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Speech Recognition Approaches for Emotion Regulation in Socially Assistive Robot

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ABSTRACT

Socially Assistive Robot (SAR) can be created and used to assist children with special needs specifically those with autism, to manage their emotions through the therapy they need, which is then programmed into the robot. The therapy used on the robot is Applied Behavioral Analysis (ABA) therapy in the form of a guessing game with pictures. This therapy utilizes one of the methods in the robot's program, which is Speech Recognition, to provide feedback from the child using the robot. Speech recognition plays a role in facilitating the interaction between the child and the robot. When the picture-guessing game starts, the robot displays an image on the LCD screen and asks the child to guess the name of the object shown in the picture. At that moment, Speech Recognition works by recording the child's voice and converting it into text, then comparing the child's answer with the correct answer. When the child answers correctly, the robot provides praise, while if the child answers incorrectly, the robot encourages the child to try answering correctly again. This system allows the Socially Assistive Robot to support children with autism in managing their emotions by combining the ABA therapy method with the program's interactive feature enabled by Speech Recognition. Speech Recognition enhances communication and interaction between the child and the robot, creating a supportive and engaging therapeutic experience.

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1. INTRODUCTION

According to the Ministry of Health of Indonesia on April 2, 2020, there were recorded 1,790 children diagnosed with Autism Spectrum Disorder. Out of this number, 112 children recovered from ASD, while 170 children passed away [1]. Autism, or Autism Spectrum Disorder (ASD), is a developmental disorder of the brain and nerves that affects human behavior and thinking patterns [2]. This disorder impacts an individual's ability to communicate, socialize, behave, learn, and engage in daily activities.

One of the therapies that can help children with autism manage their emotions is Applied Behavioral Analysis (ABA) therapy[3]. ABA therapy has been used for several decades worldwide and has shown to assist children with autism in addressing psychological and emotional issues [4]. Typically, in this therapy, a therapist utilizes specific techniques such as meditation or games to help children with autism learn emotional regulation [5]. This therapy can be implemented using a Socially Assistive Robot (SAR) in the form of a doll to attract the attention of the child.

A Socially Assistive Robot is a robot designed to assist humans in various activities, including physical therapy, education, and mental health[6][7]. SAR can be an effective solution for children with autism during ABA therapy[8][9]. SAR provides consistent and repetitive interactions, timely feedback, and makes therapy more enjoyable for children with autism. SAR can be equipped with attention-based games specifically designed to help children with autism learn emotional regulation[10][11].

One of the games that can be applied to the Socially Assistive Robot is a picture guessing game. This game involves displaying pictures on an LED screen to enhance the concentration and focus of children with autism. The robot can guide children with autism to focus on guessing the name of the object in the picture through voice-based questions. When the child answers the robot's question, the robot translates their response from speech to text. Speech recognition techniques are used to determine the accuracy of the child's answer. The games implemented in the SAR can help children with autism focus their attention and learn to control their emotions.

2. RESEARCH METHODS

In this research, the method used is Speech Recognition as a development of Socially Assistive Robot (SAR). The robot is designed starting from the formation of electronic circuits, mechanics and programming. After the robot is formed, researchers conduct testing and data collection to measure the success rate of performance on the robot. In the testing phase, researchers will test directly individually to the autistic child. During the process, the researcher records and documents the test results and determines the areas that need improvement.

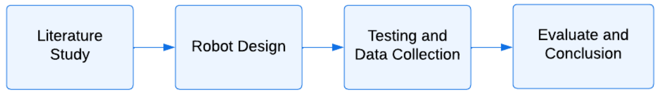

Figure 1. Research Methods

2.1. Socially Assistive Robot's Operation Flowchart

When the SAR implementing ABA Therapy is turned on and the sensors have been initialized to start a guessing game session with a child, the robot will ask questions in the form of object names displayed on an LCD. Once the child answers, the robot will record the response and use Speech Recognition techniques to identify the child's answer using a provided answer key. If the child's answer matches the answer key, the robot will say that it is correct and praise the child. Conversely, if the answer is wrong, the robot will say that it is incorrect but encourage the child to try again. The program will continue guessing the images until all of them have been completed. Then the Flowchart to describe the work process of the system discussed is shown on Figure 2 below.

