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IMPLEMENTATION OF RASPBERRY PI AS A2DP MODULE ON THE QUALITY OF SONG RECEPTION OF HUMANOID ROBOT

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ABSTRACT

This research discusses comparing the performance of Bluetooth communication on Raspberry Pi in controlling dance humanoid robots using external modules and direct communication. This research aims to understand the difference in performance between the two methods, by analyzing data transmission speed, signal stability, and communication latency that affect the quality of robot movement. In addition, this research also aims to evaluate the effectiveness of using simple filters such as low-pass filter circuits to improve the stability of Bluetooth communication on Raspberry Pi. It is hoped that this research can lead to a better understanding of the influence of both communication methods on the quality of dance humanoid robot movements.

Keywords: *raspberry pi, bluetooth, humanoid.*

INTRODUCTION

Wireless communication is a major factor in controlling humanoid robots especially in the context of dance performances. Raspberry Pi, as a versatile control platform, enables Bluetooth communication to control robots wirelessl (Al Haq, 2021). However, the performance of Bluetooth communication on Raspberry Pi can be affected by the use of external modules or direct communication without modules. A comparison between the two is essential to understand the differences, advantages, and disadvantages of each approach in controlling dance humanoid robots (Sulistyo, 2015).

In this study, the researchers compared the performance of Bluetooth communication on Raspberry Pi in controlling a dance humanoid robot using an external module and direct communication (Engin, Aksoz, Dursun, & Hamidiogullari, 2016). The main objective of the study was to understand the performance differences between the two methods, by analyzing the data transmission speed, signal stability, and communication latency that affect the quality of the robot's movements (Ala'uddin, Siradjuddin, & Winarno, 2023) . In addition, this research also evaluates the effectiveness of using simple filters such as low-pass filter circuits to improve the stability of Bluetooth communication on Raspberry Pi. It is expected that this research will result in a better understanding of the influence of both communication methods on the quality of dance humanoid robot movements, as well as provide recommendations for the development of more effective control solutions in the context of performing arts (Haryanto, Putra, Syauqy, & Maulana, 2019).

raspberry pi as a2dp module on the quality of song reception of humanoid robot

A. Dance Robot

The Indonesian Dance Robot Contest (KRSTI) is a competition that integrates elements of art into robots. The dance robots participating in this contest are humanoid robots specifically designed to dance in time with the rhythm of a song (Rifandi et al., 2021). During the contest, the robot will be placed in the arena in a ready condition. In its execution, the robot must dance when the music plays and automatically stop when the music ends (Ala'uddin et al., 2023). The music detection process in the Indonesian Dance Robot Contest (KRSTI) begins with sending music via Bluetooth Transmitter. The music is then received by the Bluetooth Receiver attached to the robot (Prasetyo, Putra, Riski, Yahya, & Ramadhan, 2023). The data received by the Bluetooth Receiver is initially an analog signal of the music frequency. Once received, this analog signal is then forwarded to the Arduino microcontroller integrated in the robot. The data will be processed into movement cues for the robot.

B. Sensor System

In music sound detection and robot motion systems in maintaining balance, the sensors used are as follows:

a. Sound Sensor

The sound sensor used by both robots is designed to be able to receive sound via Bluetooth and detect the frequency of Kancet Ledo/Gong Dance accompaniment music. The Bluetooth used is Bluetooth Audio.

b. Accelerometer

Both robots use the MMA7361 module which is an IMU (Internal Measurement Unit) sensor consisting of 2 Accelerometers type MMA7361 (to measure acceleration, detect and measure vibration, and measure acceleration due to gravity (inclination). This sensor can "sense" the acceleration experienced by the sensor on 3 axes (XYZ axis), so that it can be used to adjust the balance of the robot (Kim, 2019).

Broadly speaking, the way this module works is: data from the MMA7361 accelerometer which is analog data will be converted in digital form by an analog to digital conventer which then outputs the data and enters the OpenCr 1.0 and OpenCM 9.04 controller modules. This module is used as a data processor from the accelometer to drive 28 servo motors on each robot.

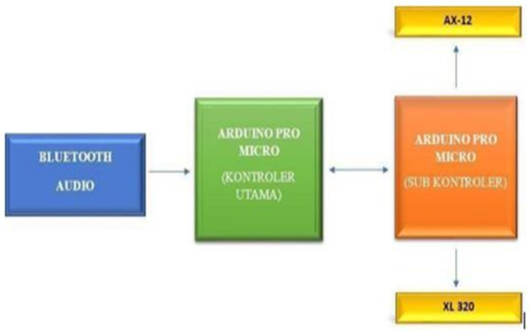


Figure 1 Sound Detection of Accompaniment Music

The robot will receive Kancet Ledo/Gong dance accompaniment music that has been prepared by the judges through Bluetooth audio. Furthermore, bluetooth audio will send digital data to the main controller, then the main controller will send motion data via the SPI line to move the 28 servo motors on the robot.

