KINEMATIC ANALYSIS OF 3 D.O.F OF SERIAL ROBOT FOR INDUSTRIAL APPLICATIONS

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Abstract: The paper address the study of motion can be divided into kinematics and dynamics. Direct kinematics refers to the calculation of end effectors position, orientation, velocity, and acceleration when the corresponding joint values are known. Inverse refers to the opposite case in which required joint values are calculated for given end effectors values, as done in path planning. Some special aspects of kinematics include handling of redundancy collision avoidance, and singularity avoidance. Once all relevant positions, velocities, and accelerations have been calculated using kinematics, this information can be used to improve the control algorithms of a robot. Most of the industrial robots are described geometrically by their Denavit-Hartenberg (DH) parameters, in the present implementation, Based on these aspects, we aim our work towards analysis of serial robot by using DH Parameters and obtained the results for industrial applications.

Introduction

A robot is a mechanical or virtual intelligent agent that can perform tasks automatically or with guidance, typically by remote control. In practice a robot is usually an electro-mechanical machine that is guided by computer and electronic programming. Even though the idea of robots goes back to ancient times of over 3000 years ago in India's Legend of mechanical elephants the first use of the word robot appeared in 1921 in the play Rossum's University robots written by the Czeck writer karel Capek (1890-1938).

MOTION SUBSYSTEM:

The motion subsystem is the physical structure of the robot that carries out a desired motion similar to human arms as illustrated below.

The elements of the motion subsystem are

Manipulator:

It is the physical structure which moves around. It comprises of links and joints normally connected in series. Each link is made of steel or aluminum. Other materials can also be used depending on the requirements. The joints are generally rotary or translator types. In the study of the robotics and mechanisms these joints are referred as revolute and prismatic joints.

A robot manipulator has three parts mainly arm, wrist and the hand. The function of the arm is to place an object in a certain location in the three dimensional Cartesian space, where the wrsit orients it. For 6 DOF robots the first three links and joints form the arm and the last three mutually in intersecting joints made a wrist.

End effectors:

This is a part attached at the end of the manipulator and so it is named. This is equivalent to the human hand. An end effector could be mechanical hand that manipulates an object or holds it before they are moved by the robot arm. Also specialized tools like the welding electrode, a gas cutting torch attached to the end of the manipulator arm for performing tasks are also considered. as end-effectors.

DENAVIT AND HARTENBERG (DH) PARAMETERS:

The Denavit Hartenberg parameters (also called DH parameters) are the four parameters associated with a particular convention for attaching reference frames to the links of a spatial kinematic chain, or robot manipulator

1) Joint offset (b): length of intersections of common normal on joint axis

2) Joint angle (θ): angle between the orthogonal projections of te common normal to the plane normal to the joint axes.

3) Link length (a): measured as the distance between the common normals to the axis.

4) Twist angle (α): the angle between the orthogonal projections of the joint axes onto a plane normal to the common normal.

so for the given type of joint i.e. revolute or prismatic one of the DH parameters is variable which is called the joint variable, whereas the other three remaining parameters are constant and are called link parameters

Forward Kinematics:

Forward kinematics is the mathematics behind the process of taking joint angles and specified link lengths and calculating the position of the end effector in the universe frame. To calculate the position of the end effector in the universe frame a series of matrix calculations must be performed that find the position of the end effector relative to each robotic joint. The universe coordinate frame (frame U) is considered to be non-moving and to be located concurrent with the Joint 1 frame which is at the shoulder of the robot. In our robot design joints one and two are also coincident with one another. Although joint two is coincident to joint one, its frame is negatively rotated by 90degrees about the x-axis. The matrix that describes the position and orientation of joint 1 in universe is designated as "T1toU." Similarly, joint two's rotation and translation into the joint 1 frame is T2to1.

To get to Joint three's frame in the universe frame a translation was made along the x-axis and z-axis, known as T3to2. Once all the rotations and translations have been placed in a 4X4 matrix for each joint, they are then multiplied together in the following order:

Toolin U=T1toU*T2to1*T3to2

This series of matrix multiplications gives the position and orientation of the end-effector (the tool) in the universe frame. Each rotational joint has a specific "joint angle" which is the angle of rotation of the joint axis from its home position. Each joint angle is designated using the Greek letter θ followed by the joint number.

Forward position analysis

In the forward or direct kinematics for positions, the joint positions of the revolute joints and the displacement of the prismatic joints are prescribed. The task is to find the end effectors pose i.e. its position and orientation from yhr closure equations as explained in the following steps:

According to the rules attach a coordinate frame to each of the n + 1 links of the robot with frame1 being attached to the fixed frame, and frame n+1 to the end effectors or the nth body

Define the Denavit and Hartenberg parameters as presented .

Write the homogenous transformation matrices for i= 1… n, represents the transformation of the body i or frame i+1 with respect to its previous body i-1 or the frame attached to it i.e. frame i

The homogeneous transformation matrix of the end effector frame with respect to frame1 i.e. is now obtained by post-multiplication of the above individual homogeneous transformation Ti, for i=1…..n.

