The RoboCup Logistics League - A Testbed for Novel Concepts in Flexible Production

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I. Introduction

Due to increasing demands on flexibility in terms of product configuration as well as delivery time triggered by the boom in e-commerce (e.g. on-line configurators, on-line shopping) production needs to be become more flexible. This trend is well known under terms like flexible production or industry 4.0. Usually in order to allow reasonable prices for products and to guarantee stable product quality and fast availability of products production is heavily automatized. Usually the automation is not very flexible and thus in contradiction with the demands on flexibility in configuration (in extreme cases lot size zero) and availability. Fortunately these demands on flexibility in production ask for new concepts and opens interesting and challenging research questions ranging from Robotics over IoT and multi-agent systems to planning and scheduling. In order to provide an interesting and appealing show case that allows research and teaching in the area of flexible production within the RoboCup initiative [1] a competition called the RoboCup Logistics League (RCLL) was founded. It resembles the setting of a flexible production plant. In this paper we like to introduce the RCLL, to show the challenges that are posted by the competition, and describe how the competition can be used to develop and evaluate new concepts in production.

II. RoboCup Logistics League

The RCLL [2], [3] is part of the RoboCup initiative and focuses on the stimulation of the development of approaches in Robotics and Artificial Intelligence using robotics competition. In this league the goal is that a team of robots in cooperation with a set of production machines produces products on demand. Two teams share a common factory floor of the size of 14m x 8m. Each team comprises of up to 3 autonomous robots and owns 7 machines. See Figure 1. There are different types of machines that resembles different production steps like fetching raw material, assembling parts, or delivering final products. The task of the teams is to develop methods that coordinate the robots (which can drive around) and machines (which are static). Robots and machine are allowed to communicate via WiFi. Robots are cooperative in the sense that they needs to interact physically with the machines, e.g. fetching raw material from a dispenser machine or provide intermediate products to machine that refines them. Usually teams use some central server that collects the information and coordinates the tasks. The products are mimicked by a stack of bases, rings, and caps. The configuration is flexible and determines the complexity of a product. In general several refining steps of intermediate products by different machines are needed to produce a final product. This setup for products was selected to have a physical interaction among the robots, the machines, and the products. A central agent randomly generates product orders with varying configurations and delivery windows. This orders are communicated to the teams' server that need to derive a production schedule and to distribute the tasks among the robots and machines. Based on the complexity of the product and if the delivery windows was meet points are awarded to the teams. For the most complex products up to 10 different steps like fetching and delivering material to machines are needed. Some of them might be parallelized or rescheduled in order to optimize the awarded points. The team that collects the most points during 17 minutes of production time wins the game.

Fig. 1. Physical setup of the RoboCup Logistics League.

III. Challenges

The interesting aspect of the setting of the RCLL is that it resembles a flexible on-demand production site which can be easily replicated while it abstracts away some aspects of a full production site where physical changes are made to the product (e.g. milling). Given the task the RCLL posts challenges in the full range from Robotics over communication and multi-agent systems to planning and scheduling. We like to list some of the challenges here.

a) Robotics:

- safe autonomous navigation
- precise manipulation of small objects

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b) Multi-Agent Systems:

- reliable communication between agents
- reliable execution of tasks
- distribution of sub-task

c) Planning and Scheduling:

- obtaining a general production plan
- optimization of production schedules
- maintaining resources - material or machines
- tracking of pre-assembled products
- reaction to issues during the execution

IV. Benchmarking System

The basic idea of the competition is that benchmarking is based on playing a number of different games (i.e., different machine layouts, different product orders) and to compare the collected points. The collected points depend on the complexity of the product (number of production steps and additional materials needed) and if the delivery window was met. The benchmarking and the execution of a game is automated to a high degree. A central server the so called referee box automatically generates the machine layout, communicates it to the teams, generate orders on a running basis, and collects feedback from the machine about initiated and completed production steps. Thus the execution and the scoring of a game is done mostly automated. A human referee is only needed to physically set up the machines and to monitor if the machines work as expected. Teams may insert and remove robots on demand. But once insert into the game the robots need to be autonomous. In order to also evaluate the robustness of the production system randomly machines are going out of service to trigger a re-planning of the schedule. After a game the referee box provides a full log of the course of the game. This logs can be used for a more detailed analysis.

Using a physical setting poses a lot of challenges related to hardware and interaction with the real world. Thus the evaluation results obviously also depend on how well a production system deals with these aspects. In order to allow focusing on the planning and scheduling aspect the RCLL is also available as a pure virtual simulation where the basic interactions and the navigation are atomic actions. See Figure 2. The competition is part of the ICAPS planning competitions and allows researcher from the planning community to test their approaches in a challenging production setting [4]. The scoring system is the same as in the real world competition. The virtual competition runs fully automated. Thus evaluations in batch mode re possible. In order to allow an easy start the virtual simulation is publicly available as docker image or bootable usb stick.

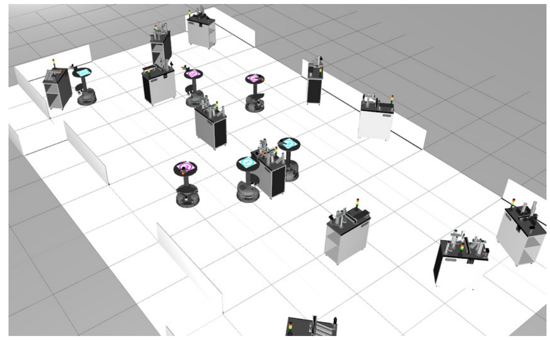

Fig. 2. Simulated setup of the RoboCup Logistics League.

V. Conclusion

Due to the increasing demand for flexibility in production novel concepts for automation in production concerning mobile robots, on-demand reconfiguration, and planning are needed. The RoboCup Logistics League provides a appealing real and virtual testbed for such concepts. In the workshop we like to present the current state of the benchmark and its challenges to practitioner in order to discuss how well the setup fits for developing industry-grade solutions and also possible needed extensions such as scaling up production time and the number of entities.

References

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