

An algorithm to enhance the robotic assembly of customized products

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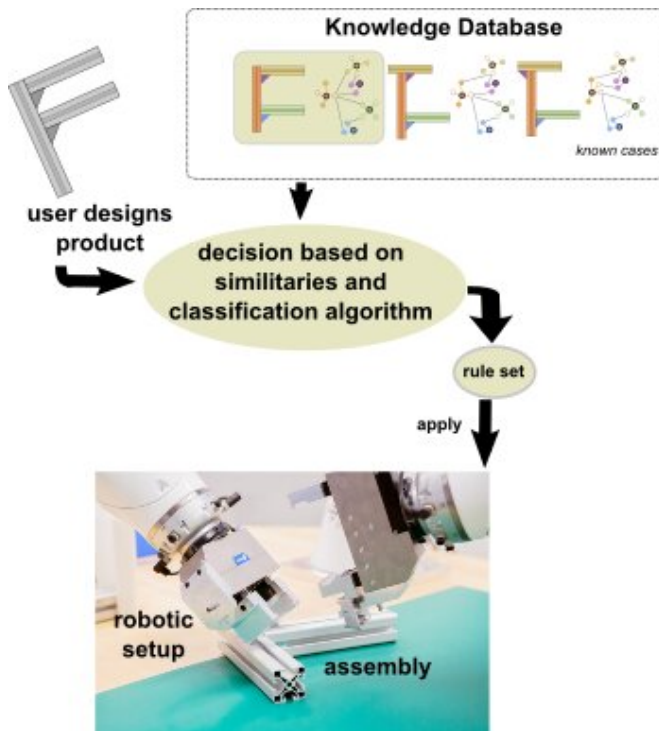


Figure explaining how the technique devised by the researchers works. Credit: Rodriguez et al.

Robots could soon assist humans in a variety of fields, including in manufacturing and industrial settings. A robotic system that can automatically assemble customized products may be particularly desirable for manufacturers, as it could significantly decrease the time and effort necessary to produce a variety of products.

To work most effectively, such a robot should integrate an assembly planner, a component that plans the sequence of movements and actions that a robot should perform to manufacture a specific product. Developing an assembly planner that can rapidly plan the sequences of movements necessary to produce different customized products, however, has so far proved to be highly

challenging.

Researchers at the German Aerospace Center (DLR) have recently developed an algorithm that can transfer knowledge acquired by a robot while assembling products in the past to the assembly of new items. This algorithm, presented in [a paper published in *IEEE Robotics and Automation Letters*](#), can ultimately reduce the amount of time required by an assembly planner to come up with action sequences for the manufacturing of new customized products.

"The main goal of an assembly planner should be to provide non-experts an automation tool for dealing with the increasing trend of customized products," Ismael Rodriguez and Korbinian Nottensteiner, co-authors of the recent paper, told Tech Xplore via email. "Our ultimate vision is that a customer or user will be able to design individual products and only needs to forward the specification to an autonomous assembly system, which can then adapt to these new products and manufacture them, without many manual efforts."

The recent study carried out by Rodriguez, Nottensteiner and their colleagues is an extension of one of their previous papers, also published in [IEEE Robotics and Automation Letters](#). In this previous work, the researchers were able to identify and represent different problems that a robotic assembly system they developed encountered while it was building a customized structure.

To outline these problems most efficiently, the system required some degree of human expert knowledge, which ultimately allowed it to map the outputs of several modules into concrete information. While the researchers were able to devise techniques that could speed up this planning process, they realized that the time their system needed to plan a sequence of actions could be reduced further by reusing information it acquired in previous trials.

"The objective of our new study was to develop a system that requires fewer explicit human instructions and that is able to reuse information to speed up planning times and generalize over larger classes of problems," Rodriguez and Nottensteiner said.

The algorithm developed by Rodriguez, Nottensteiner, and their colleagues has two main operation phases: a training and an execution phase. In the training phase, the algorithm randomly generates thousands of different possible assemblies. These assemblies are then analyzed by a number of modules, which identify constraints and automatically connect them with semantic information, which the researchers refer to as 'rules'.

These initial steps are carried out in simulations, along with tests of the geometric and kinematic feasibility of each assembly. Subsequently, all generated assemblies and the rules associated with them are stored in a knowledge database.

"At the moment of the execution, a new assembly is compared to the ones in the knowledge database by a novel pattern recognition approach that allows to find similarities between them," Rodriguez and Nottensteiner explained. "Once we have found a family of assemblies that have similar properties, we use a neural network to classify which constraints are present in the new assembly."

Essentially, once the training phase is complete, the algorithm developed by the researchers should be able to plan sequences of actions required to manufacture new objects more efficiently, by identifying and implementing constraints that are applicable to similar item assemblies, which it previously encountered in simulations. This process of recalling previously acquired knowledge and transferring it to the task at hand reduces the amount of processing and planning necessary to assemble new objects, which can in turn speed up the manufacturing process.

"We successfully modelled assemblies in a way that allows to encapsulate their constraints and also allows a robot to make decisions on the similarity between assemblies," Rodriguez and Nottensteiner

said. "These two points are crucial, since we need to represent the information (i.e., constraints) but in addition we should be able to decide if this information is relevant for other assemblies (i.e., similarity). In our opinion, results-wise, the key point is that our approach does not take only into consideration the product itself but also the capabilities of the system that is building it."

Rodriguez, Nottensteiner, and their colleagues tested their algorithm in a series of experiments, where a [robotic system](#) with two arms assembled different products using aluminum-based components. The results of these tests were highly promising, as their technique was found to considerably speed up the planning of action sequences for the assembly of a variety of objects.

In the future, the new algorithm introduced by this team of researchers could enable the development of robotic systems that can automatically manufacture customized items faster and more effectively. In their next studies, the researchers plan to test their technique further in several different scenarios. For instance, they are looking to test their [algorithm](#) in a factory setting as part of a project called [Factory of the Future](#), which will involve a number of DLR institutes. Eventually, they also hope to team up with private companies to implement and evaluate their product manufacturing techniques in real-world industrial settings.

"We want to take these ideas closer to everyday user's problems," Rodriguez and Nottensteiner said. "We believe that works in this line of research will change the way on how we understand and carry out manufacturing in future. As a research institute, we will also investigate how our techniques can support robotic assembly missions in space, e.g. the assembly of large structures in space as envisioned by [the EU project PULSAR](#)."

More information: Ismael Rodriguez et al. Pattern Recognition for Knowledge Transfer in Robotic Assembly Sequence Planning, *IEEE Robotics and Automation Letters* (2020). DOI: [10.1109/LRA.2020.2979622](https://doi.org/10.1109/LRA.2020.2979622)

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