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Design of Hexapod Robot Movement Based on Arduino Mega 2560

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Abstract. This study aims to design the movement of the hexapod robot so that it can move straight forward, turn 90 degrees forward, and move forward 180 degrees by applying the tripod gait method to produce a maximum movement pattern. The robot control system uses Arduino Mega 2560 to control the motion of 18 servo motors through the I2C interface servo motor driver - PCA9685. In straight forward motion testing, an average velocity of 6 cm/s was obtained, 90 degree forward motion testing obtained an average speed of 18 degrees/s, while the 180 degree rotational forward motion test also obtained an average speed of 18 degrees/s.

1. Introduction

A robot is a multifunctional machine that can be programmed and designed to be able to move materials, parts, tools, or tools with certain specifics through programmed variable movements to do work from a variety of tasks. The number and types of robots made are increasing. However, based on the motion tool robots are classified into two types, namely wheeled robots and legged robots. Wheeled robots are robots that move with two or more wheels, while legged robots are robots that move with legs. Some are biped, tripod, quadruped, and hexapod [6].

According to the name hexapod robot is a type of mobile robot that moves using six feet, because robots can be statistically stable using three feet so the hexapod robot certainly has higher flexibility. If there is one leg that does not work, then the robot still can run. What is more, not all robot legs are needed for stability, other legs can move freely to find new footing in walking [7].

The design and manufacture of the hexapoda fire fighting robot is in preparation for the Indonesian Robot Contest (KRI) which is routinely held annually by the Ministry of Research, Technology and Higher Education of the Republic of Indonesia. One of KRI's divisions is the Indonesian Fire Extinguisher Robot Contest (KRPAI) in the legged category. There are several hexapod robot foot movement methods, including the ripple gait, wave gait, and tripod gait. However, only the tripod gait method was applied to the hexapod robot legs. In the tripod gait method, the robot runs by lifting three legs at a time and leaving the other three legs as a foothold. Using this method one cycle can be completed in two steps so as to allow the robot to move quickly [3].

The main hexapod robot control system using Arduino Mega 2560 is an Arduino-based microcontroller development board using the ATmega2560 chip. This board has a lot of I/O pins, 54



digital I/O pins (15 of which are PWM), 16 analog input pins, 4 UART pins (serial hardware port).

In each leg the hexapod robot is driven by 3 servo motors, so that the total number of servo motors used is 18. Servo motors are used, namely the type of Hitec HS-645MG servo motor. A servo motor is a motor with a closed feedback system where the position of the motor will be informed back to the control circuit that is in the servo motor. The servo motor consists of a motor, a series of gears, a potentiometer and a control circuit. Potentiometer serves to determine the angle limit of the servo rotation. Whereas the angle of the servo motor axis is set based on the width of the pulse sent through the foot of the signal from the motor cable.

To control these 18 servo motors, PCA9685 16 channel type servo motor driver circuit is used, because 1 maximum servo motor driver can only control 16 servo motors, 2 servo motor driver circuits are used (each servo motor driver set 9 servo motors). With the use of the servo motor driver can save the use of pins on Arduino Mega which is only 2 pieces.

2. Research Methods

The approach in this study uses the Research and Development (R & D) method. Research design includes designing robotic hardware and Arduino software. Development research is often interpreted as a process or steps to develop a new product or perfect an existing product. Products in this context are not always hardware (books, modules, learning aids in classrooms and laboratories), but can also be software (software) such as programs for data processing, classroom learning, libraries or laboratories, or educational models, training, guidance, evaluation, management, etc. The steps of this process are usually referred to as the Research and Development (R & D) cycle, which consists of studying research findings related to the product to be developed, developing products based on these findings, testing fields in settings where they will be used eventually, and revising them for correct the deficiencies found in the stage of submitting the test. In programs that are more stringent than development research, this cycle is repeated until the test data shows that the product meets the defined behavioral objectives [8].

