African Journal of Advanced Pure and Applied Sciences (AJAPAS)
Online ISSN: 2957-644X
Volume 3, Issue 4, October - December 2024
Page No: 133-140
Website: https://aaasjournals.com/index.php/ajapas/index
ISI 2024: 0.877 SJIFactor 2024: 6.752 معامل التأثير العربي: 1.55

Analysis and Programming of the Robotic Arm Using the Microcontroller

Mahmoud Jlael [1*], Fathi Alsharf Ben Kora [2], Abobkr Salah Nasr [3], Abdulgader Alsharif [4]
[1,2] Department of Electrical and Electronic Engineering, Higher Institute of Science and Technology, Al-Zawiya, Al-Zawiya, Libya
[3] Department of Electronic Technology, College of Engineering Technology, Zuwara, Zuwara, Libya
[4] Department of Electrical and Electronics Engineering, College of Technical Sciences, Sebha, Libya

تحليل وبرمجة الذراع الآلي باستخدام المتحكم الدقيق

محمود محمد اجليل [1]، فتحي الشارف بن كورة [2]، أبوبكر صالح نصر [3]، عبد القادر الشريف [4]
[2،1] المعهد العالي للعلوم والتقنية، الزاوية، ليبيا
[3] قسم التقنية الإلكترونية، كلية التقنية الهندسية زوارة، زوارة، ليبيا
[4] قسم الهندسة الكهربائية والإلكترونية، كلية العلوم التقنية سبها، ليبيا

[*]Corresponding author: mahmoudjli0@gmail.com

Received: August 26, 2024	Accepted: October 05, 2024	Published: October 10, 2024

Abstract:
Due to the widespread use of stepper motors, almost any industrial process that requires precision in movement is almost devoid of stepper motors, which made us focus on this type of motor in some detail. In this paper, the focus will be on the use of stepper motors in the robotic arm due to their importance in advanced industrial processes, three motors will be used, each perpendicular to the other, this is the simplest type of robotic arm, when the number of motors is three or more, we are now considered to be in the robotic arm stage. This study includes analysis and programming. As for the analysis process, it is determining the type of movement required of the arm to perform. When the number of motors is three or more, we consider the movement in space, the MATLAB program will be used in the calculation process. As for programming, the microcontroller will be used to write the programming code to control the robotic arm to obtain the movement required for the robotic arm to perform.
Keywords: Stepping motor, Step Angle, Starting point, End point, Rotational Movement, Step increment, Step Inc.

الملخص
نظرًا للاستخدام الشائع والواسع النطاق لمحركات الخطوة، فإن أي عملية صناعية تقريبًا تتطلب الدقة في الحركة تكاد لا تخلو من محركات الخطوة، مما جعلنا نركز على هذا النوع من المحركات بشيء من التفصيل. في هذه الورقة، سيتم التركيز على استخدام محركات الخطوة في الذراع الآلي نظرًا لأهميتها في العمليات الصناعية المتقدمة، سيتم استخدام ثلاث محركات كل منها عمودي على الآخر هذه هي أبسط صورة للذراع الآلي، عندما يكون عدد المحركات ثلاثة او أكثر نعتبر الآن في طور الذراع الآلي. تتضمن هذه الدراسة التحليل والبرمجة أما عملية التحليل، فهي تحديد نوع الحركة المطلوبة من الذراع لأدائها، عندما يكون عدد المحركات ثلاثة أو أكثر، نعتبر الحركة في الفراغ وسيتم استخدام برنامج MATLAB في العملية الحسابية. أما بالنسبة للبرمجة فسيتم استخدام المتحكم الدقيق لكتابة كود البرمجة للتحكم في الذراع الآلي للحصول على الحركة المطلوبة من الذراع لأدائها.

الكلمات المفتاحية: محرك الخطوة، زاوية الخطوة، نقطة البداية، نقطة النهاية، حركة دورانيه، زيادة الخطوة.

