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Review Article

Developing AI-Driven Tools and Technologies to Enhance the Lives of Individuals with Autism: Review

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Abstract *- A developmental disease that impacts behavior, social interaction, and communication is known as Autism Spectrum Disorder (ASD). Over the years, researchers and technologists have strived to develop innovative solutions to support individuals with ASD. Early detection of ASD traits is crucial for timely intervention and management. However, existing conventional ASD screening methods often rely on lengthy questionnaires and domain expert rules, leading to subjectivity and inefficiency and the emergence of Artificial Intelligence (AI) has opened up countless possibilities. This AI advancement has the potential to revolutionize ASD diagnosis processes, benefiting medical clinics and diagnosticians. The aim is to create accessible and efficient tools that enhance the lives of individuals with autism. This review paper explores the impact of AI-driven tools and technologies on enhancing the lives of individuals with autism. Specifically, highlight the challenges and future directions in this field.*

Keywords *- Autism Spectrum Disorder (ASD), AI-driven tools, Technologies, Individuals, Developing, Machine intelligence.*

1. Background

People who have Autism Spectrum Disorder (ASD) deal with a variety of special challenges on a daily basis, such as issues with communication, social interaction, and repetitive activities. By offering creative answers to these problems, the creation of AI-driven tools and technologies has the potential to significantly improve the lives of those who have autism. These instruments can help with independence and self-management promotion, communication facilitation, and social skill improvement.

In recent years, there has been a great deal of interest in the use of AI in autism interventions. Researchers and developers are investigating a range of applications, including wearable technology, virtual reality, and machine learning algorithms. The purpose of this review is to assess the state of AI-driven tools and technology for people with autism, investigating their usefulness, efficacy, and possible effects on their lives. We can find the gaps and chances for additional development and application of AI-driven solutions to support people with autism and their families by comprehending the current research and accomplishments in this sector.

2. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by reduced eye contact, facial expressions, as well as motions of the body throughout the first three years of life. It is a multifactorial disorder influenced by both hereditary and non-genetic risk factors. Genetic studies reveal mutations disrupting normal neurodevelopment from infancy to childhood, with axon mobility and synaptogenesis linked to these gene complexes.

Neuroimaging research has revealed the importance of the amygdala and the nucleus accumbens in cognition and ASD. Despite behavioural and educational therapies being the cornerstones of ASD care, pharmacological and interventional treatments have shown some effectiveness. However, more research is needed to fully understand the fundamental architecture of ASD development and target potential therapy targets [1]. Several significant insights into the pathological alterations that take place in the brains of ASD patients in vivo have been gained from neuroimaging research. Crucially, an abnormal route of brain development associated with ASD results in variations in neuroanatomy, neurofunction, and connection.

Despite significant advancements in the creation of cellular assays and animal models, neuroimaging techniques enable us to directly assess the brain in vivo. They may help to create a more individualized treatment plan for ASD [2]. The research on the connection between Artificial Intelligence (AI) and autism is a developing topic that might progress the lives of those who are autistic. Researchers and developers may tackle the distinct obstacles encountered by persons with autism by utilizing AI algorithms. Leaders' Emotional

Intelligence (EI), which includes social skills, empathy, and self-awareness, can be enhanced by the application of AI technology [3]. Low-resource African nations might benefit from recent advancements in AI and digital twins in terms of health and wellbeing, especially in the areas of disease outbreak management and public health emergency response. AI systems apply to users. AI algorithms may be used to mine factors and identify competitive advantages for brands in user research assignments. A growing body of research is focusing on ways to integrate AI and humans in collaborative teams to achieve human-AI collective intelligence [3].

Children with autism spectrum disorders have been diagnosed using conventional ASD screening methods. These methods include early detection through machine learning algorithms and the translation of screening measures. These translation strategies make use of rigorous translation with cultural adaptation as well as forward-back translation. Research has indicated that the forward-back translation method may lead to subpar psychometric results [4].

However, using machine learning algorithms to predict ASD symptoms based on parent-child dialogue has shown promise. Support Vector Machine, Logistic Regression, K-nearest neighbour, and Random Forest classifiers are a few of these algorithms. Furthermore, cry-based screening techniques have been put forth for early and automatic ASD screening, and they have demonstrated superior performance compared to conventional classification techniques. These traditional ASD screening techniques aim to improve the accuracy and efficiency of early identification and intervention for children with ASD.

