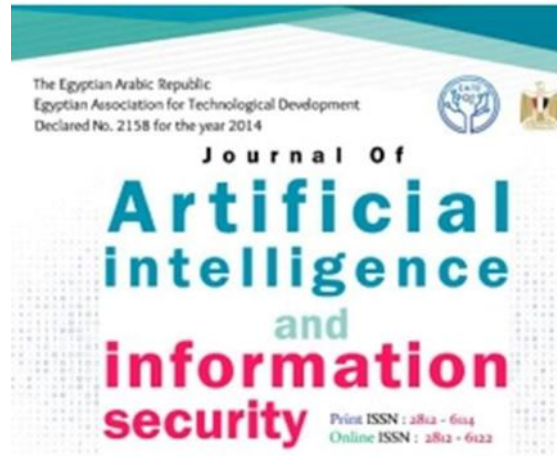




Artificial Intelligence-Powered Approaches for Autism Care: Techniques, Applications, and Future Directions

الأساليب المعززة بالذكاء الاصطناعي لرعاية التوحد: التقنيات، التطبيقات، وآفاق المستقبل

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Abstract

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition that affects communication, social interaction, and behavior. Rising prevalence rates worldwide place increasing challenges on families and clinicians, who often struggle to achieve early and reliable diagnosis. Conventional assessments, though valuable, are resource-intensive, subjective, and limited in scalability. Recent advances in Artificial Intelligence (AI) provide new opportunities to address these challenges. Techniques such as machine learning, deep learning, reinforcement learning, natural language processing (NLP), and generative approaches are being applied to improve early detection, personalize interventions, and develop assistive tools. These innovations hold promise for supporting clinicians, educators, and caregivers in both clinical and everyday contexts. However, persistent barriers—including limited datasets, algorithmic bias, and concerns about transparency, privacy, and ethics—continue to constrain broader adoption. Future progress will rely on multimodal, explainable, and culturally sensitive AI systems, validated through longitudinal and real-world studies. This review highlights both the potential and the responsibility of applying AI to autism care, emphasizing collaboration among researchers, practitioners, and families to ensure equitable and sustainable innovation.

Keywords: Autism Spectrum Disorder (ASD); Artificial Intelligence (AI); Machine Learning; Deep Learning; Natural Language Processing (NLP); Generative AI; Explainable AI (XAI); Early Diagnosis; Personalized Interventions.

المخلص

اضطراب طيف التوحد هو حالة عصبية نمائية متعددة الأوجه تؤثر على التواصل، والتفاعل الاجتماعي، والسلوك. تشكل معدلات الانتشار عالمياً تحديات متزايدة على الأسر والأطباء، الذين غالباً ما يواجهون صعوبة في تحقيق تشخيص مبكر وموثوق. وعلى الرغم من أن طرق التقييم التقليدية تظل ذات قيمة، إلا أنها تستهلك الكثير من الموارد، وتتسم بالذاتية، ومحدودة القابلية للتوسع. وتتيح التطورات الحديثة في مجال الذكاء الاصطناعي فرصاً جديدة لمواجهة هذه التحديات. حيث يتم تطبيق تقنيات مثل تعلم الآلة، والتعلم العميق، والتعلم المعزز، ومعالجة اللغة الطبيعية، والنهج التوليدية في الذكاء الاصطناعي لتحسين الاكتشاف المبكر، وتخصيص التدخلات، وتطوير الأدوات المساندة. وتُقدم تلك الابتكارات حلولاً واعدة في دعم الأطباء والمعلمين ومقدمي الرعاية في السياقات السريرية واليومية على حد سواء. ومع ذلك، لا تزال هناك عوائق مستمرة—مثل محدودية مجموعات البيانات، والتحيز الخوارزمي، والمخاوف المتعلقة بالشفافية والخصوصية والأخلاقيات—والتي تعيق التوسع في استخدامها. سيعتمد التقدم المستقبلي على أنظمة ذكاء اصطناعي متعددة الوسائط، قابلة للتفسير، ومراعية للثقافات، ومثبتة من خلال دراسات طويلة وواقعية. وتسلط هذه المراجعة الضوء على الإمكانيات والمسؤوليات المترتبة على تطبيق الذكاء الاصطناعي في رعاية مرضى التوحد، مؤكدة على أهمية التعاون بين الباحثين والممارسين والأسر لضمان الابتكار العادل والمستدام.

الكلمات المفتاحية: اضطراب طيف التوحد؛ الذكاء الاصطناعي؛ تعلم الآلة؛ التعلم العميق؛ معالجة اللغة الطبيعية؛ الذكاء الاصطناعي التوليدي؛ الذكاء الاصطناعي القابل للتفسير؛ التشخيص المبكر؛ التدخلات المخصصة.

1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by deficits in social interaction, communication challenges, and repetitive behaviors (Abualait et al., 2024; Hodges et al., 2020). According to the World Health Organization (WHO), approximately 1 in 100 children worldwide are affected, with prevalence steadily increasing in recent years (World Health Organization, 2023). A comprehensive systematic review and meta-analysis similarly highlights substantial regional and methodological variability in prevalence estimates (Salari et al., 2022). Beyond numbers, this rise reflects the growing struggles that families, educators, and healthcare providers face in supporting children with ASD in their daily lives. Early detection and intervention remain essential, offering opportunities to improve developmental outcomes and quality of life (Abualait et al., 2024; Zhang, 2025).

In recent years, Artificial Intelligence (AI) has emerged as a promising tool in autism care, not only as a technical innovation but also as a potential lifeline for families and teachers seeking timely support (Agrawal & Agrawal, 2025; Ahmed et al., 2025; Al-Nefaie et al., 2025). AI methods—ranging from machine learning (ML) and deep learning (DL) to generative models—are capable of analyzing complex behavioral, neurophysiological, and multimodal data, providing more accurate and scalable diagnostic support (Atlam et al., 2025; Kolding et al., 2025; Mahmood et al., 2025).

