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Integration of Robotic Education and Islamic Religious Education through the Line Follower Robot Working Model

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A B S T R A K

Teknologi robotik dapat dirancang sebagai inovasi yang menarik dalam pembelajaran pendidikan agama Islam. Penelitian ini mengimplementasikan inovasi teknologi robotik dengan model kerja robot line follower. Model kerja ini digunakan sebagai media pembelajaran pada materi akhlak yang meliputi akhlak terpuji (al-akhlaq al-mahmudah) dan akhlak tercela (al-akhlaq al-mazmumah). Penelitian ini menggunakan metode rancang bangun dimana hasil akhirnya adalah suatu produk. Perancangan produk meliputi perancangan garis pemandu robot line follower dan perakitan sistem perancangan robot line follower berdasarkan hasil analisis kebutuhan perangkat. Hasil implementasi perancangan garis pemandu line follower direalisasikan pada kertas Flexi dengan ukuran panjang 3 meter dan lebar 2 meter. Hasil implementasi rakitan sistem perancangan robot line follower berupa rangka fisik/robot, rangkaian sistem perangkat keras elektronik, dan program yang dibangun menggunakan bahasa C dengan compiler CodeVision AVR. Berdasarkan uji kinerja robot line follower dapat disimpulkan bahwa sistem perancangan secara keseluruhan telah berhasil direalisasikan.

A B S T R A C T

Robotic technology can be designed as an interesting innovation in learning Islamic religious education. This study implements robotic technology innovation with a line follower robot working model. This working model is used as a learning media on moral topics which includes praiseworthy morals (al-akhlaq al-mahmudah) and despicable morals (al-akhlaq al-mazmumah). This research uses a design-build method where the end result is a product. Product design includes designing a line follower robot guideline and assembling a line follower robot design system based on the results of analyzing device requirements. The results of the implementation of the line follower guideline design are realized on Flexi paper with a size of 3 meters long and 2 meters wide. The results of the implementation of the line follower robot design system are in the form of a physical frame/robot, a series of electronic hardware systems, and a program built using the C language with the Code Vision AVR compiler. Based on the performance test of the line follower robot, it can be concluded that the overall design system has been successfully realized.

1. Introduction

As emphasized in Indonesian Government Regulation No. 55 of 2007, Islamic Religious Education prepares students to become people of faith, piety, and noble character and maintain harmony [1]. This means as a subject labelled as religious education, Islamic Religious Education has a spiritual transmission that is more real than general subjects. As a compulsory subject at all levels of formal education [2], some experts consider that learning Islamic Religious Education can make students become righteous individuals [3]. Lately, Islamic religious education studied in schools is also expected to be a subject that can equip students to become moderate and tolerant students [4]–[6].

Although essential for students, several problems related to the learning process of Islamic Religious Education are still frequently encountered and need to be resolved. According to Muhaimin [7], the problems of Islamic Religious Education are concentrated in the learning process that pays little attention to the strategy of internalizing cognitive knowledge into meaning and value in each student. This phenomenon can be interpreted that the learning process of Islamic Religious Education is still conventional, without a touch of creation and innovation. In fact, along with the rapid development of products and the use of technology, the conception of implementation of learning has shifted to the embodiment of modern learning. Therefore, support related to pedagogical developments in learning Islamic Religious Education must be continued [8].

One of the contexts for the embodiment of modern learning is to bring together (integration-interconnection) religious knowledge with science-technology. This study tries to apply the integration-interconnection of Islamic Religious Education learning with robotic technology. The basis of this study is that in several previous studies, the application of technological integration or innovation in Islamic Religious Education learning was limited to maximizing Information Communication and Technology (ICT) [9], [10] through internet-based learning [11], [12] or Augmented reality [13]. Implementing the integration-interconnection of Islamic Religious Education learning and robotic technology is still rarely disclosed. Another basis is that robotic technology has provided many conveniences and advantages in various fields. Without us knowing it, robotic technology has been diffused in everyday life in various types and forms. This means that robotics is an interesting technology to be developed.

In this study, the interdisciplinary approach and the interconnectivity of Islamic Religious Education learning and

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robotic technology were realized as a line-follower robot working model. A line follower robot is a moving robot (mobile robot), which is classified as intelligent because it can work automatically without requiring manual human control. This robot works with a system to detect the guideline based on the intensity of light reflected from the surface it is traversing, which is then read by the sensor [14]. Many of these robots are designed for physical/mechanical work [15], [16], industry [17], educational research [18], to the health sector [19].

