Preface

Robots have reached every part of our society either it be the industry or the household life. Their anthropomorphic characteristics and efficient operating capabilities made them suitable to replace human operators in several applications. Especially in industrial applications such as welding, spray painting, pick and place operations, etc. in which the robotic manipulator attached with a tool is readily used. Nowadays, the manufacturing of several products in the industry is performed in the manufacturing cells. The robotic workcell contains several machines/equipment which is served by the programmable robotic manipulator. Therefore, to set up an efficient robotic workcell performing a given production task in an industry is an important research area.

Among the varieties of tasks to establish a manufacturing robotic workcell, the first task is to locate the machines and robot on the restricted workshop floor space area. To accomplished this task a layout design of the workcell is generated. After fixing the layout, the next important assignment is to control and plan the movement of the robotic manipulator. This task is accomplished by planning the trajectory of the robot's end-effector between two fixed machines in the workcell. These tasks are simulated in a programming package which can select the optimal layout and trajectory among the different possible configurations. These packages can generate the solutions in various complicated situations in the realistic environment. However, the available simulation packages have a few disadvantages which motivate towards the development of a new approach to establish a robotic workcell.

The first problem is the high license cost of professional simulation packages such as RobotStudio by ABB and their controlled programming environment. Therefore, they are not popular in the robotic research. Apart from that, the non-professional simulation packages are using inefficient modeling and simulation methods with involves several assumptions and

errors. Thus, the current trend suggests that the open user generic simulation package, which have computer-aided design (CAD) based simulation approach have been able to solve the problems in robotic workcell.

This thesis work aims to develop a new simulation approach to design a robotic workcell for industrial applications. The proposed approach is named as "*Point Cloud Simulation Approach."* This approach uses point cloud models of the machines and robots in the workcell to generate an optimal solution using the optimization algorithm. The point cloud models were generated in the AutoCAD package which is readily available in every industry. The primary advantage of using the point cloud approach is that it solves the problem under a realistic environment which generates implementable results and reduces the requirement of calibration at the industrial end. The developed approach is validated by using the data taken from an industrial robotic workcell in the foundry of M/s Electrosteel Castings Ltd., Dhanbad, India.

The proposed approach solves three problems and presents its ability to solve a different problem in one planning package. The first problem is to design the layout of a robotic workcell having four machines and a robot at the center of the cell. The objective is to search the optimal location and orientation of the machines in the workspace of the robot. The problem formulation is based on the minimization of the total angular movement of the joint motors of the robot. The collision and overlapping between the two-point clouds have been checked by using the Axis Aligned bounding box method. This method reduces the computational effort required to judge the collision. More than 50% reduction in the net joint movement has been achieved. The feedback of the generated results has been obtained by the point cloud map, which is the isometric presentation of point cloud models of machines and robots.

The second problem is to develop a multi-robot cell layout design by modifying the single robot cell. The problem in the multi-robot layout is the coordination between the two robots and the sequence followed by them. The first advantage of the point cloud method is pointed out in this layout design problem in which close tolerance between machines and robot is required. This close tolerance is only possible when the modeling and simulation of the machines and robot approach are accurate, and the collision detection method is precise.

The last problem is the trajectory planning of the robotic manipulator. In this problem, the best possible interpolation profile among three different profiles has been selected under point cloud constrained environment.

Keywords: Robotics, Optimization, Point Cloud, Simulation, Workcell, Trajectory Planning, Layout Design, Genetic Algorithm, Simulated Annealing, Computation, Numerical Analysis.