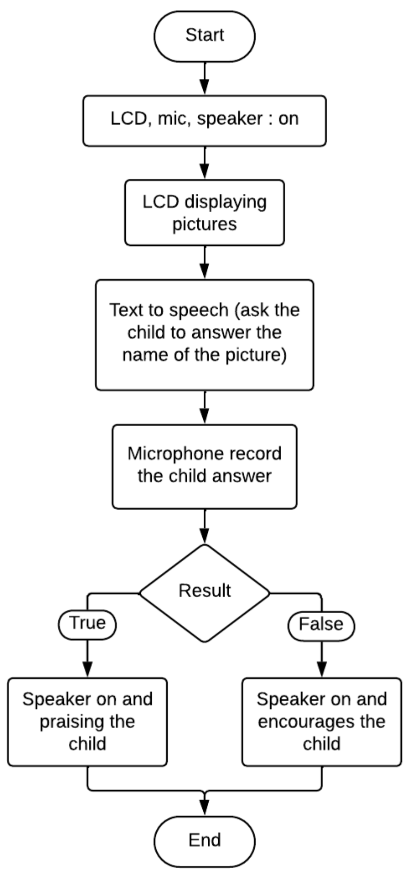

Figure 2. Scheme of Research

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2.2. Electronic Circuit Design

In assembling the robot's electronic circuit, an important component used is the Raspberry Pi 4, which will control all input and output components. Researchers use the Python programming language to process and run the system on the robot. The image will be displayed on the LCD with the aim of giving questions to the child, and the child can answer the question by speaking directly in front of the robot. To identify the child's answer, the microphone sensor will capture the frequency of the child's voice, and the data will be processed using the Speech Recognition method by the Raspberry Pi 4. After that, to determine whether the child's answer is correct or incorrect, the speaker will be activated and provide instructions to the child. This process will be repeated over and over again.

In addition, in designing the SAR robot's electronic circuit, a 3D design was also made which included all connected components, such as the Raspberry Pi 4, LCD, speakers, and microphone. The 3D design provides a visual picture of the layout and interconnection of these components, making it easier to manufacture SAR robots according to the planned design.

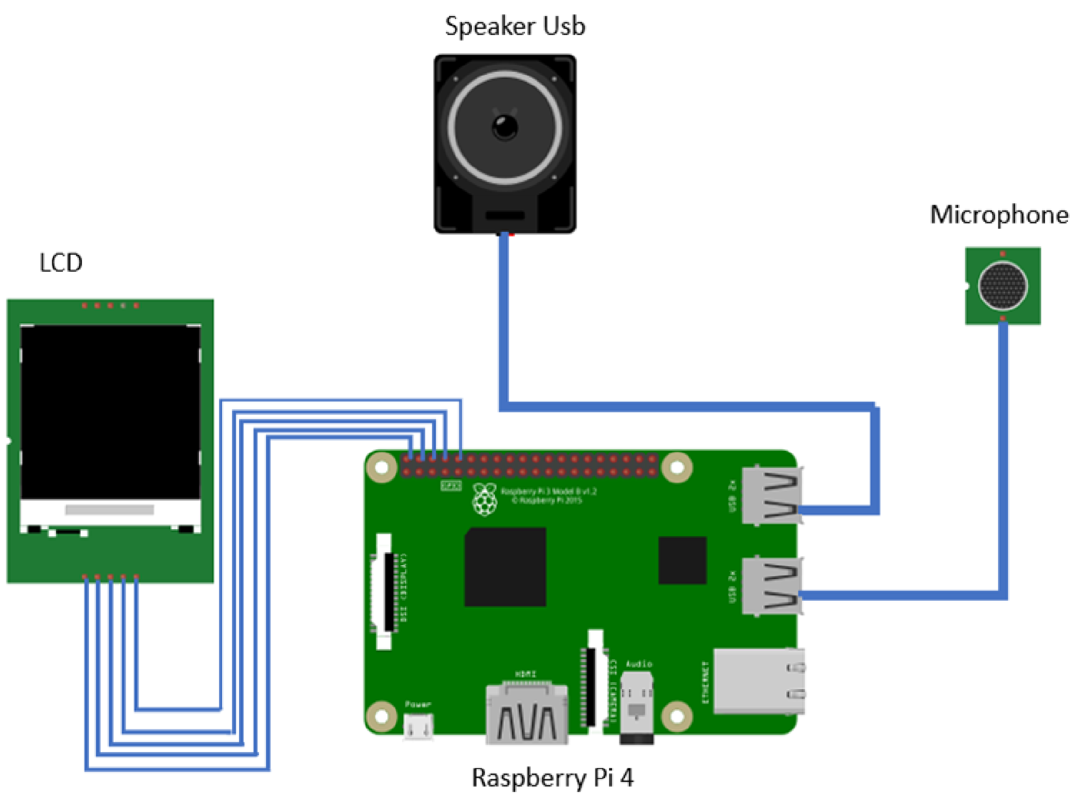
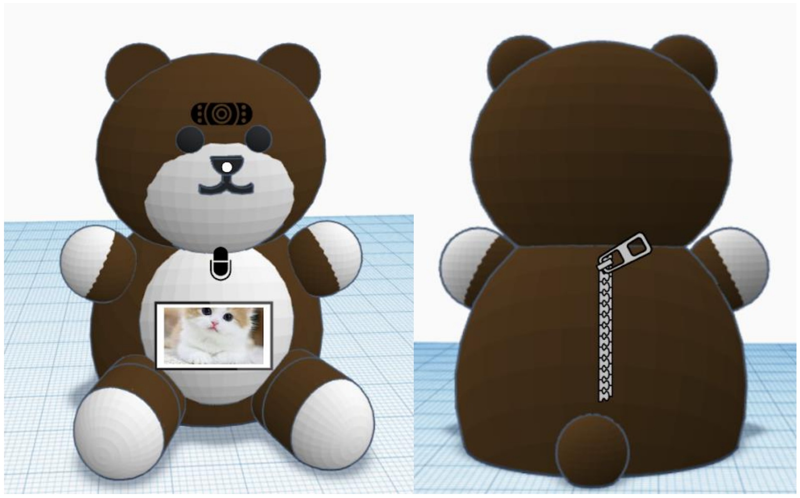


