rattaz et al., 2022; Silva, 2024). This trend underscores a broader shift in healthcare towards digital solutions to tackle complex health challenges, including neurodevelopmental disorders such as ASD

2.1. Technological Advancements in Diagnosis

One of the most prominent themes in the reviewed literature is the transformative potential of technological advancements, particularly artificial intelligence (AI), in diagnosing ASD. AI-driven tools, including machine learning algorithms, have shown promise in identifying subtle behavioral markers associated with ASD, enabling earlier and more accurate diagnoses. For example, these tools can process extensive datasets to detect patterns that may elude human observation, thereby streamlining the diagnostic process (Posar & Visconti, 2020; Hayes et al., 2021). This innovation addresses a critical issue faced by many families—lengthy diagnostic timelines—by facilitating timely interventions that can positively influence developmental outcomes.

2.1.1. Personalized Interventions

Another significant theme is the advent of personalized interventions supported by technological advancements. Tools such as telehealth platforms, mobile applications, and virtual therapies are revolutionizing ASD care by offering tailored solutions that cater to individual needs. Telehealth, for instance, has improved access to specialized care for families in remote or underserved regions, allowing them to consult with experts who provide guidance and therapeutic support (Rao, 2024; John, 2024). Moreover, mobile applications for behavior tracking and skill-building empower caregivers and individuals with ASD to engage in self-paced therapeutic activities, promoting autonomy and active participation in the intervention process. This focus on personalization emphasizes the necessity of adapting interventions to address the diverse needs of individuals on the autism spectrum.

2.1.2. Challenges in Accessibility

Despite technological advancements, the literature highlights ongoing challenges related to accessibility and equity in ASD care. A significant concern is the limited availability and affordability of technological solutions in low-resource settings, which can hinder their adoption. The findings emphasize the need for equitable distribution of technological resources and adequate training for practitioners to ensure these innovations benefit all individuals with ASD, regardless of socioeconomic or geographic constraints (Azu, 2024; Jonkman et al., 2022). Addressing these accessibility challenges is essential to preventing further disparities in healthcare delivery and outcomes for underserved populations.

2.2. The integration of AI and digital tools into ASD

The integration of AI and digital tools into ASD research and care marks a paradigm shift that could transform the field. However, this technological reliance introduces challenges such as inequities in access, particularly for families in rural or low-income areas. The literature underscores the importance of equitable implementation to ensure that the benefits of these advancements are shared across diverse populations (Keller et al., 2020).

Additionally, ethical considerations, including data privacy and informed consent, emerge as critical factors in the application of AI-driven solutions. The collection and analysis of sensitive data necessitate robust frameworks to protect the rights and privacy of individuals with ASD and their families. Establishing these ethical safeguards is essential to building trust between families and healthcare providers, which is crucial for the successful adoption of technological innovations in ASD care.

In conclusion, the literature reveals a dynamic landscape in ASD research, characterized by significant technological advancements and an increasing emphasis on personalized care. Nonetheless, it highlights the need to address persistent challenges related to accessibility and ethical considerations. Future research must prioritize developing inclusive and ethical solutions that cater to the diverse needs of individuals with ASD and their families, ensuring that these innovations deliver meaningful and equitable benefits.

3. Methods

This section describes the study's selection criteria, search strategy, justification, data extraction, and analysis. Data collection for this study uses a scoping review. According to Arksey and O'Malley (2005), the scoping review method is used to identify all relevant literature. Scoping reviews have the following tasks that must be completed in a limited amount of time: (1) identifying research questions; (2) identifying relevant studies; (3) selecting studies; (4) creating a chart; and (5) compiling, summarizing, and reporting (Arksey & O'Malley, 2005).

The Population, Concept and Context (PCC) method was used to guide the search strategy when scoping. The database used was Scopus. The following search ranges were indicated in the title, abstract and key of this study: "Artificial intelligence" OR 'AI' AND 'Autism Spectrum Disorder' OR 'ASD' OR 'Autism'.

The justification string search is as follows:

(1) Population: Research related to "autism," "ASD," or "autism spectrum disorder" is the main focus of the search.
(2) Concept: Finding research on "artificial intelligence" OR "AI" is the goal of the search.
(3) Context: This study provides a comprehensive framework to discuss various applications and implementations of artificial intelligence for individuals with autism spectrum disorder.

3.1. Eligibility Criteria

The inclusion criteria in this study include:

(1) Journals published in 2020 - 2024.
(2) English language open access final article journals that are part of electronic databases such as PUBMED, IEEE and SCOPUS.
(3) Journals that focus on the use or implications of AI on individuals with autism spectrum disorder and are in the scope of computer science to focus on the use of AI as a technology for people with autism spectrum disorder.

Exclusion criteria for this study were review and conference articles and articles that did not utilize AI technology.

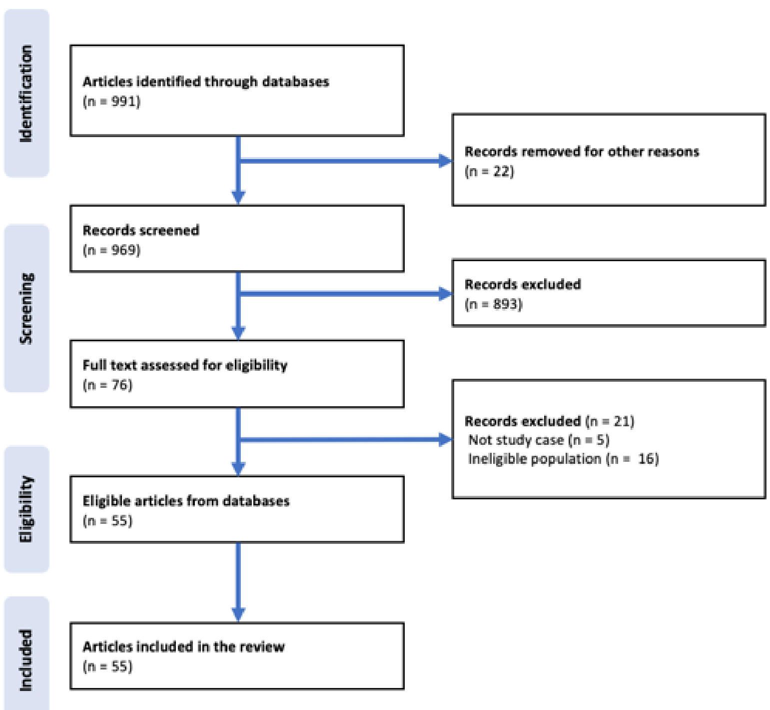
The review included peer-reviewed articles published in English, focusing on ASD diagnosis, intervention, or the integration of AI in these processes. Studies lacking empirical data or those unrelated to ASD were excluded. These criteria ensured the inclusion of high-quality, relevant research (Baoum et al., 2022; Whiteley et al., 2021). Using a consistent framework, the data charting method arranges pertinent information from chosen articles. This covers the study's focus (e.g., diagnosis, rehabilitation), the particular disability it addresses, the kind of AI technology it employs, and its findings. This methodical technique makes it easier to compare and synthesize results from many investigations.

3.2. Data Extraction and Analysis

A standardized template was used for data extraction, capturing essential details such as research objectives, methodologies, results, and contributions. Thematic analysis was employed to identify recurring themes and patterns, enabling a nuanced synthesis of the literature (Perochon, 2023; Chaturavitwong, 2023).

Based on (Figure 1.) below, it is stated that 55 publications that meet the requirements were found by screening 76 abstracts using inclusion and exclusion criteria. The authors conducted literature searches, articles, literature reviews, and data collection. To resolve ambiguities or conflicts, discussions were conducted. Using a consistent structure, the data charting technique involved gathering relevant information from the selected articles. This included the purpose of the study (e.g., diagnosis, rehabilitation), the specific disability targeted, the type of AI technology used, and the outcome. This methodical technique makes it easy to compare and synthesize results from different investigations.

Figure 1. Literature screening and shortlisting studies.



The search process identified 991 articles in total. After removing 22 duplicates, 893 were excluded for being unrelated to the scoping subject. Following this, the remaining 76 articles were assessed for eligibility. After the full text screening, 21 articles were excluded. This led to a final selection of 55 studies included in the analysis. 35 studies (64%) were dedicated to children, 16 studies (29%) were unreported, and 4 studies (7%) to the adults. The age distribution in Table 1 was determined by examining the age groups specified in each study. This information is important, as it highlights the focus of current research and potential gaps in addressing the needs of specific age group.

4. Results and Discussions

This section answers the research questions and presents quality assessment results.

Table 1. Literature Review

Authors	Conclutions	Limitations
(Mutawa et al., 2023)	It involved children aged three to six, where the experimental group interacted with the NAO robot, resulting in higher engagement and eye contact compared to the control group.	Limitations such as the robot's capacity for concurrent interactions, language difficulties, battery life, and internet access were noted, emphasizing the need for future research to address these challenges.
(Parui et al., 2023)	Functional connectivity analysis via rs-fMRI for ASD diagnosis with 84.79% accuracy	Standardized protocols for data sharing, privacy protection, and regulatory compliance are necessary to ensure ethical usage of AI-driven ASD diagnostic tools
(Tabassum, 2020)	Mobile and wireless technologies, including virtual reality, enhance learning for children, especially those with special needs, by providing interactive, multisensory environments. Applications are adaptive to intellectual ranges, promoting inclusivity.	Lack of standardized tools to evaluate available applications in the market limits the accessibility and reliability of technology for broad educational purposes.
(Abdel Hameed et al., 2022)	Proposed an AI-enabled IoT system using heart-rate sensors to assess emotional states and behaviors in autistic children. Introduced 3D visual models to improve eye contact and social communication skills.	Limited scalability and reliance on sensors may restrict widespread adoption. Effectiveness in real-world scenarios requires further validation.
(Su et al., 2024)	Proposed an AI-driven system to enhance school counseling in Taiwan. Utilized digital journaling for emotional reflection, resulting in improved social-emotional competencies.	Limited sample size and context-specific applicability may hinder generalization. Long-term outcomes and integration with traditional counseling methods require further exploration.
(Maharjan et al., 2023)	Developed an ML model using XGBoost to predict ABA treatment intensity (comprehensive vs. focused) with 89.5% accuracy. Key predictive features were bathing ability, age, and prior ABA hours.	The model relied on retrospective data, and broader real-world applications need validation. Misclassifications occurred, though they leaned toward suggesting more intensive interventions.
(Öztürk et	Integrated eye-tracking data and Bayley scales to linguistically summarize ASD developmental	Focused on descriptive techniques, requiring further exploration into

al., 2024)	assessments. Created user-friendly summaries to differentiate ASD from typically developing (TD) children.	predictive and diagnostic applications. Real-world implementation challenges of linguistic summarization were not addressed.
(El-Sattar, 2023)	EMOCASH is a virtual-agent-based multiplayer online serious game designed to improve money management and emotion recognition skills in Egyptian children with ASD. Using a 3D virtual shop scenario and the Autism ASPECTSS Design Index, it aims to transfer acquired skills to real-world contexts.	Effectiveness in diverse cultural or socio-economic backgrounds is unclear. The study focused on usability but lacks longitudinal data on real-world skill transfer and sustained improvement in participants
(Mareeswaran & Selvarajan, 2024)	Developed a machine learning model using Support Vector Machines (SVM) for early detection of ASD with 96% accuracy, utilizing age, gender, and jaundice symptoms as key features.	Dataset size and diversity may limit the generalizability of findings. Hyperparameter tuning and real-world testing require further exploration.
(Kang et al., 2024)	Proposed a unified framework integrating feature selection, extraction, and explainability for neurological disorder diagnosis using functional connectivity. Achieved superior performance using counter-condition analysis.	Framework tested on resting-state fMRI datasets (ABIDE, REST-meta-MDD) but may require validation on broader and diverse datasets for real-world applications
(Mukherjee et al., 2023)	Developed a framework using BERT and ChatGPT to detect ASD symptoms from parents' dialog. Sentiment analysis identified early warning signs, achieving 83% accuracy on curated datasets.	Limited dataset diversity sourced from social sites and online groups; real-world application and broader generalization require further validation.
(Ahmed et al., 2022)	Developed hybrid eye-tracking-based techniques integrating CNNs and SVM for ASD detection. ResNet-18 achieved 97.6% accuracy, with hybrid methods (GoogleNet+SVM) reaching 95.5%.	Focused on specific deep learning models without extensive real-world validations or dataset diversity to assess broader applicability.
(Garg et al., 2022)	Developed a deep learning model using facial image data with explainable AI integration, achieving 98.9% accuracy, 99.9% AUC, and enhanced clinical interpretability.	Relied solely on facial image datasets, which may not represent the diverse clinical manifestations of ASD across populations.
(Mengash et al., 2023	Developed the ASDC-OSAML model utilizing Owl Search Algorithm for feature selection and Beetle Swarm Antenna Search for parameter optimization. Achieved superior performance in	Focused on specific optimization techniques; real-world validation and applicability on diverse datasets require further exploration.