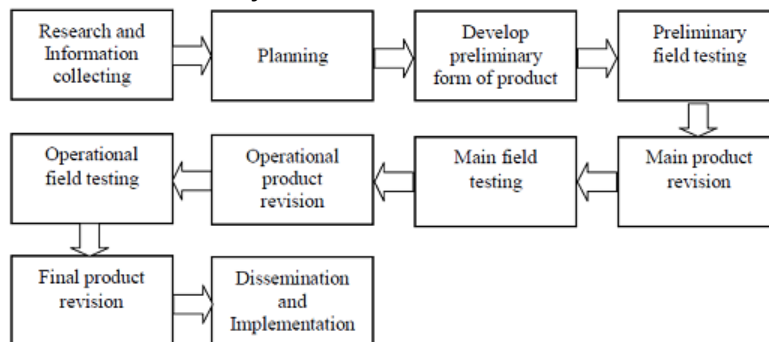


Figure 1. R & D approach according to Borg and Gall [1].

3. Research Design

The design and manufacture of the hexapod robot consists of three stages, between the design of robot mechanics, the design of control systems, and the design of programming algorithms. Robot mechanics are designed with clear acrylic material with a thickness of 5 mm. Each hexapod robot leg is designed to have two segments with three degrees of freedom, namely up and down for the first and second segments, and back and forth for both segments at once.

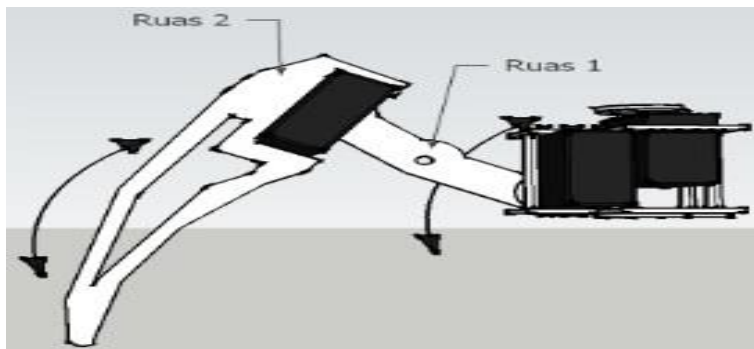


Figure 2. Designing hexapod robot legs for vertical motion [5].

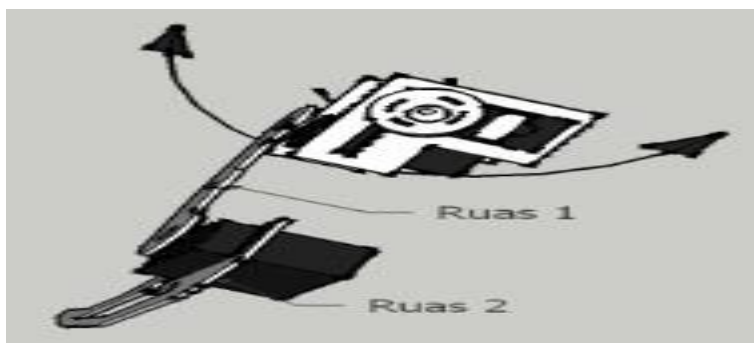


Figure 3. Design of hexapod robot legs for horizontal motion [5].

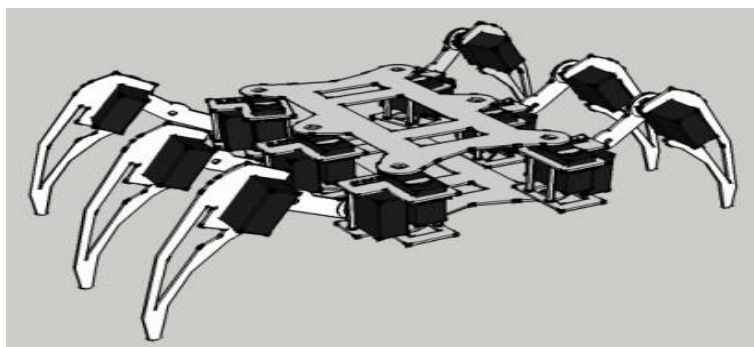


Figure 4. Design of a whole hexapod robot mechanic [5].

