Indian Journal of Natural Sciences www.tnsroindia.org.in ©IJONS

Vol.14 / Issue 77 /April / 2023 *International Bimonthly (Print) – Open Access* *ISSN: 0976 – 0997*

RESEARCH ARTICLE

Robot-Assisted Therapy for Children with Autism and Intellectual Disabilities using Deep Learning Systems

Veena N*

Assistant Professor, St Francis de Sales College, Bengaluru, Karnataka, India

Received: 15 Jan 2023 Revised: 20 Feb 2023 Accepted: 30 Mar 2023

*Address for Correspondence
Veena N
Assistant Professor,
St Francis de Sales College,
Bengaluru, Karnataka, India
E. Mail : veenanbca@sfscollege.in

ABSTRACT

In the rapidly expanding field of robot-enhanced treatment (RET), robots are used to support various therapeutic interventions. The use of robots to aid in the treatment of Autism Spectrum Disorder has gained popularity in recent years (ASD). Communication, social interaction, and behaviour are all impacted by ASD, a neuro developmental disease. The goal of RET for ASD is to connect with children who have ASD in an organized and predictable environment so they can learn and practice social skills. This paper explores the implementation of unique deep-learning neural network architectures for automatically determining whether a child is engaging with the robot during treatment sessions by concentrating their visual attention on it.

Keywords: autism, robot-assisted therapy, autism disorder, deep learning systems, human-robot interaction, intellectual disability

INTRODUCTION

Rapid technological advancement presents significant opportunities for therapeutic innovation for people with autism spectrum disorders. This seems to be especially relevant to the field of robotics (ASD). Robotic advancements in recent years have made it possible for them to do a variety of human-like tasks and to contribute to the growth of social skills in ASD patients. Despite the fact that efficacy and effectiveness studies on the therapeutic use of interacting robots with people with ASD are still in their infancy, this topic has attracted a lot of media attention during the past 10 years. Furthermore, the majority of the published research appears in robotics-focused publications rather than well-known ASD journals or clinically-focused journals. As a result, it's crucial to carefully examine current studies on the clinical applications of the technology. The clinical use of interactive robots is a promising development in light of research showing that people with ASD: exhibit strengths in understanding the physical world and relative weaknesses in understanding the social world: and are more receptive to feedback, even

social feedback, when administered via technology rather than a human (Yet, most of the support to date for its use in therapy is based on anecdotal evidence and lacks support for the generalizability of the findings.

Autism Spectrum Disorder

Autism spectrum disorder is a condition that affects how a person perceives and engages with others, which can lead to issues with social interaction and communication. Limited and recurring behavioural patterns are another aspect of the disorder. With autism spectrum disorder, the word "spectrum" alludes to the vast range of symptoms and severity. Autism, Asperger's syndrome, childhood disintegrative disorder, and an unidentified type of pervasive developmental disorder are all disorders that were formerly thought to be distinct conditions that make up the autism spectrum disorder. The name "Asperger's syndrome," which is usually considered to be at the mild end of autism spectrum disorder, is nonetheless occasionally used by some people.

Early-onset autism spectrum disorder eventually causes problems with social, scholastic, and occupational functioning in society. Children with autism usually display symptoms within the first year. A very small percentage of children appear to develop normally in the first year, but between the ages of 18 and 24 months, when they begin to exhibit signs of autism, they undergo a period of regression. Although there is no proven cure for autism spectrum disorder, rigorous early care has been shown to significantly improve the lives of many children. Autism is estimated to affect around 18 million people in India. Additionally, statistics indicate that more children in India are being diagnosed with autism.

Despite having completely normal appearances, many autistic youngsters spend their time engaging in perplexing and upsetting behaviours that differ noticeably from those of kids who are usually developing. They may have little or no interest in other people, including their parents, and engage in repeated behaviours that seem to serve no purpose. They are frequently referred to as existing "in a world of their own". ASD sufferers can be verbal or nonverbal, but not always. Although this phenomenon often referred to as savant or savant syndrome—is extremely uncommon, certain autistic people may exhibit extraordinary talent in certain fields, such as music or mathematics, as shown in the movie Rain Man. They all require support.