Moreover, **Explainable AI (XAI)** approaches are helping to build trust by making predictions transparent, enabling clinicians, caregivers, and educators to understand the reasoning behind automated recommendations (Agrawal & Agrawal, 2025; Atlam et al., 2025). AI-powered assistive technologies, including socially interactive robots and adaptive learning platforms, extend these advances into real-world environments—homes, schools, and clinics—where they can directly support communication, social engagement, and cognitive development (Omoyemi, 2024; Perry et al., 2024; Rêgo & Araújo-Filho, 2024).

Research Gap. Despite this progress, critical challenges remain. The literature is still dominated by studies relying on small, demographically narrow datasets

and mono-modal approaches (e.g., focusing on facial expressions or speech alone), limiting generalizability (Ahmed et al., 2025; Ding et al., 2024). Few large-scale, longitudinal, and cross-cultural studies have been conducted, and there is still limited evidence that AI tools are truly effective in the real-world settings where they matter most—homes, classrooms, and clinics.

Few large-scale, longitudinal, and cross-cultural investigations have been conducted, and evidence of AI effectiveness in practical settings such as homes, classrooms, and clinics remains limited (Perry et al., 2024; Sohn et al., 2025). Ethical concerns —particularly algorithmic bias, data privacy, and inclusivity— are also insufficiently addressed, creating barriers to equitable adoption (Kolding et al., 2025). These gaps are especially pronounced in Arab societies, where contributions remain minimal and culturally adapted datasets are scarce, limiting the contextual relevance of AI-powered solutions.

Objectives. This paper seeks to provide a comprehensive review of AI-powered approaches for autism care, with four main objectives:

1. To examine current AI techniques and tools used in autism screening, diagnosis, and intervention.
2. To highlight practical applications of AI across healthcare, education, and assistive technologies.
3. To analyze key challenges and ethical considerations in deploying AI for autism care.
4. To identify future research directions that can ensure equitable, explainable, and effective AI integration in autism care.

Ultimately, by synthesizing the latest evidence, this review not only informs researchers and practitioners about the transformative potential of AI in autism diagnosis and intervention, but also takes into account the daily challenges faced by families, educators, and clinicians. In doing so, it emphasizes that advancing AI in autism care is not merely a technical endeavor, but a human-centered mission aimed at fostering inclusion, improving quality of life, and supporting autistic individuals in real-world contexts.

2. Background and Related Work

2.1 Autism Spectrum Disorder: Definition and Prevalence

Autism Spectrum Disorder (ASD) is a heterogeneous neurodevelopmental condition characterized by persistent deficits in social interaction, communication difficulties, and restricted, repetitive behaviors (Abualait et al., 2024; Hodges et al., 2020). The DSM-5-TR adopts a **spectrum-based framework**, replacing earlier categorical diagnoses —such as Autistic Disorder, Asperger’s Disorder, and Pervasive Developmental Disorder (PDD)— with a single diagnosis of Autism Spectrum Disorder. The term *spectrum* emphasizes the continuum of symptom severity and functional impact observed across individuals, acknowledging the wide variability in communication, social interaction, and adaptive functioning among those with ASD (American Psychiatric Association, 2022).

According to the World Health Organization, ASD affects approximately 1 in 100 children worldwide, although prevalence rates vary across regions and diagnostic practices. Given the increasing global prevalence of ASD, the demand for scalable, accurate, and early diagnostic tools —such as AI-powered approaches— has become more pressing (World Health Organization, 2023; Zeidan et al., 2022).

2.2 Challenges in Traditional Diagnosis and Intervention

Conventional ASD diagnosis primarily relies on clinical observation, developmental history, and standardized behavioral assessments. Although effective, these approaches are time-intensive, require highly trained professionals, and are subject to inter-rater variability. In addition, limited access to specialized services in low-resource settings often delays both diagnosis and intervention (Rêgo & Araújo-Filho, 2024). Early detection is further challenged by environmental influences, culturally shaped perceptions of behavior, and overlapping symptoms with other neurodevelopmental disorders (Hodges et al., 2020). Collectively, these challenges underscore the urgent need for scalable, objective, and automated diagnostic and support tools.

2.3 Emergence of Artificial Intelligence in Autism Research

Artificial Intelligence (AI) has increasingly gained momentum as a transformative approach in autism care, offering the potential to address many

limitations of conventional methods. Recent advancements in AI have introduced innovative tools for early diagnosis, severity classification, personalized education planning, and targeted therapeutic support. Advances in machine learning (ML) and deep learning (DL) enable the automated analysis of multimodal data—such as facial expressions, speech, eye-tracking, and physiological signals—thus providing robust frameworks for early screening and accurate diagnosis (Ahmed et al., 2025; Ding et al., 2024). For instance, video-based deep learning models have demonstrated high accuracy in detecting early behavioral markers of ASD in children (Gautam et al., 2023; Serna-Aguilera et al., 2024). Moreover, explainable AI (XAI) techniques have been developed to improve model transparency and interpretability, allowing clinicians and caregivers to better understand the rationale behind AI-driven predictions and recommendations (Agrawal & Agrawal, 2025; Atlam et al., 2025).

2.4 AI Applications Beyond Diagnosis

Beyond diagnostic support, Artificial Intelligence has been increasingly applied in therapeutic and assistive domains. Socially interactive robots, gamified learning platforms, and adaptive communication tools have emerged to foster social engagement, language acquisition, and daily living skills among autistic individuals (Omoyemi, 2024; Perry et al., 2024). Recent longitudinal studies further demonstrate the effectiveness of AI-based platforms in enhancing and sustaining therapeutic outcomes for children with ASD (Atturu et al., 2025). In addition, generative AI approaches are now being explored to deliver personalized interventions and improve adaptive functioning within real-world environments (Kolding et al., 2025; Sohn et al., 2025).