)	ASD classification.	
(Bala et al., 2022)	Proposed ML models integrating feature selection techniques for ASD classification across age groups. SVM achieved 99.61% accuracy for child datasets and 97.82% for toddler subsets.	Dataset diversity and real-world application of models require broader testing to ensure robustness and adaptability in different clinical settings
(Horstmann et al., 2022)	Highlighted the importance of context-specific communication, adaptability, and customizability in robotic learning assistants. Proposed AI-based engagement detection for motivation.	Relies on stakeholder interviews; requires real-world testing with children to validate communication strategies and AI integration effectiveness.
(Thabtah et al., 2022)	Proposed machine learning models to predict autism for children, adolescents, and adults effectively.	Limited generalizability due to reliance on a specific dataset and potentially small sample size.
(Megerian et al., 2022)	Evaluated a gradient-boosted AI diagnostic tool analyzing caregiver questionnaires, home videos, and clinician input. Achieved 80.8% PPV and 98.3% NPV in primary care ASD diagnosis.	The device requires clinical judgment for final diagnosis; limited to 18–72-month-old children and dependent on input quality for determinate results.
(Jung et al., 2024)	Proposed the EAG-RS framework leveraging explainability-guided high-order functional connectivity (FC) to identify ASD-relevant regions of interest (ROIs). Demonstrated superior performance on the ABIDE dataset.	Focused solely on rs-fMRI data; broader validation on multimodal datasets and real-world clinical scenarios remains untested.
(Cheekaty & Muneeswari, 2024)	Developed convolutional deep Gaussian processes for image-based tasks, enabling enhanced feature extraction through convolutional kernels.	Focused on image classification (e.g., MNIST, CIFAR-10); no specific application to ASD datasets or classification challenges addressed
(Pavez et al., 2023)	Proposed Emo-Mirror, an intelligent system using convolutional neural networks (CNNs) to support emotion recognition in children with ASD by analyzing facial expressions in real-time.	Primarily focused on five basic emotions; lacks validation in diverse cultural settings and exploration of complex emotions that are relevant to ASD therapies.
(Arivuselvan et al., 2022	ILAT integrates assistive technologies such as IoT, AI, and AR to screen and assess children with ASD, enhancing social interaction, communication, and learning abilities. Provides tools for caregivers and psychiatrists to monitor	Primarily conceptual; lacks large-scale implementation or validation studies. Focuses on developing countries like India but may need adaptation for diverse cultural and

)	and manage aggression levels.	socioeconomic contexts.
(Wali et al., 2023)	Developed Aawn, an Arabic mobile application leveraging the Picture Exchange Communication System (PECS) to enhance communication, emotional, and organizational skills in Arab autistic children. Augmented with graphical features and designed with future AI integration.	Limited to Arabic-speaking children; broader applications across diverse linguistic and cultural contexts are not addressed. Validation of effectiveness in real-world settings remains to be explored.
(Hao & Hu, 2022)	Developed an optimized Neural Matrix Factorization (NeuMF) model integrated with K-means clustering to recommend physical education (PE) activities for autistic children. Achieved significant improvement in RMSE (1.251) and MAE (0.625), enhancing personalized curriculum recommendations.	Focused on quantitative measures of the recommendation system without extensive real-world validation. The study does not explore the impact of recommended PE activities on cognitive or emotional outcomes for autistic children.
(Alhakbani, 2024)	Proposed CNN-based facial emotion recognition to assess engagement in children with ASD, demonstrating superior accuracy compared to RF, SVM, and decision trees. Highlighted the application in improving learning and social interaction.	Limited dataset scope; broader validation in diverse demographic and clinical settings is required.
(Liang et al., 2021)	Proposed a framework combining explainable temporal coherency deep features with Layer-wise Relevance Propagation (LRP) for classifying self-stimulatory behaviors in children with ASD. Achieved state-of-the-art results using unsupervised TCDN and supervised SVM.	Limited by the availability of large annotated datasets; primarily focused on behavioral cues, without integrating multimodal data for comprehensive ASD diagnosis.
(Priyadarshini, 2023)	Proposed hybrid deep learning models combining CNN-LSTM with Particle Swarm Optimization (PSO) and GRU-CNN to enhance autism screening for toddlers and adults. Achieved superior performance compared to traditional models.	Focused on deep learning architectures; validation across diverse populations and real-world clinical data is required for broader applicability.
(Ferrer et al., 2024)	Virtual companions provide personalized learning experiences to adolescents with ASD, enabling them to recognize and respond to cyberbullying effectively.	Evaluation focuses primarily on detection accuracy, with less emphasis on long-term behavioral outcomes.
(Ruan et al., 2024)	Micro-expressions are rapid, involuntary facial movements that may indicate emotional states. However, the research paper indicates that it remains unknown whether micro-expressions can serve as a valid biomarker for diagnosing autism spectrum disorder (ASD).	Micro-expressions' validity as ASD biomarkers is unknown. ASD diagnosis is complex and variable.
(Paolucci	Leveraged AI tools like Openface to analyze subtle micro-expressions from home videos of	imited to specific facial cues like smiles; broader interaction features

et al., 2023)	infants. Found reduced frequency and intensity of social smiles in infants with ASD, aiding early detection.	or multimodal data integration (e.g., voice or gestures) are not explored.
(Hadri & Bouramoul, 2023)	Proposed an AI-driven contextual chatbot designed to support young children with autism by providing personalized dialogue, advice, and recommendations. The chatbot aims to assist in understanding emotions and preventing depression.	Limited experimental data; lacks longitudinal studies to measure the chatbot's real-world effectiveness and sustained impact on emotional health and depression prevention.
(Nagesh et al., 2022)	Proposed a framework integrating convolutional neural networks (CNNs) with genetic algorithms to optimize feature selection for ASD detection using MRI data. Demonstrated improved accuracy over traditional methods	Limited validation on diverse datasets. Real-world clinical applicability and integration into diagnostic workflows are yet to be tested.
(Kiarashi et al., 2024).	Explored sleep monitoring using infrared cameras for ASD individuals, showing a strong link between prior night's sleep quality and next-day behavior. Achieved 74% accuracy in predicting adverse behaviors.	Limited sample size (14 individuals) and specificity to the devices used; broader validation across diverse populations and settings is needed.
(Wang & Yang, 2024)	Proposed the EmoAsst framework leveraging text-guided transfer learning with pre-trained models (CLIP and wav2vec 2.0) for emotion recognition, improving performance on audio and video data. Achieved superior accuracy on the MELD dataset compared to existing approaches.	Focused on benchmark datasets like MELD; lacks real-world deployment validation for broader applications, particularly in specific populations such as children with ASD.
(Chistol & Danubianu, 2024)	Integrated ML and DL models like XGB, LSTM, and BERTweet for analyzing 90,000 tweets. The approach achieved high accuracy in identifying ASD traits, highlighting the role of early detection in social media-based diagnostics.	Reliant on publicly available text, which may not reflect all aspects of ASD symptoms. Further studies required to adapt the model to private or clinical data.
(Ercolano et al., 2024)	Achieved over 94% accuracy in gesture recognition using a 2D low-resolution camera embedded in a NAO robot, minimizing intrusion in robot-led training for children with ASD. Explored using low-power GPU systems for real-time analysis.	Focused on specific hardware (NAO robot); real-world generalizability across other platforms and settings is not explored. Long-term impact on therapeutic outcomes remains untested.
(Kareem et al., 2023)	Applied a 1D CNN model to multiple ASD datasets for children, adults, and adolescents, achieving accuracies of 99.45%, 98.66%, and 90% respectively. Demonstrated the suitability of 1D CNNs for analyzing time-series data in ASD detection.	Focused on public datasets; lacks real-world clinical validation. Dataset diversity, particularly cultural and demographic variations, remains untested.

(Mc Nally et al., 2024)	Investigated how autistic TikTok creators use ChatGPT as a digital coach and communication assistant to navigate neurotypical environments. Highlighted benefits such as harm reduction, time savings, and emotional support.	Focused on a limited dataset of 25 TikTok videos; findings are qualitative and lack quantitative validation. Broader implications across different platforms or demographics remain unexplored.
(Ullah et al., 2023)	Developed a body-worn IoT platform using multiple sensors to recognize gestures in ASD children with over 96% accuracy. Compared ML classifiers (DT, RF, ANN, KNN) for gesture recognition and highlighted optimal sensor placement for accuracy.	Focused on sign language gestures; applicability for broader gesture types or real-world deployment challenges, such as wearability or comfort for children with ASD, remains unexplored.
(Wall et al., 2023)	The paper discusses optimizing a de novo AI-based medical device for detecting pediatric autism using a predetermined change control plan. It highlights improved decision thresholds, resulting in a 66.5% determinate output and enhanced predictive values for autism detection.	High accuracy but limited definitive results provided.
(Lemaignan et al., 2024)	The robot integrated successfully within the school environment. It fostered 330 interactions over 16 hours in three weeks. Positive impact on children's well-being was observed	Lack of personalization in robot interactions noted by teachers. Limited testing of robot in speech and language therapy sessions
(Schmidt et al., 2023)	Utilized AI and machine learning to analyze 360-degree spherical video-based virtual reality (SVVR) data. Found distinct engagement patterns in autistic and neurotypical participants, revealing greater behavioral heterogeneity in the autistic group.	Study findings are preliminary, and larger sample sizes are needed for generalizability. Additional exploration of therapeutic implications for autistic individuals is required.
(Pan & Foroughi, 2024)	Applied the AlexNet architecture for edge computing in diagnosing autism spectrum disorders (ASD) via facial analysis in educational environments, highlighting cost-effective, fast, and private solutions.	Focused on facial analysis only; integration with multimodal data (e.g., audio or behavioral data) for comprehensive diagnosis is lacking.
(Podpečan, 2023)	The NAO robot demonstrated potential as a teaching tool for emotion recognition through physical gestures and interactive games, aiding children with autism in improving social and emotional skills.	Preliminary studies focus on small-scale trials with limited sample sizes. Broader longitudinal studies and cross-cultural validation are needed to establish efficacy.
(Popescu et al., 2022	Introduced PandaSays, an AI-based mobile application integrated with the Alpha 1 Pro robot for interpreting and responding to the affective states of children with autism. MobileNet CNN	Performance metrics indicate scope for improvement in model accuracy. Real-world usability and long-term engagement studies with diverse

