

# Simulating Motions of Robotic Arms Using MATLAB

Hossein Safaeifar<sup>1\*</sup>, Jafar Gerdabi<sup>2</sup>

**Abstract:** Mechanical arms have progressed substantially complete in recent years. Robotic arms can help people in remote areas or areas where access is limited, objects move easily and do things with precision and speed. A robotic arm is usually a programmable mechanical arm, with performance similar to a human arm.

Robotic arm may be total mechanism or part of a complex robot. Robotic hand is able to do any work required to design, such as welding, the object is spinning and so on. For example, robotic arms are doing a variety of tasks, such as welding and the rotating parts (spare parts) during the assembly in car assembly lines.

The purpose of this paper is motion simulation and design robotic arm by MATLAB software (code and Simulink). The equations of position, speed, and acceleration and vibration system are being earned.

Then by coding, will be displayed range of motion and how to move an object with one or two arms in space and system block diagram Simulink environment.

**Keywords:** Robot arm, MATLAB, Simulink.

## 1. INTRODUCTION

Mechanical arms are formed of solid links which are enabling to connect with each other by the relative motion of adjacent interfaces. Mechanical arms are capable of operating in various industries with a variety of pre-programmed operations. Skilled mechanical arms have progressed substantially complete in recent years.

Working with them and maintenance of them are being easy and optimal fit between the power, controllability and skill of them are been created. A unique feature of robotic arms compared with the manpower is the capacity of handling large objects and can work as hard labor or less accurately the risks do with hundred per cent accuracy and without risk to do easily.

Robotic arm is a device that consists of a series of joint axes and the behavior is similar to a human arm. The robotic arm can perform different tasks of cutting, welding and injection spray paint to do the right thing. Together robotic arm can work in the field of welding, moving parts, spray, injection, cutting and fold summed up. In this paper two-dimensional and three-dimensional simulation of robotic arm moving is done in MATLAB.

## 2. OVERVIEW OF WORK DONE

The article presents an overview of updating mechanism for industrial [1]. A brief description of the typical client devices as well as industrial robots has been presented for the first time and several types of multi-purpose belts are also presented.

In article about development efficiency equations for robot arm are used a new way of parallel and perpendicular concepts and the development of efficient closed-form equations for robot arm is provided [2]. These Methods are applies for each link rigid robot arm with rotating joints or transitional. Now the computational efficiency of this

<sup>1</sup> Engineering Department, Bozorgmehr University of Qaenat, Qaen, Iran.

<sup>2</sup> Engineering Department, University of Birjand, Birjand, Iran.

\* P.O.B. 311, Qaen, Iran, safaeifar@buqaen.ac.ir

method makes the development of the efficiency equation for the robot arm to run on a microcomputer in real time. Overall, for an industrial robot arm with six degrees of freedom, this method requires a maximum of 568 multiply and 582 summations for the development of coefficients multiplied and the overall efficiency and driving force or torque for arm robot. For the six-link robot arm, this method is certainly much less than the number of mathematical operations, Due to the fact that many relationships between the link parallel or perpendicular to the axis coordinate system are specified. Overall, as compared to other available methods for the said purpose, the method presented in this paper has higher computational efficiency and computationally faster than all existing methods.

The optimal synthesis in paper of crane robot is based on global motion parameters, a method for measuring the mechanical arm of the global elite [3]. This method is based on a new concept, as the pace of global oval, which represents the global skilled mechanical arm. Parameters which indicative of global consistency and global size of the transfer for analysis and optimization of motor speed cranes are used in cranes. Development and operation of transmission characteristics to minimize transmission errors and increase accuracy, job placement and planning is discussed.

In a paper chain to the robot arm motion, movement restrictions, classification, connection, and stimulated, in part, as a specific example of the robot has already identified several restrictions on the movements of these devices is considered [4]. The method for the synthesis of a number of motor chains in Section 1 of several different ways to synthesis chains suitable for applications such as robot hand, some of the structure that has been found is provided. So to detect movement better than any other chain to chain, a new concept of mobility is defined minimum set of chains. Another new concepts that are defined and used in a variety of motor chains, extend the chain connecting the motor relative to the type of stimulation used pair. The chains move according to their types checked. The work presented in this paper is applications for beyond the synthesis of a number of alternative structures for the robot.

