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Human Robot Interaction System for Behavioral Improvement of Autistic Children

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Abstract—An estimated one-third of people with autism are nonverbal. Many Research has been done in this field and confirms that people with autism experience a lack of communication skills, anxiety, dealing with change, bullying, etc. To assist autistic children and to improve their behavior, we have developed an artificial intelligence robot that can react to their movement via an ultrasonic sensor and can talk to them via voice commands. Using this robot, children with ASD can develop both their behavior and communication skill. The robot works in two methods. The first one is the ultrasonic sensor, implemented with an AI algorithm that can detect a person within seventy centimeters. This ultrasonic sensor sends the data to the controller and the controller receives the signal and sends an activation signal to the robot. Finally, the robot moves his head to the direction of the person is located or to the moving direction. The second method is voice commands. The robot can perform each physical action it is given via voice commands like a salute, handshaking, body movement, and answering questions achieving 97.75% average accuracy with the response time of 328.75ms. This accuracy is achieved by testing the system for 10 iterations. As autistic children hesitate to communicate freely with normal people, this human-robot interaction will improve their behavior and communication skills as well. This humanoid robot will improve the quality of living of the autistic or disabled people. This humanoid robot can be used in any public sector like school, colleges, an autism center, and industry.

Index Terms—Robotics, humanoid robot, human-robot interaction, autism spectrum disorder, AI

I. INTRODUCTION

Interaction and communication is the key fact of behavioral improvement for a child. When a normal child grows up, he learns it from his family and the people surrounding him. He gets familiar with the surroundings and learns to blend with them. This is how the child becomes social and grows up with a normal sense of humor. But, for a child with Autism Spectrum Disorder (ASD) [1] the scenario is far more different. The face problem in blending with others. They have several repeating behaviors. They like to stay away from others. They face problems in social interaction and unusual interest in objects. To help to recover their problems, our robot can attract their attention to having a humanoid structure and as well as make interaction with them to improve their behavior and social interaction.

In 2018, the Centers for Disease Control and Prevention determined that approximately one in fifty-nine children is affected by an ASD [1]. About 1 percent of the world population has autism spectrum disorder. (CDC, 2014). Studies

in Asia, Europe, and North America have identified individuals with ASD with an average prevalence of between 1% and 2%. 31% of children with ASD have an intellectual disability (intelligence quotient [IQ] 70), 25% are in the borderline range (IQ 71–85), and 44% have IQ scores in the average to the above-average range (i.e., IQ 85) [2] In the last decade, there have been a lot of studies on human-robot interaction for the behavioral improvement of autistic children. And the study indicates a significant positive sign. Autistic children can't behave normally with other people. Sometimes they behave in such a way that it is difficult for other people to understand. And that makes a communication gap between them and normal human beings. To overcome this problem, we have developed an Artificially Intelligent Robot that can company them talk to them via voice command and make physical communication by reacting to their actions. Our developed robot in more advanced in terms of accuracy and response time compared to the existing robots. Our robot will help to develop the behavior of autistic children who hesitate or feel shy about talking to others.

These are the objectives of our research for the behavioral improvement of autistic children based on human-robot interaction.

- To develop an Artificially Intelligent Robot that can make physical interaction with autistic children and talk to them via voice commands.
- To assist Autism children in improving their behavior and communication skills.
- Improve accuracy concerning accuracy and response time compared to the existing systems.
- Reduce the cost of developing such a humanoid robot.

Our proposed solution is an Artificially Intelligent Humanoid Robot that is capable of interacting with the Autistic children. The interaction includes physical and voice interaction as well as an AI algorithm to detect the person and move its head towards the person. It can answer several questions it is asked with more accuracy in short response time. It is better than this type of existing robots.

We have developed a humanoid robot shown in Fig. 1 that uses Arduino as its processing system and a 3.5-feet-tall body to look like a human child. It can interact with the autistic children in two different methods. One is physical communication. It includes handshaking, salute, picking, dropping

something. 3 ultrasonic sensors are used for real-time tracking of the person. An Artificial Intelligence algorithm is used to make the robot artificially intelligent for being attractive to the person.

