Robot application to develop the fields of Corporeality, Language, Communication, socialization and interest in Autistic Children

Carlos Enríquez Ramírez
Universidad Politécnica de Tulancingo
Mexico
carlos.enriquez@upt.edu.mx

ABSTRACT: *Today Robotics is becoming an important tool for human beings and applied in various areas of development in everyday life for example, manufacturing, aerospace, education, health. Specific this work is based a topic of health, since the use of a humanoid robot called "NAO" developed by Aldebaran Robotics as a tool to support the therapeutic process in children with Autism Spectrum Disorder (ASD) is proposed. Practical tests of this work take place in an elementary school located in a town near Mexico City, with children that show t characteristics the disease. Improvements in the fields of Corporeality, Language, Communication, Socialization and Interest of the patients are proposed, through implementing a combination of therapeutic techniques including: TEACCH method, targeted therapy, signifant-signifié, to make significant progress in the development in children behavior.*

Keywords: Robot Humanoid-NAO, Autism, Therapy, TEACCH

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1. Introduction

The use of robots in various fields such as manufacturing, medicine, exploration, among others, has increased considerably in recent years, such as in the therapeutic use in children with Autism Spectrum Disorder (ASD) [1]. Relative to the characteristics exhibited by the different models of robots that are on the market, the diversity of research on ASD treatment using robots as well as the variety of hypotheses, there have significant contributions related to the implementation of robots in the therapeutic

process in ASD children. Originally Dr. Leo Kanner defined autism in 1943 as an early childhood disorder that seriously affects the formation of human relations, describing autistic children as “absent, absorbed, selfabsorbed, a bit different and isolated in their own world.” The concept has been modified and is described as a disorder that affects child development, human interaction and communication, describing autistic children as those who have an unusual way of interacting, appear absent, have difficulty in communicating, present repetitive behavior, attachment to routine, unusual forms of play and lack of emotional feelings toward people [2].

The application of robots in the treatment of ASD has increased, causing in the children new social behaviors as joint attention and automatic imitation [3], [4]. Based on various studies and the results thereof, which are set out throughout this paper, it is decided to apply robots treatment in children with ASD. Forming a multidisciplinary team composed of specialists in Psychology and Special Education, belonging to the Support Services School Regular Unit 21 (SSSRU) public instance of Special Education, under the Ministry of Public Education of Hidalgo, this instance aims provide educational and psychological support to pupils enrolled in elemental school, with special or specific educational needs which if not addressed adequately, represent barriers to learning and participation. A team of robotics engineers and software develop has created software sequence in order to program the robot behavior in order to achieve the objectives outlined for each of the activities proposed by the health specialists, This way achieve development in the fields of corporeality, language, socialization, and interest in children who display the characteristics of the ASD. Currently for this condition in Mexico, the reported number of ASD cases is one out of every hundred children estimating a total of 115,000, with the risk that each year, new cases will increase in 6,200 children [5]. The marked increase in cases of childhood ASD has led to new strategies to support therapy, which has motivated the present research with the NAO humanoid robot for this disorder. The paper reports on the use of the humanoid robot “NAO” used for ASD treatment in two children at Lazaro Cardenas Elementary School in Jaltepec (Hidalgo, Mexico).

In addition, this document explains the methodology that consists of work steps and the model that serves as a guide for therapy using the “NAO” humanoid robot [6]; furthermore, qualitative results issued by mental health specialists are presented. Taking as references the research proposed in [7], [12], and [14], an agile methodology for software design is included to develop the behavior needs expressed by therapists and educators in the NAO humanoid robot.

It is also noted that in recent years the application of robots in the fields of education and autism treatment has increased [4]; [7]; [8]; [9] and [10]. The technical components of the robot “NAO” that come into play include such instrumentation, as video cameras for image recognition, microphones for speech recognition, voice synthesizer to communicate in spoken language and motors for a variety of movements: ambulation, head movements and arm movements, among others, are resources to make treatment sessions more attractive and fun for children [9]; [10]; [11]; [12]; [13]; [14]; [15]; [16]; [17]; [18], but also to test employment of these robotic mechanisms in the field of assisted ASD therapy. In the research reported in [14], it is mentioned that individuals with ASD syndrome more successfully engage in social interactions when social information is presented to them in an “attractive” way. This work has been developed using various materials, such as sounds and images that support *signifiant-signifié* development [19]; in addition, it applies TEACCH (Treatment and Education of Autistic and related Communication Issues) as a structured process for helping children with ASD develop social, life, leisure, communication and vocational skills [20].

