The Review of the Applications of AI Technology in the Detection and Treatment of Autism Spectrum Disorder (ASD)

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Abstract: Autism spectrum Disorder (ASD) not only has a significant impact on these patients themselves, but also has a serious impact on their families and the society. This paper is a review about the application of AI technology in order to deal with ASD. It mainly from two aspects: early detection and treatment of autism. AI-driven tools enhance early diagnosis by analyzing behavioral and developmental data, facilitating timely interventions that improve developmental outcomes. Personalized treatment plans generated by AI algorithms cater to the unique needs of each individual, maximizing therapeutic efficacy. Moreover, AI-powered social robotics and virtual reality simulations provide innovative methods for training social skills, allowing individuals with ASD to practice and develop communication abilities in controlled environments. Eventually, the appearance of LLM may accumulate the practical use of AI technology in dealing with ASD.

Keywords: ASD; AI technology; Machine learning; LLM; Robot

1. Introduction

ASD is a complex neurodevelopmental disorder that affects an individual's ability to socialize, communicate and behave. Today, ASD has become a serious, high incident problem for families with newborns. According to the Centers for Disease Control and Prevention (CDC), an average of 1 in 68 children worldwide has been diagnosed with ASD. The harm of autism not only has a significant impact on these patients themselves, but also has a serious impact on their families and the society.

The impact of autism on families is enormous. Family members need to spend a lot of time as well as energy in supporting members with autism. This could lead to significant emotional stress. In addition, the high cost of education and medical care for people with autism puts a heavy financial burden on families. At the social level, the high incidence of autism puts forward a higher demand for public resources and services, which requires corresponding adjustments in policy and resource allocation. Many people with autism continue to require ongoing support and care into adulthood. They face many obstacles in the field of independent living and career. It is very difficult for them to adapt to the complex environment of society. Although some patients excel in specific areas, in general, they are less able to live independently which means that they require long-term social support.

However, research has found that Early detection and intervention in autism can significantly reduce its harmfulness. One study of the Early Start Denver Model(ESDM) found that children with autism who were treated with ESDM showed significant improvements in social, communication, and adaptive behaviors. These children not only scored higher on tests of intelligence quotient (IQ), but also showed stronger language ability than children who did not receive the treatment. However, the cost of using human intervention is higher, and fewer and fewer people are willing to work in these industries. However, it is worth noting that the recent rapid development of AI technology provides a new direction for early detection and intervention of autism. Therefore, this paper will focus on the application of AI technology in the treatment of autism from two aspects: early detection and early intervention of autism.

According to the available literature, the theoretical community has carried out relevant research mainly from the following aspects:

2. AI technology in the detection of ASD

Different symptoms identified in ASD patients have been considered as features that can be used for ASD detection. Which contains behavioral disorder, facial expression disorder, structural disorder, Emotional disorder and mental disorder. Many researchers explored medical imageries for ASD detection and single and cross order strategy for ASD detection, which could be used to detect ASD.

Li et al. (2017), propose that through the use of imitation strategies, machine learning classifiers effectively identify adults with ASD. In their study, they used a dataset, which contains 16 ASD individuals. Each individual performed a set of hand movements. This study uses machine learning techniques to retrieve 40 kinematic constraints from 8 different simulation cases, which shows that even small data samples can be used to analyze high-dimensional data and diagnostic classification of autism through machine learning methods.[1]

Furthermore, Khan et al. (2019), note that nowadays, ASD has become more challenging due to its high incidence and number of patients. Screening is an expensive and time-consuming diagnostic method. Rapid advances in technology, algorithms, and machine learning have provided an economical and fast solution for early diagnosis of ASD. They came up with a predictive model that could help develop a mobile app to predict ASD. The model is a combination of Random Forest-CART and iterative binary 3 (Random Forest-ID3). They found that their proposed model was valid and accurate in predicting ASD.[2]

Meanwhile, Parikh et al. (2019), claim that one in 100 people worldwide has ASD. The harm caused by ASD is already serious. Early detection of ASD plays an important role in controlling and improving ASD. They conducted an experimental and statistical study to verify the effectiveness of ML(machine learning) in predicting ASD. They used cross-validation strategies to train and test machine learning models to classify people with autism and non-ASD controls. To assess categorical performance, they tested six personal traits. They conclude that machine learning models are much better and more cost-effective at predicting ASD than traditional clinical approaches.[3]

Last but not least, many scholars and writers, such as Raj and Masood. (2020) Recognize the effectiveness of ML in the early diagnosis of autism. They found that early diagnosis of ASD is critical, but for humans, they cannot process such a large amount of data in a short time. They say machine learning technology can be very useful in medical diagnosis. In this article, they analyze Naive Bayes, convolutional neural networks(CNN), neural networks, k-nearest neighbor classification(KNN), logistic regression, and support vector machines, and the use of these techniques in autism detection. They collected datasets of children and adults and tested them with all the techniques available. The resulting accuracy rates were 96.88%, 98.30% and 99.53%[4].

