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FOREWORD BY THE EDITORS

FABIO GRAMAZIO, MATTHIAS KOHLER, SILKE LANGENBERG

Three years ago, a seminal discussion on the decisive role of making in architecture was launched in a large international forum at the inaugural FABRICATE conference organised by the Bartlett School of Architecture, University College London. The main topics proposed by its Chairs, Bob Sheil and Ruairi Glynn, addressed prevailing shifts in the contemporary production of architecture: physical processes, material systems, machines and the bespoke as well as representation and manufacture.

Today's remarkable interest in intensifying the relationship between design and making in architecture seems to be driven more by research institutions and young start-up entrepreneurs than by an established architectural practice. In continuation of the profession's constructive tradition, entirely digital technologies and construction methods, such as robotic fabrication and architecture-scale 3D printing, are currently being tested with the help of prototypes, pavilions and smaller buildings. Here the question arises of if and how the innovations developed will become relevant at a larger scale of architecture. But an issue that may become even more important is whether the creative spirit originating from these digital-material explorations will lead to a change in sensibility and methods that will affect the design and building culture more fundamentally than might appear at a first glance.

While digital fabrication technologies are rapidly becoming common practice in architecture for prototyping as well as for ornamental effects, a profound knowledge of their full architectural operability and inherent capacities seems to be developing very slowly among architects. There are still experts needed who can 'solve the problems' of transforming designed digital models into built reality. However, to make the full spectrum of digital technologies in architecture accessible, to unfold it or even exhaust it, they have to be more than known techniques, they have to be considered conceptually in design from the very beginning. Therefore, the focus of the FABRICATE conference at ETH Zurich in 2014 is particularly set on contemporary research that does not just investigate the further development of technologies, but presents ways of integrating them in an early design phase in order to finally overcome the still prevalent separation of design and making and introduce new meaning and substance into the profession.

The publication includes contributions from leading research institutions such as the Bartlett School of Architecture at University College London, Harvard University, the Institute for Advanced Architecture of Catalonia, the Institute for Computational Design at the University of Stuttgart, the Institute of Technology in Architecture at ETH Zurich, Massachusetts

Institute of Technology, Princeton University, Yale University, as well as projects by Arup, Autodesk, Buro Happold, designtoproduction, Foster + Partners, Hyperbody and Scanlab. It is complemented by conversations between the keynote speakers at FABRICATE 2014 and 2011: Mario Carpo and Matthias Kohler, Neil Gershenfeld and Mark Burry, Achim Menges and Philip Beesley, Virginia San Fratello and Ronald Rael and Neri Oxman.

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We owe our thanks to a large number of friends and colleagues. Firstly, to the Co-Chairs, Bob Sheil and Ruairi Glynn, for their valuable advice and continuous support, to Marilena Skavara and Orkun Kasap for their tireless and great help in organising the conference, as well as to our whole team at ETH Zurich.

We are indebted to our Chairs and numerous peer reviewers, without whose efforts, time and work it would have been impossible to manage the large number of contributions to FABRICATE 2014. So our sincere thanks go to Hubertus Adam, Philippe Block, Tobias Bonwetsch, Michael Budig, Xavier De Kestelier, Stylianos Dritsas, Yves Ebnoether, Sean Hanna, Volker Helm, Sawako Kaijima, Axel Kilian, Branko Kolarevic, Toni Kotnik, Dirk Krolikowski, George Legendre, Marta Malé-Alemany, Wes McGee, Achim Menges, Philippe Morel, Shinya Okuda, Neri Oxman, Fabian Scheurer, Christoph Schindler, Michael Stacey, Martin Tamke, Yves Weinand and Jan Willmann.

For their support in finalising the publication, we would like to thank Veronika Darius for her management, Beverly Zumbühl for editing and especially Oliver Schmid for designing the book in a really narrow time frame. Thanks also go to all the authors for their diligence and patience.

For promotion and support, we want to thank our media partners archithese, uncube, Detail research, Architonic, world-architects.com, Stylepark and archello, as well as the Institute for the History and Theory of Architecture (gta) at ETH Zurich, ACADIA 2013 and the Fab lab Zurich for an inspiring exchange and much valued contributions.

And finally, we thank the Department of Architecture of ETH Zurich, Keller AG, NOE Formwork, Erne AG Holzbau, Bachmann Engineering AG and Computerworks for sponsoring the conference, and especially ABB and The Port Technology by Schindler for their generous financial support for this publication.

Fig. 1: Perspective view of the Silk Pavilion and its complementary basic research exhibit.
(Photo: Steven Keating.)

