ABSTRACT

Industrial robots are used in flexible automation and manufacturing systems due to advancements in information technology and engineering. An industrial robot does certain operations based on specifications for a defined motion. Robot kinematics controls the motion of the manipulator. The robot kinematics contains two sub problems: the forward kinematics and inverse kinematics. The most basic application of an industrial robot is pick and place operation in which it picks up a part at one location and moves it to another location.

Ever since the first industrial robots appeared, there has been a big concern about computing kinematics in a simple, reliable and fast way in order to optimize the robot performance. Hence, the objective of this research work is to compare different models and obtain generalized, easy and exact solution of inverse kinematics problem for industrial robots. For Kinematic analysis, an industrial robot SCORBOT ER V Plus is considered for illustration. LabVIEW (Laboratory Virtual Instrument Engineering Workbench), a powerful graphical programming software for data acquisition and control has been used here for the kinematic analysis.

In this research work, forward kinematic analysis of the industrial robot namely SCORBOT ER V Plus (consists of 12 kinematic equations and 5 inputs besides the D-H (Denavit and Hartenberg) Parameters) is done using LabVIEW and the results are validated using RoboCell software and a CAD

model. Reachability analysis, path and workspace analysis for SCORBOT ER V Plus are done in further stages. Three different positions and four unique rotations are considered for analysis. (Positions: 1.Minimum, 2.Home and 3.Maximum, Rotations: 1.Base, 2.Shoulder, 3.Elbow and 4.Wrist).

Reachability analysis is done using LabVIEW to analyse the reachable coordinates of TCP (Tool Centre Point) considering three positions 1.Minimum, 2.Home and 3.Maximum with 5 inputs besides the D-H Parameters as design variables. The X, Y, and Z values of the TCP are tabulated by varying the joint parameters uniformly between the ranges. The graphical representation of the results is used to understand reachablity of the TCP corresponding to the joint parameter increment.

Path analysis (Considering four Rotations: 1.Base, 2.Shoulder, 3.Elbow and 4.Wrist) is done by developing separate LabVIEW programmes, which provide the graphical representation of the path followed by TCP for each rotation and is verified using ROBOCELL software in Stage III. The workspace analysis is done using the data obtained from forward kinematics LabVIEW model using AutoCAD Software.

Solving the inverse kinematics is computationally expensive and generally takes more time in real time control of manipulators. Further, existence of multiple solutions adds to the challenge of the inverse kinematics problem. To address this issue, in Stage IV inverse kinematics formulae are generated. Also a LabVIEW programme has been developed to analyse inverse kinematics considering position alone and also considering combined position and orientation. In Stage V a LabVIEW programme has been developed to solve the inverse kinematics problem using Complete Iterative Inverse Kinematics Method (CIIKM) and Partial Iterative Inverse Kinematics Method (PIIKM). The same methodology can be applied to any industrial robot.