2.5 Research Gaps in Current Literature

Despite these advancements, significant gaps remain. Many existing studies are constrained by small, homogenous datasets and often adopt a narrow, mono-modal focus—such as relying solely on facial recognition or speech analysis (Ahmed et al., 2025; Ding et al., 2024). Moreover, large-scale, longitudinal, and cross-cultural validation of AI systems remains scarce, which limits their generalizability and applicability in real-world clinical and educational contexts (Salomon et al., 2025; Sohn et al., 2025). Additionally, critical ethical

concerns—including algorithmic bias, inclusivity, and data privacy—remain insufficiently addressed (Kolding et al., 2025; Omoyemi, 2024). Addressing these gaps is essential to ensure that AI-driven solutions are both clinically reliable and socially equitable.

3. AI Techniques for Autism Care

Artificial Intelligence offers a range of techniques increasingly applied in autism care, supporting early diagnosis, adaptive therapy, and assistive communication. Yet, these methods also face challenges related to data availability, generalizability, and ethics. The following section reviews key AI approaches—spanning ML, DL, computer vision, NLP, RL, and emerging paradigms such as generative and explainable AI—while Figure (1) provides a visual summary of their main applications and limitations.

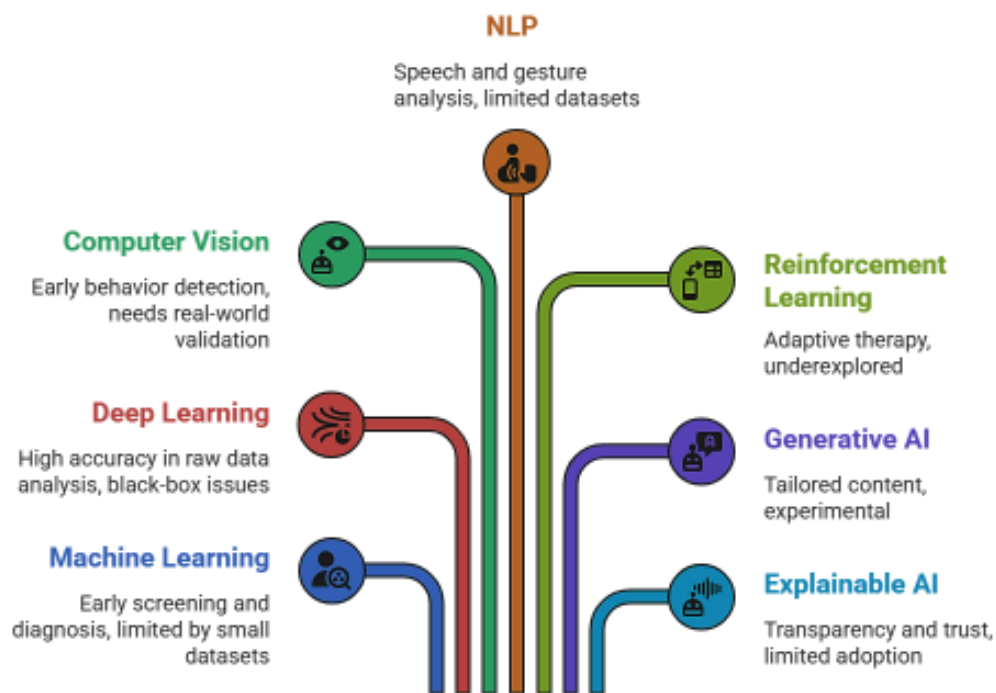


Figure (1): AI techniques for autism care

3.1 Machine Learning Approaches

Machine learning (ML) has played a foundational role in advancing autism research, offering tools that can analyze behavioral and clinical data to support early screening and diagnosis. Traditional ML algorithms, such as **support vector machines**, **random forests**, and **ensemble learning** methods, have been widely applied to classify ASD based on features extracted from

questionnaires, behavioral assessments, and physiological signals (Ahmed et al., 2025; Hatim et al., 2025). These models often achieve strong classification performance on research datasets; however, their utility is frequently constrained by small, demographically narrow samples and limited generalizability across settings and populations (Ahmed et al., 2025; Ding et al., 2024).

Real-world evaluations of AI-based autism diagnostics further underscore the need for broader external validation to ensure reliable performance outside controlled environments (Salomon et al., 2025). In parallel, hybrid pipelines that integrate predictive models with explanation layers—such as post-hoc XAI techniques—are increasingly explored to balance performance with interpretability and clinical usability (Agrawal & Agrawal, 2025; Atlam et al., 2025). These limitations have motivated a shift toward deep learning approaches, which leverage larger datasets and more complex feature representations to address some of the challenges faced by traditional ML methods.

3.2 Deep Learning Approaches

While traditional ML algorithms have laid the groundwork for AI in autism research, deep learning (DL) has emerged as a transformative advancement due to its ability to automatically learn hierarchical feature representations directly from raw data. Unlike ML methods that rely on handcrafted features, DL models—such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs)—can process complex multimodal inputs, including facial images, speech signals, and neuroimaging data, thereby achieving higher diagnostic accuracy and robustness (Al-Nefaie et al., 2025; Ding et al., 2024). Recent studies demonstrate that CNNs trained on video and image datasets can reliably detect subtle behavioral markers, such as facial expressions, eye gaze, and micro-movements, with remarkable precision in distinguishing autistic from neurotypical children (Gautam et al., 2023; Mahmood et al., 2025; Serna-Aguilera et al., 2024).

Moreover, explainable AI techniques have been introduced to mitigate the “black box” challenge in deep learning models by providing visual or statistical justifications that enhance clinical trust and usability (Atlam et al., 2025).

