An Exploration of AI-Assisted Tools in the Education of Children with Autism from the Perspective of Inclusive Education

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Abstract
With the rapid development of Artificial Intelligence (AI) technology and its widespread use in education, it is becoming increasingly feasible to build more personalized and supportive learning environments for children with autism. The aim of this paper is to explore how AI-assisted tools can promote inclusive education, with a particular focus on the specific group of children with autism. Through keyword searches of relevant papers in mainstream conferences and journals, as well as a comprehensive analysis of existing literature and case studies, we have conducted a systematic review of AI as an aid to promote inclusive education, aiming to provide valuable references for subsequent research. Studies have shown that when AI technology is appropriately applied, it can significantly enhance the social interaction skills, emotional regulation, and academic performance of children with autism. However, it is important to note that most of the current research findings focus on work published within the last few years, and thus may not fully cover relevant contributions from earlier periods. In summary, by examining the current situation of AI applied to the education of children with autism in China, we can see that AI as an assistive tool shows great potential for development and plays a crucial role in realizing inclusive education in the true sense of the word. This not only promotes educational equity, but also provides more opportunities for each child to grow.

1. Introduction

The integration of artificial intelligence (AI) into special education marks a significant advancement in the field of education and developmental support. This combination has paved the way for innovative tools and methodologies, offering a transformative impact on how educators and clinicians address learning disabilities and autism spectrum disorders (ASD). By utilizing AI technologies, researchers and practitioners can analyze complex behavioral and biological data to enhance early diagnosis, intervention, and educational outcomes for children with special needs. The growing prevalence of autism, along with its multifaceted symptoms and challenges, underscores the need for sophisticated approaches that merge interdisciplinary knowledge with cutting-edge technology.

In recent years, international research on ASD has shifted toward a multidimensional and multimodal perspective, incorporating both behavioral markers (e.g., eye contact, facial expressions, motor abilities) and biomarkers (e.g., physiological signals from MRI and EEG). This dual approach enables more precise classifications and personalized interventions for children with autism. Moreover, AI has demonstrated its potential in creating innovative systems, such as expert diagnostic tools and adaptive learning environments, which address individual needs effectively. As advancements in AI continue to reshape the landscape of special education, it is crucial to explore its evolution, applications, and impact on ASD research and practice. This study aims to review the development of AI applications in special education, analyze its contributions to supporting children with ASD, and identify emerging trends and challenges in this field.

The integration of AI into special education can be traced back to the 1990s, with Geiman (1990) pioneering the use of soft computing methods as screening tools for autism and learning disabilities. This foundational work laid the groundwork for subsequent innovations in the field. For instance, Georgopoulos et al. (2003) introduced the Fuzzy Cognitive Map (FCM), an effective technique for screening speech disorders. Similarly, Mayes and Freitas (2004) developed the MindSet application, leveraging "mind headsets" to monitor attention levels in children with Attention Deficit Hyperactivity Disorder (ADHD).

Hernandez et al. (2009) designed an expert system for detecting learning difficulties in children. This system utilized a robust knowledge base of psychological screening strategies, analyzing input variables such as age, gender, and educational level to predict outcomes like mental state and intelligence. Building on this, Jain et al. (2009) introduced PLEDDOR, a Perceptron-Based Learning Disability Detector, which employed artificial neural networks to identify conditions such as dyslexia, dysgraphia, and mathematical learning disabilities. ElSayed (2012) further advanced the field with an intelligent agent classification system that not only identified learning disabilities but also recommended tailored educational activities to meet individual needs.

