# Socially assistive robotics with Artificial Intelligence and Improving the Social Behavior for Children with NDD

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**In this research, a patient-centered interaction project for robotic therapeutic applications using the "Spark humanoid" robot for children with Neurodevelopmental problems is presented.This brand-new therapeutic approach was developed to improve the most appealing and successful pediatric therapy. The robot is equipped with a camera and a tablet computer, which it utilizes to engage patients with activities and games inside. A phase in the therapy evaluation is to combine the camera's results after it has been examined with the activities presented.The camera is meant to record feelings in real time so that the instructor may gauge the students' level of interest and any difficulties they may have while carrying out their tasks. This is so that optimal treatment amounts may be suggested using the combination of these data. This procedure makes Spark a trustworthy and predictable electronic middleman for the kid by digitizing the patient's therapy journey so that any improvement (or worsening) is tracked. The Palestine Childhood Institute, which is testing this material, is the appropriate authority.**

***Index Terms*—socially aided robots, emotion recognition, hyperactivity disorder and lack of attention.**

## I. Introduction

Insocially assistive robotics (SAR) [1], the robot's objective is to establish close and effective communication with a human user in order to provide assistance. This is done by automating guidance, coaching, motivation, and companionship and achieving measurable progress in healing, rehabilitation, learning, etc.

Attention-deficit/hyperactivity disorder (ADHD) is among the most common disorders in Palestine due to the frequent state of war in the country, according to a questionnaire that was published among the students of the Palestinian An-Najah University, Nablus, Palestine. Where more than 150 students were subjected to the World Health Organization Adult ADHD Self-Report Scale (ASRS) v1.1 [2], consisting of 17 questions, it was found that 40 percent suffer from the disorder because the disorder was not detected at an early age and was not being subjected to treatments. In addition, the students' ignorance of the disorder ranged at 42 percent, and this indicates the urgent need to improve and increase the treatment of hyperactivity and lack of concentration at early ages and to increase awareness of the disorder among Palestinian society.

11One of the most prevalent behavioral problems in children is ADHD [3]. To fully understand the origins of this behavior and decide the most relevant resources to employ in the creation of effective intervention strategies, careful observation is necessary. Children with attention deficits frequently struggle to control their emotions, which is related to their deficiencies in social and communication skills. Due to the fact that people are highly expressive and that speech tones are never consistent, it frequently happens that therapists have difficulty connecting with these kids. Additionally, in play situations, common toys frequently fail to elicit reactions and involvement from young kids.

Through daily assistance services, psychological support, and a method for individualized diagnosis through ongoing observation and interaction, SAR seeks to enhance the quality of life for these people. This will make it possible to conduct ongoing, long-term, objective observation, analysis, and assessment. SAR has recently been successful in a number of endeavors, including assisting diabetic children [4], assisting teachers with storytelling [5], and assisting parents with at-home education [6]. introduced a tiny humanoid robot for flu vaccination in the clinical setting [7]. Another study [8] demonstrated how pediatric care could utilize human-robot interaction. Robots also have the benefit of dispelling worries about children's isolation and physical inactivity, which are typically linked to computer use [9], since they engage them in interactions and promote movement [10]. As a result, we are aiming to use social robots (SAR) to help youngsters with ADHD behave better. In order to enhance the clinical circumstances in which children pursue a therapeutic route, we deepened the use of SAR solutions as a result of the contextual study we conducted in partnership with the Palestine Childhood Institute. In this project, we develop SAR technology to support pediatric psychologists working with children who have behavioral issues, primarily ADHD, in their therapeutic work. We employ a robotic technique for games and toys dubbed "Spark humanoid." It is a humanoid robot that we created with interaction with people in mind. The therapist will be given a new tool to use in order to accomplish predetermined therapeutic goals through social robotic engagement. Additionally, we aim to apply artificial intelligence algorithms to create characteristics like emotions that humans are unable to avoid. In Section 2, related work will be presented.In Section 3, the contextual research will be demonstrated. We describe the system and its design in Section 4. Section 5 addresses the use of neural networks for emotion identification and explains how artificial intelligence might help therapy. In Section 6, the experiment is presented, and in Section 7, the findings are made.

