INDUSTRIAL ROBOTS IN A FLEXIBLE ASSEMBLY SYSTEM

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Abstract. This paper describes the virtual assembly automation systems, as decision support systems, for the better knowledge of assembly operation. The study of this procedure is described as well as the necessity for assembly systems design. The work draws on research into product and manufacturing knowledge models, and uses a case study based on a simplified assembly line realized in Delphi programming medium.

The use of the virtual prototype suggests itself as the starting point to develop the real system. Based on this model, the authors developed a systematic procedure by means of Delphi language. The authors describe results obtained in their investigation concerning the virtual prototype of the flexible assembly system.

The paper describes with enough detail the adopted solutions used to perform those tasks, giving special attention to the software designed to supervise the system. To support robot work simulation, a simulator environment is developed. In this paper, the authors have proposed a virtual prototype model for assembly system architecture of robotic assembly automation and propose to extend this virtual model to prepare drive automation systems.

Keywords: flexible assembly systems, virtual robotic assembly systems, assembly automation

1. Introduction

Assembly robots have expanded production capabilities in the manufacturing world. The assembly process is faster, more efficient and precise than ever before. Invention of robots has brought about revolutionary changes in the field of industrial manufacturing. Robots have saved workers from tedious and dull assembly line jobs, and increased production and savings in the process. But, what's easy for a human assembler can be difficult or impossible for a robot.

To ensure success with robotic assembly, engineers must adapt their parts, products and processes to the unique requirements of the robot.

Industrial robots can be differentiated by those that handle tools and those that handle work. When equipped with gripper arms or tool changers, they can serve both functions.

The principal target for assembly automation with robots will be applications involving high demands on flexibility. The flexibility and the reprogramming ability of robots will contribute to their expanded use in assembly operations. The robots are flexible in the sense that they can be programmed to assemble different products.

Detecting the movement of part assembly and transforming this movement into symbolic language will sustain the virtual robot systems in control decisions making. They will be used to solve assembly problems for large industrial fields, the manual work remaining for small production volumes and excessive complexity. In certain cases some components must to be inserted manually in its reserved place, depending on the model, because of the non-standard nature of the components.

Robots are already being used in the manufacturing industry for parts handling, component insertion, assembly, and inspection when required, a high degree of repeatability. The robot should be able to pick up a part and insert it without any further manipulation. The parts should have self-aligning features, such as lips or chamfers, to help the robot insert them.

An informal analysis of manufacturing engineers in the automatic assembly indicated that the most remarkable applications for robots in automatic assembly are given by the capabilities of today's robots and the maturity of the off-line programming software.

With these conclusions in mind, we next concentrate on several issues associated to using robots for the automatic assembly.

Automatic assembly is a computerized production control technique used in the production of manufactured goods to balance output of production with demand.

Robotic automatic assembly offers many important features and advantages that are not achieved with traditional fabrication techniques. These features include inserting, pressing, rolling and consolidation of the manipulated object, all in the automatic mode, precise control of object placement and orientation. Furthermore, the use of a robot manipulator increases the flexibility of the pieces placement process and allows for the fabrication of more complex structures.

Robotic assembly in a small lot production with a high design variant at an efficient production rate remains an uncertainty due to high production costs and inadequate flexible process planning.

Two work areas for assembly operation using the robots are actually the most widespread: assembly of automotive and assembly of small parts.

2. Assembly Operations

Compared with other operations in industrial manufacture, the application of robotics to assembling operations is the area where the biggest potential for the robots' utilize is seen to be unexploited [1].

While unit effort cost in the manufacture of parts have been decreased by new materials, simplification of products, numerical control of machines and new production technologies, the robotic assembly has occurred in assembling the some delay growth into the final product. Among other things, the example to which assembly of parts can be automated will strongly determine the competitiveness of industry. Automation of assembly can only take place through more flexible assembly systems [2].

Current market demands, characterizing the situation in production assembly, are:

- increasing number of different versions and models of parts, which will be assembled;
- running of small lots;
- shorting times in production.

More flexible assembly systems are needed to preserve the existing high level of automation in high-volume production over the long term. In this connection, high hopes are placed in assembly robots as the principal element in new flexible assembly systems.

3. Assembly Automation Systems

The main distinctions between assembly automation systems consist in the weight and shape parts, cycle time, number of product versions to be assembled, and volume of production.

Automated systems for assembly cover a range involving parts weighing, from a few grams to a thousand kilograms.