Introduction
The motors are connected according to the process required in the industrial process or according to movement or moving from one point to another [1]. The number of motors required in a process is determined according to

the type of movement required, either step motor, two or three motors [2]. Connection methods can be classified according to the quantity of motors used [3]. In this paper, three-stepping motors will be used when we want movement from point to point in a straight line, a curved line, or in the form of a circle, semi-circle, or spiral movement to move a specific product [4]. The required movement in this process is obtained by installing the three motors. Each of them is perpendicular to the other, that is, perpendicular to the direction (X У Z) so that we can obtain movement in space [5].

The type of movement required for the robotic arm to perform it is determined according to the type of manufacturing process, and through this, the number of motors required to carry out this process is determined, and Figure 1 shows the presented movement required [6].

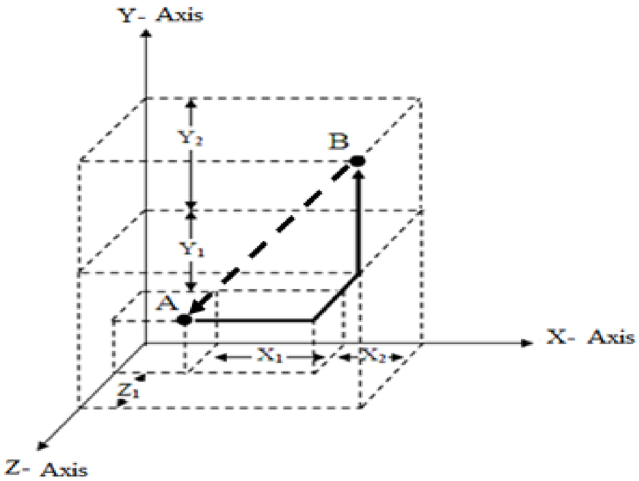

Figure 1: The type of movement required of the smart arm.

The main contribution of this study is shading the light on the programming and analyzing on the smart arm movements considering the microcontroller. The rest of the article is divided into 6 sections. Section 2 discusses the operation method of the controlling. The utilized mathematical analysis and calculation is presented in Section 3. The implemented MATLAB code is placed and discussed in Section 4. in Section 5. Finally, the article is closed by the summary conclusion in Section 6 followed by recent cited references from the literature.

The method of controlling

The control method of the robotic shield can be divided into two types: controlling the shield by pre-programming to obtain a specific and repeated movement or by control keys to obtain random movement according to the user's desire [7].

First: Controlling the shield through pre-programming. This means that the shield performs a specific industrial operation and repeats this same process for an unlimited number [8].

Secondly: The shield is controlled using a set of control keys to obtain movement according to the operator's desire.

In this paper, the first type will be studied and analyzed according to the figure shown above.

Analysis and calculation.

According to the previous figure, three stepper motors will be used [9], each perpendicular to the other to obtain movement in space, that is, perpendicular to the direction (X У Z). Each motor will be named according to the axis installed in it to facilitate the analysis and calculation process [10].

First: moving from point A to point B:

Each movement is discussed individually and then the signal is designed for each motor.

First movement: The distance traveled is 3 cm. Motor-X moves forward while motor-У and motor-Z stop.

Second movement: The distance traveled is 2 cm. The motor-X moves forward, as do the motor-У and the motor-Z, and the same signal is generated in the case of motors with the same specifications.

Third movement: The distance traveled is 3 cm. The motor-X and the motor-Z stop while the motor-У moves forward.

Second: Moving from point B to point A:

Fourth movement: The distance traveled is 5 cm. The motor-X, the Y-motor and the motor-У move backwards.

The total distance is 13 cm, the signal is designed for the four movements of the highest distance, even if one of the movements is a smaller movement distance.

If the motors are of the same specifications, i.e. step angle = 1.8 degrees, and during the calibration process it is found that motor traveled a longitudinal distance of 1.2 mm.

Number of steps in a cycle = 360/step angle

Number of steps in a cycle = 360/1.8 = 200 steps

By calibrating the motor, it was found that it travels a linear distance of 1.2 mm per cycle.

