Signal and Image Processing Letters
Vol. 4., No. 1, 2022, pp. 11-19
ISSN 2714-6677
https://simple.ascee.org/

Wheeled Robot Automated System Through Communication with Referee Box Using Base Station

Okki Prasetyo [a,1], Riky Dwi Puriyanto [a,2,*]

[a] Department of Electrical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[1] prasetyookki17@gmail.com; [2] rikydp@ee.uad.ac.id
* corresponding author

ARTICLE INFO

Keywords
Base station
Referee Box
Robot
TCP
GUI

ABSTRACT

Manual control of the robot makes the movement of the wheeled KRSBI robot inflexible and does not depend on time. This research can answer these problems. The robot can immediately know the command from the Referee box. In this final project, the author develops a communication system for the Base Station application. The communication system via WLAN at the base station uses a TCP (Transmission Control Protocol) communication system. At the Base Station which was developed with a GUI design to make it easier to control the robot. From the results of research conducted by the Base Station, referee boxes and robots can be well connected with the addition of the X, Y and angle data transmission features on the robot that are displayed on the Base Station. 2 meters is 0.045 ms, for transmission time with a distance of 4 meters is 0.049 ms, for transmission time with a distance of 6 meters is 0.048 ms, for transmission time with a distance of 12 meters is 0.049 ms, and for transmission with a range of 15 meters of 0.050 ms.

1. Introduction

Robotics has now become a part of human life. Robotics has become one of the technological developments that are widely used not only in developed countries but also in Indonesia and other countries. In some developed countries, efforts are still being made to further develop research in the field of robotics. To promote the advancement of robot technology in Indonesia, KRI has been held, an Indonesian robot competition for students that is held regularly every year. One of the KRI divisions this year is the Indonesian Football Robot Contest (KRSBI). KRI is a higher education robotics competition in Indonesia aimed at students who will regularly attend once a year. The Indonesian Robot Competition itself is organized by the Ministry of Research, Technology, and Higher Education with the intention of increasing talents and skills in the field of robotics. One of the divisions of the Indonesian Robot Content Company (KRI) is the Indonesian Wheeled Football Robot Contest (KRSBI) Wheeled [1] [2].

During the game, the robot is controlled and commanded by the referee through software that can be called a referee box. The Referee box is a game controller and one of the techniques utilized to help referees coordinate the course of the KRSBI game[3]. The benefit of the Referee box is to send the referee's decision to the robot that plays, writes the results and serves to be indicator jam game. The Referee box communication protocol sends a number of messages to both group computers namely magenta and cyan [4].

A Referee Box is a game regulator that is used by the referee to handle a match, for example, starting a match, showing the match time, showing the Match Score, showing some buttons and referee message marks. The Referee Box is used in accordance with the rules of the RoboCup MSL[5]. The referee box's ability is to assist the referee, especially in passing on the referee's choice to the playing robot, to be a match time observer, and subsequently to write the match score [6]. Specifically, at whatever point an adjudicator arranges a referee to give a gesture, the Referee Box communication protocol sends at least one message to the Base Station PC of two groups (magenta and cyan). Referee Box activities are passed on to assistant referees where each of them is associated with the same WLAN or network [7].

WLAN is a wireless communication technology where every connection between electronic devices such as sending and receiving data is carried out by air with radio wave techniques. The WLAN acts as the central transmitter and receiver of wireless radio signals [8] [9] [10]. Wireless Access Point supports Wi-Fi and is most commonly used to block public internet hotspots and business networks where larger structures and spaces require wireless coverage. WLAN is a type of air transmission that has a speed of up to 54 Mbps to beat Bluetooth and infrared, besides that WLAN has a longer range than other types of air transmission media, to find WLAN tools are also quite widely sold in the market so that to carry out learning and research activities in any case is very supportive[11] [12].

In wheeled robots, the problem faced is still many shortcomings, namely how to make the three robots and one Base Station able to communicate with each other efficiently, and the Base Station communication display used is still displayed on the ubuntu terminal so that it is still difficult to control robots. In order to minimize this problem, a communication system is needed on wheeled robots and the creation of a Graphical User Interface (GUI) pada Base Station to facilitate control of the robot so that the display on the Base Station can be developed and can improve communication on wheeled football robots [13].

This study aims to create a communication system that can help communication between the Referee Box and the robot using the Graphical User Interface (GUI) pada Base Station so that the robot can receive and translate the instructions given from Referee Box. To make the robot able to receive commands from the Referee Box, it requires the help of a Base Station application.

