Robot-Assisted Therapy for Autism Spectrum Disorder: Evaluating the Impact of NAO Robot on Social and Language Skills

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***Abstract*—**This work presents an application of social robotics, specifically the use of a NAO Robot as a tool for therapists in the treatment of Autism Spectrum Disorder (ASD). According to this, therapies approved by specialist psychologists have been developed and implemented, focusing on creating a triangulation between the robot, the child, and the therapist, aiming to improve their social and language skills, as well as communication skills and joint attention. In addition, quantitative and qualitative analysis tools have been developed and applied to prove the acceptance and the impact of the robot in the treatment of ASD.

***Keywords*—**Autism Spectrum Disorder, NAO robot, social and language skills, therapy.

I. Introduction

ASD is a developmental condition marked by challenges in social communication, adherence to routines, and repetitive behaviors. This condition affects individuals in diverse ways, making personalized intervention crucial for effective therapy. In recent years, advances in robotics have developed tools that assist in the intervention of ASD, such as the use of virtual reality and the implementation of social robots.

The use of social robots as mediators within therapeutic interventions for children diagnosed with ASD has shown positive results, as robots facilitate communication, thus opening possibilities for using them in therapies that focus on social skills [3]. Within these interventions, robots are used in activities involving imitation, joint attention, and team play, as the robot simulates a playmate [4].

In the world, about 1 out of 100 children are diagnosed with ASD [1], and in Mexico, about 1 out of 115, according to an estimation of the Spectrum Therapy Center. [2]. Therefore, the present project aims to apply social robotics to implement a therapy that enhances the social skills of children aged 3 to 10 diagnosed with ASD, using a NAO humanoid robot as a supportive tool to achieve communication triangulation between the child, the therapist, and the robot. This therapy has been previously validated by specialists in ASD care, aiming at the improvement of cognitive competencies, as well as promoting joint attention between the child, the robot, and the therapist.

Objectives

The objective of this project is to evaluate the level of acceptance and attention towards the robot by children diagnosed with ASD, as well as to improve their language skills, communication, and joint attention abilities. This is done to validate the impact of social robotics on social and cognitive skills in children diagnosed with ASD. All of this is achieved through the implementation of therapies in a controlled environment and the recording of variables such as response time, successes and errors, and overall progress for subsequent analysis.

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II. Theoretical Framework

Over the last few years, social robotics in the field of ASD treatment has expanded, and various social robots have been used to intervene in therapies. These robots' mimic expressions, body language, emotions, and eye contact help children diagnosed with ASD to improve their social skills and make it easier to relate to their environment. This tool is of great support for therapists because it does not only encourage better communication with the child, but also serves to monitor specific variables during sessions [5].

The use of social robots in the intervention of therapies for children diagnosed with ASD brings with it many advantages [6]-[8]. For instance, according to Polyxeni et al. [5], robot-based therapies have shown promise in treating children with autism by engaging them in various activities designed to improve social and emotional skills. These therapies might involve imitation, joint attention, emotion and facial recognition, triadic interaction, and tactile social behavior.

Social robots have been shown to allow children with ASD to interact more efficiently with their environment, as well as increase the chances of social interaction with other people [6]. Similarly, robots encourage children to improve their social behavior and spontaneous language during sessions, not only with the robot but also with their therapist. "Robots seem to act as a key tool to attract the attention of autistic children and promote cognitive and social development" [6]. For there to be a successful joint attention, the child must alternate his attention between a person and the object, in this case, between the robot and the therapist, to achieve a connection between his environment [5].

Studies have shown that children diagnosed with ASD prefer to focus their attention on non-social stimuli, such as toys and electronics, as these are predictable and easy to understand, and do not involve social interaction [21]. To evaluate the impact that social robots have on joint attention in children with ASD, several projects have been carried out that evaluate the effectiveness of including social robotics as a support for social skills. One of these was a study conducted by the University of Kanazawa in 2018 [6], where the social robot "CommU" (Fig. 1) was used to evaluate how a social robot can improve joint care in children with ASD. This robot was chosen because it can move its eyes, which generates assertive eye contact. The study involved 68 children aged 5 to 6 years, who were divided into two groups: one with a human agent plus the intervention of the robot, and the other with only the human agent. Three interaction activities were carried out, lasting approximately 5 minutes, in which different social skills were evaluated.

Fig. 1 CommU Robot

In the same study [6], in the group where the CommU robot intervened, the robot encouraged the child to generate a triangulated attention together with the therapist by looking at the child and some phrases. So, when the robot made eye contact with the child, three steps were taken to achieve this triangulation: 1) to look at the object that was being used in the activity, 2) to look at the child again, 3) to look at the therapist causing the child to do the same. In this way, if the child followed the visual behavior of the robot, it would create a link of attention between the robot, the object of the activity, and the therapist. As a result, the children in the intervention group with the robot achieved better joint attention, which later facilitated interaction with other people. This study concluded that the use of a social robot as a mediator in therapies can lead to an improvement in social skills.