Figure 3. Electronic Circuit Design



(a) (b)

Figure 4. 3D Design of Robot (a) Front view, (b) Back view

3. RESULTS AND DISCUSSION

3.1. Speech Recognition Testing for Socially Assistive Robots in Children with Autism

This study aims to test the ability of speech recognition on the SAR Robot which will be used in the ABA therapy process for autistic children. In this test, the robot is tested to recognize the speech spoken by the child to the robot. At this testing stage, data is taken using a certain distance as a benchmark for the accuracy of the robot in capturing sound or speech recognition.

Table 1. Speech Recognition Testing with Various Distances

Range (cm)	**Pictures**	**Childern**					**Average(%)**
		1	2	3	4	5	
20	Chicken	1	1	1	1	1	100%
	Cat	1	1	1	1	1	
	Bird	1	1	1	1	1	
	Spoon	1	1	1	1	1	
	Ruler	1	1	1	1	1	
	Plate	1	1	1	1	1	
	Mug	1	1	1	1	1	
Total		7	7	7	7	7	
40	Chicken	1	1	1	1	1	91%
	Cat	1	1	1	1	1	
	Bird	1	1	0	1	1	
	Spoon	1	1	1	1	1	

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	Ruler	1	1	1	1	1	
	Plate	1	1	1	1	1	
	Mug	1	0	1	1	0	
Total		7	6	6	7	6	
60	Chicken	0	1	1	1	1	71%
	Cat	1	1	1	1	1	
	Bird	1	0	1	0	1	
	Spoon	1	0	0	1	1	
	Ruler	1	1	1	1	1	
	Plate	0	0	1	1	1	
	Mug	0	0	0	1	1	
Total		4	3	5	6	7	
80	Chicken	1	0	0	1	0	51%
	Cat	1	0	0	0	0	
	Bird	1	0	1	0	0	
	Spoon	0	1	1	0	1	
	Ruler	0	1	0	1	1	
	Plate	1	1	0	1	1	
	Mug	0	1	0	1	1	
Total		4	4	2	4	4	

Note: A value of 1 indicates the robot's success in identifying the sound and a value of 0 indicates the robot's failure to identify the sound.

This test is carried out in a quiet and calm state so that there is no disturbing sound. Researchers took data from various distances that might occur when using the robot, namely at a distance of 20 cm, 40 cm, 60 cm, and 80 cm. The robot was tested on 5 children who were asked to play or guess the image 4 times with each round of 7 images, this test was carried out with the same image and a predetermined distance.