2. Methodology

The focus of this research is qualitative, because the individuals involved in the research development cannot be reduced to variables. This research is not probabilistic, since it is aimed at children with ASD. The results of therapies are captured in real time, using a video camera that stores relevant events, while using a robot.

2.1 Subjects

To test the NAO robot in the therapeutic process, two males were selected aged 6.5 years and 11.2 years with varying degrees of ASD. Table I shows the initial diagnostic characteristics of the participants.

2.2 Procedure

To carry out the implementation of the NAO robot in the therapeutic process, the therapist plans various phases. At the first, there are the lifting requirements and the initial patient information as a key element for the therapeutic process with each ASD child. In this fashion, activities are generated as defined by the group of specialists (psychologist, education specialists) to obtain a set of steps, as shown in Figure 1, and to guide the activities to be completed over a period of eight months.

Feature	Person 1	Person 2
Interaction	Poor socialization no sense of belonging, obsessive behaviors, without social conventions (greeting and farewell) and low frustration tolerance.	Poor socialization, recognize few people around, inability to maintain the fixed gaze, does not respect authority figures, no iniative whatsoever for a particular topic or a specific circumstance and remains in only one state of emotion
Corporal Scheme	It is able to describe and recognize the parts of your body when ask him, but not to describe or to recognize its, functionality, he does not distinguish laterality (left - right)	He recognize himself in the mirror but not the specific characteristics, he recognizes their gender and the other gender. Not recognize laterlity (near far, left, right, time)
Language	He uses a poorly structured oral language, but understandable, allowing the other person understands their demands.	He shows severe communication problems like poor pronunciation, he expresses through the vocalization doing some syllables, sounds or onomatopoeia. He doesn't linking the signifying with meaning
Attention	Their attention is dispered, mainly, in writing activites, reading, drawing and numbers. In play activities, the child stays concentrated for a larger period of time.	Its level is poor, similar to that of a toddler, with little willingness and interest in work and its immediate surroundings. He is easily distracted and evades activities.
Interest	He is interested and motivated when he is in the classroom support activities that are different from those raised in the common room.	Currently he is reluctant to the new way of working that is intended, avoids activities generally only want to be in the classroom without, working, also is difficult to bring him to therapy.

Table 1. Previous diagnosis of participants with ASD

Each phase is divided into sections, which are listed in Table 2. Phase I is related to therapeutic session zero, each phase is accompanied by a number of sessions.

Figure 1. Phases of therapy with the robot NAO

Phase	Session Number	Description
I. Initial Phase	0	It is the It is the initial session, which is repeated in each of the following phases, as it serves to welcome the child and familiarize with the robot.
II. Recognition eight domestic animals with anomatopoeia	1	The robot was programmed to play sound of the onomatopoeia of the following 4 animals: rooster, donkey, cow, pig. The duration of the sound was 5 minutes for each animal. The animal photography also was displayed for the same period time.
	2	Session 1 is reaffirmed.
	3	Onomatopeyas number made by animals was increased. Programming the robot to reproduce the sound, for four animals more (horse, dog, cat, bird).
III. Animal recognition divided into two fields: farm and home.	1	The robot was programmed to say a brief description of such animals: Dog: “It’s an animal that barks, live in our home and wags its tail when he’s happy”; Cat: “It’s an animal that meows, purrs and loves to climb trees”; Cow: “It is an animal white with black spots and produces milk and meat and lives on the farm.”
	2	The robot asks the child to do a classification among household pets and livestock, the sequence that follows the robot is through the question “Can you classify animals and farm house?” Previously, the child was instructed to perform sorting, this allows reaffirm its process of identifying and sorting possibilities.
IV. Body parts of eight animals	1	Scheme Phase II, where the robot performs short questions and accompanies the animal onomatopoeia is used again, introducing a variant, that is to say, an image of the divided animal is presented to them, in order for the child will associate the part with the onomatopoeia.
	2	The Session 1 of this phase is repeated with the intention to reaffirm the Knowledge, besides one more time, the classification between farm animals and home is required.
V. Recognition of animal products.	1	Oralization by the description of the animal, the child recognizes what is spoken and assigned its derivatives, the robot using oralization describes the animal, in order for the child to identify and list the animal products (meat, milk, etc.) via humanoid robot indication.

Table 2. Description of the phases of work and number of the session therapy in each phase

3.3 Resources

To simulate the behaviors, a humanoid robot was programmed using the Deming cycle [21] (Plan-Do-Check- Act) as a reference, as described below:

PLAN - With the assistance of specialists, various scenarios and a number of phases were defined which all like elements: specific goals, number of sessions, strategies and materials.

DO - The health specialists design a number of activities to be implemented in a given time. These activities are modeled and coded in a programming language called “choreographer” as shown in Figure 2.