Despite these advances, persistent challenges —particularly dataset bias, demographic limitations, and the lack of cross-cultural validation— continue to constrain the generalizability of DL-based autism diagnostic systems.

3.3 Computer Vision Approaches

Computer vision has emerged as one of the most prominent applications of AI in autism research, particularly through the use of deep learning techniques (Ahmed et al., 2025; Perry et al., 2024). Convolutional neural networks (CNNs) and related architectures are widely employed to capture and analyze subtle visual cues associated with ASD, including facial expressions, gestures, and movement patterns (Gautam et al., 2023; Mahmood et al., 2025; Serna-Aguilera et al., 2024). These approaches enable the automated assessment of behavioral markers, offering scalable and non-invasive alternatives to traditional diagnostic methods (Atlam et al., 2025; Mahmood et al., 2025; Perry et al., 2024).

Video-based deep learning frameworks have demonstrated strong performance in detecting atypical behaviors and social interaction patterns in children, making them valuable for early screening and diagnosis (Gautam et al., 2023; Serna-Aguilera et al., 2024). Automated facial expression recognition has also been applied to identify emotional processing differences in children with ASD, with recent studies employing explainable deep learning models to improve transparency and clinical interpretability (Atlam et al., 2025). In addition, large-scale experiments on facial image datasets highlight the potential of such tools to complement conventional diagnostic practices and provide objective biomarkers (Mahmood et al., 2025).

Beyond facial and video analysis, computer vision has also been applied to **eye-tracking systems**, which can reveal atypical visual attention patterns —such as reduced fixation on socially relevant stimuli— commonly associated with ASD. In parallel, movement analysis has been explored to capture motor irregularities that may serve as supplementary indicators in the diagnostic process. While both approaches provide valuable complementary insights for early detection, their robustness across diverse populations remains limited and requires further validation in real-world contexts (Mahmood et al., 2025; Perry et al., 2024).

3.4 Natural Language Processing (NLP)

Natural Language Processing (NLP) has been widely employed in autism research to evaluate **speech patterns, vocabulary development, and overall communication style**, which are often atypical in autistic individuals (Agrawal & Agrawal, 2025). Linguistic and early gesture markers are particularly significant for early detection, as delays in gesture development and atypical speech patterns are among the earliest warning signs of ASD. For example, infants later diagnosed with ASD demonstrate a reduction in social gestures by 12–13 months of age (Liu et al., 2024; Zhang, 2025).

3.5 Reinforcement Learning and Gamified Interventions

Reinforcement learning (RL) has opened pathways for personalized and adaptive interventions in autism therapy. RL-based models can dynamically adjust therapy sessions according to the child's responsiveness and progress, offering tailored support that evolves over time (Atturu et al., 2025). Gamified learning platforms create engaging and interactive environments where children with ASD can practice communication, social interaction, and cognitive skills. These platforms enhance motivation and skill acquisition by leveraging game-based dynamics, which sustain user engagement over time (Perry et al., 2024).

From the researcher's perspective, while RL has been increasingly applied in adaptive AI systems for therapy personalization (Clabaugh et al., 2019), its integration into gamified interventions remains underexplored, highlighting the need for further empirical validation through longitudinal and large-scale studies. This gap is particularly evident in Arab contexts, where research contributions in this domain are still scarce, and culturally adapted datasets and intervention models remain underdeveloped.

3.6 Generative AI and Explainable AI

Generative AI (GenAI), including large language models (LLMs) and generative adversarial networks (GANs), have recently been investigated in autism care as a means to simulate social interactions, produce tailored educational materials, and design adaptive therapeutic environments (Kolding et al., 2025; Sohn et al., 2025). These tools hold potential for addressing individual differences by generating contextually relevant interventions that

evolve with the learner. In parallel, Explainable AI (XAI) has gained prominence as a critical complement to predictive models, ensuring that system outputs are interpretable, transparent, and clinically trustworthy (Agrawal & Agrawal, 2025). By providing rationales behind predictions, XAI technology builds confidence among clinicians, caregivers, and policymakers, thereby facilitating real-world adoption.

From the researcher’s perspective, however, both GenAI and XAI remain at a nascent stage in autism applications, with current evidence largely limited to conceptual frameworks or small-scale pilot studies. Ethical and regulatory concerns, including risks of bias propagation, privacy violations, and accountability, pose further obstacles to scaling these technologies into routine clinical or educational practice. This gap is particularly evident in Arab contexts, where GenAI- and XAI-driven autism research is nearly absent, underscoring the pressing need for culturally adapted datasets and ethically grounded implementations.

To conclude this section, Table (1) provides a comparative overview of the reviewed AI techniques, summarizing their applications, advantages, and challenges to support a clearer understanding of their roles in autism care.

Table (1): AI techniques in autism care

Technique	Main Contribution	Applications in ASD	Limitations
Machine Learning (ML)	Classifies ASD using structured data (e.g., questionnaires, physiological signals).	Early screening, diagnosis support.	Small/narrow datasets, low generalizability.
Deep Learning (DL)	Learns features directly from raw data (CNNs, RNNs).	Facial expression, speech, neuroimaging analysis.	Bias, lack of cross-cultural validation, black-box issue.
Computer Vision	Extracts subtle visual/social cues.	Video-based behavior detection, facial expression recognition, eye-tracking.	Limited real-world validation, demographic sensitivity.
Natural Language Processing (NLP)	Analyzes speech, language, and gesture markers.	Early detection via communication patterns.	Scarcity of large annotated datasets.

