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An exploratory critical review on assistive robotics applied to autism spectrum: employability challenges

Eldon Glen Caldwell Marín
Department of Industrial Engineering
University of Costa Rica
San José, Costa Rica
eldon.caldwell@ucr.ac.cr

Miguel Cazorla
University Institute for Computing Research
University of Alicante
Alicante, Spain
mcazorla@dtic.ua.es

Mauricio Zamora
Smart, Lean & Cognitive Systems Lab.
University of Costa Rica
San José, Costa Rica
mauricio.zamora@ucr.ac.cr

José García and Jorge Azorin-Lopez
Industrial Informatics and Computer Networks Research Group
University of Alicante
Alicante, Spain
jgr@dtic.ua.es, jazorin@dtic.ua.es

Abstract

Robotics has been applied to assist autistic people with different approaches and therapy goals. In this paper, we describe the results of an exploratory analysis of research approaches, methods and paradigms that frequently are used and reported. Our critical perspective seeks links to the social responsibility in terms of inclusive employability and equity. We have found that research is geared towards robotic assistance to therapists typically to improve relationship skills. The use of robots, moreover, implies that specialists are not necessarily present all the time so it is essential that autistic people accept the robot as a supporting technology.

We conclude that is common to find research that focus on experimental design with a robot action in scheduled moments, physically controlled when people are exposed. In addition, experiments with robotics applications in virtual worlds interconnected with "physical world" under a cyber-physical concept are not frequently considered. However, evidence of validated progress in clinical terms is not conclusive, so this seems to be a real limitation for employability increase of autistic people. Also, research with rigorous methods aimed at obtaining robust clinical results is a great opportunity, especially if a strong link is made in increasing the employability of autistic people.

Keywords

Robotics, autistic people, assistive robotics, virtual robotics platform, inclusive employment

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1. Introduction

This work is focused on the reported scientific research on robotics assistance to improve social relations skills. According to authors like Scassellati B., Admoni H., and Mataric M [20] a lot of efforts are made on the autistic spectrum, particularly, the assistance to therapists in the treatment of people with autism.

Assistive Robotics is on the rise with interest in research that seeks the development of collaborative robots [22, 21]. Much of this research seeks to improve therapeutic outcomes that aim for the quality of life of people with different types of disorder (one of them is autism). However, approaches and types of research are still clinically analyzed because a lot of this scientific efforts are reported in media devoted to technology and robotics rather than to clinical practice.

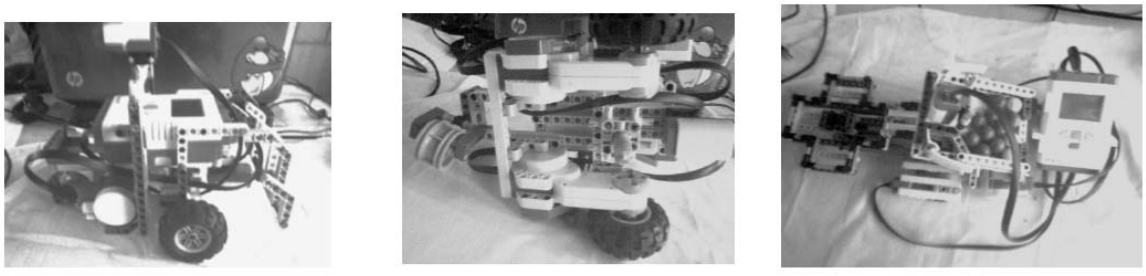
The following sections present an exploration of the state of the art of robotic assistance research in autism for therapeutic purposes, focus on employability opportunities. The paper is divided into three sections, beginning with the description of research approaches, methods and analytical tools. In the second section we describe the most frequent perspectives and a discussion about the reported progress and finally we present conclusions and possible future research opportunities.

2. Autism Spectrum Disorder (ASD) and the way robotics research is conducted

Cho Seong-Jin & Ahn Dong Hyun establish in their 2016 research that "Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by persistent deficits in the ability to communicate and interact socially across multiple contexts, along with identifiable patterns of restricted and repetitive behaviors, interests and activities. The fundamental cause of ASD is a neurobiological impairment that obstructs the normal function of the brain, and its effects are found not in any specific area; rather it manifests with diverse symptoms that reach across the whole range of development" [6].

People with autism have problems to socialize as they do people who do not have this disorder because of the difficulty they have to make sense of the environment that surrounds them [4]. Cruz & Salazar [4] establish that in a great amount of research until the year 2014, it has been obtained as a result that people with autism have difficulties with interactions with others, otherwise with a "robot therapist", feeling a certain affinity with this.

