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A ROBOT FOR CHILDREN ON THE AUTISTIC SPECTRUM

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Abstract

The purpose of this study is to design and develop a robot that supports the development of social, emotional, and communication skills in children with Autism-Spectrum Disorder (ASD). The integration of robotics in autism therapy has shown significant promise in enhancing social, communicative, and cognitive skills in children with ASD. Developing a robot for autism therapy involves a structured design-based research (DBR) process to ensure the robot effectively meets the needs of children with autism. Social robots are designed to interact with children in a way that is engaging and supportive, helping to improve skills such as eye contact, emotional recognition, and joint attention. These robots utilize advanced AI and machine learning algorithms to adapt to the individual needs of each child, providing personalized therapeutic interventions. Studies have demonstrated that robots can effectively reduce social anxiety and improve social interactions among children with ASD, making therapy sessions more enjoyable and effective. Moreover, robots offer a consistent and repeatable means of delivering therapy, which can be beneficial in standardizing treatment protocols. The use of robotics also allows for the collection of precise data on the child's responses and progress, facilitating more accurate assessments and adjustments to therapy plans. As research continues to evolve, the potential for robots to become a standard tool in autism therapy becomes increasingly feasible, offering a promising adjunct to traditional therapeutic methods.

Keywords: Autism, Autistic spectrum, Robot, Social interaction, Therapy.

1. Introduction

Robot is one of the applied technology for supporting human needs and human being [1-5]. Recently, robot is increasingly being integrated into autism therapy, offering innovative ways to support social and communication skill development in children with Autism-Spectrum Disorder (ASD). ASD needs special treatment, in which the robot can support [6-8]. These robotic systems provide structured and predictable interactions, which are beneficial for children who often struggle with the variability of human interactions [9]. One prominent example is the NAO robot, which is utilized to help children recognize and respond to emotions. NAO uses consistent facial expressions, voice modulation, and body movements to teach emotional recognition and social cues. Studies involving NAO have shown that children engage more readily with the robot, seeing it not just as a toy but as a social partner, which aids in developing social skills [10-12].

Additionally, the RoboCA3T system integrates robot avatars with computer-assisted therapies to improve joint attention and imitation skills. These are crucial areas for social interaction, and the system's use of personalized content and AI-based automatic gaze and pose detection algorithms have demonstrated significant improvements in these skills among children with autism. Other robots, like Milo, have been used in educational settings to help children with autism improve their communication abilities. Milo's slower speech pace and human-like expressions provide a model for children to mimic, leading to better social engagement and self-regulation [13-17].

Kiwi, a socially assistive robot, has also been employed in studies to engage children with autism through interactive games that adapt to their engagement levels. This personalized approach not only enhances social skills but also academic performance, illustrating the broad potential of robotic interventions. In summary, robots in autism therapy offer a promising complement to traditional methods, providing structured, engaging, and personalized interactions that can significantly enhance social and communication skills in children with autism [18-20]. However, no robot has been developed in Indonesia to help children with autism which focuses on facilitating communication and social interaction. The purpose of this study is to design and develop a robot that supports the development of social, emotional, and communication skills in children with Autism-Spectrum Disorder (ASD). The novelty of this research is making robot for child on autism, focusing for interaction, emotion, and communication.

2. Literature Review

2.1. Robot Control

In making robot controls with an accelerometer and keypad on a smartphone, blocks are used in the diagram as in Fig. 1.

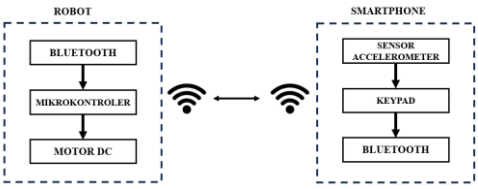

Fig. 1. Robot control block diagram.