2. Research Method

The Wheeled Robot communication system uses Visual Studio to create a GUI design for the Base Station using the TCP protocol [14][15]. The communication system between robots consists of 2 laptops where 1 laptop acts as a Base Station, the other laptop acts as a Referee box. Initially, the robot is connected to the router using NodeMCU, so that when the game starts, the robot can connect to the router.

2.1. System Design

In this system design, the Base Station will receive data from the Referee Box via a switch, then the Base Station will send Referee Box data to the robot via a Wireless Access Point connected via the Switch. So that the robot and Base Station can exchange data [16]. Furthermore, to find out the command data from the referee box application that is received by the Base Station application and sent to the robot is appropriate or not appropriate. When the game is about to take place, the first thing to do is the Base Station connection to the Referee box. In this test it functions to find out the command data from the referee box application received by the Base Station application and sent to the robot is appropriate or not appropriate. When the match is about to take place, the first thing to do is connect the Base Station to the judge's referee box by saving the IP and entering the referee box code 28097 which will be used during the match. Then after connecting to the Referee box by entering the IP of the laptop used for the Referee box. When the connect button is on the Base Station GUI, an option will appear whether you want to connect to the Base Station ok or cancel and if it is selected ok then the Referee box will appear selecting cyan and magenta teams in the Referee box. So that it can be seen in Fig. 1 is a block diagram of communication system design.

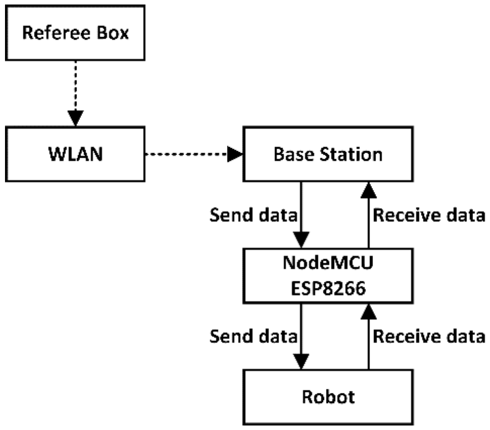

Fig. 1. Design a communication system

In this study, a Base Station application was created that functions to monitor the status where the robot and forward commands from the Referee Box automatically and the robot provides value feedback which includes coordinate values, status, characters from the Referee Box. In order to communicate between the application and the robot, a network connection is needed that will be directly connected to the wheeled soccer robot [17].

2.2. Flowchart Robot Communication System

In the flowchart of the robot communication system where the Referee box will open a connection first as a server, if the Base Station IP has been registered in the Referee box data and the Referee box will be connected to the same network, the Base Station can be connected to the Referee box with port 28097 (default). However, if there is an interruption during the connection or the connection is lost, the base station must reconnect. If the Base Station is successfully connected to the referee box, the next step is to wait for the Base Station to wait for the referee box to determine which team data the Base Station will receive. Can be seen in Fig. 2 is a robot communication system flowchart.

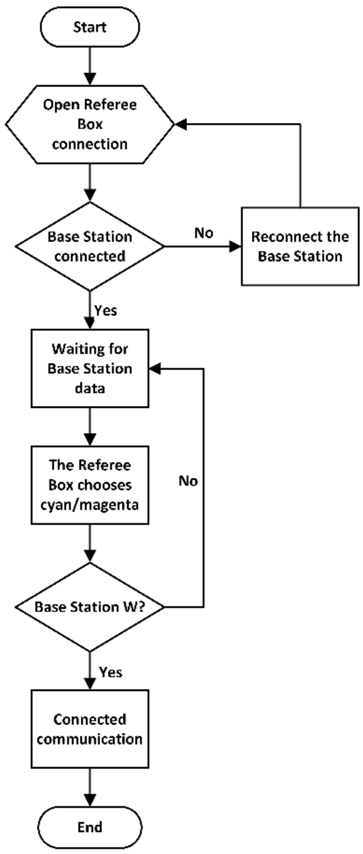

Fig. 2. Communication system flowchart

In this study the Base Station will receive a data char in the form of 'W' if the Base Station is successfully connected to the referee box. Then the Base Station will wait for data again from the Referee box, namely the data that will kick off first. If Base Station receives data 'k' which means the magenta team takes the first kick off, Base Station will carry out an attack strategy and if it receives 'K' data, the cyan team will take the first kick off and carry out a defensive strategy. But if the Base Station does not or has not received the kick off data from the Referee box, the Base Station will wait until it receives the kick off data. After receiving the team kick off data, the Base Station will wait for the start command from the Referee box. If the Base Station has received the start data, the Base Station will carry out the playing strategy according to the team kick off data received earlier and if not, the Base Station will wait until the Referee box sends the start data. Then the Referee box sends stop data, if the Base Station receives stop data, the Base Station will send data 's' to the robot. If the Base Station has not received stop data, the Base Station will wait for stop data from the Referee box

