The Kinematic Analysis Of Four Degrees Of Freedom For A Medical Robot And Control It By Labview And Arduino

(Simulation And Implementation)

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Abstract: *This study presents the kinematic analysis of a four-degree freedom medical robotic arm using the Matlab and the robotic-tool, the arm was designed using a solid work program, As well as details of the control of the real design of this arm using Arduino Mega 2560, The specialist enters the position to be reached by the automatic arm (injection position), Or moving the arm to any position by entering the values of the corners of the joints, In this search, we have moved the arm to the selected position Without injecting into the muscle which need another study and a medical sensor determines the amount of needle entry in the muscle, According to criteria determined by the specialist and can be added to the designed interface.*

Keywords: *Kinetic study, medical robot, four degrees freedom, Labview, Arduino Mega 2560.*

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I. INTRODUCTION

The word Robot is launched on mechanical machines Capable of performing pre-programmed actions that Show intelligent behavior, especially when simulating Human behavior.

The great technological development Of these robots has made it part of many fields, including The medical field, on the other side, the robotic arms with a needle in the medical center appeared to occupy an Important Position. These arms were used in the injection of Solid-skinned needle needles in blood donation centers, It is important to conduct the kinetic study of these robotic Arms so that researchers and specialists can control them.

II. MATERIALS AND METHODS OF RESEARCH

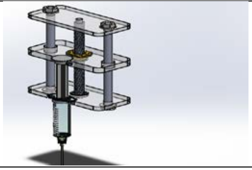
- The first stage: It was a desk research, study and translation of the references in the subjects related to the robotic arms and analysis of movement, as well as the references of SERVO-DC engines, a review of the specialized researches for simulation in the Matlab environment.
- Stage 2: The robotic arm is designed using the SOLD WORK program.
- Stage3: Conducting a dynamic study of the robot arm using the D-H method and simulating it in a Matlab environment.
- Stage4: Build and control the practical model using the Arduino Mega 2560 and Labview chip.

III. MECHANICAL DESIGN OF ROBOTIC ARM

Design in solid work program:

We started by designing the robotic arm model on solid work consisting of base, shoulder, forearm, wrist, actuator and five servo motors.

Table [1] the constituent parts of the robotic arm

the shape	the shape	pace
2	1	Base.1 Shoulder.2
4	3	Forearm.3 Wrist.4
		5. Injection, Needle

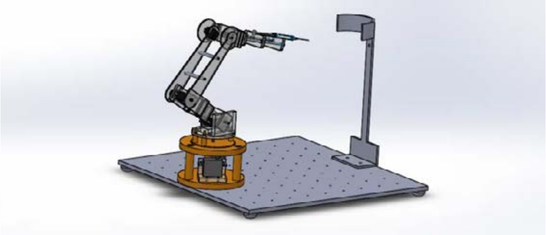


Fig.1. The final model of the robotic arm

Figure.1 shows the final model of the robotic arm in a sold work environment with the coordinate platform and the hand carrier.

IV. THEORETICAL OVERVIEW:

1. Analysis of the motion of the robotic medical arm (four degrees of freedom) using the D-H method:

We aim to represent D-H to find the mathematical model of the robotic arm to determine the position and direction of the end of the effect relative to the base, we must set the coordinates of the base and end of the robotic arm in addition to all joints, as the mechanical arms consist of joints so that each link movement withdrawal or Rotary depending on the type of joint and are formed between the axes of these links Ouler angles.

2. Study of the forward movement:

The study of the robot's front movement determines the position and direction of the end of the arm and the joint variables as each joint represents one degree of Freedom and the position of each joint determined by its rotation angle {θ_1......... θ_n}, We represent the wholesale robot base coordinate { x_0 , y_0 , z_0 } .

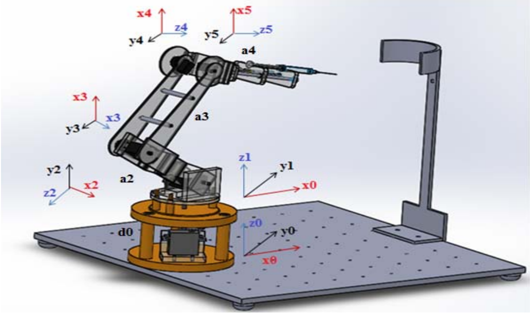


Fig. 2. The coordinates of the robotic arm.