)	achieved a classification accuracy of 56.25%, outperforming ResNet50 and VGG16.	ASD populations are needed for comprehensive validation.
(Jugunta et al., 2023)	Achieves 99.12% accuracy, surpassing existing techniques. Enhances interpretability and reduces diagnostic subjectivity. Aims to improve early diagnosis and intervention for ASD	Potential biases in healthcare settings are not examined. Future research should include multi-modal data for better understanding
(Itani & Thanou, 2021)	Combined anatomical and functional brain networks using Graph Signal Processing (GSP) and decision trees for ASD diagnosis, achieving superior accuracy on the ABIDE dataset. Identified the frontal and temporal lobes as critical for classification.	Relies heavily on fMRI data, which is costly and less accessible in many clinical contexts. Broader validation with multimodal data and diverse populations is needed.
(Rabie & Saleh, 2023)	Achieved high accuracy (93%) and low error (7%) in ASD diagnosis, leveraging blood test data and hybrid optimization techniques.	Evaluation metrics like accuracy and F1-score indicate strong performance, but real-world validation is limited.
(Yang et al., 2021)	Introduced 2D CAM, 3D CAM, and Grad-CAM for analyzing structural MRI data to identify biomarkers such as the left amygdala and right hippocampus, aiding ASD diagnosis	Focused on voxel values and specific ROIs; broader datasets and additional imaging modalities are required for validation and enhanced diagnostic applicability.
(Rubio-Martín et al., 2024)	Explored BERT, XGB, and Bi-LSTM on social media text for ASD diagnosis with 88% accuracy. Demonstrated the potential of NLP tools in screening ASD traits from unstructured data sources.	Heavily reliant on social media data, which may lack consistency and clinical relevance. Real-world clinical validation and testing in diverse populations are needed
(Alam et al., 2023)	Achieved 98.9% accuracy in ASD diagnosis using facial image datasets with pre-processing and augmentation, integrating explainable AI for clinician-friendly insights.	Requires additional validation in real-world clinical settings. Limited testing on diverse demographic datasets.
(Alam et al., 2024)	ResNet50V2 with face alignment preprocessing achieved 93.97% accuracy and 96.33% AUC for ASD diagnosis, highlighting the importance of aligned training samples in improving deep learning model performance.	Limited to a single face alignment algorithm (MTCNN). Broader exploration with different alignment techniques and datasets is necessary to validate the findings.
(Penev et al.,	Demonstrated significant improvement in Social Responsiveness Score-2 (SRS-2) after 4 weeks of consistent use.	Limited to controlled settings and requires additional research for broader clinical application and

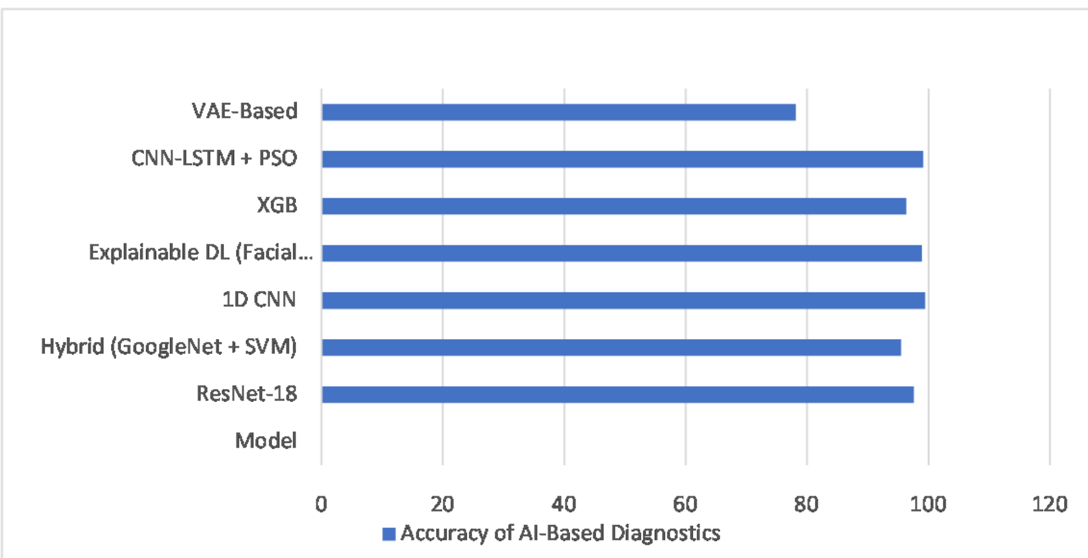
2021)		longitudinal effects.
(Washington et al., 2022)	Demonstrated that crowd annotations, even with visual privacy transformations like pixelation or blurring, align closely with clinical autism impressions, achieving AUROC up to 90%.	Misdiagnosis rates increase with privacy transformations; the method requires further testing on diverse datasets to ensure scalability and generalizability.
(Zhang et al., 2022).	Proposed a framework using step distribution curve-based feature selection and a pre-trained VAE to improve ASD classification, achieving 78.12% accuracy with high sensitivity and specificity.	Focused on rs-fMRI data only; multimodal data integration remains unexplored for enhanced diagnostic utility.

Previous studies have broadly highlighted the significant potential of AI in enhancing the accuracy, efficiency, and accessibility of services for individuals with Autism Spectrum Disorder (ASD). Advanced techniques, such as Convolutional Neural Networks (CNNs), Support Vector Machines (SVMs), and hybrid models, have demonstrated impressive accuracy rates of up to 99% in early ASD detection. Moreover, multimodal approaches that combine visual, auditory, and textual data hold promise for offering a comprehensive understanding of ASD.

AI-powered technologies have also facilitated the development of intervention tools, including educational robotics, mobile applications, and IoT-based systems, aimed at improving social skills, communication, and behavior management. However, existing research has identified certain limitations, such as insufficient validation in real-world settings, a predominant focus on pediatric populations, and limited accessibility in resource-constrained regions. Additionally, there remains a pressing need for an ethical framework to address concerns related to data privacy, algorithmic transparency, and obtaining informed consent.

4.1. Accuracy of AI-Based Diagnostics

Figure 2. Accuracy of AI-Based Diagnostics



The figure 2 highlights several key insights: (1) Deep learning-based models, such as CNN and ResNet-18, consistently achieve high accuracy, demonstrating significant potential for automated diagnosis based on visual data. (2) Hybrid models, like GoogleNet combined with SVM, excel by integrating the strengths of machine learning and deep learning, enhancing robustness and accuracy. (3) Explainable AI (XAI) is becoming increasingly critical to improve the interpretability of diagnostic outcomes, thereby supporting its application in clinical settings.

Convolutional Neural Networks (CNNs) are specifically designed to process data with a grid-like topology, making them ideal for image analysis tasks. Utilizing convolutional layers to automatically extract features from images, followed by pooling layers to reduce dimensionality, CNNs excel in capturing hierarchical feature representations from raw pixel data, offering a significant advantage over traditional image processing techniques. Studies have demonstrated their high accuracy in applications such as tumor detection and classification in radiology (Esteva et al., 2019; Litjens et al., 2017). Building upon CNN architectures, ResNet-18, a deep residual network, introduces skip connections that facilitate the effective flow of gradients during training. This innovation enables ResNet-18 to outperform conventional CNNs, particularly in complex medical imaging tasks where capturing nuanced patterns is critical (He et al., 2016). Additionally, hybrid models that integrate deep learning and traditional machine learning approaches, such as GoogleNet combined with Support Vector Machines (SVM), offer further advancements in diagnostic accuracy and robustness. GoogleNet's inception modules enable multi-scale feature extraction, addressing variations in size and shape commonly encountered in medical imaging (Szegedy et al., 2015). When combined with SVM's strong classification capabilities, hybrid models effectively enhance generalization, reduce overfitting, and achieve superior performance, especially in scenarios with limited labeled data (Zhang et al., 2019). These integrated approaches leverage the strengths of both methodologies, providing more reliable and accurate diagnostic outcomes.

4.2. Research Distribution by Category

Table 2. Distribution of Research in 2020 - 2024 by Category

Category	Number of Studies	Percentage (%)
Diagnosis	15	27.27%
Intervention	13	23.64%
IoT & Sensors	10	18.18%
Emotional & Social	12	21.82%
Multimodal	5	9.09%
	55	100%

The data indicates a diversified focus in research related to Artificial Intelligence (AI) for Autism Spectrum Disorder (ASD), categorized into five primary domains. Below is a detailed analysis of each category:

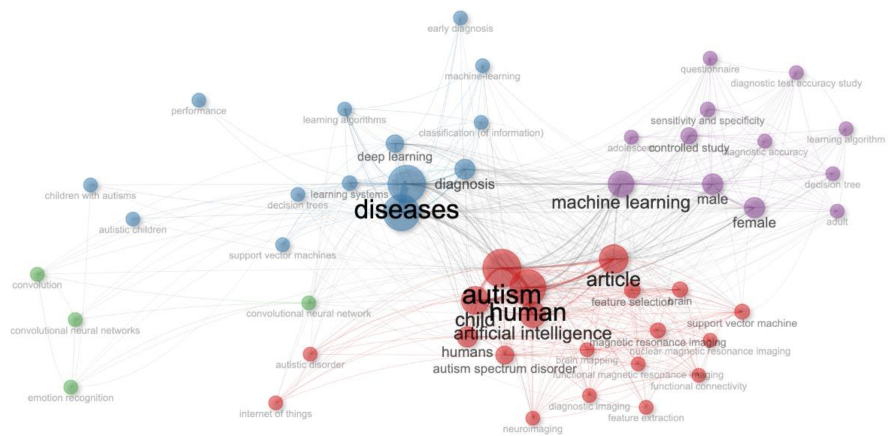
- Diagnosis (27.27%)
  Research efforts are predominantly concentrated on diagnostic applications of AI, reflecting the critical need for accurate and early identification of ASD. Tools such as Convolutional Neural Networks (CNNs) and ResNet-18 are widely used in this domain, achieving high accuracy rates for identifying neurological markers associated with ASD (Ahmed et al., 2022). These advancements address the limitations of traditional diagnostic methods, which are often subjective and rely heavily on observational data. Studies have also explored computer vision techniques and speech pattern analysis to detect early symptoms, demonstrating significant reliability and reducing diagnostic variability (Krupa-Kotara, 2023).
- Intervention (23.64%)
  Intervention-focused studies investigate how AI can be leveraged to support therapy and skill development in children with ASD. Technologies such as social robots (e.g., NAO) and interactive learning platforms have been integrated with AI algorithms to improve social interaction, communication, and emotional recognition skills (Mutawa et al., 2023). These interventions are especially effective in enhancing engagement and retention in therapy sessions.
- IoT & Sensors (18.18%)
  Internet of Things (IoT) and sensor-based applications are gaining traction for real-time monitoring and behavioral analysis. For example, wearable devices equipped with AI analyze physiological data, such as heart rate variability, to assess emotional states and behavioral patterns in individuals with ASD (Abdel Hameed et al., 2022). These tools offer continuous monitoring, providing caregivers and clinicians with valuable insights into the individual's condition.
- Emotional & Social (21.82%)
  Research in this category emphasizes the role of AI in enhancing emotional recognition and social skills. Explainable AI (XAI) and emotion recognition systems have been employed to identify and interpret facial expressions, voice tones, and body language, facilitating the development of tailored interventions. For instance, the Emo-Mirror system uses AI to teach children how to recognize and respond to emotions effectively (Wali et al., 2023).
- Multimodal (9.09%)
  Multimodal studies integrate diverse data types, such as visual, auditory, and textual inputs, to provide a holistic understanding of ASD characteristics. Although this category accounts for the smallest proportion of research, its potential is substantial. Integrated models like CNN-LSTM and decision support frameworks have demonstrated significant improvements in diagnostic accuracy by combining data from multiple modalities (Jung et al., 2024).

The distribution of research categories underscores the multi-faceted approach AI technologies are taking to address ASD challenges. Diagnosis remains a priority, but the rise of intervention-focused and IoT-based studies demonstrates the potential of AI to impact not just detection but also therapy and ongoing support. Future efforts should emphasize expanding multimodal applications and validating AI tools in diverse real-world settings to ensure their effectiveness and inclusivity.