The second method is the voice-based method. AI algorithm and a speaker helps the robot to talk to the autistic children. It can perform every command it is given. The voice-based commands include a lot of common things like asking questions, telling the robot to do something like turning head, lifting hands, etc.

The whole system needs a lot of instruments to be built. We faced a lot of difficulties in building the system. Instruments used in the system are mostly manufactured by the cheap Chinese manufacturer. And that hampers the quality of the instruments. A lot of instruments got damaged during the building and testing process. This caused us to increase our budget for building the system. We estimated about fifty thousand for the system but it took a little bit more to be completed.

As autistic children normally stay away from normal human beings, this AI Robot can probably the best option to communicate to them for improving their behavior. This humanoid robot looks attractive. So, probable this would be the best thing that a caustic child would adopt.

Paper Organization: The rest of the paper is organized as follows: Section II discusses some related works. Then Section III discusses our proposed system prototype. Finally, Section IV presents the evaluation of our developed model and followed by conclusion.

II. RELATED WORK

Shamsuddin *et al.* developed a Humanoid Robot[3]. The key finding of this study indicates that 4 out of 5 children showed a decrease in autistic activity (in communication subscale) when the robot performs HRI modules during the single child-robot interaction session. This encouraging result suggests that the NAO robot has been able to attract the attention of the children, keep each child engaged with the robot during interaction and thus have a positive effect on communication actions of the children.

Dickstein-Fischer *et al.* developed another humanoid robot[4]. Relating this to the children's FSIQ, it can be deduced that autistic children with FSIQ of moderately impaired are receptive to robot-based intervention.

Shamsuddin *et al.* developed another Humanoid Robot learning program for autism diagnosis communication-care[5]. This study indicates autistic children with moderately impaired intelligence show positive response to robot-based intervention.

Yang *et al.* had shown that robot interaction has no adverse effects and that the different interaction situations of the robot were correlated with less autistic behavior [6]. Extending this effect on school-going children needs experiences that are in line with the lessons of special education. The research seeks to suggest the incorporation of a robot into the existing

learning environment, specifically autism, for children with special needs.

Othman *et al.* have developed a way for the development of social skills[7]. Children with autism spectrum disorder (ASD) may lack communication and social skills, which are important for teamwork and quality of life with other people. Typically, autistic children have trouble perceiving and expressing social cues and emotions, a disorder that overshadows their lack of language skills, much further. Recent work has shown that robots can help improve autistic children's social skills, promoting imitation, contact, eye gaze, and communication with individuals. This paper aims at explaining the theoretical basis for how robots can be effective in developing children's social skills with Autism.

Yang *et al.* also discusses empirical literature, along with a special emphasis on social robots built specifically to develop children with autism's social skills [8].

Dautenhahn *et al.* developed a system for user recognition by camera[9]. The user identification for the intelligent service robot is suggested based on facial and speaker details gathered from the camera and microphone. They used the Fisher face method for face recognition for this purpose. In this setting, the choice of the Fisher face approach is inspired by its insensitivity to broad variance in the direction of light, face pose, and facial expression. Besides, they used the Gaussian Mixture Model (GMM) classifier which uses Mel-Frequency Cepstral Coefficients (MFCC) as a voice recognition feature vector.

Xue *et al.* used the weighted sum method respectively to fuse cosine similarity and log-likelihood generated from the classifier Fisher face and GMM [10]. The experimental results reveal that through the research robot platform named WEVER built-in ETRI, the presented fusion method showed a better performance than the Fisher face and GMM classifier itself.

Shieh *et al.* developed an interactive Nurse Robot[11]. What one should serve purposely. An interactive nurse robot that has operated successfully in-home environment is being developed. The mobile robot, powered by two motors/wheels, consists of image processing, speech recognition, semantic analysis, local/remote interaction, and autonomous mobile components to provide control, contact, accompanying, patrol and urgent warning functions for nursing.

