Rebooting robots

By experimenting with new robotic construction processes, architects can imbue digital design with sensuous materiality and architectural substance, argues Jan Willmann.

From the onset of building industrialisation in the early 20th century, the technological basis for architecture was more visionary than reality, but not entirely without precedent. The recent re-emergence of robots in construction has opened up new possibilities of assembly and fabrication. The task of architecture is to create buildings, not just buildings of ideas, but buildings of mass production is becoming obsolete. In the Second Digital Age, the employment of robotic technology in architecture is opening up the prospect of an entirely new material articulation that will fundamentally alter architectural design and the culture of building as we know it.

Our research work with robots at ETH Zurich is heavily anchored in this vision of discovery and exploration: what happens if architecture absorbs the proposed connection between computational logic and material realisation as a new basis for the discipline's practices. The industrial robot, because of its ability to perform an unlimited variety of non-repetitive tasks under the explicit control of a digital design at the scale of architecture, is an enabling for this transformation. As architects, we should not focus on the technological developments of robots themselves, no matter how fascinating they might be, but instead establish an architectural perspective on them by exploiting the potential of digital fabrication and design. It is essential that architecture and the conditions specific to its production inform our approach to robotic fabrication and not vice versa. Only then can we significantly expand the range of architectural design and production options, enabling a new material differentiation and complexity to emerge and find expression.

Robotic fabrication in architecture dates back to the early 1980s. There have been several attempts to develop construction robots for use in building sites, one of the more advanced of them being the mobile bricklaying robot BROCO, conceived in 1980 by a professor at Stuttgart University and later sponsored by the Swiss National Bank. During the last decade, over 50 international research institutions have set up research facilities for robotic architectural construction fostering promising architectural case studies and prototypical structures. The range of robotic processes is gradually expanding from prototyping towards the direct use of robots on the construction site and the exploration of novel material systems.

In our Fertile Material Depositing project a 3 kg robot with a 1.8 m³ cubic area of plastically deformable material is thrown as far as 7.4 m across at speeds of up to 0.6 m/s, which aggregates into a self-compacting structure. A rotating laser scanner was used to constantly generate a 3D model of the process, which led back to the robot ensuring that the fabricated structure ultimately matched the defined reference geometry. Neither the impact location nor the impact behaviour of the material is exactly predictable so design is no longer purely geometry-based. Rather it is defined as a set of loose rules that incorporate the material's behaviour. The design process becomes a constructive collaboration between material behaviour and dynamic forces that guide the flow of thinking curves, impact scenarios and feedback processes all become integral parts of the architectural design. In remote depositing material delivery from a distance, the robot oversees the boundaries of conventional digitally controlled production and geometrically predetermined manufacture, while challenging assumptions about the nature of what constitutes a machine aesthetic. The designer is confronted with an expanded and largely unexplored design space.

In the 811 project Flight Assembled Architecture, a multi-chamber flying system was assembled and completely assembled over 1,200 blocks to form a porous, self-supporting structure. The flying robots were able to operate freely in airspace and amalgamate the building materials. The structure makes use of a grid as a construction organisation that allows for a great degree of freedom in the arrangement of nodes. However, the grid does not run horizontally as in a conventional urban plan, but it is turned vertically. The resulting cylindrical tower is not only self-stabilising but also embodies a new type of urban organisation fostering a revision of the city as a robot-built urbanity. Through these projects and others it is becoming evident that the robot can catalyze a seminal change in the production conditions of architecture, playing an essential role in a close creative dialogue with reality. Through robots the digitalisation of architecture becomes physical and tangible, taking away the abstract and forced artificial character from the digital in architecture and infusing it with aesthetic and significant and identity.

It is remarkable that current debates about the relationship between human beings and machines voice, almost exclusively, reservations pertaining to the potential destruction of jobs, craft traditions and social values, although the technologies we have repeatedly feared painful structural changes on society, in the end increased productivity not only resulted in a higher standard of living but also led to new professions and jobs. Architecture will not be immune to these changes induced by robotic technology, but the answer to this profound challenge is to establish a reciprocal link between robotic technology and the material reality of architecture. The synthesis of these previously separate domains will dissolve dichotomies between digital vs manual, digital vs physical, and dynamic vs static, resulting in an increased sensuousness that originates from the integration of the creative, material and cultural expressive content of digitally fabricated architecture.