Data size: Total number of steps to cover the distance

Data size = 200 * 13 cm / mm1.2 = 21666 steps

step Inc: longitudinal distance in one step

step Inc = 13cm/21666 = 0.006 mm

First movement: data size = 3 cm/0.006mm =5000

Second movement: data size = 2 cm/0.006mm =3333

Third movement: data size = 3 cm/0.006mm =5000

Fourth movement to move from point B to point A:

Data size = 5 cm/0.006mm = 8333

This is expressed mathematically by the following relationship:

$$\mathrm{A(n)} = \begin{pmatrix} \mathrm{n} < Array\ Size/2 & \sum_{k=1}^{n=\text{Array Size}/2} \text{Step Inc} \\ \mathrm{n} > Array\ Size/2 & \sum_{k=\text{Array Size}/2}^{n=\text{Array Size}} -\text{Step Inc} \end{pmatrix}$$

MATLAB Code

To ensure the accuracy of the calculation process, the MATLAB program is used to observe the shape of the produced signal, which represents the type of movement sent to the motors, in addition to the number of transmitted possibilities and the absence of loss in the signal [11] .

```
Signal Array = 0;

Time = 0;

Array Size = 13333;

Sum Data1=0; Sum Data2=0;  Sum Data3=0;

Step Inc = 0.006;

For loop Counter =1 to 5000

Time = Time + 0.001

Sum Data1 = Sum Data1 + Step Inc;

Sum Data2 = Sum Data2 + 0;

Sum Data3 = Sum Data3 + 0;

A(Counter) = Sum Data;

Plot (Time, Sum Data1);

Plot (Time, Sum Data2);

Plot (Time, Sum Data3);

End
```

```
For loop Counter =1 to 3333
Time = Time + 0.001
Sum Data1 = Sum Data1 + Step Inc;
Sum Data2 = Sum Data2 + Step Inc;
Sum Data3 = Sum Data3 + Step Inc;
A(Counter) = Sum Data;
Plot (Time, Sum Data1);
Plot (Time, Sum Data2);
Plot (Time, Sum Data3);
End

For loop Counter =1 to 5000;
Time = Time + 0.001
Sum Data1 = Sum Data1 + 0;
Sum Data2 = Sum Data2 + Step Inc;
Sum Data3 = Sum Data3 + 0;
A(Counter) = Sum Data;
Plot (Time, Sum Data1);
Plot (Time, Sum Data2);
Plot (Time, Sum Data3);
End
For loop Counter = 1 To 8333
Time = Time + 0.001
Sum Data = Sum Data1 – Step Inc
Sum Data = Sum Data 2 – Step Inc
Sum Data = Sum Data 3 – Step Inc
Plot (Time, Sum Data1)
Plot (Time, Sum Data2)
Plot (Time, Sum Data3)
End.
```

	The conditions	The shape
1	The motor is off	
2	The motor is moves forward	
3	The motor is moves reverse	

Figure 2: The conditions and shapes status of the smart arm.