Ban *et al.* proposed a robot which is intended to serve children and/or elders at home, and its appearance and behavior should be loveable and safe [12]. The experimental results show that the interactive nurse robot does accomplish the goals of attracting and caring for kids.

III. METHODOLOGY

We have developed a humanoid robot for the autistic children shown in Fig. 1. Our system works in two different methods. The first one is the ultrasonic based AI system that can track a person within 70 cm. The sensor receives the raw data and sends it to the Arduino for processing. Arduino processes data and sends a response signal to the

robot performing the actions. The second method is voice-based commands. The robot can perform almost every task it is given through voice commands with about 96% accuracy and in a slower response time. The voice commands are given remotely using Bluetooth technology.



Fig. 1: Image of the Humanoid Robot

A. System Design

The functional block represents the main building blocks of the system shown in Fig. 2. It shows how the sensors take data from the environment and how the data is processed and turned into action through physical interaction. The functional block of our humanoid robot is given below.

1) Functional Block Diagram of the System: In this functional block diagram of the system, the basic flow of the system is shown. How the system is connected via a microcontroller with other components and how it is receiving and sending data is demonstrated here in this diagram.

2) Flow Chart of the System: In our system, after switching on the robot it needs to be connected with the phone via the internet. The phone also connects with Microcontroller through Bluetooth. It receives data from both sensors and voice commands. After receiving data it decodes data for both voice

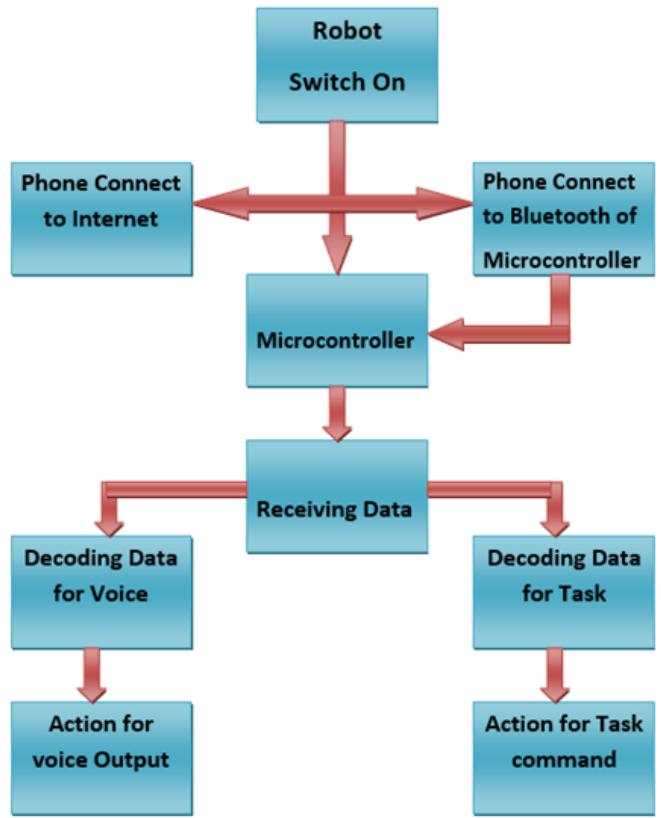


Fig. 2: Functional Block of the System

and task and takes action according to the data. Flow Chart of the System shown in Fig. 3.

B. Circuit and Connections

Circuit diagram of our system and Connections are shown in Fig. 4. All the hardware and equipment used in our system are shown in section III-C.

C. Hardware Specification

The whole system is based on an Adruino Microcontroller. We also used ultrasonic sensors for tracking the person. Our system works as an assistant for the autistic children. All the equipment are used are shown below :

- Arduino Mega 2560.
- Micro SD card module.
- HC-05 Bluetooth Module.
- Battery(2200mA).
- Bauck Module LM2596.
- Servo Motor (MG995) with Bracket.
- Ultrasonic Sensor HC-SR04.
- Micro SD Card(32 GB).
- Breadboard, etc.