In a paper published in 2019 [5], the benefits of using social robots as tools to improve social and emotional skills of children with ASD were evaluated. Also, the several projects that are mentioned in this article are evidence of the expansion of the social robotics field over the years. Moreover, it shows that therapies for the treatment of ASD that include robots as tools, can have a positive impact on the advancement of the children with whom they intervene, since social robots help them to improve their communication skills not only social, but also emotional. In addition to helping them to engage more with their environment and achieve a positive interaction with the people around them.

As well to socialization skills, the projects described throughout this section have also explored other cognitive areas that help children diagnosed with ASD develop other skills such as attention, imitation, and team play, which are often deficient in children.

The CASTOR project of the Colombian School of Engineering "Julio Garavito" and the University of Rosario [9], worked on the creation of a robot (Fig. 2) that provides a support tool in the realization of therapies for children diagnosed with ASD, maximizing therapeutic results. This study included 35 children diagnosed with ASD, aged between 2 and 10 years, who were divided into two groups: control group and study group. The control group consisted of 14 boys and 3 girls. They were not allowed to interact with the robot, and the therapist stopped the children's attempt to touch it. While, in the study group, they had complete freedom with the robot so they could interact with it at any time. It is important to mention that in this project [7], both groups worked under the same experimental conditions and participated in the same therapy, with the only difference being the contact with the robot. The therapy consisted of two parts, the first stage aimed at familiarization between the child and the robot. In the second stage, the robot begins by telling the child "Let's play", then points to a body part along with the name and asks the child to indicate where that body part is. When the child answered correctly, the robot would say "very good", otherwise the robot would again point to the body part. The robot was programmed to indicate four parts of the body: head, eyes, nose, and mouth.

For the CASTOR project [7], quantitative variables were established to be measured during the sessions. These variables were divided and measured by researchers and therapists. On one hand, the variables measured by the researchers were: spontaneous interaction (when the child touched the robot for no reason), induced interaction (when the child touched the robot when the therapist indicated it) and activity performance (the number of times the child correctly identified body parts). While the variables to be measured by the therapists were: visual contact with the robot, emotional response of the child, social interaction with the robot, physical interaction with the robot, interest in the robot and visual contact with the robot.

The statistical analysis revealed no significant differences in most variables evaluated by therapists. However, a 41.7% increase in high performance for emotional response was noted in the study group compared to the control group. Also, the results indicate that the use of robots in activities with children with ASD does not diminish the effectiveness of therapies.

Nowadays, this robot has had its modifications, especially physically to look like a toy and be resistant to physical contact. The therapies developed by him consists of a series of activities with four levels, where memory, focused attention, physical and verbal imitation, recognition of emotions and follow-up of instructions are worked [10].

Fig. 2 Castor Project

On the other hand, the NAO robot is a 58 cm humanoid robot equipped with tactile sensors, able to recognize voices, objects, and faces, interact with humans using an artificial intelligence system, and that physically looks like a toy. Thanks to these features, the robot has been used as a platform to develop various social robotics projects, specifically in the field of medicine and mainly working with children diagnosed with ASD around the world.

Fig. 3 NAO Robot

A study conducted at the University of Denver [11] evaluated the level of care provided by children with ASD with an NAO robot. Eleven children with highly functioning ASD, ranging in age from 7 to 17 years, participated in this study. The activities consisted of several games where the NAO required participants to look it in the eye to validate the answer. As a result, children-maintained eye contact with the NAO robot 50% of the time, which concluded that social robots help at the level of eye contact, joint attention, and general social activities in children with ASD.

On the other hand, an analysis carried out by Bartl-Pokorny et al., [12], in which reports of about 570 children with ASD who were receiving therapeutic interventions with social robots, mainly NAO and ZECA. The aim of analyzing the impact of robot-based intervention or HRI for children and adolescents diagnosed with ASD for activities related to the management and recognition of emotions (shown in Fig. 4). It is concluded that interaction with social robots benefits the interaction skills of people with this disorder, as well as improves integration and perception, which helps in the management of emotions. In addition, the analysis mentions that the NAO robot is the most popular among interventions, especially for social activities.

