Recognizing Anxiety in Autism Children through Blood Pressure Monitoring with a Socially Assistive Robot

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Abstract. Socially Assistive Robot (SAR) is used to detect anxiety levels in children with Autism Spectrum Disorder (ASD), a condition that is often accompanied by difficulties in recognising and expressing emotions, including anxiety. The importance of anxiety detection lies in its impact on the behaviour and social interactions of these children. This study prioritises blood pressure monitoring as an indicator to detect anxiety, using a digital tensimeter (MPS20N0040D sensor) integrated in the SAR. Children with ASD, both those with Asperger Syndrome and Classical Autism, interacted with the SAR equipped with a tensimeter. The findings showed that the SAR was able to accurately measure blood pressure and provide an effective indication of anxiety levels, given the strong correlation between blood pressure and anxiety. These results demonstrate the potential of the SAR as a reliable anxiety monitoring tool in children with ASD and a blood pressure detection solution in addition to that performed by medical personnel. The implementation of this SAR technology can be applied to each school or special home for Autism Spectrum Disorder (ASD) children by having this robot, making it easier for caregivers or teachers of autism children, they do not need to go to the health center or hospital to find out the child's health condition. In addition, this SAR technology can be implemented in each health center or hospital, which is useful when there are patients who have special needs such as children with autism.

Keywords: Socially Assistive Robot (SAR), Autism Spectrum Disorder (ASD), Anxiety, Digital Tensimeter.

1 Preliminary

Autism Spectrum Disorder (ASD) is a complex developmental disorder that affects the functioning of the brain and nervous system, and has a significant impact on an individual's behaviour and thinking. The disorder generally appears in childhood and lasts throughout life, changing the way an individual communicates, socialises, acts and interacts with others. Individuals with ASD often have different abilities than most people and appear to live in a world of their own.[1] The National Autistic Society notes that many children with ASD experience anxiety, which if left untreated, can develop into destructive behaviour, self-harm, or even depression. [2]

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One approach to detecting anxiety in children with Autism Spectrum Disorder (ASD) who may not show direct signs of anxiety is through blood pressure monitoring. Children with ASD often do not express anxiety or stress in easily recognisable ways, so blood pressure measurement can be an important indicator in determining their anxiety levels. According to the American Heart Association's PALS Guidelines, normal blood pressure ranges for school-aged children are 97-115 mmHg for systolic pressure and 57-76 mmHg for diastolic pressure. [3]-[4]

A Socially Assistive Robot (SAR) is a robot designed to provide support in specific situations by using interaction strategies, such as verbal communication and gestures. SARs are particularly effective in helping to reduce anxiety in children. SARs act as a substitute for human tasks with the function of comforting and promoting health, especially emotional health, in children with Autism Spectrum Disorder (ASD). Children with ASD often experience fluctuations in anxiety and high levels of fear, which can cause them to feel uncomfortable, become aggressive, self-injure, or have tantrums for no apparent reason. [5]-[6]

The urgency of this research arises as a form of social care and support for Autism Spectrum Disorder children who are sheltered at the Gentaralam SLB Autism foundation, where the researchers have designed a Socially Assistive Robot (SAR) which will assist in detecting blood pressure in Autism Spectrum Disorder children. This Socially Assistive Robot (SAR) will help identify the level of anxiety in children, according to the results of blood pressure that comes out later, where this robot will later perform hand movements which will then be directed to the child for measurement with the help of other people to make it easier. This study is indeed only focused on measuring blood pressure measured in children, that blood pressure is one of the significant (main) factors, but actually to determine the level of anxiety in children there are physiological factors that must also be considered, namely other indicators such as Body Temperature and Heart Rate.

2 Overview

Volunteer Robot Technology is a form of robotic technology that is capable of interacting through voice and movement, allowing for a more natural interaction with the user. This technology is one of the three categories of robots that are widely used in the healthcare field. In general, nursing robots can be grouped into three main categories, namely Assistive Robotic (AR), Socially Interactive Robot (SIR), and Socially Assistive Robot (SAR). [7]

Each of these categories has a different role in supporting healthcare. This research specifically focuses on one of these types of robots, the Socially Assistive Robot (SAR), which is designed to provide interactive support to patients without direct physical contact, especially in helping children with special conditions such as autism. SARs have an important role in providing assistance that can improve the social wellbeing and overall health of patients through social interaction and monitoring of vital conditions.