4.3. Discussions

RQ: What are the potential benefits of artificial intelligence (AI) for people with Autism Spectrum Disorder in the field of computer science?

Figure 3. Deployment Flowchart Research



These observations underscore the transformative potential of AI technologies in enhancing the accuracy and timeliness of Autism Spectrum Disorder (ASD) diagnoses. Traditional diagnostic methods are often subjective and prone to variability, while AI-driven approaches address these limitations by analyzing extensive datasets to uncover behavioral and neurological markers that might escape human observation. For instance, computer vision techniques have been successfully applied to identify early signs of autism, significantly improving diagnostic reliability (Krupa-Kotara, 2023). Moreover, integrated decision support systems (IDSS) have demonstrated superior performance compared to conventional methods, providing a more standardized and evidence-based framework for diagnosing Autism Spectrum Disorder (Alsaidi, 2024).

Artificial Intelligence (AI) plays a pivotal role in revolutionizing the design and delivery of tailored interventions for individuals with Autism Spectrum Disorder (ASD). By leveraging AI's ability to analyze and adapt to individual needs, interventions can be more personalized, effective, and inclusive. One prominent example is the application of Virtual Reality (VR), which creates immersive environments where individuals with Autism Spectrum Disorder can practice social interactions, communication, and behavioral responses in a controlled and supportive setting. This approach allows users to engage in realistic scenarios that simulate real-world challenges while minimizing sensory overload, a common difficulty for many individuals with ASD. Research by Malihi et al. (2020) highlights the effectiveness of VR-based interventions in fostering skill development and behavioral learning among children with Autism Spectrum Disorder. These immersive experiences enable children to repeatedly practice specific behaviors, such as making eye contact or initiating conversations, in a non-threatening environment. This repetitive exposure helps reinforce positive behaviors and build confidence, which can be transferred to real-world interactions. Moreover, AI-powered systems take these interventions a step further by utilizing real-time progress data to continuously adapt the intervention strategies. For example, if an individual demonstrates improvement in one area, the system may introduce more complex scenarios to maintain engagement and challenge their skillset. Conversely, if difficulties are observed, the system can adjust the complexity or focus on foundational skills, ensuring the intervention remains effective and supportive (Lahiri et al., 2021). This adaptability is especially important in meeting the varied needs and abilities of individuals within the Autism Spectrum Disorder (ASD) community. Since each person with ASD is unique, AI's capacity to customize interventions ensures that every individual benefits from a tailored approach that aligns with their specific characteristics Additionally, such systems can provide caregivers and therapists with actionable insights, offering data-driven feedback to refine and enhance the intervention process (Abdel Hameed et al., 2022). Beyond VR, other AI applications, such as robotic systems and gamified learning platforms, are also being employed to support skill acquisition in Autism Spectrum Disorder. These tools often integrate interactive elements and AI-driven analytics to create engaging learning experiences while tracking progress. By providing consistent feedback and adapting to the user's needs, these systems can sustain motivation and facilitate long-term improvement (Mutawa et al., 2023). In summary, AI-driven interventions represent a transformative approach to addressing the unique needs of individuals with Autism Spectrum Disorder. Through immersive technologies like VR and adaptive systems powered by real-time data analysis, these interventions not only promote skill development and behavioral learning but also offer a scalable and personalized solution for diverse profiles. Future advancements in AI and related technologies hold the potential to further enhance the inclusivity, accessibility, and effectiveness of Autism Spectrum Disorder interventions (Krupa-Kotara, 2023).

AI-powered educational tools offer significant improvements in supporting students with ASD. Applications that employ activity schedules, for instance, have been found to promote appropriate behaviors and assist students in navigating daily routines (Genc-Tosun et al., 2023). These tools often include visual aids and reminders, helping students maintain focus and autonomy. Furthermore, AI can assist educators by identifying students' specific learning needs, enabling the development of customized instructional strategies aligned with individual learning preferences AI technologies, including social robots and interactive applications, have emerged as valuable tools for enhancing social skills among individuals with ASD. These tools simulate real-world social scenarios and provide real-time feedback, allowing users to practice communication and social cues in a safe, low-stress environment. Studies have demonstrated the potential of social robots to improve engagement and social interaction among children with ASD, fostering essential skills in an accessible format (Hoogdalem et al., 2021). AI has the potential to address significant accessibility challenges in ASD care, particularly for individuals in underserved or remote areas. Telehealth platforms powered by AI offer scalable solutions that connect families with ASD specialists regardless of geographic location. These platforms democratize access to quality care and reduce the disparities in service availability that often hinder timely interventions (Drahota et al., 2020). Such innovations hold promise for expanding the reach of ASD support services in low-resource settings. While the potential benefits of Artificial Intelligence for ASD are substantial, ethical considerations must be addressed to ensure equitable and responsible implementation. Issues such as data privacy, informed consent, and algorithmic bias require careful management to uphold the rights and dignity of individuals with ASD. Future research should focus on establishing ethical frameworks that guide the development and deployment of AI technologies, ensuring that these innovations align with principles of fairness and inclusivity.

5. Conclutions and Recommendation

5.1. Conclutions

This study reviewed 55 publications published between 2020 and 2024 using a scoping reviews approach to find trends, contributions, and difficulties in the diagnosis and treatment of autism spectrum disorder (ASD) using artificial intelligence (AI). According to the report, artificial intelligence has a significant impact on improving healthcare for people with ASD. Some of its main contributions include:

(1) Advances in Early Diagnosis
AI models such as Convolutional Neural Networks (CNNs), ResNet-18, and hybrid models (GoogleNet + SVM) offer high accuracy in ASD diagnosis, overcoming the limitations of subjectivity of traditional methods. These technologies enable early detection through analysis of behavioral patterns, neuroimaging, and genetic data, providing opportunities for faster intervention and better long-term outcomes.

(2) Personalization of Interventions
AI-based technologies support the development of solutions tailored to individual needs. Platforms such as Virtual Reality (VR) and telehealth provide access to remote therapies that can be customized based on real-time data, ensuring continued effectiveness of interventions. This approach has improved engagement, social skill development, and communication abilities of individuals with ASD.

(3) Multimodal and Holistic Approaches
Approaches that integrate visual, auditory and textual data are beginning to show great potential in improving diagnostic accuracy and intervention relevance. Although still limited, these approaches provide holistic insights that contribute to the development of evidence-based methods to address the complexities of ASD.

(4) Accessibility and Ethical Challenges
The research highlighted gaps in access to AI-based technologies, especially in low-income and remote areas. Lack of training for practitioners and technological infrastructure are major barriers. In addition, issues of data privacy and transparency of AI algorithms need to be addressed to ensure ethical and inclusive applications.

(5) Lack of Adult Research and Longitudinal Studies
Most existing research focuses on children, leaving significant gaps in the understanding of the needs and solutions for adult individuals with ASD. In addition, the lack of long-term studies limits the evaluation of the effectiveness of Artificial Intelligence based on interventions in the context of time.

5.2. Research Implications

The findings of this study offer valuable insights into both the potential and challenges of utilizing Artificial Intelligence (AI) for the diagnosis and intervention of Autism Spectrum

Disorder (ASD). A significant implication is the urgent need to strengthen policies that facilitate the adoption of AI-based technologies, particularly in regions with limited resources. Measures such as subsidizing technological devices, providing training for healthcare professionals, and improving infrastructure are crucial to ensure equitable access for all individuals. Furthermore, multimodal approaches that combine visual, auditory, and textual data present a promising avenue for enhancing diagnostic accuracy and tailoring interventions, thereby offering a more comprehensive understanding of ASD's complexities (Jung et al., 2024).
This study also underscores the necessity of establishing robust ethical and data privacy frameworks. These frameworks should encompass transparent algorithms, secure handling of sensitive data, and mechanisms for obtaining informed consent, all of which are essential for fostering public trust in AI-driven technologies (Lundberg & Lee, 2017). Additionally, there is a pressing need to focus research efforts on adults with ASD, a group often overlooked despite their unique challenges, particularly in developing social skills and achieving independence (Krupa-Kotara, 2023). Collaborative efforts involving computer scientists, medical professionals, and policymakers are critical to designing AI solutions that are effective, holistic, and user-centered (Mutawa et al., 2023). These findings and implications provide clear guidance for future research and the development of more inclusive, sustainable, and impactful AI-based services for individuals with ASD.

5.2. Limitations and Future Research

The study also highlights several limitations that warrant attention. A primary limitation is the restricted access to AI-based technologies in resource-limited regions, where inadequate technological infrastructure and the high cost of devices significantly hinder adoption. Furthermore, the absence of a comprehensive ethical framework for regulating the collection and use of sensitive data from individuals with ASD raises concerns about privacy and algorithm transparency. Another notable limitation is the predominant focus of existing research on children, leaving substantial gaps in understanding and addressing the needs of adults with ASD, who also require tailored interventions, particularly in areas such as social skills and independence. Additionally, the lack of longitudinal studies limits the ability to evaluate the long-term effectiveness and sustainability of AI-based interventions. Most of the studies analyzed were conducted in high-income countries, which poses challenges in generalizing findings to resource-constrained regions, such as developing nations. Addressing these limitations will guide future research toward becoming more inclusive, globally relevant, and responsive to the diverse needs of the ASD population.

References

Abdel Hameed, M., Hassaballah, M., Hosney, M. E., & Alqahtani, A. (2022). An AI-enabled Internet of Things-based autism care system for improving cognitive ability of children with autism spectrum disorders. *Computational Intelligence and Neuroscience*. https://doi.org/10.1155/2022/2247675

Aderinto, N. (2023). Autism in Africa: Prevalence, Diagnosis, Treatment and the Impact of Social and Cultural Factors on Families and Caregivers: A Review. Annals of Medicine and Surgery, 85(9), 4410–4416. https://doi.org/10.1097/ms9.0000000000001107

Ahmed, I. A., Senan, E. M., Rassem, T. H., Ali, M. A. H., Shatnawi, H. S. A., Alwazer, S. M., & Alshahrani, M. (2022). Eye tracking-based diagnosis and early detection of autism spectrum disorder using machine learning and deep learning techniques. Electronics (Switzerland). https://doi.org/10.3390/electronics11040530

Ahmed, K., Khan, M., Rizwan, U., & Mehmood, Z. (2023). Adaptive learning systems for autism education using cognitive models. Expert Systems with Applications. https://doi.org/10.1016/j.eswa.2023.119349

Akrofi, J. N. S. (2023). Exploring the Autism "Diagnostic Odyssey" in the Greater Accra Region of Ghana. South African Journal of Occupational Therapy, 53(3), 77–86. https://doi.org/10.17159/2310-3833/2023/vol53n3a

Alam, M. S., Rashid, M. M., Faizabadi, A. R., & Zaki, H. F. M. (2024). POWER OF ALIGNMENT: EXPLORING THE EFFECT OF FACE ALIGNMENT ON ASD DIAGNOSIS USING FACIAL IMAGES. IIUM Engineering Journal. https://doi.org/10.31436/iiumej.v25i1.2838

Alam, M. S., Rashid, M. M., Faizabadi, A. R., Mohd Zaki, H. F., Alam, T. E., Ali, M. S., Gupta, K. D., & Ahsan, M. M. (2023). Efficient Deep Learning-Based Data-Centric Approach for Autism Spectrum Disorder Diagnosis from Facial Images Using Explainable AI. Technologies. https://doi.org/10.3390/technologies11050115

Alarifi, S. (2024). Interventions Addressing Challenging Behaviours in Arab Children and Adults With Intellectual Disabilities and/or Autism: A Systematic Review. Journal of Applied Research in Intellectual Disabilities, 37(2). https://doi.org/10.1111/jar.13205

Al-Beltagi, M. (2024). Pre-Autism: Advancing Early Identification and Intervention in Autism. World Journal of Clinical Cases, 12(34), 6748–6753. https://doi.org/10.12998/wjcc.v12.i34.6748

Aldred, C. (2023). Paediatric Autism Communication Therapy Improved Long-Term Child Outcomes. Open Access Government, 38(1), 40–41. https://doi.org/10.56367/oag-038-10745

Alhakbani, N. (2024). Facial emotion recognition-based engagement detection in autism spectrum disorder. International Journal of Advanced Computer Science and Applications. https://doi.org/10.14569/IJACSA.2024.0150395

Alnuaimi, M., Alnuaimi, M. F., Alwan, R., & Ahmed, F. (2024). A blockchain-based secure framework for autism spectrum disorder patient data management. Information Systems. https://doi.org/10.1016/j.is.2024.102107

Alzamzami, A. A. (2023). Screening Tools Interventions and Strategies for Early Identification and Management of Autism Spectrum Disorders. International Journal of Community Medicine and Public Health, 10(10), 3870–3874. https://doi.org/10.18203/2394-6040.ijcmph20232865

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (5th ed.). American Psychiatric Association.