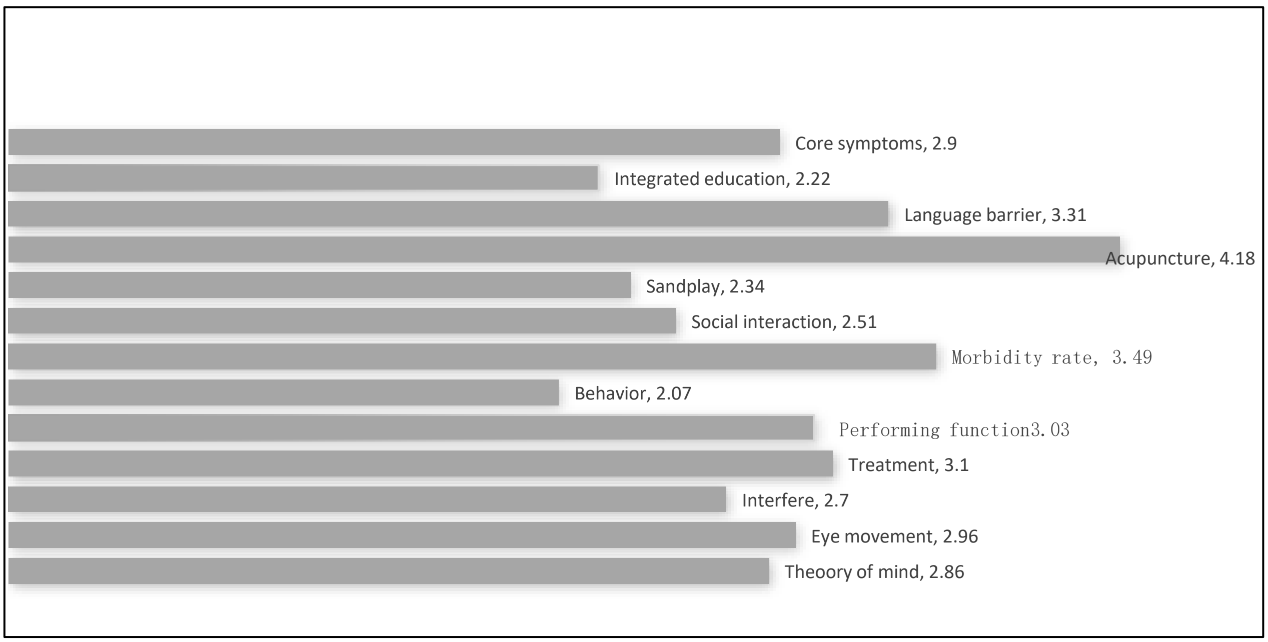


Fig. 1 keywords with Strongest Citation Bursts

Research into ASD has followed a dynamic trajectory over the years. Early studies focused on the psycho-theoretical abilities of children with autism (2013). Between 2014 and 2015, attention shifted toward analyzing eye movement patterns, intervention strategies, and the development of executive functioning. From 2016 to 2018, researchers explored behavioral performance, social interaction skills, and sandplay therapy, while interest in acupuncture therapy, language disorder management, and integrated education emerged around 2019.

More recent research (2020–2022) has concentrated on ASD's core symptoms, early identification techniques, behavioral management, social skills development, sleep quality, and intellectual growth. Notably, studies have also examined the impact of vitamin D on autism and rehabilitative care measures. By analyzing publication trends in China from 2012 to 2022, it becomes evident that ASD research has gained significant traction, with a steady increase in the number of studies published since 2014.

This rich history of AI applications in special education highlights the transformative potential of technology in addressing complex challenges in ASD diagnosis and intervention. By synthesizing these advancements, this review aims to identify gaps and emerging opportunities to guide future research in the field.