Social Assistive Robotics for Children with Autism

Given the complexity and broad amplitude of the autism "spectrum," which covers a range of disorders and degrees of severity, it is advisable to adopt a multi-modal intervention that may be customized to the needs of the individual in order to maximize the therapeutic advantages. Robots' controlled autonomy has therefore been utilized to give these children social partners they can get along with. With the help of multimodal interfaces (speech, gestures, and input devices), Socially Assistive Robotics (SAR), a novel field of robotics application, creates new platforms and services to assist users through advanced interaction driven by their needs (such as tutoring, physical therapy, daily life assistance, and emotional expression). Robots have been successfully used in recent research to mediate interactions between people and people with ASD. Participating human partners demonstrate gains in affective behaviour and attention sharing. Since communicating with a robot can be less daunting than with a human, social robots may benefit people with ASD who have trouble communicating.

Humanoid robots, which resemble humans but are far less complex than humans, may help ASD children learn more readily and subsequently make it less complicated to transfer the abilities they have gained via imitative human-robot interaction to child-human contact. In fact, imitation as a communication tool has been linked to good social behaviour and is seen as a reliable indicator of social abilities. Impersonation is used in therapy to improve bodily awareness, a feeling of self, creativity, leadership, and the capacity to begin interactions because children with autism sometimes struggle to imitate the behaviour of others. Numerous advantages of robot assistants in treating children with ASD have been demonstrated by recent robotics research.

Research Questions

- When compared to conventional therapy methods, does robot-assisted therapy help autistic children with their social skills?
- What specific aspects of robot-assisted treatment work best to encourage social interaction and interaction in autistic children?
- How do autistic kids react to and perceive robots in therapies, and how does this affect how effective the therapy is?
- Can robot-enhanced therapy be provided remotely, and if so, how does this alter how well it works to help autistic youngsters with their social skills?
- When compared to conventional therapy methods, are robots used in therapy to make autistic children more motivated and engaged?
- What are the attitudes of parents and other caregivers of autistic children towards including robot-assisted therapy in their child's treatment plan?
- How do the long-term effects of robot-assisted therapy for autistic kids compare to conventional therapy modalities?
- How cost-effective is robot-assisted therapy for autistic children compared to conventional therapy methods?
- How can robot-enhanced therapy be modified to match the unique requirements of various autistic children, and how can this method be personalized to maximize its efficacy?

The Objective of the Study

This study's objective was to conduct a critical assessment of the literature on the clinical applications of robotics for people with ASD in light of the application framework mentioned above. Our review was limited to papers that provided sufficient diagnostic information and clinical outcome data for the technique's evaluation and were either published in peer-reviewed journals or peer-reviewed, published conference proceedings. We highlighted crucial methodological aspects of therapy trials involving people with ASD, such as how participants were found and how diagnoses were verified, the suitability of control conditions/groups, and sample sizes. Understanding the existing state of empirically-based evidence for this experimental therapy approach, identifying gaps in the literature, and laying the groundwork for future study were the objectives.

Framework for Therapeutic Application of Robots

Robots are gaining significance in the healthcare industry and may have therapeutic applications in an assortment of contexts. Here is a potential strategy concerning how robots could potentially be used in therapy:

Assessment: Determine the patient's needs, objectives, and preferences through an assessment. Depending on the patient's health, the potential advantages, and the risks, decide whether a robot is the right option.

Robotic preference: Consider a robot that is appropriate for the patient's requirements and objectives while making your decision. Take into account the interface design, programming, and capabilities of the robot.

Robot personalization: Tailor the robot's interface and programming to the needs and preferences of each patient. To increase patient involvement and pleasure, customize the robot's looks and actions.

Therapeutic action: Use a robot to administer a therapeutic intervention, such as physical therapy, cognitive training, or social assistance. As well as maintaining an eye on the patient's development and input, make sure the robot is operating safely and effectively.

Evaluation: Measure the individual's effects, such as cognitive improvement, quality of life, and contentment, to evaluate the effectiveness of the robot-based intervention. To assess the comparative efficacy and cost-effectiveness of the robot-based intervention, compare it to other interventions or control situations.

Optimization: Based on the results of the evaluation and the patient's comments, improve the robot-based intervention. To further improve the robot's therapeutic impact and usefulness, keep improving its programming, interface, and content.

Ethical concerns: Discuss issues like privacy, autonomy, and informed consent that is relevant to the use of robots in healthcare. Ascertain that the robot-based intervention respects the patient's rights, beliefs, and preferences and does not violate them or subject them to discrimination or damage.

