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1. Abdullah ÇAKAN, 2. Fatih Mehmet BOTSALI

INVERSE KINEMATICS ANALYSIS OF A PUMA ROBOT BY USING MSC ADAMS

1-2. Selcuk University, Faculty of Engineering, Mechanical Engineering, Konya, TURKEY

Abstract: This work presents a different approach to inverse kinematics analysis of a PUMA robot. PUMA robot is an industrial robot arm with open chain mechanism that is used in different purposes. PUMA robot has a complicated inverse kinematics expressions that needs to be solved. In this paper, the inverse kinematics problem is solved by using MSC ADAMS instead of knowing inverse kinematics expressions and calculating this expressions. PUMA robot multi-body dynamics model is built by MSC ADAMS and joint angles are derived for a circle-shaped trajectory. Used trajectory and derived joint angles are given in the form of the graphics.
Keywords: robot, robot arm, puma robot, multi-body dynamics, inverse kinematics

INTRODUCTION

PUMA (Programmable Universal Machine for Assembly) robot is an industrial robot arm with open chain mechanism that is used in different purposes like welding, surgery, laser tracking systems, etc [1-3].Inverse kinematics is to obtain the joint angles for a desired trajectory or position of the end point the robot [4]. PUMA robot has a complicated inverse kinematics expression that needs to be solved. There are several numerical and experimental studies in literature about solving inverse kinematics of PUMA robot by using different algorithms or software's [5-7].

In this paper, the inverse kinematics problem is solved by using MSC ADAMS instead of knowing inverse kinematics expressions. PUMA robot multi-body dynamics model is built and joint angles are derived using MSC ADAMS. Inverse kinematics analysis is the first step of trajectory tracking control studies. PID control and adaptive fuzzy logic control are some of the control methods of trajectory tracking [8-9].

MODELING AND INVERSE KINEMATICS ANALYSIS

In this section modeling and inverse kinematics analysis of the PUMA robot is described. Model of the PUMA robot is built by MSC ADAMS that is multi-body modeling software to build and simulate mechanical systems dynamic analysis.

PUMA robot has six degrees of freedom with a spherical wrist. In this paper only first 3DOF is studied without wrist that shown in Figure 1. Modeled PUMA robot joint angles and component dimensions of the robot is shown in Table 1.

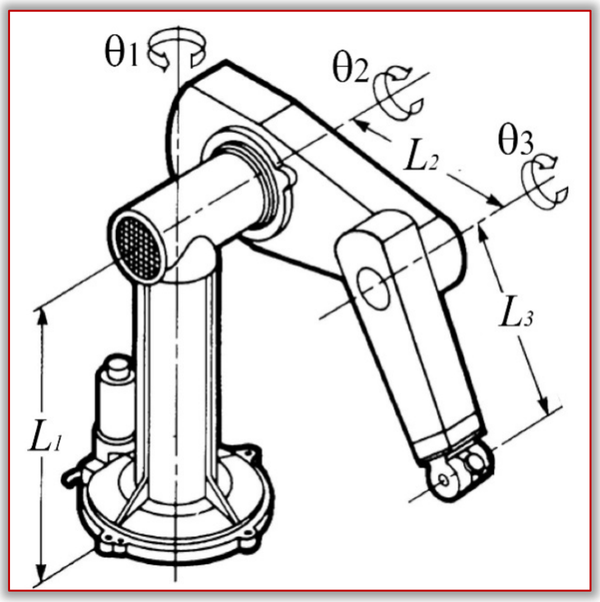

Figure 1. PUMA Robot dimensions and joint angles.

Table 1. Joint angles and component dimensions

θ_1	Waist angle	0 deg
θ_2	Shoulder angle	0 deg
θ_3	Elbow angle	-45 deg
L_1	Trunk length	0.180m
L_2	Upper arm length	0.120m
L_3	Forearm length	0.125 m

Inverse kinematics (IK) is to obtain the joint angles for a given trajectory or position to end point the forearm. PUMA robot has a complicated inverse kinematics expression that needs to be solved.

The inverse kinematics problem is solved by using MSC ADAMS and simulated by using MATLAB co-simulation instead of knowing inverse kinematics expressions and calculating this expressions.

A circle-shaped trajectory is given to end of the forearm with using MSC ADAMS capability of giving motion to the points and joint angles are derived for the trajectory. X and Y coordinates of circle generated and used as an input by MATLAB shown in Figure 2 and Figure 3. Circle-shaped trajectory is shown in Figure 4 created with X and Y coordinates.