Table (2) shows the D-H parameters of the robotic medical arm

I	θ_i	a_i	ai	d_i
1	θ_1	90	0	L1
2	θ_2	0	L2	0
3	θ_3	0	L3	0
4	θ_4	0	L4	0

From here we find the matrix of the coordinates of the position of the influencing and the spin matrix:

$$p({}_{4}^{0}\mathrm{T}) = \begin{bmatrix} c\theta_1(L_4c(\theta_4+\theta_3+\theta_2)+L_3c(\theta_3+\theta_2)+L_2c(\theta_2)\,) \\ S\theta_1(L_4c(\theta_4+\theta_3+\theta_2)+L_3c(\theta_3+\theta_2)+L_2c(\theta_2)\,) \\ L_1+L_4S(\theta_4+\theta_3+\theta_2)+L_3S(\theta_3+\theta_2)+L_2S(\theta_2) \end{bmatrix} \quad (1)$$

$$R({}^{0}_{4}\mathrm{T}) = \begin{bmatrix} c\theta_1\big(c(\theta_4+\theta_3+\theta_2)\big) & -S\theta_1 & -C\theta_1(S(\theta_4+\theta_3+\theta_2)\,) \\ S\theta_1(C(\theta_4+\theta_3+\theta_2)\,) & C\theta_1 & -S\theta_1(S(\theta_4+\theta_3+\theta_2)\,) \\ S(\theta_4+\theta_3+\theta_2) & 0 & c(\theta_4+\theta_3+\theta_2) \\ & & \end{bmatrix} \tag{2}$$

Where α the angle of direction of the end effect a given by the relationship:

$$\alpha = \theta_1 + \theta_2 + \theta_3 \tag{3}$$

3. Studying the reverse movement of the robotic arm:

The reverse motion calculation depends on the final position of the moving end, where the angles of the joints are calculated by knowing the coordinates of the position, and the study of reverse *Size of Author Photographs* motion is difficult due to the multiple solutions achieved for the specific position, we will rely on our study of reverse motion on the engineering solution:

$$\tan\theta_1 = \frac{p_y}{p_x} \tag{4}$$

When the value of the first angle changes, the end position changes and the whole arm moves in accordance with the x, y axes. The value of the first angle is given by arc tan as follows:

$$\theta_1 = \arctan\left(\frac{p_y}{p_x}\right) = \operatorname{atan2}(py_1, px_1 \tag{5}$$

$$\theta_1 = \pi + \arctan\left(\frac{p_y}{p_x}\right) \tag{6}$$

The second and third angles are calculated by returning to the position calculation equations:

$$1.\, x = (l_2\cos\theta_2 + l_3\cos(\theta_2+\theta_3) + l_4\cos(\theta_2+\theta_3+\theta_4)) * cos\theta_1$$
$$2.\, y = (l_2\cos\theta_2 + l_3\cos(\theta_2+\theta_3) + l_4\cos(\theta_2+\theta_3+\theta_4)) * sin\theta_1$$
$$3.\, z = l_1 + l_2 * sin\theta_2 + l_3 * \sin(\theta_2+\theta_3) + l_4 * \sin(\theta_2+\theta_3+\theta_4)$$

Quadrature and the combination of equations (1) and (2) we find:

$$\mathrm{x}^2 + \mathrm{y}^2 = [l_2\cos\theta_2 + l_3\cos(\theta_2+\theta_3) + l_4\cos(\theta_2+\theta_3+\theta_4)]^2$$

Where:

$$4.\, A_1 = \sqrt{\mathrm{x}^2+\mathrm{y}^2} - l_4\cos(\theta_2+\theta_3+\theta_4)] = l_2\cos\theta_2 + l_3\cos(\theta_3+\ \theta_4)$$
$$5.\, A_2 = z - l_1 - l_4 * \sin(\theta_2+\theta_3+\theta_4) = l_2 * sin\theta_2 + l_3 * \sin(\theta_2+\theta_3)$$

The common solution between (5) (4) we find:

$$\theta_2 = 0.5\sin^{-1}\left(\frac{\left(\frac{({A_1}^2+{A_2}^2)+{L_2}^2-{L_3}^2}{2L_2}\right)^2 - {A_1}^2 + {A_2}^2}{2A_1A_2}\right) \tag{7}$$

$$\theta_3 = \operatorname{acos}\left(\frac{A_1^2 + A_2^2 - L_2^2 - L_3^2}{2L_2 * L_3}\right) \tag{8}$$

Calculates the angle : θ_4

$$\theta_4 = a - \theta_3 - \theta_2 \tag{9}$$

V. SIMULATION:

We simulated the arm in the Matlab environment, where we built a forward motion model to calculate the elements of the matrix $({}^{4}_{0}T)$ and a reverse motion model, using D-H and Robotic tools according to specific steps.

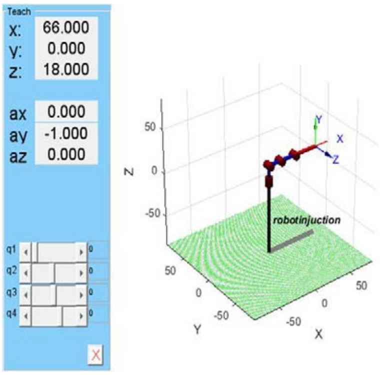

Teach
X: 66.000
y: 0.000
z: 18.000
ax 0.000
ay -1.000
az 0.000
q1 0
q2 0
q3 0
q4 0

Fig.3. Forward motion modeling using D-H equations.