The first process from the smartphone side is connecting Bluetooth with a microcontroller, thus communication between devices is connected. Then after connecting, and selecting the control mode used, the smartphone starts sending data to the microcontroller for processing, it can be seen that the robot is moving forward, backward, turning right, turning left, tilting right, tilting left, and stopping. Once this is known, the microcontroller starts sending commands to the DC motor to move the robot according to data from the accelerometer sensor on the smartphone.

2.2. HC-05 Bluetooth module interface circuit with microcontroller

The HC-05 Bluetooth module interface circuit with the Arduino Uno microcontroller is shown in Fig. 2.

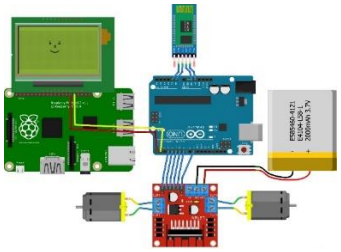

Fig. 2. Bluetooth module interface circuit with microcontroller.

Arduino Uno communicates with Bluetooth HC-05 by serial communication to retrieve data that has been sent by the Smartphone. Then the serial data is processed by Arduino, where later the data is used to control/drive the DC motor via the L298N motor driver module. The Raspberry Pi communicates with the Arduino Uno by serial communication to retrieve data that has been sent by the Smartphone. Then the serial data is processed by the Raspberry Pi where later the data is used to display images and sound according to the serial data taken from the Arduino Uno.

2.3. Software Design

To make it clearer, you can see the overall flowchart of the robot work with a smartphone in Fig. 3.

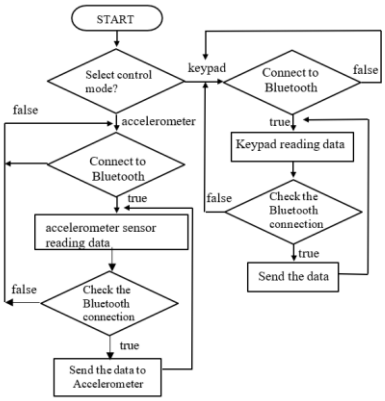

Fig. 3. Flowchart of the robot work with a smartphone.

In making the program, first, create an omni-robot control workflow with an accelerometer and keypad on the smartphone so that it can run as expected or according to sequential logic from start to finish and reduce errors in making the program later, starting from the program on the smartphone as a controller then program on Arduino as a command receiver.

3. Method

Developing a robot for autism therapy involves a structured design-based research (DBR) process to ensure the robot effectively meets the needs of children with autism. Here's a detailed DBR method for creating such a robot. Understand the specific needs and challenges faced by children with autism to inform the robot's design and functionality. Conduct a comprehensive review of existing research on autism and current therapeutic methods. Key areas include social skills development, communication challenges, and sensory sensitivities. Engage with therapists, educators, parents, and children to gather firsthand insights and identify specific therapeutic goals that the robot should address. Analyse successful case studies of existing robots used in autism therapy to determine effective features and identify gaps that new designs can fill.

4. Results and Discussion

Creating a robot specifically designed for autism therapy involves several critical steps, from understanding the unique needs of children with autism to integrating advanced technologies that facilitate effective interactions. Here's a detailed guide on how to build such a robot. Figure 4 explains the steps of making a Hello Bot.

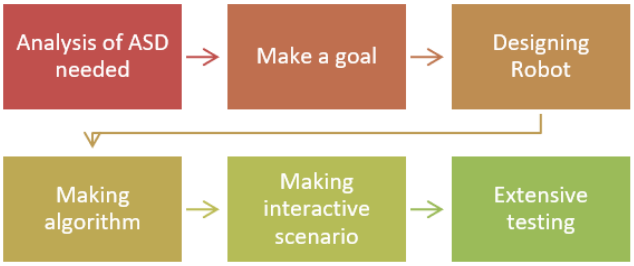

Fig. 4. Step of making Hello Bot.