The working model of the line follower robot in this study is used as an educational medium to realize the function of Islamic Religious Education in preparing students to become people of noble character. In eleven countries, it is stated that the main cause of economic and civilizational backwardness in a nation is the decline of ethics and morals upheld by society [20]. The study results show that learning integrated with robotics can attract interest and increase student learning motivation [21], [22].Therefore the line follower robot working model is implemented in the scope of good morals (*al-akhlaq al-mahmudah*) and bad morals (*al-akhlaq al-mazmumah*), because one of the references for the success of learning Islamic Religious Education is the morals of students, especially at the level of primary school.

The working model design features a line follower robot that moves automatically following the guideline/track. Along the guidelines, several boards are read as good and bad morals. The guideline will lead to one final point, namely heaven. In the working model, it will be shown, through artificial intelligence, whether the robot can move towards the final point (analogy of heaven) or not. The robot's movement is determined through the number of boards of good and bad morals that it passes along the guideline.

2. Experimental Procedure

This study uses the design-build method. The flow chart of the work stages is shown in Figure 1.

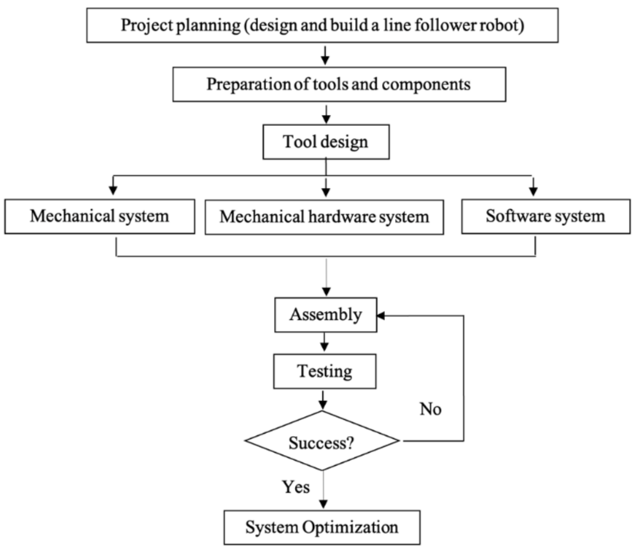

Figure 2. Flowchart of Design and Build Work Stages

2.1. *Devices and Components*

Several devices and components are used in making line follower robots; those are hardware devices and software tools. The hardware devices required for the design of the line follower robot can be seen in the following Table 1.

Table 1. *Hardware* robot *line follower devices*

No	Device	Function
1	Arduino microcontroller	Robot movement controller
2	DC Motor	Robot Walker
3	DC Motor Driver	DC motor rotation speed controller
4	Line Sensor (LED and Photodiode)	Guideline detector
5	Color Sensor	Detects the color of the morals board and triggers the robot's automatic motion and movement toward the destination point
6	Acrylics and Wheels	Robot Frame
7	Battery	Power Supply

Meanwhile, the software tools needed to support the work of the hardware devices are Windows-based operating systems and programming languages (C Language).

2.2. *Designing*

At the designing stage, there are two activities carried out, those are designing the guideline and designing the line follower robot system based on the results of the device requirement analysis.

1) Designing *guideline*

The robot guideline is a black track with a width of 2 cm and a white base. The line follower robot moves based on a trajectory, wherein the trajectory is a black line with a certain width and a white background [23]–[25].

2) *Designing System*

In outline, the line follower robot design system includes:

a) Mechanical System Design: Things that must be considered in designing the mechanical systems are the selection of materials and robot construction. Material selection will greatly affect the robot's construction (strength, weight, and durability).
b) Electronic Hardware System Design: Electronic hardware systems are composed of electronic circuits based on component functions to form robot work. The circuits contained in the electronic hardware system are sensor circuits, minimum system circuits, and DC motor driver circuits.
c) Software System Design: Software system design is made to control the work of each System. The software system was built using the C language with the Code Vision AVR compiler.