The brain disease known as Autism Spectrum Disorder (ASD) is characterized by issues with communication, social interaction, and repetitive behavior. Although it is frequently labelled as a mental illness, newer research indicates that a systemic disease assessment is more appropriate. Five categories may be used to classify the causes and dangers of ASD: genetic, epigenetic, organic, psychogenic, and environmental. Supporting people with ASD requires early intervention, but a major issue is the lengthy diagnostic waiting period.

High-accuracy virtual reality social interactions, such as shopping with an embodied agent, can be used to screen for ASD. In order to categorize individuals, machine learning techniques might examine behavioural reactions made during these exchanges. The decreased prior theory, which views ASD as a disease of prediction, appears to be validated by empirical data, suggesting abnormal connections between different brain regions and resistance to trustworthy contextual priors [5]. Useful AI apps have been created to support physicians, assist in the early detection of autism, and be a major contributor to early intervention. These applications aid in the diagnosis and detection of Autism Spectrum Disorder (ASD) by utilizing Artificial Intelligence (AI) techniques, including Machine Learning (ML) and Deep Learning (DL). In order to quickly and objectively diagnose ASD, Artificial Intelligence (AI) algorithms have been developed to evaluate brain MRI data, namely Diffusion Tensor Imaging (DTI) and functional MRI (fMRI) [6].

Using text as input, Natural Language Processing (NLP) methods and AI models have been used to detect ASD with excellent accuracy in classifying texts that may have been written by ASD users [7]. Eye-tracking datasets have been subjected to machine learning techniques, such as supervised and unsupervised learning, in order to offer a data-driven second opinion for ASD diagnosis [8]. Convolutional Neural Networks (CNNs) have also been utilized in facial analysis to accurately identify ASD in infants based on facial features and expressions. These AI programs provide useful resources for ASD early detection and intervention [8].

This study is organized as follows: after introducing the traditional ASD screening techniques in the “Literature Review” section, pertinent intelligence works on the use of machine learning for autism detection are reviewed. Next, we will enumerate a few studies that discuss practical AI applications that aid in the early identification of autism, support doctors, and play a significant role in early intervention. Finally, it is important to note that we primarily concentrated on studies that were published within the previous five years, given the quick pace of technological advancement.

3. Traditional Assistive Technologies for ASD

3.1. Discuss Current Assistive Technologies and Their Limitations

When treating individuals with Autism Spectrum Disorder (ASD), traditional `assistive technologies have been extensively researched and used [9]. These tools are designed to help people with ASD overcome obstacles in their daily lives and enhance their functional abilities. Augmentative and Alternative Communication (AAC) technology encompasses a range of technologies, including software, communication apps, and speech-generating equipment [10].

Assistive Technologies for Cognition (ATC) is another area that encompasses techniques such as video modelling and social storytelling. Low-tech and mid-hightech gadgets are also utilized to help people with ASD manage their stress and anxiety. The efficient use of assistive technology in supporting people with ASD is still restricted and has specific limits despite the potential advantages. More investigation is required. Nevertheless, there are still barriers to and restrictions on the useful application of Assistive Technology (AT) in supporting people with ASD [9]. The use of Assistive Technology (AT) to help people with Autism Spectrum Disorders (ASD) overcome obstacles such as poor

communication, social interaction, and cognitive abilities is the subject of the current study. Different areas of intervention, such as the therapy of phobias, social interactions, academic skills, and job performance, have led to the development of various AT devices and tools. The application of AT to treat stress and anxiety in people with ASD remains unexplored despite its exciting promise. Future studies should focus on overcoming these obstacles and creating simple, affordable ways to include AT in the daily lives of individuals with ASD.

3.2. Explore the Need for Advanced AI-Driven Solutions

The communicative and diagnostic needs of people with Autism Spectrum Disorder (ASD) cannot be adequately met by conventional assistive devices. Advanced AI-driven solutions are required to get beyond these restrictions and offer assistance that is more precise and effective. Particularly when it comes to the processing of brain imaging data from Magnetic Resonance Imaging (MRI), AI technologies like deep learning and machine learning have demonstrated potential in aiding with the diagnosis and identification of ASD [11].