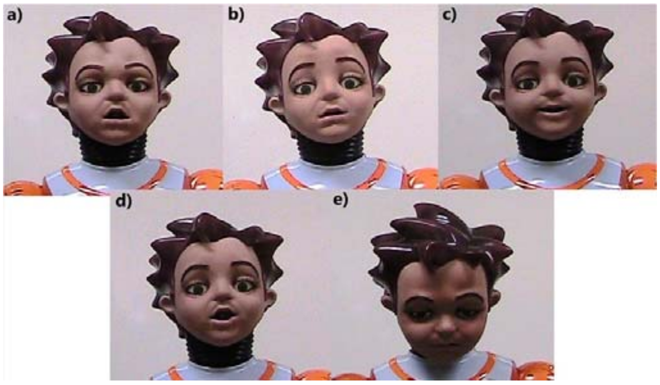

Fig. 4 Zeca's gestures

Moreover, the project "Naotism Project: how humanoid robots encourage the emergence of behaviors necessary for communication" [13], uses a humanoid robot NAO in a special kindergarten class in France, as it can be seen in Fig. 5. The aim of this project is to evaluate and verify the positive impacts of robot presence on children with ASD. The interaction parameters for this project stipulate that robot intervention in the classroom is for 2 to 3 times a week as part of the morning routine or in individual work sessions with a maximum duration of 5 minutes [14]. In class intervention involves participating in a series of activities that encourage joint attention and imitation such as: greeting, following instructions, and imitating gestures. While the individual intervention consists of the specialized teacher handling the robot from a tablet so that it takes the place of mediator and indicates to the child what to do, from color recognition, order shapes or figures, among others. This way the teacher is able to animate and validate the answers from another location in the classroom. Thanks to this intervention, they were able to observe a positive and significant change in indicators such as eye tracking, learning and social skills, as well as allowing adults to get closer to children.

Fig. 5 Naotism Project

In addition, social robots have been used for several years as a help tool for children with ASD to improve their communication, their way of interacting, to recognize images, as well as to develop their social skills [15]. Likewise, it helps to break with isolation, facilitate interaction with other people, enhance decision-making capacity and favor joint attention [16]-[18]. This is possible with assisted therapies between the robot, the child, and a companion where positive reinforcements are provided when the child performs an activity well. In addition, to avoid stereotypical behavior, it is necessary to maintain a regulation of the environment such as the tone of voice, the brightness of the lights, the colors of the robot and even gradually changing variables in each therapy. In this way, the child is helped to improve its adaptability of behavior in the different scenarios [19].

Similarly, communication is a very broad spectrum that involves verbal and non-verbal factors, so it is not only words or word games and intonation, but also facial expression and body movements. There are certain variables that allow to evaluate fluency in communication, as well as whether there is an assertive communication or not. Specifically, four variables were considered to measure the progress of each of the children through the sessions, these variables are:

- Response time.
- Learning the relationship of concepts.
- Attention time to the robot.
- Number of hits and errors.

Therefore, it can be observed that there are several studies and analyses that validate the use of a robot to improve the skills of people with ASD, mainly social and interaction skills. Due to the age range established for this project, it was sought studies that worked with children within similar ranges, since the techniques used to intervene in ASD may vary according to age.

III. First and Second Phase

In the developed therapy, pictograms are used as a communication and organizational tool with children. These pictograms are entirely comprehensible, with clear and schematic signs that synthesize the message [13]. The pictograms used have been endorsed by specialist psychologists (Fig. 6). In this way, pictograms are used throughout the therapy to establish communication between the robot and the participating child.

The therapy begins with the robot greeting the child and asking them which category they would like to play (animals, clothing, fruits and vegetables, places, and things). Subsequently, the therapist selects the category by pressing the tactile head sensor on the robot's head, and depending on the selected category, the corresponding cards are placed in the workspace. Randomly, the robot asks the child to show it one of the images, so the child must select the correct card and show it to the robot. If necessary, the child can ask their therapist for help to promote joint attention. If the response is correct, the robot says a motivating phrase to encourage the child to continue; in case of an error, positive reinforcement is used to promote triangulation between the child, the therapist, and the robot. If the child did not hear or understand the question, they can repeat it by pressing the tactile head. Upon reaching 5 correct answers, the robot ends the activity and returns to the main menu, then asks if the child wants to play with another category or wants to finish the game. The established number of correct answers was based on specialists' recommendations, and in case two consecutive errors are made in the same question, the next question is presented to prevent the child from feeling stressed.

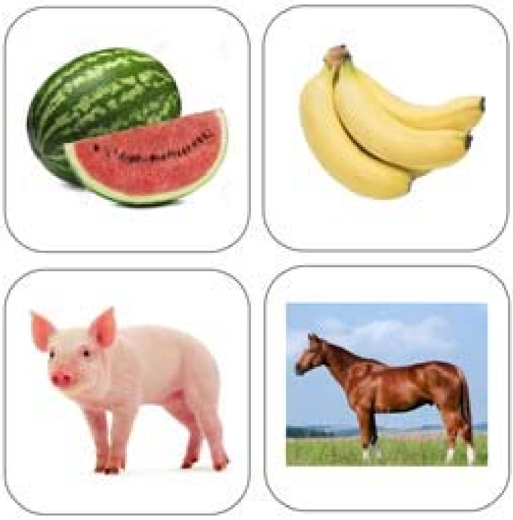

Fig. 6 Pictograms and Images used in therapies

It is important to mention that every session of the therapy is recorded with a video camera for subsequent analysis by psychologists, who evaluate the progress of each therapy and provide feedback on various aspects such as gaze tracking and attention time during the session. The parents of each participating child must sign the corresponding agreements for the sessions to be recorded without any issues. In addition, the parents of the child and the team members who are present at the session, answer post-session questionnaires to quantify the data from each session. These questionnaires have qualitative questions but are quantified through yes/no responses, allowing specialists to analyze progress in the sessions and quantify the data to obtain therapy results.

