Optimization of robot path using off-line simulation and method for changing tool using a wireless communication device

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Abstract: This paper presents an effective method of performing an optimization of the robot path using an off-line simulation concept along with a method for changing the robot tool using a wireless communication device. The robot controller was also worked upon & the control concept was being developed with the help of a native robot programming language. The method for changing the tool for a robotic manipulator comprised of a wireless communication device for controlling the data communication on the tool. The simulation and the off-line programming was carried out successfully. This not only saved the time and improved the quality, but also boosted the customer's confidence. The focus on the work considered in this paper was to practice the simulation and the off-line programming tools used in the robotic research in the day-to-day activities and deliver the end result meeting and exceeding the customer's requirements and expectations. During this research work, various concepts of simulation and off-line programming were used at different phases for the completion of the spray-painting application underneath the body of an automobile. A method for changing the tool in an industrial robotic manipulator using a wireless communication device thus reduced the hard wiring and increased the reliability in the system. Here, the communication or the control cables are not necessary between the robot arm and the moveable robot tool, which is at the end of the robot manipulator. The simulation results show the effectiveness of the developed method.

Keywords: Automation, Robot controller, Simulation, Robot programming language, Wireless communication, Tool.

I. INTRODUCTION

In recent years, automation has become an integral part of the modern manufacturing facilities. There is no surprise with this trend of automation, because manufacturing enterprises are under increasing pressure to bring in consistency in quality and reduce the cost. Robots are used to achieve this full-fledged automation. Industrial robots are being used more & more in many fields of industry where they are replacing the human operators engaged in repetitive, onerous & potentially hazardous tasks [1]. Robots have revolutionized the industrial workplace. Thus, thousands of manufacturers rely on the productivity, high-performance & savings provided by the modern day industrial automation. According to the Robotic Institute of America (RIA) ; a robot is defined as a re-programmable multifunctional manipulator designed to move various objects, tools, materials or specialized devices through various programmed motions for the performance of a variety of tasks. In the current practice, before a robot does a particular job, first the task is being simulated and then, it is carried on forward to the implementation stage.

The objective of the work considered in this paper is the robot cell simulation & the off-line programming. Also, the verification & running the developed off-line programs with the changing of a robot tool using an wireless communication means is discussed.

2. ROBOT SIMULATIONS

Simulation of any job is defined as the "the first step of the engineering process for system design". Simulation is the process of imitating the real dynamics of a robot with a set of mathematical formulas. Simulation tools provide an off line system to represent what equipment and parts are included in a work cell and how the overall robotic system does its job in terms of process throughput, cycle time etc. PC based simulation provides a way to verify the layout, interferences, robot reach, and fixturing requirements of a work cell. The simulation reduces a great amount of costs & time that would have incurred due to experimentation otherwise. Simulation is a graphical software tool but also, and probably more importantly, is an engineering method. Two packages are used here.

