POPULAR SCIENTIFIC ABSTRACT

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Agile Interaction with Industrial Robots

Recent technological advancements have prompted manufacturing companies to transition from legacy systems to more sophisticated solutions. In particular, Human-Robot Interaction (HRI) offers numerous benefits to these companies by enhancing efficiency, safety, and overall productivity. However, implementing HRI in specific processes, such as the manual assembly of injection molds performed by skilled operators for maintenance, presents several challenges. Firstly, there is a lack of detailed digital descriptions of assembly operations for both humans and machines. Secondly, there are limited reference implementations for collaboration scenarios with multi-robotic systems, including collaborative robots and standard industrial robots. And lastly, there are insufficient workspace monitoring solutions for safe interaction between operators and robots in shared workcells.

This PhD dissertation proposes a systematic solution to address these challenges through three aspects, Agility, Interaction, and Safety. For agility, a Bill of Process (BOP) is developed to capture and digitalize the manual processes. This BOP integrates the expertise of experienced operators with existing data (e.g., Bill of Materials) available in the partner company's Product Lifecycle Management database. The proposed BOP provides enhanced clarity about the assembly process in detail, facilitating seamless access for stakeholders and agile integration with other platforms through exporting it. To utilize the exported BOP efficiently, Digital Twin (DT) technology is employed to import it using importers specially designed to fit the external data into a data structure of the DT platform. The DT also contains virtual replicas of products, systems, and processes, enabling simulation-based robot control to allow advanced interaction between human operators and robots. Lastly, to ensure the safety of operators and machines, a workspace monitoring system is implemented with a combination of conventional and supportive safety systems. This system enables agile interaction while ensuring a prompt response to safety concerns, with the emergency stop constantly on standby for immediate activation.

In conclusion, this proposed systematic solution facilitates the transition of manual injection mold assembly processes to HRI with multi-robots in a shared workcell. It achieves this by integrating strengths from various elements, resulting in practical solutions and valuable research contributions.