In the process of applying the therapies, there is a preliminary stage before the activity described with the pictograms. This is a presentation session for the child to familiarize with the environment and the elements they will be working with. This initial interaction between the child and the robot helps determine if there is an interest in participating. In this session, the robot introduces itself and ask the child basic information such as their name and age and invites them to play in the upcoming sessions. Subsequently, the first therapy session with the pictograms is conducted, where the dynamics of the activity are explained to the child. The results of this first session are not considered statistically significant for various reasons, such as changes in their daily routine, adaptation to the controlled environment, uncertainty in response times, limited understanding of the dynamics, and lack of interest. During the initial sessions, the child is adapting to their surroundings and the dynamics of the therapy, so it is important to avoid any bias in analyzing these results.

The application of these therapies initially took place online through video calls due to health and safety measures during the pandemic. It was identified that there was a bias in the application of these sessions as there are various variables that cannot be controlled, such as external environmental stimuli or unstable internet connections. Additionally, the interaction with the robot is limited. Therefore, the data obtained from these sessions were disregarded in the analysis of the results. Subsequently, several therapy sessions have been conducted in person within the facilities of the Universidad Anahuac Mexico Sur, from which various data have been obtained using the previously mentioned analysis tools to derive the results. These results are subsequently used to personalize the therapies based on the progress and improvement of each child's skills to achieve continuous progress.

A. Duration and Frequency

The therapy has an approximate duration of 15 to 30 minutes, as suggested by specialist psychologists, as children may become impatient or lose interest in the activity if it lasts for a longer time. If necessary, the children can engage in more than one round of the activity, allowing them the freedom to choose the category they want to participate in. The therapy occurs twice a week on the recommendation of psychologists since in this way the therapy could have a greater degree of effectiveness.

B. Population

This therapy is aimed at children within a specified age range (3 to 8 years) who also meet the criteria of having some level of interaction ability and no severe language disorder, as established by specialists in the field of ASD care. This range was established, since when children are at this age, they have had fewer interventions, and the therapies offer better results, allowing to measure progress in shorter time frames. Accordingly, children who wish to participate must submit a document that guarantees their diagnosis of ASD and the aforementioned characteristics.

C. Environment

The therapies take place within a specially designed space as a controlled environment, aiming to reduce excess stimuli (odors, colors, and noises) to prevent the children from feeling overwhelmed. To adapt this space, mats were placed in the workspace along with the NAO Robot (see Fig. 3), the video camera for session recording, working materials, and multiple chairs for the parents and team members. Additionally, the space is delimited in a way that ensures an appropriate distance between the child and the robot, to avoid any accidents where the robot might inadvertently harm the child during its movements. The distribution of spaces within the controlled environment can be seen in Fig. 7, which also specifies the designated positions for the people present in the space.

It is worth mentioning that the technical team members present in the session space only intervene during the initial sessions to assist with robot operation. In subsequent sessions, they are only present in case of emergencies, as the therapists are trained on how to operate the robot during the session to avoid any distractions for the child.

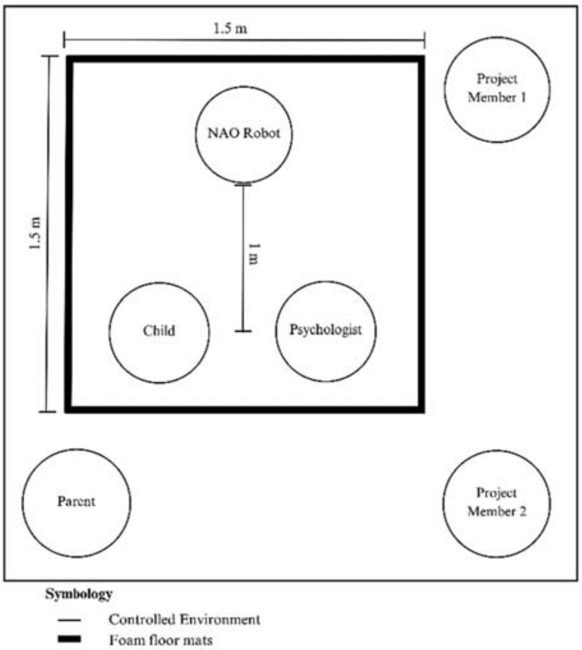

Fig. 7 Controlled Environment for First and Second Phase

IV. Third Phase

For this phase of the project, a therapy proposal was made, based on the specifications made by the Teleton Autism Centre (CAT, in its Spanish acronym) to be able to collaborate with this institution. In this therapy, children will continue to develop their social and language skills, but this time by identifying the objects on the cards in specific circumstances and working in groups and not individually.

It is necessary to have the cards with the different images of the categories and a project member is going to dictate from the terminal whether is wrong or right, this was because the children do not have the control to keep the card of the image static for the robot to identify it. Similarly, it is important to have a controlled environment and the help of a therapist or companion, to encourage triangulation and joint attention with the child.