This Socially Assistive Robot (SAR) operates based on a system workflow consisting of three main components: input, process, and output, which are described

through a Block Diagram. This Block Diagram effectively shows how the system starts with data collection from a digital tensimeter (MPS20N0040D sensor), which is then processed by the controller. Once the data has been processed, the system produces an output, either a response or an action, derived directly from the information that has been processed. By providing a clear and detailed description of these stages, the diagram is very helpful in understanding the flow of data through the system and explaining the interaction between each component to achieve the end result.

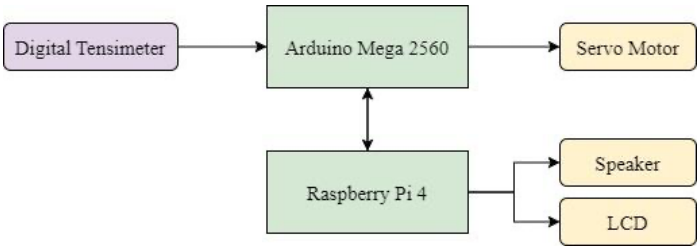

Fig. 1. Hardware Block Diagram of SAR Robot

Figure 1 outlines how the Socially Assistive Robot (SAR) system works in detect-ing blood pressure in a child with Autism Spectrum Disorder (ASD). The system starts with an input in the form of a sensor that detects blood pressure (using an MPS20N0040D sensor integrated in a digital tensimeter). This sensor is the main component in detect-ing physi-cal changes associated with anxiety.

The process in this system involves two controls, namely Arduino Mega and Raspberry Pi, which function as the control centre to execute commands received from the input. After the data is processed, the system produces outputs in the form of Socially Assistive Robot (SAR) hand and head movements through servo motors, as well as real-time data transmission that will display the results of detections through sensors on ASD children on the LCD screen. In addition, the system is also equipped with a speaker that provides sound as an indicator when before and after blood pressure is measured in ASD children.

In this system, the tensimeter uses an MPS20N0040D-S sensor that operates with a 5 Vdc supply, has a pressure range of 40 kpa, and a bridge resistance between 4-6 KΩ.[8] This sensor is connected to an Arduino Mega 2560 board, which is equipped with an ATmega2560 microcontroller (16 MHz), 54 digital I/O pins, 16 analogue inputs, 4 UARTs, as well as a USB connection, power jack, ICSP header, and reset button.[9] In addition, this system also uses a Raspberry Pi 4 which has a 64-bit ARM-Cortex A72 quad-core processor with a speed of 1.5GHz and LPDDR4 RAM options of 2/4 GB to support various computing functions. [10] In the actuator section, the servo motor is controlled by an Arduino Mega 2560 with an operating voltage of 4.8-8.4 V and a running current between 140-200 mA.[11] The system is also equipped with a USB speaker capable of converting electrical signals into audio with a frequency range of 20Hz to 20,000Hz [12], as well as a 7-inch LCD display connected to the Raspberry Pi via a ribbon cable to the DSI port, sharing 2 A of power between the two units. [13]

3 Methodology

3.1 System Design

The design of the SAR robot in this study utilises cutting-edge technology applied at every stage. The system's workflow illustrates how the robot automatically interacts with children, from activating the device to taking high-precision blood pressure measurements, to respond directly to the child's health condition. This approach ensures that the robot can take appropriate and safe actions, making it a highly effective tool for monitoring the blood pressure of children with autism