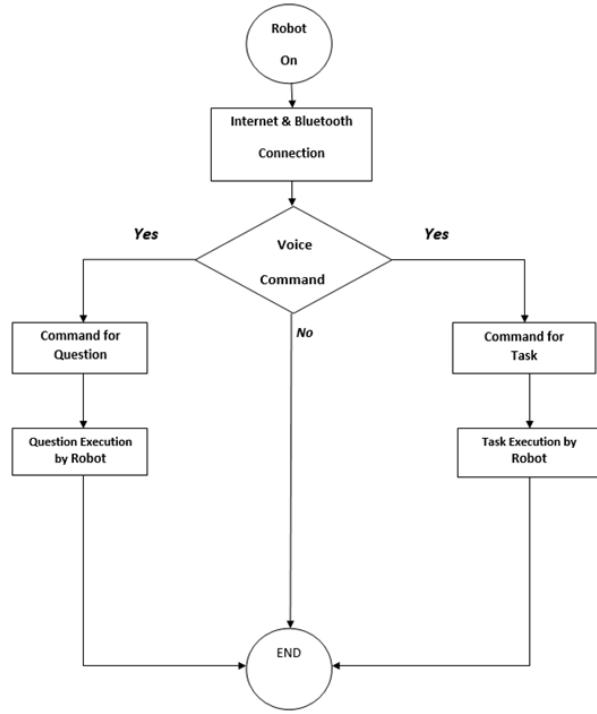


Fig. 3: Flow Chart of the System

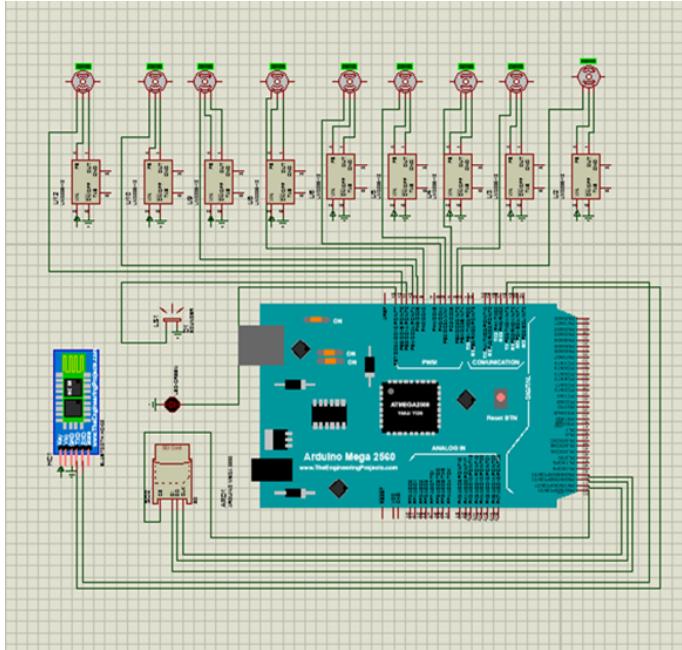


Fig. 4: Complete Circuit Diagram of the system

IV. RESULT ANALYSIS

A. Testing and Performance

After implementing the hardware and software we try our humanoid system in the real world. In this subsection, we are going to show the performance and the test results of our system.

B. Real world performance

Implementation is the level of a system where the phase-wise design is switched to an effective way. The implementation phase is the formation of a new system to install and manage it. There is the most ultimate level of a successful system that is working effectively and smoothly based on the system requirements. Several functionalities have to include while implementing and developing a unique system. It is vital to train the users after completing a system developing and testing process. During the training process, if it is hard to understand the system process by the end-user then have to provide some extra lectures, important documents, and related materials which might be easier for the user to realize the working procedure of the system. After finishing the elementary training, it is inevitable to be trained upon about problem solving, corresponding validation checking and so on.