Through the above research, there is every reason to believe that the application of AI and ML technology in the early detection of ASD has excellent economic effects, and its own feasibility has been affirmed. At present, methods to detect autism based on convolutional neural networks and machine learning have been studied and practiced. Take, for example, Y Fan et al. used data from three publicly available databases to build the convolutional neural network: the SFARI database, a comprehensive database of all genes associated with autism spectrum disorder risk; BrainSpan database, currently the most comprehensive transcriptome database on human brain development; And the GEN-CODE database, a dataset containing all the genetic signatures in the human and mouse genomes. They then extracted ASD features. After extracting features or fusing features, a large number of features are often obtained. Although more features can provide more information to the model, these features may not be all effective, and may even affect the classification effect of the model. Therefore, it is important to effectively select the large number of features obtained. A good feature selection method can not only improve the prediction accuracy, but also reduce the calculation time by eliminating redundant data. To process this data, the researchers employed a convolutional neural network (CNN), a type of feedforward neural network that significantly reduces the complexity of the model by sharing weights via convolutional cores and filters. CNN is favored by many researchers because of its strong self-learning ability and superior parallel processing performance, especially in image learning. At present, there are many mature models based on CNN, such as LeNet, VGG, ResNet and so on.[5]

Therefore, AI is mainly applied to the early detection of ASD with its excellent large-scale data processing capability. Current research focuses on finding large data sets and using AI deep learning to achieve low-cost and accurate detection of ASD.

3. AI technology in the treatment of ASD

On the other hand, AI has increasingly had the potential to intervene in ASD in recent years. Thanks to the development of highly intelligent AI such as ChatGPT, providing AI interventions to patients with ASD, such as providing personalized treatment plans according to their conditions, or using AI to create communication objects for patients to save costs and care for the increasing number of ASD patients, these solutions were unimaginable a few years ago, but now, some researchers are already doing just that.

There has been an increasing use of new technologies such as connected objects, Artificial Intelligence, humanoid robots, augmented reality, and virtual reality in our daily lives. Currently, the most accessible solutions for individuals with autism are applications such as web or tablet[6]. With the growing sophistication of humanoid robotics, robots have demonstrated great potential as therapeutic mediation tools in the field of cognitive disorders [7]. The Humanoid Robot as a Therapeutic Mediation Tool for Individuals with Autism Numerous studies have shown the fact that children with ASD prefer interactive robots over static toys. Thus, machine appearance is less distressing than human characteristics, and they are more responsive to instructions initiated by robot movement rather than human movement [8]. Specifically, humanoid robots provide individuals with ASD with predictable and identical movements, synthetic voices without distinct personality in limited intona-

tions, and associated software that can simulate basic "social and affective"abilities. These characteristics significantly reduce the anxiety and improve the sensory receptivity in ASD patients[8].

Through visual displays, symbols, or voice outputs, these social robots can facilitate communication with ASD patients, allowing them to express themselves more effectively. They encourage people with ASD to initiate social interactions by providing appropriate social cues, suggestions, or activities. They exist in a supportive and non-judgmental way to help patients build confidence and overcome social barriers. One advantage of social robots is that they allow people with ASD to generalize the skills learned in human-computer interaction to real-world social situations. More specifically, social robots can provide a structured and controlled environment for people with ASD to practice social skills. As a result, people with ASD can transfer these skills to interactions with humans and navigate social environments more effectively.
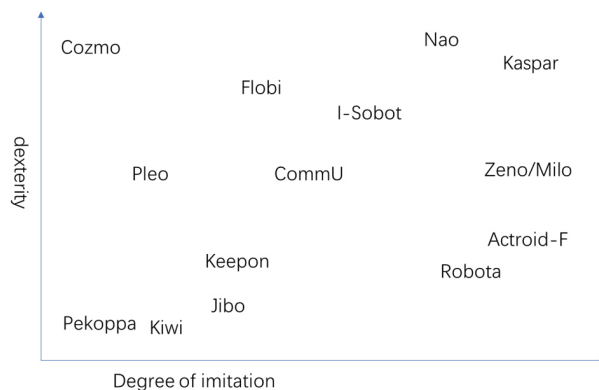

Figure 1. A Brief Review of Social Robots

Many people with ASD have difficulty with their own emotional regulation and understanding the emotions of others, and social robots have great potential to address this as well. Through interactive activities and games, social robots teach people with ASD many skills, including emotion recognition, regulation skills and social problem-solving skills.

Last but not least, social robots are able to tailor interactions and interventions to individual needs and preferences. Through machine learning algorithms, robots can analyze individual responses and adjust their cues or activities to provide a personalized learning experience. This adaptability enhances engagement and helps tailor skill development to the specific challenges and strengths of each individual with ASD.

