Syntax Admiration: p-ISSN 2722-7782 | e-ISSN 2722-5356 Vol. 5, No. 11, November 2024

Optimizing Communication for a Humanoid Subs-Talker Robot Using RSSI Analysis on ROS System

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Abstract

This study aims to optimize communication for the humanoid "Subs-Talker" robot using Receive Signal Strength Indicator (RSSI) analysis within the Robot Operating System (ROS). The background of this research highlights the importance of stable and strong inter-robot communication in the Indonesian Humanoid Robot Soccer Contest (KRSBI-H), where robots need to function in synergy. The method involves measuring signal strength at specific distances, both with and without the use of an extender device, utilizing the InSSIDer application for RSSI data recording and analysis. The results show that using an extender improves communication stability, especially at longer distances (7.2 and 9.0 meters), although the impact is minimal at closer distances. The discussion suggests that an extender can be an effective solution for enhancing inter-robot communication quality in competitions. In conclusion, the extender significantly improves the communication range and signal quality among robots, supporting optimal performance in collaborative robot interactions within the competition arena.

Keywords: Humanoid Robot, RSSI, ROS System, Robot Communication, Robot Soccer Contest.

Introduction

Communication between robots has become a crucial part of the development of swarm robots (Nedjah & Junior, 2019);(Chung, Paranjape, Dames, Shen, & Kumar, 2018). Group robots or multiple system robots are robots that work optimally when working together with other similar robots (Niermann, Doernbach, Petzoldt, Isken, & Freitag, 2023);(Miyagawa et al., 2019) The way of working in groups requires optimal communication so that each robot can perform its own tasks well (Nedjah, Ribeiro, & de Macedo Mourelle, 2021). The use of multiple robot systems can be seen in the Indonesian Robot Contest, especially in the Indonesian Humanoid Football Robot Contest division (KRSBI-H) (Damar et al., 2023);(Wen, He, & Zhu, 2018).

The Indonesian Humanoid Football Robot Contest Division (KRSBI-H) competes against two teams of soccer robots like football in general. A team of soccer robots generally consists of two to three robots in a match that have their own roles. The role of robots is divided into three, namely attackers, defenders, and goalkeepers. This role is carried out synergistically so that good communication between the three robots is needed.

The Darwin OP3 robot is a humanoid robot that operates through the ROS system. ROS or Robot Operating System is a framework used to control and move robots (Rottmann, Studt, Ernst, & Rueckert, 2020). ROS has various functions called topics. On the topic of communication, there are two roles that run, namely subscribers and talkers or called subs-talkers. This communication topic is carried out through programs and signals. So the Receive Signal Strength Indicator (RSSI) method is used to measure how strong the signal is used (Nagah Amr, ELAttar, Abd El Azeem, & El Badawy, 2021).

Receive Signal Strength Indicator (RSSI) is an analysis method that measures the reception of signal strength from a device (Yang, Guo, Guo, Zhao, & Zhao, 2020). RSSI will provide an output in the form of signal strength in dBm - where the smaller the unit, the worse the signal quality. Signal quality can be an indicator of the cause of a communication that is not optimal.

Communication optimization is aimed at improving the communication capabilities of the Darwin OP3 robot as a robot in the Indonesian Humanoid Football Robot Contest Division (KRSBI-H) (Cha, 2018);(Chien, Chen, & Chan, 2023). This research focuses on solving problems that are often experienced when the KRSBI-H race takes place, one of which is the communication that is often interrupted between robots (Simões, Amaro, Silva, Lau, & Reis, 2020);(Gasteiger, Hellou, & Ahn, 2023). Many factors affect this condition, one of which is the condition of the signal received and emitted by the robot. Some solutions can be done through the addition of hardware in the form of extenders and software in the form of program code repairs.

Research Methods

Overview

The Darwin OP3 robot will be designed and tuned as in the actual race conditions. This is intended to provide a real picture of the game conditions. The robot will be searched for signal strength at certain distances with a maximum distance of 9 meters. This distance selection is based on Fig 1 which is the field size of the Indonesian Humanoid Football Robot Contest Division (KRSBI-H) with a focus on the length of the field, which is 9 meters.

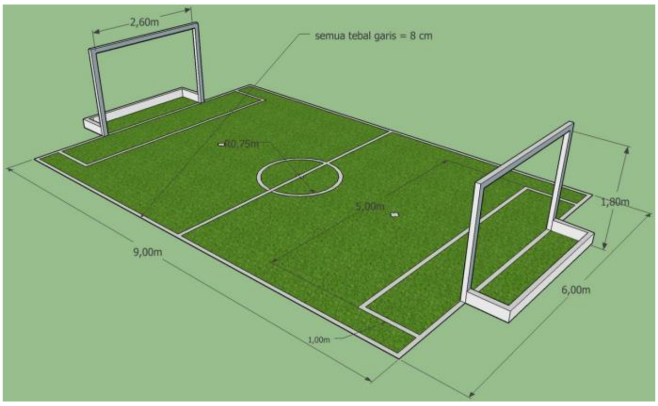

Fig. 1. Field of Humanoid Robot Soccer Competition.

