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Development of an Algorithm for Analysis of Workspace of the Robix Robot Manipulator using MATLAB

S.N. Mulande[1], K.K. Sharma[2] and Ratishchandra Huidrom[3]

[1]M.Tech Scholar, Department of Mechanical Engineering National Institute of Technology, Silchar Assam, India
[2]Department of Mechanical Engineering National Institute of Technology, Silchar Assam, India
[3]M.Tech Scholar, Department of CS Engineering National Institute of Technology, Silchar Assam, India
E-mail: sandipmulande@gmail.com, 2kksharma1313@rediffmail.com, 3ratish.cseworld@gmail.comAbstract

Abstract—*In this paper, an algorithm to calculate the 3D workspace based on Denavit-Hatenberg (D-H) parameters to indicate the number of possible target solution and orientation, have been developed and validated. The existing Robix robot is modeled in CAD software and the respective D-H parameters have been calculated. The data so found out is given as an input for the Matlab simulation in order to visualize the 3D- workspace. Further, the analysis is carried out in RoboAnalyzer. The results obtained from both analyses are compared and conclusion has been drawn.*

1. INTRODUCTION

Robot is a kinematic structure which can perform motions for particular task with specified work volume and design model. It must have flexibility and dexterity in order to accomplish accuracy in the task. This paper explores the 3D workspace for optimization of the path and confines the work volume based on its utility Robot as to build a Model is challenging for the designer to control mechanism and dimensions to withstand working environment several algorithm have been developed and helped to determine workspace of a Robot. A similar attempt was made in developing an Algorithm.

Today's manufacturing environment is subjugated by market status and mass customization required. Reconfigurable manufacturing systems are identified as a means of improving the production outcome by shorter product lifecycle in response to sudden market changes and needs [3]. To achieve the flexibility and quickly changing systems are required. It is significant to know whether the robot end- effector can reach a particular target point in its workspace at a suitable orientation to allow modification in the placement. Currently, this reach problem is performed by visual inspection, simulation and by visually analyzing the workspace of the robot. Applications will have need of the tool to be at a certain position and orientation to perform the essential tasks. The workspace with forward kinematic can be defined as the set of all target points that it can be reach in space. The robot workspace does not compare with specific kinematic action which takes place simultaneously in its simulation. It is therefore important to introduce a parameter that can compare workspace analysis with kinematic. This is said to be functional validate workspace, which is subset of the work volume.

2. LITERATURE REVIEW

All target point is defined with its position and orientation related to the structures base frames and visualize reachable space, the workspace is calculated and graphically presented [1]. The 'outer limit of space' model representing all possible positions which may be engaged by a mechanism during its all possible range of motion (for all positions and orientations) is called the work volume. In the robotic domain, it is also known as the robot working envelope or workspace [2]. A new modeling approach has utilize, where the 2D and 3D visualize through the boundary workspace is generated by using a method identified as the Filtering Boundary Points (FBP) algorithm, [3]. By employing symbolic reduction techniques in conjunction with the division of the resultant equations into on-line, temporary variables and off-line constraints, well-organized formulations of the Jacobian, inverse Jacobian, and inverse Jacobian multiplied by a vector have been developed by [4]. The kinematics singularities of each family were analyzed and interpreted both algebraically and geometrically and the singular configurations of 6R robots with spherical wrist in general and the KUKA KR-15/2 industrial robot in particular, are analytically described and classified by [5]. the authors first simple and complex machine trajectory is defined as series of united points in 3D space. Each point is defined with its position and orientation related base frames. The Robotic arm can be designed to achieve predefined tasks and define the target tasks for Handicapped People [6]. The results were demonstrated with those obtained using the Dynamic Simulation module of Autodesk Inventor. RoboAnalyzer can be downloaded for free from http://www.roboanalyzer.com and can be used almost instantly [7]. Reconfigurable manufacturing systems (RMS), whose components are reconfigurable machines and control as well as methodologies for their systematic design and a number of robotic responsibilities are considered with regard to the complexity of desired structure and mechanical configurations. We also give examples of robix robot [8-9]

3. METHODOLOGY

In order to find analytically the expressions for the boundary surfaces of manipulators and following the objective is written as follows :

1. Design of a CAD model of Robix robot and its development by Finite Element model.
2. To develop a set of analytical criteria to obtain the positioning of the end effector in terms of grasping number of target points and plots the 3D workspace as Matlab output.
3. Kinematic analysis to be carried out in RoboAnalyzer and validate it by Matlab result.