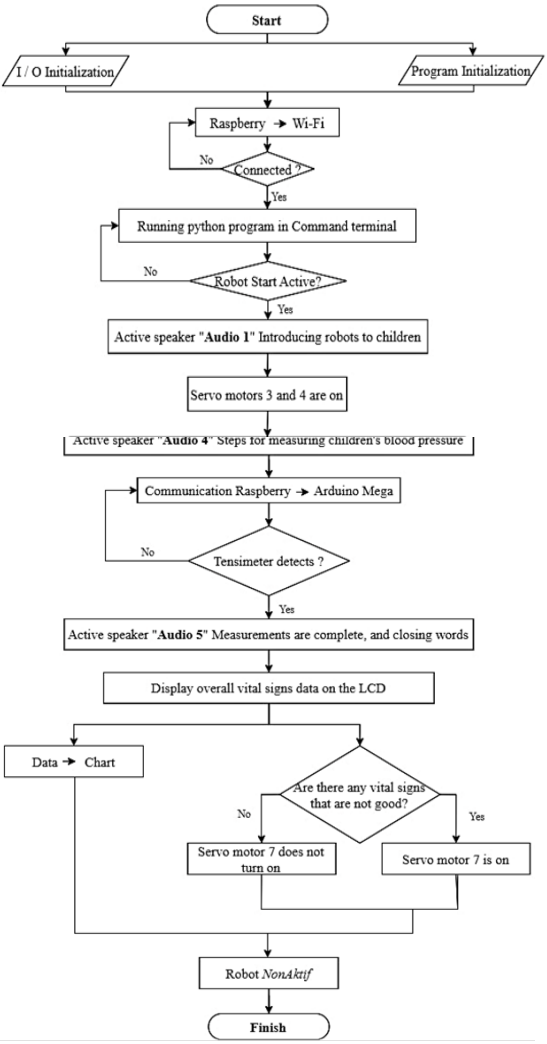

Fig. 2. Design Flowchart System SAR Robot

In the flowchat image above, it only focuses on measuring blood pressure, but this SAR system can also be implemented to add new parameters to measure vital signs other than blood pressure, namely body temperature and heart rate, this can be done by connecting additional sensors to the system, so that later it can improve SAR technology further to be applied more widely in the world of health, especially blood pressure, body temperature, and heart rate.

3.2 Testing and Analyzing

System testing is the process of executing a software system to determine whether the system conforms to predefined specifications and functions as expected. In this research, the testing system used involves programmes written in Python and C++, which have been designed on each component of the control system.

Through the proper programming process, the system is expected to run smoothly and produce accurate data, namely blood pressure, both for systolic and diastolic pressure.

The test results for the Socially Assistive Robot (SAR) research are summarized and detailed in the table below, providing an overview of the robot's performance and effectiveness during the study.

Table 1. Blood Pressure Measurement in Children with Autism Spectrum Disorders.

Classification of Autistic children	Systolic	Diastolic
Asperger Syndrome 1	97.5 mmHg	62.5 mmHg
Asperger Syndrome 2	104.2 mmHg	71.2 mmHg
Classical Autism 1	158.2 mmHg	89.1 mmHg
Classical Autism 2	157.2 mmHg	123.2 mmHg
Classical Autism 3	139.1 mmHg	93.1 mmHg

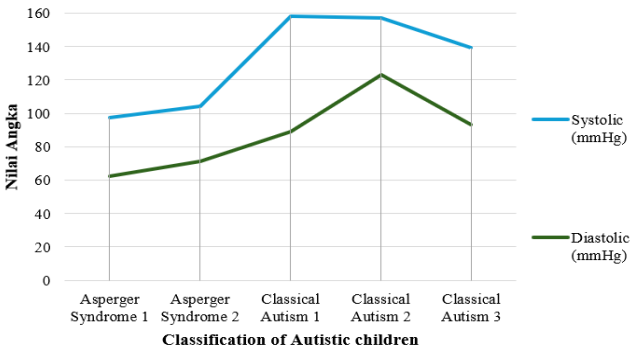

Fig. 3. Graph Blood Pressure Measurement in Children with Autism Spectrum Disorders.

The blood pressure measurements in this study were compared with reference data from the World Health Organisation, specifically the American Heart Association PALS guidelines [3], to identify differences in blood pressure between children with autism at various levels of severity and children without autism.