## II. Related Work

Assistive Robotics (AR) has entered many different aspects of life and have occupied an important role over the past years, as they play an important role in helping humans in their daily activities, including the category of social assistive robotics SAR, which focuses on social interaction. Hence the importance of applying this robotics in the field of helping children with behavioral disorders. Nowadays, many researches have focused mainly on the use of AR in the treatment of autism disorder, where Scassellati [11] confirmed that robots have the ability to provide quantitative data necessary in the treatment and diagnosis of pathological conditions and follow up on their progress, also it has been proven the directly relationship between robots and raising the degree of motivation and participation in patients. Especially for those who find it difficult to interact with human therapists, some of them even prefer robotics to humans As for children with NDD, it has been found that they have difficulty in social thinking, playing and taking care of themselves. Gelos-Mini, et al [12], have demonstrated that the use of robots will improve their way of life and develop their cognitive and social skills. The important role of AR's in treating the children with neuro developmental disorders has been shown to be very effective as reported by Amato, et al [13] in their paper that studied the effect of SARs on the therapy of children with ADHD, their experiment was conducted on kids between the age of 7 and 10 years, the goal was to measure the degree of welcoming of the support given by the established technology. Fridin, Angel and Azery [14] studied in their research the extent of the authority, acceptance and interaction of robots on kindergarten children, in other words they studied the impact of assistive robotics on kindergartens. The study was conducted on children between the ages of 4 and 8 years. The sample number reached 19 children. The researchers measured the robot's communication with the child in terms of visual and physical communication, voice and facial expressions. After completing the experiment, the researchers concluded that the child would accept the presence of the robot and could also accept its authority and follow its commands even if the robot intruded within their personal space. It is worth to mention that although the implementation of their proposed technology was intended to be for children with ADHD, but their experiment was conducted with normally developing children. The authors' proposed technology is based on the previous studies, also it is not dedicated to a single NDD condition but for varying level of NDDs, this will help the kids' with their therapy process so that therapists may keep track of their progress.

## III. Methodology

### A. Contextual Investigation

Robotics has enabled humans to perform tasks that were previously impossible, or at least not so precise, with their hands. also it has played a fundamental role in the treatment and help of people suffering from trauma, dementia, autism spectrum disorders, cerebral palsy, and ADHD in the field of eHealth. As of the last five years, robotics have been applied to ADHD treatment and support, showing that the implementation of this technology has become attractive to therapists as an alternative treatment option (based on Scopus and WoS databases). In collaboration with a diagnostic and therapeutic center in Nablus, we met and interviewed developmental psychiatrists and psychologists. In the interview, we focused on understanding the therapeutic process associated with ADHD. A pdf file was created for each interview in order to preserve only the data required for analysis. The thoroughly examined data was recorded in a document for simple communication with the design team. Children with ADHD present different symptomatology, As a result, therapists indicated that treatment routes must be tailored to the individual patient. As these children are constantly on the lookout for stimuli, stimulation control is a fundamental part of therapy. Children with attention deficits need predictability, these children must be able to predict what will happen next. They believed that the humanoid robot may serve as a child's trustworthy and predictable technological middleman. The personalization of the therapeutic path has shown to be the unique component of our system among the therapeutic activities for which increasing attention is anticipated. The following functional requirements developed following the analysis phase: - Identifying facial expressions, - individualized treatment approach, - acquiring data in real-time, - processing of data, - tracking of treatment progress.

the research, which capitalized on the findings of the contextual inquiry, aimed to give therapists a comprehensive tool that could make data collection and analysis simpler, but more importantly, we wanted to give them the chance to try out a new method of cognitive behavioral therapy using artificial intelligence. Our objective was to show how modern technologies like artificial intelligence can improve NDD therapy as it is practiced now. the proposed technique was created to help therapists treat NDD patients by capturing their attention and making therapy less boring and more exciting. It works flawlessly with a humanoid robot equipped with a touchscreen and capable of communicating with patients via our software. Because of the system's link to a remote server, the patient receives tailored workouts in the form of games. Spark is the humanoid robot currently in use.

Spark, as noted in the preceding paragraph, has a touch screen and a video camera. Figure 1 depicts the system's architecture.