Ardeleanu, K. (2024). Self-Identification of Autism: Why Some Autistic Adults Lack a Clinical Diagnosis and Why This Matters for Inclusion. Autism. https://doi.org/10.1177/13623613241297222

Arivuselvan, K., Nadesh, R. K., & Perumal, R. S. (2022). ILAT (Software as a Service): Interactive Learning Application Tool for Autism Screening and Assessment in children with Autism Spectrum Disorder. International Journal on Recent and Innovation Trends in Computing and Communication. https://doi.org/10.17762/ijritcc.v10i11.5783

Asadinezhad, M. (2024). Machine Learning-Based Feature Selection for Predicting Autism Spectrum Disorder in Pediatric Neurodevelopmental Disorders. Med Discoveries, 3(6). https://doi.org/10.52768/2993-1142/1167

Association, A. P. (2013). Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) (5th (Ed.)). American Psychiatric Association. https://doi.org/10.1176/appi.focus.11.4.525

Azu, M. A. (2024). Clinician–caregiver Informant Discrepancy Is Associated With Sex, Diagnosis Age, and Intervention Use Among Autistic Children. Autism. https://doi.org/10.1177/13623613241279999

Bakheet K., D. . M. (2021). Linear and nonlinear analysis of intrinsic mode function after facial stimuli presentation in children with autism spectrum disorder. Computers in Biology and Medicine, 133, 104376. https://doi.org/10.1016/j.compbiomed.2021.104376

Bala, M., Ali, M. H., Satu, M. S., Hasan, K. F., & Moni, M. A. (2022). Efficient machine learning models for early stage detection of autism spectrum disorder. Algorithms. https://doi.org/10.3390/a15050166

Banihani, R. (2022). Prevalence of Autism Spectrum Disorder (ASD) in All Individuals Diagnosed With Down Syndrome (DS): A Systematic Review and Meta-Analysis Protocol. Journal of Clinical and Medical Research. https://doi.org/10.37191/mapsci-2582-4333-4(4)-118

Baoum, S., Gusti, W., Fardus, E., Alghanem, F., Hassan, M., Mohamed, F., Al-Khawaja, M., Algahtani, N., Aljadaan, A., Garoof, W., & Antar, A. A. (2022). Autism Screening in Family Medicine Practice: Early Detection, Barriers and Benefits. Journal of Healthcare Sciences, 02(05), 67–72. https://doi.org/10.52533/johs.2022.2501

Barnhart, R. K. (Ed.). (1988). Chambers dictionary of etymology. The H. W. Wilson Company

Bashir, N. (2024). Autism in Pakistan: Understanding the Challenges and Seeking Solutions. Eri, 4(1), 96–104. https://doi.org/10.61866/eri.v4i1.65

Bhatt, S. (2024). Development of an App for Diagnosing Autism. International Journal of Science and Research Archive, 12(1), 2406–2410. https://doi.org/10.30574/ijsra.2024.12.1.1007

Bhatt, S. (2024). Integration of Virtual Reality (VR) and Artificial Intelligence (AI) in Autism Therapy. International Journal of Science and Research Archive, 12(1), 2400–2405. https://doi.org/10.30574/ijsra.2024.12.1.1006

Boulé, M., & Rivard, M. (2023). Emotional Experience of Families With an Immigrant Background Throughout the Autism Service Trajectory in Early Childhood. Families in Society the Journal of Contemporary Social Services, 105(2), 204–222. https://doi.org/10.1177/10443894231167640

Brown, S. & McIntyre, D. (1993). Making sense of teaching. Open University

Buranova, N., Dampf, M., Stevenson, B., & Sohl, K. (2022). ECHO Autism: Early Intervention Connecting Community Professionals to Increase Access to Best Practice Autism Intervention. Clinical Pediatrics, 61(8), 518–522. https://doi.org/10.1177/00099228221090710

Carter, E., Hughes, A., & White, L. (2023). Exploring augmented reality as a tool for improving autism therapy outcomes. Augmented Reality and Virtual Environments. https://doi.org/10.1007/s12395-023-00129-8

Chaturavitwong, P. (2023). Speech and Language in Children With Autism Spectrum Disorders. Siriraj Medical Bullentin, 16(1), 69–74. https://doi.org/10.33192/simedbull.v15i4.256480

Cheekaty, S., & Muneeswari, G. (2024). Exploring sparse Gaussian processes for Bayesian optimization in convolutional neural networks for autism classification. IEEE Access. https://doi.org/10.1109/ACCESS.2024.3351168

Chen, Y.-H., Wang, W., & Zhang, C. (2023). A computer-vision-based system for early autism screening using facial microexpressions. Pattern Recognition. https://doi.org/10.1016/j.patcog.2023.109197

Chistol, M., & Danubianu, M. (2024). Automated detection of autism spectrum disorder symptoms using text mining and machine learning for early diagnosis. International Journal of Advanced Computer Science and Applications. https://doi.org/10.14569/IJACSA.2024.0150264

Choi, H., Park, J., & Shin, S. (2024). Parent-mediated interventions using digital platforms for children with autism. Research in Autism Spectrum Disorders. https://doi.org/10.1016/j.rasd.2024.101019

Christopher, K., & Lord, C. (2022). Best Practice Assessments for Autism Spectrum Disorders in Schools. Psychology in the Schools, 59(7), 1454–1468. https://doi.org/10.1002/pits.22680

Cooper, L., Evans, T., & Morgan, R. (2024). The impact of personalized music therapy on sensory processing in autism. Music Therapy Perspectives. https://doi.org/10.1093/mtp/miac024

Drahota, A., Sadler, R. C., Hippensteel, C., Ingersoll, B., & Bishop-Fitzpatrick, L. (2020). Service Deserts and Service Oases: Utilizing Geographic Information Systems to Evaluate Service Availability for Individuals With Autism Spectrum Disorder. Autism, 24(8), 2008–2020. https://doi.org/10.1177/1362361320931265

Drakeford, O. M. (2024). Reimagining Autism Research in the U.S.: A Synergistic Approach Between Social Work, Public Health, and Data Analytics. International Journal of Applied Research in Social Sciences, 6(12), 2916–2928. https://doi.org/10.51594/ijarss.v6i12.1768

Drakeford, O. M. (2024). Transforming Autism Care in the U.S.: Conceptualizing a Data-Driven, Social Work-Based Framework for Early Diagnosis and Intervention. International Journal of Frontiers in Medicine and Surgery Research, 6(2), 117–125. https://doi.org/10.53294/ijfmsr.2024.6.2.0051

Duan L.; Liu, Y.; Lee, J., L. . X. (2009). Cluster-based outlier detection. Annals of Operations Research, 168(1), 151–168. https://doi.org/10.1007/s10479-008-0371-9

El-Sattar, H. K. H. A. (2023). EMOCASH: An intelligent virtual-agent based multiplayer online serious game for promoting money and emotion recognition skills in Egyptian children with autism. International Journal of Advanced Computer Science and Applications. https://doi.org/10.14569/IJACSA.2023.0140414

Ercolano, G., Rossi, S., Conti, D., & Di Nuovo, A. (2024). Gesture recognition with a 2D low-resolution embedded camera to minimize intrusion in robot-led training of children with autism spectrum disorder. Applied Intelligence. https://doi.org/10.1007/s10489-024-05477-z

Faraji, S., Najafabadi, M. G., Zandi, H. G., & Parent-Nichols, J. (2022). Water-Based Exercise Therapy and Improvement in the Motor Skills and Cognitive Function of Children With Autism Spectrum Disorder: A Commentary. Russian Open Medical Journal, 11(1). https://doi.org/10.15275/rusomj.2022.0112

Farzana, W., Sarker, F., Chau, T., & Mamun, K. A. (2024). Technological Evolvement in AAC Modalities to Foster Communications of Verbally Challenged ASD Children: A Systematic Review. Ieee Access, 1. https://doi.org/10.1109/access.2021.3055195

Ferrer, R., Ali, K., & Hughes, C. (2024). Using AI-based virtual companions to assist adolescents with autism in recognizing and addressing cyberbullying. Sensors. https://doi.org/10.3390/s24123875

Garg, A., Parashar, A., Barman, D., Jain, S., Singhal, D., Masud, M., & Abouhawwash, M. (2022). Autism spectrum disorder prediction by an explainable deep learning approach. Computers, Materials and Continua. https://doi.org/10.32604/cmc.2022.022170

Geannopoulos, Z. F. (2024). Outcomes in PEERS® for Adolescents Across Neurodevelopmental Disorders: ADHD, Autism, and Their Co-Occurrence. Advances in Neurodevelopmental Disorders, 8(4), 614–626. https://doi.org/10.1007/s41252-023-00380-z

Genc-Tosun, D., Özkan, Ş. Y., & EYİİP>, Ö. D. (2023). How the Activity Schedules Impact the Children With Autism Spectrum Disorder? A Meta-Analysis. Kuramsal Eğitimbilim, 16(1), 1–19. https://doi.org/10.30831/akukeg.1109787

Govaerts, S., Verbert, K., Klerkx, J., & Duval, E. (2010). Visualizing activities for self-reflection and awareness. Lecture Notes in Computer Science, 6483, 91-100.

Green, J., Porter, E., & Smith, K. (2024). The effectiveness of virtual learning environments for children with autism spectrum disorder. Journal of Educational Computing Research. https://doi.org/10.1177/0735633123123456

Grzadzinski D.; Landa, R.; Watson, L.; Guralnick, M.; Zwaigenbaum, L.; Deák, G.; Estes, A.; Brian, J.; Bath, K.; Elison, J.; Abbeduto, L.; Wolff, J.; Piven, J., R. . A. (2021). Pre-symptomatic intervention for autism spectrum disorder (ASD): defining a research agenda. Journal of Neurodevelopmental Disorders, 13(1), 49. https://doi.org/10.1186/s11689-021-09393-y

Hadri, S. A., & Bouramoul, A. (2023). Towards a deep learning based contextual chatbot for preventing depression in young children with autism spectrum disorder. Smart Health. https://doi.org/10.1016/j.smhl.2022.100371

Hall, R., Knight, T., & Adams, J. (2023). Social robot interactions: Enhancing communication skills in children with autism. International Journal of Social Robotics. https://doi.org/10.1007/s12369-023-01082-4

Hao, H., & Hu, S. (2022). Recommendation optimization of physical education for developing the intelligence of autistic children following intelligent collaborative filtering algorithm. Mobile Information Systems. https://doi.org/10.1155/2022/1388872

Harris, P., White, D., & Kelly, G. (2024). AI-driven diagnostic tools for autism spectrum disorder: Current capabilities and limitations. Diagnostics. https://doi.org/10.3390/diagnostics14010234

Hayes, J., Ford, T., & Russell, G. (2021). Autism Diagnosis as a Social Process. Autism, 26(2), 488–498. https://doi.org/10.1177/13623613211030392

Hoogdalem, L. E. v., Feijs, H. M. E., Bramer, W. M., Ismail, S., & Dongen, J. D. M. van. (2021). The Effectiveness of Neurofeedback Therapy as an Alternative Treatment for Autism Spectrum Disorders in Children. Journal of Psychophysiology, 35(2), 102–115. https://doi.org/10.1027/0269-8803/a000265

Horstmann, A. C., Mühl, L., Köppen, L., Lindhaus, M., Storch, D., Bühren, M., Röttgers, H. R., & Krajewski, J. (2022). Important preliminary insights for designing successful communication between a robotic learning assistant and children with autism spectrum disorder in Germany. Robotics. https://doi.org/10.3390/robotics11060141

Hu, L. (2023). How Do Media Representations of Autism Affect the Mental Well-Being of Autistic Families in China? Journal of Humanities Arts and Social Science, 6(4), 702–707. https://doi.org/10.26855/jhass.2022.12.028

Huang, W. D., Yoo, S. J., & Choi, J. H. (2008). Correlating college students' learning styles and how they use Web 2.0 applications for learning. In C. Bonk (Ed.), Proceedings of World

Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (pp. 2752-2759). AACE.

