02 IMPLEMENTATION OF THE LAGRANGE INTERPOLATION FUNCTION IN THE MOTION PLANNING SYSTEM OF A 1 DOF ROBOT ARM.pdf

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IMPLEMENTATION OF THE LAGRANGE INTERPOLATION FUNCTION IN THE MOTION PLANNING SYSTEM OF A 1 DOF ROBOT ARM

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ABSTRACT

A manipulator robot is a robot that has a mechanical system consisting of an arrangement of arms and joints that can produce controlled movements. With the arrangement of arms and joints, the motion of the manipulator robot can be likened to the motion of a human arm. A robotic arm usually consists of several joints including the base, shoulder, elbow, roll, gripper, and pitch of the gripper. Robot movement is generated from mathematical calculations performed in the controller. The motion of the manipulator robot follows a motion trajectory. The motion trajectory is made based on a collection of stop points and effectors. The stopping points are obtained from integers from 10 < 160, the numbers are positive and the values are not in the form of fractions or decimal numbers. Forecasting this point can be done using Lagrange interpolation. This study aims to create a robot motion trajectory design system using Lagrange interpolation. Lagrange interpolation is engineered to be embedded in precise microcontroller control systems. In this study, an Arduino Uno R3-based microcontroller was used as a data acquisition module.

Keywords: Robot manipulator, Arduino Uno, Lagrange Interpolation

1. INTRODUCTION

A robot is one of the means that can help human tasks or work [1], [2]. In this day and age, robots are widely used to replace human tasks. [3]. A robot can work if there is a microcontroller to regulate its performance, one of which is Arduino, [4] Where the Arduino system is an open-source system both in hardware and software [5],[6] With an open-source system everyone can easily get good software or hardware. All information related to Arduino, both hardware and software, can be downloaded on the website. A manipulator robot is a robot that has a mechanical system consisting of an arrangement of arms and joints that can produce controlled movements [7] [8] With the arrangement of arms and joints, the motion of the manipulator robot is likened to the motion of a human arm. A robotic arm usually consists of several joints including the base, shoulder, elbow, roll, gripper, and pitch of the gripper. Each joint has a degree of freedom (DOF). The trajectory of motion carried out by the manipulator robot can be carried out in various fields, one of which is in the 2-dimensional field. Robot movement is generated from mathematical calculations carried out in the controller. The manipulator robot motion follows a motion trajectory, [10]. The motion trajectory is created based on a set of stop points and effectors. Making this motion trajectory needs to be done by a motion planning system that is embedded in the robot unit.[11]. The mission is done by moving the robot from one starting point to the destination point. The space between the starting point and the destination needs to be forecasted. Forecasting the empty point is done so that the robot moves well. Forecasting this point can be done using Lagrange interpolation [11], [12],[13]. This study aims to create a robot motion trajectory design system using Lagrange interpolation. Lagrange interpolation is engineered to be embedded in precise microcontroller control systems. In this study, an Arduino Uno R3-based microcontroller was used as a data acquisition module. Lagrange interpolation is engineered to be embedded in precise microcontroller control systems. In this study, an Arduino Uno R3-based microcontroller was used as a data acquisition module. Lagrange interpolation is engineered to be embedded in precise microcontroller control systems. In this study, an Arduino Uno R3-based microcontroller was used as a data acquisition module.

2. RESEARCH METHODS

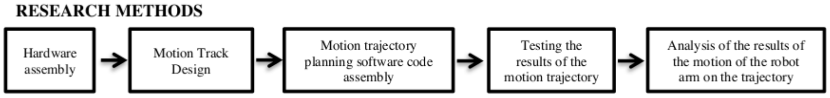
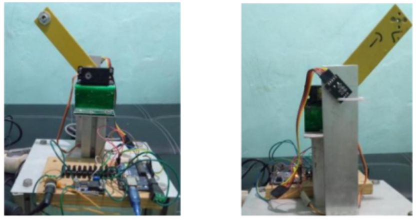


Figure 1. Research Procedure

Figure 1 is the process of this research to realize the implementation of the Lagrange interpolation function in the motion planning system of a 1 DOF arm robot. The explanation of the stages or research procedures can be explained as follows:

a) Hardware assembly



(a) (b)

