CHAPTER 9

CONCLUSIONS AND SCOPE FOR FUTURE WORK

The prime objective of the research work is to develop a mathematical model of an industrial robot to obtain the position and orientation of TCP. For this research, an industrial robot SCORBOT ER V Plus is considered for illustration. To achieve this, in Stage I a LabVIEW programme (consists of 12 kinematic equations and 5 inputs besides the D-H Parameters) has been developed. The results are validated using RoboCell software and also using a CAD model. The analysis of reachability, path and workspace for SCORBOT is done in stages. During the analysis three different positions and four unique rotations are considered. (Positions: 1.Minimum, 2.Home and 3.Maximum, and Rotations: Base, Shoulder, Elbow and Wrist).

In Stage II a LabVIEW programme has been developed for determining the position of TCP considering three positions 1.Minimum, 2.Home and 3.Maximum with 5 inputs besides the D-H parameters as design variables.

Path and work space analysis (Considering four Rotations: 1.Base, 2.Shoulder, 3.Elbow and 4.Wrist) is done by developing separate LabVIEW programmes in Stage III, and is verified using RoboCell software.

Inverse kinematics computes the joint trajectories needed for the robot to guide the welding tip along the part. The existence of multiple solutions adds to the challenge of the inverse kinematics problem. Solving the inverse kinematics is computationally expensive and generally takes a very long time in the real time control of manipulators.

To address this issue, in Stage IV Inverse kinematics formulae are generated. A LabVIEW programme has been developed to analyse inverse kinematics considering position alone, considering combined position and orientation. Also in Stage V, a LabVIEW programme has been developed to analyse simple inverse and iterative inverse kinematics.

Both CIIKM and PIIKM iterations have been successfully developed in this work using LabVIEW.

The following analyses have been done in stages for this work:

1. Forward kinematics analysis
2. Reachability Analysis
3. Path analysis
4. Workspace Analysis
5. Inverse kinematics analysis

The procedure developed in this work has the following advantages:

1. Forward kinematic architectures have been successfully developed and tested. It gives appropriate results.
2. The LabVIEW is used as the ADE (Application Development Environment). It is user friendly in terms of the presentation and the end result.

3. Iterative inverse kinematic architectures have been successfully developed and tested. It produced accurate results.

4. Iterative inverse method developed in this work has a very good GUI (Graphical User Interface).

5. It is easier to program and implement efficiently when compared to the methods reported in literature.

6. It is computationally superior and faster than the methods available in the literature.

7. With little modifications if need be, it can be extended to get FKM, RAM, PAM, WAM for other types of robots as well.

8. It also simplifies the design process and shortens the design cycle, reduces development costs and improves product quality.

9. The end-user can change the variable parameters of the robot. This technology can also be extended to other robot control such as path planning, optimal routing, error compensation control and other aspects.

10. The developed method exhibits improved search speed and gives accurate solution.

Special features of the design optimization procedure used in this work are as follows:

- It has been proved that LabVIEW is a very powerful software tool for building solutions for inverse kinematics of serial robots.
- A new objective function in STAGE V which plays a key role in inverse kinematics of this industrial robot has been considered.
- The proposed FKM has modified reproduction schemes for the RAM, PAM, WAM, and IKM.

The forward and inverse kinematics models are compared and validated. The LabVIEW and RoboCELL software are extensively used to evolve and validate the developed models. The modeling and analysis done using this software will be very helpful to directly apply to industrial solutions. Various databases like reachable points and workspace are generated in table and graphical forms. The derived kinematics equations are validated. The computational techniques are used to provide the solution.

This research work clearly explains the procedure of forward and iterative inverse kinematic analysis of serial robots for a task specified industrial robot. It also promotes the future research work based on real time applications of pick and place operations by machine vision approach for immediate industry acceptance.

SCOPE FOR FUTURE WORK

- Further testing and improvement of the algorithm for more complex robots and also tasks incorporating the real constraints by making use of dynamics of robot manipulator can be considered.

- Various range of joint parameters and D-H Parameters for other industrial robots can be considered and analyzed.

- This procedure with suitable modifications can be applied for mobile robots also.