A. Architecture The system notices the child using the application through one of the camera built into Spark , and then employs emotion recognition algorithms to assess the patient's level of attention and any issues. The therapist can create the most effective treatment plan and behavioral strategies by using artificial intelligence to analyze the child's facial expressions and determine his emotional condition. The information gathered by the camera is integrated with the test findings. This combination is then evaluated using assessment metrics and computerized data analysis algorithms to suggest appropriate therapeutic activity levels and, most importantly, to provide the therapist an idea of the level of patient engagement. This procedure results in the digitization of the patients' healing direction, allowing for the monitoring of any improvement (or degradation). The presence of a robot

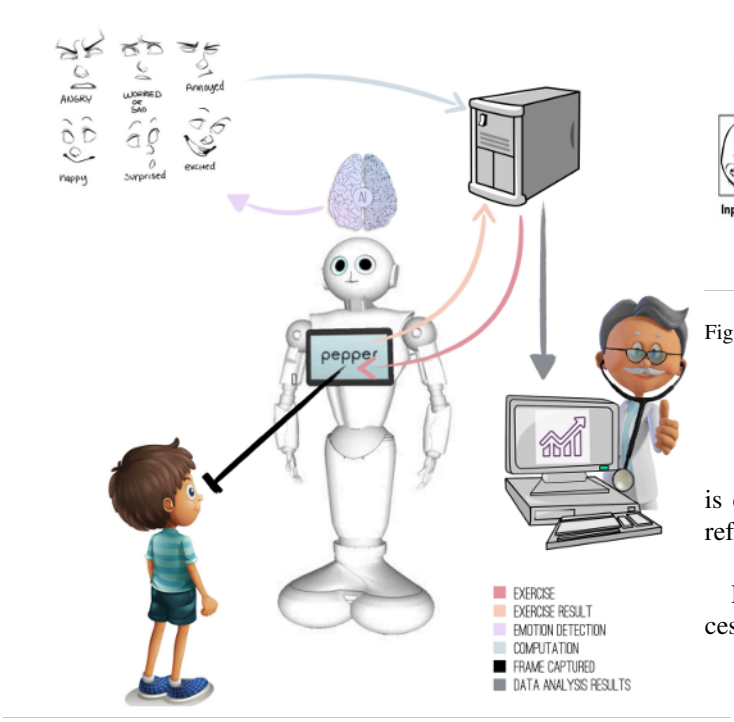



Fig. 1. The System Workfow

is seen as a game by kids. Children therefore understand that they are receiving therapy but do not experience stress. For the child, Spark develops into a trustworthy and predictable technical intermediary that makes the patient an engaged, independent, and autonomous participant in therapy sessions.

### *B. ARTIFICIAL INTELLIGENCE IN THE SYSTEM*

This paragraph will demonstrate how artificial intelligence can assist the therapist in following this course. The youngster will be observed during the therapy session, as was demonstrated in the earlier part. by the webcams on the humanoid robot to examine his feelings. Convolutional neural networks (CNN) have been used to classify emotions. CNNs are machine learning algorithms that have excelled in a wide range of video and image processing-related applications. As a result, these algorithms are applied to the collected photos, which first identify faces and then identify facial expressions. The trend of the collected data will then be examined to produce a qualitative measure that will be used to assess the effectiveness of the therapy, and to allow Spark to comfort the youngster with a message. An illustration of the numerous components that make up the system for recognizing emotions is shown in Fig. 2.

Face Detection: A Multi-task Cascaded Convolutional Network (MTCNN) was used to recognize faces. The MTCNN utilizes three convolutional networks in cascade to identify the faces and positions of the four points of reference (Fig. 3).

1. In the first step, a shallow CNN is utilized to quickly capture candidate faces. 2. In the second phase, a more complicated CNN is utilized to identify candidate faces or to delete false positives. 3. In the third phase, a third CNN