The optimized route planning paper cranes according to a dynamic system, looking for a solution to the problem of robot motion control with minimal cost along a geometric path specified [6]. Time optimized motion and mechanical energy minimum from disk (the drivers) are intended to be used to build a multi-objective function. The optimization problem is subject to physical limitations. Mathematical modeling of nonlinear equations of motion leads to a mechanical arm. Numerical results for the three and six degrees of freedom are provided with a mechanical arm.

### 3. MATHEMATICAL MODELING

Design is calculation the length of three members of the robotic arm. In this section, equation of position, speed and acceleration are examined. In general, each member can have an angular velocity and an angular acceleration. Figure 1 shows the dimensions of the member 2.

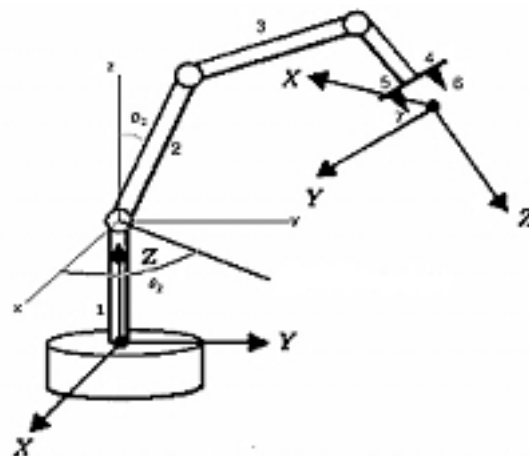


Figure 1: The angles of link 2

To design a robotic arm, the position (or velocity or acceleration) of some points of collection must be determined. That's why the equations of joint (where the motor is placed) must be specified. Equations of position, velocity and acceleration of joints in three dimensions are according to equation 1 where  $p_i$ ,  $q_i$  and  $s_i$  are  $x$ ,  $y$  and  $z$  components of the  $i$ -th link to the beginning of the link.

$$\vec{r}_i = \left( \sum_1^i p_i \right) \hat{i} + \left( \sum_1^i q_i \right) \hat{j} + \left( \sum_1^i s_i \right) \hat{k}$$

$$\vec{V}_i = \sum_1^i \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \omega x_i & \omega y_i & \omega z_i \\ p_i & q_i & s_i \end{vmatrix}$$

$$\vec{a}_i = \sum_1^i \left( \left( \omega x_i \hat{i} + \omega y_i \hat{j} + \omega z_i \hat{k} \right) \times \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ \omega x_i & \omega y_i & \omega z_i \\ p_i & q_i & s_i \end{bmatrix} + \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ a x_i & a y_i & a z_i \\ p_i & q_i & s_i \end{bmatrix} \right) \quad (1)$$

To obtain the equations of vibrating systems, only the first three members are considered where angle between the  $i$ -th member and  $y$ -axis is  $\theta_i$ .

The force diagram each of the three members is drawn. The equations of torque and power of members 1, 2 and 3 must be written. Note that the member 2 and 3 has a linear acceleration and torque equation of the center of mass can be expressed as Equation 2.

$$\sum M_G = J_G \times \ddot{\theta} + m \times a_f \times d \quad (2)$$

#### 4. SIMULATION

In this section, a model in Simulink is created to determine the scope and motion simulation and robot arm design. Map of robot arm moving without exaggeration, truly sophisticated. Two different modes of moving a robotic arm are shown in figure 2.

Imagine a robot arm that some object in your workspace, and how to move the arm in the workspace that is intended to point? To do this, it is assumed that exactly the same as a robotic arm that can be controlled in three-

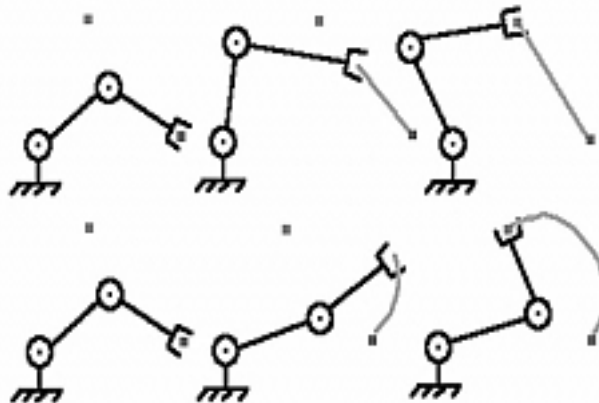


Figure 2: Movement path of robotic arm in plane

dimensional space. At the same time we must ensure that the joints and links do not hit anything. Doing this is very difficult. There are several modes for a robotic arm. Each member can make within a period.