For assembly operation a great roll is attributed to gripper. The gripper architecture depend by shape of part handled. A part with two parallel surfaces can be handled by a two-fingered gripper. A circular part can be handled by its outside edges or, if it has a hole in the middle its inside edges. Adding a small lip to a part can help a gripper reliably manipulate the part and increase the efficiency of the system.

If the robot will handle more than one type of part, the parts should be designed so they can all be manipulated with the same gripper. The parts can be delivered to the robot riding loosely on a conveyor. A vision system, mounted above the conveyor or on the robot arm, tells the robot where to find the parts and which ones are in the correct orientation. The parts must to have a consistent visual appearance. They can also include features that enable easy recognition.

Another specific parameter, of the assembly automation system, is cycle time. Cycle times extend from less than a second for small parts to several minutes for large ones.

Cycle times are governed by the annual output, with a certain minimum being set by the weight to be handled and size of the parts. Large and heavy parts cannot be assembled in arbitrarily short cycle times.

Complexity is used as a term to describe the total number of separate parts in the assembled product, not meaning that all of them are to be assembled by one and the same system.

Products composed of multiples parts can be finally assembled from a small number of subassemblies. Many companies distinguish between preassembly and final assembly even within one assembly setup. Division of overall assembly is made according to the total number of parts in the final product [3].

The three, categories of the products composed of multiples parts:

- products composed of 30 parts or less manufactured in large numbers with short cycle times and in typical "preassembly" operations.
- products of 30 to 500 parts are assembled in combinations of separate parts and previously made subassemblies.
- products having more than 500 parts are representative of the "final assembly" category. They differ from the others in being mainly assembled from subassemblies together with the individual parts to fasten them in place.

Design of the assembly stations themselves and the transfer facilities between them, is determined by these principal distinctions. Cycle times are considerably longer than for the typical pre-assembly operations.

4. Virtual Components of Robots Assembly Systems

The main actors for flexible assembly system are the industrial robots. The new assembly systems would exploit the existence of the intelligent robot systems, as an integral component of a three part strategy that includes highly flexible robots, dexterous end-effectors and harmony integration with people.

The assembly system' components would facilitate the "mission" of the automation, to allow a set of assembly tasks and/or assistance to others. This capability will also enable the rapid "teaching" and "reassignment" of the robot(s) to other tasks as required by production mix.

The industrial robots may be used for assembly operations, under certain conditions. There are many boundaries. To identify these boundaries the virtual prototypes are recommended [4].

In this paper the authors propose the Delphi informatics medium, for the qualitative simulation of the robots assembly systems, using the visual programming [5]. The simulator created was used to test the performances of the controller and the mechanical system integrated. It is a DELPHI code, that always us to create the virtual prototype. This can be used to perform analysis and design studies on any robot assembly system. In the behavioural simulation one supposes the pure motion, without reference to the masses or forces involved in it.

In Figure 1 one presents two virtual robot arms structure:

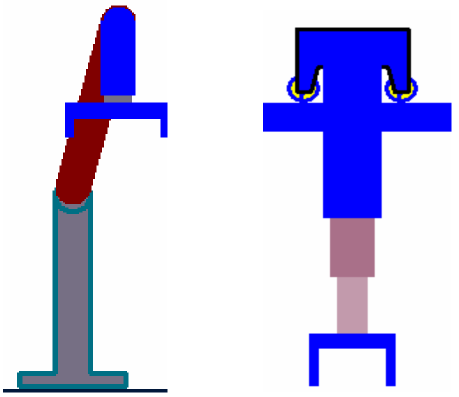

Figure 1. Virtual robot arms structure

These can be combined with manual workstations and single-purpose automatic stations. Simple products can however be assembled completely by a robot designed for the job.

The main components from which programmable assembly cells can be constructed are pictured in Figure 2.

