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Robots Used In Therapy For Children With Autism Spectrum Disorder

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ABSTRACT:- For more than three decades, various aspects of robotics have been used in the treatment of children with autism spectrum disorders (ASD), especially humanoid robots that look like human beings with their phenotypic characteristics. However, their form of communication is much simpler. Since one of the primary difficulties of children with ASD is precisely the ability to communicate and interact with others or the environment, the realization of communication with robots has proven to be helpful as a therapeutic technique. Namely, several studies have confirmed the positive effect of robots in the therapy of children with ASD, especially in teaching communication and social skills[1][2][3]. That is why robots are increasingly used in the therapy and rehabilitation of children with ASD in some countries, and humanoid robotics is constantly evolving. This paper aims to offer an overview of the current use of essential humanoid robots in the treatment of children with ASD and their use in the Republic of Croatia and present the crucial characteristics of humanoid robots and their role in the treatment of children with ASD.

Keywords:- children with autism spectrum disorder (ASD), robotics in children with ASD, therapeutic robots, therapy of children with ASD

I. INTRODUCTION:

WHY ROBOTS IN THE THERAPY OF CHILDREN WITH ASD?

Given the wide range of ASD difficulties, approaches to therapy and rehabilitation of children and people with autism spectrum disorder have changed throughout history: from psychotherapy, behavioral therapy, environmental therapy, group therapy to many other treatments and therapies such as music and art therapy, play therapy or kinesitherapy. Recently, parent-mediated treatments, group models, and combination treatments (medical and behavioral) have been increasingly developed and tested, and family involvement in rehabilitation and therapeutic procedures is almost necessary. With the development of technology and mainly digital technology, social-interactive robots have been introduced in the therapy of children with ASD. Namely, it has been shown that for some children with autism, interaction with other people can be unpleasant, i.e., that it is difficult for them to achieve due to the overload of face-to-face interaction. Therefore, it is much easier for these children to focus their attention and learn social skills from their teachers and therapists – precisely the people in charge of helping them in their social adjustment or the tiny robots that are interesting to them.
For this reason, social robots have begun to be used in the treatment of children with ASD as tools for teaching a variety of skills. For example, social robots create engaging, attractive, and meaningful play situations that force children with ASD to interact with them, so one of the new applications of social robotics is the therapy of children with ASD [4]. The following is an overview of robots used during different periods in the therapy of children with ASD.

II. FEATURES OF ROBOTS USED IN THE THERAPY FOR CHILDREN WITH ASD

Throughout the development of robots used in therapy with children with ASD, scientists and researchers have used many different robots, some of which have been less and some more successful. For example, researchers at the University of Hertfordshire have used non-humanoid mobile robots in their autism

studies: puppet-like robots and a child-sized humanoid robot called Kaspar [5]. Japanese researchers used Infanoid, a machine-like robot, and a small snowman-like robot called Keepon [6]. Researchers from the University of Pisa used the realistic robot FACE [7]. In contrast, researchers from the University of Sherbrooke and Toyota used less real humanoid robots in their studies, such as Tito and HOAP-3 [8].

Today, when much more attention is paid to robotic assistance therapy, the question arises as to the necessary characteristics that a robot should contain for therapeutic work with children with ASD. Robot makers should first carefully consider its aesthetics [9]. Speaking of the physical appearance of a robot, the starting point is whether the robot should be as credible a human replica as possible, that is, as similar as possible to a human or should not look like a human at all. There are different scientific approaches to this issue.

For example, some authors say children with ASD prefer robots that do not look too much like a natural person [10]. On the other hand, others advocate a naturalistic approach in the therapy of children with ASD and suggest that a more realistic clinical environment for children allows for a more straightforward generalization of what is learned in everyday life [11]. This means that the more a robot looks like a human, the better results it will have in its purpose. For example, robots that are more suited to human appearance, with credible characteristics and movements, can make it easier for children with ASD to perceive and understand social behaviors [12]. Likewise, the authors point out the advantages of robots that do not look like humans at all in the sense that their advantage is less complexity which also means fewer distractors for children with ASD, emphasizing that in this way, children with ASD more easily adopt desired social behaviors. Whether a humanoid or non-humanoid robot is better for a child with PSA, each child is an individual for himself. Therefore, the choice is practically personal.