Technique	Main Contribution	Applications in ASD	Limitations
Reinforcement Learning (RL)	Adaptive, personalized therapy.	Gamified interventions, therapy adjustment.	Underexplored, few large-scale longitudinal studies.
Generative AI (GenAI)	Creates tailored educational/therapeutic content.	Simulating social interaction, adaptive learning.	Still experimental, ethical/privacy risks.
Explainable AI (XAI)	Adds interpretability to AI predictions.	Improves clinical trust, caregiver understanding.	Limited adoption, mostly pilot studies.

4. Applications of AI in Autism Care

AI has moved beyond experimental models to real-world applications in autism care, directly impacting diagnosis, intervention, communication, and family support. These applications illustrate how AI tools are increasingly integrated into homes, classrooms, and clinics, offering both opportunities and challenges. Figure (2) provides a visual overview of the main application areas of AI in autism care, highlighting their core focus and contributions.



Figure (2): AI applications in autism care

4.1 Early Diagnosis and Screening

Early identification of ASD is critical for optimizing therapeutic outcomes and supporting developmental progress. AI-powered diagnostic systems leverage multimodal data, such as facial images, eye-tracking, speech, and physiological signals, to detect early signs of autism with higher accuracy than conventional assessments (Ahmed et al., 2025; Serna-Aguilera et al., 2024).

Deep convolutional neural networks and other computer vision models have demonstrated strong performance in distinguishing autistic from neurotypical children using facial image classification, efficiently processing large volumes of images to support preliminary screening and potentially enhancing the accuracy of early ASD detection (Gautam et al., 2023).

Despite these advances, clinical adoption of AI systems for early ASD detection requires larger and more diverse datasets, cross-cultural validation, and transparent interpretability to ensure generalizability and reliability in real-world clinical and educational contexts (Salomon et al., 2025).

Based on the current literature, it can be concluded that AI-based approaches for ASD screening have so far focused primarily on image-based classification. Their potential application in adaptive, caregiver-interactive questionnaires remains unexplored, highlighting an important direction for future research.

4.2 Severity Classification and Individual Profiling

Beyond initial diagnosis, accurately assessing symptom severity and generating individualized profiles is essential for tailoring interventions in children with ASD. Traditional categorical frameworks, such as those defined in the DSM-5-TR, provide three severity levels based on support requirements (American Psychiatric Association, 2022). However, these rigid subdivisions may not fully capture the considerable heterogeneity in symptom presentation, intensity, and functional impact across individuals.

AI-powered approaches provide flexible, data-driven alternatives that complement traditional frameworks. **Hybrid reasoning systems**, which integrate rule-based knowledge or decision tree models with machine learning algorithms, enable explainable severity classification, supporting clinicians in understanding the rationale behind predictions while maintaining diagnostic accuracy (Agrawal & Agrawal, 2025; Alsbakhi et al., 2025). Simultaneously, **multimodal data integration**—combining behavioral, visual, auditory, and physiological signals—enhances profiling by capturing diverse autism traits in a holistic manner. This approach allows for more precise patient grouping based on shared characteristics, facilitating personalized intervention planning and improving clinical decision-making (Atlam et al., 2025; Dcouto & Pradeepkandhasamy, 2024; Khan & Katarya, 2025).

AI-driven severity classification and profiling not only inform clinicians but also empower caregivers by identifying individual strengths and challenges, thereby enhancing the personalization of therapeutic strategies. These approaches represent a significant advancement over traditional methods, offering both interpretability and adaptability in clinical and educational contexts for children with ASD (Ahmed et al., 2025; Salomon et al., 2025).

4.3 Therapeutic and Educational Interventions

AI-driven therapeutic applications have expanded rapidly, providing adaptive and interactive platforms to support skill development in children with ASD. Reinforcement learning-based systems dynamically adjust intervention programs according to the child's progress, ensuring personalized support. Gamified learning environments further enhance motivation and engagement while targeting communication, social interaction, and cognitive skills (Atturu et al., 2025). Socially assistive robots and virtual reality platforms have also demonstrated effectiveness in improving emotional recognition and adaptive functioning (Perry et al., 2024; Rêgo & Araújo-Filho, 2024). Longitudinal studies suggest that these AI-enabled platforms can sustain benefits over extended periods, although scalability and cost-effectiveness remain areas requiring further evaluation (Atturu et al., 2025; Perry et al., 2024; Rêgo & Araújo-Filho, 2024).

4.4 Communication Support and Assistive Technologies

AI-powered Augmentative and Alternative Communication (AAC) systems represent a transformative advancement in autism care. These systems leverage predictive language models to suggest words or phrases for nonverbal individuals, facilitating smoother and more effective communication (Omoyemi, 2024). Advanced speech-to-sign and sign-to-speech technologies further bridge communication barriers, enabling greater inclusivity across educational, clinical, and social environments. In addition, smart mobile applications offer step-by-step guidance for daily tasks, promoting independence and self-reliance among autistic individuals (Mahmood et al., 2025). Despite their potential, challenges related to accessibility, affordability, and ethical design must be carefully addressed to ensure equitable access and avoid exclusion, thereby maximizing the positive impact of these technologies.

4.5 Wearable and Sensor-Based Solutions

Wearable AI-enhanced devices have demonstrated significant potential in predicting, monitoring, and managing behavioral and physiological challenges in children with ASD. By capturing signals such as heart rate variability, movement patterns, and stress markers, these systems can provide early warnings for meltdowns or sensory overload episodes, enabling proactive interventions that enhance safety and well-being (Arbili et al., 2025; Cano et al., 2024). Commercial wearable devices further support daily functioning by offering real-time feedback and personalized guidance, contributing to independence and self-regulation (Hernández-Capistrán et al., 2024).

The integration of wearable sensors with Internet of Things (IoT) platforms enables continuous monitoring and the development of individualized care strategies, providing valuable data for personalized intervention planning (Arbili et al., 2025; Cano et al., 2024; Hernández-Capistrán et al., 2024). Despite these advantages, challenges related to accessibility, affordability, data privacy, and user comfort must be carefully addressed to ensure equitable and ethical implementation (Arbili et al., 2025; Hernández-Capistrán et al., 2024).