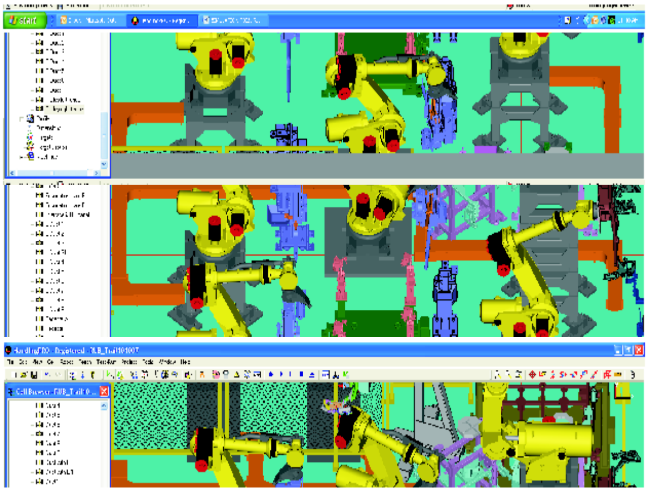


Fig. 1 : Simulation using FANUC Robo-guide

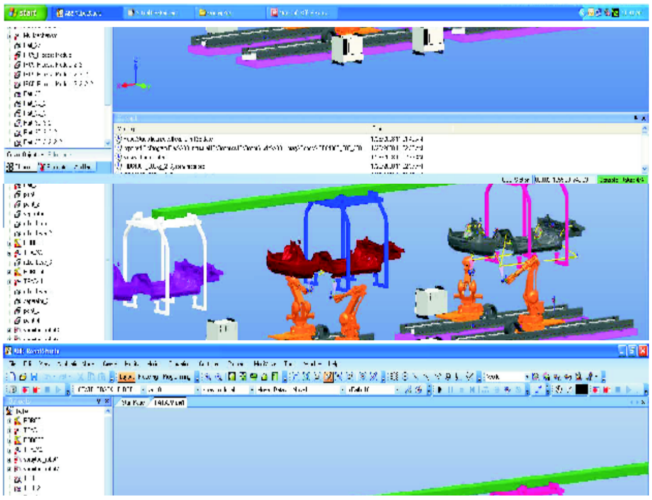


Fig. 2 : Simulation using ABB Robot studio

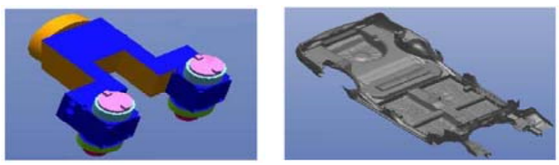
The benefits of robot simulation and offline programming exhibited in our work are as follows. They are : slashes time and money, provides profitability and affordability, avoids costly mistakes, allows for graphical programming, provides PC based programming, eliminates costly larger systems, provides high accuracy, provides sophisticated calibration, promotes concurrent engineering, promotes design for manufacturability, reduces scarp and costly rework & reduces the requirement of the skilled laborers on the shop floor [2]. Two simulations using Fanuc robot guide and ABB robot studio are shown in the Figs. 1 & 2 respectively [3].

3. REQUIREMENT STUDY

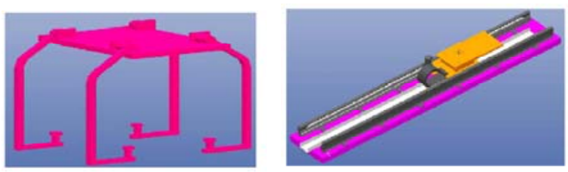
The customer requirement is to automate the underbody spraying application of an automobile using robots, in order to achieve some objectives, such as to increase productivity, to achieve uniform coating, reduce wastage, reduce human intervention as the PVC may be harmful, adaptation, to reduce the time of production and quick changing over to new models. The customer gave the following inputs to commence the work [4]. They are : CAD models of the various car body and hanger (that carries the car body), the quality requirements in terms of coating thickness, the space availability, cycle time and the process details. The following process related inputs were also provided for the project's simulation study. They included the paint/ coat specifications, such as the pogoplast A104-RT / 21055, which is PVC based PU paint with high noise suppression qualities and basically used as a anticorrosion anti-chip agent. The spraying method with compressed air (pneumatic) & a spraying speed of 0.9-1.0 m/s is also provided [5].

4. WORK CELL CREATION

The generation of the work cell in the simulated environment using the simulation package is described as follows. The current project's work cell consists of 2 identical stations, placed at a particular pitch. The car bodies are mounted on the specially designed hangers. A motorized chain conveyor drives these hangers. Each station consists of the 2 nos. of ABB robots mounted on linear rails on either side of the car body, 2 nos. of robot controllers for each robot. Each of the above robots is equipped with the spraying nozzles, the hoses, and pneumatic valves for spraying [6]. There are 2 nos. of sealant dispensing units & 1 set of body identification system with 1 set of hanger stopping and clamping mechanism. Some of the 3D models of cell components are shown in Fig. 3.



(a) Spraying nozzle with adapter (b) underbody of car



(c) Hangars (d) slide units for robots

Fig. 3 : 3D models of cell components

The WC creation includes the basic activities such as 3-D solid modeling and data translation, robot selection, robot end effector selection, robot tool adapter design, cell kinematics, robot programming including path and work coordinate creation, ergonomics analysis, sequence of operation - SOP definition, production layout and material flow optimization [7]. Before creating the cell, the required things are made in 3D software and then transferred to the simulation software. The required robot is selected by considering some parameters such as work envelope, payload, and applications. By taking this parameters ABB's IRB 2400/16 with S4C+ controller is selected. The robot end effector and tool adapter design is carried out in 3D software and then transferred to simulation software [8]. The selected robot, end effector and tool adapter are shown in the Fig. 4. After modeling of all the required data the complete cell components were imported and placed in the work cell in Fig. 5.

Fig. 4 : Robot selected for spray painting with the end-effector and the tool adapted in the simulation