2.3. *Assembling*

The assembly is based on the design that has been designed for the mechanical System, electronic hardware system, and software system. During the assembling stage, tools and components must be installed in the correct place and position to avoid short circuits in the system circuit. The assembly must also be carried out carefully and thoroughly because both at the input and the output, there are electrical devices that will conduct electric current if a voltage is applied.

2.4. *Testing*

The test is intended to see the design accuracy and performance of the mechanical system devices, electronic hardware systems, and software systems after being integrated into a line follower robot. In this case, ensuring performance between devices in the System can provide correct input processing results and provide expected behavior and output.

3. Result And Discussion

3.1 *Guideline Design Implementation Results*

The line follower robot guideline design is implemented on Flexi paper with a length of 3 meters and a width of 2 meters (Figure 2).

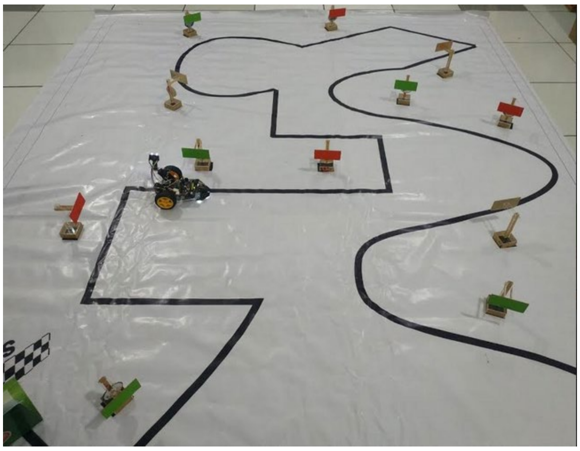

Figure 2. Moral boards placed on a flexible paper and at the side of the guideline

In this study, the guideline is used as the track for the line follower robot performance test, wherein the side of the track is designed with three conditions with the principle that the line follower robot can distinguish different colors.

1) *First Condition*

Several good morals boards are placed along the side of the track. The maximum number of good morals boards that can be placed is 15 pieces. The side of the track is designed like this to test the ability of the line follower robot to detect the color of the good morals board, which is green. In this case, the artificial intelligence reads the color of the board, and the result of this condition is realized as an automatic movement of the line follower, which will move toward the final point (analogy of heaven).

2) *Second Condition*

Several bad morals boards are placed along the side of the track. The maximum number of bad morals boards that can be placed is 15 pieces. The side of the track is designed like this to test the ability of the line follower robot to detect the color of the bad moral's boards, which is red. In this case, the artificial intelligence reads the color on the board, and the result of this condition is an automatic movement of the line follower robot, which will not move toward the final point (analogy of heaven).

3.2 *Results of Implementation of Line Follower Robot System Design*

The results of the implementation of the line follower robot system design can be seen in Figure 3.

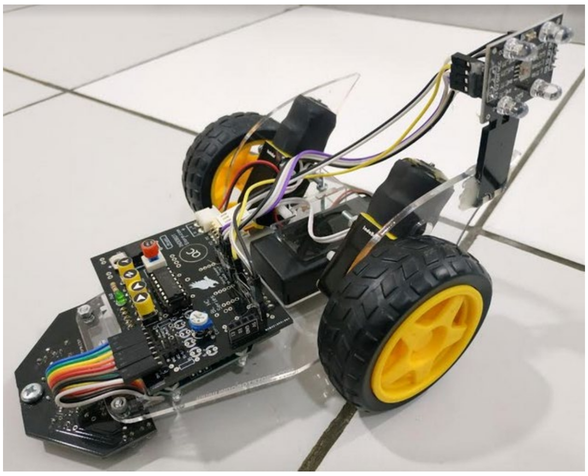

Figure 3. Line follower Robot System

The results of the implementation of the line follower robot system design are as follow:

1) *Mechanical System Implementation Result*

The result of implementing the mechanical system design is in the form of a physical robot framework. In general, the robot's physical form is in the form of a car frame with two wheels. The framework function is as a place or holder for all robot components (the entire electronic hardware circuit is neatly arranged according to its function).

The material used for the robot frame is acrylic. Acrylic is a type of transparent plastic that is like glass but is more elastic, lighter, malleable, and not easily broken. This material is often used to manufacture line follower robot frames [26], [27].