Resulth and Discussion

The measurement is divided into several pieces of distance, namely 1.8 meters, 3.6 meters, 5.4 meters, 7.2 meters, and 9.0 meters. The signal strength will be searched based on these distances. Then this value will be recorded in the form of a table. These values will then be compared and the pattern will be searched by utilizing the Receive Signal Strength Indicator (RSSI) method. This measurement is supported by the InSSIDer application which provides convenience in terms of UI as in Fig 2. The app will display a graph of the signal strength received by the device. The recorded signal strength is in the unit of -dBm where the smaller the value of this unit, the weaker the signal strength will be.

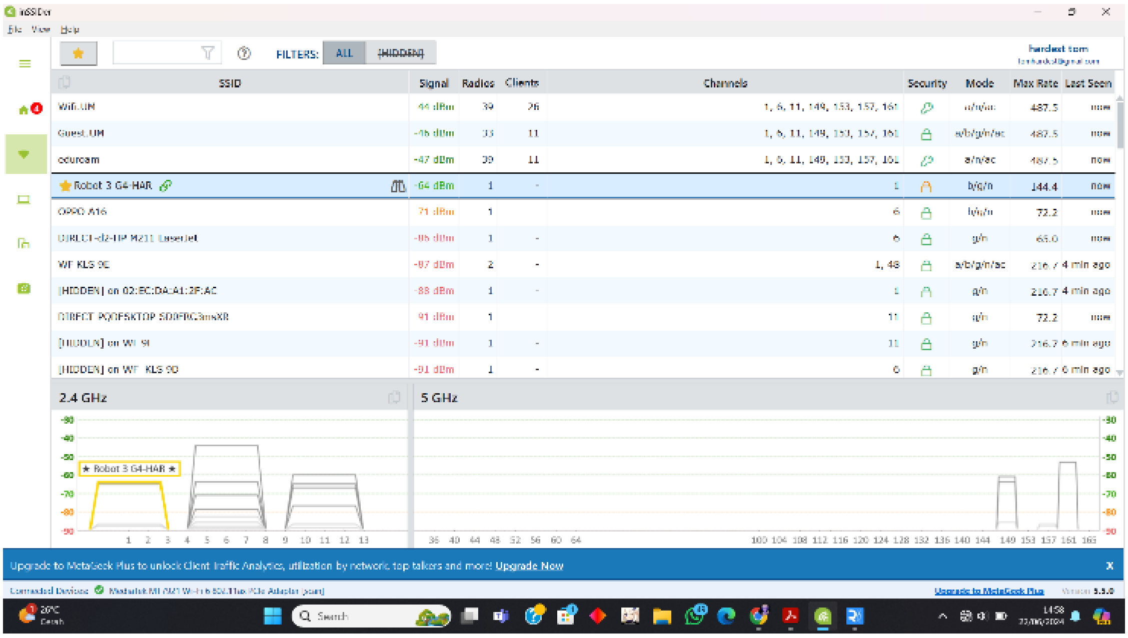

Fig. 2. InSSIDer UI.

The results of these measurements are then grouped into categories according to the Receive Signal Strength Indicator (RSSI) method as shown in Fig 3. Category is the result of processing signal strength data obtained through the:

$$RSSI = A - 10n \log d$$

The value n is the signal propagation constant or exponent (path loss exponent), d is the distance from the sender and A is the strength of the received signal within 1 meter with dBm units.

Signal Strength	TL;DR	
-30 dBm	Amazing	Max achievable signal strength. The client can only be a few feet from the AP to achieve this. Not typical or desirable in the real world.
-67 dBm	Very Good	Minimum signal strength for applications that require very reliable, timely delivery of data packets.
-70 dBm	Okay	Minimum signal strength for reliable packet delivery.
-80 dBm	Not Good	Minimum signal strength for basic connectivity. Packet delivery may be unreliable.
-90 dBm	Unusable	Approaching or drowning in the noise floor. Any functionality is highly unlikely.

Fig. 3. RSSI indicator for WiFi

B. Instrument

This study uses the OP3 robot with specifications that can be seen in Table 1. The three robots used have specifications so that the data taken can be objective. So that the data obtained will be consistent for each case even if it is tested on other robots.

Table I. Robot Darwin OP3 Sespification

Component	Specifications
Main Controller	INTEL NUC i3 Intel Core i3 processor dual core 8GB RAM DDR4 SODIMMs 2133MHz 128GB M.2 SSD
Networking	Intel 10/100/1000 Mbps Ethernet 802.11ac (2.4GHz, 5GHz) Bluetooth 4.1
Battery	Lipo 3cell 11.1v 1800mA
Installable OS	Debian Mint
Development Environment	OS : Linux (64-bit) C++, ROS, DYNAMIXEL SDK

Communication in the OP3 robot is divided into subs and talkers. Talker is when the OP3 robot delivers messages or data to other robots while subs are when receiving messages or data from other robots. Both subs and robot talkers will check if there are other robots that can be targeted. If there is one, then the robot is prepared to send or receive data. The data received will be processed into a decision. How it works can be seen in Fig 4 for talker and Fig 5 for subs.