To start the therapy, the NAO robot will first introduce itself to the children, and then tells them a short story, which consists of simple everyday situations, such as a picnic day, a holiday, among others. Afterwards, the robot asks the children something related to the story and one child needs to show the corresponding picture, encouraging the child to make the most appropriate decision, with the help of the therapist and the other children. In addition, the robot will try to give the child a clue by pointing at the image with his finger or pointing with his gaze. This is to enable the child to develop the ability to follow eyes or movements, as well as teamwork and follow verbal instructions. This therapy will allow children to work or develop spatial cognition, where they will have to operate in a controlled environment that allows them to search and follow the clues that their teammates provide to find the right answer. Once the child chooses the card, the NAO will validate the child's response and always counting on the therapist's feedback.

A. Duration and Frequency

The duration of the therapy is in between 15 and 30 minutes, because children may easily lose attention and may associate therapy as a tedious activity, which affects their implementation. It is worth mentioning that for this new group modality, the duration and frequency is still pending approval by specialists, since the population is in different parts of the spectrum and the period of attention may vary.

B. Population

For group therapies, it is expected to work with children between 3 and 10 years old, diagnosed with ASD with the abilities that the CAT specifies and in any part of the spectrum.

It is worth mentioning that all the young participants must have first interactions with the robot, where their adaptation to the controlled environment is observed, as well as the level of acceptance towards the robot.

C. Environment

For this therapy, a closed space was proposed (Fig. 8), delimited by three walls, where the images will be placed. In addition, to avoid over-stimulation in children, this space should have the least visual or sensory distractors, or those that influence the development of the therapy. The therapy group will consist of three children, this according to indications from the Institution to have a better management of behavior.

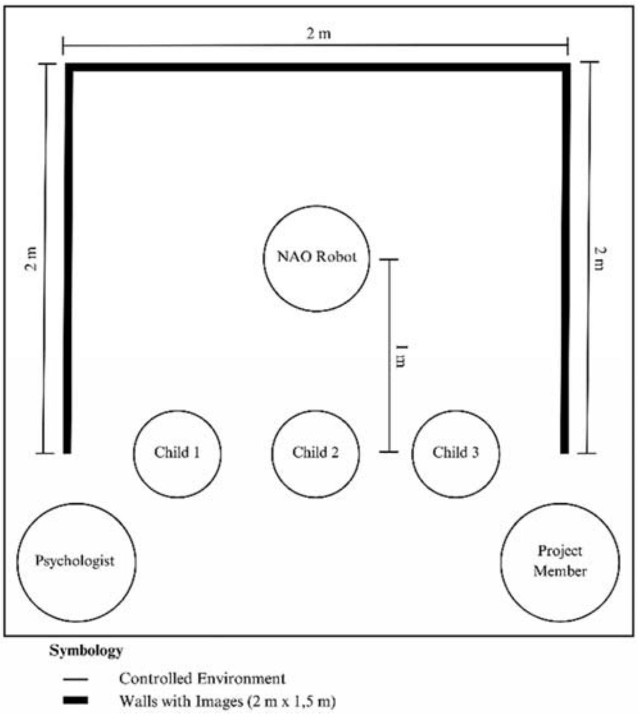

Fig. 8 Controlled Environment for Third Phase

As for the NAO robot, it stays on the ground, in the center of space, respecting certain distance limits to avoid any accident and promote the safety of the child. The images shall be arranged randomly on the walls of the bounded space.

Fig. 8 shows an outline of the delimited space for this therapy.

V. Programming Procedure

Within the development of the programming of these therapies, tools were integrated which allow customizing and optimizing their operation, to improve the interaction of the participants with the robot and their playmate within a controlled environment. All the commands and libraries used for robot control come from the databases provided by Aldebaran, on the other hand the tools such as the database and face/vision recognition codes use open-source libraries for python.

A. Local Network

The first step was to establish a local network connection between a computer running the Linux Ubuntu 16.04 operating system and the NAO humanoid robot. To establish this connection, the SSH (Secure Shell) protocol was used, which allows secure communication between two systems, a client and a server, and thus to be able to connect between them remotely. All this was done by means of a code in the Python 4 programming language, in which the robot can be accessed using its IP address and the SSH protocol, in order to exchange or send information.

With the help of the local network, complete control of the NAO robot functions is obtained through the commands of the ALProxy library, which uses the Naoqi software to control the robot, as well as to send and receive data from the computer. This will allow that in each session it is possible to differentiate the users from the server, which will be able to save and extract the results obtained from the databases, to carry out a correct analysis of the results.

For this phase of the project, a process of installation and programming of codes was carried out with a local computer that takes the role of administrator of the database, in the same way a modem or router was needed, IP address changes of the robot that were being used and netmasks. This process is intended to ensure that the programs that are executed during the therapies are not saved directly in the NAO's memory but are saved on the server and executed through specific commands.