Figure 2 Results assembly robot arm 1 DOF

Figure 2 (a) is the result of a mechanical design of a robotic arm for a motion trajectory viewed from the backside along with its electronic circuit. Figure 2 (b) is the result of the mechanical design of a robotic arm for the trajectory of motion seen from the front contents. The results of the hardware design will explain the mechanical form of the robot, the electrical components of the robotic arm system, and testing the robot's mechanical movement. The mechanical form includes a 1 DOF robot arm, the position of the servo motor (joint) as the joint.

b) Planning Motion Track

The robotic trajectory system in this design is the robotic arm will move past the stop point. The number of at least stopping points depends on the results of the Lagrange interpolation calculation.

c) Motion trajectory planning software code assembly

Assembling the software code in this research makes a program in Arduino software that contains several variables combined with mathematical calculations, namely Lagrange interpolation and inverse kinematics. Where the output of this program is the movement of the robot arm. Broadly speaking, kinematics discusses the relationship between the degrees of freedom of each joint, the position, and the orientation of the end effectors on the robotic arm. In designing the inverse kinematic method, the formula was obtained from the design of the link and joint robot. The calculation of the formula aims to get the value of the angle. The inverse kinematic changes the motion plan into a value that must be given to the actuator in this case the servo motor. With the kinematic model, a programmer can determine the input configuration that must be fed to each servo to achieve the desired goal. To get the values of these parameters, the robot must first know the manipulator it has, both the size and number of motors it has, and the existing degrees of freedom.

d) Motion Trajectory Result Test

The test is carried out by comparing the results of calculations performed on Arduino Uno with manual calculations performed on MS. excel.

1) Test track map:
   In testing this trajectory map by entering 4 coordinate points. Where the value of each coordinate point is the number 10 < 150 and is positive. Then compare the results of the Lagrange interpolation calculations performed on Arduino Uno with the interpolation calculations performed on MS. excel, see if the calculation results are the same or different.
2) Kinematic inverse test:
   In the inverse kinematic test, it takes x and y data values. Where the data x and y are obtained from the data from the calculation of the Lagrange interpolation. Then compare the inverse kinematic calculations performed by Arduino Uno with manual calculations performed in MS. excel and see the calculation results are the same or different

e) Analysis of the results of the motion of the robot arm on the trajectory

Analysis of the results of the motion of the robotic arm on the trajectory includes the following:

1) Response time
   a. Rise time (*Rise Time Tr*), is the time for the wave to go from 0.1 to 0.9 of the highest value.
   b. Completion time (*Settling Time, Ts*), is the response time to reach the desired goal and remains in it from the final value.
   c. Peak time (*Peak time, tp*), is the time it takes to reach the first peak or maximum

2) The steady-state error response is defined as the difference between a predetermined input and output.
3) Stability, stability is seen from two criteria:
   a. The system is stable if each bound input produces a finite output.
   b. A system is unstable if bound inputs produce unbounded outputs

3. RESULTS AND DISCUSSION

The test results are used to analyze the data on whether the robot can work according to a predetermined design.

a) Motion trajectory testing

The test is carried out by comparing the results of the Lagrange interpolation calculations carried out by the Arduino Uno microcontroller with manual calculations carried out in Ms. excel.

Experiment 1 with the following stop points:

Coordinate point 1: X1 : 10 Y1 : 35
Coordinate point 2: X2 : 34 Y2 : 67
Coordinate point 3: X3 : 56 Y3 : 90
Coordinate point 4: X4 : 135 Y4 : 123

So that from the number of 4 stopover points above, if a graph is made, it will be like the image below

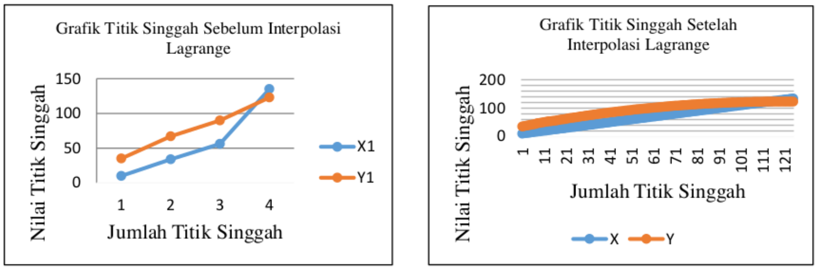


Figure 6. graphs before and after the experimental Lagrange interpolation process 1