They also report in their research the construction of three different robots using the platform as shown in figure 1. The first robot was used to traverse a labyrinth which aims at the autistic child to recognize their surroundings and follow the Robot without skipping any obstacle. The second robot dispenses and classifies balls of different color aiming that the child can repeat the same classification that the robot did previously. And the last robot draws a geometric figure on a cardboard so that the child can place corresponding geometric figures where the robot drew them, ie if the robot drew a circle, the child is given a circle so that he can place it in the drawing. The activities were designed so that the participants repeat what the robot performs to evaluate the learning imitating actions that facilitate the socialization in their environment [4].



a. b. c.

Figure 1. An example of robotic platform used by Cruz Ardila J. C., Salazar Y. A., 2014.

This study of 2014 is a typical type of research that is being carried out with assistance robots in therapies, since a quasi-experimental interaction is observed in which the behaviors are recorded in controlled exercises and qualitative evaluations are established in the company of therapists . In addition, the interaction spaces are face-to-face and for short periods [2, 5, 8, 12, 13].

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However, other works report the search for more interactivity. For example, the research by Liu, L., Li, B., Chen, I.-M., Jui Goh, T., & Sung, M. of 2014 [14], in which they hypothesize that children with autism have an intrinsic interest in technology, therefore robots can be used to develop pro-social behaviors. They use a friendly-looking robot to teach a skill that the autistic participant can learn and imitate; and then transfer or apply in interactions with humans. Interaction sessions are geared towards inducing social skills such as greetings and games, bringing comfort and empathy. The implemented therapy provides a less invasive learning atmosphere and they found that robots can contribute to meeting the therapist's goals for specific courses of action for self-introspection and self-improvement; besides that the therapy does not generate dependence of the therapist and the robot arouses the interest and can be attractive and gratifying in a ludic environment. However, the results are exploratory and clinically inconclusive [14].

Another type of work focuses on data collection techniques to understand the machine learning requirements [16, 17, 24] to recognize patterns of behavior that may be more effective in generating well-being in autistic people with some kind of condition or singularity which differentiates their interaction with others. This is because it is well known the degree of variability that is sometimes perceived in states of mind and ways of expressing emotions within the autistic spectrum, day to day and even hour by hour [23, 25].

Calderita et al. [3] claim that robots can provide an integrated social assistance. In his research the construction of a robot is done as assistant of a therapist for sessions of physical rehabilitation. In this type of process, resources are typically limited and the effectiveness of rehabilitation is correlated with the extent to which people stick to and advance in the indicated therapy. Therefore, if therapy sessions can be increased, the evidence shows that the improvement in competencies will be in a shorter time.

This is difficult for some people because the specialist does not have unlimited time so it is sought the assistance of a robot that can be programmed so that the autistic person can follow the indications without the presence of the therapist. This would allow the autistic person to have more rehabilitation sessions, reducing their recovery time, while saving resources to the medical center by not having to increase their payroll [3, 10].

In addition, it is reported that the effectiveness of the treatment depends on the perseverance of the patient and the effectiveness of the human-robot interaction depends on the degree of acceptance of the patient towards the robot, which is correlated with its human aspect, ie, if robot assistant has a humanoid friendly form it is more feasible for the autistic person to accept it as tutor or assistant for follow-up therapy [3].

This type of research has also been found in alternative fields in which social robotics is developed; for example, in the care of the elderly, in the physical rehabilitation and care of people with cognitive disabilities [15, 28]. However, as mentioned earlier, research on social robotics has often been focused on people within the autistic spectrum [25].

Another relevant aspect in this type of research is that the robot must be subordinate, that is, be able to adapt its behavior to the personality and profile of the autistic person so that he can offer a motivating and attractive therapy. Different studies have demonstrated the positive impact of robot therapies on people who are unwilling to work with human therapists [27].

To achieve adaptability to temperaments, experimentation with facial language and smooth or non-mechanized movements, different technologies are used by means of advanced robots, many of them humanoids such as KASPAR [26], FACE [6] or NAO [22]. But research is also reported using robots designed from animal-like structures such as Keepon [1] or Pleo [6]. In all cases, the methods are quasi-experimental and seek to assess communication or learning capabilities under controlled conditions.

A resource of recent use is virtual reality technology interconnected with robots [18], as reported by García-Vergara S., Brown L., Won Park H. & Ayanna M. Howard [11], where therapy was incorporated into games designed to provide engagement and motivation to improve the participation of the autistic person in different collaborative situations.

The system was characterized by the ability to individualize the rehabilitation protocol through the adaptation of a game configuration and to be able to record the measures and evaluate the rehabilitation results to provide

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autonomous feedback to the therapist in real time. The integration of the multiplayer option demonstrated the achievement of greater motivation in the execution of the games. Positive changes were also identified in the perception and feelings observed in the participants that interacted with the robot, so there was also an increase in social experience [11].