If period of 1 is 45 degrees and period of 2 and 3 of are 180 degrees, the paths of endpoints of 3 members are displayed in figure 3.

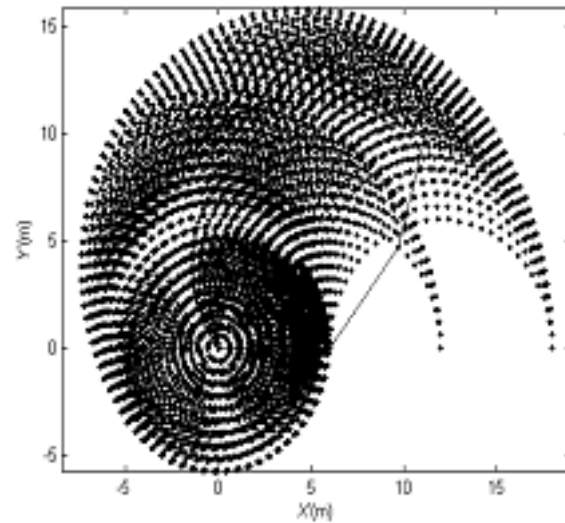


Figure 3: Movement space of robotic arm in plane

## 5. DESIGNING OF ROBOTIC ARM ON THE PLANE

To simplify the design, a robotic arm on the seven-member is checked in plane. Figure 4 shows the seven members of a robotic arm.

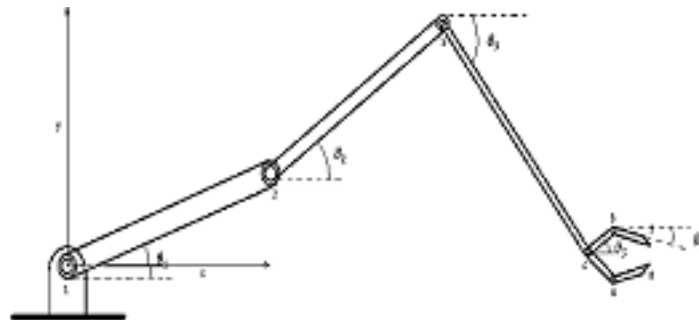


Figure 4: Robotic arm in plane

To design a robot arm, 7 design parameters (which are the members) must be calculated. To calculate the length, there are many initial conditions, which are divided into three categories:

- Design based on movement of each joint member in particular member 4
- Design based on velocity of each joint member in particular member 4
- Design based on acceleration of each joint member in particular member 4

Design may be based on a combination of the above methods. In any case, 14 parameters of robotic arm must determine, such the length and angle of the 7 are unknown that should be calculated. Note that the 7 angles are not design component, But because these angles are appear in equations appear, there one condition must be for each angle so all of the equations to be solved.

The range  $(L_1, \theta_1)$  and  $(L_2, \theta_2)$  and  $(L_3, \theta_3)$  and space of joint 4 also determines so the number of arms that can work with the conditions specified.

The number of arms that can be designed with requirements in equation 3 is equal to  $g^6 = 262144$ , where  $g$  is the number of the loop ( $g = 8$ ).

$$\begin{aligned} 2\ m < L_1 = L_2 = L_3 < 6\ m \\ 10^\circ < \theta_1 = \theta_2 = \theta_3 < 80^\circ \\ \Delta L = 0.5\ m \end{aligned} \tag{3}$$

If the coordinates of joint 4 are in the period (7,8), the 32768 arm can be designed. This shows that the situation should be much more limited than the number of responses obtained.

If one mode of the 32768 states considered and changing the angles of the three bars determined, three lengths and three angles  $L_1, L_2, L_3, \theta_1, \theta_2$  and  $\theta_3$  can be achieved using the coordinates of three points from three levels of a robotic arm.

