

Anxiety Detection for Autism Children through Vital Signs Monitoring using a Socially Assistive Robot

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ABSTRACT

Socially Assistive Robot (SAR) to detect anxiety levels in children with Autism Spectrum Disorder (ASD), a condition often accompanied by difficulties in recognising and expressing emotions, including anxiety. Early recognition of anxiety in children with Autism Spectrum Disorder (ASD) is crucial as it can affect their behaviour and social interactions. This SAR monitors vital signs namely blood pressure, heart rate and body temperature. This study involved children with Autism Spectrum Disorder (ASD) with two conditions, namely Asperger Syndrome and Classical Autism who interacted with a Socially Assistive Robot (SAR) equipped with a tensimeter (MPS20N0040D sensor) for blood pressure, MAX30100 sensor for heart rate, and MLX90614 sensor to measure body temperature. Results show that the Socially Assistive Robot (SAR) is able to measure vital signs with high accuracy and provide an indication of anxiety levels effectively, as vital signs correlate with anxiety levels. These findings demonstrate the potential of the Socially Assistive Robot (SAR) as a reliable tool in anxiety monitoring in children with ASD, with important implications for the development of future therapeutic interventions.

Keywords: Socially Assistive Robot (SAR), Autism Spectrum Disorder (ASD), Anxiety, MLX90614, MAX30100, Tensimeter (MPS20N0040D).

1. INTRODUCTION

According to the Director General of Public Health, 1% of the world's 160 children have Autism Spectrum Disorder (ASD). The number of ASD cases in Indonesia is estimated to increase every year. A total of 5,530 cases of Autism Spectrum Disorder (ASD) were reported during the period 2020-2021, including children who received treatment at Puskesmas. [1]

Autism Spectrum Disorder (ASD) is a serious and complex developmental disorder of brain and neural function that affects human behaviour and thought processes. The disorder usually begins in childhood and lasts a lifetime, and affects the way a person communicates, socialises, behaves and interacts with others. People with ASD usually have different abilities than most people, they often seem to be in a world of their own.[2] Many children on the autism spectrum (ASD) experience anxiety, which if it persists can lead to meltdowns, self-harm and even depression, according to the National Autistic Society. [3]

One way to prevent children with Autism Spectrum Disorder (ASD) who experience anxiety but do not show it is to detect anxiety. This is because children with ASD sometimes do not show immediate anxiety or stress. Vital signs, such as blood pressure, heart rate and body temperature can help determine the level of anxiety in a child. Normal vital signs in school-aged children based on the American Heart Association's PALS Guidelines: blood pressure (97-115 mmHg systolic) and blood pressure (57-76 mmHg diastolic), heart rate (75-118 bpm), and body temperature (35.5-38 °C). [4]-[5]

Socially Assistive Robot (SAR) is a robot that has a system that can provide assistance in certain contexts using interaction strategies, such as communicative speech and gestures. Therefore, SAR is very helpful in reducing anxiety in children.[6] Socially Assistive Robot (SAR) is a robot that functions to replace human tasks, entertain, and offer health especially on the emotional health of children with autism spectrum disorder (ASD). These children have fluctuating levels of anxiety and high levels of fear, which can cause them to feel uncomfortable and become aggressive, self-harming, and have tantrums for no reason. [7]

In several previous studies, many Wearable devices (SAR technology and robots) were obtained that aim to detect and treat symptoms that cause stress or anxiety in children with Autism Spectrum Disorder (ASD), including: PARO Robot, a seal robot developed in Japan that is only able to measure the body temperature of children, KILIRO Robot, a parrot robot that is able to check the anxiety of children with Autism Spectrum Disorder (ASD) through saliva and urine and then measure blood pressure and heart rate, Empatica E4 Bracelet (Smart Wrist Band), a bracelet to measure children's anxiety through body temperature and heart rate, and Hexoskin Shirt, a smart shirt that is able to measure heart rate and breathing in children with Autism Spectrum Disorder (ASD). [8]-[12]

From several explanations about the condition of children with Autism Spectrum Disorder (ASD) and existing Wearable devices, there has not been found a Socially Assistive Robot (SAR) as a vital signs meter with sensors as a whole, namely blood pressure, heart rate, and body temperature.