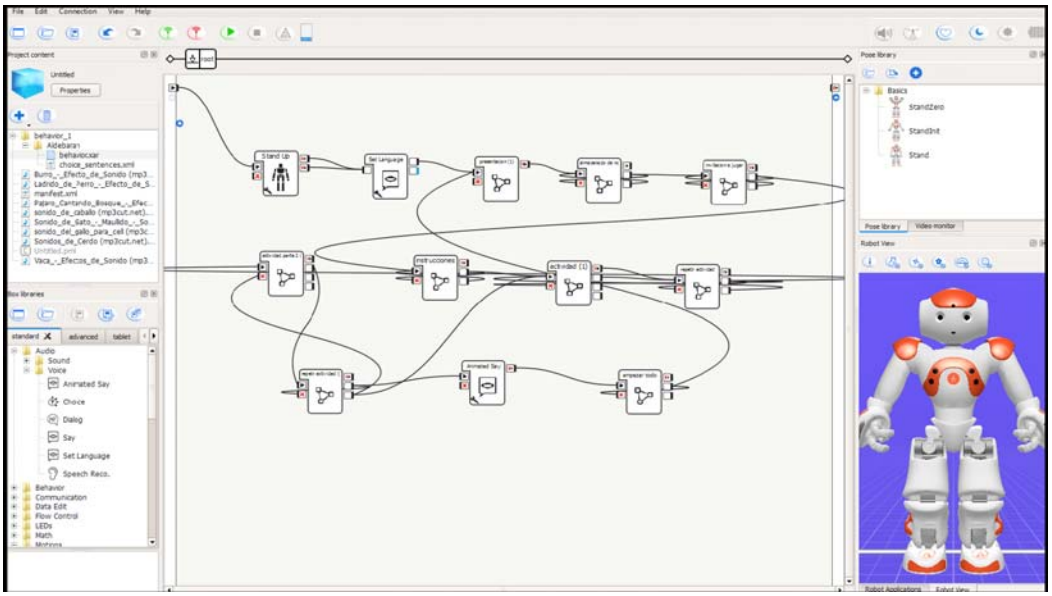

Figure 2. Main Program NAO robot

CHECK - At this point, before the patient session, meetings with specialists are held in order to identify the behaviors that will be incorporated into the robot to support therapy in children with ASD.

ACT - Treatment is implemented. As shown in Figure 3, this session takes place in the classroom; the materials employed are for achieving the objectives.

The resources used for the development of the phases were pictures and sounds of farm animals and pets, because the technical characteristics of the NAO robot allow reproducing the onomatopoeia in order to reproduce the familiar sounds and images to strengthen *signifant-signifié* development.

3. Results

Using the NAO robot in the treatment of children with ASD-oriented strategies mentioned in Deming methodology, significant progress has been made in the clinical field (Table 3).

4. Discussion

Discussion of the results are based on the recognition of experience gained by the interdisciplinary team of the Support Services Unit 21 Regular School and the Polytechnic University of Tulancingo (PUT) at least in the state of Hidalgo, Mexico. This first result is judged as positive having two fields of knowledge: Educativo and Technological provide a precedent for regional research. About how a resource such as NAO Robot, can be a didactic support in the development of formal learning of students like ASD.

Phase	Objective	Patient 1	Patient 2
1	Developing the process of familiarizing the robot in the process of therapy.	Welcome note that takes place at the beginning of each therapy session.	Welcome note that takes place at the beginning of each therapy session.
2	Develop the educational situation of child and link with the semantic field of animals, encouraging their participation in language, attention and interaction.	Successfully presented the didactic situation, because the patient was reluctant and with little participation during the first session. The learning model with the robot, is showed to the child, the child expresses fear and distress. At the third session of this phase. The child responds appropriately to the questions of the robot "NAO", but his body language expresses: fear, anxiety, low confidence and therefore little participation.	The child faces assisted therapy without any difficulty, the minor is interested but he feels intimidated by the robot because it creates feeling fear and mistrust. It is remarkable that sometimes the boy does not understand the language and fails to correctly identify what is required, because it does not built a concept through the robot questions, the child asks to teacher about the robot, based on previous situations where the semantic field was discussed. In the fourth session, the child directs his gaze to the robot, he speaks and referred to robot like a person, when the robot's eyes shine, immediately the patient is interested in their body scheme.
3	Support knowledge of the semantic field; giving priority to: analysis, communicative and functional language, interest in the teaching situation.	Clearly, managing semantic field, the boy gives information, recognizes and respects the workflow and he anticipates their answers. His anxiety level is decreased, it responds to modeling language, more easily accessible to the invitation to work in the classroom.	He is interested in the teaching situation; the child is receptive and motivated. The concentration level increases as his memory, remember past session, properly handle the semantic field, the child requires a lot of support from the psychologist to understand the speech of the robot.
4	Identify the parts of a whole, encouraging the body schema the animal and himself.	No difficulties in handling the content, the instructor presents the segmented animal and the child recognizes this as a whole (solves the puzzle with the animal figure), psychologists interpret it as a strengthening of dissociative thought. The patient takes a segment of the animal and makes the representation of whole animal. The child performs a simple symbolic chain of "significant - meaning", that is, figure - part (head / foot) - concept. He makes decisions and intentions to select, through questions, a part of an animal. The child attention has been favored and is much higher than expected. The anticipation level unleashes behaviors (classifies farm animals and from house).	As the sessions progress begins to lose interest, but he manages concentrate on activity, also he wants to perform other activities previously done in the classroom. The minor does selection of the parts, rearranges and selects the he considers more representative. The tone of voice of the child begins to have more tonalities, representative forms and diversity.