By selecting the specific length and angle, the model simulated that box pass from one specific place to another. Then this model is modeled by MATLAB Simulink. For example, two different states of the robot arm with the equation 4 are shown in figures 5 and 6.

$$\begin{aligned} L_1 = L_2 = L_3 = 6\ m \\ 0^\circ < \theta_1 < 12^\circ \\ -20^\circ < \theta_3 < 0 \end{aligned} \tag{4}$$

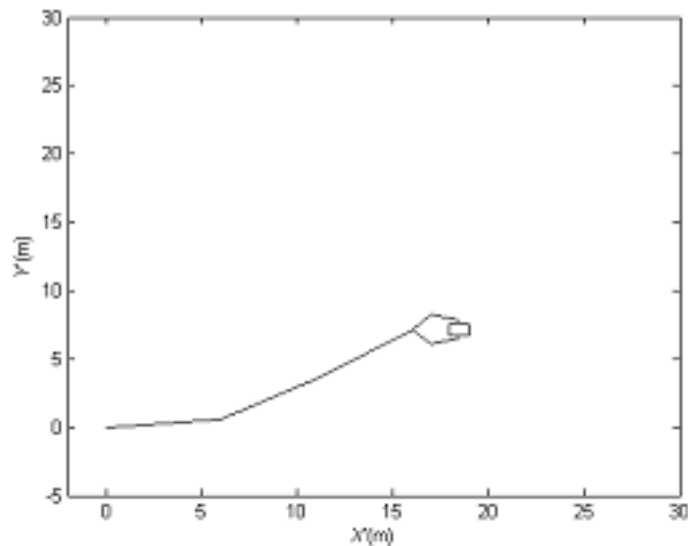


Figure 5: One state of robotic arm in plane

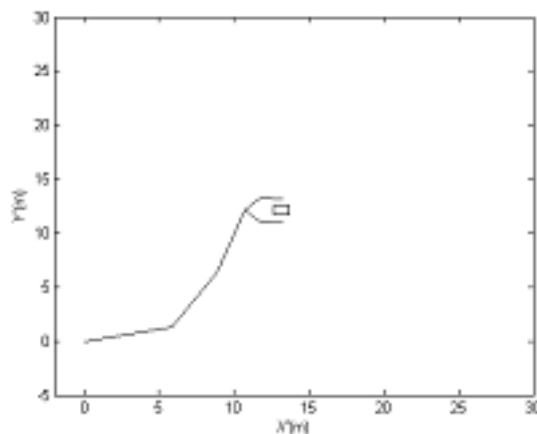


Figure 6: Another state of robotic arm in plane

## 6. MODEL IN SIMULINK

The final version of model after designing in Simulink is shown in figure 7 which is also can be designed with programming.

Links 1 and 2 turns 15 degrees and link 3 turns -15 degrees. One robot arm is shown in figure 8 for example.

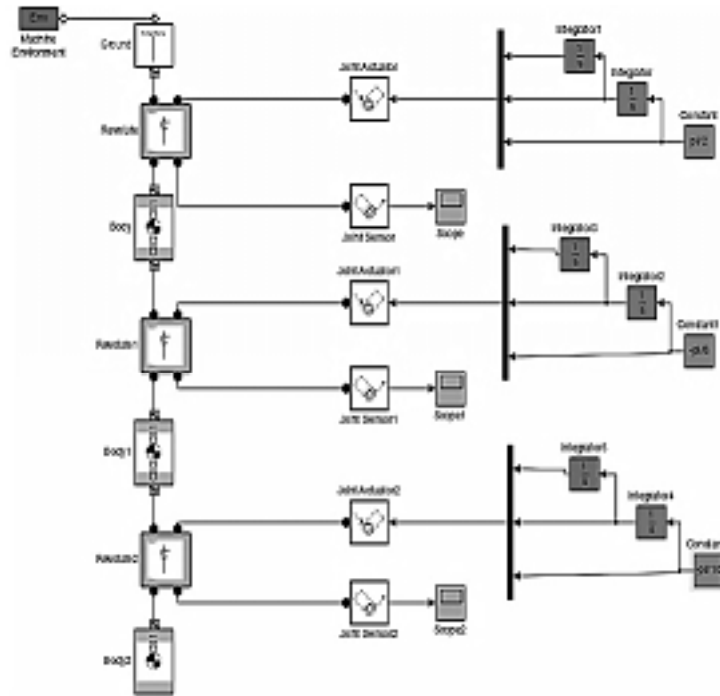


Figure 7: Block diagram of robotic arm



Figure 8: One state of robotic arm in SIMULINK

## 7. SIMULATING THE MOVEMENT OF TWO ROBOTIC ARMS IN PLANE

Simulating the movement of two robot arms is done by considering the following characteristics.

$$L_1 = L_2 = L_3 = 6$$

$$0 < \theta_1 < 12^\circ$$

$$0 < \theta_2 < 5.95^\circ$$

$$-20^\circ < \theta_3 < 0$$

For example, four states of robotic arms are shown in figures 9 to 12 for moving a box on the plane.