Additionally, by leveraging machine learning and deep learning algorithms to improve verbal and nonverbal communication through IoT devices, AI-based solutions can aid in improving communication for people with ASD [11]. These cutting-edge AI-powered technologies have the power to completely transform the ASD assistive technology market and offer more individualized and efficient

4. Applications of AI in Autism Support

4.1. Discuss Current Assistive Technologies and Their Limitations

Machine Learning (ML) is one use of AI in autism support that is used to diagnose Autism Spectrum Disorder (ASD) [8]. ML techniques, such as supervised and unsupervised learning and the use of eye-tracking datasets to identify behavioural patterns of gaze, have been used in the diagnosis of ASD [8]. By offering a data-driven second opinion, machine learning can successfully complement the diagnosis of ASD [11].

Furthermore, deepfakes, a type of generative artificial intelligence, have the potential to be employed by individuals with autism as an assistive tool [11]. Deepfakes have useful uses in the entertainment and education industries, and investigating their potential as assistive technologies may have implications for human-computer interaction. Furthermore, digital technology and AI applications enable significant developments in mental diagnoses and ASD differential diagnosis, enabling personalized prognoses and treatment regimens. These devices can also offer ongoing monitoring of symptom development and help identify symptom exacerbations early. It's crucial to remember, though, that digital tools shouldn't take the place of clinical judgment; rather, they should support physicians in reaching more objective and fact-based conclusions. By examining facial characteristics, facial expression recognition systems that make use of deep learning models have been created to determine the emotional state of people with ASD [12].

4.1.1. Explain How AI Chatbots and Virtual Assistants Facilitate Communication and Language Development

Furthermore, children with ASD have been taught to converse and have their comprehension of social interaction enhanced by AI robots [12]. These AI-based tools have demonstrated noteworthy results in the early detection, supervision, and treatment of people with ASD, offering hope and options for the use of AI in special group assistance in the future.

AI has been applied extensively in the field of autism support, especially in the domains of social interaction skills, diagnosis, and intervention [13]. AI virtual assistants and chatbots are essential for helping autistic people communicate and enhance their language skills. With the help of these technologies, people may practice communication skills in a secure and regulated setting while receiving tailored and interactive support [13].

4.1.2. Discuss Speech Recognition and Natural Language Processing Techniques

AI chatbots can help people improve their language and social skills, hold conversations with them, and offer guidance and feedback [11]. Conversely, virtual assistants may help people with everyday tasks like making plans, sending out reminders, and giving information, all of which can improve their independence and communication skills. Chatbots and virtual assistants that use AI are useful tools for individuals with autism to improve their communication and language skills.

Text has been utilized as input for the detection of ASD utilizing Artificial Intelligence (AI) models such as decision trees, extreme gradient boosting (XGB), K-Nearest Neighbors' algorithm (KNN), and Bidirectional Encoder Representations from Transformers (BERT) in conjunction with Natural Language Processing (NLP) approaches [14]. When it comes to identifying writings that may have come from people with ASD, these models have demonstrated an accuracy of over 84%. AI robots have also been used to guide situational game engagement and provide early diagnosis and monitoring of youngsters with ASD [7]. Speech processing methods, such as voice recognition and natural language processing, have been used to study the speech and language development of children with autism spectrum disorders. These methods have demonstrated promise for automated evaluation of spoken language development, demonstrating a high degree of classification accuracy both between speech and nonverbal vocalisation and between adult and child speech.

4.2. Social Skills Training

4.2.1. Describe How AI Enables Personalized and Interactive Social Skills Training

AI uses conversational agents and Intelligent Virtual Agents (IVAs) to provide individualized and interactive social skills training. With their increased complexity and realism, these agents may now provide tailored support in a variety of settings, including "exergames" for physical training [15]. The limitations of traditional training techniques have been overcome by social skills training systems that incorporate conversational agents and have demonstrated promising outcomes in teaching appropriate social and communication skills.