TABLE I: Confusion Matrix for Different Movement

Serial No		TP	TN	FP	FN
1	Handshake	98	0	2	0
2	Salute	TN	97	0	2
3	OK	FP	100	0	0
4	Take/Cake	FN	95	0	4

TABLE II: Confusion Matrix for Different Movement Continued

Serial No		TP	TN	FP	FN
5	Left	TP	98	0	2
6	Right	TN	97	0	2
7	Up/App	FP	96	0	3
8	Down/Don	FN	97	0	2

TABLE III: Confusion Matrix for Different Voice Action

Serial No		TP	TN	FP	FN
1	Hello	TP	99	0	1
2	Name	TN	99	0	1
3	PM	FP	97	0	2
4	Supervisor	FN	97	0	2

From TABLE I,II and III, we found a number of movements for each action and a number of no-action for each movement. The Robot was performing each action according to instruction but in few cases, it was idle and did no-action. Based on the performing action, the five performance parameters are being calculated. The five performance parameters are accuracy, precision, recall, F-measure and response time which are calculated using Eq.1, Eq.2, Eq.3, Eq.4, and Eq.5.

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \times 100\% \quad (1)$$

$$\text{Precision} = \frac{TP}{TP + FP} \quad (2)$$

$$Recall = \frac{TP}{TP + FN} \quad (3)$$

$$F - Measure = 2 * \frac{Precision \times Recall}{Precision + Recall} \quad (4)$$

$$ResponseTime = T1 + T2 \quad (5)$$

Where TP represents True Positive and is the Correctly Recognized number of values, TN represents the True Negative and is the total number of no-movement. The FP and FN represent the False Positive and False Negative, which is zero in this case. The Accuracy, Precision, Recall and F-Measure are calculated from confusion matrices as shown on TABLE I,II and III.

For response time, we have considered the total time ($T1 + T2$) that the robot takes after the voice command is received (receiving time $T1$) and starts the specific movement (executing time $T2$). The response time matters when it comes to developing a system that was previously built partially or there exists some related systems. The TABLE IV below demonstrates the Accuracy, Precision, Recall, and F-Measure of the different movements.

TABLE IV: System Accuracy, Precision, Recall and F-Measure for Different Movement.

	Accuracy (%)	Precision (%)	Recall (%)	F-Measure (%)	Response Time (ms)
Handshake	98	98	100	98.98	300
Salute	97	97.97	98.97	98.46	350
Ok	100	100	100	100	300
Take/Cake	95	95.95	98.95	97.42	350
Average	97.5	97.98	99.48	98.72	325

1) *Discussion on Movements.*: The above TABLE IV demonstrates the accuracy, precision, recall, f-measure, and response time for different movements of the Robot. The calculation is based on the equations provided above. The table shows that our system is capable of being successful full with a high average accuracy rate of about 97.5% and an average response time of 325ms for the movement. We hope our developed system will be of great help with this high accuracy rate and lower response time to the autistic children. Some image of movements of our humanoid robot are shown in Fig. 5 and Fig. 6. Where Fig. 5 shows movement for left and consecutively right, up and down. And Fig. 6 shows movement for Hankshake and consecutively Salute, Ok and Take.

TABLE V: System Accuracy, Precision, Recall and F-Measure for Different Voice Action.

	Accuracy (%)	Precision (%)	Recall (%)	F-Measure (%)	Response Time (ms)
Hello	99	99	100	99.48	350
Name	99	99	100	99.48	330
PM	97	97.97	98.97	98.46	300
Supervisor	97	97.97	98.97	98.46	350
Average	98	98.49	99.49	98.97	332.5