2) *Electronic Hardware System Implementation Results*

Electronic hardware systems are composed of electronic circuits based on component functions to form the robot's work. The circuits contained in the electronic hardware system are as follows:

a) Sensor Circuit (Line Sensor and Color Sensor) as the Input; The line sensor is a part of the line follower robot, which detects a line on a surface or not. Therefor the line sensor is placed face down as close as possible to the surface. The line follower robot's line sensor consists of two main components, namely the LED as a light emitter and a photodiode as a light receiver. Light Emitting Diode (LED) will emit light if given a 5-volt voltage from the robot's power supply. If the emitted light hits the white surface/line, it will be reflected and received by the photodiode. However, if the light emitted by the LED hits a black surface/line, it will be absorbed by the black color from that surface; as a result, the photodiode does not receive the reflected light emitted by the LED. The results of the difference in the intensity of the reflected light received by this photodiode are then represented as line follower robot parameters in detecting surfaces and lines; then, the robot will determine its next movement [23].

The color sensor is used to detect the color of good morals boards (green) and bad morals boards (red), which are passed by the line follower robot when it is traversing along the track. In this case, the sensor detects color through a scanning process on the object so that a frequency value is obtained based on the red, green, and blue pigments and the light that is reflected from the object. Furthermore, the frequency value of each light and pigment content is then averaged, resulting in a single-color value which is the basis for color determination. The use of color sensors in line follower robots has also been done with RGB color sensors before [28].

b) Minimum System Circuit as Control Center/Input Processing; The minimum system circuit is made to operate the microcontroller. That is, without a minimum system circuit, a microcontroller cannot function. The minimum system circuit is generally connected to other circuits to carry out certain functions. In this study, the minimum system circuit consists of: first, a reset system which is used to automatically reset the microcontroller so that it can re-execute the program from the beginning. Second, the oscillator circuit functions as a clock source. Third, a series of ports (I/O) that function as microcontroller input-output controllers. Arduino can be used to perform this function [29].

c) DC Motor Driver Circuit as Output Controller; The output power of the microcontroller is very small; as a result, it cannot drive the line follower robot. Therefore, the microcontroller is embedded with a motor driver circuit that controls the direction of rotation and speed of the DC motor. The DC motor rotation direction controls in the form of clockwise or counterclockwise movement [30], [31]. The function of the control system is to transmit control signals in the form of logic or pulses at the input.

The entire electronic hardware system consists of input, process (controller), and output (Figure 4).

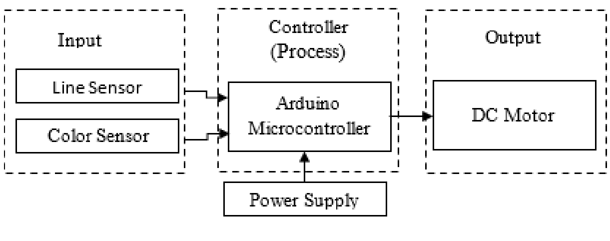

Figure 4. Hardware System Block Diagram

The input media as a robot movement controller comes from the line and color sensors. The input data is in the form of information as an analog signal. In the processing stage, analog signals are converted into digital signals by translating the information into coded letters and symbols by the microcontroller as the control center. Furthermore, after the input and process are executed; as a result, the DC motor will function as a driving force for the robot to move. The microcontroller can control DC motor rotation [32].

3.3 *Software System Implementation Results*

The results of the software system design implementation consist of program algorithms in the form of flowcharts and program scripts to execute mechanical system design and electronic hardware system. The results of the software system design implementation in the form of a flowchart can be seen in Figure 5.