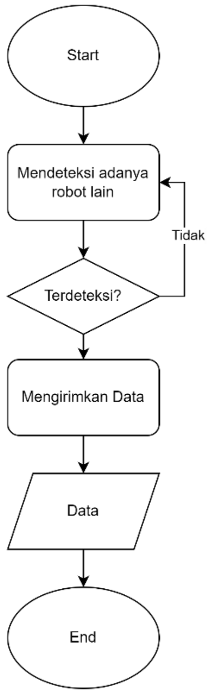

Fig. 4. Talker of Flowchart.

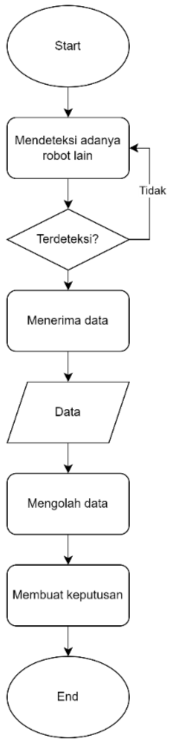

Fig. 5. Subs of Flowchart.

The device used is constant to provide unchanging data. So here a laptop specification is used as shown in Table 2. Then an extender is also used, namely TL-WN725N which supports wireless IEEE 802.11b, IEEE 802.11g, dan IEEE 802.11n.

Table 2 Laptop Spesification

Component	Specifications
Processor	12th Gen Intel(R) Core(TM) i5-12500H
Networking	Mediatek Wi-Fi 6 MT7921 (2x2) Bluetooth 5.3
Installable OS	Windows 11

C. How it's going

The laptop and Robot are placed in such a position as in Fig 6. The laptop will receive a signal from the robot and calculate it using InSSIDer. The signal strength value will be recorded. Testing is carried out over 5 iterations. This test was also carried out in the case of the application of *an extender* on a robot.

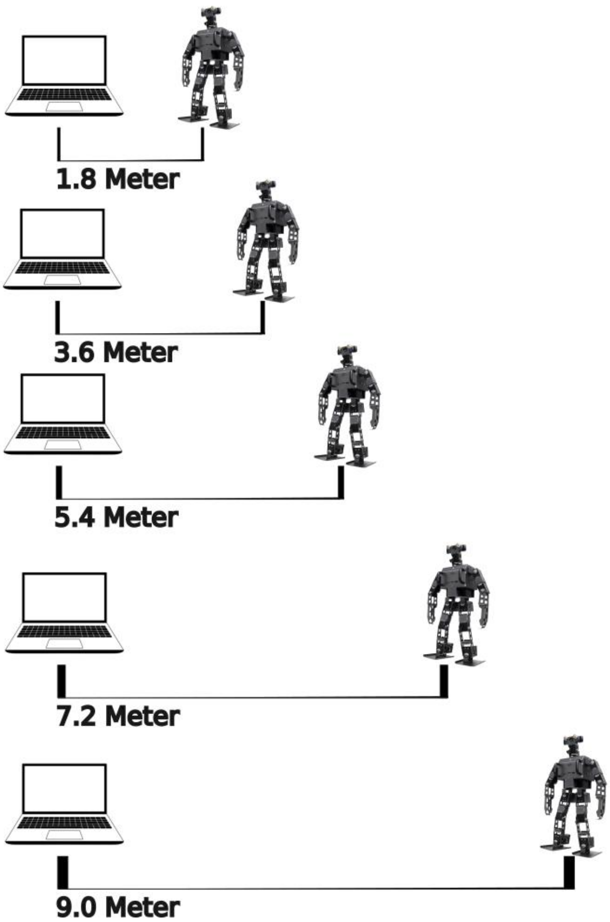

Fig. 6. Robot and Laptop Position.

A. Testing without extender

Signal Strength Measurement (-dBm)	**Distance between transmitter (talker) and receiver (subs)**				
	1.8 meters	***3.6 meters***	***5.4 meters***	***7.2 meters***	***9.0 meters***
Iteration 1	59	61	64	68	68
Iteration 2	59	68	65	65	70
Iteration 3	62	65	68	63	69
Iteration 4	65	68	62	66	69
Iteration 5	64	59	63	66	63

B. Testing with extender

Signal Strength Measurement (-dBm)	**Distance between transmitter (talker) and receiver (subs)**				
	1.8 meters	***3.6 meters***	***5.4 meters***	***7.2 meters***	***9.0 meters***
Iteration 1	59	60	57	61	62
Iteration 2	58	58	61	61	62
Iteration 3	57	56	61	61	62
Iteration 4	58	58	61	62	65
Iteration 5	58	59	61	62	64

Conclusion

Testing without an extender and testing with an extender provide a performance that is not too different. It can be seen in the case of 1.8 meters, 3.6 meters, and 5.4 meters giving not too different results. But indeed, using an extender provides better stability. This is different from the 7.2 meter and 9.0 meter cases which provide a big difference. It is seen that the extender provides better power and longer range. This results in the extender being able to improve the quality of communication from the robot.

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