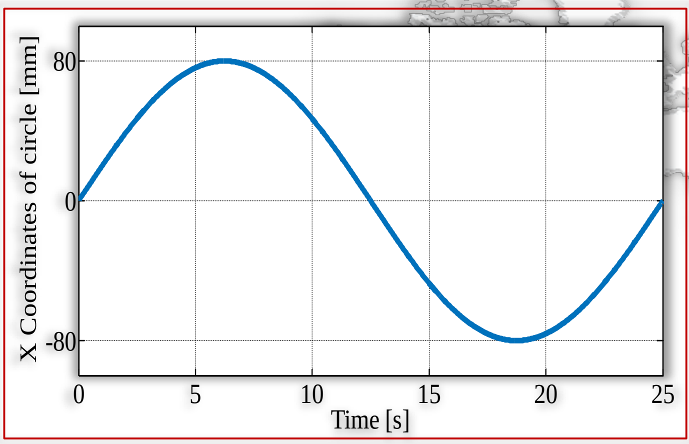

Figure 2. X Coordinates of the circle-shaped trajectory

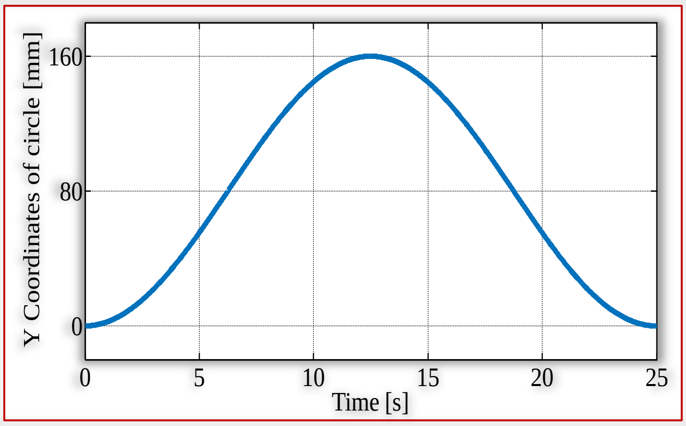

Figure 3. Y Coordinates of the circle-shaped trajectory

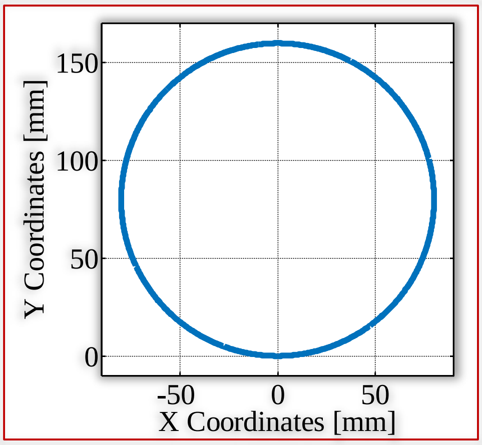

Figure 4. Circle-shaped trajectory created with X and Y coordinates

RESULTS AND DISCUSSION

Inverse kinematics problem of PUMA robot is solved by using MSC ADAMS and MATLAB co-simulation capabilities and joint angles are derived for the circle-shaped trajectory. As a result of inverse kinematics analysis Derived waist angle θ_1 is shown in Figure 5, derived shoulder angle θ_2 is shown in Figure 6 and derived elbow angle θ_3 is shown in Figure 7.

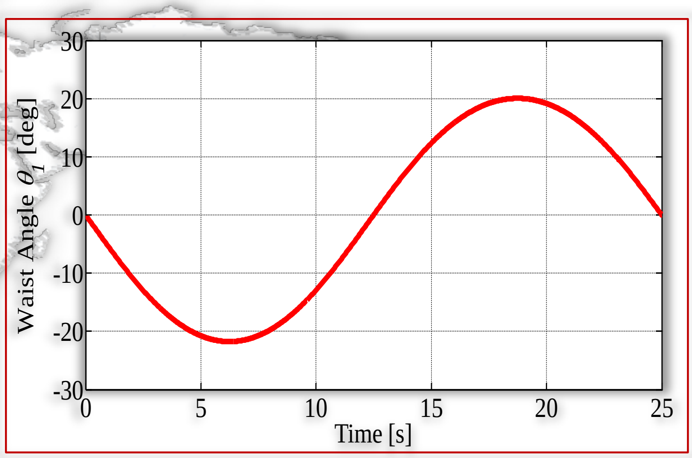

Figure 5. Waist angle

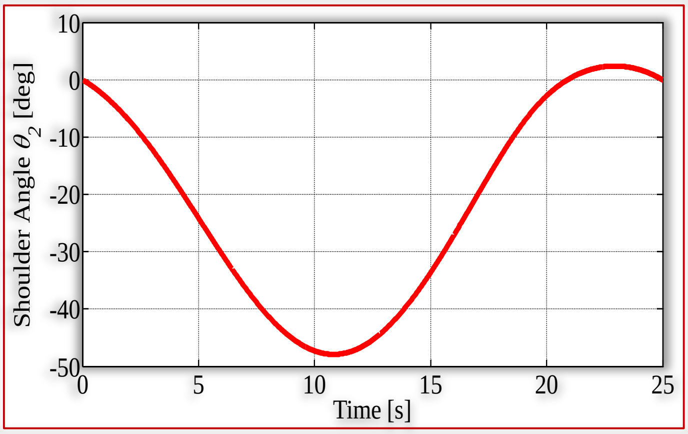

Figure 6. Shoulder angle

Moreover, simulation of inverse kinematics analysis gives visual animations as a result. Snapshots from the animation of analysis are given in Figure 8.

