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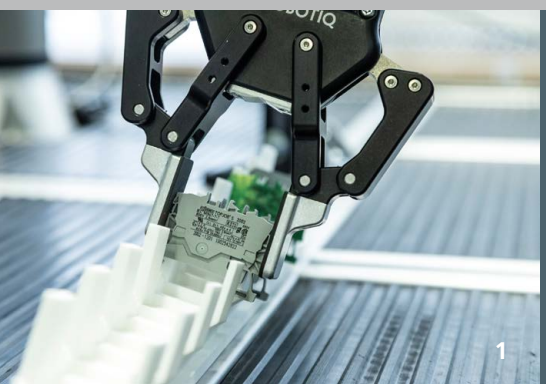
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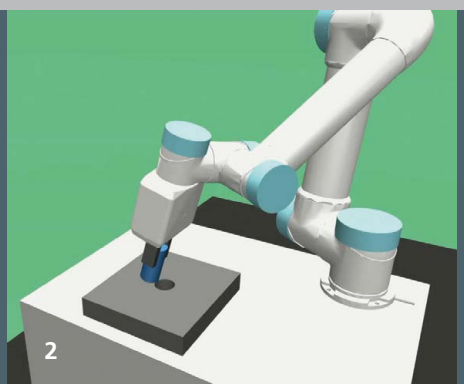
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1 *Robot picking up a control cabinet terminal for assembly.*
2 *Digital twin and training environment.*
3 *Transferring the learned process into reality.*

SELF-LEARNING CYBER-PHYSICAL ROBOT SYSTEMS

FOR CONTROL CABINET ASSEMBLY

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Current situation

In times of mass personalization, companies increasingly need to use adaptable manufacturing systems. Robots play a particularly important role as versatile automation components. However, programming robot systems often takes as long as it would to carry out the production step manually. This is especially true for complex assembly applications with tolerances. Up to now, such tasks can only be automated with elaborate, force-controlled robot movements Consequently, despite the fact that processes can be automated from a technical point of view, the use of robots often remains uneconomical due to the programming and reprogramming required. Flexible, robot-based automation solutions therefore have to be able to react independently to inaccuracies and tolerances and be quick and easy to program.

Automating the assembly of control cabinets, for example, is relatively simple but is rarely carried out in practice because it is not flexible enough. This lack of flexibility is the focus of this research work. Thanks to recent developments in artificial intelligence, promising tools are now available for automating the non-value-adding task of robot programming. This makes even the assembly of small lot sizes with high product diversity cost-effective.

Our approach

The experts at Fraunhofer IPA are developing a system of self-learning cyber-physical robots at their "Center for Cognitive Robotics". The system essentially consists of a digital twin of the robot cell in a physical simulation environment and a machine learning (ML) framework. The algorithms

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implemented in the framework control the robot so that it learns the underlying assembly process in the simulation through trial and error – without using or possibly damaging a single, real component. Artificial intelligence takes over the programming of the robot, even enabling the above-mentioned control cabinets to be assembled.

Process models specialized in the assembly of control cabinets teach the robot to perform the assembly process correctly. Once it has been trained, the robot is capable of reacting reliably to inaccuracies and tolerances by varying parameters relevant to the process. Through the use of modern machine learning algorithms, the robot is even capable of learning from its mistakes. To train the robot programs, the Fraunhofer IPA experts rely on robot skills that are not dependent on hardware. These skills both encapsulate the complexity of robot programming for the ML algorithm and enable the subsequent reliable, force-controlled execution of the respective tasks on the real system.

In this way, the demanding task of joining control cabinet terminals can be accomplished even without prior knowledge of how to program an industrial robot. Once the technology has been successfully developed, the system is easy to adapt to other applications.

"Early Adopter Program"

Do you assemble control cabinets yourself or do you specialize in manufacturing control cabinet terminals? Or are you looking for ways to make your production process – or a specific application – flexible and future-proof? To make your introduction to the development of intelligent automation technologies as easy as possible, even if you have few resources of your own, we have set up our "Early Adopter Program". As a participant, you can exchange ideas with the experts from Fraunhofer IPA whenever you wish and make the newly developed technology work for you. From technical discussions to the use of your control cabinets and terminals in real test setups, you can freely choose how much you want to be involved. In addition, you will learn everything about the "Cognitive Robotics" at our regular events.

Your advantages

Through our "Early Adopter Program", you have the chance to participate in the development of the technology at an early stage and benefit from the following:

- The use of future-proof automation solutions by implementing leading-edge technologies
- Inclusion of your specific issues in the development of the technology
- Evaluation and validation of the technology for your application
- Financial security through development within the scope of funded research projects

Current information

Have we aroused your interest?
Then visit our website
www.ipa.fraunhofer.de/en/cognitive-robotics
to find out everything about the latest technological developments. Applications for participation in the "Early Adopter Program" can be submitted until 31.12.2020.

4 *Joining control cabinet terminals on the physical robot system.*