2. MATERIAL AND METHODS

2.1 HARDWARE DEVELOPMENT

This system block diagram offers a comprehensive depiction of the system's workflow, delineating its three fundamental components: input, process, and output. The diagram effectively illustrates how the system begins by acquiring data from various sensors, which serves as the initial input. Following this, the system engages in a series of processing steps to analyze and interpret the data, thereby generating relevant and actionable information.

After the processing phase, the system produces an output, which can take the form of a response or an action, directly derived from the processed information. By providing a clear and detailed representation of these stages, the diagram significantly aids in understanding the flow of data through the system, elucidating how each component interacts to achieve the final output.

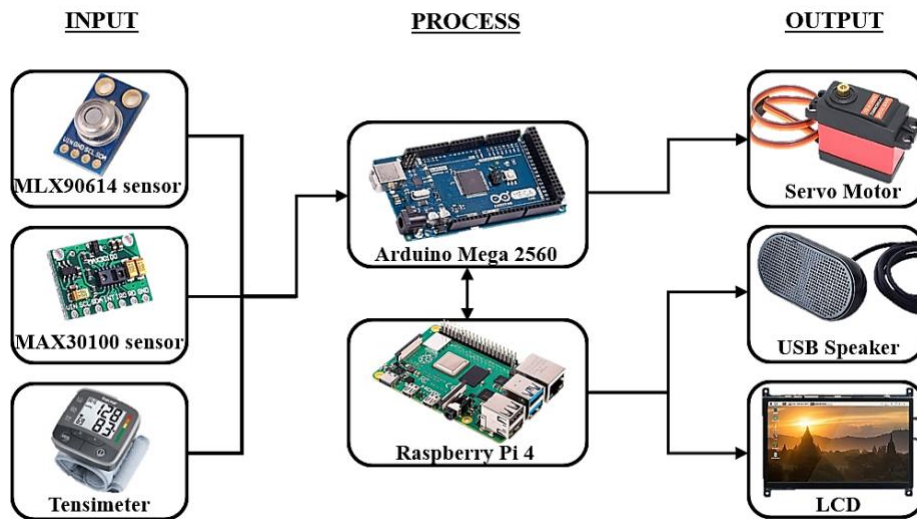


FIGURE 1. Diagram Block System SAR Robot

The block diagram describing the main system in this Socially Assistive Robot consists of several components with the following specifications :

- **MLX90614 sensor:** Body temperature sensor (3V/5V) with factory calibration for sensor temperature (-40...+125°C) and object temperature (-70...+380°C), SMBus compatible. [13]
- **MAX30100 sensor:** Heart rate sensor (1.8V/3.3V) with ultra-low shut-off current (0.7μA), programmable sample rate, and LED current for power saving. [14]
- **Tensimeter (MPS20N0040D-S Sensor):** Sensor on a tensimeter with 5 Vdc supply, 40 kpa pressure range, and 4-6 KΩ bridge resistance. [15]
- **Arduino Mega 2560:** Board with ATmega2560 microcontroller (16 MHz), 54 digital I/O pins, 16 analog inputs, 4 UARTs, USB connection, power jack, ICSP header, and reset button. [16]
- **Raspberry Pi 4:** Features a 64-bit ARM-Cortex A72 quad-core (1.5GHz) and options for 2/4 GB LPDDR4 RAM. [17]
- **Servo motor:** Operated by Arduino Mega 2560, with 4.8-8.4 V operating voltage and 140-200 mA running current. [18]
- **USB Speaker:** Converts electrical signals to audio (20Hz - 20,000Hz). [19]
- **LCD 7 inch:** Connects to Raspberry Pi via ribbon cable to DSI port, sharing 2Amp power across both units. [20]

2.2 SAR ROBOT FLOWCHART PROCESS

The SAR robot system in this study uses advanced technology that is integrated at every step. This system flowchart shows how the robot automatically interacts with children, from switching on the device to monitoring vital signs with great accuracy. The robot measures blood pressure, heart rate and body temperature to respond directly to the child's health condition. In this way, the robot ensures appropriate and safe actions, making it an excellent tool for measuring the vital signs of children with autism.