From these results, it can be said that using MSC ADAMS is a successful and effective method for solving inverse kinematics of a PUMA robot and dynamics of other mechanical systems.

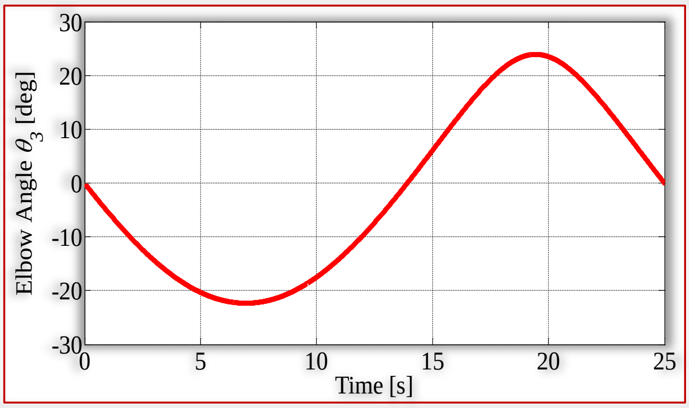

Figure 7. Elbow angle

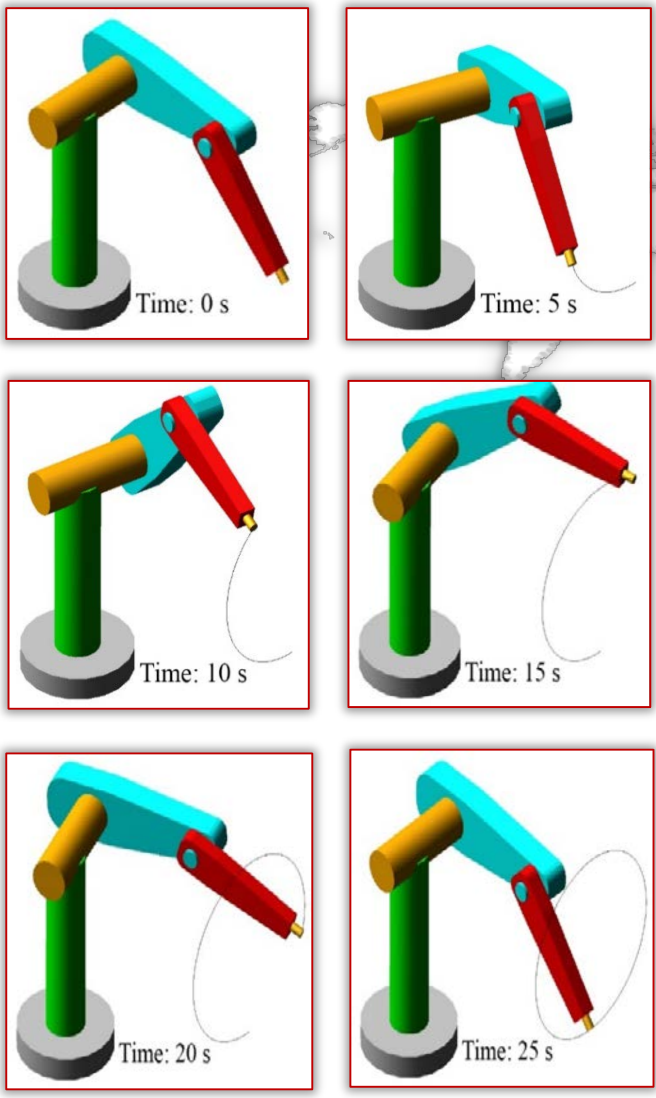

Figure 8. Snapshots from the simulation

CONCLUSION

This paper presents a different approach to inverse kinematics analysis of a PUMA robot that is an industrial robot arm with open chain mechanism. Inverse kinematics problem of PUMA robot is solved by using MSC ADAMS and joint angles are derived for the circle-shaped trajectory.

Thus, these types' robots and mechanical systems can be modeled and analyzed without mathematical model by using engineering software. As a result of the paper, proposed analysis method verified by simulations and derived joint angle results are given in the form of the graphics.

The main contribution of the paper to the literature is that different type inverse kinematics analysis approach is implemented. Furthermore, this paper can be a reference to the trajectory control studies of the robots for the future works.

Note

This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016, referred here as [10].

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