Research on robots interacting effectively with autistic children

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Abstract. This paper focuses on designing a robot that can efficiently relieve pressure and heal children with autism. autism, a common and unavoidable disease, happens in 1 in 100 children worldwide, and is not easy to recover, especially for children. While many organizations have explored the effectiveness of social robots, only a few robots are available that encompass helpful functions. In this paper, a few new functions or changes, such as portable design and more attractive and complex interaction design, can significantly improve the possibility of healing. The research incorporated the detailed design of the robot and meta-analysis as the data analysis method. Our data come from previous research from different areas of the world. The robot reveals that current robots are still incapable of comprehensive interactions and what future designs are expected to be included.

Keywords: autism, robot, human-robots interaction.

1. Introduction

Autism, a range of difficulties for people with it, such as social skills, communication difficulties, and repetitive behaviors, are common problems worldwide. The data showed that 1 in 100 children in the world has autism, as reported by the World Health Organization. Population-based epidemiological studies in the West have reported increases in the prevalence of autism over time, ranging from 30.8 per 10,000 in 2000 to 157 per 10,000 in 2009 to 169 per 10,000 in 2018 [1]. Several factors may influence the development of autism, and it is often accompanied by sensory sensitivities and medical issues such as gastrointestinal (GI) disorders and sleep disorders, as well as mental health challenges such as anxiety, depression, and attention issues [2]. However, there is no exact conclusion on the causes of autism [3]. Even though researchers did experiments focusing on the trends of likely factors of autism, biologists and psychologists haven't agreed on the factors. Since it's been a long and expensive process, finding the sources of autism is less practical than solving the problem of autism.

In a 2019 study, Kumazaki claimed that children who have autism deliver better performance with a robot when accompanied by a human partner [4]. The results of this research revealed an improving social ability to communicate and interact with people among the participants involved. In a study led by Yale researcher William Weir on August 22, 2018 [5], researchers aimed to encourage children with autism to react to the robot they made. Their robot could encourage children to practice talking and telling stories to the robot. The robot discussed in this paper aims to incorporate social behaviors to teach children with autism, as human-like robots can aid in faster learning. Specific communication training is crucial due to the vast variability of autism [6]. However, the robot's limitations, such as immobility, restrict its ability to perform human actions like playing a pet or walking, and the complexity of computer programming makes it difficult for non-computer science researchers to make changes to their research [7]. Thus, this paper includes a simplified computer program for beginners. Additionally, this study combines Dr. Weir's robot's features with movable feet and other functions to investigate the correlation between different functions. Also, children with extreme autism may not want to talk to a human-like robot but instead like to start with other features like a robot.

2. Design of the robot

Step 1: Use 3D One, a 3D-Modeling app, to create your preferred parts. The clear control panel includes unique shapes and multiple functions, such as curving and hollowing.

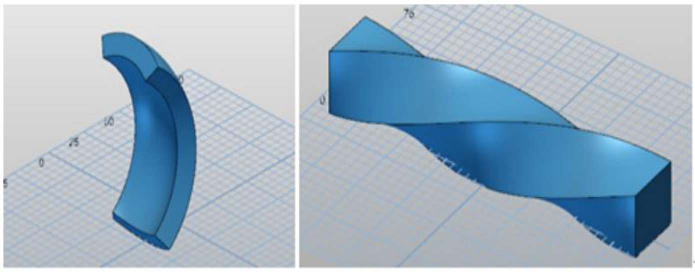

Figure 1. Demonstration of the body.

Step 2: Create a head with a length of around 55mm, a width of around 40mm, and a height of 8 mm. Reserve the place for two eyes with 5mm between them. Then use the “inverse operation” to hollow out the eyes. Finally, put on some decorations chosen by the children.

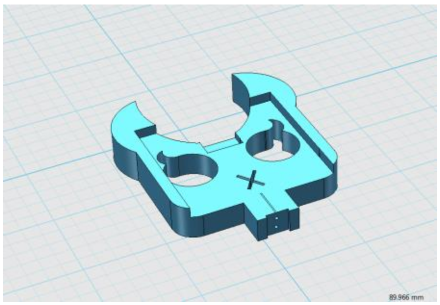

Figure 2. Head of the robot.

Step 3: Now, as Figure 3 shows, with the knowledge mentioned above, make the following parts. Be careful, and don’t hollow out the whole rectangle box because the box has to have width. Use the 3D-printer to print out these parts. Remember, since the printer prints from the bottom to the top, it’s important to flip some of the parts, such as the first figure in F3. Otherwise, it will collapse and hurt the ejector.