In other words, social robots can serve many ASD patients at the same time. Due to the aforementioned personalization and the high intelligence of today's AI, such social robots only need a new set of hardware to serve a new ASD patient. This will be a good solution to the problem of scarce ASD medical resources and people's reluctance to engage in ASD treatment. This will save on the cost of treating ASD and expand the resources that can be allocated to patients with ASD.

In recent advancements in the field of artificial intelligence and robotics, the integration of the social robots with OpenAI technologies has demonstrated significant potential in enhancing interactions for individuals with ASD. Bertacchini et al. used Pepper, a social robot developed by the Softbank company, to test the feasibility of this approach[9].

Morgan et al. (2022) showed how Peppers and other types of robots can fulfill as many as 10 major roles in a variety of clinical settings in addition to the tasks described earlier in educational and social framework. The two predominant roles were surgical and rehabilitation and mobility. Although robots have been studied primarily in the operating room and the rehabilitation unit, Peppers are used in other settings, from the hospital ward to the pharmacy and in the rehabilitation unit and for inpatients. Health care needs are constantly changing, as demonstrated by COVID-19, and robots can help adapt to these changes[10].

Based on Pepper's performance in the medical field, the researchers plan to adapt it in order to treat patients with ASD. The process starts with configuring Pepper's hardware and software, which allows it to make more efficient use of sensors and actuators. The most important part to this integration is the use of OpenAI's natural language processing (NLP) and ML algorithms to facilitate seamless communication. Since Pepper itself is equipped with speech recognition, it is able to capture the audio data from the ASD patients and send it to OpenAI's API, which then transcribe the audio for further processing. Then, the natural language understanding (NLU) algorithm will interpret these transcripts to generate context-appropriate responses. These responses are converted into natural speaking speech by OpenAI's speech synthesis system to increase the sense of intimacy for users with ASD. In addition, Pepper will tailor interactive conversation scripts for ASD patients to ensure user engagement and effective communication.
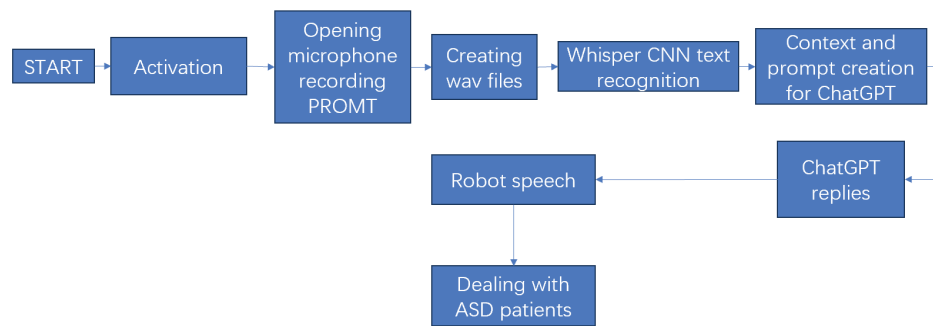
Figure 2. Processes of communication between ChatGPT and Pepper

However, in the end, the researchers point out that while there are many potential benefits of using Pepper, there are also several challenges as well as ethical issues. Firstly, Patients may become overly dependent on robots, especially in long-term care settings. Besides, since Pepper is allowed to collect and store the data of patients, there are concerns about the patients' privacy and data security. Thirdly, while robots can assist with care, they cannot replace the empathy provided by human caregivers. So, although Pepper shows promise in both neurodevelopment and healthcare, its use should be carefully considered and it should complement human care instead of replace it.

4. Conclusion

In conclusion, there is every reason to believe that the application of AI technology in the detection and treatment of ASD represents a promising direction for dealing with ASD. Some AI-driven tools have proven their efficacy. To be more specific, the detection algorithm based on the huge case database and advanced machine learning technology improves the accuracy and speed of early ASD detection, reduces the detection cost, and facilitates large-scale detection. At the same time, the integration of advanced AI systems with humanoid robots highlights the potential to create interactive and adaptive therapeutic environments for people with autism. It has the potential to provide a cost-effective, and scalable solution for the ongoing support and care of ASD patients. In curative effect, it is able to significantly improve the social skills and cognitive function of people with ASD. As AI technology continues to evolve, it will provide increasingly effective ways to address the complex needs of people with ASD, ultimately reducing the burden on families and society.

In addition, based on the pace of development of AI technology today, there is every reason to believe that new technologies such as LLM and AI Agent will soon be applied to inject new blood into the treatment of ASD. Studies have shown that LLMs hold significant promise as supportive tools in therapy, demonstrating strengths in empathetic engagement and adaptability in conversation.[11] This has the potential to provide people with ASD with a more authentic communication environment to help them recover socially.

However, while enjoying the dividends brought by the application of AI technology, we should also face up to the ethical issues. The feelings and opinions of patients and their families should be taken into account. For instance, how could the privacy of patients' personal data be protected? How about the patient depend so much on social robots that leads to his/her alienation of family members? In order to be successfully put to practical use, AI tools must overcome these problems.

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