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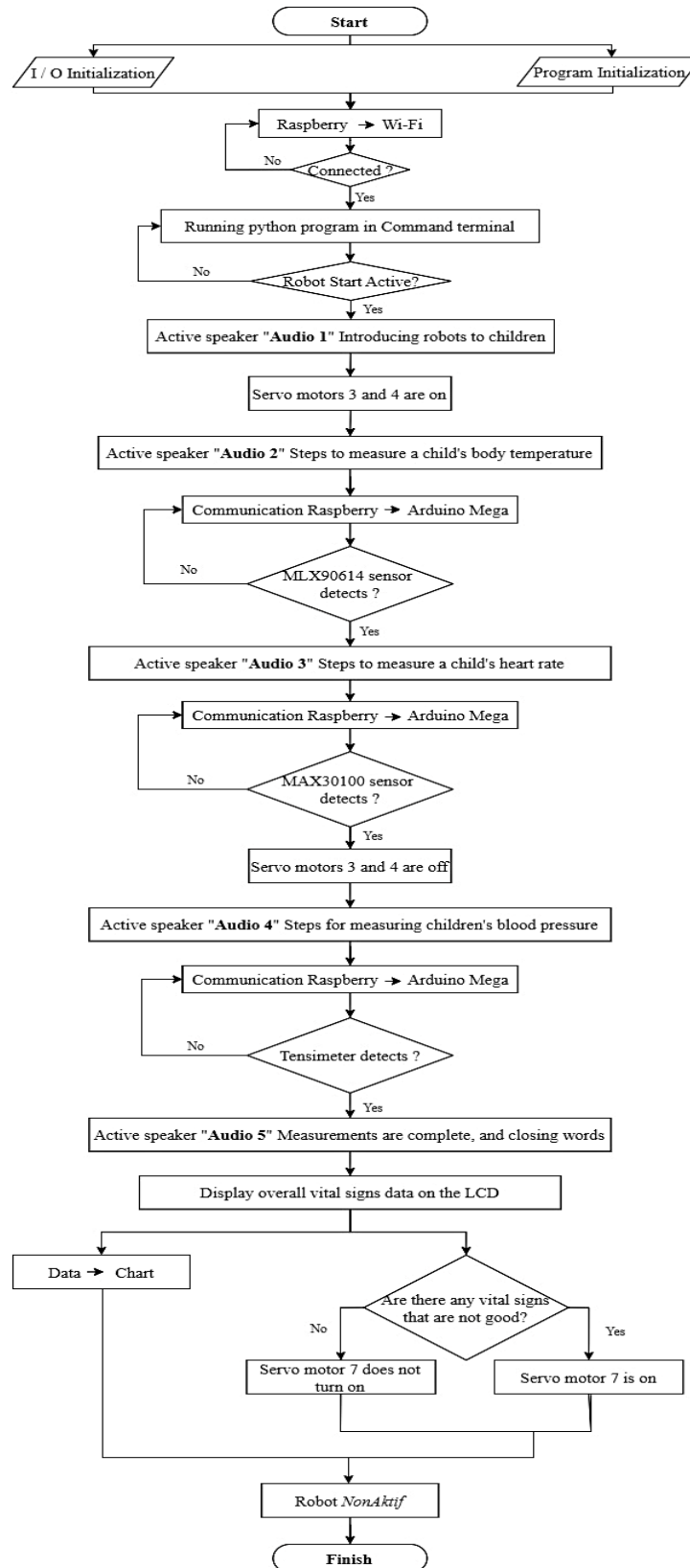


FIGURE 2. Flowchart System SAR Robot

2.3 HARDWARE AND SOFTWARE INTEGRATION

At this stage, what will be done is to integrate the hardware and software that has been designed, then evaluate whether the system that has been built can run and interact with each other or not. To ensure that the integration that runs is correct according to the system function, it is carried out by running the C++ program from the arduino mega and the python program from the raspberry pi, so that this SAR Robot functions as a vital signs meter (blood pressure, heart rate, and body temperature).