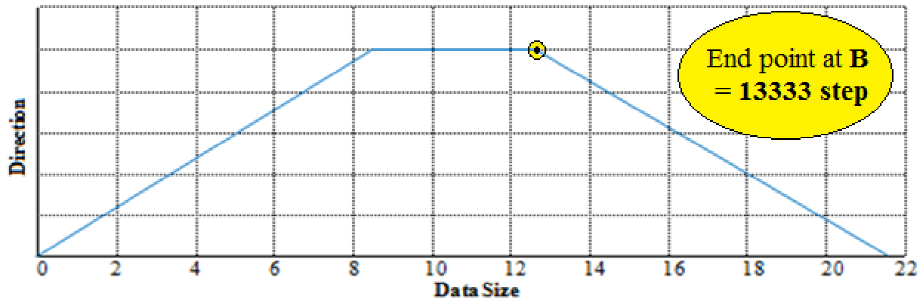

Figure 3: The signal sent to the motor -X

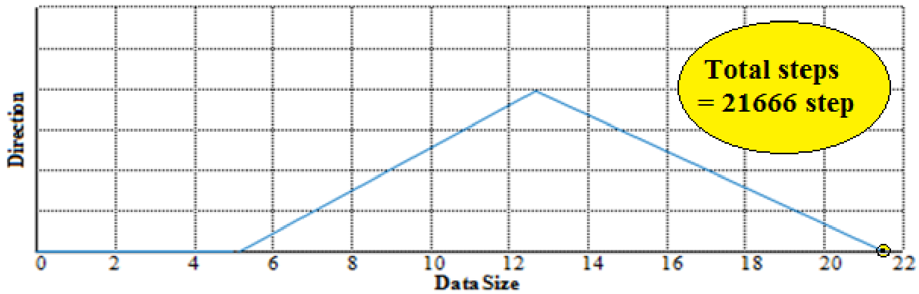

Figure 4: The signal sent to the motor -Y

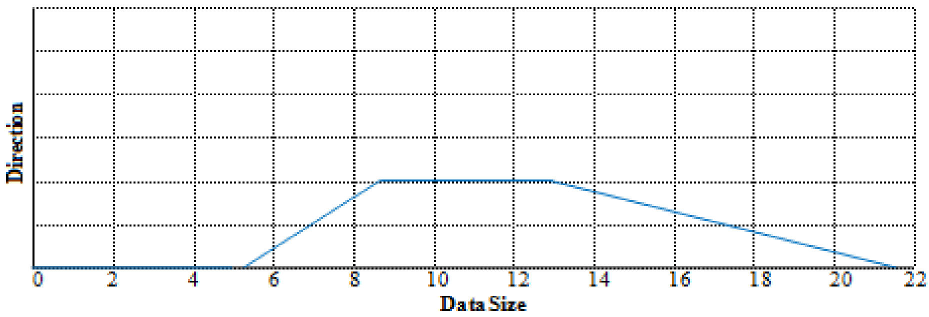

Figure 5: The signal sent to the motor –Z

Notice from the drawing above that the three motors reached point B at the same time after sending 13,333 steps for each motor and returned to the origin point A at the same time after sending 8,333 steps, i.e. the total number of possibilities or steps equals 21,666 steps.

Programming commands.

After completing the calculation and analysis process, we will begin writing the programming commands for the microcontroller using the (Micro C for PIC) program.

```
int  seq1 [8] ={0x02,0x06,0x04,0x0c,0x08,0x09,0x01,0x03};
int  seq2 [8] ={0x20,0x60,0x40,0xc0,0x80,0x90,0x10,0x30};
int j=0 ;
int n=0;
int i=0;
void main( ) {
trisb=0 ;
portb=0 ;
trisc=0 ;
portc=0 ;
```

```
do{
portb=seq1 [ i ];
delay_ms(5);
i=i+1;
if ( i == 8 ){ i=0 ;}
n=n+1 ;
} while ( n < 5000);

n=0 ;
delay_ms(100);

do {
i= i +1;
portb=seq1 [ i ];
delay_ms(5);
portb=seq2 [ i ];
delay_ms(5);
portc=seq1 [ i ];
delay_ms(5);
if ( i == 7){ i=-1 ;}
n=n+1;
} while ( n < 3333);
n=0 ;
delay_ms(100);

do {
i= i +1;
delay_ms(5);
portb=seq2 [ i ];
delay_ms(5);
if ( i == 7){ i=-1 ;}
n=n+1;
} while ( n < 5000);

n=0 ;
delay_ms(100);

do {
i= i - 1;
portb=seq1 [ i ];
delay_ms(5);
portb=seq2 [ i ];
delay_ms(5);
portb=seq1 [ i ];
delay_ms(5);
if ( i == 0){ i=8 ;}
n=n+1;
} while ( n < 8333);
{
```

After completing the program writing process, the validity of the program data is tested by designing a circuit using the proteus program to simulate the practical circuit to ensure the correctness of the program and the method of connecting parts or operate the circuit in the correct manner and obtain the desired movement. The following figure shows the shape of the circuit designed with the proteus program.