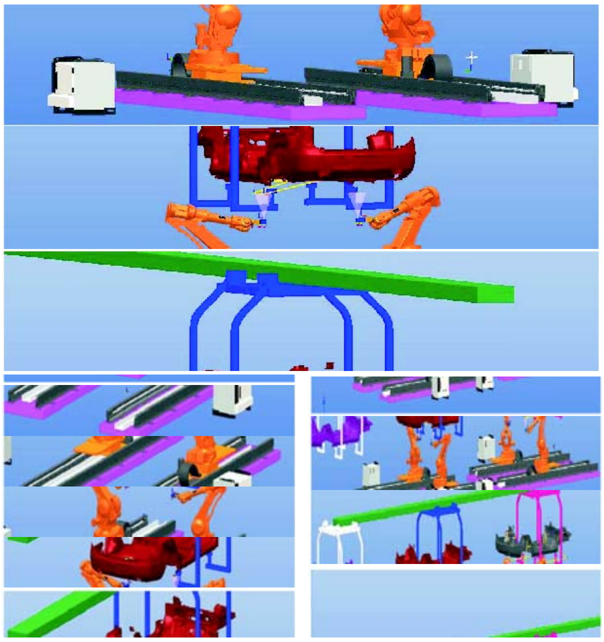


Fig. 5 : Work cell creation for spray-painting

5. Path Creation

The activities carried out in the sequence they appear prior to the path generation are creating targets and paths, checking target orientation, checking reachability, synchronizing the program to the virtual controller, performing text based editing, collision detection, testing the program [9]. The simulated tool path created in the simulation is shown in Fig. 6 with the sample program code is shown in Fig. 7.

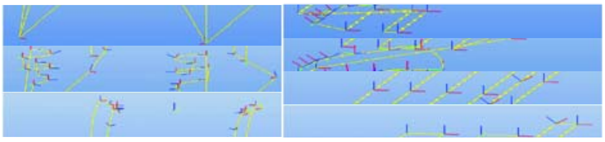


Fig. 6 : Creation of the tool path in the 3D space

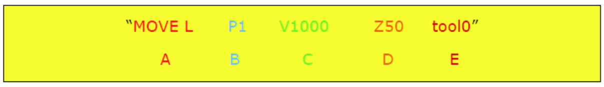


Fig. 7 : Program code

A - The name of the instruction, which moves the robot linearly

B - The value of the instruction's position

C - Determines the velocity of the robot

D - Determines the precision of the robot's position

E - Specifies which tool is active

6. ETHERNET COMMUNICATION

Ethernet / IP is a communication system suitable for use in industrial environments & allows industrial devices to exchange time-critical application information. These devices include simple I/O devices such as sensors, transmitters / receivers, actuators as well as complex control devices such as PLC, welders, and process controllers. The robot supports one adapter connection [10]. This connection is normally to a cell controller or PLC to exchange cell interface I/O data. The Ethernet / IP Adapter option is to be loaded to support this functionality. The robot supports upto 7 scanner connections. The IP address is next configured so that bi-directional data transfer takes place. All these facilities are incorporated in the simulation study.

7. METHOD FOR CHANGING THE TOOL OF AN ROBOT USING WIRELESS MEANS

This is a proposed method for changing a tool for a robot or manipulator comprising a wireless communication device for control and/or data communication on the tool. Communication or control cables may not be necessary between the robot arm and the moveable robot tool. One or more wireless communication members comprised on the robot tool may also be powered by the contact less power supply in another embodiment.

Tool changes are time consuming & may cause production delays. It is important that tool changes are carried out in a predictable way so that technical specifications related to quality do not vary and that planned production is not disrupted. The present study provides improvements to methods for controlling an industrial robot arranged with at least one arm arranged with a tool comprising a wireless communication member which wirelessly controlled tool may be changed or exchanged automatically. The method is described briefly as follows [11].

This study may be described as comprising a control method for an industrial robot equipped with a wirelessly controlled tool, the method comprising of registering at some point in the architecture of the control system information that a tool change will take place. Preferably and not exclusively, this comprises providing the information to a wireless base station that the tool change is planned to take place [12].

Providing this information allows the control system, or at least the wireless base station, to "expect" communication loss from a given wireless tool, and thus communication of an error or alarm for this event is prevented. One or more embodiments of the simulation study further describes that this improvement may conveniently be achieved by reserving a certain field in the communication link between the overlying control system (e.g., robot controller or PLC) and the wireless radio base station, which field may be reserved for information regarding a tool change [13].

Then, when a tool change is scheduled, the overlying control system sends that information to the radio base station. When the base station reads information regarding a tool change it "knows" that it will loose contact with a specific node at a time in the near future and can therefore prepare a safe disconnection of the radio link. This will ensure that a planned tool change is distinguished from an unplanned loss of communication and will give the overlying control system improved control of the wireless system by eliminating alarms or errors due to predictable communication disruptions [14].

8. CONCLUSION

The optimization of robot tool path using off-line simulation and method for changing tool using a wireless (ethernet) communication device was briefly discussed in this research paper. The simulation and the off-line programming were successfully carried out. This not only saves production time, but also improves the quality of finished product so that all errors are rectified in simulation stage itself. During this work, various concepts of simulation & offline programming were used at different phases of simulation & the research work gave us excellent results.

This paper suggests a method for changing the tools in an industrial robot using a wireless communication device, thus reducing the hard wiring and increasing the reliability in the system. Here, communication or control cables are not necessary between the robot arm and the movable robot tool. After the completion of simulation and offline programming, the programs have to be downloaded in the real robot controller and then experimentally verified, which is not the concept of this paper. The authors like to acknowledge Difacto Robotics, Bangalore, for their coordination & help rendered during the completion of this research work.

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