Experiment 2 with the following stop points:

Point coordinates 1: X1 : 10 Y1 : 15
Coordinate point 2: X2 : 23 Y2 : 67
Coordinate point 3: X3 : 56 Y3 : 88
Coordinate point 4: X4 : 89 Y4 : 99

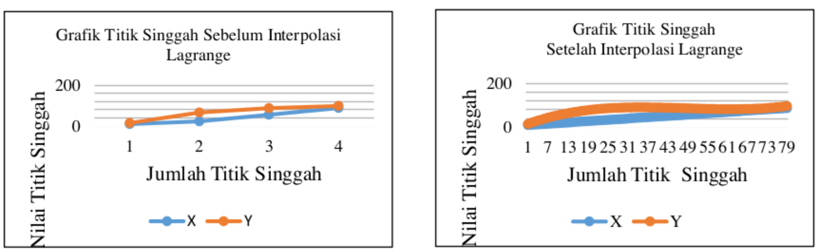


Figure 7. graph before and after the Lagrange interpolation process experiment 2

Experiment 3 with the following stop points:

Point coordinates 1: X1 : 11 Y1 :38
Coordinate point 2: X2 : 56 Y2 : 77
Coordinate point 3:X3 : 99 Y3 :100
Coordinate point 4:X4 : 140 Y4 : 156

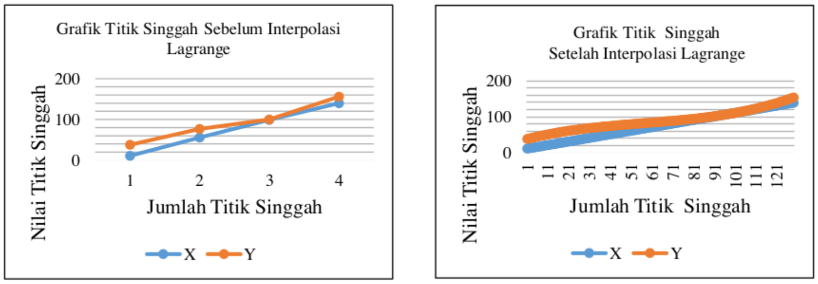


Figure 8. graphs before and after the 3 trial Lagrange interpolation process

b) Robot Testing Against Trajectory Points

Comparing the results of the movement of the robot with the inverse kinematic calculation carried out in ms. excel.

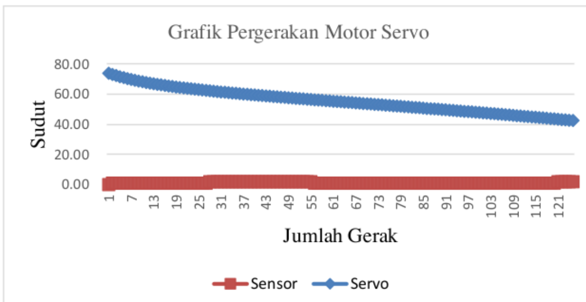


Figure 9. graph of the movement of the experimental servo motor 1

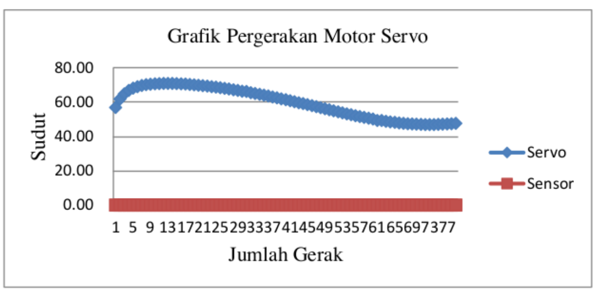


Figure 10. graph of the movement of the experimental servo motor 2

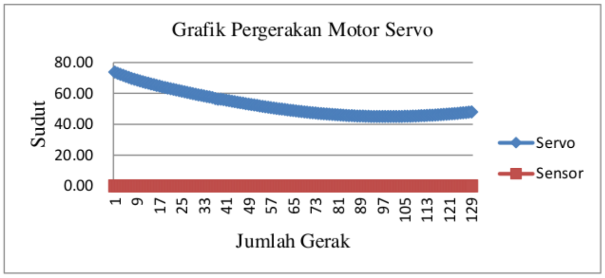


Figure 11. graph of the movement of the experimental servo motor 3

c) Testing Robot Motion Against Time

In this testing process, measurements of angular motion are carried out using a longitude ruler. The longitude ruler is placed parallel to the servo motor shaft. Meanwhile, to measure the time using a stopwatch.