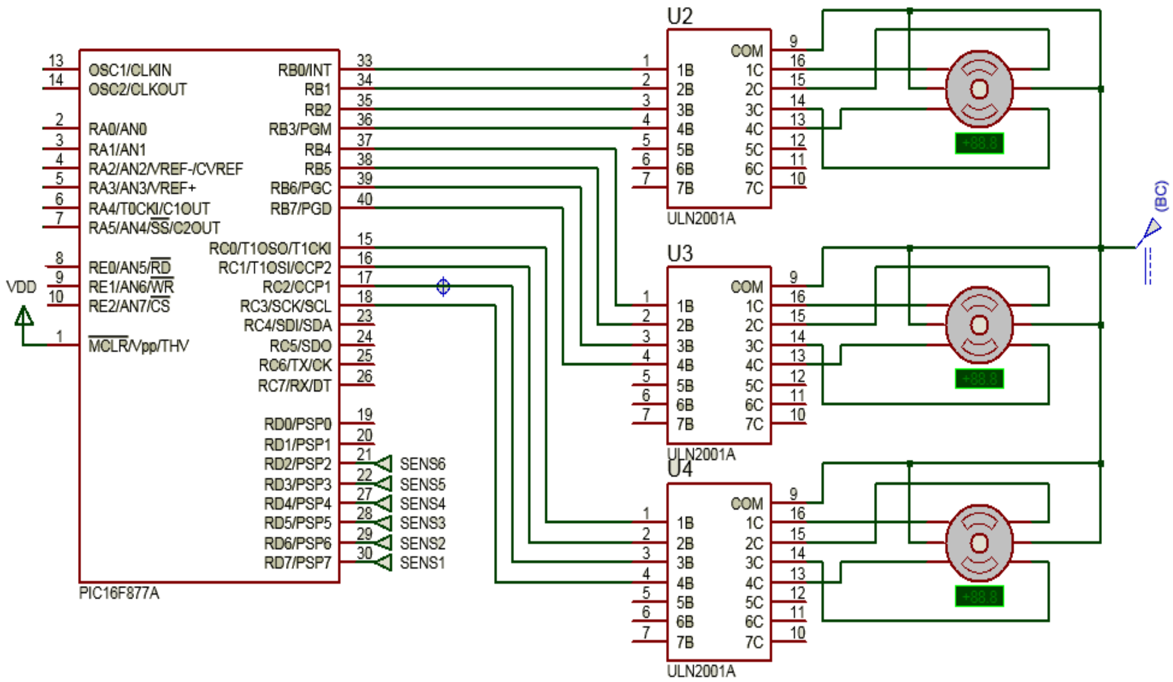

Figure 6: Simulated circuit.

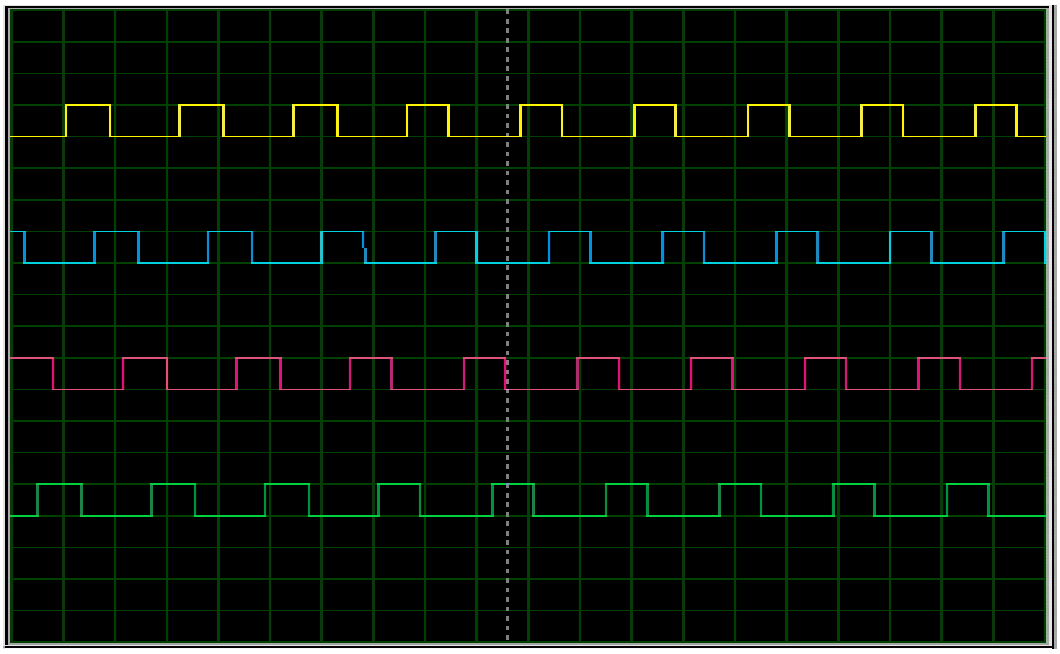

Figure 7: The shape of the signal sent to the motor.