4. SOFTWARE FEASIBILITY

In these software feasibilities, to solve the need is completed by taking best programme. Here CATIA V5 is used for modeling the robot arm and Matlab for analysis the workspace of robot.

5. ASSEMBLY OF ROBIX ROBOT ARM

In assembly operation, it has taken part, combine part assemblies. Assembly made in CATIA V5 enables to place component parts as well as subassembly together. Resultant assembly can be altered, analyzes and configured

Robix robot Assembly is shown below:

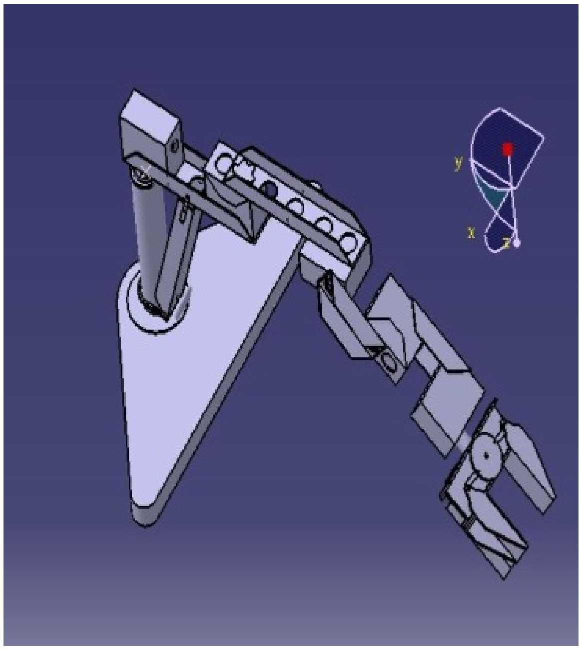

Fig. 1 Assembly of Robix robot

The Robix robot is modeled by taking dimension same as existing robot in robotic laboratory and some experiments were performed on it to take the D-H parameter. This is a pick and place robot and it can be used in chemical laboratory and perform the experiments

6. FORWARD KINEMATIC ANALYSIS IN ROBOANALYZER AND D-H PARAMETER

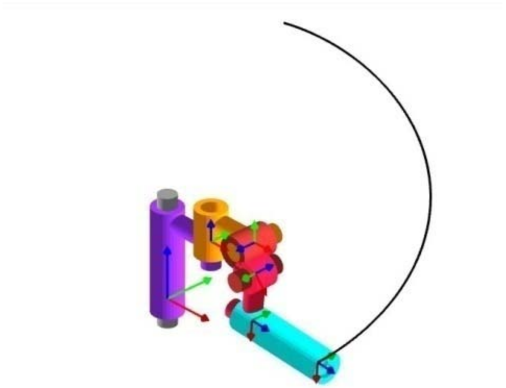

Fig. 2: Forward kinematic analysis in RoboAnalyzer for a 5 degree-of-freedom Robix robot.

This model structure is represented by the orientation of each joint and shows the gripper position with respect to the base and forward kinematics from input of initial value to final value as shown in table1

Table 1: D-H parameters for Robix robot

Link	Joint Type	Joint offset b (mm)	Link length a (mm)	Initial Value(Θ)	Final Value(Θ	Twist Angle (α)
1	Revolute	131.5	90	0	60	0
2	Revolute	36	90	0	60	90
3	Revolute	22.5	40	-50	60	180
4	Revolute	0	80	45	60	90
5	Revolute	136.062	0	0	60	0

7. WORKSPACE FOR THE ROBIX ROBOT

The 3D Workspace has been achieved by changing the joints limits between the minimum and maximum values. Therefore individual workspace of each link is discovered sequentially and then attach each possible 2D target points to the next target points.

In algorithm, firstly we used the simple formulae to find out 2D workspace and then secondly Rotational matrix equation for each joint is applied so to find rotation about z-axis to merge with the x-axis and the translation matrix equation is applied to find the translation along x-axis but in this algorithm we used number of link to find out workspace of robot.