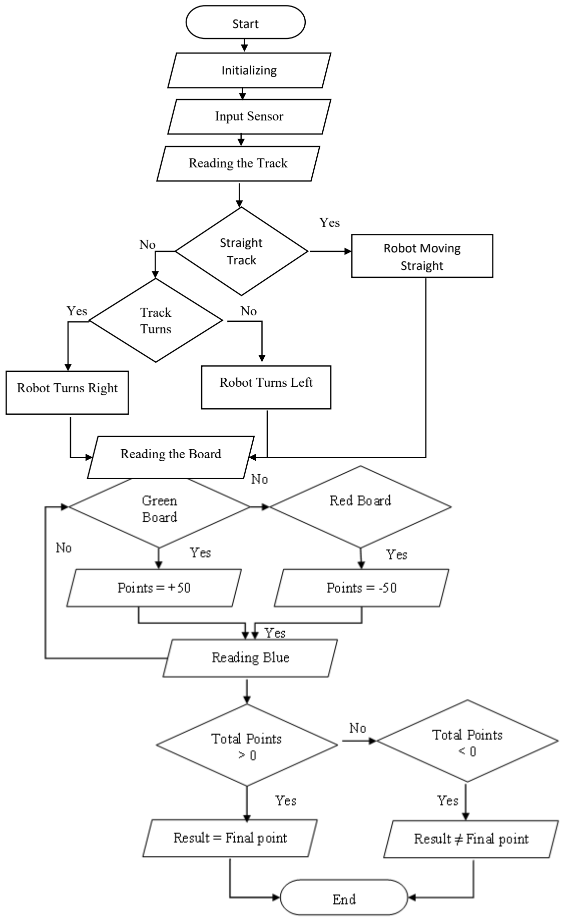

Figure 5. Flowchart of the Program Algorithm

The flowchart in Fig. 5 begins by turning on the line follower robot first. Then the line follower robot is placed on a black guideline track. The robot will detect the track's color through the line sensor in this case. After that, the line follower robot will detect the color of good and bad moral boards through the color sensor. In the end, through artificial intelligence analysis, the line follower robot can decide what action to take next and move automatically whether it is moving towards the final point or not.

The results of the software system design implementation are in the form of a program script containing the initialization of the microcontroller pins, which will be the input and output of the program. Initialization of the input pin is required to activate the output pin function. The following is an example of the program script that was created:

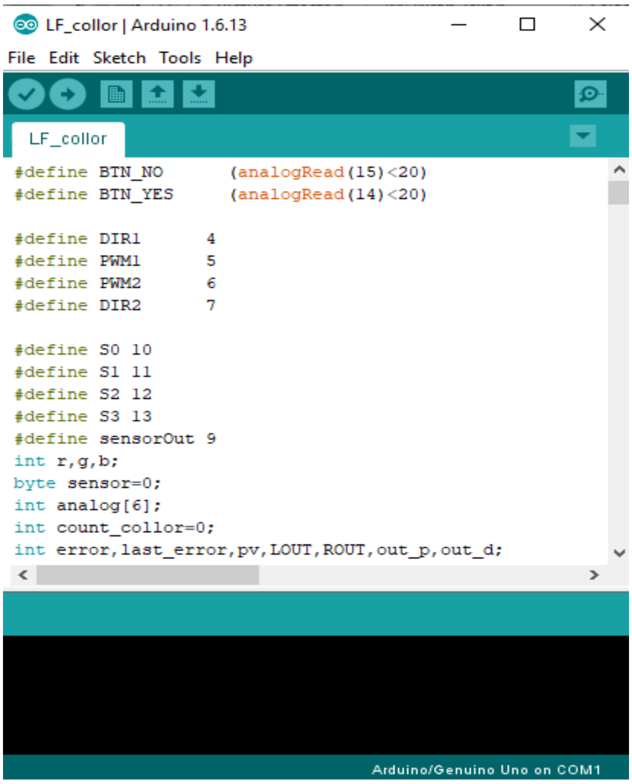

Figure 6. Program script 1

Explanation of the program script in Fig. 6:

a) **#define S0 10** initializes pin 10 on the Arduino as pin S0 on the color sensor, as well as for #define S1 and #define sensor Out.
b) **Int r,g,b**; create new terms r, g, b, and are used to initialize the color sensor's red, green, and blue values.
c) **Sensor bytes = 0**; creates a new term "sensor" and sets its normal value as 0.

The program script 1 is an example of initializing the robot's guideline. int peka[] = {,,,,,}; means creating a new term 'peka' to set the sensitivity of the robot's sensor to the guide line/track. In this case, the artificial intelligence will analyse the track, and the robot will automatically move and walk straight, turn right, or turn left based on the analysed result.