Print the legs and other parts of the robot according to the users’ design.

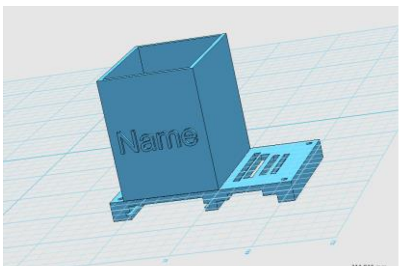

Figure 3. The DIY top of the robot.

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Step 4: Prepare a Nano shown in Figure 4 mainboard and extension board, which are called the “brain” of the robot. The blue portion is the mainboard, and the green portion is the extension board.

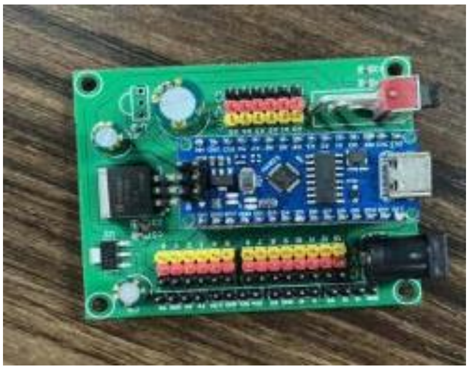

Figure 4. Nano board.

Step 5: Ultrasonic Transducers can emit and collect ultrasonic waves. But the light angle could not be too large. Otherwise, it won’t collect the waves this research needs.

Figure 5. Ultrasonic transducer.

Step 6: Connect it to the Nano board as Figure 6 shows.

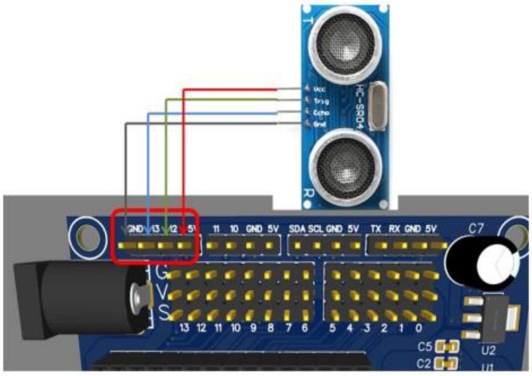

Figure 6. Connection process.

Step 7: Connect the motors to the correct port, as shown in Figure 7. Caution: connecting to the wrong port may cause a short with a lot of heat and break the board.

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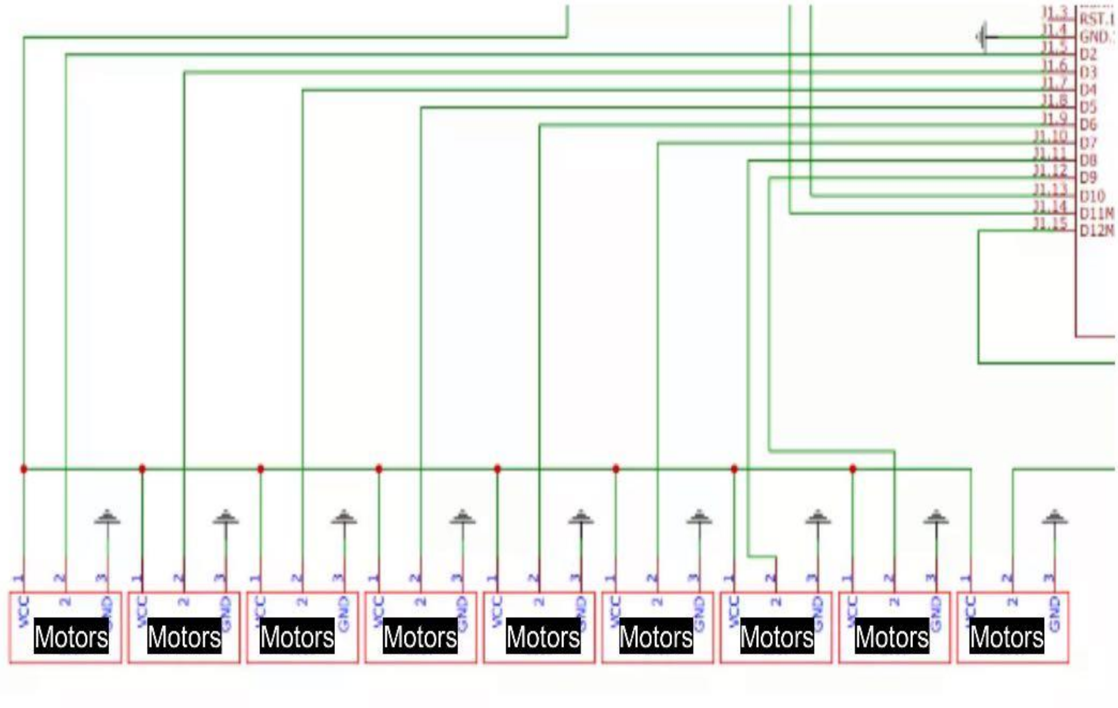

Figure 7. Electrical figure.