The sound sensor is designed to be able to select the types of input frequencies. The frequencies that can be selected are bass with a frequency range of 60Hz - 160Hz, middle with a frequency range of 400Hz - 2.5kHz, and trible with a frequency range of 6.25kHz - 16kHz (Pucher, Gattringer, & Müller, 2019). By using the theme raised in 2020, namely Kancet Ledo/Gong Dance, the dance movements were carried out based on the analysis of the Kancet Ledo/Gong Dance accompaniment music received by the sound sensor (Satrio Pambudi, Wiharta, & Putra Sastra, 2018). The dance movement is divided into 5 zones, in the first zone (start) the robot moves to zone A. In zone A there are two movements to be performed by the robot, namely the pambuka movement and the nganjat movement. In zone B, the movement that must be done is the ngasai motion. In zone C, the robot must perform the purak barik motion.

Finally, in the closing zone, the robot performs the closing prayer of Kancet Ledo/Gong Dance. The selection of movements is determined as the table of movement changes from one movement to another is determined when the detection of the sound sensor is within the predetermined bass level.

METODE PENELITIAN

A. System Overview

Based on the figure above, there are three blocks of system stages, namely input or input, processing and output or output. The following is an explanation of each stage:

1. In the input block, there is one analog sound sensor and Raspberry Pi device. The sound sensor will read the sound input and Raspberry Pi will decipher the signal into a filter in Raspberry Pi which becomes an input parameter that will be transferred to Arduino Uno Atmega 328.
2. Input by Raspberry Pi is processed by the Arduino Uno microcontroller to get a band or frequency band as a system parameter which will produce data. the data will be processed on the Raspberry Pi. The parameters are then processed to get the output.
3. The system output is a unit of tempo value obtained from the Raspberry Pi frequency bands after several processes. Another output is an indication of movement that directly shows the values of the input parameters received by Arduino Uno as sound. The system results in a PCB Raspberry Pi module that is easily connected to the sound sensor module and the arduino uno microcontroller (Haq, 2018). The module is designed this way to facilitate the use of the system.

B. Hardware Design

The two parts of the hardware design are the Raspberry Pi design with sound sensor and the motion indication design. The former should include components necessary for the performance of the Raspberry Pi, such as several resistors and capacitors to set the internal timing of the Raspberry Pi or set the input frequency (Aryanti, Ikhthison Mekongga, 2016). To facilitate external connections, the Raspberry Pi module is equipped with several pin-headers, especially for the analog sound sensor module and the arduino uno microcontroller. Thus, the system performance starts with the sound sensor module, then the Raspberry Pi module, and finally the arduino uno microcontroller (Inoue, Uemura, Minagawa, Esaki, & Honda, 1985). The motion indication is mounted on the same PCB board as the Raspberry Pi IC and its supporting components. The motion indication will provide an output that will be entered by Raspberry Pi. The hardware design schematic is shown in the figure below.

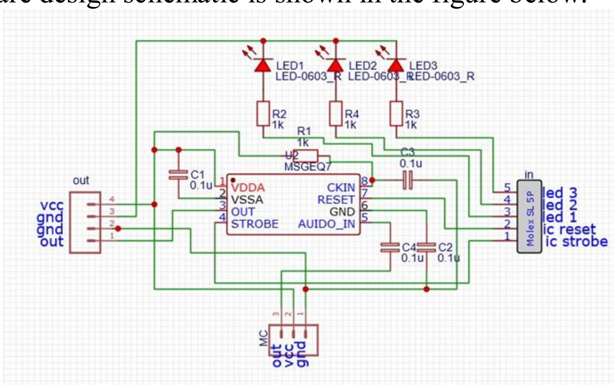


Figure 2 Systematic Picture of Hardware Design

Figure 3 Design body robot

The picture above is the KRSTI Robot which will be the subject of this research

C. PCB Design Drafting

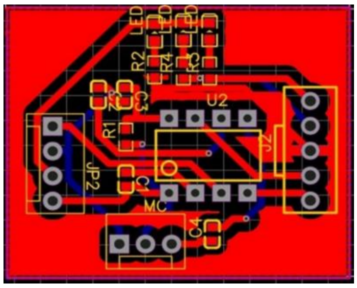


Figure 4 PCB Visualization Drawing

PCB or Printed Circuit Board design is done by visualizing the schematic in the picture above. The PCB design measures 33mm and 27mm.