The program script 2 in Fig. 7 is an example of initializing the color of good morals (green) and bad morals (red). int detect red [] = {,,,}; means creating a new term 'detect red' as a condition for reading the color 'red' on the color sensor, as well as setting the required combination of color detection values for red, green and blue to make the color reading statement 'red color'. This same principle also works for int detect green and int detect blue.

r

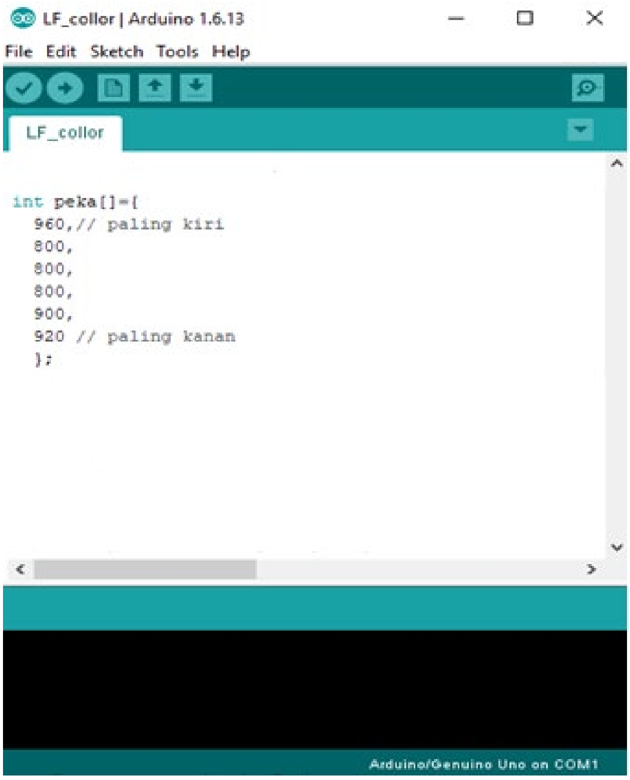

Figure 7. Program script 2

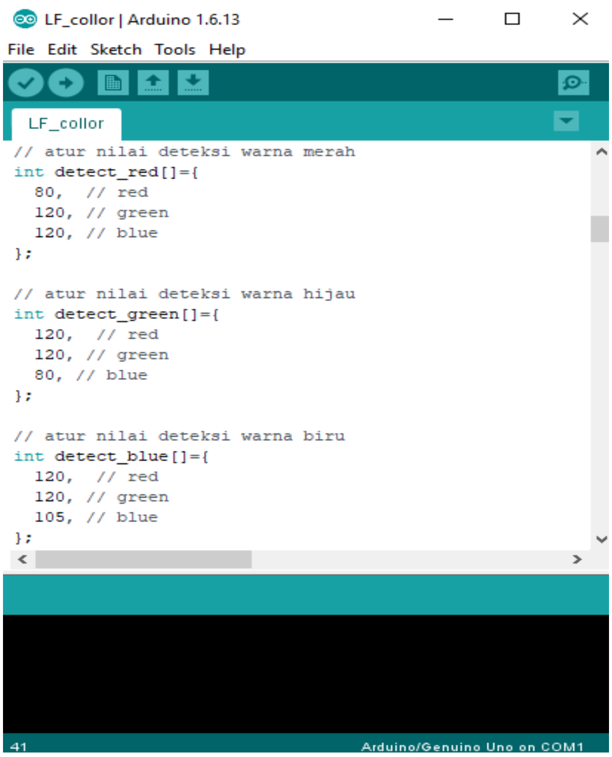

Figure 8. Program script 3

In the program script 3 in Fig. 8 shows void detect_color () {} means to create a new term 'detect_color and make a color reading statement on the colo sensor according to the conditions made in int detect red. The color will read as 'red' if the red value is less than the conditional red value and the green and blue color values are greater than the green and blue conditional values. This same principle also works for int detect green and int detect blue.