While going through the professional literature and comparing all the characteristics that a therapeutic robot should have, we have listed the characteristics that we consider necessary for the therapeutic robot to have, and we have explained why. Robots of different types have different positive and negative features. However, perhaps the most essential characteristic of a robot is performing the desired activities devised by therapists working with ASD children [13]. The robot should be visually attractive to the child and attract his attention. Still, the colors should be neutral and not aggressive to reduce hyperstimulation that negatively affects the child's attention and interferes with his daily functioning [14]. The robot's face should be simple and with little detail to reduce possible hyperstimulation and resulting confusion.

The robot's size should match the child's height to make it easier to make eye contact and generally less intimidating. Robots must have a range of motion and degrees of freedom similar to those of a child to get as close as possible, and movements must also not be sudden and impulsive to prevent intimidation of the child. Furthermore, the robot should be able to move small, light objects and be made so that it is safe for the child and protected from the child. The activities of children with ASD are primarily unpredictable, so robot creators should make robots resistant to bumps and falls. From a hardware aspect, the structure of a robot can be made modular, which means that if one part is damaged, there is no need to replace the whole robot, but only that particular part [13]. If the child reacts undesirably to the robot, if the child rejects it, it is necessary to ensure a possible prompt stoppage. Robots should still have a certain amount of autonomy [4], but not completely. Therefore, the therapist needs to control the robot and its actions and adapt them to the child's interests and level of focus.

For children with ASD, it is essential to encourage proper task execution to ensure that the child feels rewarded for achievement [10]. For children with ASD, incentives in the form of rewards have proven to be very successful, especially since every task they have mastered is excellent progress. This means that it is necessary to design a user interface that allows therapists to program the robot understandably while remaining flexible enough to use all the desired features of the robot being used. The robot-controlled user interface must also meet specific requirements to achieve this goal: it must be easily understood by therapists, adaptable to sudden changes, and controlled by a hand-held device [13]. Therefore, the therapist should be able to program the robot for their use. This means that creators must design a user interface that allows therapists to program robots in a way they can understand [13]. The whole session may be planned, but this is not recommended, as children with ASD can be unpredictable, and their effect on the session is not linear. Therefore, the therapist should be able to adapt the robot's actions to the child's current interest and progress during the session and should be able to respond in a timely and valid manner to changes and situations that may not be planned. Therefore, we would conclude that it is necessary to dose its physical aspects not to cause undesirable behaviors in children with ASD at therapeutic robots. Consequently, it is also essential that the therapist retains a more significant dose of autonomy in configuring the robot and the therapy session to adapt the robot to each child individually because each child has different needs and goals.

III. TYPES OF ROBOTS USED IN THE THERAPY OF CHILDREN WITH ASD

Since we have encountered more humanoid robots during our practice, we will list specific humanoid robots in this article. Today, there are a lot of humanoid robots, which were created to help ASD children speak

and develop social competencies. Here are some of the robots which are most often used in robot-assisted therapy for ASD children. These robots were chosen because there is the most data in the literature on their application in working with children with ASD. Therefore we believe that they are most often used in robot-assisted therapy and give the best results.

MARIA –is a child-sized robot with human female features (eyes, nose, mouth, hair, eyelashes, cheeks), stylized into a robotic-toy style that presents a mix of anthropomorphic and non-biomimetic appearance [15]. It has touch screen multimedia devices, and humans control it. What is unique with MARIA robots is that it has self-presentation, which is used to help children feel more confident and comfortable interacting with the robot. The hypothesis was to prove if a mobile robot with a similar height and self-presentation could promote interaction in a few sessions without any previous training from the child. The main idea of this work was to make a proof-of-concept application, to know whether the robot MARIA with multimedia content can make ASD children develop their social skills [15]. At the end of an experiment, ASD children socialized with the robot through reactions such as satisfactorily presenting social abilities, staring at the robot, touching it, and imitating the mediator. According to the above results, it can be seen that the Maria robot is suitable for use in robot-assisted therapy of children with ASD since the children generally responded positively to it, and the robot fulfilled the set goal.

