

OPTIMIZING CYCLE TIME OF A FLEXIBLE MANUFACTURING CELL USING SIMULATION SOFTWARE

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Abstract: A flexible manufacturing cell (FMC) is defined as a highly automated manufacturing system. The design of these kinds of systems is characterized by massive alternatives of components positions and paths. While in practice there is always the attempt to minimize the cycle time, dealing with a lot of alternatives - in respect to components positioning and paths planning - is necessary. There are a lot of constraints and boundary limits of such systems too. For that reason, it is a very difficult task - sometimes it is impossible - to achieve an optimal configuration of FMC components positions and paths without using simulation and 3D CAD-software.

This paper introduces two different solutions for cycle time optimization based on a flexible manufacturing cell for handling cover parts. The simulation was made on the simulation software Arena 7.0 for two different scenarios. The components positions and paths as well as collision detections are verified on the ABB 3D simulation software RobotStudio 3.0.

Keywords: FMC, simulation, optimization, paths planning, components positions

1. Introduction

Motion planning is a classical problem in robotics. In general, the motion planning problem is extremely difficult to solve without 3D Software Tools. In complex planning scenarios, a robot with a complicated shape may have to move and twist through a maze of very tight passages while maintaining all of the constraints imposed on it. In this work the planning problem will be posed as follows: Given a complex environment one or more movable objects, which we refer to as the robots arm, and a set of constraints, find a collision-free path for the robots from their initial positions and orientations to their goal configurations that respect all of the constraints. An example of this general problem framework is shown on Fig.1.

2. Introduction of the simulation tool RobotStudio

To simulate and optimize the cycle time of a manufacturing cell the simulation tool RobotStudio by ABB was used. RobotStudio is built up on the ABB Virtual Controller, an exact copy of the real software that runs a robot in production. It thus allows very realistic simulations to be performed, using real robot programs and configuration files identical to those used on the shop floor. The Virtual Controller also contains a virtual Teach Pendant Unit which allows you to handle the simulated robot exactly the same way as a real robot. Major benefits are:

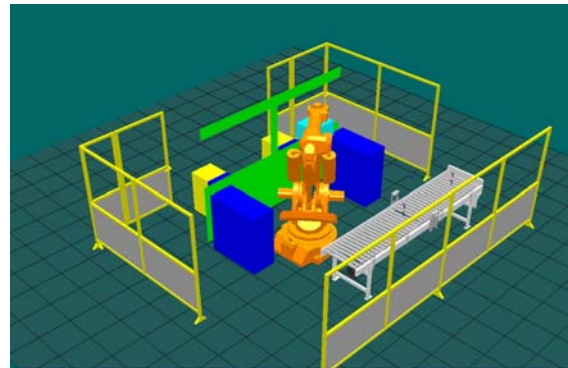


Fig.1.Animation of a flexible manufacturing cell.

- reduce time to market by programming the system without the need of the real work cell
- increase uptime by introducing and programming new parts without interrupting production
- higher part quality through creation of more accurate paths
- increase productivity by optimizing robot programs

3. Introduction of the simulation tool ARENA

To simulate the different scenarios of a manufacturing cell the simulation tool ARENA was used. ARENA is designed for business consultants, business analysts and engineers. Arena Basic Edition software lets you bring the power of modelling and simulation to business process improvement. Working with Arena's Standard Edition, it provides an interactive environment for building, graphically animating, verifying and analyzing simulation models.

The Arena Professional Edition is an advanced simulation system. With the Professional Edition, you can design a unique Arena template that is specific to your particular project, company or industry. The Professional Edition builds on Arena's natural hierarchical structure enabling you to create new simulation tools in a graphical, easy-to-use environment.

With Arena, you can:

- **Model** your processes to define, document and communicate
- **Simulate** the future performance of your system to understand complex relationships and identify opportunities for improvement
- **Visualize** your operations with dynamic animation graphics
- **Analyze** how your system will perform in its "as-is" configuration and under a myriad of possible "to-be"

alternatives so that you can confidently choose the best way to run your business

4. Optimizing Robot Paths in RobotStudio

The RobotStudio with 3D graphics provides a very powerful tool to optimize robot paths. An optimized path means: the shortest path of robot motion between two points or two robot targets. To reach this goal, we have to choose such an allocation of components in a flexible manufacturing cell, which provides the movement of the robot from one point to another with less among of time. But, during the allocation of components, we are conflicting with a various number of constraints, which have to be respected to get a real world planning of FMC.

The optimizing process begins with the simulation of different allocations of components. To get realistic simulations for each constellation, the same rules should be provided. In this case, the number of constellations is very high. Unfortunately, RobotStudio has no tool, which provides the automation of this procedure. For that reason, we have to do that manually.

5. Scenarios in ARENA

ARENA enables us to study the behaviour of the FMC within a production system. With ARENA we will have the capabilities to evaluate the different scenarios. The first scenario uses one turn around table with two places for the Input/Output of work pieces. In this case the FMC is easy and cheap, but provides a very pure solution. The robot has to wait for the Working Cell until the work pieces are processed and the quality is tested. In the second scenario the model was made with a turn around table with four places that provides the queuing of parts as well as the Input/Output of the Working Cell. Now, the robot can move the parts between the Incoming/Outgoing conveyors and Working cells without delays.

The reliability of the second scenario is very high in competition with the first one. In case of a delay of one component within the FMC, the system interacts very smart, separating that part of the system temporary and doing another sequence. With this strategy we allow, that parts of the system get more time to accomplish that task.

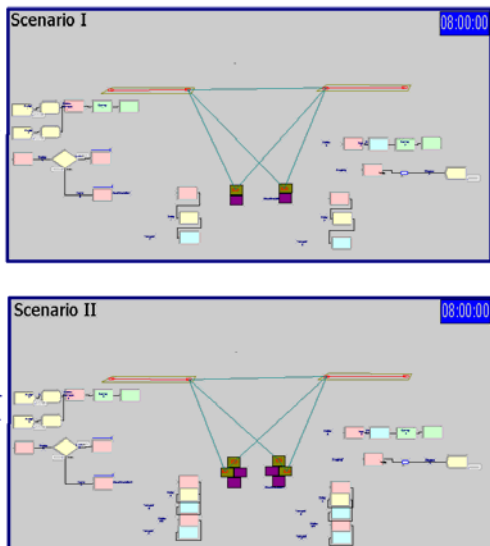


Fig.2. Simulation of two scenarios using ARENA.

6. RESULTS

This paper presents simulations of a model of a flexible manufacturing cell. The purpose of the simulations was to find out that allocation of components, which provides the shortest movement of the robot between the targets. That was achieved by taking into consideration all boundary limits and the stability question about the whole production system. After sufficient numbers of simulations made on RobotStudio and ARENA, we got the results, which are presented on Table.1.

There is evident, that the second scenario provides a much better solution with a very high production throughput and a very high level of stability for the production system. From an economic point of view, the second solution is just a little bit more expensive than the first scenario.

Throughput of System (parts/min)				
For	10(min)	20(min)	30(min)	40(min)
Scenario 1	20(parts)	40(parts)	60(parts)	80(parts)
Scenario 2	25(parts)	51(parts)	76(parts)	102(parts)

Table.1. Evaluation of scenarios in the different time periods.

7. Conclusion

The aim of this Paper was to introduce the two different simulators RobotStudio and ARENA solving one practical problem. While in RobotStudio with 3D Graphics features we can provide the realistic allocation of FMC components and collision detections, ARENA takes care of evaluating the different scenarios in long term of time and interaction of FMC with other components of the productions system as well.

The Results of this study are shortly presented in a table.

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