Sánchez Martin C., Lan Yu Ju and Lin Tsung-Ju [18], about this type of research, present in 2014 a meta-analysis of 56 articles and their starting point was to find successful activities for learning languages and the purpose of the designed activities. The most commonly encountered activity was role-playing and cultural knowledge. They identified platforms such as "Second Life", "World of Warcraft" and "Active Worlds"; and report that the virtual world is used in two main ways: first, to make the link with other people to learn the language; and second, to perform cultural exploration critically. In their study, role play is presented as an activity developed to promote problem solving, critical thinking, meaningful collaboration, authentic learning, and participant autonomy.

3. Research gaps and needs

3.1 Teleological and methodological aspects

As reported by Diehl J, Schmitt L. M., Villano M, Crowell CR in 2012, the purpose of many of the investigations is oriented towards the study of "responses to robots or robot-like characteristics, eliciting behavior, modeling, teaching, or practicing skills and providing feedback or encouragement, that is, the use of a robot as purveyor of behavioral contingencies or social support during an activity" [9, 10].

However, in this analysis we also find a fifth category: the purpose of stimulating the human-human relationship with the robot as a linking instrument [7, 8, 19]. In this fifth teleological category, there is the intensive use of virtualization technologies and greater application of machine learning to adapt to a specific ludic objective.

So far, our documental analysis points that the main gap is the poorly generalizable results reported in the investigations reviewed [1], because in the methodological design, research is still geared towards exploratory and quasi-experimental objectives.

The great variability in the conditions in which a robot can interact in a therapeutic context makes it very difficult to conduct clinically conclusive studies. In none of the five teleological dimensions mentioned above clinical results, that show evidence of causality but only correlation or perceived improvement, have been obtained. Theoretical understanding or clinical diagnosis is still not clearly influenced by assistive robotics with therapeutic application to benefit people with autism [1, 9].

3.2 Employability challenges

The challenge of social robotics applied for assistance purposes for autistic people is still in the search for clear evidence of how the goals of personalized therapeutic processes improve, so that the robot can adapt to the diverse needs of autistic people and, in addition, the robot can learn courses of action about patterns of frustration or temperament that are associated with adaptability decisions [8, 22].

In practical terms, the possibility that research with assistant robots used in therapies for people with autism impacts on their chances of being hired on an equal footing still seems to be far away [28].

The reasons are manifold, but the ineffectiveness found in terms of the fact that robots really make a therapeutic difference to increase social relations skills and other competencies highly valued in labor contexts seems to be decisive. Studies based on meta-analysis show little progress in verifying that assistance robotics has a real influence on the effectiveness of diagnostic, therapy and evaluation processes for the fulfillment of rehabilitation or skills improvement objectives [1, 9, 28].

For example, Wolbring Gregor found in 2016 that research in Canada was not strongly linked to employability purposes with plausible results. Its conclusion is expressed as follows:

"The study found that robots were rarely mentioned in relation to the employment situation of disabled people. If they were mentioned the focus was on robots enhancing the employability of disabled people or helping so called abled-bodied people working with disabled clients. Not one article could be found that thematized the potential

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negative impact of robots on the employability situation of disabled people or the relationship of disabled people and robots as co-workers. The finding of the study is problematic given the already negative employability situation disabled people face" [28]. This conclusion, of course, included the Autism Spectrum Disorder.

This is similar than the main conclusion of Begum M., Serna R.W., Yanco H.A. in 2016 talking about the human robot interaction research (HRI): "Robotics research over the past decade has demonstrated that many children with autism spectrum disorders (ASDs) have a strong interest in robots and robot toys and can connect with a robot significantly better than with a human. Despite showing great promise, research in this direction has made minimal progress in advancing robots as clinically useful for ASD intervention. Moreover, the clinicians are generally not convinced about the potential of robots. A major reason behind this is that a vast majority of HRI studies on robot-mediated intervention (RMI) do not follow any standard research design and, consequently, the data produced by these studies is minimally appealing to the clinical community" [1].

It is clear that research with rigorous methods aimed at obtaining evidence-based clinical results is a great opportunity, especially if a strong link is made in increasing the employability of autistic people. In this sense, the quasi-experimental exploratory method commonly used must evolve towards proposals more oriented to the evidence based on clinical results with study of causality.

In addition, most of the proposals focus on a face-to-face work of robots in interaction with autistic persons and the applications in virtual worlds interconnected that allow to extend the robotic interactions without presence of the therapist are not frequent.