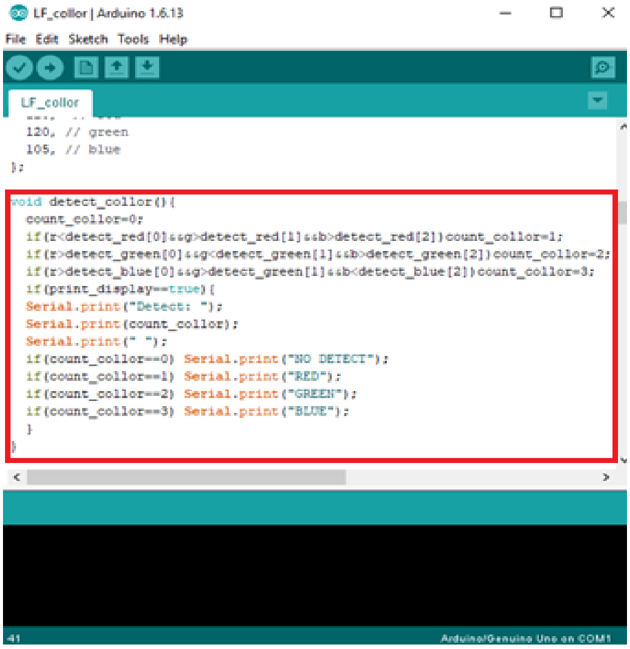

Figure 9. Program script 4

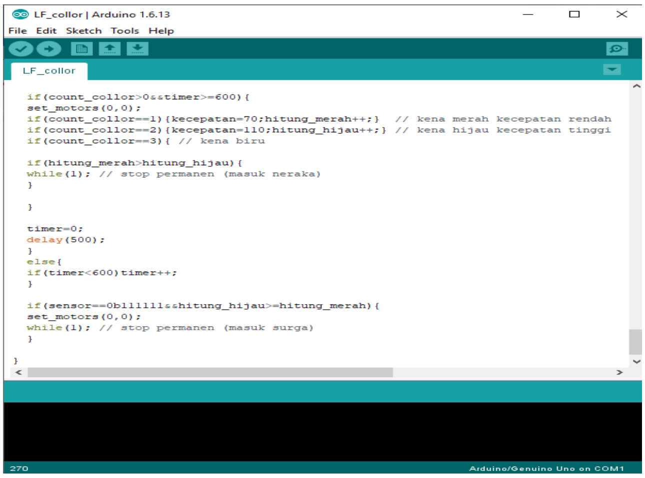

Figure 10. Program script 5

The program script 4 (Fig. 9) is an example of artificial intelligence initialization in automatic movement, whether the robot will move toward the final point.

Explanation of script 5 (Fig. 10):

a) If (count_collor>0&&timer>=600) {} means to make an action when the robot reads the color of the board.
b) Set_motors (0,0); means to make the robot stop for a moment when reading the color of the moral's boards.
c) If (count_collor==1) {kecepatan=70; hitung_merah++;} means that when the robot reads the red board, the robot's speed will decrease to 70 (normal = 90), and the red points will increase by 1.
d) If (count_collor==2) {kecepatan=110; hitung_hijau++;} means that when the robot reads the green board, the robot's speed will increase to 110 (normal = 90), and the green points will increase by 1
e) If (count_collor==3) {} means that the robot reads a blue board, the robot will take the following actions:
f) If(hitung_merah>hitung_biru) {} means if the total points of red are more than the total points of green, then while (1) // means the robot will stop or not go to the final point/destination.
g) If(sensor==0b111111&&hitung_hijau>=hitung_merah) {set_motors(0,0); meaning that if the total points of red are equal to or less than the total points of green, then while (1) // means that the robot will go to the final point/destination.

The justification mechanism for the assembly accuracy of the overall design system is carried out by testing the performance of the line follower robot. The test results show that the line follower robot follows the trajectory (walks straight, turns right, or turns left). This means that the line follower robot can correctly detect the color of the guideline, which is black. The line follower robot is also precise in detecting differences in the color of good and bad morals boards. In the end, the line follower robot managed to move automatically whether it is moving towards the final point/destination. In this case, the success requirement in testing the line follower robot design system is adjusting lighting conditions. Lighting conditions can be made ideal by minimizing outdoor light that enters the room. Room lighting is controlled by the lights or lamps in the room.

4. Conclusions

The design of the working model of the line follower robot has been successfully implemented on guidelines, mechanical systems, hardware, and software. Based on the contents and discussion described, it can be concluded: (1) The result of implementing the mechanical System is a physical robot of a car frame, (2) The results of the implementation of the electronic hardware system are sensor circuits, minimum system circuits, and DC motor driver circuits, (3) The results of the software system implementation are in the form of a program script that defines the color of the guideline or tracks and defines the color of good and bad morals boards to control the robot's movement, (4) The results of testing the overall design system show that the line follower robot can correctly detect the color of the guideline and the color of the moral boards through room lighting control, (5) The results of the design of robotic technology innovations in this study can be used as alternative media in learning Islamic Religious Education, especially in introducing good and bad morals.

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