On each robot leg is driven by 3 servo motors, so that the total number of servo motors used in hexapod robot mechanics are 18 pieces. One servo motor has 3 pins (Vcc, Gnd, Signal) which are connected to the control system (Arduino Mega). The type of servo motor used is Hitec HS-645MG. A servo motor is a motor with a closed feedback system where the position of the motor will be informed back to the control circuit that is in the servo motor. The servo motor consists of a motor, a series of gears, a potentiometer and a control circuit. Potentiometer serves to determine the angle limit of the servo rotation. Whereas the angle of the servo motor axis is set based on the width of the pulse sent through the foot of the signal from the motor cable.



Figure 5. Servo motor Hitec HS-645MG.

To control the 18 servo motors, PCA9685 16 channel type servo motor driver circuit is used, because 1 maximum servo motor driver can only control 16 servo motors, 2 servo motor driver circuits are used (each servo motor driver set 9 servo motors).

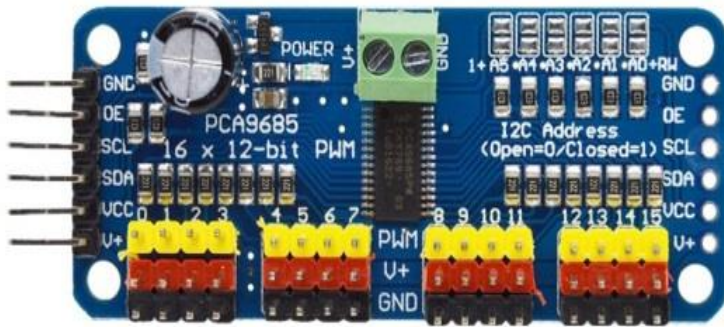


Figure 6. Servo motor driver-PCA9685.

PCA9685 which features 16 PWM channels using only 2 pin i2c/twi ports. Not only that, if 16 PWM channels are still considered lacking, we can still double the number of PWM channels by expanding the PCA9685 module to 62 modules (or equivalent to 992 PWM channels). With the use of the servo motor driver can save the use of pins on Arduino Mega which is only 2 pieces.

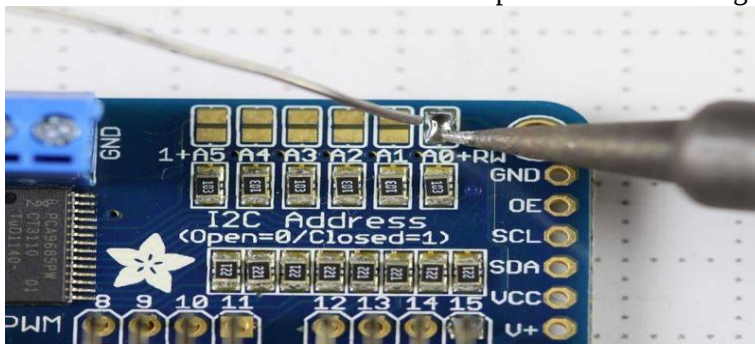


Figure 7. Pins jumper to increase the use of PCA9685 servo motor drivers more than one.

In the design of the hexapod robot control system, Arduino Mega 2560 is used. Arduino Mega 2560 is a controller that uses ATmega 2560 as the processor. Arduino Mega 2560 has 54 pin input and digital output pins. Of the 54 pins, 15 pins are used for PWM output. In addition, there are 16 pins that are used for analog input and for UART (Universal Asynchronous Receiver Transmitter) there are 4 pins.

The power source used for Arduino Mega 2560 is sourced from outside which is obtained from an external power supply. Arduino Mega 2560 can work at a voltage of 6-20 volts. However, if the voltage used exceeds 12 volts, the current that flows will be large so that it will make the PCB (Printed Circuit Board) become hot. Excessive heat can cause damage. If the voltage used is less than 7 volts, the voltage obtained will not be stable. Therefore, the recommended voltage is between 7-12 volts so that the controller can work properly.

