POPULAR SCIENTIFIC ABSTRACT

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Agile Service-based Programming of Multi-robot Systems

Nowadays, robotic systems are widely used in the manufacturing industry to increase production speed and quality of assembly processes. The setup and reconfiguration of robotic work cells often take a long time, but in cases of high-volume production, robotic automation is still profitable. On the other hand, introducing automation to cases of high-mix and low-volume production is a challenging task due to the great variations of products and processes. The successful integration of robots in small series production will, in many cases, require both agile hardware and software that can be quickly reconfigured for new typologies of assembly. The goal of this PhD project is to simplify the process of programming robotic systems for such production tasks.

Based on the collaboration with the partner companies KUKA, LEGO, and Danfoss, this project analyzes the challenges related to the introduction of automation in cases of high-mix production. In order to achieve the desired flexibility for the robotic cells, it is necessary to consider variations in both products and assembly processes, reduce the complexity of programming automation systems, develop versatile execution strategies, and provide communication interfaces between the automation devices. Digitization is the driving force at the core of the technologies explored for solving the outlined flexibility challenges.

In the presented solution, a virtual description of robotic systems is created in the form of a so-called Digital Twin in a software tool that allows running simulations of assembly tasks and executing the same logic using physical components. Automation tasks are represented as so-called “services” and visualized as function blocks in a Visual Programming interface. Programs are automatically generated based on a digital description of the assembly task and can then be easily customized thanks to the simplified programming interface, reducing the complexity of handling product variants. The components involved in the automation system are reciprocally connected and exchange data between the physical and virtual domains.

The scientific contributions of this work have been applied to two case studies based on the manufacturing challenges of the partner companies LEGO and Danfoss. The implementation of physical demonstrator platforms provides the opportunity to show concrete results that inspire the companies and suggest possible deployment in real production domains.