5	Stimulate communication and expression through analysis of the animal's products and the resolution of problems that increase their cognitive abilities.	The recognition of semantic field has been achieved and the didactic situation is established, the child has a better behavior. He answers a few questions, without graphics (with simple words or onomatopoeia). The child goes directly to the classroom interested in activities; He can go to the bathroom alone and not distracted, going back to their activities. In previous sessions he left the room and did not return. Make modeling language and translates to other words (pig instead of "oink"). Now, he is no longer reluctant to physical contact or the psychologist. Makes the greeting and farewell when entering and leaving of the classroom support.	The boy shows disinterest, has managed to give meaning to the robot, does not fear the robot and considers it an apparatus. He makes use of social conventions (greeting, farewell) is more interested in the people that in the robot and He recognizes some spellings. Through deduction and discrimination he manages to answer the questions of the psychologist to designate the name of the animal by writing it on the appropriate image (spelling- grammar), builds larger and more complex symbolic chains. In general terms, the boy has strengthened a more suitable and outgoing personality; cognitively he uses and manages information in order to solve problems, recognizes questions and questioning, assigns logical and coherent responses although at times he is mistaken.

Table 3. Results

Figure 3. Child-Therapist-Robot working session

Firstly the development of specific algorithms, designed by the team of engineers PUT. They permitted the implementation of NAO robot, and its contribution in fields social and education. Being students with ASD features, the range of usefulness of this robot extends to the field of health. Having contribution to the specific therapy providing important findings on improving social interaction (in particular areas of communication and language) of participating children. The results show that children with ASD significantly improve interactive activity through the established communication with the robot. On the other hand

your therapist worked as a bridge that allowed the boys to establish the relationship with a greater assertiveness, it is to emphasize the development of the interest shown by the children involved to the robot. Presented sequences were interesting responses from fear, anxiety and distrust of the unknown to establish a bond of trust and familiarity between a mechanical device (robot) and the Human, and all this with respect to the characteristics of ASD. The bridge of communication was through a combination of therapies assisted, as in this case the TEACCH method and successive approximation and assisted and then direct interaction with the Robot, permitting to one of the children left in a gradual way the use of the Robot. Because he perceived as an inanimate object, and began establishing social interactions and objective communication. First with her psychologist, and then with other adults and peers. The authors of this article believe it is possible in subsequent phases of research to increase the number of participating children and certainly they will plan new strategies to have a new advance in each of the participating children with ASD.

The first approach with the NAO humanoid-robot yielded positive results. In addition to this, it is hoped that the process can be replicated in other children with ASD. To strengthen the therapy, use was made of various strategies and the TEACCH method. With the addition of successive approximations and assisted therapy, these methods were used for the planning of each of the activities. The part untreated in this first approach is the emotional experience. To treat this area, it would be necessary to add another element to the triad Child- Therapist-Robot. This could be another child to replace the robot and to interact with the autistic child in order to leave only ASD child-Therapist- Child without ASD and promote the concept of socialization.

This paper presents the results of a pilot study, demonstrating a favorable response of the children involved; demonstrating, positive aspects in the development of their corporeality, language, communication, socialization, and interest, which are quantified in the reports issued by specialists (psychologist, educational staff). Furthermore the hypothesis that mentions that the robot serves as a tool to strengthen the characteristics mentioned above is confirmed. A significant achievement observed after eight weeks of sessions is that the patient to consider the robot as a toy and focuses on the development scheme of the proposed activities, because with the development of algorithms the process called *signifant-signifié* is strengthened, taking advantage of sound reproduction and the robot movements.

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