Figure 12. response time to the experimental angle of 1

Information:

An angle of 0.03 degrees is a conversion of an angle of 73.97 degrees

An angle of 31.46 degrees is a conversion of an angle of 49.09 degrees

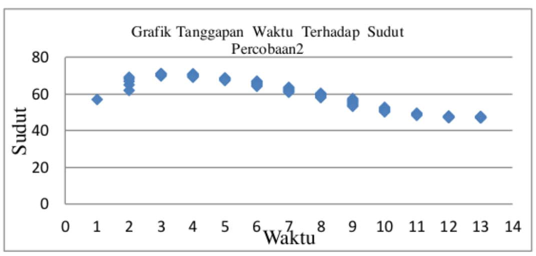


Figure 13. response time to the experimental angle of 2

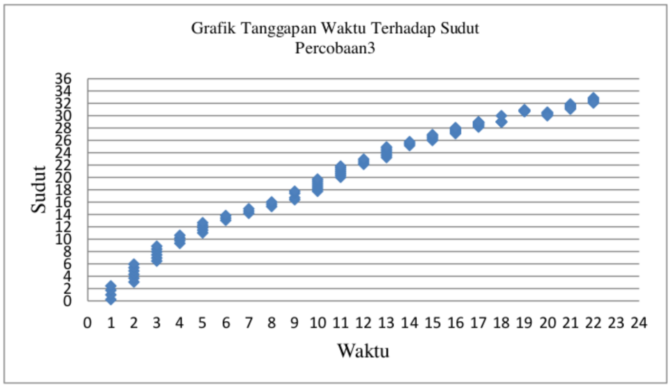


Figure 14. response time to trial angle 3

Information:
An angle of 0.22 degrees is a conversion of an angle of 73.78 degrees
An angle of 32.07 degrees is a conversion of an angle of 47.93 degrees

The trajectory of the robotic arm is made using 4 stopping points. Then the 4 stopover points are predicted using Lagrange interpolation. Where the Lagrange interpolation calculation process is carried out on the Arduino Uno. After the Lagrange interpolation process, the stopover points were initially 4 points, then increased a lot. With so many stopover points, the movement of the robot arm becomes smoother and takes some time to get to the last point. The movement of the servo motor is controlled by PWM (Pulse Width Modulation). In this study, the PWM value was obtained from the results of the inverse kinematic calculation. Where the values of x and y for the inverse kinematic calculation are obtained from the results of the Lagrange interpolation calculation. From the results of the rise time test,

1) First, try
   a. *rising time,* from the table data when the robot starts to move from 10%, namely the angle of 6.6 and a time of 4 seconds until it moves 90%, namely the angle to 28.6 and the time is 19 seconds from the target. So the rise time is 19 seconds - 4 seconds equals 15 seconds.
   b. *delay time,* from the table data the delay time is calculated when the arm motion reaches half the target, which is an angle of 55.01 and with a time of 12 seconds
   c. *Steady-state time*, from the table data, the steady-state time is seen when the arm motion reaches the 100% target, which is 21 seconds.
   d. *peak time,* The peak time is obtained when the robot arm begins to touch the first overshoot. From the graph data, the peak time of the first experiment was 21 seconds.

2) Second try
   a. *Ride time*, from table data when the robot starts to move at 10%, namely the angle of 69.87 and a time of 3 seconds until it moves 90%, which is the 47.16th angle and the time of 12 seconds from the target. So the rise time is 12 seconds - 3 seconds equals 9 seconds.
   b. *delay time,* from the table data the delay time is calculated when the arm motion reaches half the target, namely an angle of 61.56 and with a time of 7 seconds
   c. *steady-state time,* from the time table data the steady-state is seen when the arm motion reaches the 100% target, which is 13 seconds.
   d. *peak time,* The peak time is obtained when the robot arm begins to touch the first overshoot. From the graph data, the peak time of the first experiment was 13 seconds.