In addition to producing nonverbal actions, these systems may communicate with users through voice recognition, response selection, and speech synthesis [15]. Furthermore, AI makes it possible to include socially interactive behaviours into artificial agents by fusing empirical methods that learn from human-human interactions with analytical techniques influenced by the social and cognitive sciences.

4.2.2. Discuss Virtual Reality and Social Robots as Tools for Social Interaction

Two elements that enhance the effectiveness of social skills training programs are after-action and real-time interactive feedback, which offer individualized feedback and immersive experiences, respectively. In general, Artificial Intelligence (AI) makes it possible to create accessible, secure, and situation-specific social skills training programs that are both interactive and customized. Social robots and Virtual Reality (VR) have been investigated as social interaction aids in social skills training. Through the creation of realistic settings that enhance social interaction ability and appropriateness, Virtual Reality (VR) gives youngsters suffering from hyperactivity or attention deficit disorder.

(ADHD) a more effective therapy alternative to traditional tactics. Additionally, it has been discovered that training in social spaces and scenarios that are similar to real life using immersive Virtual Reality (VR) is beneficial for those with Autism Spectrum Disorder (ASD) [16]. Furthermore, social skills training with several humanoid robots has been designed to assist people with ASD in improving their sociability and empathy as well as familiarizing themselves with other people's viewpoints [16]. These results imply that social robots and Virtual Reality (VR) may potentially improve social interaction abilities in people with ASD and ADHD, respectively.

4.3. Behavioral Monitoring and Intervention

Research has shown that social skills training programs can help children with conduct disorders with behavioral issues. To address social skill impairments in a variety of groups and circumstances, evidence-based social skills therapies grounded in Applied Behavior Analysis (ABA) have been created. The goal of these therapies is to improve a variety of social skills, such as maintaining eye contact and engaging in dialogue.

For people with Autism Spectrum Disorder (ASD), evidence-based behavioral interventions delivered through social skills groups can be successful [17]. It has been demonstrated that incorporating participant interests, such as social skills training based on LEGOs, can improve social skill accuracy in training environments for people with ASD. Nonetheless, more investigation is required to ascertain the applicability and external validity of the skills taught in social skills groups.

4.3.1. Discuss Virtual Reality and Social Robots as Tools for Social Interaction

AI is crucial to the observation and analysis of behavioural patterns. AI is applied in the delivery of behavioural health services to increase the efficacy and efficiency of care for clients at every stage of the process, from evaluation and diagnosis to intervention withdrawal or continuous monitoring [18]. AI-powered intelligent monitoring systems have made significant strides in enhancing the effectiveness of hindsight watching and adapting to unforeseen circumstances.

Personalized and timely behavioural intervention may be offered via Conversational User Interfaces (CUI) that are based on domain expertise and outfitted with AI models and monitoring tools [19]. In order to solve the issue of low accuracy in behaviour prediction, wearable sensors and a variety of biosignals have been used in conjunction with AI and deep learning approaches to evaluate human behaviour. AI and machine learning methods are utilized in the context of wildlife conservation to handle and analyze enormous volumes of data collected from sensors, assisting in the comprehension and preservation of animal behaviour.

4.3.2. Discuss AI-Based Intervention Strategies and Feedback Mechanisms

The field of behavioural monitoring and intervention involves investigating AI-based intervention tactics and feedback systems. By utilizing ai technology, these techniques seek to increase the efficacy and efficiency of mental health treatments. Using conversational user Interfaces (CUI) with AI models for text production and emotion recognition is one strategy [19]. With the use of monitoring technologies like wearables and mobile phones, these CUIs can offer tailored behavioural therapies in real-time. Another strategy is the use of AI techniques in mental health service delivery, where academics are starting to do so in order to increase service delivery efficiency and discover new information that boosts intervention efficacy [18].

Furthermore, AI-based therapies have been used to address children's behavioural issues; they have shown

promising results when combined with behaviour monitoring tools and technology such as cognitive training and operant conditioning techniques.

Additionally, Artificial Intelligence (AI)-based nudging techniques have been created to maximize hand hygiene practices. These tactics use certain psychological or environmental cues to elicit automatic and unconscious hand hygiene behaviours. In order to guarantee intervention adherence and validity, technology-based interventions such as digital health and telehealth have their own fidelity protocols [20].