The figure above shows the shape of the digital signal sent to one of the motors.

Conclusions

In this research, the type of control of the robotic arm was classified into two types. The first type is the pre-programmed robotic arm, meaning that the arm performs the pre-programmed movement and repeats that movement.

As for the second type, the movement is controlled by the user through the control keys, so the movement is according to the user's desire.

In addition to that, knowing how to analyze the calculation and movement required for the robotic arm to perform and how to write the programming code for the microcontroller to obtain that movement, and through simulation programs and tracking the movement of the motors, we obtain the best results for the robotic arm to perform a specific operation in a vacuum and return to the starting point without loss. Any data, through the use of three stepper motors.

References

[1] C. Liu, K. T. Chau, C. H. T. Lee, and Z. Song, "A Critical Review of Advanced Electric Machines and Control Strategies for Electric Vehicles," Proc. IEEE, vol. 109, no. 6, pp. 1004–1028, Jun. 2021, doi: 10.1109/JPROC.2020.3041417.

[2] T. Amanuel, A. Ghirmay, H. Ghebremeskel, R. Ghebrehiwet, and W. Bahlibi, "Design of Vibration Frequency Method with Fine-Tuned Factor for Fault Detection of Three Phase Induction Motor," J. Innov. Image Process., vol. 3, no. 1, pp. 52–65, 2021, doi: 10.36548/jiip.2021.1.005.

[3] Y. Lin, H. Zhao, and H. Ding, "Real-time path correction of industrial robots in machining of large-scale components based on model and data hybrid drive," Robot. Comput. Integr. Manuf., vol. 79, p. 102447, Feb. 2023, doi: 10.1016/j.rcim.2022.102447.

[4] G. Katırcı, F. E. Civan, M. A. Zabara, and B. Ülgüt, "Observing the Effect of Architecture on Spiral and Bobbin Lithium Thionyl Chloride (Li/SOCl 2) Batteries with Temperature-Dependent Electrochemical Impedance Spectroscopy (EIS)," J. Electrochem. Soc., vol. 171, no. 7, p. 070509, Jul. 2024, doi: 10.1149/1945-7111/ad5d20.

[5] M. Bolderman et al., "Physics-guided neural networks for feedforward control with input-to-state-stability guarantees," Control Eng. Pract., vol. 145, p. 105851, Apr. 2024, doi: 10.1016/j.conengprac.2024.105851.

[6] S. Mohith, A. R. Upadhya, K. P. Navin, S. M. Kulkarni, and M. Rao, "Recent trends in piezoelectric actuators for precision motion and their applications: a review," Smart Mater. Struct., vol. 30, no. 1, 2021, doi: 10.1088/1361-665X/abc6b9.

[7] M. Yousefzadeh, H. Eliasi, and M. Jalilirad, "Dynamic Modeling and Chaos Suppression of the Permanent Magnet Synchronous Motor Drive with Sliding Mode Control," J. Electron. Electr. Eng., Oct. 2023, doi: 10.37256/jeee.2220233484.

[8] A. S. D. Alarga, A. G. E. Abdallah, A. A. Ahmed, and S. Adbar, "A New algorithm for a novel physiotherapy robot for upper-lower limbs," in 2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering, MI-STA 2022 - Proceeding, 2022, pp. 38–42. doi: 10.1109/MI-STA54861.2022.9837697.

[9] M. Habil, F. Anayi, Y. Xue, and K. Alnagasa, "Analyzing the Design and Performance of a DC Linear Stepper Motor," Machines, vol. 11, no. 8, p. 785, Jul. 2023, doi: 10.3390/machines11080785.

[10] T. Li, Y. Zhao, and L. Hou, "Adaptive Sliding Mode Control With Disturbance Observer for Speed Regulation System of Permanent Magnet Synchronous Motor," IEEE Access, vol. 11, pp. 17021–17030, 2023, doi: 10.1109/ACCESS.2023.3245635.

[11] S. T. Karris, with MATL*AB ® Applications*, no. Ix.