NAO –This is a 40cm tall robot that can walk, talk, dance, and engage children in so many different activities to improve their ability to imitate and read facial expressions and body movements. This robot has been programmed using the robot's speech, action, and facial expressions capabilities, to implement several different therapeutic sessions to improve joint attention and imitation of ASD children. For example, a robot can wave, say hello and goodbye, one-leg balancing for the autistic children to imitate the action, point to different pictures, ask the autistic child to do the same, express happiness for a gift, or encourage the children or sadness during clinical interventions. It can also provide verbal reinforcement based on the effectiveness of the responses given by the autistic child, teach children different colors by changing the color of the LEDs in his eyes and body while introducing the shade, playing music for children while dancing, etc [16]. According to studies, using the humanoid robot NAO in the rehabilitation of autistic children is expected to help ASD children interact and practice their social interactions with NAO robots. The results showed that children with autism are positively affected by NAO, giving encouraging responses in social interaction when they are interacting with the robot [17]. Furthermore, it is proven that ASD children feel more accessible and more relaxed in interactions with robots and can respond to their commands. The results also show that two-way communication between ASD children and robots in real-time significantly positively impacts the responses towards the robot, which represents a step forward in the communication skills of ASD children. Since the NAO robot is made with the latest technology and at a high professional level, we certainly believe that its inventors thought of all the therapy details. But, as can be seen from the research results, the robot has fulfilled the set goals.

KASPAR –is a humanoid child-sized robot designed to help ASD children. It can play, sing, imitate eating, play the instruments, do the hygiene, and do all the other stuff people do in their everyday lives. The robot is launched to develop a »social« robot having two missions: first, and mainly, to be a »social mediator« responsible for facilitating communication between autistic children and the people with whom they are in daily contact—other children (autistic or not), therapists, teachers, and parents—and also to serve as a therapeutic and learning tool designed to stimulate social development in these children [18]. Its purpose is to teach ASD children a variety of skills that other children master, more or less thoroughly, without any need of special education: understanding others' emotions and reacting appropriately, expressing their feelings, playing in a group while letting everyone take turns, imitating and cooperating with others, etc [18]. The results showed that ASD children interacted very fast and spontaneously with KASPAR, which made a solid ground for achieving his main goal and developed social communication skills as greetings, social interaction skills as eye gaze, learning emotions, etc [19]. The conclusion is that ASD children feel free to interact with KASPAR, which helps them to learn faster, communicate with others more, behave better and apply what they have learned in everyday life. As the results showed that children with ASD respond excellently to the KASPER robot, its goal to be a mediator between therapist and children has been realized. Therefore, it is certainly desirable to use it in robot-assisted therapy.

MILO –is one of the most famous robots used in the educational work of ASD children. The robot looks like a little boy, and because of that, it can be more attractive to ASD children because it seems like one of them. MILO holds voice-activating lessons to improve the communication, social and emotional skills of ASD children [20]. In therapy with MILO, ASD children work through various modules such as recognizing emotions and expressing empathy following the robot's verbal instructions and facial features. MILO's expressive face attracts ASD children the most because they connect more with the human-like face than with an animated screen. Some research shows that ASD children typically engage for about 3% of any session with the human therapist, but with Milo, the children are involved 85% of the time. After a lesson like the one about

greeting a friend, ASD children were eager to try out their new knowledge, making huge social breakthroughs with friends and family [21]. Because it is the most well-known and, according to the literature, most commonly used robot in robot-assisted therapy of children with ASD, the creators of the MILO robot have perfected it so much that the therapist's intervention in the therapy session is minimized. Therefore, MILO has become the most autonomous robot, and children adore it.