4.6 Family and Caregiver Support Tools

AI technologies extend beyond direct interventions for autistic individuals to support caregivers and families. Virtual assistants and AI-driven chatbots provide real-time guidance, emotional support, and evidence-based recommendations, assisting parents in navigating the complexities of autism care. Additionally, decision-support systems aid caregivers in selecting appropriate therapies, educational resources, and practical strategies for handling daily challenges tailored to their child's specific needs. By facilitating informed decision-making and offering ongoing support, these tools contribute to reducing caregiver burden and fostering inclusive, nurturing environments (Atturu et al., 2025; Alsbakhi et al., 2025; Perry et al., 2024).

Table (2) offers a comparative overview of AI applications in autism care, summarizing their key contributions, strengths, and challenges. It provides a clearer perspective on the practical roles of these applications while highlighting their limitations in real-world contexts.

Table (2): AI techniques in autism care

Application Area	AI Techniques Used	Key Contributions	Limitations / Challenges
Early Diagnosis & Screening	Computer Vision, CNNs, Eye-tracking, Speech & Physiological analysis	Detects early ASD markers with higher accuracy than conventional methods	Limited datasets, lack of cross-cultural validation, interpretability concerns
Severity Classification & Profiling	Hybrid ML models, Decision Trees + ML, Multimodal integration	Flexible severity classification, holistic individual profiling, supports personalized interventions	Heterogeneity in symptoms, limited large-scale validation
Therapeutic & Educational Interventions	Reinforcement Learning, Gamified Platforms, Social Robots, Virtual Reality	Adaptive therapy, personalized learning, improved emotional & social skills	Scalability, cost-effectiveness, long-term validation needed
Communication Support & Assistive Tech	AAC with Predictive Models, Speech-to-Sign, Smart Apps	Enhances communication for nonverbal individuals, supports daily living skills	Accessibility, affordability, ethical design issues
Wearables & Sensor-based Solutions	AI-enhanced Wearables, IoT Platforms	Real-time monitoring (stress, HRV, movement), proactive interventions	Data privacy, affordability, user comfort
Family & Caregiver Support	Virtual Assistants, Chatbots, Decision Support Systems	Guidance, emotional support, therapy selection, reduces caregiver burden	Reliability, cultural adaptation, ethical concerns

5. Challenges and Limitations in Applying AI to Autism Care

AI holds great promise for autism care, but there are several barriers to its implementation in real-world contexts. These challenges include issues of data, bias, trust, ethics, and infrastructure. Recognizing and addressing these limitations is critical to ensuring safe, equitable, and effective implementation. Figure (2) provides a visual overview of these challenges and their impact on the broader use of AI in autism care.

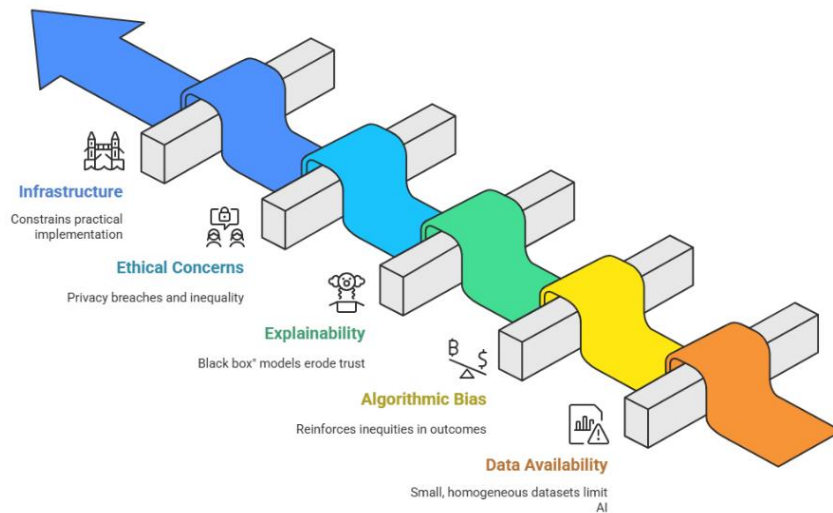


Figure (3): Key challenges and limitations in applying AI to autism care

5.1 Data Availability and Quality

One of the most persistent challenges in applying AI to autism care is the limited availability of large-scale, diverse, and high-quality datasets. Most current studies rely on relatively small or homogeneous samples, often collected in controlled clinical or laboratory environments, raising concerns about the generalizability of AI models across different cultural, linguistic, and socioeconomic contexts (Ahmed et al., 2025; Ding et al., 2024; Zeidan et al., 2022). Furthermore, privacy restrictions and ethical considerations limit the sharing of sensitive behavioral and medical data, constraining model development and broader applicability (Kolding et al., 2025).

5.2 Algorithmic Bias and Generalizability

AI models are highly sensitive to the datasets on which they are trained. If training data lack cultural or demographic diversity, models may inadvertently reinforce biases, leading to inequitable outcomes (Omoyemi, 2024). For instance, facial recognition systems trained predominantly on Western populations may underperform in non-Western contexts (Atlam et al., 2025). This lack of generalizability undermines trust and adoption in global healthcare systems. Ensuring fairness requires the use of diverse datasets and ongoing validation in real-world, cross-cultural settings (Salomon et al., 2025).

5.3 Explainability and Trust

A significant barrier to the clinical adoption of AI in autism care is the “black box” nature of many machine learning and deep learning models. When the rationale behind predictions is unclear, clinicians and caregivers may be reluctant to rely on AI-generated recommendations (Agrawal & Agrawal, 2025). Although Explainable AI (XAI) techniques have been introduced to enhance transparency, their implementation in autism-specific applications remains limited. Fostering trust in these systems requires not only technical interpretability but also presenting AI outputs in a manner that is accessible and understandable to non-expert users (Atlam et al., 2025).