Based on Table 1, testing with a distance of 20 cm, all pronunciations can be clearly recognized by the robot so that it shows the value of 1 all and produces a percentage of accuracy of 100%. In the second distance, which is 40 cm, the robot could recognize the children's voices with a success rate of 91%. There were three times indicating that the robot failed to recognize the children's voices. These failures were caused by several conditions, including the children's impatience in waiting for the robot's response. The robot continued to record the children's voices even when they kept talking, resulting in three instances with a value of 0.

At a distance of 60 cm, the robot achieved a success rate of 71%. There were several instances with a value of 0 generated by the robot. At this distance, children with autism started to lose focus in answering the robot's questions and tended to answer quickly and

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repeatedly. Additionally, the distance also affected the microphone's ability to capture the children's voices, making it slightly more challenging for the robot to recognize the voices at a 60 cm distance. At an 80 cm distance, the robot only had a 51% success rate. Only half of the game could be completed by the robot, while the other half failed to recognize the children's voices. Many factors influenced the data collection at this distance, apart from the relatively far distance. The children lost focus and exhibited tantrum behaviors during the game, and the noise from the children caused the robot to continuously record all the sounds, leading to the robot's failure in recognizing the voices.

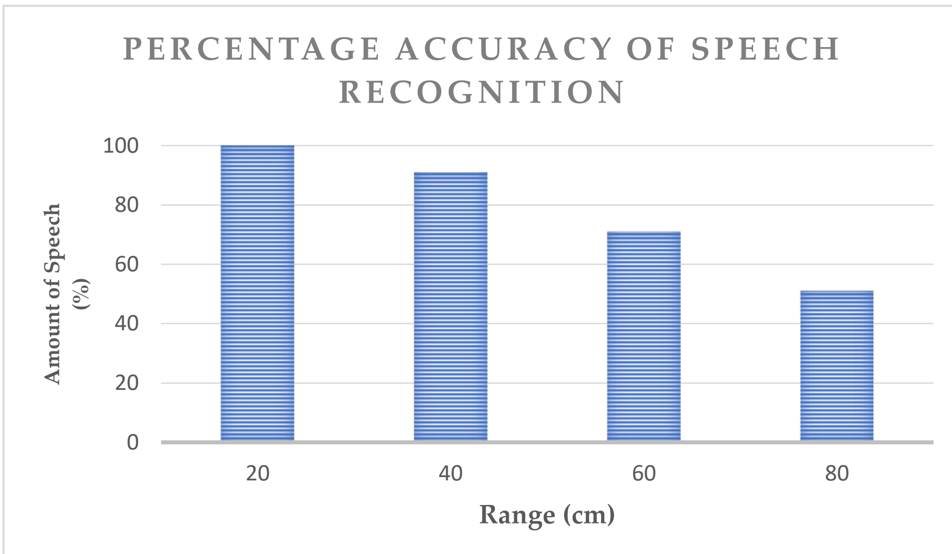

Figure 2. Percentage Of Speech Recognition

Figure 4 depicts the graph of speech recognition test data on SAR robot using a bar chart for easy comprehension of the results. The x-axis represents the distance used in the data, while the y-axis represents the percentage value of successful speech recognition recognized by the SAR robot.

From the graph, it can be observed that at close distances to the robot (20 cm), the success rate of the robot is 100% in recognizing speech. However, after testing the robot at greater distances, the success percentage in recognizing children's pronunciation gradually decreases. At a distance of 40 cm, the robot achieves a success rate of 91%. In this condition, the robot is still considered good at performing speech recognition.

However, at a distance of 60 cm, the robot's performance in speech recognition starts to decline to 71%. The farthest data point taken is at a distance of 80 cm, with a success rate of 51%. This indicates that the robot can only recognize half of the children's pronunciation at its optimal performance. Here, distance plays a crucial role in determining the robot's success rate in performing speech recognition. This indicates that distance and noise can affect the success rate of the robot in identifying sound. Additionally, the unattractiveness

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of the robot in sound identification is considered a problem.

4. CONCLUSION

The conclusion of this research is that the ability of the SAR robot to recognize children's voices when using the robot as a medium for ABA therapy with a guessing game is highly dependent on the distance between the robot and the child. Additionally, there are several other conditions that can cause the robot to fail in speech recognition, such as noise and prolonged duration of voice recording. This indicates that distance and noise can influence the success rate of the robot in identifying sound. Additionally, the unattractiveness of the robot in sound identification is considered an issue. This research provides important insights for the development of SAR robots to improve their performance and effectiveness in interacting with children with autism.

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