B. Database

For the creation of a database, the visual database design tool, MySQL Workbench, was used. During this stage, the database was designed dividing the columns into the variables: id child, face, name, last name, age, last update, allowed volume, inappropriate led colors, speech rate, accepted pronunciation, type of voice, progress animals, progress places, progress things, progress fruits and vegetables. The code developed for the database can be seen in Figs. 9 (a) and (b).

```
print ("Resultados de mysql.connector:")

import mysql.connector

miConexion = mysql.connector.connect (host='
    localhost', user= 'root', passwd='Rolando1',
     db='nao_anahuac')

cur = miConexion.cursor()

cur.execute("SELECT nombre,apellido, edad,
    ultima_actualizacion,volumen_permitido,
    leds_no_apropiados,  velocidad_del_habla,
    pronunciacion_aceptada, tipo_de_voz,
    avance_animales, avance_lugares,
    avance_cosas, avance_frutas_y_verduras FROM
    ficha_tecnica")
```

Fig. 9 (a) Python code for database visualization

```
for name, lastname, age, last_update,
    allowed_volume, no_appropiate_leds,
    speech_speed,
pronunciation_allowed, voice, progress_animals,
    progress_places, progress_things,
    progress_fruits in cur.fetchall():

 print(name, lastname, age, last_update,
    allowed_volume, no_appropiate_leds,
    speech_speed, pronunciation_allowed, voice,
    progress_animals, progress_places,
    progress_things, progress_fruits)

myConnection.close()
```

Fig. 9 (b) Python code for database visualization

Variables were selected based on observations and comments provided by trained psychologists. With this tool (Fig. 10), statistics of progress in each child are provided, to analyze each case more precisely and objectively observe the progress in the therapies provided, that is, to maintain continuity and record of the activities, in this way it will be possible to obtain a long-term projection of progress in children's social and communication skills, so that together with the community of health professionals, the quality of life of children diagnosed with ASD can be improved.

name	last_name	age	last_update	allowed_volume	not_allowed_leds	speech_rate	accepted_pronunciation	type_of_voice	progress_animals	progress_places	progress
pablo	alonso	7	2012-11-11	medium	AA	medium	medium	typical	level 5	level 3	level 2
pablo	alonso	7	2012-11-11	medium	AA	medium	medium	typical	level 5	level 3	level 2
NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL

Fig. 10 Database visualization within MYSQL Workbench

After the creation of the database, a direct connection between the NAO robot and the database was created to expedite the collection of data during each therapy, which will be received directly from the robot.

The creation and connection of the database organizes the information of each child throughout the sessions, considering the specifications of each child, their progress, their likes, and dislikes. In this case, the data collected are the counting of successes and errors that are recorded during each game within the session. In addition, to carry out this task, it was necessary to make a connection with the Python programming language to be able to link the other tools that will be used for the project, with the database.

C. Face Recognition

Face Recognition consists of the robot being able to recognize the face of the person that is in front of it, locating the eyes, the eyebrows, the nose, and the corners of the mouth. Once the face is detected, the code will use the database to access the characteristics that the robot needs to be configured with depending on the person with whom it is working. For this tool, the cv2 and *face_recognition* libraries of Python are used, which allow to recognize and characterize the faces that are registered by mapping specific points.

In this case, the code (Figs. 11 (a), (b)) used uses the image of a particular person which will be registered in the code's database. When running the code and turning on the camera, a scan or recognition is performed in which the previously saved image is linked with the image that is being received in real time, once the image has been identified, a comparison will be made with what is registered in the database, and if it is similar, the name of the person in the image is recorded, otherwise there will be no record, but a face will be detected.

D. Image Arrangement Matrix

For the first stage, a test script was carried out in Python (Fig. 12), where the cards are randomly grouped into three matrices, obtaining three 4x4 matrices, which correspond to the three physical walls of the controlled environment: left, right and front wall. In addition, when drawing the cards in the cells of the matrix, these are also coded with a number and a position. Once obtained, the matrices are printed so that the therapist can visualize the order and accommodate the physical cards within the controlled environment, and subsequently, the narrative of the story begins.

```
#import required libraries
import time
import cv2
#if using the picamera, import those libraries
    as well
from picamera.array import PiRGBArray
from picamera import PiCamera

#point to the haar cascade file in the directory
cascPath = "haarcascade.xml"
faceCascade = cv2.CascadeClassifier(cascPath)

#start the camera and define settings
camera = PiCamera()
camera.resolution = (320, 240) #a smaller
    resolution means faster processing
camera.framerate = 32
rawCapture = PiRGBArray(camera, size=(320, 240))

#give camera time to warm up
time.sleep(0.1)

# start video frame capture
for still in camera.capture_continuous(
    rawCapture, format="bgr", use_video_port=
    True):
  # take the frame as an array, convert it to
    black and white, and look for facial
    features
  image = still.array
  gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
  faces = faceCascade.detectMultiScale(
    image,
    scaleFactor = 1.1,
    minNeighbors = 5,
    minSize=(30, 30),
    flags = cv2.cv.CV_HAAR_SCALE_IMAGE
  )
```

