From Milk Run to Delivery Service – Hybrid Teams in Flexible Manufacturing

The milkman was the inspiration behind the production logistics concept of the milk run: if too much milk was delivered, it then spoiled before it could be used, so the man provided a full bottle only if he found an empty one. The same idea is applied to industrial production for the control of materials, although with a fixed schedule and fixed lot sizes. In contrast, the concept of the delivery service enables demand-oriented picking and delivery of components to the actual production situation. In addition, the delivery robot may also be tasked to bring a drink or a snack for the operator, contributing to a positive work environment.

▶ DFKI, together with partners ZF Friedrichshafen, EngRoTec, and Festo, develops a joint research demonstrator for hybrid manufacturing scenarios that integrates the findings of four earlier projects funded by the Federal Ministry of Education and Research (BMBF). CEBIT 2018 is the occasion for presenting the entire system, which is on exhibit distributed over two stands: the Federal Ministry of Education and Research (BMBF) stand (E52) and the DFKI exhibit stand (F62) in Hall 27.

The efficient upgrading of convertible production at the process, product, and device level is the focus of the research effort to support the use of heterogeneous, mobile and stationary robots for socio-technical production using a controllable INDUSTRIE 4.0 infrastructure. Components are researched and tested to ensure flexible interaction between people, machines and services in hybrid teams on the basis of existing and newly learned skills.

The integrated demonstrator is based on the following project results:

- Controllable, service-based infrastructure from the **collaborative project BaSys 4.0**,
- Socio-technical production support by hybrid teams from the **collaborative project Hybr-iT**,
- "Piloted learning" of new skills from **Project TRACTAT**, and
- Robotic platforms from the **German-Czech Innovation Laboratory for Human Robot Collaboration in INDUSTRIE 4.0 (MRK 4.0)**.

Under the lead management of Fraunhofer IESE, the **collaborative project BaSys 4.0** develops an open service platform for the 4th industrial revolution. The software platform for INDUSTRIE 4.0 is designed to efficiently support variable production at the process, product, and device levels. It uses a model-based, software engineering approach: models are developed to capture domain-**specific** entities such as variants, orders, bills of material, production processes, capabilities, resources, facilities and, on the other hand, to capture domain-**agnostic** entities such as services, processes, administrative shells, communication, types, instances.

The principles of functional abstraction and modularization of requirements and capabilities apply. Refinements and definitions at the respective production level are made only as far as necessary

In the German-Czech Innovation Laboratory, scenarios for human-robot collaboration in INDUSTRIE 4.0 are being developed and tested.

to ensure maximum latitude for dynamic adjustments and optimizations. The support of the migration of existing production systems for compatibility with BaSys 4.0 systems is a key focus of the project concerning the acceptance of the approach at the companies.

DFKI has set up a controllable, cost-effective, and time-efficient service-based infrastructure to implement the required dynamics of INDUSTRIE 4.0 production systems, which is guided by production-specific questions:

- **Why** should **what** happen?
- **How** and **where** should it happen?
- **Who** makes it happen?

This approach uses a service platform for the conversion of production lines to support upgrading of multifunctional resources (mobile robots) with new capabilities. Implementation is accomplished via a holistic, production-ready plug & produce process and the exploitation of orchestrated individual capabilities. The resulting productivity advantage is automatically achieved through permanent production optimization: This autonomous system continuously detects and dynamically implements a production step refinement (HOW, WHERE, WHO).

Under the lead management of DFKI, the **collaborative project Hybr-iT** studies hybrid and intelligent human-robot collaboration (HRC); the focus is on hybrid teams in variable, cyber-physical production environments. Heterogeneous, mobile, and stationary robots support socio-technical production as illustrated with the BaSys 4.0 service platform for HRC integration using the example of a dynamic milk run for mobile and stationary production stations and ergonomic workplace design.

The programming of complex processes takes place through functional abstraction of specific devices and simple composition on the process level. This allows a regulated and controllable interrupt of autonomous processes through human intervention. It also enables a controlled transition from virtual to real commissioning of a production component.

The demonstrator highlights key aspects of hybrid teams such as collegial interaction between humans and robots, multimodal human-robot communication (via voice input and output and even from smartwatches), sensor-assisted flexible interaction between robots, as well as the safety aspects of mobile co-bots. This is all based on the outstanding implementation of various robot capabilities:

- Simple transport orders via a mobile robot platform
- Combined transport requests with parallel execution of a production step
- Automated quality control
- Automated loading of the transport robot
- Sensor-assisted object gripping

The **TRACTAT project** accepts one of the main challenges of autonomous systems: the transition of control from humans to the autonomous system. The team develops a general approach as well as the formalization for the realization of a seamless and effective transition, especially in complex, ambiguous situations. One possible application is for providing new capabilities for the continuous optimization of production as an autonomous system, for example, for existing production processes or to remedy failure-related bottlenecks.

The challenge in this scenario involves “piloted learning” through of a fast, remote teach-in, in which the learning robot is provided with the new capability by a “teach-in-expert” at a service center (i.e., not present on site). This teacher uses a tactile interface comparable to the target robot, such as a sufficiently similar robot.

In summary, the results exhibited show the use of hybrid teams in variable production are expressing the underlying concept of INDUSTRIE 4.0, where optimizing productivity and job satisfaction is based on two central objectives:

- **Good work:**
  further development of point by point assistance systems to ensure safe and pleasant human-robot cooperation in teams.
- **Good numbers:**
  achieve competitive and cost advantages with shorter engineering phases and less downtime.

In addition to the project partners, other supporters of the demonstrator project are: LAP Laser Applications, SICK, and WOLL MASCHINENBAU.

MORE INFORMATION

http://hybr-it-projekt.de
www.basys40.de
http://tractat.dfki.de
www.power4production.de/industrie-4-0-projekte/mrk-4-0

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