4.4. Sensory Integration and Regulation

The literature has examined AI-powered systems and tools for sensory integration. The goal of these instruments is to treat sensory integration dysfunction, a neurological condition that impairs proprioception, vestibular function, and sense data processing [21]. It has been demonstrated that using sensory integration exercises helps kids develop their attention.

Furthermore, a school-based study discovered that when a sensory integration intervention was combined with teacher consultation, it enhanced kids with sensory integration and processing difficulties' functional management and active involvement. These results imply that, for people with sensory integration difficulties, sensory integration therapies may enhance sensory processing and control when paired with AI-powered tools and technology.

4.4.1. Explore AI-Powered Sensory Integration Tools and Technologies

The subject of sensory integration and control might undergo a revolution thanks to AI-powered tools and technology. These resources can support children's learning processes and aid in the development of executive functions, such as attention [21]. The act of arranging and combining environmental and bodily inputs to facilitate perception and learning is known as sensory integration. Problems with mobility, bodily awareness, and the processing of information from many senses might result from dysfunction in sensory processing.

A kid's behavior and development can be greatly impacted by sensory control issues, such as those seen in Autism Spectrum Disorder (ASD). Effective management and support of sensory control disorders depend on early recognition and intervention. Recognizing and treating babies and young children's sensory dysregulation can reduce the risk of problems and enhance their general wellbeing. Researchers and practitioners can improve evaluation, intervention, and support techniques for people with sensory integration and regulation issues by employing AI-powered tools and technology.

4.4.2. Discuss Virtual Reality Therapy for Sensory Challenges

The use of virtual reality therapy as a possible solution for sensory difficulties has been investigated. Research has demonstrated the advantages of integrating virtual reality therapy alongside traditional forms of treatment for those with sensory deficiencies. For instance, virtual reality added to Sensory Integration Therapy (SIT) and Traditional Physical Therapy (CPT) significantly improved gross motor skills, balance, and mobility in children with cerebral palsy, according to a pilot randomized control trial [22].

Virtual Reality Treatment (VRT) and Sensory Integration Therapy (SIT) proved to be more successful than SIT alone in the implementation of an Instrumented Sensory Integration Treatment Program for patients with vestibular disorders, yielding encouraging findings [22]. These results imply that virtual reality treatment can improve outcomes when paired with other therapies.

5. Benefits and Limitations of AI-Driven Tools

AI-powered technologies have a number of advantages and drawbacks. These resources might provide learners with individualized learning experiences, shorten learning sessions, and expose them to various cultures. Additionally, they can support the tracking, detection, and reporting of corruption, especially in relation to important governmental tasks.

AI systems may also provide replies that resemble those of a person, give information, carry out discussions, and generate original ideas [23]. There are restrictions to take into account, though. Currently, AI methods may not be transparent and rely on sparse data for training.

Additionally, they can deliver absurd or inaccurate results, in which case consumers would need to assess the data cautiously and confirm it with credible sources. Moreover, contextual subtleties and the requirement for human contact are still absent from AI technologies for language acquisition.

5.1. The Advantages of AI Solutions in Supporting Individuals with ASD

TAI- powered with Autism Spectrum Disorder (ASD), can benefit from powered solutions in a number of ways. By offering children with Neurodevelopmental Disorders (NDDs) individualized learning experiences and therapies, these technologies can enhance results. They can help with ASD early diagnosis and identification, enabling prompt assistance and intervention.

Improved treatment results can result from applying AI methods to forecast objectives accomplished by persons with ASD during Applied Behavior Analysis (ABA) therapy [23]. For those studying a foreign language, AI language learning technologies can also shorten learning times, speed up learning, and offer individualized learning experiences [6].

Artificial Intelligence (AI) technologies can help identify individuals who could have ASD by using Natural Language Processing (NLP) techniques and AI models, improving the accuracy of detection and diagnosis [7]. All things considered, AI solutions have the potential to greatly enhance the quality of life for people with ASD by offering individualized learning experiences, early identification, and customized therapies.