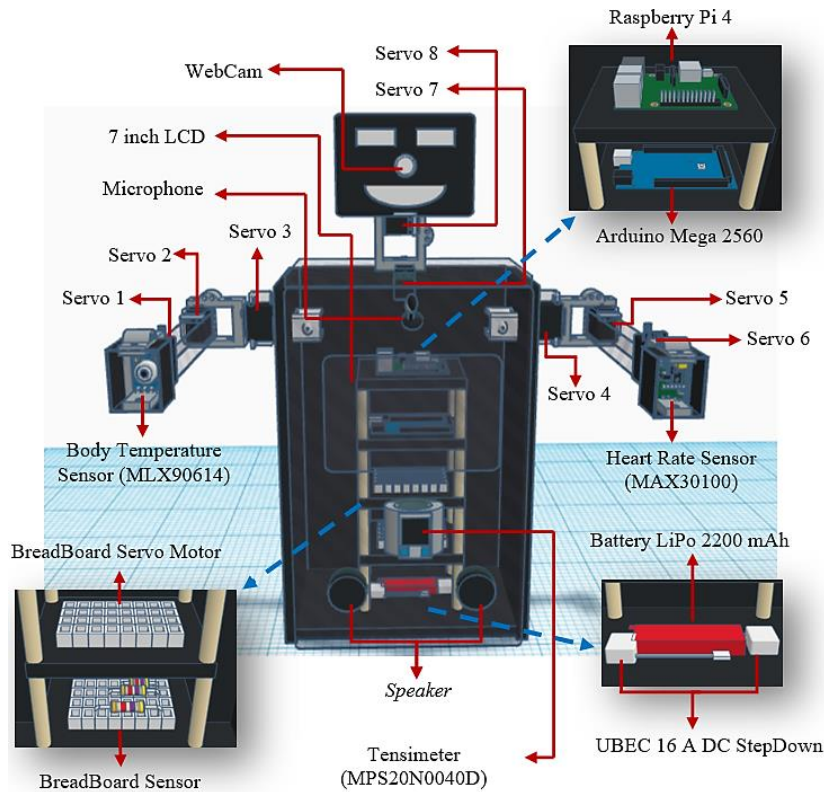


FIGURE 3. Hardware and Software Integration

3. RESULTS AND DISCUSSION

The results of the SAR robot design that has been integrated, is able to measure the vital signs of children with autism spectrum disorder (ASD). The process of taking vital signs data by the SAR robot is carried out on children with autism with two levels of autism, namely Asperger Syndrome and Classical Autism. By testing this design tool, it is easy to compare differences in children's vital signs based on the level of autism.

3.1 VITAL SIGNS MEASUREMENT DATA

The results of vital signs measurements in this study were carried out on children with autism with a sample of 5 children, with different classifications of

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autism. The following are the overall measurement results of blood pressure, heart rate, and body temperature shown in Table 1.

TABLE 1.
Vital Signs Measurement in Autism Spectrum Disorder Children

Classification of Autistic children	Body Temperature	Heart Rate	Systolic/Diastolic
Asperger Syndrome 1	35.85 °C	97.5 bpm	97.5/62.5 mmHg
Asperger Syndrome 2	36.8 °C	92.7 bpm	104.2/71.2 mmHg
Classical Autism 1	37.07 °C	102.3 bpm	158.2/89.1 mmHg
Classical Autism 2	37.28 °C	129.7 bpm	157.2/123.2 mmHg
Classical Autism 3	37.72°C	120.9 bpm	139.1/93.1 mmHg

The results of vital signs measurements in this study were compared with reference data from World Health Organization, namely the American Heart Association PALS Guidelines [4], to see the difference in vital signs of autistic children based on the severity of autism with the vital signs of normal children.