D. Software Design

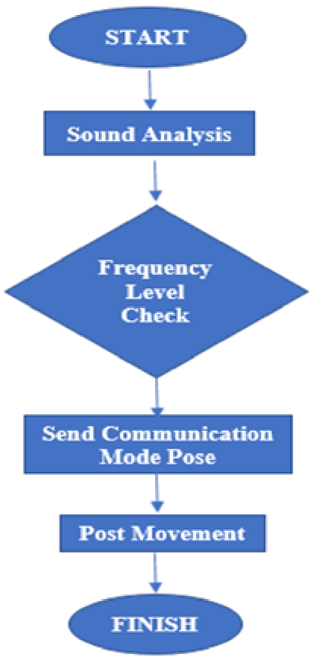


Figure 5 Systematic Flowchat

As the flowchart above says, the system will start by analyzing the voice signal. Then when the voice signal is analyzed, the signal will start a frequency level check using the

MSGEQ7 filter. then the data is sent as a communication signal in pose mode, then the pose mode communication signal will output in the form of a pose movement.

E. System Implementation

The system implementation resulted in a well-used detection system. The implementation begins with the implementation of the MSGEQ7 module by connecting the sound sensor processed on the Arduino Uno externally(Ji, Pan, Xu, & Wang, 2022). Then the movement design is carried out on the module to be an indication of the system output. After the hardware implementation is done, then the software implementation is done. The system must be able to receive input from outside the system in the form of sound and then become an output (McCarthy, 2012).

HASIL DAN PEMBAHASAN

Table 1 Raw Data

File	Max Value	Min Value	Mean Value	RMS Value	Dynamic Range (DR)	Crest Factor (CF)	Signal Duration (s)
Source	0,93679	-0,86154	-4.3910^{-19}	0,1111	108,5369	18,5186	227
Bluetooth Module 1	1	-1	$9,980410^{-19}$	0,15901	188,1449	15,9715	228
Bluetooth Module 2	1	-1	$-9,646510^{-19}$	0,15909	169,6389	15,9674	227
Bluetooth Module 3	1	-1	$7,298410^{-19}$	0,15907	122,0432	15,9683	227
Raspberry 1	0,99765	-1	$-2,751710^{-19}$	0,13643	186,5102	17,3015	228
Raspberry 2	0,99631	-0,99466	$-9,59810^{-19}$	0,13653	195,8912	17,2632	227
Raspberry 3	0,99204	-0,99808	$7,517410^{-19}$	0,13645	212,5504	17,2841	228

The table above is the raw data that is produced by doing 3x experiments using the same file and different times. Then to continue the analysis process, we normalize it by equalizing the RMS Value as in the table below.

Table 2 Data Normalization

File	Max Value	Min Value	Mean Value	RMS Value	Dynamic Range (DR)	Crest Factor (CF)	Signal Duration (s)	Euclidian Similarity	Similarity
Source	8.432	-7.7547	3.4410^{-19}	1	108.5369	18.5186	227	Base	Base
Bluetooth Module 1	6.2889	-6.2889	-7.79^{-19}	1	188.1449	15.9715	228	2.596.429.712	97.40357029
Bluetooth Module 2	6.286	-6.286	5.2410^{-19}	1	169.6389	15.9674	227	2.600.460.669	97.39953933
Bluetooth Module 3	6.2866	-6.2866	3.3010^{-19}	1	122.0432	15.9683	227	259.962.666	97.40037334
Raspberry 1	7.3123	-7.3295	1.4910^{-19}	1	186.5102	17.3015	228	1.197.715.797	98.8022842
Raspberry 2	7.2972	-7.2852	1.2710^{-19}	1	195.8912	17.2632	227	122.808.847	98.77191153
Raspberry 3	7.2706	-7.3148	-2.9710^{-19}	1	212.5504	17.2841	228	1.241.918.665	98.75808134

In the table above the RMS Value has been generalized to a value of 1, this makes the max value and min value change. At max value, the highest value is generated by the source file of 8.432 and the lowest value is generated by the Bluetooth module file of 6.286. Then at the min value the highest value is generated by the Bluetooth module file -6,286 and the lowest value is generated by the source file of -7,7547. Furthermore, the dynamic range can be seen from the spectrogram graph, the higher the dynamic range value, the more green color will be shown on the spectrogram graph and the highest value in the dynamic range is produced by the Raspberry file of 212.5504 dB.