Although research conducted in this area does not explicitly examine clinical therapies as do research in the other categories, they do directly compare how people with ASD react to robots or individuals with characteristics/behaviours that are comparable to robots and those that are human. It is crucial to note that we are concentrating on the overall strategy of deploying robots rather than any specific objective behaviour.

Data and Statistics on Autism Spectrum Disorder

- One in 36 children has an autistic spectrum disorder diagnosis, according to the CDC's Autism and Developmental Disorders Surveillance Network (ADDM) (ASD).
- Reports of ASD from people with various socioeconomic, racial, and ethnic backgrounds
- ASD is more likely to occur in boys than in girls by a factor of more than 4.

According to caregivers' reports, between 2009 and 2017, 17% of children aged 3 to 17 were found to have an intellectual disability. They include attention-deficit/hyperactivity disorder, blindness, and cerebral palsy

METHODS

The following outlines the methods that can be applied to the machine learning experiments in the study

Convolution Neural Networks with Region Proposal (R–CNN)

In autism research, the use of region proposition (R-CNN) holds great potential in enhancing the accuracy and rapidity of identifying characteristics and patterns in brain imaging data. The connection and structural abnormalities of the brain in autistic individuals have been examined using brain imaging techniques like MRI and fMRI. Nonetheless, it takes a lot of time and processing to analyze such a big amount of image data.

R-CNN has been employed in autism research to improve the analysis accuracy and efficiency of brain imaging data. R-CNN effectively locates regions of interest in brain imaging using object propositions, which may then be further examined using CNN. It has been proven that using this method accelerates and increases the precision of autism-affected brain region detection. It is also been employed in autism studies to discover imaging biomarkers that can be used as diagnostic indicators for autism. One recent study, for instance, employed R-CNN to examine fMRI data and discovered a network of brain regions that showed decreased functional connectivity in autistic individuals. With the use of this biomarker, early intervention for autistic individuals may be facilitated

K–Nearest Neighbour Classifier

This approach has shown promising results in identifying subgroups of individuals with autism who share common characteristics and symptoms. One study used K-NN to classify individuals with autism based on their behavioural and clinical features, such as age, sex, IQ, and autism symptoms. The K-NN algorithm was able to classify individuals with autism into subgroups based on their shared characteristics, such as age and autism symptoms. This approach could potentially be used to identify subtypes of autism and develop targeted interventions for each subtype. Another study used K-NN to classify individuals with autism based on their brain connectivity patterns. The K-NN algorithm was able to identify subgroups of individuals with autism who shared similar brain connectivity patterns. This approach could potentially be used to develop personalized interventions for individuals with autism based on their specific brain connectivity patterns. Moreover, K-NN has also been used in the diagnosis of autism. A recent study used K-NN to classify individuals with autism based on their eye-tracking patterns. The K-NN algorithm was able to accurately classify individuals with autism with a high degree of accuracy. This approach could potentially be used as a non-invasive diagnostic tool for autism.

HOG Descriptors

To examine and categorize brain images according to their structural features, researchers studying autism have used Histogram of Oriented Gradients (HOG) descriptors. HOG descriptors are a popular technique for extracting features to examine the texture and form an image. In one study, structural MRI scans of the brains of people with autism and people who are usually developing were examined using HOG descriptors. According to the analysis, the HOG descriptor may distinguish between the modifications to brain architecture between those with autism and people who are usually developing as shown in figure 2. According to the study, HOG descriptors can be utilized as a feature extraction method to find structural variations in autistic people's brains. Moreover, HOG descriptors have been applied to the analysis of EEG signals in autistic people. One study compared the time-frequency characteristics of EEG signals in people with autism versus others who are usually developing. Based on the research, HOG descriptors can distinguish between variations in the time-frequency characteristics of EEG data in people with autism and those who are usually developing. According to the study, HOG descriptors can be utilized as a feature extraction method for examining EEG signals in autistic people.

DISCUSSION

Robot-assisted therapy is a promising application area for intelligent social robots. However, most studies in the paper focus on autistic people without ID or do not analyze comorbidities. There are very few studies in this area, which can be considered one of the current gaps between scientific research and clinical application. In the clinical context of ASD with ID, the goal is to use robots for social assistance to assist therapists, reducing the workload by allowing the robots to take over certain parts of the intervention. It includes monitoring and recording children's activities, actively engaging children when distracted, and adapting robot behaviour to each child's level of intervention. In order to achieve this, computational intelligence techniques should be used to enhance the robot's capabilities to favour greater adaptability and flexibility, allowing the robot to be integrated into any therapeutic setting in accordance with the particular needs of the therapist and the individual child.