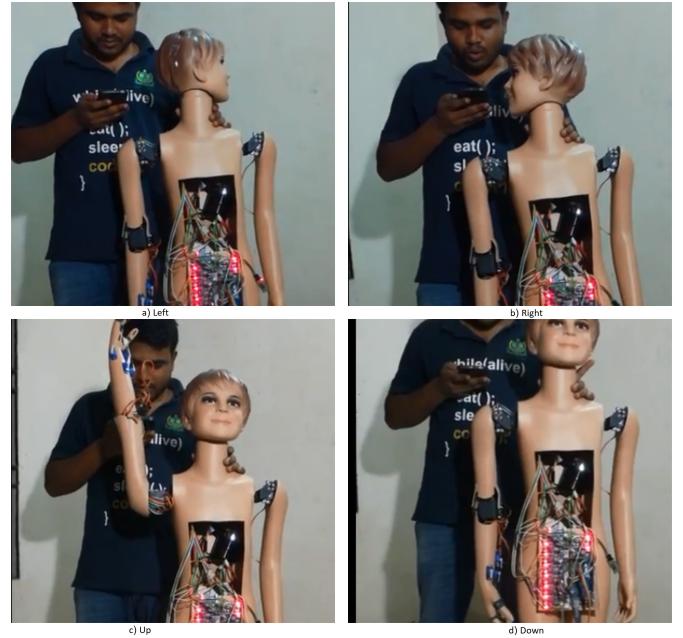


Fig. 5: Image of different movements of Humanoid Robot(Left, Right, Up and Down)

2) *Discussion on Voice Actions*: The TABLE V shows the accuracy, precision, recall, f-measure, and response time for different voice actors. The system was performing well with an average accuracy of 98% and an average response time of about 332.5ms. We tested the system for 100 iterations and the feedback was amazing. We hope this robot would be of great help to the autistic children.

C. Comparison

Below is the comparison table of the developed system and the existing system that has some similar functionality.

TABLE VI: Comparison analysis concerning the average accuracy and response times of our proposed system with other related systems

	No of Action	Accuracy(%)	Response Time(ms)
Proposed	20	97.75	328.75
NAO[3]	18	96	400
KASPAR[5]	15	96	450
PROBO[11]	12	96	500

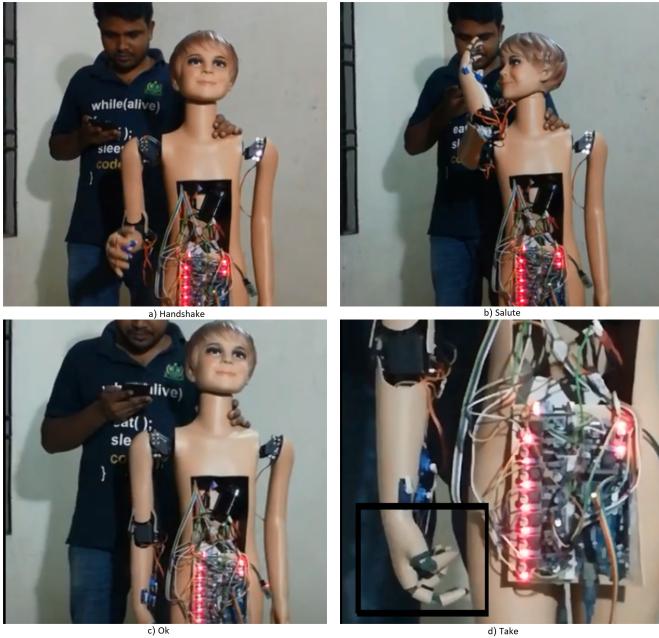


Fig. 6: Image of different movements of Humanoid Robot(Hankshake, Salute, Ok and Take)

Our developed system is better in terms of accuracy and response time than those systems in the comparison TABLE VI. The existing NAO has only 18 actions with no physical movement. It has an average accuracy of 96% with a response time of 400ms average for each action.

Compared to the NAO, our system is performing with 97.75% average accuracy with a response time of only 328.75ms which have been calculated by averaging the average accuracy and response times from TABLE IV and TABLE V. Similarly for KASPAR and PROBO showed in TABLE VI.