2.3. Base Station GUI Design

Base Station is a computer that runs application software to automatically manage robot work based on orders received from the Referee Box [18]. Base Station coordinates the activities of each robot in playing ball. The Base Station is a PC that is used to forward messages from the Referee Box to the robot, for that situation a multicast group is used. The base station can also be used to filter the state of the robot. In Fig. 3 is a graphical user interface (GUI). There is a first robot group, where each of the groups contains a field image, a referee box group, a manual coordinate group, a player robot group, a ball status group, the first robot group, with each of the groups inside there is a toolbox-toolbox [19] [20].

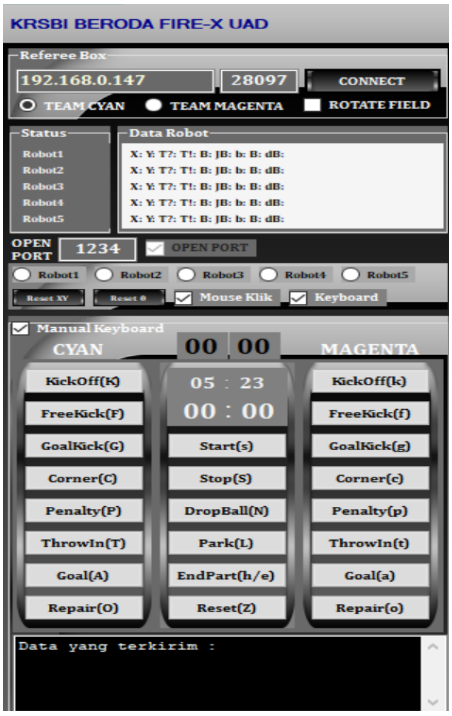

Fig. 3. GUI design on Base Station

In Fig. 3 is the button feature used on the Base Station. The following is an explanation of each button in the Base Station application:

- 6 main instructions:
  a) Start = s (Orders the robot to move)
  b) Stop = S (Orders the robot to stop)
  c) Drop ball = N (when the robot is dead lock)
  d) Park = L (When the game ends)
  e) End Part = h/e (When the first chapter is over)

   f) Reset = Z (To reset the referee box)

- 8 Instructions on team cyan and team magenta:
  a) Kick off = K/k (Initial positioning)
  b) Free kick = F/f (free kick)
  c) Goal kick = G/g (Ball over goal)
  d) Corner = C/c (corner kick)
  e) Penalty = P/p (White point kick)
  f) Throw in = T/t (Throw the ball in)
  g) Goal = A/a (goals for the team)
  h) Repair = O/o (Robot is damaged and must be repaired)
- Group referee box:
  a) Combo box IP Address = Enter the IP referee box
  b) Combo box PORT = Enter the PORT referee box
  c) Connect = Make a connection to the referee box
  d) Team cyan = Connection to team cyan
  e) Magenta team = Connection to the magenta team
  f) Rotate field = Connection failed
- Group Box Robots:
  a) Robot status = Many robots are used
  b) Robot data = Monitoring data sent by robots
  c) Check box connection = Connection status of the robot used
  d) Timer = Game time
  e) Score = Number of goals in the match
  f) Text box monitor = Displays data received from the referee box and sent to the robot

3. Result and Discussion

In testing this serves to find out the command data from the referee box application received by this is used to check the correctness of the command data from the referee box application received by the Base Station application and sent to the robot. In this test, it was carried out to find out how the communication system works by using the Microsoft Visual Studio application as a GUI creation on the Base Station and by using the multicast method as the Base Station communication and referee box with socket programming used is TCP (Transmission Control Protocol).

3.1. Testing of application Data Transmission Communication Feferee Box, Base Station and Robot

In testing this data transmission aims to find out the data sent from the referee box to the Base Station is actually sent to the robot on the main menu command. The results of system testing can be seen in Tables 1, 2 and 3.