This comparison aims to see the differences in blood pressure conditions between the two ASD groups.

Table 2. Comparison of Blood Pressure in Asperger Syndrome ASD Children.

Blood Pressure	**Data Source**	
	This Study (N ; Mean ± SD)	WHO (PALS Guidelines)
Systolic (mmHg)	2 ; 100.85 ± 3.25	97 – 115 mmHg
Diastolic (mmHg)	2 ; 66.85 ± 4.35	57 – 76 mmHg

Table 3. Comparison of Blood Pressure in Classical Autism ASD Children.

Blood Pressure	**Data Source**	
	This Study (N ; Mean ± SD)	WHO (PALS Guidelines)
Systolic (mmHg)	3 ; 151.5 ± 8.78	97 – 115 mmHg
Diastolic (mmHg)	3 ; 101.8 ± 15.22	57 – 76 mmHg

Description: N : Number of children by autism classification, Mean : The average value of each child in the same autism classification group, SD (Standard Deviation) : The degree of dispersion of the data from the mean value.

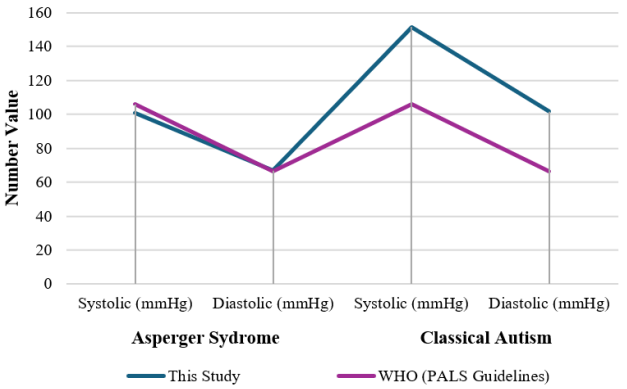

Fig. 4. Comparison of Blood Pressure in Asperger Syndrome and Classical ASD Children.

Analysis of Results From the two tables above, it can be seen that the blood pressure (systolic and diastolic) of children with autism shows different effects, when compared

between their autism classification and the blood pressure of normal children aged 9-10 years. Children with Asperger's syndrome have blood pressure that is still within normal limits, while children with Classical's autism tend to show higher blood pressure than normal children in that age range.

From the results obtained through testing and analysis, the effect of blood pressure is very significant, greatly affecting anxiety based on the level of Autism in the child, where this study focuses on two levels, namely mild Asperger and severe Classic. This is able to support a tool with more complex parameters, one of which is the E4 Bracelet which is a study to detect anxiety in children with autism as well. The E4 Bracelet is a research tool that can be used, providing real-time physiological data as well as analysis and visualization software. The E4 Bracelet has been used in several studies to measure anxiety and stress in special populations such as ASD and has been shown to be reliable and valid in several studies on IBI and HR averages (Pfeiffer et al, 2019; Airij et al, 2020; Benedicto et al, 2022;). However, the study showed that the E4 Bracelet was unable to provide very accurate data even though the sample involved 30 children, considering that the parameters of the device only consisted of body temperature and heart rate. [14]

When compared to this study, the parameters used were only blood pressure and the results showed a very clear difference in anxiety in each autistic child, namely the blood pressure of children with classic severe autism was very high compared to the blood pressure of children with mild Asperger's autism, this shows that if the vital signs parameters are combined, it is very likely that the device will be more accurate in determining anxiety in autistic children, so in short, the vital signs parameter that greatly influences is blood pressure, with this blood pressure detection being able to significantly advance the field of anxiety monitoring in children with ASD.

4 Conclusions

Socially Assistive Robot (SAR) that has been well designed and integrated using various components as well as programming, is able to detect blood pressure in children with Autism Spectrum Disorder (ASD). The results show that children with Classic Autism classification tend to experience higher levels of anxiety compared to children with Asperger's Syndrome classification, which is reflected in their higher blood pressure. Guided by the American Heart Association's PALS Guidelines, it can be concluded that there is a significant relationship between blood pressure and autism severity, with children with more severe autism showing higher blood pressure.

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