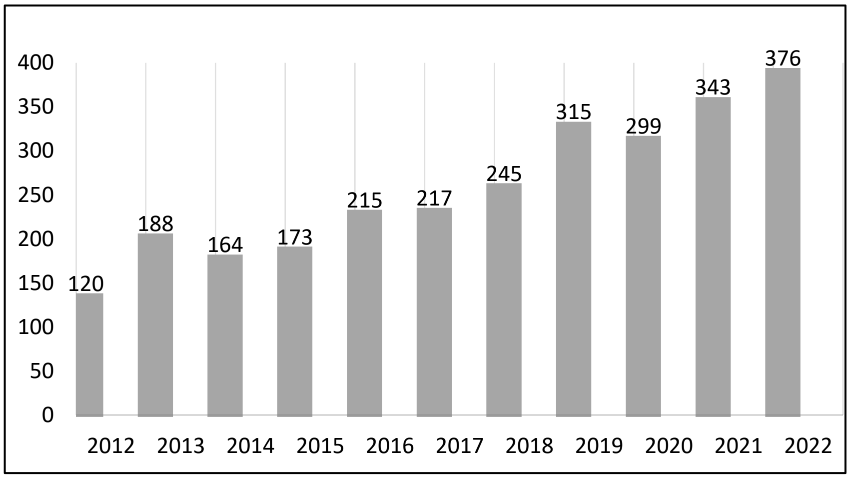


Fig. 2 Map showing the distribution of our annual number of publications

2. Research Methods

2.1 Foreign studies

The study by Shamsuddin et al. used quantitative metrics to assess the progress of children with autism spectrum disorders (ASD) in understanding human expressions, and the effects were measured through pre and post-test comparisons and comparisons between the experimental and control groups. The results of the study suggest that the NAO robot serves as an effective medium to assist children with ASD to better understand and learn human expressions. By interacting with the NAO robot, these children not only acquired the ability to recognize and infer emotions, but also were able to effectively apply these skills to real interpersonal situations, thus opening new paths to enhance their cognitive functioning. On the other hand, Kajopoulos et al. trained the attention of children with ASD with the help of a pet robot called "CuDDler" and systematically statistically analyzed the changes through quantitative methods. In this study, the children were guided to complete designated play tasks based on the orientation of the robot's head. After several weeks of training, the researchers noted a significant improvement in the participants' attention.In addition, Bevill et al. introduced a robot with facial expression recognition and the ability to communicate emotions through speech and gestures, and also quantitatively assessed children's growth in their ability to express natural emotions and interact. The study showed that children made significant progress in expressing natural emotions and interacting with others through imitative learning. Together, these studies reveal the great potential of robotics in assisting the development of children with ASD.

2.2 Domestic Research

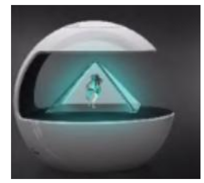
The research conducted by Prof. Liu Xiaofeng and his team on the NAO robotic training platform focuses on the use of the technology to implement interventions and education for children with Autism Spectrum Disorder (ASD). To ensure the validity and reliability of the study, adequate statistical efficacy was first ensured by calculating the required sample size, and clear criteria for participant inclusion were established. Study participants were then randomly assigned to either the experimental or control group, ensuring consistency in baseline characteristics between the two groups. The research team crafted a series of interactive NAO robot-based activities that were structured and repeatable. In addition, the length, frequency, and specific schedule of the interventions were planned in detail to maintain consistency from one intervention to the next. Standardized assessment tools such as the Social Responsiveness Scale (SRS) and the Autism Diagnostic Observation Scale (ADOS) were used for data collection. Prior to the formal start of the intervention, an initial assessment was administered to all participants to document their initial level of social skills, emotional understanding, and verbal communication. The entire experimental process included, but was not limited to: documenting specific situations during the intervention, post-intervention re-assessment, training the professionals who implemented the intervention, carrying out the intervention according to the plan, continuous monitoring and making necessary adjustments to the program, organizing the collected data, conducting descriptive and inferential statistical analyses, interpreting the research results, writing and publishing an academic report, sharing the results of the experiment with peers, and conducting subjects' steps such as long-term follow-up. The results of the study show that the NAO robot is not only effective in engaging the interest of children with autism, but also significantly improves their behavioral control and ability to focus attention, and helps to enhance their performance in social interactions. This work not only demonstrates the potential value of the NAO robot in the field of special education, but also provides valuable experience for the further development of teaching tools for children with autism.

3. Result and Discussion

To date, a wide range of intelligent educational robots with different functions have been developed globally. Below we will focus on three specific types of robots: robots that can assist with drawing, robots with 3D projection capabilities, and robots that support motion interaction. Each of these three types of intelligent educational robots addresses a different aspect of education, not only enriching teaching methods, but also providing a more personalized and interactive learning experience for children with autism. As technology advances, we expect to see more innovative educational robots in the future, providing greater support for the growth and development of children with autism.