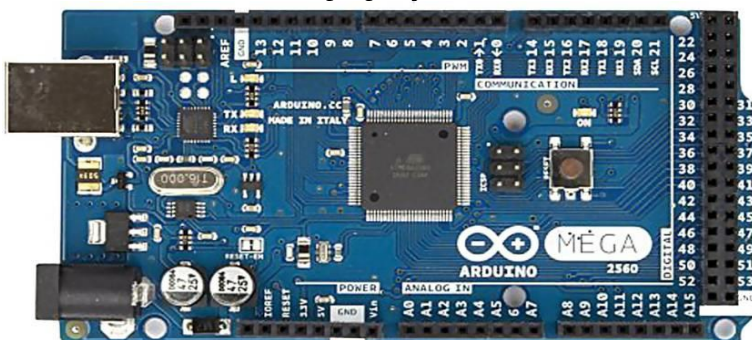


Figure 8. Arduino Mega 2560.

In designing programming algorithms using Arduino (IDE) software. The IDE is Integrated Development Environment, or in easy language it is an integrated environment that is used as development. It is referred to the environment because through this software that Arduino is programmed to perform functions embedded through programming syntax. Arduino uses its own programming language that resembles C. The Arduino (Sketch) programming language has been changed to make it easier for beginners to do programming from the original language. Before being sold to the market, the Arduino microcontroller IC has been implanted a program called bootlader which functions as an intermediary between the Arduino compiler and the microcontroller.

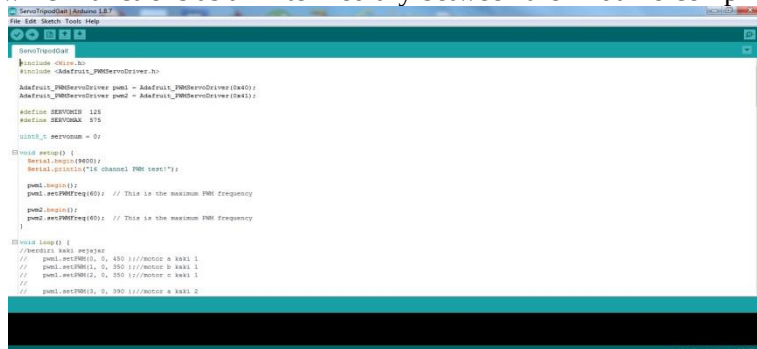


Figure 9. Arduino IDE software.

Arduino IDE is made from the JAVA programming language. The Arduino IDE also comes with a C/C++ library commonly called Wiring, which makes input and output operations easier. This Arduino IDE was developed from Processing software which was overhauled into an Arduino IDE specifically for programming with Arduino.

Before programming using the Arduino IDE, the hexapoda robot movement pattern was first designed. The hexapod robot movement pattern is designed so that it can move straight forward, turn forward, and move forward with maximum movement patterns. There are several hexapod robot foot movement methods, including the ripple gait, wave gait, and tripod gait.

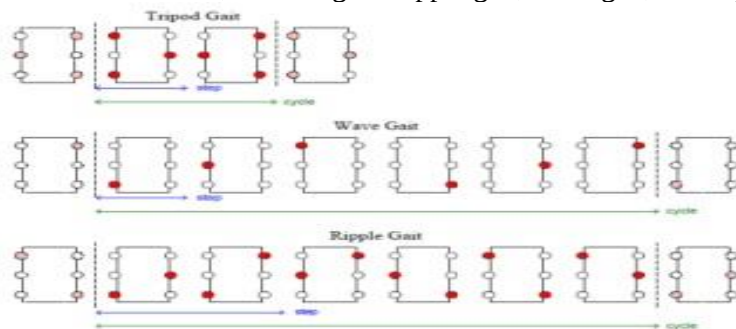


Figure 10. Illustration of hexapod robot foot movements in various methods.

However, only the tripod gait method was applied to the hexapoda robot legs. In the tripod gait method, the robot runs by lifting 3 legs at a time and leaving the other 3 legs as a foothold. Using this method 1 cycle can be completed in 2 steps so as to allow the robot to move quickly.