## 7. DESIGN ROBOTIC ARM IN SPACE

Designing robotic arm in space is similar to design in plane design with this difference that 3 members move in space. In this design 9 unknown parameters such as  $l_1, l_2, l_3, \theta_1, \theta_2$  and  $\theta_3, \phi_1, \phi_2, \phi_3$  must be calculated with using of 9. By selecting the specific length and angle, the model is simulated that box pass from one specific place to another. Four states of the robotic arm are shown in figures 13 to 16 for example.

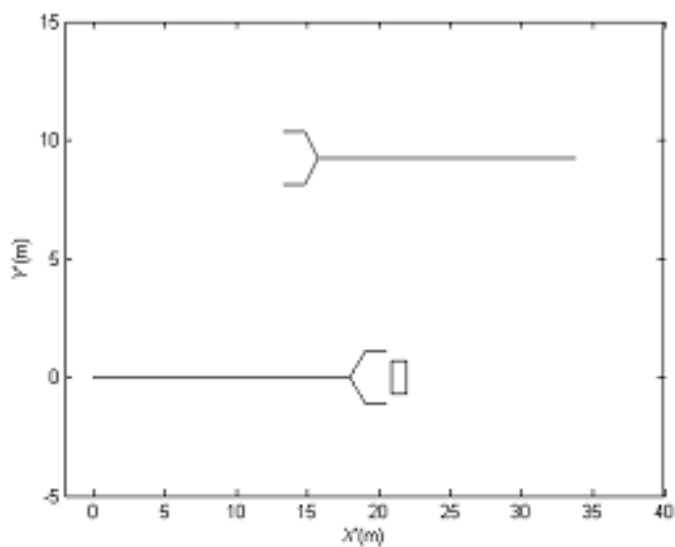


Figure 9: First state of 2 robotic arms in plane

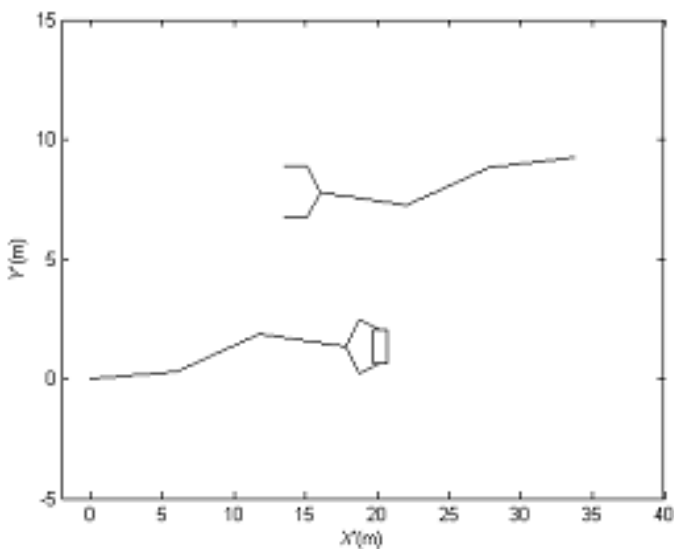


Figure 10: Second state of 2 robotic arms in plane

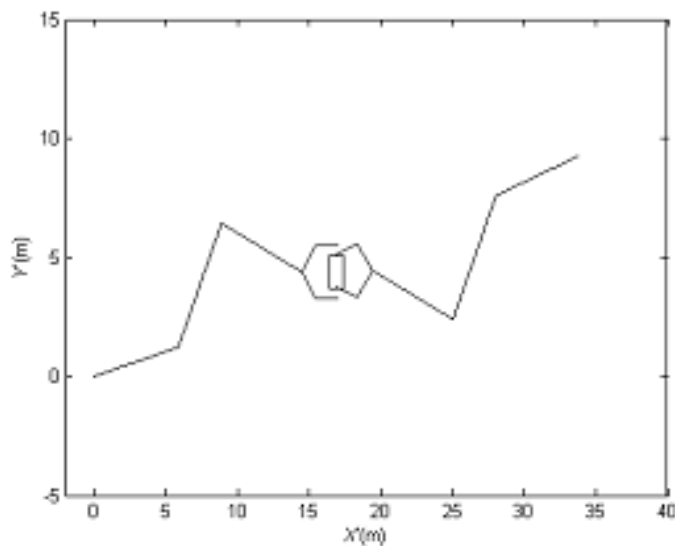


Figure 11: Third state of 2 robotic arms in plane

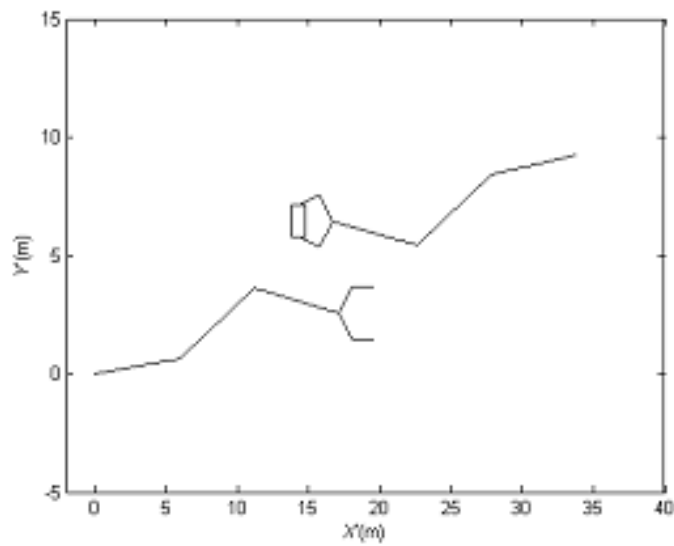


Figure 12: Forth state of 2 robotic arms in plane

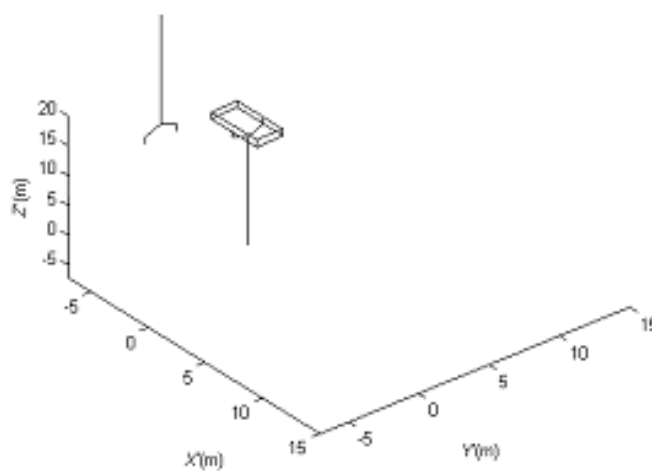


Figure 13: First state of 2 robotic arms in space