4. Conclusions and future works

According with Diehl J, Schmitt L. M., Villano M, Crowell C.R. [9], Begum M., Serna R.W., Yanco H.A. [1] and Cho Seong-Jin & Ahn Dong Hyun [6], we found that the purpose of many of the investigations is oriented towards the study of "responses to robots or robot-like characteristics, eliciting behavior, modeling, teaching, or practicing skills and providing feedback or encouragement, that is, the use of a robot as purveyor of behavioral contingencies or social support during an activity" [9]. However, in this work we also find a fifth teleological category: the purpose of stimulating the human-human relationship with the robot as a linking instrument [7, 8, 19]. In this fifth teleological category, there is the intensive use of virtualization technologies and greater application of machine learning to adapt to a specific ludic objective.

We also conclude that is common to find research that focus on experimental design with a robot action in scheduled moments, physically controlled when people are exposed. However, evidence of validated advances in clinical terms is still incipient, so this seems to be a real limitation for employability increase of autistic people.

In the future, research with rigorous methods aimed at obtaining evidence-based clinical results is a great opportunity, especially if a strong link is made in increasing the employability of autistic people. In this sense, the quasi-experimental exploratory method commonly used must evolve towards proposals more oriented to the evidence based on clinical results with study of causality.

Another great opportunity for research in the future is the use of virtual reality experience of autistic people in combination with an avatar of a physical robot. This is an innovative way to search continuous and real time exposure to therapy protocols without therapist physical supervision but virtual, taking into account that experiments with robotics applications in virtual worlds interconnected with "physical world" under a cyber-physical concept are not frequently considered.

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Biography

Eldon Caldwell is "Outstanding Service Award" of the Industrial Engineering and Operations Management Society, USA; full professor (Cathedraticus) University of Costa Rica with over 25 years of teaching and research experience. After his Bachelor and Master degree in Industrial Engineering at University of Costa Rica, he obtained several Master degree (MBA, Health Systems, Social Marketing, Operations Engineering) and finally a Ph.D. in Industrial Engineering at the University of Nevada, USA/Autonomous University of Central America, CR. Currently he is Chairman of Industrial Engineering Department at University of Costa Rica and his research interests include smart, lean and cognitive systems, robotics, cyber-physical systems and intelligent technologies for educational systems implementation in workplace for equitable employment of people with disabilities. Contact: eldon.caldwell@ucr.ac.cr

Miguel Cazorla received a BS degree in Computer Science from the University of Alicante (Spain) in 1995 and a PhD in Computer Science from the same University in 2000. He is currently Associate Professor in the Department of Computer Science and Artificial Intelligence at the University of Alicante. He has done several postdocs stays: ACFR at University of Sydney with Eduardo Nebot, IPAB at University of Edinburgh with Robert Fisher, CMU with Sebastian Thrun and SKERI with Alan Yuille. He has published several papers on robotics and computer vision. His research interest are focused on computer vision and mobile robotics (mainly using vision to implement robotics tasks). Currently he is Director of University Institute for Computing Research at University of Alicante, Spain. Contact: mcazorla@dtic.ua.es

Mauricio Zamora currently teacher and assistant professor at University of Costa Rica with over 10 years of teaching and research experience. Bachelor of Science in Systems Engineering at International University of the Americas, he is a doctoral researcher in Computing Sciences (Automation and Robotics) at the University of Alicante, Spain and researcher in the Smart, Lean and Cognitive Research Laboratory at University of Costa Rica. His research interests include information retrieval, computer vision, machine learning, robotics and natural language processing. Contact: mauricio.zamora@ucr.ac.cr

José García received his Ph.D. degree, with specialization in Computer Vision and Neural Networks, from the University of Alicante (Spain). He is currently Associate Professor at the Department of Computer Technology of the University of Alicante. His research areas of interest include: computer vision, neural networks, man-machine interfaces, ambient intelligence, parallel and multicore architectures and visual surveillance systems.He has authored +40 publications and revised papers for several journals like Neurocomputing, Applied Softcomputing, Image Vision and Computing, IET on Image Processing, SPIE Optical Engineering and many others, chairing sessions in IJCNN and participating in program committees of several conferences including IJCNN, ICRA, ICANN, IWANN, KES, ICDP and others. Contact: jgr@dtic.ua.es

Jorge Azorin-Lopez completed a degree in Computer Science Engineering and a Ph.D. degree in Computer Science at the University of Alicante (Spain. Since 2001, he has been a faculty member of the Department of Computer Science Technology and Computation at the same university, where he is currently an Associate Professor. His current areas of research interest include modelling vision systems to perceive under adverse conditions, real scenes segmentation and labelling, automated visual inspection and reconfigurable hardware.
At present, he is an academic visitor at Institute of Perception Action and Behaviour of the University of Edinburgh. He is working on 3D shape inspection of semi-specular surfaces. Contact: jazorin@dtic.ua.es

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