CONCLUSION

The use of interactive robots with individuals who have Autism Spectrum Disorder in therapeutic settings has a lot of potential advantages. These benefits include the inherent appeal of technology to those on the autism spectrum, robots' capacity to repeatedly execute simple and isolated behavioural traits, and the ease with which they can be programmed and customized to provide specialized care for each child. Despite these exciting prospects, this field of study is still in its infancy, therefore further investigation is required to establish the incremental validity of this methodology.

REFERENCES

1. Diehl, J. J., Schmitt, L. M., Villano, M., & Crowell, C. R. (2012). The Clinical Use of Robots for Individuals with Autism Spectrum Disorders: A Critical Review. Research in autism spectrum disorders, 6(1), 249. https://doi.org/10.1016/j.rasd.2011.05.006
2. Salhi, I., Qbadou, M., Gouraguine, S., Mansouri, K., Lytridis, C., &Kaburlasos, V. (2022). Towards Robot-Assisted Therapy for Children With Autism—The Ontological Knowledge Models and Reinforcement Learning-Based Algorithms. Frontiers in Robotics and AI, 9. https://doi.org/10.3389/frobt.2022.713964
3. Viola, P.; Jones, M. Rapid object detection using a boosted cascade of simple features. In Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR 2001), Kauai HI, USA, 8–14 December 2001; Volume 1, pp. I-511–I-518.
4. Diehl, J. J., Schmitt, L. M., Villano, M., & Crowell, C. R. (2012). The Clinical Use of Robots for Individuals with Autism Spectrum Disorders: A Critical Review. Research in autism spectrum disorders, 6(1), 249. https://doi.org/10.1016/j.rasd.2011.05.006

5. Di Nuovo, A.; Conti, D.; Trubia, G.; Buono, S.; Di Nuovo, S. Deep Learning Systems for Estimating Visual Attention in Robot-Assisted Therapy of Children with Autism and Intellectual Disability. Robotics2018, 7, 25. https://doi.org/10.3390/robotics7020025
6. Di Nuovo A, Conti D, Trubia G, Buono S, Di Nuovo S. Deep Learning Systems for Estimating Visual Attention in Robot-Assisted Therapy of Children with Autism and Intellectual Disability. Robotics. 2018; 7(2):25. https://doi.org/10.3390/robotics7020025
7. Di Nuovo, Alessandro, Daniela Conti, Grazia Trubia, Serafino Buono, and Santo Di Nuovo. 2018. "Deep Learning Systems for Estimating Visual Attention in Robot-Assisted Therapy of Children with Autism and Intellectual Disability" Robotics 7, no. 2: 25. https://doi.org/10.3390/robotics7020025
8. T. Ahmed, Z. A., H. Aldhyani, T. H., Jadhav, M. E., Alzahrani, M. Y., Alzahrani, M. E., Althobaiti, M. M., Alassery, F., Alshaflut, A., & Alzahrani, N. M. (2022). Facial Features Detection System To Identify Children With Autism Spectrum Disorder: Deep Learning Models. Computational and Mathematical Methods in Medicine, 2022.

Table 1: Application categories for interactive robots in medical therapy.

Classification	Explanation	Possible Application Examples
Exercising skills	A robot is employed to learn and perform a desired action or ability.	Robot engages in scripted interaction with the child to help them practice a skill while modeling behaviour for them to imitate
Evoking actions	Robot engages in an activity or interaction with the child to inspire a particular behaviour.	To collect distinguishing characteristics for a diagnostic assessment. To encourage socialization conduct with an interactive human partner, such as joint attention
Responses to robots	Compares speed, and/or frequency of interactive replies given to a robot or a conversation partner who exhibits robot-like traits to those given to a human or device that is not robotic.	The research sheds light on how children with ASD may react to robots or traits that resemble robots in diverse ways, although they do not directly have clinical applications.
Giving feedback or support	Robots provide social assistance or behavioural alterations during an activity.	Robot provides assistance and the required reminders to encourage interaction with another active partner when a child accomplishes a specific skill.