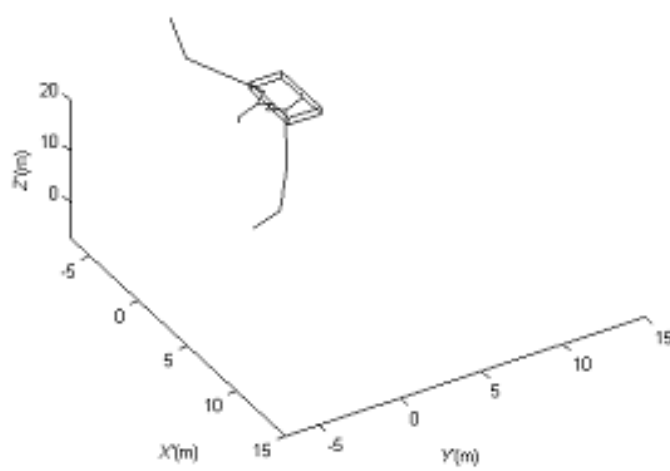


Figure 14: Second state of 2 robotic arms in plane

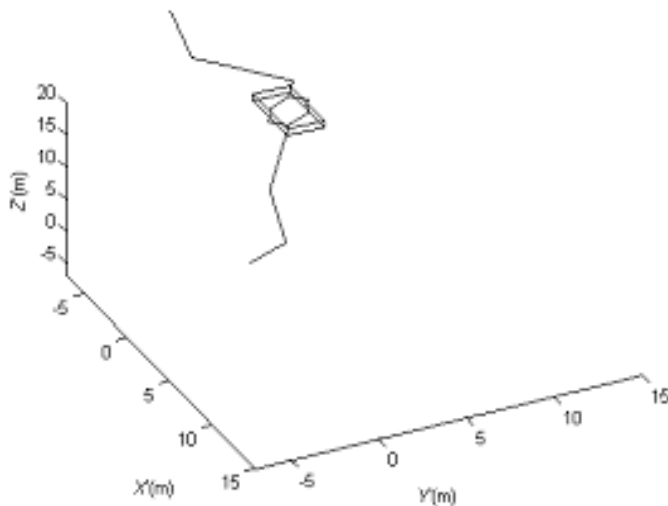


Figure 15: Third state of 2 robotic arms in plane

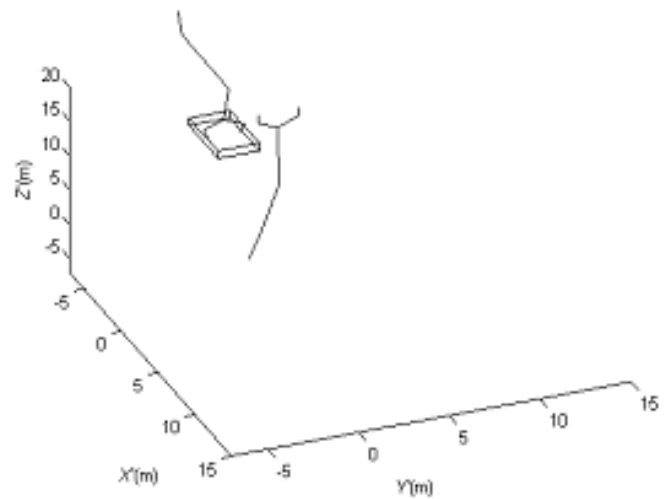


Figure 16: Forth state of 2 robotic arms in plane

## 8. CONCLUSIONS

The purpose of design in plane is calculating the length of links. Solving equations with MATLAB is very time-consuming because they are nonlinear equations. Assuming the endpoints of the link 3 are passes of three points with specific coordinate and angles of each link are specified, length 3 members can be calculated. With selecting the coordinates, the bars may be positive or negative. Assuming the endpoints of the link 3 in space are passes of three points with specific coordinate and angles of each link are specified, length 3 members can be calculated. The negative length is justified with respect to polar coordinates, but too large size makes it impossible to design.