V. CONCLUSION

Autism is a lifelong experience that needs different methods of intervention in the educational and therapeutic context. This research sets out a first phase in how humanoid robots will play a part in the special schools.

In order to help the autistic children and change their behavior, we have created an automated, intelligent robot that can respond to their movement via an ultrasonic sensor and can communicate to them via voice commands. Kids with ASD will use this robot to improve both their actions and communication skills.

We have developed a system prototype that can perform our mentioned operation. But in our system, it can perform these operations with its right hand only. It is because we only implement it for the right hand. So we can say it is not any technical error. We will try to make our system more advanced in future research using this system prototype.

The research would be applicable to assist Autism children to improve their interactions. The research may be applicable in any other public area such as industries, schools, colleges or

institutions, etc. to assist disabled people. As this humanoid robot is better in terms of accuracy and response time this system can save money and provide more flexibility.

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REFERENCES

- 1 N. inform, "Autistic spectrum disorder (asd)," <https://www.nhsinform.scot/illnesses-and-conditions/brain-nerves-and-spinal-cord/autistic-spectrum-disorder-asd>, 2019, accessed on 10/20/2019.
- 2 A. Speaks, "Autism statistics and facts," <https://www.autismspeaks.org/autism-facts-and-figures>, 2019, online;Accessed on 10/20/2019.
- 3 S. Shamsuddin, H. Yussof, L. I. Ismail, S. Mohamed, F. A. Hanapiah, and N. I. Zahari, "Humanoid robot nao interacting with autistic children of moderately impaired intelligence to augment communication skills," *Procedia Engineering*, vol. 41, pp. 1533–1538, 2012.
- 4 L. Dickstein-Fischer, E. Alexander, X. Yan, H. Su, K. Harrington, and G. S. Fischer, "An affordable compact humanoid robot for autism spectrum disorder interventions in children," in *2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. IEEE, 2011, pp. 5319–5322.
- 5 S. Shamsuddin, H. Yussof, F. A. Hanapiah, S. Mohamed, N. F. F. Jamil, and F. W. Yunus, "Robot-assisted learning for communication-care in autism intervention," in *2015 IEEE International Conference on Rehabilitation Robotics (ICORR)*. IEEE, 2015, pp. 822–827.
- 6 X. Yang, M.-L. Shyu, H.-Q. Yu, S.-M. Sun, N.-S. Yin, and W. Chen, "Integrating image and textual information in human-robot interactions for children with autism spectrum disorder," *IEEE Transactions on Multimedia*, vol. 21, no. 3, pp. 746–759, 2018.
- 7 A. Othman and M. Mohsin, "How could robots improve social skills in children with autism?" in *2017 6th International Conference on Information and Communication Technology and Accessibility (ICTA)*. IEEE, 2017, pp. 1–5.
- 8 J.-Y. Yang and D.-S. Kwon, "The effect of multiple robot interaction on human-robot interaction," in *2012 9th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI)*. IEEE, 2012, pp. 30–33.
- 9 K. Dautenhahn, "Methodology & themes of human-robot interaction: A growing research field," *International Journal of Advanced Robotic Systems*, vol. 4, no. 1, p. 15, 2007.
- 10 Z. Xue, S. Ruehl, A. Hermann, T. Kerscher, and R. Dillmann, "An autonomous ice-cream serving robot," in *2011 IEEE International Conference on Robotics and Automation*. IEEE, 2011, pp. 3451–3452.
- 11 M.-Y. Shieh, C.-M. Lu, C.-C. Chen, C.-Y. Chuang, and Y.-S. Lai, "Design and implementation of an interactive nurse robot," in *SICE Annual Conference 2007*. IEEE, 2007, pp. 2121–2125.
- 12 K.-D. Ban, K.-C. Kwak, H.-S. Yoon, and Y.-K. Chung, "Fusion technique for user identification using camera and microphone in the intelligent service robots," in *2007 IEEE International Symposium on Consumer Electronics*. IEEE, 2007, pp. 1–6.