Table. 1 Robot Type Analysis

Robot type	Working Principle	Product Advantages	Product Pictures
Drawing Function Robot	A sand painting robot is an automated preparation capable of creating sand paintings on its own. The robot is capable of selecting an image to be painted on a screen and analyzing that image to determine the painting path using a built-in algorithm. It utilizes motion control technology and the principle of Mecanum wheels to move precisely on a flat surface to complete the sand painting of the selected image.	The dynamic nature of sand art helps children learn to accept and adapt to changing situations. Dynamically changing sand art captures children's attention, enhances their imagination, provides visual stimulation, and helps to improve their visual tracking skills and concentration.	 Sand Painting Robot

	The Scribit Drawing Robot is an innovative drawing robot that turns any vertical surface into a dynamic canvas. This robot can draw images, text, and even update news and weather information.	Scribit can automatically update content according to a predetermined schedule, such as daily routines or learning tasks, which can be beneficial for children with autism as it helps them establish regularity in their daily lives.Scribit can create engaging visual content, such as drawings, storyboards, or instructional charts, to help them better comprehend and remember information.	 Scribit Drawing Robot
3DProjectionFunctionRobot	3D holographic screen casting is a technology that creates realistic three-dimensional images that look like they are suspended in the air and can be viewed around them. Holography is based on the use of the principles of interference and diffraction of light.	3D holographic projection screens can visualize abstract concepts to help children with autism understand and remember information. Holographic projection screen can simulate various real-life situations to help children with autism understand and cope with these situations, and improve their adaptability.3D holographic projection screen can visualize abstract concepts to help them better understand and remember information. For example, scientific concepts or math problems can be demonstrated through 3D models.	 3D Holographic projection
	A projection robot is a device that combines projection technology and robotics to project images or video on a variety of surfaces and often has some interactive capabilities.	Projector robots can provide interactive multi-player games that encourage children with autism to play with other children or adults, thus improving their social skills. Projector robots can display different emotions and facial expressions to help children with autism learn to recognize and understand the emotions of others.	 Projection Robot
Motion Interactive Robot	Mechanical energy provides the energy required by the robot. The power generated by the electric motor needs to be transferred to the robot's actuators through a series of mechanical transmissions such as gears, belts, chain drives, levers, linkage mechanisms, electromagnets, screws, and guide rails.	Dancing robots can interact with children through simple dance movements, encouraging them to imitate and participate. This interaction helps children with autism learn social rules and non-verbal communication skills.	 Dance Robot

4. Conclusion

In a comprehensive analysis, we found that AI technology can significantly enhance behavioral skills, concentration, natural emotional expression, interactive communication skills, and cognitive abilities in children with autism spectrum disorders (ASD). In addition, several studies have shown that parental acceptance and adaptation to AI-based interventions are generally high. By streamlining operational processes, automating content, and lowering the threshold for participation, IT-based intervention programs make it easier for both parents and regular school teachers to participate in the intervention process. Such simplicity and ease of use not only improves the actual implementation efficiency of interventions, but also strengthens the cooperation between families and schools, thus providing more comprehensive support for children with autism. Nonetheless, the application of AI still faces a number of challenges. The first and foremost issue is data processing and privacy protection. Artificial intelligence relies on the analysis of large amounts of data, which often contains sensitive information about children with autism. However, specific measures on how to properly protect user privacy are rarely detailed in current research. Second, the amount of data available to the education sector is still relatively limited compared to fields such as finance and healthcare. This, coupled with the problems of inconsistent data standards and incomplete data collection within the education sector, has resulted in overall data quality that needs to be improved. Considering that each child with autism exhibits different characteristics due to the uniqueness of his or her congenital conditions, educational experiences, living environment, psychological state and physical condition, it is necessary to design and apply AI technology to individual differences in order to promote inclusive education more effectively, so as to achieve personalized intervention programs. In the future, the advantages of AI should be fully utilized to create a learning platform that better suits the needs of children with autism, and help each child to obtain the most suitable educational resources and development opportunities.

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