### References

- [1] Fun Ya Chen, GRIPPING MECHANISMS FOR INDUSTRIAL ROBOTS AN OVERVIEW, Mechanism and Machine Theory Vol. 17, No. 5, pp. 299-311, 1982.
- [2] Chang-Jin Li, T.S Sankar, DEVELOPMENT OF EFFICIENT CLOSED-FORM DYNAMIC EQUATIONS FOR ROBOT MANIPULATORS USING PARALLEL AND PERPENDICULAR CONCEPTS, Mech. Mech. Theory Vol. 28, No. 2, pp. 233-248. 1993.
- [3] J.R. Singh, J. Rastegar, OPTIMAL SYNTHESIS OF ROBOT MANIPULATORS BASED ON GLOBAL KINEMATIC PARAMETERS, Mech. Math., Vol. 30, No. 4, pp. 569-580, 1995.
- [4] C.R. Tischler, E.A Samuel, K.H Hunt; KINEMATIC CHAINS FOR ROBOT HANDS - II. KINEMATIC CONSTRAINTS, CLASSIFICATION, CONNECTIVITY, AND ACTUATION, Robotics and Design Group, Mech. Mech. Theory Vol. 30, No. 8, pp. 1217-1239, 1995.
- [5] F.S.P. Saramagoa, V. Steffen Jr; OPTIMIZATION OF THE TRAJECTORY PLANNING OF ROBOT MANIPULATORS TAKING INTO ACCOUNT THE DYNAMICS OF THE SYSTEM, Mechanism and Machine Theory, pp. 883-894, 1999.