Q= Q1Q2……Qn

P=a1+Q1a2+…….+Qn-1an

Q=orientation of the end effector with respect to the fixed frame

P=position of the origin of the frame attached to the end effector

Inverse Kinematic analysis:

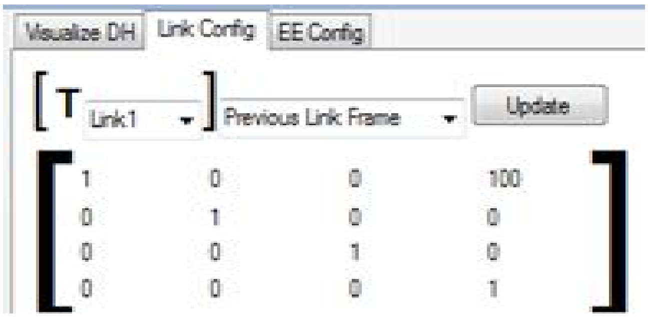
The reverse process that computes the joint parameters that achieve a specified position of the end effector is known as inverse kinematics.

Inverse kinematics refers to the use of the kinematics equations of a robot to determine the joint parameters that provide a desired position of the end-effectors'. Specification of the movement of a robot so that its end-effector achieves a desired task is known as motion planning. Inverse kinematics transforms the motion plan into joint actuator trajectories for the robot. The movement of a kinematic chain whether it is a robot or an animated character is modeled by the kinematics equations of the chain. These equations define the configuration of the chain in terms of its joint parameters. Forward kinematics uses the joint parameters to compute the configuration of the chain, and inverse kinematics reverses this calculation to determine the joint parameters that achieves a desired configuration.

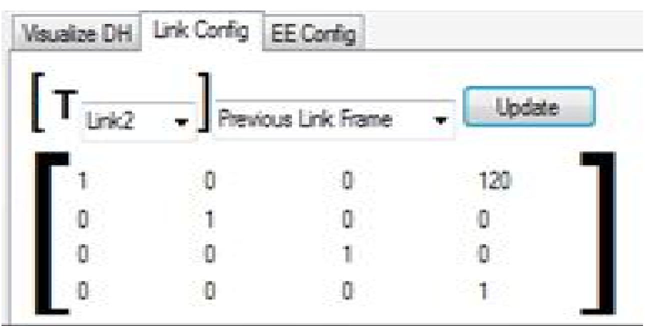
3DOF (RRR) In Robo Analyzer:

The analysis of the joint is done by selecting RRP in 3 dof .The four parameters are to be filled in the DH parameters for the input for the analysis they are joint offset(b),joint angle(θ), link angle(a),twist angle(α)

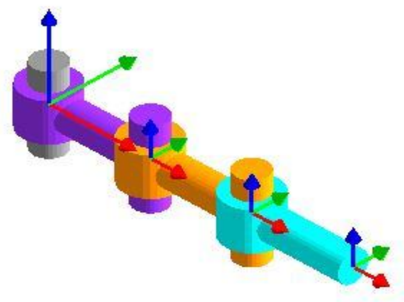
D.H. Parameters Link 1 Matrix:



D.H. Parameters Link 2 Matrix:

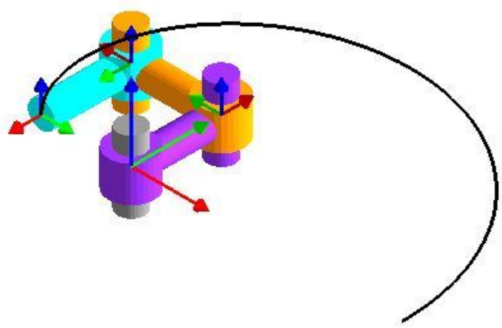


3 RRR Robot using Robo Analyzer



It gives the design that we gave in those parameters in 3D model .The link configuration and end effectors' configuration is also updated by using input parameters. Now on the analysis on pressing the forward kinematics option (Fkin) it will analyze the parameters and after completion it shows Analysis is completed.Now we can simulate the 3D model by using the playing keys as according the figure for the RRR

Forward simulation



It show the simulation of the joint and it also show the path the joint or link revolved

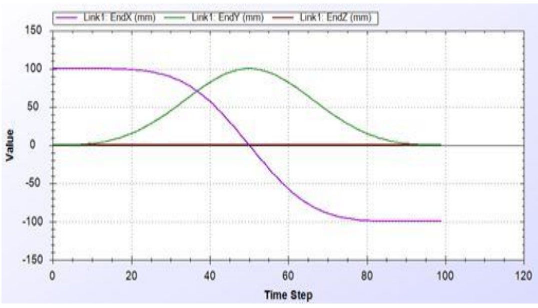
Final value (JV) deg or mm:

JOINT TYPE	INTIALVALUE (JV)deg or mm	FINAL VALUE(JV)deg or mm
REVOLUTE	0	90
REVOLUTE	0	90
REVOLUTE	0	90

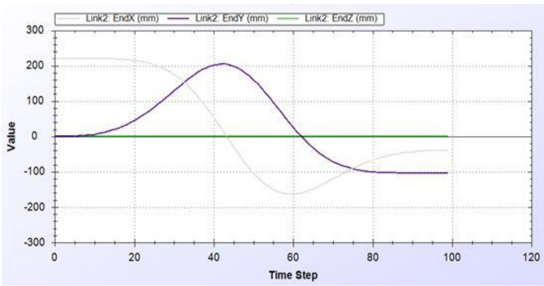
Graph of the links and joints:

Graph plot of link 1, link 2, and link 3

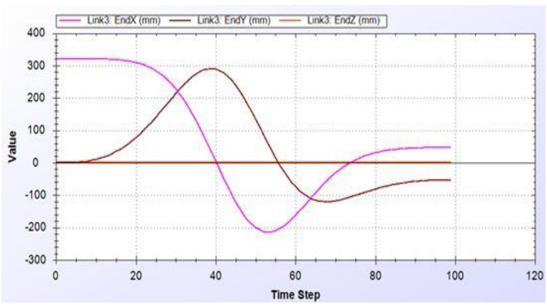
For link 1:



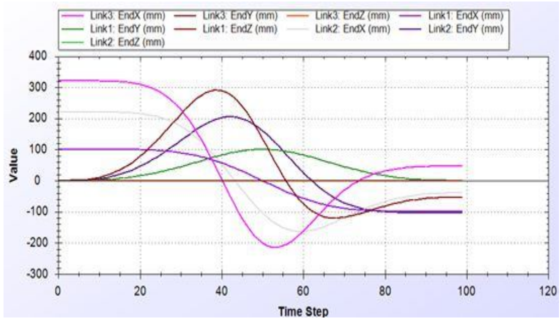
For link 2:



For link 3:



Graph which comprises of all links:



Inverse kinematics:

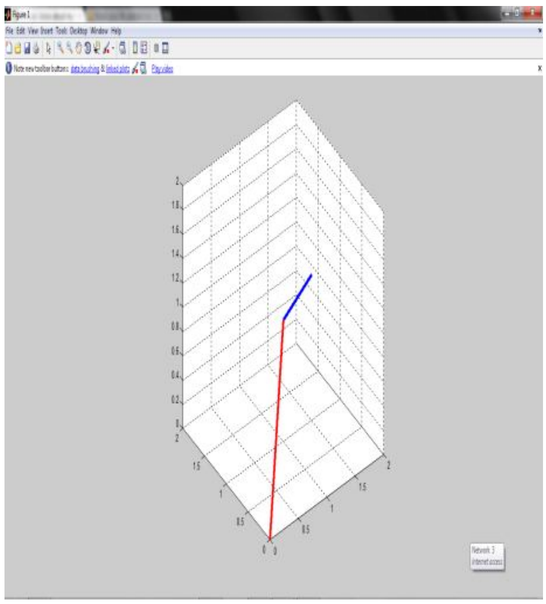
Solutions of inverse kinematics:

Solution 1: Solution 2:

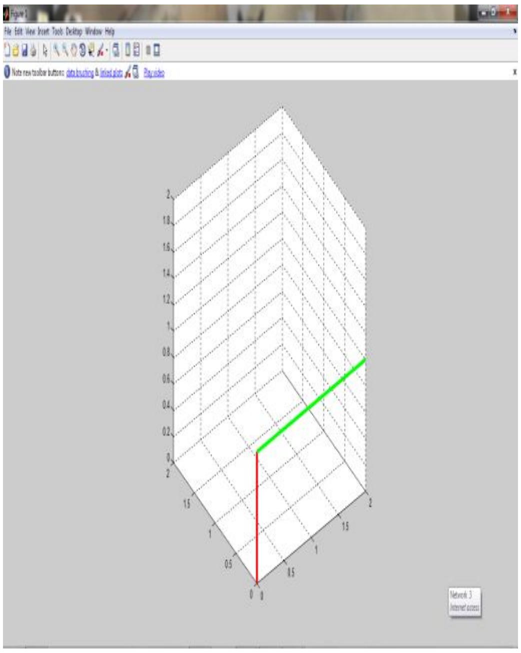
Theta 1 (deg)	-60	Theta 1 (deg)	-60
Theta 2(deg)	120	Theta 2(deg)	120
Theta 3(deg)	150	Theta 3(deg)	30

MAT LAB SIMULATION:

Crude code for a 3 link RRR robot given DH parameters:



MAT LAB RESULT 2:



Hence the RRR was simulated by using mat lab Crude Code and where ass the results obtained in the form og graphs and the results are obtained as same as theoretical values.

Conclusion:

Results for Forward and inverse kinematics of the 3RRR robot was obtained, were as 2 solutions are obtained, generally inverse kinematics have no.of solutions. We compute Crude code of RRR in mat lab and we obtained the Working area and solutions where as the solutions are as similar to the theoretical and we shown the graphical representation of forward kinematics by using robo analyzer and they are matched with the Crude Code of RRR in mat lab.

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