Step 8: Figure 8 demonstrates the most important part of the full coding design. The most common and applicable app for robots is Arduino. The first step is to set the motor. Remember to set the “delay” variable so that the motor won’t speed up too fast.

```
#include <Servo.h>
  Servo myservo;
  int pos = 0;
void setup() {
  // put your setup code here, to run once:
    myservo.attach(9);
}

void loop() {
  for(pos=0;pos<=180;pos++){
    myservo.write(pos);
    delay(15);
  }
  for(pos=180;pos>=0;pos--){
    myservo.write(pos);
    delay(15);
  }
}
```

Figure 8. One part of the code.

Step 9: Then, create a Bluetooth controller by MIT APP Inventor. APP Inventor could convert your code into puzzles, as shown in Figure 9.

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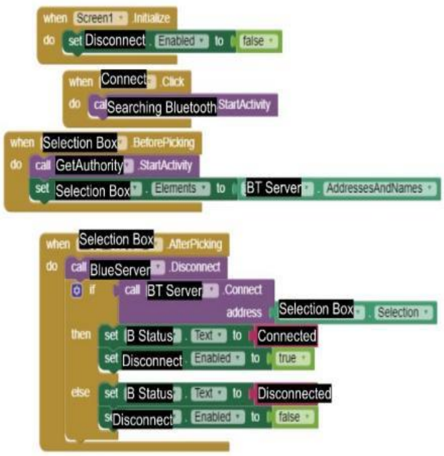

Figure 9. Bluetooth process demonstration.

Step 10: Design the mobile app. The final app looks like Figure 10.

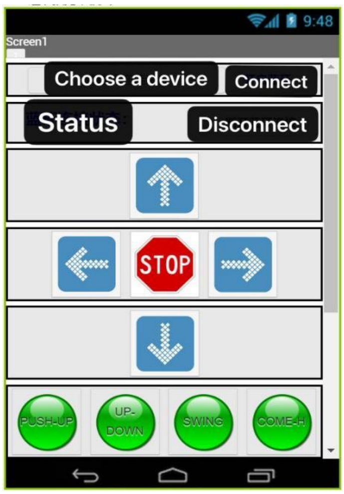

Figure 10. Mobile controller app.

Step 11: The following are the full oral and movement commands that we incorporated. Future researchers can follow the comments to make some changes.

3. Data analysis

This paper will use meta-analysis, which aims to "assess the evidence for the effectiveness of specific interventions… often over a relatively small number of studies." and to "reach broader generalizations among the larger number of study outcomes." The researchers combined data from several articles to develop more complex analyses and several inferences and conclusions. The goal of employing meta-analysis was taken into consideration to establish pertinent results and recommendations. This research includes 25 studies in total that explored the potential of robotics in supporting children with autism. The study, likewise, aimed to "estimate the heterogeneity of the effects, which indicates the consistency of the effect across studies" By analyzing the previous results provided by a 2021 research, we can estimate the practicability of solving problems by the robot and potential improvements. Before starting the analysis, we recognize the robot's traits– capable of communicating and reacting with people and following commands.

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Table 1. Traits of the robots and participants investigated in some studies.

Number of Studies	Publisher	Type of Robot	Participants ages	level
1	Aryania et al. (2020)	Arc humanoid robot	9-11	Functioning autism and IQ score > 70
2	Berk-Smeekens et al. (2020)	Nao humanoid robot	3-8	IQ score > 70
4	Zhang et al. (2019)	Nao humanoid robot	5-8	IQ score of 105
5	Conti et al. (2018)	Nao humanoid robot	5-10	With some intelligence disability
6	Desideri et al. (2018)	Nao humanoid robot	9	Extreme autism due to intelligence deficient
7	Feng Y et al. (2018)	Nao humanoid robot	5-6	Not recorded
8	Koch(2018)	Humanoid robot	5-12	Little cognitive disability
9	Kumazaki et al. (2017)	Mobile app-controlled humanoid robot	10-17	Functioning autism
10	Palestra et al. (2017)	Nao humanoid robot	5-10	IQ > 70
Table 1. (continued).				
11	Schadenburg et al. (2019)	Zeno humanoid robot	8-19	verbal/no verbal
12	Mengoni et al. (2017)	KASPAR humanoid robot	5-12	Mild autism
13	Scassellati et al. (2018)	Social robot	6-12	Nonverbal IQ >70