This measure workspace of each individual link and adding each link workspace we get all possible points of workspace

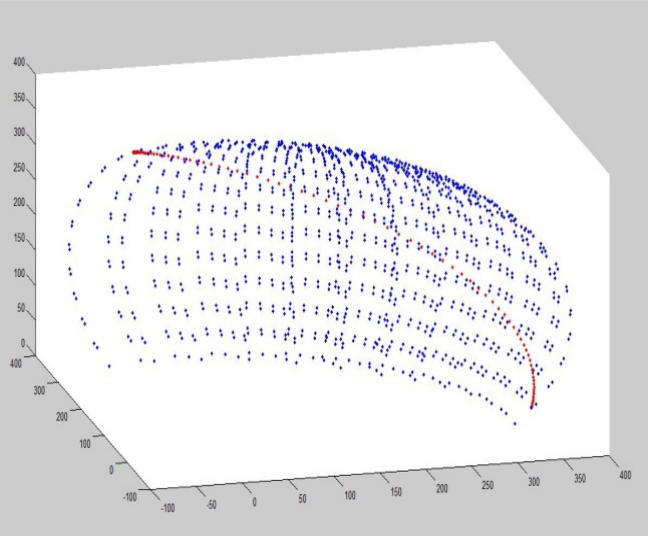

Fig. 3: 3D workspace of robix robot with forward kinematic analysis

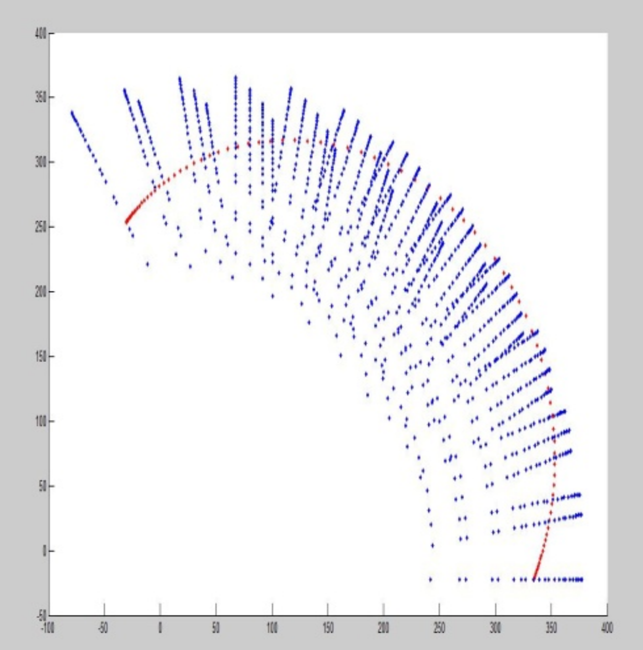

Fig. 3: 2D workspace of robix robot with forward kinematic analysis

In Fig. 2 and 3, Red points mean the forward kinematics motion performs in RoboAnalyzed and Blue points are the all possible target points of the end effector drawn in Matlab using the algorithm. Graph have been plotted using co-ordinates data points of RoboAnalyzers and Matlab, so it validate to the result gained by developed algorithm

8. CONCLUSIONS

In this paper workspace analysis is carried out. This gives better assessment for all number of degrees of freedom robot with its kinematics and an algorithm to predetermine regions of feasible operation for selected kinematic chain mechanisms is presented. The feasible operating space represents kinematics motions and required task space that belongs to the robot workspace. After the basic region of valid operation space is determined, assessment is done to find out complex workspace very easily, executed virtually and these methods are employed to determine feasibility prior to exact approach and modification in the manufacturing environment. A 3D visualization with kinematics will help process designers develop valid travel point in a appropriate fashion. Additionally, designers will be able to develop travel paths in regions that are insensitive to singularities when modifications due to (i) in field improvement, (ii) new product design or (iii) modifications due to new kinematic motions are required. These regions are identified graphically. The Matlab code is developed to plot all the calculated target points of end effector, which generates the workspace of the Robot. This study has been done for the Robix robot.

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