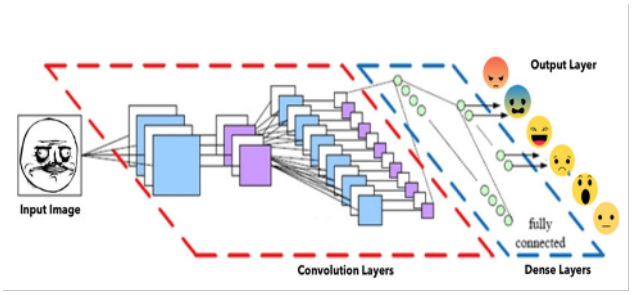
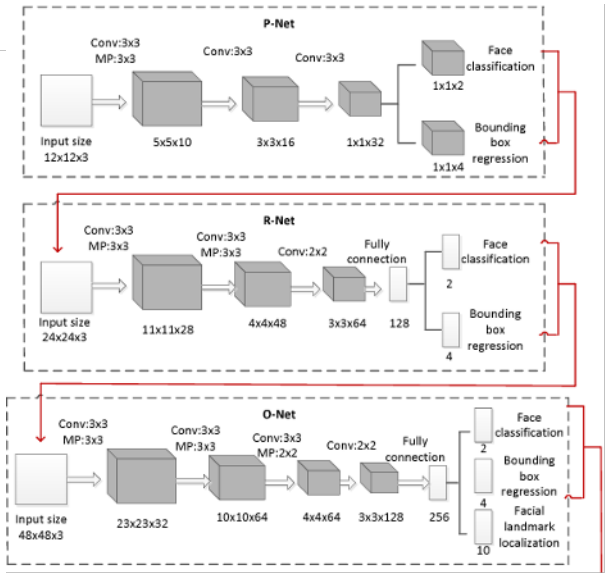



Fig. 2. Convolutional Neural Network

is employed to fine-tune the results and determine the face's reference points.

Let's take a closer look at the three aforementioned processes (Fig. 4) [15].




1) Proposal Network (P-Net): This network uses "bounding box regression" to determine the bounding boxes associated with the items sought, in this instance the faces. The overlapping bounding boxes are merged after minimal modification

2) R-Net (Refine Network): The output of the P-Net is connected to the input of the R-Net. R-Net decreases the number of candidates by merging overlapping candidates, using bounding box regression calibration, and suppressing non-maximal candidates. R-Net determines whether or not a candidate is a face, then generates a bounding box vector of four elements and a facial reference points vector of ten elements.

3) Output Network (O-Net): Similar to R Net, the last phase attempts to characterize the face in greater detail and displays the locations of the five facial reference points for the two eyes, one nose, and two mouths (fig5) [14].

B. Emotion Recognition We employ a CNN for the categorization of emotions, which uses the faces the MTCNN returned as output as input. The network is set up in the following way:

| convolutional layer | features | kernel | stride | batch |
|---|---|---|---|---|
| layer1 | 64 output | 3x3 | 2 | normalization, and ReLu. |
| layer2 | 128 output | 5x5 | 2 | normalization, and ReLu. |
| layer3 | 512 output | 3x3 | 2 | normalization, and ReLu. |
| layer4 | 256 output | 3x3 | 2 | normalization, and ReLu. |
| layer5 | 256 output | 3x3 | 2 | normalization, and ReLu. |
| layer6 | 256,512 | 6x6 | 2 | normalization, and ReLu. |

The emotion assigned to the input picture will be the output of this CNN, and the bounding box enclosing the recognized face and a label reflecting the assigned emotion will be shown on the video stream.

C. Dataset After collecting a sample of 28821 images [16], researchers mapped the emotional keywords to create seven broad categories:

3993 images for "Anger",
436 images for "Disgust",
4103 images for "Fear",
7164 images for "Happy",
4938 images for "Sad",
3205 images for "Surprise",
4982 images for "Neutral".

D. Capture of the predominant emotion In the last stage, the experimental stage, we chose to test the Spark robot on five children at the Palestinian Institute for Childhood, and different levels were chosen. The children were subjected to exercises, each child had an exercise commensurate with his level. The exercise was created in two stages, the first on paper, and an example matching it was chosen in the level On the tablet (Robot Spark), the difficulties of the exercises were included, and the child's feelings were captured during the exercise, and in the case that he finds it difficult, he is returned to the lower level automatically. The following chart shows the feelings that were captured for the child Carrying out the analysis of