5.4 Ethical and Privacy-Preserving Approaches

The deployment of AI in autism care raises significant ethical issues. Sensitive data — including video recordings, speech samples, and physiological signals— must be collected, stored, and processed securely to prevent breaches of privacy (Kolding et al., 2025). One promising approach to mitigating privacy risks is **Federated Learning**, which enables collaborative model training across institutions without centralizing sensitive data, thereby preserving confidentiality while maintaining diagnostic accuracy (Wang et al., 2024). Beyond privacy, inclusivity is also essential: AI-driven AAC systems and therapeutic tools must be designed to avoid reinforcing social inequalities (Omoyemi, 2024). The lack of standardized regulations for AI in healthcare further complicates responsible implementation, highlighting the need for stronger governance frameworks.

5.5 Practical and Infrastructural Constraints

Despite demonstrating effectiveness in research settings, the practical implementation of AI tools in autism care can be constrained by infrastructural and economic barriers. Many low-resource regions lack access to advanced diagnostic equipment, reliable internet connectivity, or adequately trained personnel to operate AI systems. Furthermore, the high costs associated with developing and deploying these systems limit their widespread adoption, particularly in educational and home-based settings (Atturu et al., 2025; Rêgo & Araújo-Filho, 2024).

Table (3) provides a structured comparison of these challenges, outlining their descriptions, practical implications, and references. This synthesis supports a clearer understanding of how technical, ethical, and infrastructural barriers intersect, offering guidance for more responsible and inclusive deployment of AI in autism care.

Table (3): Key challenges and limitations in applying AI to autism care

Challenge Area	Description	Practical Implications
Data Availability & Quality	Reliance on small, homogeneous datasets; privacy and ethical constraints limit data sharing.	Reduced generalizability across cultures, languages, and socioeconomic groups; hinders robust model development.
Algorithmic Bias & Generalizability	Models trained on non-diverse datasets risk reinforcing biases.	Inequitable outcomes, underperformance in non-Western or underrepresented populations; weakens trust and adoption.
Explainability & Trust	Many AI models operate as “black boxes,” with limited transparency.	Clinicians and caregivers may hesitate to rely on AI; need for user-friendly explainable outputs.
Ethical & Privacy Issues	Sensitive behavioral and medical data must be securely handled; lack of clear regulations.	Risks of data breaches and social inequalities; absence of governance frameworks complicates deployment.
Practical & Infrastructural Constraints	Limited resources in low-income regions; high costs of AI systems; shortage of skilled personnel.	Barriers to adoption in schools, homes, and clinics; reduced scalability and accessibility.

6. Future Directions for AI in Autism Care

AI in autism care is evolving rapidly, with future directions pointing toward more personalized, transparent, and integrated systems. These developments span multimodal diagnostics, adaptive interventions, IoT-enabled monitoring, and generative AI simulations, alongside stronger ethical and cross-cultural frameworks. Figure (4) illustrates these directions, highlighting how they aim to bridge current gaps and improve real-world impact.

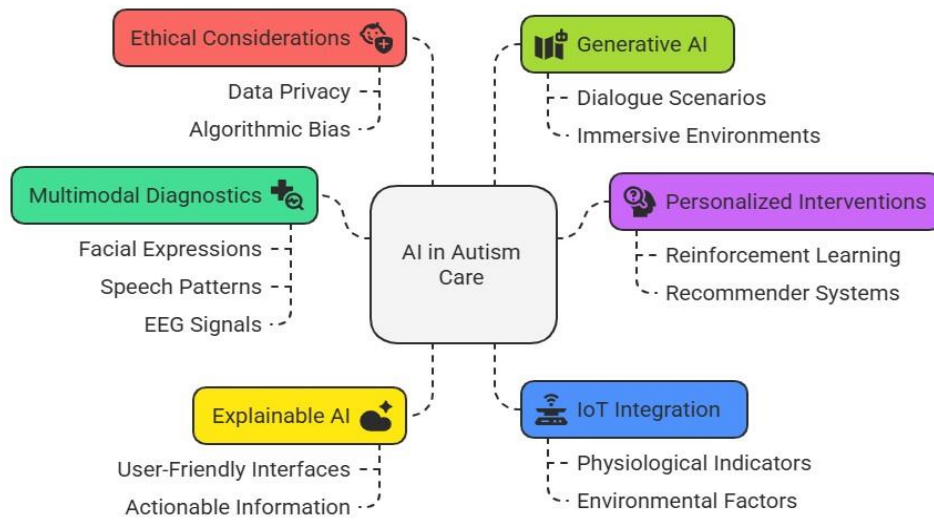


Figure (4): Future direction for AI in autism care

6.1 Multimodal and Longitudinal Diagnostics

Future research in AI-driven autism care is expected to focus on multimodal diagnostic systems that integrate diverse data sources —such as facial expressions, speech patterns, EEG signals, behavioral observations, and physiological metrics— into unified predictive models (Hatim et al., 2025; Mahmood et al., 2025; Serna-Aguilera et al., 2024). By combining multiple modalities, these approaches can improve diagnostic accuracy and better capture the heterogeneous nature of autism compared to single-method strategies (Ahmed et al., 2025; Ding et al., 2024). Furthermore, longitudinal studies that track developmental progress over months or years are essential for validating AI tools in real-world contexts, ensuring their reliability and robustness across diverse populations (Ahmed et al., 2025; Salomon et al., 2025). To enable such collaboration across institutions while preserving confidentiality, privacy-preserving frameworks like **federated learning** can facilitate the integration of distributed multimodal datasets without centralizing sensitive information (Wang et al., 2024).