QTrobot (QT) – is a humanoid robot with an expressive social appearance. It has a screen as its face, allowing the presentation of facial emotions using animated characters, and has 14 degrees of freedom to present upper-body gestures [22].QT helps ASD children create a link with the outside world by teaching them new emotions and social and communication skills. Some statistical analyses revealed that ASD children directed more attention towards the QT than towards the human, imitated the robot as much as the human, and engaged in fewer repetitive or stereotyped behaviors with the robot than with the human [23]. These results support previous research demonstrating the usefulness of robots in short interactions with ASD children and provide new evidence to the benefit of robots in reducing repetitive and stereotyped behaviors in children with ASD, which can affect children's learning, continue the authors. Because children with ASD find it difficult to express emotions and human facial expressions often offer them too many signals, the QT robot is suitable for use in robot-assisted therapy precisely because of its straightforward presentation of feelings consisting of only a few characters on the robot's screen/face.

ROBOTA – is the name of a series of mini-humanoid doll-shaped robots. It's actually about the whole project called Robotics aims to develop robotics that creates educational robotic toys. Such a trend seeks to understand the role of a »fun« robot in a child's academic development. Such an approach goes beyond building playful robots, whose sole purpose is to entertain users, emphasizing the robot's educational and therapeutic role [24]. The robot emphasizes the humanoid aspect of the robot, i.e., the human appearance of the robot's face to create a natural human environment for children with ASD, and therapies are conducted in such a way that the robot invites children with ASD to engage in simple imitation games, using legs, arms, and head. Studies with ROBOTA have two goals: 1) to systematically test the reaction of children with autism with poor functioning to various human characteristics of the robot; 2) assess the extent to which children with autism with dysfunction can distinguish between perceptions resulting from their actions and perceptions resulting from the actions of others [24]. The results of the studies indicated the children's initial preference for interaction with a plain, featureless robot over the interaction with a human or human-like robot [10]. They also showed that some children could communicate with the robot without the therapist, but generally, the robot was best used as a mediator between the therapist and the children. Therefore, it is necessary to create a therapy that would include more robots and fewer therapists so that children could feel more relaxed in interaction with the robot.

Generally, looking at individual robot's characteristics and their functions in robot-assisted therapy, we can conclude that robots mainly differ in physical characteristics. For example, research shows that children respond better to robots whose physical appearance is more superficial and contains little detail. Robots generally have the same goal, and they intend to create a pleasant, relaxed, and friendly relationship with children, but this is something that must be constantly worked on. Because of the wait, robots must continuously improve. We repeat that each child is unique and should be approached individually according to his needs, so it is good to have more robots on the market that have their advantages over others.

In the table below, there is a summary list of the most commonly used robots in the therapy of children with ASD and their basic characteristics.

Table 1: List of robots and their characteristics used in the therapy of children with ASD

ROBOT	BRAND	YEAR[4]	CHARACTERISTICS
ROBOTA	DIDEL SA	1997	□ series of mini-humanoid doll-shaped robots □ 45 cm high, 14 cm wide, weighs 1.5 kg □ simple imitation games, using legs, arms and head
KASPAR	University of Hertfordshire	2005	□ humanoid child-sized robot □ simple facial expressions and gestures □ can play, sing, imitate human actions
NAO	SoftBank Robotics	2008	□ 40cm tall robot and can walk, talk, dance □ ability to imitate and read facial expressions and body movements □ waving, saying hello and goodbye, one-leg balance
MARIA	Federal University of	2013	□ child sized robot with human female features □ mix of anthropomorphic and non-biomimetic appearance

[4]Year of first manufacture

	Espirito Santo		touch screen multimedia devices
MILO	RoboKind	2015	60cm tall humanoid robot interact with people using vocal and facial expressions holds voice-activating lessons
QT	LuxAI	2017	humanoid robot has screen as its face, allowing the presentation of facial emotions 14 degrees of freedom to present upper-body gestures

IV. ROBOT-ASSISTED THERAPY FOR CHILDREN WITH ASD IN CROATIA

In Croatia, robot-assisted therapy is carried out with children with ASD. Still, the area of creating and using humanoid robots in working with children with ASD is just in the beginning. In Croatia, robots and their use in children with ASD, as far as is known from the literature, are dealt explicitly with mainly at the Faculty of Electrical Engineering and Computing (FER) and the Faculty of Education and Rehabilitation Sciences (ERF), University of Zagreb. Of course, other universities in Croatia also research this topic, but there is not enough information in the recent literature.