5.2. Recognize the Limitations and Ethical Considerations in Using AI for Autism Support

While AI-driven resources for autism assistance provide many advantages, there are drawbacks and moral dilemmas to be aware of. By utilizing brain imaging methods like MRIs, these instruments can help with the objective and early diagnosis of autism, resulting in quicker identification and intervention. By employing machine learning techniques and doing extensive variable analysis, they can further enhance the prediction of treatment. However, there are moral questions about the application of AI to autism assistance. It is crucial to make sure that these instruments are utilized as supportive resources for clinical judgment rather than as the only means of diagnosis [6].

Furthermore, as AI systems might not be able to comprehend the subtleties of language in context, there is a need for increased human contact during the learning process [23]. Furthermore, any biases and the effects on patient autonomy and privacy must be carefully considered when using AI in healthcare.

5.3. Applications for Early Diagnosis and Supportive Education for ASD

Timely intervention for ASD requires early diagnosis. With their ability to provide objective and trustworthy assessments at the cognitive, behavioral, and neural levels, digital technologies have the potential to enhance mental health diagnostics. Artificial intelligence and these technologies work together to provide tailored treatment plans and prognoses, which support the methodical and ongoing evaluation of symptom development.

Furthermore, in order to improve contact with the outside world, coping mechanisms, communication techniques, and treatments must be started as soon as ASD symptoms are detected [24]. To maximize results, treatments for children with ASD in supportive education must start early. Programs for focused professional development give teachers the skills, information, and knowledge they need to effectively interact with and instruct students with ASD.

6. Integration Challenges and Future Directions

The need for more DL-based models and ways to alleviate the arduous nature of the procedure are obstacles to the integration of AI and MRI for ASD diagnosis. Future prospects include investigating how AI could help with ASD diagnosis and detection, as well as continuing to refine DL methods.

6.1. Discuss the Challenges in Implementing AI-Driven Tools in Real-World Settings

There are several obstacles to overcome when implementing AI-driven technologies in practical situations. A significant obstacle to the widespread use of Machine Learning (ML) solutions is their immaturity in industrial environments. The requirement for AI to be seamlessly integrated with humans and the current infrastructure, including data availability, storage, and analysis, presents another difficulty.

Furthermore, the unpredictable nature of real-world situations, out-of-dataset scenarios, and deployment infrastructure elements may make even the most well-designed AI models fail. Moving towards vertically integrated artificial intelligence development. In addition, there is worry about the clinical processes' lack of added value in terms of cost and possible clinical hazards [25]. Potential approaches like MLOps and Causal ML have been identified as ways to tackle these topics. In general, these issues must be resolved for AI-driven technologies to be successfully used in practical situations.

6.2. Recognize the Limitations and Ethical Considerations in Using AI for Autism Support

The presented abstracts have revealed integration issues in a number of sectors, including data integration and digital twins in cyber-physical systems. The necessity of creating and integrating digital twins as Systems-of-Systems (SoS) gives rise to these difficulties.

Semantic and structural integration issues in the realm of data integration are brought on by the variety of data sources and require attention. The papers also emphasize how important it is to investigate possible future developments and areas that require more study.

For example, the reusability of digital twins should be taken into account in studies on building them as SoS [26]. Further research is needed on the deployment of 5G networks and innovative integration concepts, such as haptic Internet and virtual reality, in the context of Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) [26]. Additionally, early diagnosis and therapeutic efforts in diverse cultural contexts can be guided by an awareness of the impact of many characteristics, including race, ethnicity, and socioeconomic position, on health attitudes and psychosis risk.

7. Conclusion

The use of AI-powered products by people with Autism Spectrum Disorder (ASD) has significantly improved. These resources, which were created with the use of machine

learning models, have been used to help kids with ASD who struggle academically. They have demonstrated efficacy in enhancing supportive education and social interaction. Artificial Intelligence (AI) systems integrated into technological platforms have been utilized to forecast treatment results and offer real-time ABA therapy dose recommendations based on distinct patient features. AI and machine learning have also been used to anticipate problems and identify ASD early on without the need for human interaction, enabling the right treatment to be administered at the right time.

AI algorithms and natural language processing methods have been applied to categorize writings that may have been produced by people with ASD, producing a highly accurate prediction model. Furthermore, through interactive settings, robotic solutions powered by AI have demonstrated potential for enhancing social interaction and detecting ASD.

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