6.2 Personalized and Adaptive Interventions

Personalization is expected to be a defining feature of next-generation AI applications in autism care. Reinforcement learning and generative AI approaches hold promise for designing therapy sessions that dynamically adapt to each child's developmental progress, ensuring interventions remain both engaging and effective (Atturu et al., 2025; Sohn et al., 2025). Moreover,

personalized recommender systems can suggest tailored educational resources, coping strategies, and social interaction activities, thereby enhancing therapeutic outcomes while also improving caregiver and user satisfaction (Rêgo & Araújo-Filho, 2024).

6.3 Explainable and Transparent AI

Explainability will remain central to the adoption of AI in clinical and educational settings. Future systems must embed Explainable AI (XAI) techniques that provide clinicians and caregivers with transparent insights into predictions and recommendations (Agrawal & Agrawal, 2025). Beyond technical interpretability, efforts should focus on user-friendly interfaces that translate model outputs into clear, actionable information (Atlam et al., 2025). Such developments will enhance trust and accountability, accelerating integration into healthcare and education.

6.4 Integration with IoT and Wearable Technologies

The integration of AI with the Internet of Things (IoT) and wearable technologies offers significant potential for continuous, real-time monitoring of individuals with autism (Arbili et al., 2025; Cano et al., 2024; Hatim et al., 2025; Hernández-Capistrán et al., 2024). By combining physiological indicators (e.g., heart rate variability, electrodermal activity) with environmental factors (e.g., ambient noise and light levels), future AI-enabled systems have the potential to predict behavioral challenges and recommend adaptive interventions (Arbili et al., 2025; Cano et al., 2024; Hernández-Capistrán et al., 2024). Such intelligent ecosystems may enhance home-based care, empowering families to manage daily routines more effectively while reducing dependence on frequent clinical visits (Clabaugh et al., 2019; Atturu et al., 2025).

6.5 Ethical, Regulatory, and Cross-Cultural Considerations

As AI applications in autism care continue to expand, ethical and regulatory frameworks must adapt to safeguard data privacy, ensure inclusivity, and mitigate risks of algorithmic bias (Kolding et al., 2025; Omoyemi, 2024). Equally important is the development of culturally sensitive AI systems trained on diverse, region-specific datasets to enhance their global relevance and applicability (Zeidan et al., 2022). To achieve safe and effective implementation, policymakers and researchers should work collaboratively to

establish standardized protocols for clinical validation, certification, and large-scale deployment of AI-powered autism tools.

In this context, emerging approaches such as **federated learning** also merit regulatory attention, as they offer practical pathways for protecting sensitive data while supporting international collaboration in ASD research (Wang et al., 2024).

6.6 Generative AI for Simulation and Training

Generative AI demonstrates considerable potential in developing realistic simulations that can be applied in both social skills training and professional education. For instance, large language models can generate adaptive dialogue scenarios tailored to children with autism or create immersive training environments for therapists and educators (Kolding et al., 2025). Such applications not only complement traditional therapeutic methods but also provide scalable, cost-effective, and personalized solutions that enhance the overall impact of care and training.

Table (4) provides a structured synthesis of these emerging directions, summarizing their core focus and potential impact. This comparative view highlights how technical, ethical, and cultural innovations intersect to guide the next generation of AI applications in autism care.

Table (4): Future directions in AI for autism care

Future Direction	Key Focus	Potential Impact
Multimodal & Longitudinal Diagnostics	Integrating facial, speech, EEG, behavioral, and physiological data; validated by long-term studies	Improves diagnostic accuracy and robustness across diverse populations
Personalized & Adaptive Interventions	Reinforcement learning, generative AI, recommender systems	Delivers dynamic, individualized therapies; boosts caregiver satisfaction
Explainable & Transparent AI	Embedding XAI and user-friendly interfaces	Builds trust, accountability, and adoption in clinical / educational practice
Integration with IoT & Wearables	Combining physiological signals with environmental data	Enables real-time monitoring, proactive interventions, and home-based care

Future Direction	Key Focus	Potential Impact
Ethical, Regulatory & Cross-Cultural	Privacy, inclusivity, bias mitigation, culturally sensitive datasets	Ensures fairness, global relevance, and safe deployment of AI systems
Generative AI for Simulation & Training	LLMs and simulation environments for therapy and professional education	Provides scalable, cost-effective, and immersive training and support

7. Conclusion

Artificial Intelligence (AI) has emerged as a transformative force in healthcare, and its applications in autism care highlight its potential to reshape not only clinical practices but also the daily experiences of families and educators. Through advances in machine learning, deep learning, reinforcement learning, and natural language processing, AI is opening new pathways for early diagnosis, personalized interventions, and assistive communication. Current tools range from diagnostic decision support to individualized learning platforms, socially assistive technologies, and caregiver support systems, demonstrating AI's growing capacity to improve the quality of life for autistic individuals and those who support them.

However, important challenges remain. The lack of large and diverse longitudinal datasets, persistent algorithmic bias, and the opaque “black-box” nature of many models limit their reliability and trust in real-world practice. Ethical and privacy concerns—including issues of inclusivity and equitable access—add further complexity, particularly in low-resource settings where families, educators, and clinicians already struggle with limited support and infrastructure.

Looking ahead, the promise of AI in autism care lies in developing multimodal, explainable, and adaptive systems validated across diverse populations and real-world contexts. Achieving this requires not only technical progress but also strong regulatory frameworks, rigorous clinical validation, and close collaboration among researchers, clinicians, educators, policymakers, and families. Ultimately, by addressing current limitations while embracing emerging innovations, AI has the potential to promote inclusion, ease the everyday challenges faced by families and educators, and empower autistic individuals to thrive and reach their fullest potential.

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