Itani, S., & Thanou, D. (2021). Combining anatomical and functional networks for neuropathology identification: A case study on autism spectrum disorder. Medical Image Analysis. https://doi.org/10.1016/j.media.2021.101986

Jiang X.; Luo, H.; Yin, S.; Kaynak, O., Y. . L. (2022). Quo vadis artificial intelligence? Discover Artificial Intelligence, 2(1), 4. https://doi.org/10.1007/s44163-022-00022-8

Jiang, X., Yang, Y., Zeng, S., Huang, X., & Zhao, Y. (2022). The Application of AI Robots in Autism Spectrum Disorder Children. Learning & Education, 10(8), 185. https://doi.org/10.18282/l-e.v10i8.3116

John, B. M. S. (2024). The Characterization of Feeding Challenges in Autistic Children. Autism, 28(9), 2381–2393. https://doi.org/10.1177/13623613241227518

John, B. S., & Ausderau, K. (2021). Relationships Between Household Income and Functional Independent Behavior for Children With Autism. Otjr Occupational Therapy Journal of Research, 41(4), 243–250. https://doi.org/10.1177/15394492211012654

Johnson, R., Patel, A., & Wilson, C. (2024). The role of gamification in autism education and intervention. Educational Technology Research and Development. https://doi.org/10.1007/s11423-024-10112-3

Jones, L., Wilson, R., & Carter, S. (2024). Advances in speech recognition systems for non-verbal individuals with autism. Speech Communication. https://doi.org/10.1016/j.specom.2024.103021

Jonkman, K. M., Back, E., & Begeer, S. (2022). Predicting Intervention Use in Autistic Children: Demographic and Autism-Specific Characteristics. Autism, 27(2), 428–442. https://doi.org/10.1177/13623613221102748

Joudar A. S.; Hamid, R. A.; Zahid, I. A.; Alqaysi, M. E.; Albahri, O. S.; Alamoodi, A. H., S. S. . A. (2023). Artificial intelligence-based approaches for improving the diagnosis, triage, and prioritization of autism spectrum disorder: a systematic review of current trends and open issues. Artificial Intelligence Review, 56(S1), 53–117. https://doi.org/10.1007/s10462-023-10536-x

Jugunta, S. B., El-Ebiary, Y. A. B., Saravanan, K. A., Prasad, K. S. R., Koteswari, S., Rachapudi, V., & Rengarajan, M. (2023). Unleashing the Potential of Artificial Bee Colony Optimized RNN-Bi-LSTM for Autism Spectrum Disorder Diagnosis. International Journal of Advanced Computer Science and Applications. https://doi.org/10.14569/IJACSA.2023.0141173

Jung, W., Jeon, E., Kang, E., & Suk, H.-I. (2024). EAG-RS: A novel explainability-guided ROI-selection framework for ASD diagnosis via inter-regional relation learning. IEEE Transactions on Medical Imaging. https://doi.org/10.1109/TMI.2023.3337362

Kadi, I. (2024). Intelligent Models for Early Autism Detection From MRI Images. Studies in Engineering and Exact Sciences, 5(2), e8464. https://doi.org/10.54021/seesv5n2-273

Kang, E., Heo, D.-W., Lee, J., & Suk, H.-I. (2024). A learnable counter-condition analysis framework for functional connectivity-based neurological disorder diagnosis. IEEE Transactions on Medical Imaging. https://doi.org/10.1109/TMI.2023.3337074

Kareem, A. K., AL-Ani, M. M., & Nafea, A. A. (2023). Detection of autism spectrum disorder using a 1-dimensional convolutional neural network. Baghdad Science Journal. https://doi.org/10.21123/bsj.2023.8564

Keller, R., Chieregato, S., Bari, S., Castaldo, R., Rutto, F., Chiocchetti, A., & Dianzani, U. (2020). Autism in Adulthood: Clinical and Demographic Characteristics of a Cohort of Five

Hundred Persons With Autism Analyzed by a Novel Multistep Network Model. Brain Sciences, 10(7), 416. https://doi.org/10.3390/brainsci10070416

Khoirunnisa A. N.; Dewi, L., A. N. . M. (2023). Design and Prototype Development of Augmented Reality in Reading Learning for Autism. Computers, 12(3). https://doi.org/10.3390/computers12030055

Khoirunnisa M.; Shahbodin, F.; Dewi, L., A. N. . M. (2024). Augmented Reality Based Personalized Learning in Autism Spectrum Disorder Reading Skills. Journal of Special Education Technology. https://doi.org/10.1177/01626434241236738

Kiarashi, Y., Suresha, P., Rad, A., Reyna, M., Anderson, C., Foster, J., Lantz, J., Villavicencio, T., Hamlin, T., & Clifford, G. (2024). Off-body sleep analysis for predicting adverse behavior in individuals with autism spectrum disorder. IEEE Journal of Biomedical and Health Informatics. https://doi.org/10.1109/JBHI.2024.3455942

Kim, S., Lee, D., & Cho, J. (2023). A machine learning-based system for predicting autism spectrum disorder traits. IEEE Transactions on Neural Networks and Learning Systems. https://doi.org/10.1109/TNNLS.2023.3056721

Klintwall S., L. . E. (2014). Early and intensive behavioral intervention (EIBI) in autism. Comprehensive Guide Autism, 1, 117–137.

Koehler, J. C., & Falter-Wagner, C. M. (2023). Digitally Assisted Diagnostics of Autism Spectrum Disorder. Frontiers in Psychiatry, 14. https://doi.org/10.3389/fpsyt.2023.1066284

Krupa-Kotara, K. (2023). Sensory Integration Disorders in Children With Autism Spectrum Disorder—A Review Study. Appl. Psychol. Res., 2(1), 548. https://doi.org/10.59400/apr.v2i1.548

Lan, Y. J., Lyu, B. N., & Chin, C. K. (2019). Does a 3D immersive experience enhance Mandarin writing by CSL students? Language Learning & Technology, 23(2), 125-144. https://doi.org/10125/44686

Langer R. N., M. . L. (2021). The future of artificial intelligence at work: A review on effects of decision automation and augmentation on workers targeted by algorithms and third-party observers. Computers in Human Behavior, 123, 106878. https://doi.org/10.1016/j.chb.2021.106878

Laszlo, A., & Castro, K. (1995). Technology and values: Interactive learning environments for future generations. Educational Technology, 35(2), 7-13.

Leadbitter, K., Macdonald, W., Taylor, C., & Buckle, K. L. (2020). Parent Perceptions of Participation in a Parent-Mediated Communication-Focussed Intervention With Their Young Child With Autism Spectrum Disorder. Autism, 24(8), 2129–2141. https://doi.org/10.1177/1362361320936394

Lee, C. E., Shogren, K. A., Segal, J., Pezzimenti, F., Aleman-Tovar, J., & Taylor, J. L. (2021). Goal Attainment Scaling—community-Based: A Method to Incorporate Personalized Outcomes Into Intervention Research With Youth and Adults on the Autism Spectrum. Autism, 26(1), 178–187. https://doi.org/10.1177/13623613211024492

Lee, H.-J., Choi, Y., & Park, K. (2024). Real-time AI-driven tool for monitoring behavioral progress in children with autism. Sensors. https://doi.org/10.3390/s24030566

Lemaignan, S., Newbutt, N., Rice, L., & Daly, J. (2024). "It's important to think of Pepper as a teaching aid or resource external to the classroom": A social robot in a school for autistic children. International Journal of Social Robotics. https://doi.org/10.1007/s12369-022-00928-4

Liang, S., Sabri, A. Q. M., Alnajjar, F., & Loo, C. K. (2021). Autism spectrum self-stimulatory behaviors classification using explainable temporal coherency deep features and SVM classifier. IEEE Access. https://doi.org/10.1109/ACCESS.2021.3061455
Lord M.; Le Couteur, A., C. . R. (1994). Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. Journal of Autism and Developmental Disorders, 24(5), 659–685. https://doi.org/10.1007/BF02172145
Lord S.; DiLavore, P. S.; Shulman, C.; Thurm, A.; Pickles, A., C. . R. (2006). Autism From 2 to 9 Years of Age. Archives of General Psychiatry, 63(6), 694. https://doi.org/10.1001/archpsyc.63.6.694
Lord S.; Lambrecht, L.; Cook Jr., E. H.; Leventhal, B. L.; DiLavore, P. C.; Pickles, A.; Rutter, M., C. . R. (2000). The Autism Diagnostic Observation Schedule—Generic: A Standard Measure of Social and Communication Deficits Associated with the Spectrum of Autism. Journal of Autism and Developmental Disorders, 30(3), 205–223. https://doi.org/10.1023/A:1005592401947
Lord T. S.; Charman, T.; Cusack, J.; Dumas, G.; Frazier, T.; Jones, E. J. H.; Jones, R. M.; Pickles, A.; State, M. W.; Taylor, J. L.; Veenstra-VanderWeele, J., C. . B. (2020). Autism spectrum disorder. Nature Reviews Disease Primers, 6(1), 5. https://doi.org/10.1038/s41572-019-0138-4
Lu, Y. (2019). Artificial intelligence: a survey on evolution, models, applications and future trends. Journal of Management Analytics, 6(1), 1–29. https://doi.org/10.1080/23270012.2019.1570365
Luelmo, P., Sandoval, Y., & Kasari, C. (2020). Undocumented Mexican Mothers of Children With Autism: Navigating the Health Care and Educational Service Systems. International Journal of Developmental Disabilities, 68(4), 567–577. https://doi.org/10.1080/20473869.2020.1850159
Maharjan, J., Garikipati, A., Dinenno, F. A., Ciobanu, M., Barnes, G., Browning, E., DeCurzio, J., Mao, Q., & Das, R. (2023). Machine learning determination of applied behavioral analysis treatment plan type. Brain Informatics. https://doi.org/10.1186/s40708-023-00186-8
Malihi, M., Nguyen, J., Cardy, R. E., Eldon, S., Petta, C., & Kushki, A. (2020). Short Report: Evaluating the Safety and Usability of Head-Mounted Virtual Reality Compared to Monitor-Displayed Video for Children With Autism Spectrum Disorder. Autism, 24(7), 1924–1929. https://doi.org/10.1177/1362361320934214
Malone, T. W. (1984). Toward a theory of intrinsically motivating instruction. In D. F. Walker, & R. D. Hess (Eds.), Instructional software: Principles and perspectives for design and use (pp. 68-95). Wadsworth Publishing Company.
Malwane, M. I., Nguyen, E. B., Trejo, S. A., Kim, E. Y., & Cucalón-Calderón, J. R. (2022). A Delayed Diagnosis of Autism Spectrum Disorder in the Setting of Complex Attention Deficit Hyperactivity Disorder. Cureus. https://doi.org/10.7759/cureus.25825
Manohar P.; Chandrasekaran, V.; Rajkumar, R. P., H. . K. (2019). Early diagnosis and intervention for autism spectrum disorder: Need for pediatrician-child psychiatrist liaison. Indian Journal of Psychological Medicine, 41(1), 87–90.
Manzini, A., Jones, E. J. H., Charman, T., Elsabbagh, M., Johnson, M. H., & Singh, I. (2021). Ethical Dimensions of Translational Developmental Neuroscience Research in Autism. Journal of Child Psychology and Psychiatry, 62(11), 1363–1373. https://doi.org/10.1111/jcpp.13494

