Preface

The work presented in this book exhibits the continuing evolution of robotic fabrication in architecture, art, and design. Once the domain of only a handful of institutions, the application of robotic technologies in these disciplines is consistently growing, led by interdisciplinary teams of designers, engineers, and fabricators around the world. Innovators in the creative disciplines are no longer limiting themselves to off-the-shelf technologies, but instead have become active participants in the development of novel production methods and design interfaces. Within this emerging field of creative robotics a growing number of research institutions and professional practices are leveraging robotic technologies to explore radical new approaches to design and making.

Over the last several decades there has been a widely discussed adoption of digitally driven tools by creative disciplines. With designers seeking to push the limits of what is a possible using computational design, parametric modeling techniques, and real-time process feedback, industrial robotic tools have emerged as an ideal development platform. Thanks to advances by established manufacturing industries, the accuracy, flexibility, and reliability of industrial robots has increased dramatically over the last 30 years. The accessibility of the technology to new users has also increased dramatically, with many manufacturers adopting open standards for connectivity and programming. Designers have taken the flexible nature of industrial robotic technology as more than just an enabler of computationally derived formal complexity; instead they have leveraged it as an opportunity to reconsider the entire design-to-production chain.

This is not to say that industrial robots have become mainstream. As with all digital technologies that have entered into creative disciplines, the development of knowledge surrounding the use of robotic fabrication methodologies is ongoing. And while the productive impact of their possibilities and resistances on these disciplines remains an exciting and contested territory, they have had a palpable effect that is actively shaping contemporary discourse.

Rob|Arch

Initiated by the Association for Robots in Architecture as a new conference series focusing on the use of robotic fabrication within a design-driven context, Rob|Arch—Robotic Fabrication in Architecture, Art and Design, provides an opportunity to foster a dialog between leading members of the industrial robotic industry and cutting-edge research institutions in architecture, design, and the arts. In December 2012, the first conference was hosted by its founders Sigrid Brell-Cokcan and Johannes Braumann in Vienna, Austria; now in its second iteration the 2014 conference travels to North America, hosted by the University of Michigan Taubman College of Architecture and Urban Planning. The Taubman College is well known as an academic institution for its diverse and multifaceted approach to design education, as well as its long-standing traditions in pursuing making as a form of knowledge creation.

One of the features of the Rob|Arch conference series is its focus on fabrication workshops, where leading research institutions and creative industry leaders host workshops lead by collaborative teams from around the globe. For the 2014 conference workshops there was an open call for proposals, with eight workshops selected to be held at the University of Michigan, Carnegie Mellon University, and Princeton University. Many of the workshops are based on cutting-edge work currently in progress, and their accompanying texts are published in the "Workshop Papers" section of the book.

The selected workshops cover a wide range of experimental robotic fabrication processes. The contribution from the Institute for Computational Design at University of Stuttgart focuses on their novel methodology for the production of wound composite components using cooperative robotic manipulators to produce variable units from reconfigurable tooling. A collaborative team from the University of Technology, Sydney and the University of Michigan is investigating robotic bending, cooperative assembly, and welding toward the production of complex architectural components. A workshop taught by a collaboration between the University of Michigan and IAAC focuses on sensing and material feedback within a cooperative robotics workcell. Bot & Dolly, one of the Industry Keynotes for 2014, will lead a workshop on procedural fabrication that showcases their innovative control software. Bot & Dolly is design and engineering studio that specializes in automation, robotics, and filmmaking. At Carnegie Mellon University's dFab Lab one workshop will couple cooperative robotic steam bending with integrated sensing techniques, while a team from the University of Innsbruck and the Harvard GSD will lead a workshop utilizing cooperative manipulators for the development of novel building components using phase change polymers. A third workshop at CMU will be led by a team from the Harvard GSD and TU Graz on the sensor-informed fabrication of reformable materials. And last, but not least, Princeton University will host a workshop on augmented materiality, using real-time sensor feedback and custom hardware interfaces to explore the closed-loop fabrication of structurally-optimized components.

Reflecting on the workshop and scientific paper submissions a number of themes emerged that will define both this year's conference and the near-future of robotic fabrication research, many paralleling the state of robotics and automation in other manufacturing industries. Sensor-enabled processes and robotic vision are addressed in a number of papers, both as techniques for in-process tolerance gauging and as adaptive path-planning tools. From the exploration of sensor enabled on site construction techniques, to new techniques for digitally controlled metal forming, designers and architects are expanding the capabilities of the tools at their disposal. Additionally, research projects involving cooperative robots are becoming more common, as research labs around the world have invested in multirobot work cells. This can be viewed as an indication that robotic fabrication research in architecture and design is about much more than just the subtractive or additive techniques analogous to traditional CNC processes: researchers are actively developing production methods which represent entirely new paradigms for fabrication. This is not to suggest that novel work on additive, subtractive, and material forming processes is not occurring; on the contrary, a number of papers address these topics, at scales ranging from the size of a building component, to a mobile platform capable of reaching the scale of a building.

One aspect that has been critical to this adoption has been continued focus by researchers and designers to challenge the norms of standard industrial workflows and machine interfaces. Such research continues to be a key aspect of advancing the possibilities for robotic technology to empower the design process. What is significant, however, is that robotic tools are enabling designers and architects to develop processes that suit the material, scalar, and tectonic needs of their discipline. Robotic technologies provide the ideal platform for developing fabrication processes in an experimental, iterative framework, without reinventing the machines of production.

Perhaps the most exciting trend in the field has been the growing level of knowledge transfer occurring between researchers, designers, and industry partners. The integration of robotic technologies into the workflows of creative industries has demanded renewed levels of cross-disciplinary collaboration. To further this exchange, industry partners were invited to submit papers documenting recent projects in the context of their value to art, architecture, and design. Their submissions illustrate the diversity of research and development going on in the industry, from force-control and adaptive gripper applications demonstrated by Schunk, to lightweight robotic systems by KUKA, dedicated material removal robots by Stäubli, and linked kinematic handling with cooperative robots by ABB.

As new technologies are developed across a wide range of robotic industries, innovators in the creative disciplines will continue to adapt and transform these tools to suit their specific applications. This is more than simple technology transfer, however, as robotic technologies are having a visible impact on the discourse surrounding the means and methods of production in the creative industry. Around the world this discourse is shaping not only how designers look at fabrication technologies, but the entire methodology by which they engage design and material production. As creative industries continue to explore and develop new applications for robotic technology, we look forward to new innovations enabled through collaboration between industry, academia, and the growing community of designers, programmers, and trendsetters surrounding "Robots in Architecture."

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