Kinematics of Mechanics
ME-206

MID-SEM PROJECT

FORWARD KINEMATICS MANIPULATION OF A 2-R ROBOTIC ARM USING MATLAB

*The following works are performed and the project is prepared by **Pranav Mittal (2K19/ME/167)** for the purpose of Mid-semester Project Evaluation for Kinematics of Mechanics and submitted to Prof. R.C. Singh.*

ABSTRACT

Kinematic and dynamic modeling of serial robot manipulators is a challenging task but to obtain the best performance of the system, the study of the kinematic and dynamic mechanism of the system is essential. To study and analyze the kinematic interaction of each link for various configurations, a planar robot manipulator is used as a simplified model for kinematic and dynamic analysis. In this project, the mathematical equations for kinematic modeling of a two-link planar robot manipulator having two revolute joints are derived and equations are analyzed by obtaining MATLAB code. The kinematics separate into two types, forward (direct) kinematics and inverse kinematics and this same for dynamics also but my focus is on formulating and analyze forward kinematics only. In forward kinematics, the length of each link and the angle of each joint is given and we have to calculate the position of any point in the work volume of the robot. In dynamic analysis, to be able to control a robot manipulator as required by its operation. MATLAB code in the form of several M-files are developed for kinematics of two-link planar manipulator and results are plotted in the form of graphical representation.

Robotic Arm

A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion or translational displacement.

The robotic arm is used for multiple industrial applications, from welding, material handling, and thermal spraying, to painting and drilling. The robotic technology also provides human-like dexterity in a variety of environments.

Theory

A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand.

Forward Kinematics: Forward kinematics refers to the use of the kinematic equations of a robot to compute the position of the end effector from specified values for the joint parameters.

Governing Equation

The equation to determine the position of end-effector is as follows:

$$X_2 = X_1 + L_1.\cos\Theta_2$$
$$Y_2 = Y_1 + L_2.\sin\Theta_2$$
$$X_1 = L_1.\cos\Theta_1$$
$$Y_1 = L_1.\sin\Theta_1$$
$$X_0 = Y_0 = 0$$

Where;

(X_0, Y_0) = coordinates of origin i.e. base

(X_1, Y_1) = end coordinates of Link 1

(X_2, Y_2) = end coordinates of Link 2 i.e. end-effector

L_1, L_2 = length of Link 1 and 2 (m)

Θ_1, Θ_2 = angle of Link 1 and 2 (degree)

Solution

Programming Language: MATLAB

Procedure/Steps:

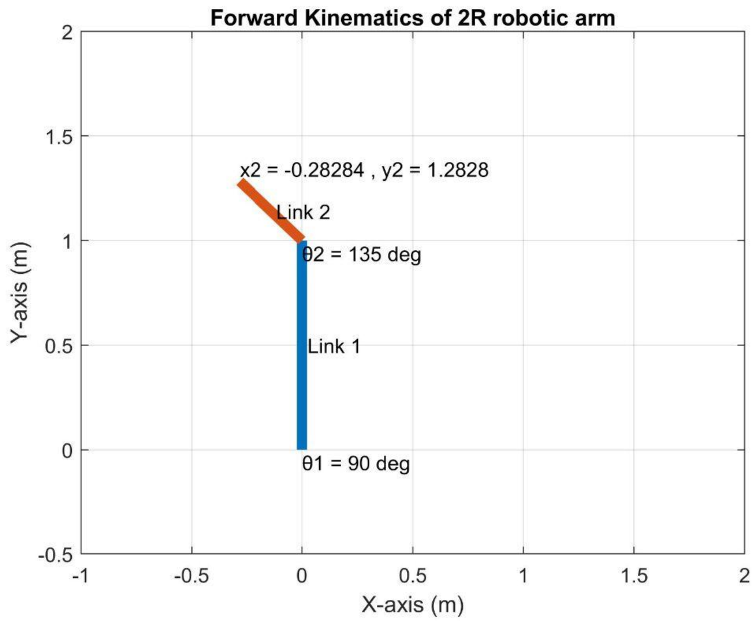
1. Assign suitable variables to store length and angle for the links.
2. Create a for loop for the generation of frames and declare a variable named counter (ct) to start with.
3. The first loop (i) will be ranging from 1 to the maximum value of θ (theta1) whereas the second one (j) will be ranging from 1 to the maximum value of θ2 (theta2).
4. For one count of loop i, loop j would finish complete rotation and compute the values as shown in the code.
5. The images are plotted with the help of plot function.
6. Finally, the counter will increment by 1 (ct+1) until loop i is finished and step #4 and #5 are repeated.
7. getframe() captures the individual frame and stores it in an array M.
8. To create an animation of all the frames generated,
    a. assign the frame movie in array M.
    b. assign appropriate file name and extension in videofile().
    c. open() begins to extract the files.
    d. writeVideo writes data from an array to the video file.
    e. close() terminates the operation.