The first step is to recognize the robot's kinds and participants of different levels so that the results are more representative of trends. Our humanoid robot differs from the previous ones because it has a bug’s body instead of a human’s. A bug’s body can release pressure on children when they react to the robot because they may fear a “fake” human talking to them. But a bug’s body and nearly a human’s face make children curious about playing with it and can gradually encourage children to talk more

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through the communication function. Someone argues that the less humanoid robot may not make children with autism practice talking to real people. But if a child is afraid of talking to the robot, they will refuse to allow any form of the robot to appear in their surroundings. According to Cho and Ahn [8], the design of the robots can vary, provided that their purpose for use is identified to target the deficits of children with ASD, such as improving concentration, facilitating joint attention, and modeling appropriate social behavior. In terms of the types of robots used, it is shown that 12 out of the total number of articles employed humanoid robots in their experiments for assisting children with autism. These robots are designed to resemble the physical appearance of a small child. They are highly attentive to the needs of children, making them very appealing to children with autism who often struggle with social skills. Humanoid robots with interactive features have been shown to be effective in eliciting more responses from children with autism in terms of recognizing and duplicating emotions. The presence of a robot that resembles a human's behaviors but has other appearances can serve as a playmate and companion to these children, contributing to the development of their social skills. Technologically designed robots, according to Cho and Ahn, "can develop suitable social interaction skills and behaviors among students."

Table 2. Robots' effects on expected skills of children with autism.

Number of studies	Expectation	effects
1	Social engagement	The robot improved the social engagement of some children with autism
2	Social and emotional skills	Participants demonstrated excellent children effects, which are simulated by robots' movement, speech, and games
3	Learning deception and distrust	Marks the potential of following the social rules
4	Cognitive skills	The robot showed an effective method to improve cognitive and emotional levels.
5	Body communications	Most of the participants showed clear changes before and after the experiment.
6	Social reactions to the Language	The robot positively affected the participants depending on the variables participants were tested.
7	Reactions to different events	The robots were effective on improving the social skills of children with autism

Table 2 presents an overview of the targeted skills in studies involving the use of robots and their effects on participants. The studies either focused on multiple skills or specific ones. 23 out of 25 studies explored the use of robotics to support social performance among children with autism, followed by language and cognitive skills in five and four studies, respectively. autism is known to cause deficiencies in socialization, particularly in socio-emotional reciprocity, interaction, and nonverbal communication. Studies aimed at improving these social skills, allowed participants to establish age-appropriate social competence despite their limitations [9]. Language and communication skills were also found to be problematic among children with autism. Additionally, some struggle with cognitive skills such as planning, problem-solving, and reasoning.

Many studies have demonstrated the potential of robotics to support children with autism. Robots have been shown to improve target skills and enhance the level of performance in children with autism. They have also been found to decrease the responsibilities of caregivers during tasks and improve communication abilities and attention span. However, some studies have reported limitations in the effects of robotics-based interventions on children with autism, such as varying results among participants and limited improvements in certain skills. But our robot can perfectly solve these problems.

4. Conclusion

This study focuses on making the healing robot more comprehensive and introducing new designs on the robot to help children with autism efficiently. It aims to create a human-like robot with different features to meet the needs of extreme autism patients who are not nervous about being healed. Even though there is no direct data, the meta-analysis of articles acknowledged that technology-based tools have a promising potential to enhance the skills and performance of individuals. The robot can also be easily revised by the codes and design we had so that further researchers either want to use it to examine their studies or compare our robot with ones they make so that they can improve and change. 3D modeling is becoming a popular DIY design tool recommended for designing a robot, whether more human-like for other needs or less human-like for more narrowed needs. However, the robot is still in the very ealy stages of its practicability. There are flaws, such as the robot’s slow movement, and the whole robot looks heavy, which is inconvenient to use in a small area. Wheels can replace the feet of the robot, and the face can be added to a touch screen with facial expressions so that the student is more likely to respond to the robot. In addition, the designs should be based on more children’s opinions. But overall, there are unlimited designs and more accessible tools and computer programs for other researchers to use the data or the robot to fully heal autism.

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