Furthermore, the crest factor is the value produced by the song to prove the received sound signal is valid (Muller, Ellis, Klapuri, & Richard, 2011). Then in the signal duration of the songs received, only a few are 1 second different and there are several similarities in the duration signals received, this occurs due to noise. Furthermore, the Euclidean similarity is to measure the distance of how far the difference in max value and min value is to the source. Then the similarity is the percentage resulting from Euclidean similarity, and the resulting raspberry has a percentage of 98% similarity in receiving songs.

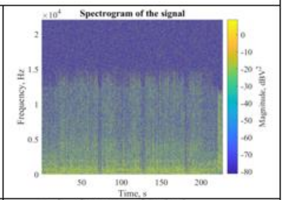
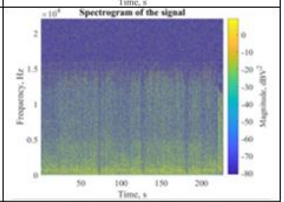
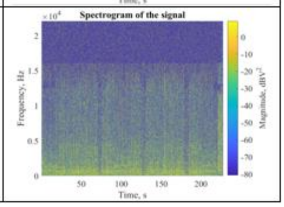
Spectrogram	
Source	
Bluetooth	
Raspberry Pi	

Figure 6 Spectrogram graph

This spectrogram is used to measure the signal spectrum with frequency consistency in time. On the source graph, the dynamic range at frequencies 12.50 kHz - 15 kHz shows values of -20 to -30 dBV^2 Magnitude. In Bluetooth, the dynamic range frequency shows that the frequency of 15 kHz is at -15 to -20 dBV^2 Magnitude. On the Raspberry Pi dynamic range shows 17 kHz is in a stable state at -15 dBV^2 Magnitude.

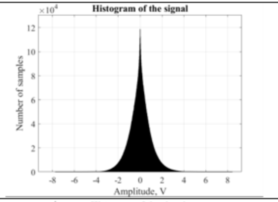
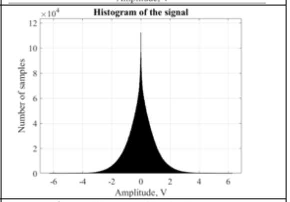
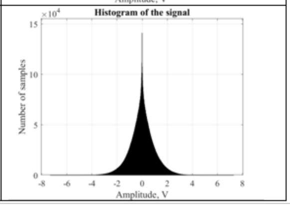
Histogram	
Source	
Bluetooth	
Raspberry Pi	

Figure 7 Histogram graph

This histogram is used to measure the signal spectrum with amplitude. The source has a max value of $12*10^4$ with an amplitude range of -4 V to 4 V. On bluetooth has a max value of $11*10^4$ with an amplitude range of -3 V to 3 V. The raspberry has a max value of $14*10^4$ with an amplitude range of -4 V to 4 V.

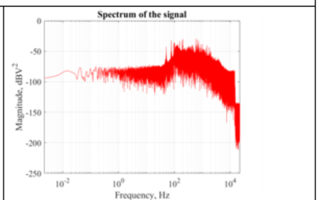
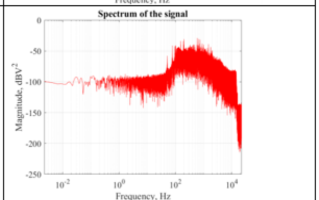
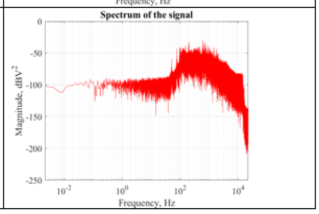
Spectrum	
Source	
Bluetooth Module 1	
Raspberry Pi	

Figure 8 Spectrum graph

This spectrum is used to determine the magnitude with frequency. At the source, the frequency ranges from 10^{-2} Hz to 1 Hz, a starting point value above -100 dBV^2 magnitude is obtained. In the range of 1 Hz to 100 Hz, the magnitude fluctuates between -125 dBV^2 to 100 dBV^2. In Bluetooth devices, the frequency ranges from 10-2 Hz to 1 Hz, with the starting point exactly at 100 dBV^2 magnitude. In the range of 1 Hz to 100 Hz, the magnitude varies between -90 dBV^2 to -140 dBV^2. Whereas on the Raspberry Pi, for frequencies ranging from 10-2 Hz to 1 Hz, with a starting point below -100 dBV^2 magnitude. In the range of 1 Hz to 100 Hz, the magnitude changes between -90 dBV^2 to -150 dBV^2.

CONCLUSION

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