Table 1. Main menu test results on the Referee Box application

Trial	Order Referee Box	Display on Base Station	Display on the robot	Information
1	START	s	s	Succeed
2	STOP	S	S	Succeed
3	DROPBALL	N	N	Succeed

In the test results Table 1, the referee box tries to send the main menu with commands, namely Start, Stop, Dropball, Park, and EndPart. Then it can be shown that the data sent by the Referee Box to the Base Station and sent to the robot. For example, the START command which is represented by the character 's' and received by the Base Station is also 's' and then sent to the robot so that the final result of the data received from the robot to the Base Station is 's'.

Table 2. Test results on the cyan menu on the Referee Box application

Trial	Order Referee Box	Display on Base Station	Display on the robot	Information
1	Kick Off	K	K	Succeed
2	Free Kick	F	F	Succeed
3	Goal Kick	G	G	Succeed
4	Throw In	T	T	Succeed
5	Corner	C	C	Succeed
6	Penalty	P	P	Succeed
7	Goal Cyan	A	A	Succeed

In the test results of Table 2 the referee box tries to send a cyan menu with commands namely Kick off, Free kick, Goal kick, Throw in, Corner, Penalty and Goal cyan. Then it can be shown that the data sent by the Referee Box to the Base Station and sent to the robot. For example, the Free Kick command is represented by the character 'F' and is received by the Base Station as well as 'F' and then sent to the robot and the final result of the data received from the robot to the Base Station is 'F'.

Table 3. Hasil testing on the magenta menu in the Referee Box application

Trial	Order Referee Box	Display on Base Station	Display on the robot	Information
1	Kick Off	k	k	Succeed
2	Free Kick	f	f	Succeed
3	Goal Kick	g	g	Succeed
4	Throw In	t	t	Succeed
5	Corner	c	c	Succeed
6	Penalty	p	p	Succeed
7	Goal Magenta	a	a	Succeed

In the test results of Table 3 the referee box tries to send a magenta menu with commands namely Kick off, Free kick, Goal kick, Throw in, Corner, Penalty and Goal magenta. Then it can be shown that the data sent by the Referee Box to the Base Station and sent to the robot. For example, the Kick off command is represented by the character 'k' and is received by the Base Station also 'k' and then sent to the robot, and the final result of the data received from the robot to the Base Station is 'k'. So from the above experiment, we can conclude that data sent from the referee box and received by the robot from the Base Station is marked with a success statement. In the above studies, the success rate was 100%.

3.2. Test the speed of transmission of data transmission

This test was carried out to determine the average speed of transmission or delay in sending communication data by using Wire Shark software. So that it can monitor and capture data traffic on the Base Station and referee box. The results of system testing can be seen in Table 4.

From the results of Table 4, the transmission of data transmission shows that data is sent from the Referee box to the Base Station where each time a data transmission is obtained, the average duration of transmission time or transmission time with a range of 2 meters is 0.045 ms, for transmission time with a range of 4 meters is 0.048 ms , for a transmission distance of 6 meters is 0.048 ms, for a transmission distance of 12 meters is 0.049 ms, and for a transmission distance of 15 meters is 0.050 ms.

Table 4. Transmission Time of sending data over the extended distance on the TCP Protocol

Test to	Transmission Time (ms)					Received data packets
	Distance 2 Meters	Distance 4 Meters	Distance 6 Meters	Distance 12 Meters	Distance 15 Meters	
1	0.053	0.054	0.052	0.055	0.052	k (kick off)
2	0.045	0.050	0.040	0.043	0.053	f (free kick)
3	0.042	0.047	0.045	0.046	0.053	g (goal kick)
4	0.039	0.045	0.052	0.046	0.053	t (throw In)
5	0.050	0.054	0.049	0.052	0.048	c (corner)
6	0.044	0.042	0.050	0.050	0.042	p (penalty)
7	0.045	0.040	0.053	0.054	0.054	a (goal cyan)
8	0.041	0.053	0.044	0.048	0.043	S (stop)
Average	**0.045**	**0.048**	**0.048**	**0.049**	**0.050**	

3.3. Test the Accuracy of X, Y and Angular Data Coordinates on the Robot

This test functions to determine the accuracy of the coordinates for sending robot data received by the Base Station application. The data sent is in the form of robot coordinate values, namely X, Y and angles. The following are the test results of the accuracy of sending data for robot motion in the Base Station application with 5 experiments. So that data can be obtained from the robot and sent to Base Station as shown in Tables 5, 6, 7 and 8.