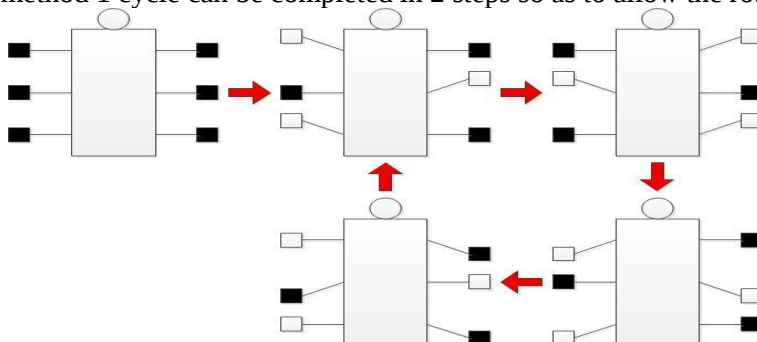


Figure 11. Illustration of hexapod robot foot movements in the tripod gait method.

The working principle of the system of this research, which starts when Arduino Mega on the hexapoda robot is given 9V and 12V voltage, the indicator light will turn on and the hexapoda robot is ready to move because it has been given a logic motion pattern of tripod gait.

4. Results

After completion at the design stage, then proceed with the testing phase. At this stage, the time that can be reached by the hexapod robot is to do a straight forward movement, turn forward 90 degrees, and rotate forward 180 degrees. The test is done in a closed room with a flat road surface made of ceramic (floor).

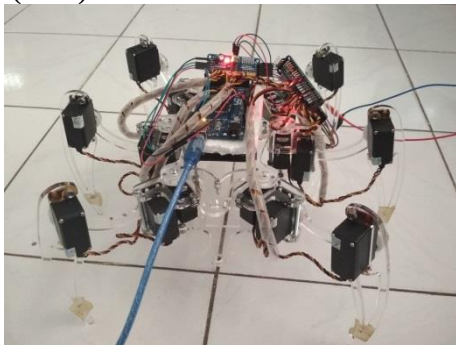


Figure 12. The hexapod robot looks forward.

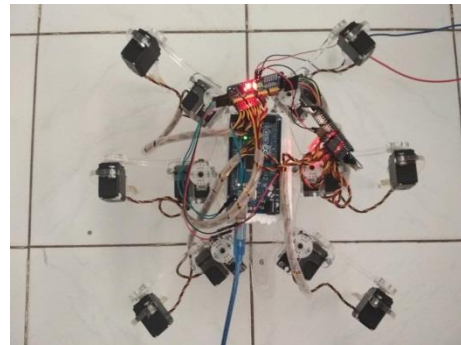


Figure 13. The hexapod robot looks up.

Measurement of the travel time of hexapoda robot movement is measured by using a stopwatch and measuring the distance traveled in centimeters. Measurement of turn and spin direction is measured by determining the initial angle and the end angle achieved by the movement of the hexapod robot.

Table 1. Straight forward road movement

Test	Distance (cm)	Time (s)
1	30	5.3
2	30	5.3
3	30	5.2
4	30	5.1
5	30	4.9
6	30	4.9
7	30	4.9
8	30	4.8
9	30	4.8
10	30	4.8
Average	30	5
Speed	6 cm/s	

Table 2. The forward road movement turns 90 degrees

Test	Angle Degree ($^{\circ}$)	Time (s)
1	90	5.2
2	90	5.2
3	90	5.1
4	90	5.1

5	90	5
6	90	5
7	90	4.9
8	90	4.9
9	90	4.8
10	90	4.8
Average	90	5
Speed	18 ⁰ /s	

Table 3. The forward road movement rotates 180 degrees

Test	Angle Degree (°)	Time (s)
1	180	10.3
2	180	10.2
3	180	10.1
4	180	10
5	180	10
6	180	10
7	180	9.9
8	180	9.9
9	180	9.8
10	180	9.8
Average	180	10
Speed	18 ⁰ /s	

5. Conclusion

The results of the discussion have been explained, it can be concluded that the application of the movement of the tripod gait method on hexapod robots produces an average straight forward speed of 6 cm/s, and is able to move turns and rotates with an average speed of 18 degrees per second. Hexapoda robot is able to move perfectly on a flat road surface made from ceramic (floor).

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