Mareeswaran, M. A., & Selvarajan, K. (2024). A computational intelligent analysis of autism spectrum disorder using machine learning techniques. IAES International Journal of Artificial Intelligence. https://doi.org/10.11591/ijai.v13.i1.pp807-816

Martinez, P., Gonzalez, R., & Ruiz, L. (2024). Exploring the use of chatbots for autism therapy: Challenges and opportunities. International Journal of Human-Computer Studies. https://doi.org/10.1016/j.ijhcs.2024.103109

Marukyan, V. (2023). Child With Autistic Spectrum Disorder: Care and Challenges. Armenian Journal of Special Education, 7(2), 78–91. https://doi.org/10.24234/se.v7i2.11

McNally, K., Wright, K., Goldkind, L., Kattari, S. K., & Victor, B. G. (2024). Disability expertise and large language models: A qualitative study of autistic TikTok creators' use of ChatGPT. Social Media and Society. https://doi.org/10.1177/20563051241279549

Megerian, J. T., Dey, S., Melmed, R. D., Coury, D. L., Lerner, M., Nicholls, C. J., Sohl, K., Rouhbakhsh, R., Narasimhan, A., Romain, J., Golla, S., Shareef, S., Ostrovsky, A., Shannon, J., Kraft, C., Liu-Mayo, S., Abbas, H., Gal-Szabo, D. E., Wall, D. P., & Taraman, S. (2022). Evaluation of an artificial intelligence-based medical device for diagnosis of autism spectrum disorder. Npj Digital Medicine. https://doi.org/10.1038/s41746-022-00598-6

Mengash, H. A., Alqahtani, H., Maray, M., Nour, M. K., Marzouk, R., Al-Hagery, M. A., Mohsen, H., & Al Duhayyim, M. (2023). Automated autism spectral disorder classification using optimal machine learning model. Computers, Materials and Continua. https://doi.org/10.32604/cmc.2023.032729

Mengi D., M. . M. (2022). Artificial Intelligence Based Techniques for the Detection of Socio-Behavioral Disorders: A Systematic Review. Archives of Computational Methods in Engineering, 29(5), 2811–2855. https://doi.org/10.1007/s11831-021-09682-8

Montiel-Nava, C., Montenegro, M. C., Ramírez, A. C., Valdez, D., Rosoli, A., García, R., Garrido, G., Cukier, S., Rattazzi, A., & Paula, C. S. d. (2023). Age of Autism Diagnosis in Latin American and Caribbean Countries. Autism, 28(1), 58–72. https://doi.org/10.1177/13623613221147345

Morgan, T., Bailey, J., & Davis, P. (2024). Virtual reality for sensory integration in children with autism spectrum disorder. Journal of Sensory Studies. https://doi.org/10.1111/joss.12783

Mukherjee, P., Gokul, R. S., Sadhukhan, S., Godse, M., & Chakraborty, B. (2023). Detection of Autism Spectrum Disorder (ASD) from natural language text using BERT and ChatGPT models. International Journal of Advanced Computer Science and Applications. https://doi.org/10.14569/IJACSA.2023.0141041

Mutawa, A. M., Al Mudhahkah, H. M., Al-Huwais, A., Al-Khaldi, N., Al-Otaibi, R., & Al-Ansari, A. (2023). Augmenting mobile app with NAO robot for autism education. Machines. https://doi.org/10.3390/machines11080833

Nagesh, N., Patil, P., Patil, S., & Kokatanur, M. (2022). An architectural framework for automatic detection of autism using deep convolution networks and genetic algorithm. International Journal of Electrical and Computer Engineering. https://doi.org/10.11591/ijece.v12i2.pp1768-1775

Narciso, R. (2024). Understanding and Supporting the Diversity of the Autistic Spectrum. Cuadernos De Educación Y Desarrollo, 16(2), e3337. https://doi.org/10.55905/cuadv16n2-027

Nguyen, K. (2024). Applying Artificial Intelligence in Diagnosis and Treatment of Autism Spectrum Disorder in Children. Journal of Student Research, 13(2). https://doi.org/10.47611/jsrhs.v13i2.6803

Nguyen, T., Pham, Q., & Tran, L. (2024). Internet of Things-based solutions for improving daily living skills in children with autism. Future Generation Computer Systems. https://doi.org/10.1016/j.future.2024.102738

Nisar M., S. . H. (2023). Neuroimaging genetics approaches to identify new biomarkers for the early diagnosis of autism spectrum disorder. Molecular Psychiatry, 28(12), 4995–5008. https://doi.org/10.1038/s41380-023-02060-9

O'Grady, M. (2021). A Study on the Impact of Coaching in Enhancing the Potential of Young Adults With Diagnosis of Autism to Better Manage Life Transitions. Transpersonal Psychology Review, 23(2), 16–21. https://doi.org/10.53841/bpstran.2021.23.2.16

Okoye, C. (2023). Early Diagnosis of Autism Spectrum Disorder: A Review and Analysis of the Risks and Benefits. Cureus. https://doi.org/10.7759/cureus.43226

Oliveira, K. N. C. de, Fernandes, L. R., Santos, M. H. A. dos, Rodrigues, A. A., Bomtempo, C. M. S., & Feitosa, M. B. O. (2022). Late Diagnosis of Autism Spectrum Disorder (ASD): Repercussions and Challenges Encountered in Adolescence and Adulthood. International Journal of Advanced Engineering Research and Science, 9(11), 35–42. https://doi.org/10.22161/ijaers.911.5

Öztürk, D., Aydoğan, S., Köök, İ., Akın Bülbül, I., Özdemir, S., Özdemir, S., & Akay, D. (2024). Linguistic summarization of visual attention and developmental functioning of young children with autism spectrum disorder. Health Information Science and Systems. https://doi.org/10.1007/s13755-024-00297-4

Padgett, D. (2020). Learning theories: Understanding the 4 major ones for the classroom. https://www.leaderinme.org/blog/learning-theories/

Pan, Y., & Foroughi, A. (2024). Evaluation of AI tools for healthcare networks at the cloud-edge interaction to diagnose autism in educational environments. Journal of Cloud Computing. https://doi.org/10.1186/s13677-023-00558-9

Pandya S.; Verma, J., S. . J. (2024). A comprehensive analysis towards exploring the promises of AI-related approaches in autism research. Computers in Biology and Medicine, 168, 107801. https://doi.org/10.1016/j.compbiomed.2023.107801

Pang, Y. (2024). Service for Children With ASD From Culturally Linguistically Diverse Settings at a Glance. International Education Studies, 17(3), 34. https://doi.org/10.5539/ies.v17n3p34

Paolucci, C., Giorgini, F., Scheda, R., Alessi, F. V, & Diciotti, S. (2023). Early prediction of autism spectrum disorders through interaction analysis in home videos and explainable artificial intelligence. Computers in Human Behavior. https://doi.org/10.1016/j.chb.2023.107877

Pardeshi, P. D. C. (2024). Review Paper on an Early-Stage Autism Spectrum Detection System. International Journal of Advanced Research in Science Communication and Technology, 155–158. https://doi.org/10.48175/ijarsct-17224

Park, J.-W., Seo, K., & Kang, M. (2024). Deep reinforcement learning framework for personalized therapy in autism spectrum disorder. Neuroinformatics. https://doi.org/10.1007/s12021-024-09577-8

Parui, S., Samanta, D., Chakravorty, N., Ghosh, U., & Rodrigues, J. J. P. C. (2023). Artificial intelligence and sensor-based autism spectrum disorder diagnosis using brain connectivity analysis. Computers and Electrical Engineering. https://doi.org/10.1016/j.compeleceng.2023.108720

Patel, S., Kumar, V., & Shah, N. (2023). The integration of AI and wearable technology in autism care. IEEE Access. https://doi.org/10.1109/ACCESS.2023.3256789

Pavez, R., Diaz, J., Arango-Lopez, J., Ahumada, D., Mendez-Sandoval, C., & Moreira, F. (2023). Emo-mirror: A proposal to support emotion recognition in children with autism spectrum disorders. Neural Computing and Applications. https://doi.org/10.1007/s00521-021-06592-5

Penev, Y., Dunlap, K., Husic, A., Hou, C., Washington, P., Leblanc, E., Kline, A., Kent, J., Ng-Thow-Hing, A., Liu, B., Harjadi, C., Tsou, M., Desai, M., & Wall, D. P. (2021). A Mobile Game Platform for Improving Social Communication in Children with Autism: A Feasibility Study. Applied Clinical Informatics. https://doi.org/10.1055/s-0041-1736626

Pérez, A., Díaz, M., & González, P. (2024). Enhancing autism therapy sessions with augmented reality-based social stories. Journal of Visual Communication and Image Representation. https://doi.org/10.1016/j.jvcir.2024.104936

Perochon, S. (2023). Early Detection of Autism Using Digital Behavioral Phenotyping. Nature Medicine, 29(10), 2489–2497. https://doi.org/10.1038/s41591-023-02574-3

Pizur-Barnekow, K., Lang, A. C., & Barger, B. (2020). Development and Utility of the Family-Centered Autism Navigation Interview. Autism, 25(4), 1154–1160. https://doi.org/10.1177/1362361320972890

Podpečan, V. (2023). Can you dance? A study of child-robot interaction and emotional response using the NAO robot. Multimodal Technologies and Interaction. https://doi.org/10.3390/mti7090085

Popescu, A.-L., Popescu, N., Dobre, C., Apostol, E.-S., & Popescu, D. (2022). IoT and AI-based application for automatic interpretation of the affective state of children diagnosed with autism. Sensors. https://doi.org/10.3390/s22072528

Porter, M., Omar, M., Campus, C., & Edinburgh, S. (2008, January). Marketing to the bottom of the pyramid: Opportunities in emerging market. Paper presented at the 7th International Congress Marketing Trends, Venice, Italy.