3) Third try

a. *Time*, from the table data when the robot starts to move at 10%, namely an angle of 66.52 and a time of 3 seconds until it moves 90%, which is an angle of 45.98 and a time of 20 seconds from the target. So the rise time is 20 seconds - 3 seconds equals 17 seconds.

b. *Delay time*, from the table data the delay time is calculated when the arm motion reaches half the target, namely the angle of 48.82 and the time is 14 seconds.

c. *steady-state time,* from the time table data the steady-state is seen when the arm motion reaches the 100% target, which is 22 seconds.

d. *Peak time*, The peak time is obtained when the robot arm begins to touch the first overshoot. From the graph data, the peak time of the first experiment was 22 seconds. By looking at the test results, the overshoot value and the steady-state error value is 0% where the output value produced is by the input value. Based on the graph, the form of the transition response follows the value of the stopover point made in the form of an overdamped response.

4) CONCLUSION

Prediction of the robotic arm's trajectory has been successfully made using Lagrange interpolation. From the test results, the rise time, peak time, and steady-state time for each experiment were different depending on the initial value of the stop point. In the process of working, this initial stop point will affect the number of new stop points after the Lagrange interpolation process. The more stopover points that are made after the Lagrange interpolation process, the more time it takes to reach the goal. For example on the first try, the rise time is 15 seconds, the delay time is 12 seconds, the steady-state time and the peak time are 21 seconds. While the second experiment increased 9 seconds, 7 seconds of delay, steady-state time, and 13 seconds of peak time. Then for the third experiment, the rise time is 17 seconds, the delay time is 14 seconds, the steady-state time and the peak time are 22 seconds. By looking at the test results, the overshoot value and the steady-state error value is 0% where the output value produced is by the input value. Based on the graph,

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GRADEMARK REPORT

FINAL GRADE

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GENERAL COMMENTS

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FOCUS

State a clear claim/topic sentence and stay focused on supporting it.

MEETS EXPECTATIONS	A precise claim/topic sentence based on the historical topic and/or source(s) is present. The response maintains a strong focus on developing the claim/topic sentence, thoroughly addressing the demands of the task.
APPROACHES EXPECTATIONS	A claim/topic sentence based on the historical topic and/or source(s) is present, but it may not completely address the demands of the task, or the response does not maintain focus on developing it.
DOESN'T MEET EXPECTATIONS	The claim/topic sentence is vague, unclear, or missing, and the response does not address the demands of the task.

EVIDENCE

Represent relevant historical information accurately.

MEETS EXPECTATIONS	The most appropriate evidence is presented to support the topic sentence, and all information is historically accurate.
APPROACHES EXPECTATIONS	Appropriate evidence may be presented to support the topic sentence, but it may be inadequate or contain some historical inaccuracies.
DOESN'T MEET EXPECTATIONS	Evidence is general, inappropriate, or inadequate in support of the topic sentence, or is largely inaccurate.

DEVELOPMENT

Explain how evidence supports the topic sentence.

MEETS EXPECTATIONS	The response demonstrates reasoning and understanding of the historical topic and/or source(s), and sufficiently explains the relationship between claims and support.
APPROACHES EXPECTATIONS	Some reasoning and understanding of the historical topic and/or source(s) are demonstrated. The response attempts to explain the relationship between claims and support.
DOESN'T MEET EXPECTATIONS	The response does not demonstrate reasoning and understanding of the historical topic and/or source(s), and explanation of the relationship between claims and support is minimal.

ORGANIZATION

Present ideas in a logical structure that shows the relationships between ideas.

MEETS EXPECTATIONS	An effective organizational structure enhances the reader's understanding of the information. The relationships between ideas are made clear with effective transitional phrases.
APPROACHES EXPECTATIONS	An organizational structure is evident, but may not be fully developed or appropriate. Transitional phrases may be used but the relationships between ideas are somewhat unclear.
DOESN'T MEET EXPECTATIONS	An organizational structure is largely absent and the relationships between ideas are unclear.

LANGUAGE

Communicate ideas clearly using vocabulary specific to the historical topic.

MEETS EXPECTATIONS	Ideas are presented clearly, using vocabulary specific to the historical topic. If errors in conventions are present, they do not interfere with meaning.

APPROACHES EXPECTATIONS	Ideas are mostly clear, using some vocabulary specific to the historical topic. Some errors in conventions are present that may interfere with meaning.
DOESN'T MEET EXPECTATIONS	Ideas are not clear, using little to no vocabulary specific to the historical topic. Several errors in conventions interfere with meaning.