TABLE 2.
Comparison of Vital Signs in Asperger Syndrome ASD Children

Vital Signs	Data Source	
	This Study (N ; Mean ± SD)	WHO (PALS Guidelines)
Body Temperature (°C)	2 ; 36.32 ± 1.87	35.5 – 38 °C
Heart Rate (bpm)	2 ; 95.1 ± 2.4	75 – 118 bpm
Systolic (mmHg)	2 ; 100.85 ± 3.25	97 – 115 mmHg
Diastolic (mmHg)	2 ; 66.85 ± 4.35	57 – 76 mmHg

TABLE 3.
Comparison of Vital Signs in Classical Autism ASD Children

Vital Signs	Data Source	
	This Study (N ; Mean ± SD)	WHO (PALS Guidelines)
Body Temperature (°C)	3 ; 37.36 ± 6.55	35.5 – 38 °C
Heart Rate (bpm)	3 ; 117.63 ± 11.42	75 – 118 bpm
Systolic (mmHg)	3 ; 151.5 ± 8.78	97 – 115 mmHg

	3	;	
Diastolic (mmHg)	101.8	±	57 – 76
	15.22		mmHg

Description

- N : Number of children based on autism classification
- Mean : Average value of each child, with the same autism classification
- SD : How far the data spreads from the average (Standard Deviation)

The results of the two tables above explain that the vital signs of Autism children have an effect, between their classification and the vital signs of normal children (9-10 years old). Asperger Syndrome has vital signs that remain in the range of normal children, while Classical Autism has some vital signs that are higher than the range of normal children.

3.2 GRAPH OF VITAL SIGNS MEASUREMENT DATA RESULTS

The following is a graph of the results of blood pressure, heart rate, and body temperature measurements that have been measured in five children with autism with different autism classifications, found in Figure 4.

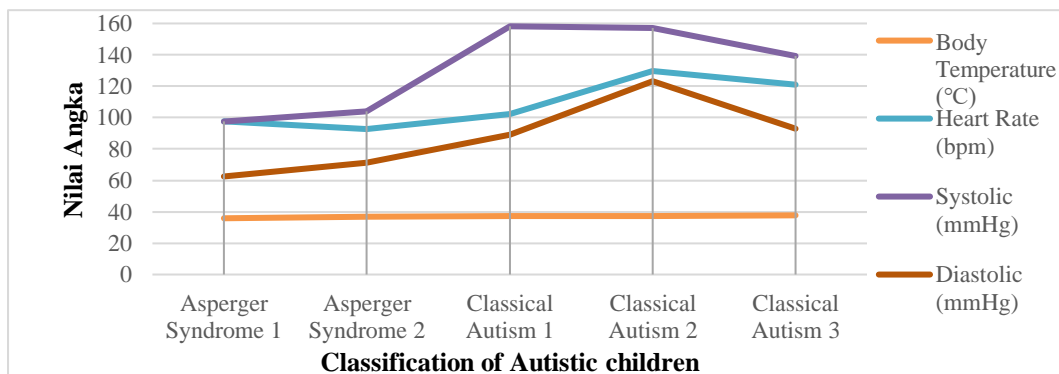


FIGURE 4. Graph of Combined Measurement of Vital Signs in ASD Children

The results of the measurement of vital signs that have been compared with the reference data from the World Health Organization, namely the American Heart Association PALS Guidelines, are displayed in graphical form, to make it easier to see the comparison between the two in Figure 5 and Figure 6.