Fig. 11 (a) Face recognition code test

As the robot tells the story, it asks the children questions about some concept, which can have several answers within the matrices, and to encourage them to select a possible answer, the robot points to the location of the area where the possible cards are located. Children must select the correct answer and show it to the robot to determine if the answer is correct or not. For the count of successes and errors, the same code of the individual image therapy was carried out, which uses an if comparator to add a success or error, as the case may be.

```
#for each face, draw a green rectangle around
  it and append to the image
for(x,y,w,h) in faces:
  cv2.rectangle(image, (x,y), (x+w, y+h),
  (0,255,0),2)

#display the resulting image
cv2.imshow("Display", image)

# clear the stream capture
rawCapture.truncate(0)

#set "q" as the key to exit the program when
  pressed
key = cv2.waitKey(1) & 0xFF
if key == ord("q"):
  break
```

Fig. 11 (b) Face recognition code test

```
    import random
#word bank
data = {
    'animals': ["horse", "pig", "duck", "
    elephant", "hen", "cat","bird", "dog", "
    turtle"],
    'clothing': ["shirt", "cap", "watch", "glove
    ", "hat", "tennis", "pants", "shoe", "flats"
    ,
                "sock","sweater"],
    'things' : ["plane", "television", "
    cellphone", "glasses", "dish", "bag", "chair
    ", "pencil",
               "bicycle", "table","fork", "
    knife", "bed", "bus"],
    'fruits' : ["strawberry", "apple", "lemon",
    "brocoli", "carrot", "grape", "orange", "
    watermelon"]
}

#creation of matrices
print("Matrices:")
print("Matrix 0 (left):", data['animals'])
print("Matrix 1 (center):", data['clothing'])
print("Matrix 2 (right):", data['things'])
print()
```

Fig. 12 Image arrangement matrix code

VI. Evaluations

To carry out an analysis of the results and progress obtained during the sessions, it was decided to use as a measurement tool a questionnaire made up of 30 questions that could be resolved with "yes" and "no" answers, as well as a count of correct and incorrect answers that is done during each session.

Said questionnaire must be answered by the parent or companion of the child with the objective of collecting qualitative variables, which were determined in conjunction with psychologists and/or specialists in ASD care, to subsequently evaluate the real impact that is being generated in the children.

In turn, work is underway to define the corresponding measurement instruments for each of the defined variables. To better monitor the variables in the sessions, a video camera is used, which records the sessions for subsequent data collection and indicator analysis.

Based on the results obtained, these will be compared with metrics endorsed by specialists, such as tests dedicated to the evaluation of specific skills within the development of language and social skills such as: adaptive capacity, respect for interpersonal distance with the robot and companion, eye contact establishment when communication begins, turns its body in a listening attitude when someone talks to it, facilitates the integration of another partner into the group, number of correct and incorrect answers, response time, and vocabulary.

```
import cv2
import face_recognition
import sqlite3
conn = sqlite3.connect('prueba.db')
c = conn.cursor()

from naoqi import ALProxy #Libreria nao
tts = ALProxy("ALTextToSpeech", "192.168.15.7",
    9559) #conexion para el say
proxy = ALProxy("ALLeds","192.168.15.7",9559) #
    conexion para leds
tts.setLanguage("Spanish") #lenguaje
motion = ALProxy("ALMotion", "192.168.15.7",
    9559)

from naoqi import ALProxy
proxy = ALProxy("ALVideoDevice","192.168.15.7"
    ,9559)
```

Fig. 13 (a) Database and face recognition synergy code

```
imagen_personal = face_recognition.
    load_image_file("foto_personal.jpeg")
personal_encodings = face_recognition.
    face_encodings(imagen_personal)[0]
encodings_conocidos = [
    personal_encodings
]
nombres_conocidos = [
    "Te encontre"
]
webcam = cv2.VideoCapture(1)
font = cv2.FONT_HERSHEY_COMPLEX
reduccion = 5
h=1

print("\nRecordatorio: pulsa 'ESC' para cerrar.\
    n")

while 1:
    loc_rostros = []
    encodings_rostros = []
    nombres_rostros = []
    nombre = ""

    valido, img = webcam.read()

    if valido:
        img_rgb = img[:, :, ::-1]

        img_rgb = cv2.resize(img_rgb, (0, 0), fx
    =1.0/reduccion, fy=1.0/reduccion)

        loc_rostros = face_recognition.
    face_locations(img_rgb)
        encodings_rostros = face_recognition.
    face_encodings(img_rgb, loc_rostros)

        for encoding in encodings_rostros:
            coincidencias = face_recognition.
    compare_faces(encodings_conocidos, encoding)

            if True in coincidencias:
                nombre = nombres_conocidos[
    coincidencias.index(True)]
    while h==1:
          iid = 56
              mm = c.execute("SELECT id, nombre
    FROM superprueba WHERE id = '%s'" % iid)
```

