Extending the Robotic Workspace by Motion Tracking

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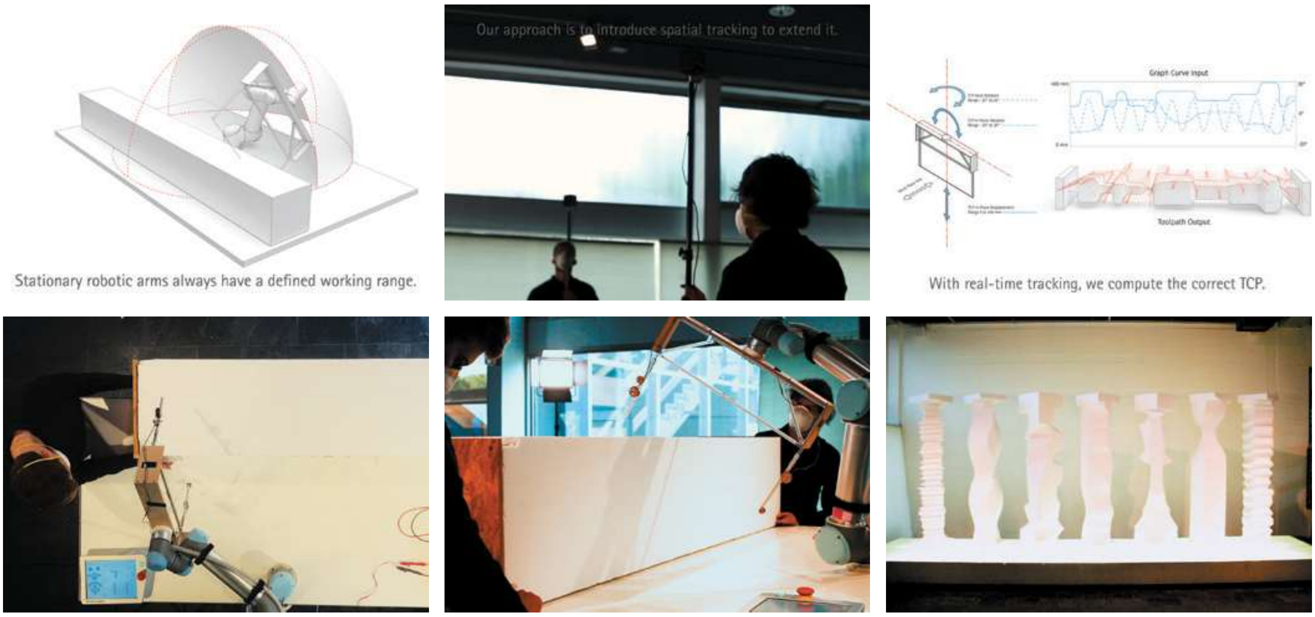

Problem Definition

Stationary robots have a defined workspace, which limits the size of workpieces. Industrial robots usually expand these limits by adding an additional axis, thus relying on expensive, low-tolerance hardware and custom integration to the system. Contemporary collaborative robots have allowed novel ways of human-robot collaboration by providing a safe robotic work environment. While far more agile than industrial robots, these collaborative robots still have the same size-to-workspace ratio and thus the same limitations in handling larger workpieces.

Solution

We suggest a solution where a low-cost motion tracking system, HTC Vive, is attached to the workpiece, which then updates the robotic toolpath in real time. This allows an operator to manually move large pieces of material through the stationary robotic workspace. The robot then performs local manipulations in the area of the workpiece, which is at that point in time in reach of the robot's end-effector. Such a scenario would widen the application of robots in the realm of fabricating architectural components as well as bringing traditional craftsmanship and robots closer together.

Proof of Concept

To test this concept, we defined a task of fabricating a series of 2 meters tall architectural columns employing robotic hot-wire cutting large Styrofoam workpieces using a UR5 robot. Each column was cut out of a single block of 2000 mm x 400 mm x 400 mm material. The workpiece was equipped with two Vive trackers. The material was manually pushed along a linear guide. The technical set-up for this proof-of-concept is built around Rhino, Grasshopper, and the Robots plug-in for generating UR-Script code and sending it to the controller via a socket connection. The Vive position was acquired via the Steam VR API and streamed into Grasshopper.

IMAGE CREDITS

All video stills by the authors.

Victor Sardenberg is an architect and researcher. He is Associate Researcher in Digital Methods in Architecture at Leibniz Universität Hannover, where he develops a computational framework for quantification of the architectural aesthetics experience. He holds a postgraduate MA with a specialization in Architecture and Urban Design from the Städelschule Architecture Class, Frankfurt am Main, and a bachelor's degree in Architecture and Urbanism from Mackenzie University, São Paulo.

Marco Schacht is a master's student of Architecture and Urban Planning at Leibniz Universität Hannover. He started working as a student assistant in Digital Methods in Architecture during his bachelor's degree and continued his work during his master's studies, where he was also able to take part in research and teaching. During his studies, he mainly focuses on digital fabrication, especially robotics.

Mirco Becker has been a Professor of Digital Methods in Architecture at the Leibniz Universität Hannover faculty of Architecture and Landscape since August 2016. From 2012 to 2016 he was Stiftungsprofessor of Architecture and Performative Design at the Städelschule Architecture Class, Frankfurt. He holds an MArch degree from the Architectural Association, London, where he graduated from the AA Design Research Lab in 2003. In 2012 he founded informance, a Berlin-based design-integration consultancy for the building industry. Earlier, he pursued his particular interest in computational design in architecture with Zaha Hadid Architects, Foster & Partners Specialist Modeling Group, and Kohn Pedersen Fox Computational Geometry Group, which he led for five years as a Senior Associate Principal.