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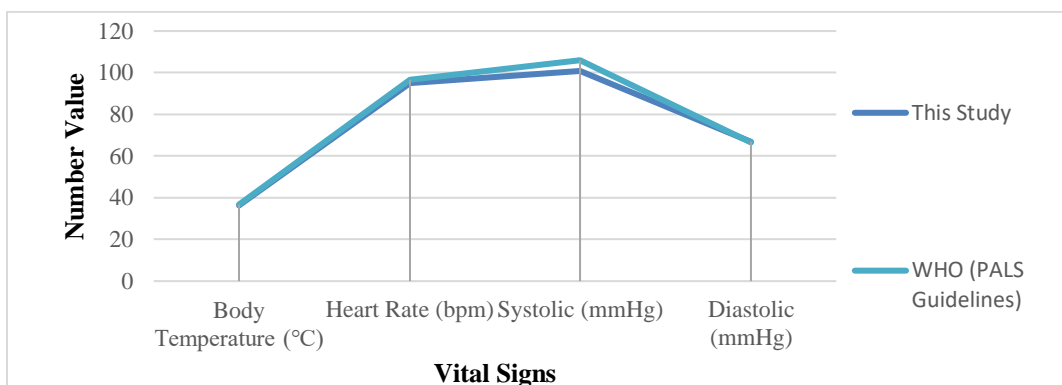


FIGURE 5. Comparison Chart of Vital Signs in Asperger Syndrome ASD Children with WHO Data

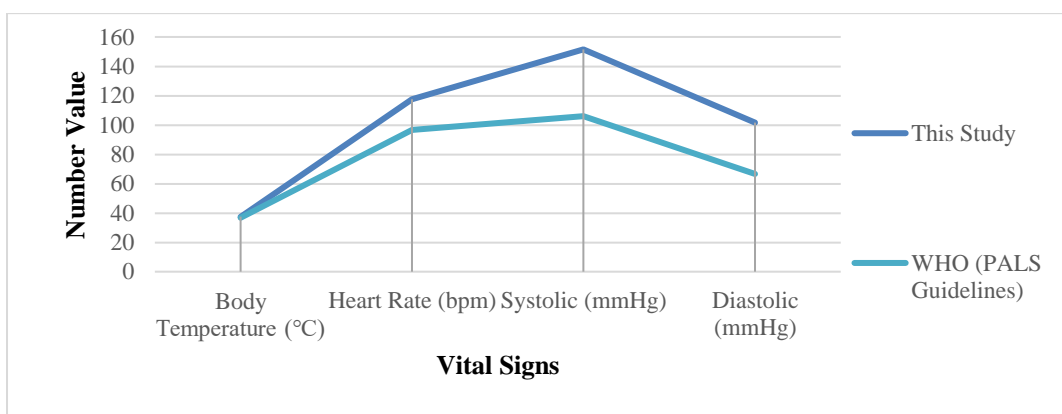


FIGURE 6. Comparison Chart of Vital Signs in Classical Autism ASD Children with WHO Data

4. CONCLUSION

Based on the results of data testing in this study, namely the measurement of vital signs (blood pressure, heart rate, and body temperature) of Socially Assistive Robot (SAR) for Autism Spectrum Disorder (ASD) children that have been carried out, the following are the conclusions of this study :

1. Socially Assistive Robot (SAR) has been successfully designed with sensors to detect body temperature, heart rate, and blood pressure in children with Autism Spectrum Disorder (ASD), and all components work well.
2. Children with Classical Autism classification of Autism showed a tendency of higher anxiety compared to children with Asperger Syndrome classification of Autism, as seen from the results of higher body temperature, heart rate, and blood pressure measurements.
3. The results of these vital signs measurements were guided by the PALS Guidelines of the American Heart Association, which showed an association between vital signs and the level of autism in children with autism.



ACKNOWLEDGEMENTS

Deepest gratitude is extended to all parties who have generously contributed to the success of this research. Sincere appreciation is particularly due to Politeknik Negeri Sriwijaya for their steadfast support, which included not only the provision of essential facilities but also the opportunity to carry out this important study. Special thanks are also warranted for everyone involved in the development and implementation of the Socially Assistive Robot (SAR) as a tool for monitoring vital signs in children with Autism Spectrum Disorder (ASD). The collective dedication, expertise, and collaboration of all contributors were crucial in bringing this project to its successful completion. This research, with its significant potential impact, would not have been achievable without the unwavering commitment and joint efforts of all those involved. Their invaluable contributions have been fundamental to the realization of this project, and profound thanks are offered for their exceptional involvement and support.

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