Fig. 13 (b) Database and face recognition synergy code

```
            print("Tabla seleccionada")
          row = mm.fetchone()
        print (row)
        print ("Comenzando")
        tts.say("Hola Diana, como estas")
        proxy.fadeRGB("FaceLeds","green",5.0)
        motion.moveTo(0.1,0.0,0.0)
    h=2


          else:
              nombre = "Quien eres?"
  tts.say("Quien eres?")

          nombres_rostros.append(nombre)

      for (top, right, bottom, left), nombre
  in zip(loc_rostros, nombres_rostros):
          top = top*reduccion
          right = right*reduccion
          bottom = bottom*reduccion
          left = left*reduccion

          if nombre != "Quien eres?":
              color = (0,255,0)
          else:
              color = (0,0,255)


          cv2.rectangle(img, (left, top), (
  right, bottom), color, 2)
          cv2.rectangle(img, (left, bottom -
  20), (right, bottom), color, -1)
          cv2.putText(img, nombre, (left,
  bottom - 6), font, 0.6, (0,0,0), 1)

      cv2.imshow('Output', img)


      #Salir con 'ESC'
      k = cv2.waitKey(5) & 0xFF
      if k == 27:
          cv2.destroyAllWindows()
          break

webcam.release()
```

Fig. 13 (c) Database and face recognition synergy code

The analysis of the results regarding the progress of the children obtained in the therapies is periodically evaluated by the psychology departments of the Universidad del Desarrollo, Santiago de Chile (UDD, in its Spanish acronym) and the Universidad Anahuac Mexico Sur.

Once the data of these analyzes are obtained, these faculties deliver a report on the results obtained with the child, in addition to providing feedback on the improvements that can be made to the therapy, either from the type of interaction that comes to between the children and members of the team present, optimizations of the therapy for the following stages, improvements for the controlled environment, etc.

VII. Results

A synergy was made with the database codes and face recognition (Figs. 13 (a)-(c)) using the local network as a mean of communication. These allowed the connection between the three tools so that once face identification in real time is achieved, the robot automatically applies the actions specified within the database and registers the results obtained for each session.

Based on the answers obtained in the forms delivered during the sessions, and with the support of the Faculty of Psychology of the Universidad Anahuac México, analysis and evaluation of the progress of the participating children were carried out. To quantify these results, the questions and answers were recorded in tables, as the example shown in Table I, that allowed graphical observation of the changes that occurred during each session. In addition, a document was delivered with an analysis that includes observations, recommendations, and a general summary of the child's development, which was also delivered to the parents.

In the case of individual therapy sessions, progress was observed in the development of the child's social skills, enabling her to maintain a conversation with her playmate while engaging in the activity. Another relevant point is the observed change in attention and motivation displayed during the session. Initially, the child showed little interest in the activity, but as the sessions progressed, she exhibited more enthusiasm. Additionally, following medical recommendations, she started taking medication to maintain attention throughout the day.

For the group therapy, the developed code shows the matrix arrangements where the cards of each category are randomly placed into three 4×4 matrices, each assigned a specific position. When the arrangement is done, the code prints the order so that the therapist can place the physical cards on the controlled environment, and the robot knows where to point.

As the robot tells the story, children must fill in the blanks with the correct option. there are several possible answers, so they must choose the one that fits best.

On this initial stage, the code will be tested as a demo, to check its functionality and the interest it generates within children. The use of several possible answers encourages the kid to decide according to the context, which will increase their socials skills and help them develop critical thinking.

VIII. Conclusion

Regarding the technical part, later stages will aim to implement image recognition algorithms in addition to the facial recognition that already exists, so that the robot identifies the cards autonomously and makes the therapies completely customizable and adaptable to the children's needs and progress. This will be done using Python libraries that are compatible with the NAOqi version used in the robot, so that the programming logic operates correctly.

TABLE I
RECORDED DATA FROM THE THERAPY SESSIONS

	Session 1		Session 5	
Question	Parent / Tutor	Playmate	Parent / Tutor	Playmate
How often does the child easily approach the monitors?	Almost always	Almost always	Sometimes	Almost always
How often does the child approach to the other playmate or parent to find the right answer?	Sometimes	Sometimes	Sometimes	Almost always
How often does the child ask for help to the parents?	Sometimes	Almost always	Almost always	Sometimes
Does the child get easily distracted despite being in a controlled environment?	Yes	Yes	Yes	No
Does the child maintain the same level of interest throughout the entire intervention?	No	No	No	Yes
Does the child exhibit strange and repetitive movement with the body or hands?	Yes	Yes	Yes	No

In the same way, with the aforementioned tools for personalization, it is expected to apply therapies with a more advanced level of difficulty, which allows a continuous evolution in the participants as their progress in language and social skills increases. In the case of the metrics evaluated during the sessions, it is proposed as the next stage to continue the joint work with specialist psychologists, to establish new parameters and evaluate the existing ones efficiently, and thus achieve a qualitative evaluation and quantitative analysis, which will allow demonstrating the progress of the participants throughout the interventions.

On the other hand, the matrices code for the group therapy is still in the testing phase and awaiting approval for the proposed controlled environment measures for this intervention. Once approval is obtained from the institution, therapy tests will begin with small groups of neurotypical children to prove its efficiency and make the necessary modifications suggested by specialists for subsequent application in children diagnosed with ASD.

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