The first attempt of including robots in work with children with ASD in Croatia is The Autism Diagnostics project with a robotic evaluator (ADORE) project.ADORE project (HRZZ:93743-2014) is the result of cooperation between experts from the Faculty of Electrical Engineering and Computing (FER) and the Faculty of Education and Rehabilitation Sciences (ERF), University of Zagreb. The main research question of the ADORE project is whether there is a possibility of developing such a robot-assisted diagnostic protocol that could be applied in clinical settings by diagnostician clinicians working with children aged two to six years [25]. The research results could shorten the time of diagnosis, increase the therapeutic effects when the child is still small, and thus significantly reduce the costs incurred by the child's family [26]. The main expected result of the ADORE project is a protocol of spontaneous behaviors and operationalized codes of fundamental importance for the diagnosis of ASD, which are suitable for the robot to successfully observe and measure the child's reaction, eye vocalization, vocalization proximity to objects, and proximity to a person, normal handling of toys, stereotypical behavior, mannerisms, gestures, etc.) [26].

As part of this project, a robot named RENE was designed. Rene is a robot that comes from the NAO series of robot platforms, but Croatian experts adapted him to the needs of their research in therapy with children with ASD. A robot cannot replace a human in the diagnostic process; however, it can help that process run faster and more objectively. Equipped with a camera, microphone, and speakers, the humanoid robot RENE records a child's voice and assesses, among other things, their behavior and how eye contact is established [27]. Rene's software can also adapt to the reactions it receives from children and can do further activities according to them.

Rene is programmed in FER. FER is the faculty that has contributed the most to the development of educational robots and robots in general in Croatia that is used in various industries. The robots are produced within the faculty at the Center for Artificial Intelligence. Three robotic research laboratories operate very successfully within the Center for Artificial Intelligence at FER [28]. FER is also known for programming the robot named Pepper for use in activities for children with ASD. Pepper is intended primarily to achieve complex interaction with children with ASD and the environment in which it is located. Pepper is programmed to communicate verbally with children with ASD, recognize human faces and their emotions, and expand communication through a virtual channel with the help of accessories, such as tablets. His appearance is reminiscent of 'good people who can help, motivate, be companions in activity [28].

Reviewing the recent literature, there is not much information on projects and research conducted on this topic in the Republic of Croatia. However, it is undoubtedly a topic still in its infancy and has started to be relevant. Still, after 2019, little literature writes about it, most likely due to the emergence of a pandemic situation in the world. We believe that works on this topic will be published and that there will be more data on the use of robots in working with children with ASD. Since laboratories at FER are in charge of robotics and the use of robots, both in other industries and in Croatia, we believe that such potential should be used to the maximum because it would be beneficial in working with children with ASD. Another advantage is that FER staff has already programmed the robots used to work with children with ASD. We should now continue with this work and conduct as much research as possible regarding robot-assisted therapy of children with ASD.

V. CONCLUSION

Robots in therapeutic work with children with ASD can have multiple roles and benefits. First of all, humanoid robots have been shown to have better emotional contact with children from the autism spectrum and engage in inclusive play [1][2][3], which is essential for developing emotional and social skills. Activities in the game with humanoid robots encourage a safe and comfortable environment for the child, providing him with the

possibility of freedom and play without fear. Third, a humanoid robot can serve as a mediator between the child and the therapist by enabling the child to more quickly develop the social skills essential to contact peers and others. A particular advantage of the humanoid robot in therapeutic work with children with ASD is their individualization, i.e., the ability to adapt their performances to each child individually [10]. From all the above, it can be concluded that the use of humanoid robots in therapeutic work with children with ASD has many functional roles and that technological advances and advances in the IT field certainly contribute to the creation of modern and advanced robots that will undoubtedly be used in therapeutic work in the future changing and improving their performance for the benefit of children with ASD. Although, so far, only few entities are engaged in the training and development of therapeutic robots, the last few years have shown that Croatia is on the right track to include robots in therapy of children with ASD. Now, it is important not to stop and to continue developing and supporting robot-assisted therapy for children with ASD.

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