Posar, A., & Visconti, P. (2020). Is It Autism? Some Suggestions for Pediatricians. Türk Pediatri Arşivi. https://doi.org/10.14744/turkpediatriars.2020.59862

Priyadarshini, I. (2023). Autism screening in toddlers and adults using deep learning and fair AI techniques. Future Internet. https://doi.org/10.3390/fi15090292

Rabie, A. H., & Saleh, A. I. (2023). A new diagnostic autism spectrum disorder (DASD) strategy using ensemble diagnosis methodology based on blood tests. Health Information Science and Systems. https://doi.org/10.1007/s13755-023-00234-x

Rao, V. S. (2024). Parent Mediated Interventions for Children With Autism Across India: A Qualitative Study. Journal of Indian Association for Child and Adolescent Mental Health, 20(1), 59–64. https://doi.org/10.1177/09731342241226505

Rattaz, C., Loubersac, J., Michelon, C., Geoffray, M., Picot, M., Münir, K., & Baghdadli, A. (2022). Factors Associated With Age of Diagnosis in Children With Autism Spectrum Disorders: Report From a French Cohort. Autism, 26(8), 2108–2116. https://doi.org/10.1177/13623613221077724

Rearabiloe, M. (2023). A Narrative Review on the Prevalence of Autism in a South African Context. Environment and Social Psychology, 8(3). https://doi.org/10.54517/esp.v8i3.1726

Risi C.; Gotham, K.; Corsello, C.; Chrysler, C.; Szatmari, P.; Cook, E. H.; Leventhal, B. L.; Pickles, A., S. . L. (2006). Combining Information From Multiple Sources in the Diagnosis of Autism Spectrum Disorders. Journal of the American Academy of Child & Adolescent Psychiatry, 45(9), 1094–1103. https://doi.org/10.1097/01.chi.0000227880.42780.0e

Rivera, A., Perez, M., & Delgado, S. (2023). Cognitive training games for autism: Effects on executive function and attention. Journal of Cognitive Enhancement. https://doi.org/10.1007/s41465-023-00456-8

Ruan, M., Zhang, N., Yu, X., Li, W., Hu, C., Webster, P. J., Paul, K. L., Wang, S., & Li, X. (2024). Can micro-expressions be used as a biomarker for autism spectrum disorder? Frontiers in Neuroinformatics. https://doi.org/10.3389/fninf.2024.1435091

Rubio-Martín, S., García-Ordás, M. T., Bayón-Gutiérrez, M., Prieto-Fernández, N., & Benítez-Andrades, J. A. (2024). Enhancing ASD detection accuracy: a combined approach of machine learning and deep learning models with natural language processing. Health Information Science and Systems. https://doi.org/10.1007/s13755-024-00281-y

Sadek, E. T., Seada, N. A., & Ghoniemy, S. (2020). Computer Vision Techniques for Autism Symptoms Detection and Recognition: A Survey. International Journal of Intelligent Computing and Information Sciences, 20(2), 89–111. https://doi.org/10.21608/ijicis.2020.46360.1034

Sassu, K. A., & Volkmar, F. R. (2022). Autism and Intersectionality: Considerations for School-based Practitioners. Psychology in the Schools, 60(2), 408–418. https://doi.org/10.1002/pits.22757

Schertz, H. H., Lester, J. N., Erden, E., Safran, S., & Githens, P. (2020). Challenges and Contributors to Self-Efficacy for Caregivers of Toddlers With Autism. Autism, 24(5), 1260–1272. https://doi.org/10.1177/1362361319899761

Schmidt, M., Glaser, N., Palmer, H., Schmidt, C., & Xing, W. (2023). Through the lens of artificial intelligence: A novel study of spherical video-based virtual reality usage in autism and neurotypical participants. Computers and Education: X Reality. https://doi.org/10.1016/j.cexr.2023.100041

Schunk, D. H. (2016). Learning theories—An educational perspective (7th ed.). Person.

Shahamiri F., S. R. . T. (2020). Autism AI: a New Autism Screening System Based on Artificial Intelligence. Cognitive Computation, 12(4), 766–777. https://doi.org/10.1007/s12559-020-09743-3

Sharma, R., Bhattacharya, S., Gupta, R., Das, A., & Saha, B. (2023). Multimodal emotion recognition for autism care using hybrid deep learning models. Neurocomputing. https://doi.org/10.1016/j.neucom.2023.03.082

Silva, B. L. d. (2024). I Am an Autistic Mother With an Autistic Child": Documentary Analysis of Family Overload. Revista De Gestão Social E Ambiental, 18(8), e08516. https://doi.org/10.24857/rgsa.v18n8-179

Singh, A., Gupta, P., Rao, R., & Kapoor, R. (2023). Smart wearable technology for autism spectrum disorder therapy support. Applied Soft Computing. https://doi.org/10.1016/j.asoc.2023.110905

Smile, S., Raffaele, C. T., & Perlin, R. (2020). Re-Imagining the Physicians' Role in the Assessment of Feeding Challenges in Children With Autism Spectrum Disorder. Paediatrics & Child Health, 26(2), e73–e77. https://doi.org/10.1093/pch/pxaa008

Smith, H., Black, M. H., Thompson, C., Falkmer, M., Falkmer, T., Girdler, S., & Milbourn, B. (2023). Exploration of Caregiver Experiences of Reported First Signs of Autism. Child Care Health and Development, 49(5), 879–888. https://doi.org/10.1111/cch.13096

Smith, J., Brown, L., & Taylor, M. (2023). Virtual reality as a tool for improving social skills in individuals with autism. Computers in Human Behavior. https://doi.org/10.1016/j.chb.2023.107242

Su, S.-W., Hung, C.-H., Chen, L.-X., & Yuan, S.-M. (2024). Development of an AI-based system to enhance school counseling models for Asian elementary students with emotional disorders. IEEE Access. https://doi.org/10.1109/ACCESS.2024.3483456

Sumiła, A. (2022). Autyzm – Dylematy Diagnostyczne. Między Biologią a Objawami. Psychologia Rozwojowa, 27(2), 27–41. https://doi.org/10.4467/20843879pr.22.009.17466

Tabassum, K. (2020). Using wireless and mobile technologies to enhance teaching and learning strategies. Indonesian Journal of Electrical Engineering and Computer Science. https://doi.org/10.11591/ijeecs.v17.i3.pp1555-1561

Taylor, P., Brooks, M., & Richards, A. (2023). Augmentative and alternative communication technologies for individuals with autism. Assistive Technology. https://doi.org/10.1080/10400435.2023.1145837

Thabtah, F. (2017). Autism Spectrum Disorder Screening. Proceedings of the 1st International Conference on Medical and Health Informatics 2017, 1–6. https://doi.org/10.1145/3107514.3107515

Thabtah, F., Spencer, R., Abdelhamid, N., Kamalov, F., Wentzel, C., Ye, Y., & Dayara, T. (2022). Autism screening: an unsupervised machine learning approach. Health Information Science and Systems, 10(1), 26. https://doi.org/10.1007/s13755-022-00191-x

Thomas, H., Edwards, K., & Simpson, J. (2023). Using eye-tracking technology to understand attention patterns in children with autism. Journal of Autism and Developmental Disorders. https://doi.org/10.1007/s10803-023-05922-1

Tingley, M. W., Monahan, W. B., Beissinger, S. R., & Moritz, C. (2009). Birds track their Grinnellian nice through a century of climate change. Proceedings of the National Academy of Science, USA, 106, 19637-19643.

Tiwari, R., Kaur, J., Goyal, S., Sharma, A., & Kumar, N. (2023). An intelligent system for autism spectrum disorder classification based on EEG signals. Biomedical Signal Processing and Control. https://doi.org/10.1016/j.bspc.2023.105504

Ullah, F., AbuAli, N. A., Ullah, A., Ullah, R., Siddiqui, U. A., & Siddiqui, A. A. (2023). Fusion-based body-worn IoT sensor platform for gesture recognition of autism spectrum disorder children. Sensors. https://doi.org/10.3390/s23031672

Wali, A., Alfrihidi, M., Alasiri, N., & Alsabei, N. (2023). Aawn: An interactive mobile application for improving the communication skills of Arab children with autism. TEM Journal. https://doi.org/10.18421/TEM123-10

Wall, D. P., Liu-Mayo, S., Salomon, C., Shannon, J., & Taraman, S. (2023). Optimizing a de novo artificial intelligence-based medical device under a predetermined change control plan: Improved ability to detect or rule out pediatric autism. Intelligence-Based Medicine. https://doi.org/10.1016/j.ibmed.2023.100102

Wang, M., & Yang, N. (2024). EmoAsst: Emotion recognition assistant via text-guided transfer learning on pre-trained visual and acoustic models. Frontiers in Computer Science. https://doi.org/10.3389/fcomp.2024.1304687

Wankhede M.; Shukla, M.; Nathiya, D.; R., R.; Kaur, P.; Goyanka, B.; Rahangdale, S.; Taksande, B.; Upaganlawar, A.; Khalid, M.; Chigurupati, S.; Umekar, M.; Kopalli, S. R.; Koppula, S., N. . K. (2024). Leveraging AI for the diagnosis and treatment of autism spectrum disorder: Current trends and future prospects. Asian Journal of Psychiatry, 101, 104241. https://doi.org/10.1016/j.ajp.2024.104241

Washington, P., Chrisman, B., Leblanc, E., Dunlap, K., Kline, A., Mutlu, C., Stockham, N., Paskov, K., & Wall, D. P. (2022). Crowd annotations can approximate clinical autism impressions from short home videos with privacy protections. Intelligence-Based Medicine. https://doi.org/10.1016/j.ibmed.2022.100056

Whiteley, P., Carr, K., & Shattock, P. (2021). Research, Clinical, and Sociological Aspects of Autism. Frontiers in Psychiatry, 12. https://doi.org/10.3389/fpsyt.2021.481546

Wieckowski, A. T., Zuckerman, K. E., Broder-Fingert, S., & Robins, D. L. (2022). Addressing Current Barriers to Autism Diagnoses Through a Tiered Diagnostic Approach Involving Pediatric Primary Care Providers. Autism Research, 15(12), 2216–2222. https://doi.org/10.1002/aur.2832

Wilson, M., Carter, J., & Hughes, T. (2023). Robotics in autism therapy: An overview of recent advancements. Robotics and Autonomous Systems. https://doi.org/10.1016/j.robot.2023.103581

Wulandari, I. A. (2024). Pengembangan Sistem Pendeteksi Gangguan Spektrum Autisme Dengan Menggunakan Metode Certainty Factor. Jurnal Komtika (Komputasi Dan Informatika), 8(1), 92–101. https://doi.org/10.31603/komtika.v8i1.11399

Xing, N. (2024). Artificial Intelligence to Support Children With Autism. Japmi, 2(1), 31–43. https://doi.org/10.60087/vol2iisue1.p43

Xu, W., Zhang, Y., & Chen, L. (2024). Mobile applications for autism therapy: Development and usability assessment. Journal of Autism and Developmental Disorders. https://doi.org/10.1007/s10803-024-06321-6

Yang, R., Ke, F., Liu, H., Zhou, M., & Cao, H.-M. (2021). Exploring sMRI Biomarkers for Diagnosis of Autism Spectrum Disorders Based on Multi Class Activation Mapping Models. IEEE Access. https://doi.org/10.1109/ACCESS.2021.3069211

Yanga, R. (2024). Retrospective Analysis of the Challenges and Highlights of Parenting Two-Year-Old Children Who Were Subsequently Recognised as Autistic. Advances in Autism, 10(4), 340–355. https://doi.org/10.1108/aia-02-2024-0012

Yoder, P. J., Stone, W. L., & Edmunds, S. R. (2020). For Which Younger Siblings of Children With Autism Spectrum Disorder Does Parent-Mediated Intervention Work? Autism, 25(1), 58–69. https://doi.org/10.1177/1362361320943373

Zhang Y., C. . L. (2021). Study on artificial intelligence: The state of the art and future prospects. Journal of Industrial Information Integration, 23, 100224. https://doi.org/10.1016/j.jii.2021.100224

Zhang, F., Wei, Y., Liu, J., Wang, Y., Xi, W., & Pan, Y. (2022). Identification of Autism spectrum disorder based on a novel feature selection method and Variational Autoencoder. Computers in Biology and Medicine. https://doi.org/10.1016/j.compbiomed.2022.105854

Zhang, T., Li, Y., Yang, X., & Chen, H. (2024). Natural language processing for enhancing communication in children with autism spectrum disorder. Artificial Intelligence in Medicine. https://doi.org/10.1016/j.artmed.2024.102600

Zhao, Y., Wang, X., & Liu, Q. (2023). Real-time emotion recognition systems for autism support using wearable sensors. Sensors and Actuators A: Physical. https://doi.org/10.1016/j.sna.2023.113546