Code

The MATLAB program to plot the simulation for forward kinematics of a 2R robotic arm is shown below.

```
% Program for forward kinematics of a 2R robotic arm manipulator.
% Inputs:
% (NOTE: 1 - First Link, 2 - Second Link)
% Length of links (m)
l1 = 1;
l2 = 0.4;
% Angle with the horizontal (degrees)
a1 = linspace(0,90,9);
a2 = linspace(0,135,13.5);
% Solution:
% Counter and loop initialization
ct = 1;
for i = 1:length(a1)
 theta1 = a1(i);
 for j = 1:length(a2)
 theta2 = a2(j);
 % Coordinates
 % Initial point of link 1
 x0 = 0;
 y0 = 0;

 % Final point of link 1 i.e. Initial point of link 2
 x1 = l1*cosd(theta1);
 y1 = l1*sind(theta1);

 % Final point of link 2
 x2 = x1 + l2*cosd(theta2);
 y2 = y1 + l2*sind(theta2);

 % Assigning the parameters
 txt1 = ['θ1 = ' , num2str(theta1) , ' deg'];
 txt2 = ['θ2 = ' , num2str(theta2) , ' deg'];
 txtend = ['x2 = ' , num2str(x2) , ' , ' , 'y2 = ' , num2str(y2)];
 % Plot:

 plot([x0 x1],[y0 y1],[x1 x2],[y1 y2],'linewidth',5)
 xlabel('X-axis (m)')
 ylabel('Y-axis (m)')
 title('Forward Kinematics of 2R robotic arm')
 text(x0,y0,txt1,'VerticalAlignment','top')
 text(x1,y1,txt2,'VerticalAlignment','top')
 text(x2,y2,txtend,'HorizontalAlignment','left','VerticalAlignment','bottom')
 text(0.5*(x0+x1),0.5*(y0+y1),' Link 1')
 text(0.5*(x1+x2),0.5*(y1+y2),' Link 2')
 grid on
 axis([-1 2 -0.5 2])
 pause(0.3)
 M(ct) = getframe(gcf);
 ct = ct+1;
 end
end
% Creating the animation:
```

```
movie(M);
```




```
videofile = VideoWriter('Forward Kinematics of a 2R Robotic arm.avi','Uncompressed AVI');
open(videofile);
writeVideo(videofile,M);
close(videofile);
```

Output: The simulation of the robotic arm is coded successfully.

Animation Enclosed.

Conclusion:

Thus, the program for a 2R robotic arm forward kinematics was coded and the position of the end-effector was simulated in MATLAB plot as a video.

References

- https://www.seas.upenn.edu/~meam520/notes/planarkinematics.pdf
- file:///C:/Users/Pranav/Downloads/kinematic-modelling-and-simulation-of-a-2-r-robot-using-solidworks-and-verification-by-matlab-simulink.pdf
- https://in.mathworks.com
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