Table 5. Test results for the accuracy of sending data for forward robot motion

NO	Display on the robot			Display on the Base Station			Information
	X	And	Corner	X	And	Corner	Succeed
1	-101	5	356	-101	5	356	Succeed
2	-101	-6	1	-101	-6	1	Succeed
3	-105	5	1	-105	5	1	Succeed
4	-101	1	357	-101	1	357	Succeed
5	-110	4	359	-110	4	359	Succeed

Based on Table 5 is the result of sending data from the robot with forward motion then the data is sent to the Base Station with 5 trials. Where the robot sends 5 data packets and it can be seen that the data sent by the robot is the same as the data received by the Base Station. So, the percentage of success is the number of success rates divided by the number of trials. From the results above, it is obtained that the communication results in sending robot data to the Base Station is a success rate of 100%.

Table 6. Test results for the accuracy of sending data for the robot's backward motion

NO	Display on the robot			Display on the Base Station			Information
	X	And	Corner	X	And	Corner	Succeed
1	101	6	1	101	6	1	Succeed
2	105	0	1	105	0	1	Succeed
3	102	0	5	102	0	5	Succeed
4	102	-3	2	102	-3	2	Succeed
5	109	-3	1	109	-3	1	Succeed

Based on Table 6 is the result of sending data from the robot with forward motion then the data is sent to the Base Station with 5 trials. Where the robot sends 5 data packets and it can be seen that the data sent by the robot is the same as the data received by the Base Station. So, the percentage of success is the number of success rates divided by the number of trials. From the results above, the results of communication in sending robot data to the Base Station is a success rate of 100%.

Table 7. Test results for the accuracy of sending data for the robot moving right

NO	Display on the robot			Display on the Base Station			Information
	X	And	Corner	X	And	Corner	Succeed
1	-2	-101	359	-2	-101	359	Succeed
2	-3	-101	5	-3	-101	5	Succeed
3	-3	-105	3	-3	-105	3	Succeed
4	-6	-105	5	-6	-105	5	Succeed
5	-5	-100	5	-5	-100	5	Succeed

Based on Table 7 is the result of sending data from the robot with forward motion then the data is sent to the Base Station with 5 trials. Where the robot sends 5 data packets and it can be seen that the data sent by the robot is the same as the data received by the Base Station. So, the percentage of success is the number of success rates divided by the number of trials. From the results above, the results of communication in sending robot data to the Base Station is a success rate of 100%.

Table 8. Test results for the accuracy of sending data for left sliding robot movements

NO	Display on the robot			Display on the Base Station			Information
	X	And	Corner	X	And	Corner	Succeed
1	-6	110	352	-6	110	352	Succeed
2	7	104	355	7	104	355	Succeed
3	2	101	355	2	101	355	Succeed
4	-6	110	352	-6	110	352	Succeed
5	7	104	355	7	104	355	Succeed

Based on Table 8 is the result of sending data from the robot with forward motion then the data is sent to the Base Station with 5 trials. Where the robot sends 5 data packets and it can be seen that the data sent by the robot is the same as the data received by the Base Station. So, the percentage of success is the number of success rates divided by the number of trials. From the results above, the results of communication in sending robot data to the Base Station is a success rate of 100%.

4. Conclusion

In the results obtained from the process of testing the communication test between the referee box, the Base Station application and the robot it is proven that the data sent and received have the appropriate similarity and the test rate is 100%. The TCP protocol can be used for communication systems between Referee Box computers, Base Station computers, and Robots using a WLAN network with a range of 2 meters, an average transmission time of 0.045343125 is obtained, 4 meters obtains an average transmission time of 0.048674375 ms, 6 meters obtained an average transmission time of 0.04870825 ms, 12 meters obtained an average transmission time of 0.049678375 ms and 15 meters obtained an average transmission time of 0.050467125 ms. From the results of testing the transmission time or delay, it can be seen that the farther the data transmission distance, the greater the average transmission or delay. The results obtained from testing the accuracy of the coordinates of the robot data with the Base Station application, it is evident from several experiments that have been carried out that sending robot data to the Base Station application remains the same with a success rate of 100%.

References

[1] M. R. Prasetyo, I. K. Wibowo, M. M. Bachtiar, R. A. Priambudi, K. Anwar and P. B. K. Segara, "Implementation Voice Command System for Soccer Robot ERSOW," *2020 International Electronics Symposium (IES)*, pp. 247-252, 2020.