1. Front-end motion model in Matlab environment:

The forward movement of the robotic arm and the direction angles were modeled in the Matlab environment, using Robotic tools according to the following steps:

- Activating the tool Robotic tools.
- Enter values for constants (L1, L2, L3, L4).
- Enter the D-H parameters derived from Table (2) using the instruction
- L (i) = Link ([thi *ai* di ai])
- Determine the scope of the robot's operation by specifying the area of the junction angles.
- Determine the type of robot (serial robot).
- Build forward motion robot kinematic
- Rob.fkine ([th1 th2 th3 th3])
- Build the interface as above.
- Calculate the position and direction of the moving end of the robot when moving the angle sliders.

2.Reverse motion model in the Matlab environment:

The reverse motion model is based on the D-H and robotic-tools. This model enables you to obtain the values of the joint angles when you enter the coordinates of the position of the moving end and its direction according to the following steps:

- Activating the tool Robotic tools.
- Enter values for constants (L1, L2, L3, L4).
- Enter the D-H parameters
- derived from Table (2) using the instruction
- L (i) = Link ([thi di ai])
- Determine the scope of the robot's operation by specifying the area of the junction angles.
- Determine the type of robot (serial robot).
- Determine the direction array values .qready
- Enter the transition matrix to the selected position
- Td = transl ([px py pz])
- Build a reverse kinetic motion
- q = ROb.ikine (Td, qready, [1 1 1 0 0 0]);
- Build the interface.
- Enter the selected position from the command window

VI. PRACTICAL SIDE:

• introduction:

The robotic arm is practically designed, controlled by the Arduino Mega 2560, the Labview and servo motor MG 995g except the injector motor micro servo continues, and add limit switch to reduce the robot's work area and prevent its collision with the coordinate platform.

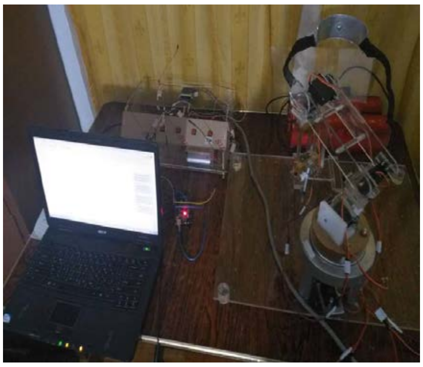


Fig.4. The practical model of the robotic arm.

1. ARDUINO MEGA 2560:

The largest of the Arduino chipset contains 54 digital ports, 15 of which are PWM ports providing us with 40Ma and we have 16 analog inputs. The processor in this chip is ATMEGA 2560.

2. Servo motors:

These engines are equipped with electronic circuit to precisely control the direction and rotation of the shaft of the engine and its angular and a set of gears and a conveyor for high torque and constant movement, the angle is precisely determined by the variable resistance within the motor that gives a voltage proportional to the voltage. The voltage is compared to the resistance with a reference voltage generated by the control circuit, proportional to the required angle. When v_out = v_ref becomes error = 0 the engine stops.

3. Labview Interface:

You need to download Labview Interface for Arduino library, which we need to work on the Labview program, and you must inject this library into the Arduino microcontroller to secure the connection between the Arduino and the IDE.

It should also be noted that the release of the IDE program affects the communication process, since in our project we used version 1.0.5. Because it is compatible with the type of accessories for our Labview version (LabView2017).

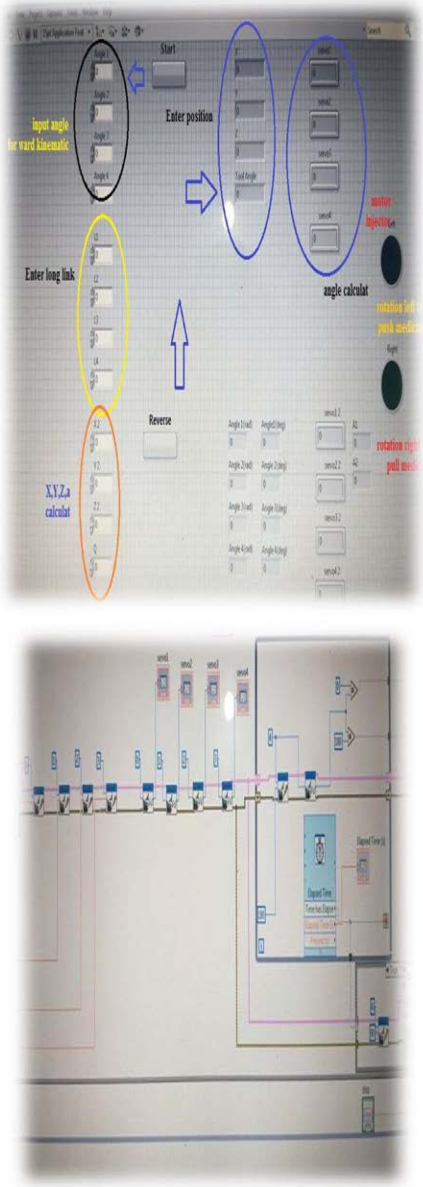


Fig.5. Labview Interface.

VII. CONCLUSION:

In this study, the movement of the robotic arm used in the medical field was analyzed and controlled using Labview, That allowed easy control of the robotic arm by connecting with the Arduino chip and building, The interface makes it easier for the user to communicate and control the robotic arm and direct it to the desired set point

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