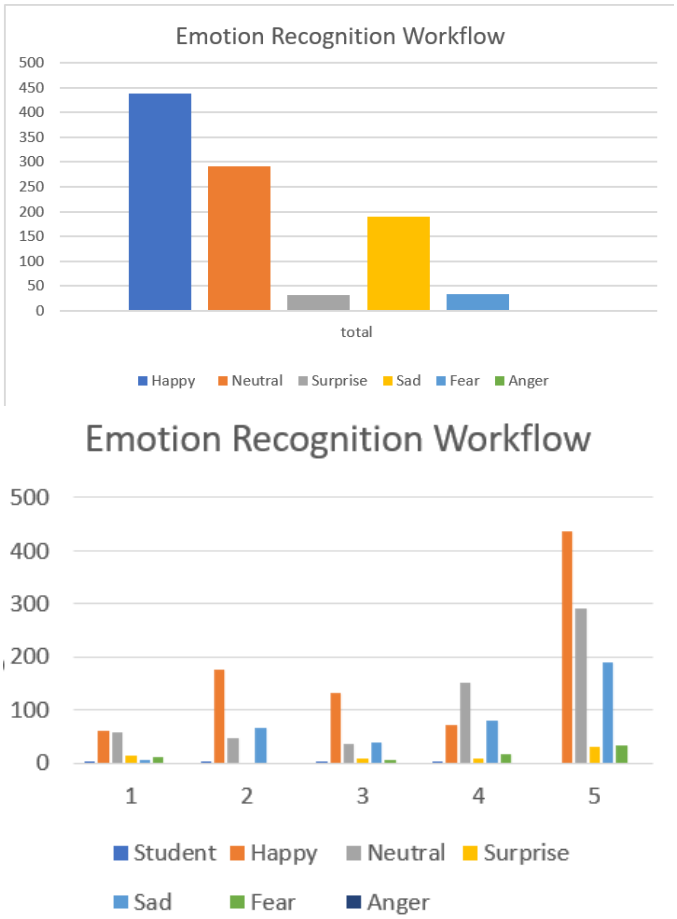



Fig. Emotion Recognition Workflow.

It is crucial to pay attention to the subject's emotions during the therapy phase so that we can notice their moods.In fact, the therapist may observe if the kid is able to retain concentrate during the session (as if he or she looks away, the term "distracted" will be recorded) or if he or she is becoming bored and need a change of pace. Simultaneously, Spark employs the most recent mode value to present the young patient with appropriate feedback as well as a motivational phrase. To do this, a dictionary of encouraging words has been established and constructed for each emotion so that Spark may "choose" at random what to say while taking into account the most recent feeling that has been logged.

## IV. RESULTS AND DISCUSSION

Experiments were conducted at the Palestinian Institute for Childhood in May 2023, in which children interacted at different levels with the Spark robot, as previously explained. The experiments took place during two sessions. During the first session, the children were introduced to the spark processor, and the children were explained how to interact with the robot. The children immediately agreed to a humanoid robot, who began to cooperate and showed a high degree of interest. Or in the second session, in the first experiment, they were given a puzzle exercise on paper, dimensions 9 * 9, and the extent of the child's interaction with the paper was calculated and the time it took to perform the task, then they were given a puzzle of the same level, dimensions 9 * 9 on the Spark robot, and the time spent was calculated, and it was done Giving them

exercises to write numbers and letters, and it was noticed that the method of holding the pen and dealing with it was better in the Spark robot than on paper. They were confused about how to start. Some students started with paper, then the robot, and others started with the robot, then the paper The results of the time it takes the children to complete the tasks on paper and on the Spark robot are shown in the following table:

| Theoretical | with Spark |
|---|---|
| 25:69 | 12:34 |
| 50.59 | 33.28 |
| 39.28 | 37.98 |
| 55 | 41 |
| 50 | 60 |

During the children's performance of the tasks, the beam was opened and the children's feelings were taken during the performance of the task to be taken as feedback to evaluate the child. In the exercise of writing numbers, they were given writing from 0 to 3, and the results ranged between happy and normal, but when we moved to the number 4 due to the presence of a large number of angles, We found feelings or fear and wonder on their faces. All this feedback was transferred to a report and sent to the therapists at the Palestine Childhood Center.

In order to be able to examine the extent to which the workers in the Palestinian Childhood Center accept the integration of artificial intelligence in treatment methods for children with neurological disorders, we conducted a questionnaire, which is a set of questions.Extracted from a UTAUT questionnaire based on the UTAUT paradigm, it offers good acceptance and intent to employ A humanoid robot for therapeutic application in behaviorally challenged children discontent.

## V. CONCLUSION AND FUTURE WORK

Both children and therapists found the idea of using artificial intelligence with robots during the therapeutic process interesting and attractive. The system that the authors have developed led to providing an appropriate therapeutic environment based on patients' conditions. The next step of this investigation will be to complete this experimental study with a larger number of patients so that clearer results can be obtained in order to know the weaknesses in the proposed system.

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