[2] A. Latif, K. Shankar, and P. T. Nguyen, "Legged fire fighter robot movement using PID," *Journal of Robotics and Control (JRC)*, *1*(1), 15-19, 2020.

[3] A. Rivina, "Designing a Play Strategy on a Final Project," 2018.

[4] T. Ardhiansyah, I. Syarifuddin, M. R. Naufal, Y. Pramono, and O. T. Hartatik, "Automatic Movement of Wheeled Football Robots Through Communication with Referee Boxes Using Base Station," pp. 978–602, 2017.

[5] A. Jalil, "Robot Operating System (Ros) And Gazebo As Interactive Robot Learning Medium," Ilk. J. Ilm. , vol. 10, no. 3, pp. 284–289, 2018.

[6] J. E. Gómez, D. C. Corrales, I. D. López, J. A. Iglesias and J. C. Corrales, "Incremental Versus Non-Incremental Learning in Volcano Monitoring Tasks: A Systematic Review," *2018 Seventeenth Mexican International Conference on Artificial Intelligence (MICAI)*, pp. 51-59, 2018.

[7] D. Susianto and A. Rachmawati, "Network Implementation and Analysis Using Wireshark, Cain and Abels, Network Minner," J. Cendikia, vol. 16, pp. 120–125, 2018.

[8] M. B. Satriyo, K. Anam, and M. A. P. Negara, "Wheeled Football Robot Control System using Finite State Machine (FSM)," *ELKOMIKA J. Tek. Electrified energy. Tech. Telecommun. Tech. Electron*, vol. 9, no. 2, p. 344, 2021.

[9] Nasron, I. Salamah, and W. Rahman, "Application of Web Base as Controller and NodeMCU 1 . 0 (esp-8266) as a medium of communication on the control of a wheeled football goalkeeper robot," *semin. Nas. Science and Technology. Terap. VII 2019*, vol. 0, pp. 1–8, 2019.

[10] A. Satya Putra, A. Aribowo, and H. Tjahyadi, "Development of Wireless Communication Systems for Controlling Football Robots," J. RESTI (Sist. and Technol Engineering. Information), vol. 2, no. 2, pp. 444–451, 2018.

[11] P. Yuliyanti and R. Sirait, "Design and Analysis of Data Communication Systems Between Two Wheeled Football Robots Using Wifi," vol. 1, no. 2, p. 289, 2018.

[12] J. Ma, and T. S. Dahl, “A Cross-Platform Tactile Capabilities Interface for Humanoid Robots,” *Frontiers in Robotics and AI*, vol. 3, no. 17, 2016.

[13] F. Tjoanapessy et al. , "Base Station Applications For Wheeled Football Robots," *J. Tech. Inform*., vol. 14, no. 3, pp. 285–290, 2019.

[14] N. Rezkinanda and R. Anggoro, "Development of the AODV Multicast Protocol by Accounting for Euclidean Distances Based on Position, Speed and Transmission Delay on VANET," *JUTI J. Ilm. Technol. Inf.* , vol. 15, no. 2, p. 140, 2017.

[15] D. A. Widhining Kusumastutie and F. A. Fiolana, "Designing a Wheeled Football Robot Coordination System at the Base Station Using TCP/IP," *JEEE-U (Journal Electr. Electron. Eng. UMSIDA*, vol. 4, no. 1, 2020.

[16] E. A. Habibie and M. Muskhir, "Designing Goalkeeper Robot Monitoring Through Access Points as a Robot Control Medium," *JTEIN J. Tek. Electro Indones.*, vol. 2, no. 1, pp. 113–118, 2021.

[17] S. Yu, "Arduino based Balancing Robot," *2019 International Conference on Electronics, Information, and Communication (ICEIC)*, Auckland, pp. 1-2, 2019.

[18] Z. -q. Zhang, N. -n. Zhang and H. Yu, "Research on Decision Model of Soccer Robot System," *2018 IEEE/ACIS 17th International Conference on Computer and Information Science (ICIS)*, pp. 831-835, 2018.

[19] R. Dikarinata, I. K. Wibowo, M. M. Bachtiar and M. A. Haq, "Searching Ball Around ROI to Increase Computational Processing of Detection," *2020 International Electronics Symposium (IES)*, pp. 207-212, 2020.

[20] K. Jahnavi and P. Sivraj, "Teaching and learning robotic arm model," *2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)*, pp. 1570-1575, 2017.