Before starting the design process, it is essential to have a deep understanding of ASD and the challenges faced by individuals with this condition. ASD affects communication, social interactions, and behaviour, often making it difficult for individuals to recognize emotions and engage in typical social activities. Research indicates that structured, predictable interactions are beneficial for children with autism. The primary goal of the robot should be to support the development of social, emotional, and communication skills. It should be capable of displaying emotions, recognizing user responses, and providing appropriate feedback. Establishing these objectives helps guide the design and functionality requirements. The robot's appearance should be friendly and non-threatening to encourage interaction, with a design that includes a digital screen or expressive face and a body capable of simple gestures.

Incorporate emotion recognition and expression capabilities using advanced sensors and algorithms, allowing the robot to display different emotions through facial expressions, body language, and voice modulation. Program the robot with interactive scenarios and games to teach social and communication skills, adapting the difficulty level based on the child's performance and engagement. Use deep learning to personalize interactions, tailoring them to each child's needs by collecting data on their responses and engagement levels. Safety is paramount, so the robot should be designed without sharp edges or small parts and be easy to use and understand. The advantages of the features of Hello Bot for autism are shown in Table 1. Finally, this study can bring new ideas for supporting research in the special need education.

Table 1. Advantages features of Hello Bot.

Advantages	**Information**
Non-verbal cues and Gestures	Touch and Movement: A lot of social robots have touch sensors built in, so they react to physical cues like pats, embraces, and button presses. To teach appropriate physical contact skills, robots such as NAO can respond to touch by playing pre-recorded messages or doing certain actions. [21]. Look, expressions on the face, Children are frequently engaged by robots through eye contact and facial movements. Children's comprehension of emotions and the development of cooperative attention depend heavily on these nonverbal clues. [22].
Verbal communication	Speech Recognition, Proficient robots recognize and react to basic spoken orders or inquiries from kids through speech recognition technology. Children can practice speaking and communicating in a safe setting with the assistance of this interaction. [23]. Pre-Recorded Messages, Robots can deliver pre-recorded messages or prompts, which can be useful for initiating conversations or guiding activities. This method provides a predictable and structured way for children to practice verbal communication [24].
Visual and Auditory Feedback	Screen Displays, some robots incorporate screen displays that show images, videos, or text to complement verbal instructions. This multi-modal approach can aid in the comprehension and retention of information [25]. Sound and Music, Robots may use sound effects or music to maintain engagement and provide auditory feedback during interactions. This can be particularly effective for children who respond well to auditory stimuli [26].
Interaction	Role-Playing and Storytelling, Robots often engage children in role-playing games or storytelling activities, which can improve social skills and creativity [27, 28]. Educational Games and Activities, Educational robots can conduct learning activities that teach academic skills like counting, reading, and problem-solving [29]. Emotion Recognition and Expression. For instance, they might display different facial expressions and ask the child to identify the emotion or encourage the child to express how they feel using visual aids [30, 31]. The structured and predictable nature of robot interactions provides a comfortable learning environment for children with autism. Studies have shown that these interactions can lead to improvements in social engagement, communication skills, and emotional understanding [32].

Interactive robots are effective for use in developing social communication skills in children on the autism spectrum. Extensive testing with the target demographic is essential, involving pilot studies with children diagnosed with autism to gather feedback and refine the robot's design and functionalities to ensure it meets therapeutic goals effectively. Robot trials were carried out for 2 months, on 10 autistic children aged 3-7 years, involving 10 teachers.

5. Conclusion

Children with autism spectrum disorder (ASD) may benefit greatly from the social, linguistic, and cognitive skills that robotics integration in autism therapy has demonstrated to hold. Social robots are made to engage and support kids in their interactions, which helps them develop important life skills including joint attention, emotional detection, and eye contact. By using cutting-edge AI and machine learning algorithms, these robots can customize therapy approaches to meet each child's unique needs. Research has indicated that the use of robots in treatment sessions can effectively lower social anxiety and enhance social interactions in children diagnosed with ASD, resulting in more pleasurable and productive sessions. Additionally, robots provide a reliable and reproducible therapeutic delivery method, which is advantageous for standardizing treatment regimens.

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