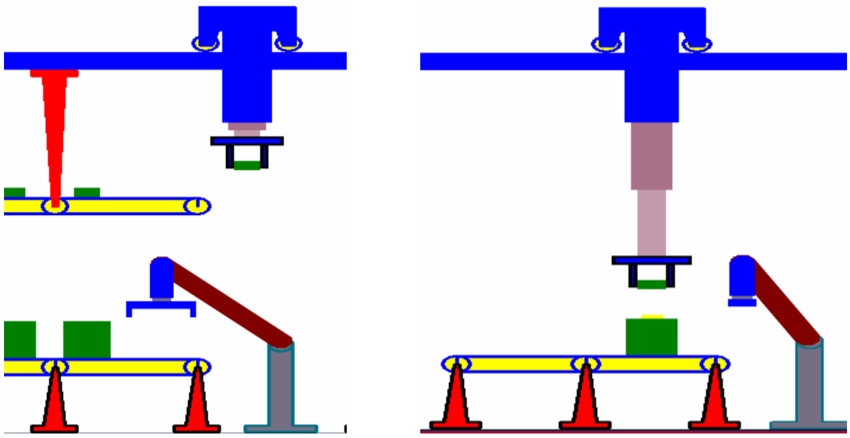

Figure 2. Flexible assembly cells

Modelling and simulation plays important roles in the process of robotic software development. It allows control algorithms to be tested and configurations to be experimented, before they are deployed to real robots assembly systems. To support robot work simulation, a simulated virtual environment is used. To demonstrate the capability of robot to interact with the virtual environment, the mobile robots for assembly were developed and are presented in a gradual way.

This example illustrates the usages and configurations of robot simulation under different situations.

Figure 3 shows the simulation of an application for parts assembly using the industrial robots.

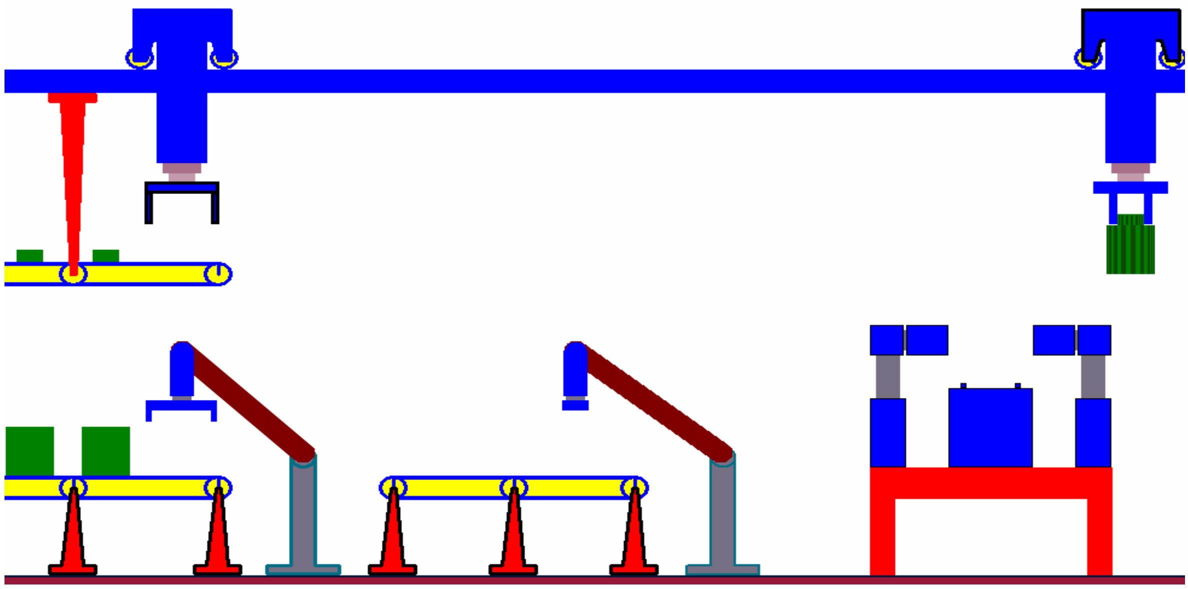

Figure 3. Virtual flexible line for assembly

The material handling equipment takes various forms depending upon the variations of mission, the speed requirement of the activity, and the flexibility of movement requirements. This range of capability is covered by dedicated part loaders/discharges Cartesian coordinate robots and fully articulated robots. Part handling conveyors extend the capability of these robotic devices in this type of flexible manufacturing system.

Close coupled parallel conveyors provide the network for the work-piece to be processed through the work cells. The robots perform all of the part handling functions to load, turn over, reload and unload the parts.

This assembly system shows how industrial robots can be employed more extensively in the assembly units.

5. Conclusions

Processes planning simulation, at virtual prototype level, have been established to allow planning of the control program.

In robotic assembly operations thus far, the flexibility inherent in the equipment, has hardly been utilized. According to the forecasts, intensifying competition in the world's marketplaces will lead to a strong increase in the numbers of industrial robots for assembly operations.

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