Table 2: Identified Prevalence of Autism Spectrum Disorder Data Aggregation from across all sites for the ADDM Network 2000–2020

Year of Surveillance	Birth Year	Number of Reported ADDM Sites	Combined Prevalence per 1,000 Children (Range Across ADDM Sites)	This relates to about 1 in X children.
2020	2012	11	27.6 (23.1-44.9)	1 in 36
2018	2010	11	23.0(16.5-38.9)	1 in 44
2016	2008	11	18.5 (18.0-19.1)	1 in 54
2014	2006	11	16.8 (13.1-29.3)	1 in 59
2012	2004	11	14.5 (8.2-24.6)	1 in 69
2010	2002	11	14.7 (5.7-21.9)	1 in 68
2008	2000	14	11.3 (4.8-21.2)	1 in 88
2006	1998	11	9.0 (4.2-12.1)	1 in 110
2004	1996	8	8.0 (4.6-9.8)	1 in 125
2002	1994	14	6.6 (3.3-10.6)	1 in 150
2000	1992	6	6.7(4.5-9.9)	1 in 150

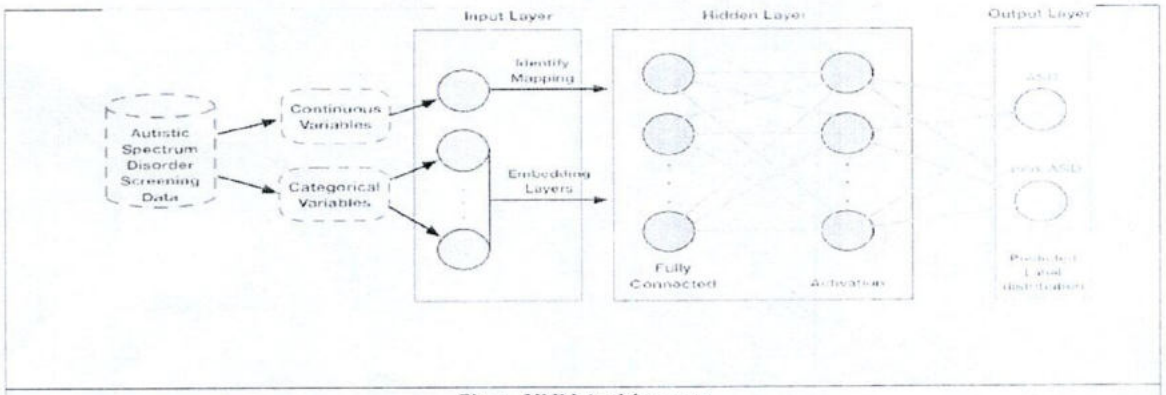

Fig. 1. KNN Architecture

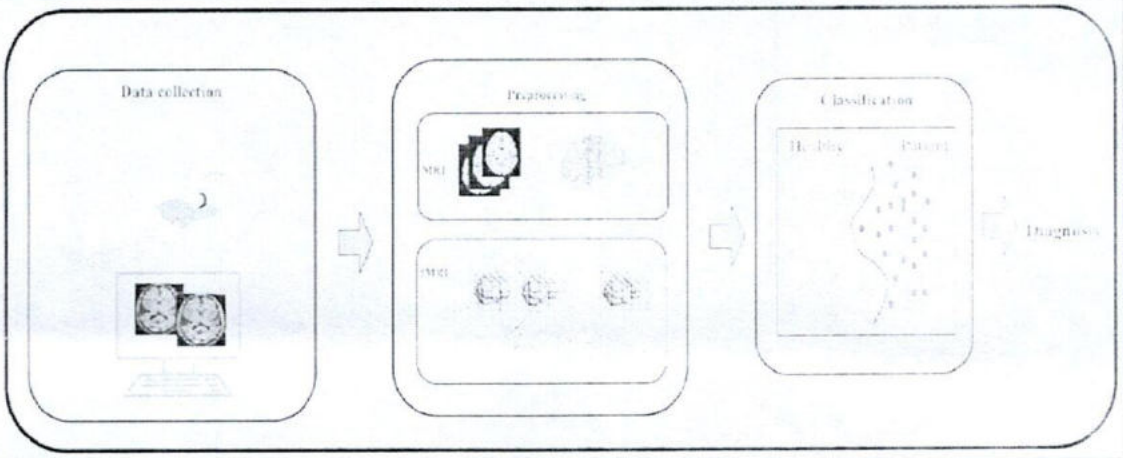

Fig. 2. HOG descriptors process mechanism