SILK PAVILION: A CASE STUDY IN FIBRE-BASED DIGITAL FABRICATION

NERI OXMAN, JARED LAUCKS, MARKUS KAYSER, JORGE DURO-ROYO, CARLOS GONZALES URIBE (MEDIATED MATTER GROUP, MIT MEDIA LAB)

The Silk Pavilion explores the relationship between digital and biological fibre-based fabrication on an architectural scale. Its primary structure is comprised of 26 silk-threaded polygonal panels laid down by a CNC (Computerised Numerical Control) machine. Inspired by the silkworm's ability to generate a 3D cocoon out of a single multi-property silk filament, the Pavilion's overall geometry was created using an algorithm that assigns a single continuous thread across patches, providing functional density gradients informed by environmental constraints such as light and heat. Overall density variation was informed by deploying the *Bombyx mori* silkworm as a biological multi-axis multi-material 3D 'printer' in the creation of a secondary fibre structure. 6500 silkworms were positioned on the scaffold spinning flat non-woven silk patches to locally reinforce the CNC-deposited silk structure. The paper provides a review of basic research into the silkworm's spinning behaviour, material and structural characterisation, computational simulation and fabrication strategy devised for the full-scale construction of the Pavilion. Potential applications for large-scale fibre-based digital fabrications that involve biological fabrication conclude the paper.

BACKGROUND AND MOTIVATION

FIBRE-BASED CONSTRUCTION

Digital fabrication processes, such as layered manufacturing, typically involve the layered deposition of materials with constant homogeneous physical properties.[1] Yet most natural and biological materials are made of fibrous structures locally aligned and spatially organised to optimise structural and environmental performance.[2] In the fields of product and architectural design, specifically, the automotive and avionic industries, fibre-based digital fabrication has typically been confined to the development and application of high-performance composites.[3] These materials and their related processes are typically toxic and harmful to the environment. Based on previous research and inspired by the *Bombyx mori* silkworm, this research explores the possibility of merging digital and biological fabrication to deliver a holistic and sustainable design approach in the production of non-woven fibre-based constructions.[4]

Construction processes found in nature such as woven spider nets or aggregate bird's nests are characterised by the animal's ability to generate, distribute, orient, densify and assemble fibre-based composite material.[5] Spiders, for example, can generate fibres with varying properties based on a particular need or function. These fibres are optimised for a wide range of different conditions including, but not limited to, mechanical properties such as strength and toughness. In addition to many existing types of silks, the silk itself may be rapidly adapted to different parameters during the silk spinning process. The final webs take into account a delicate balance of function, environmental conditions and material efficiency as limited by the energy resources of the spider.[6] Similarly, the silkworm can control the ratios of fibres and matrix to generate a wide array of mechanical properties ranging across tensile and compressive structures.[7]

BASIC RESEARCH INTO FIBRE-BASED COCOON CONSTRUCTION OF SILKWORMS

ANATOMY, BEHAVIOURS AND METHODS

The *Bombyx mori* silkworm is an arthropod with a body of approximately two to three inches in length. A division in the legs around the mid-portion of the body allows the worm to bend freely from side to side in its typical figure of eight motion (fig. 2). The silkworm's spinneret is located near its head, allowing the organism to extrude upwards of one kilometre of raw silk fibre. It traditionally spins silk in its fifth instar (stage between moults) after one to two months of feeding on mul-

Fig. 2: A *Bombyx mori* silkworm spins silk fibre on a digitally fabricated scaffolding structure.

berry leaves as it matures into a silk-producing caterpillar. When prepared to spin, the silkworm typically triangulates a three-dimensional space or corner forming a tensile structure within which the cocoon is formed.[8]

Silk production typically involves the harvesting and soaking of completed cocoons in a soapy water bath. The edge of an individual fibre is then pulled out of the bath and spun onto a spool for silk thread production. This production method requires the spinning of a full cocoon and a shortened life cycle for the silkworm, eliminating the opportunity for reproduction.

ADVANCED IMAGING TECHNIQUES AND QUANTITATIVE ANALYSIS OF SILK COCOONS

Basic research was conducted to further observe, understand and predict the motion and material deposition behaviour of the silkworm, implementing the following tools, techniques and technologies:

(1) Dynamic tracking was achieved by the application of magnetometer motion sensing to motion-capture a silkworm over the course of a 3-day cocoon construction period, during which the silkworm was tracked by attaching a miniature magnet to its head. The organism was placed in a boxed space fitted with three magnetometers capturing the worm's movement in 3D space. Data collected were converted into a visual representation of a point cloud (fig. 3).

(2) Wide-angle high resolution MicroCT (microtomography) and SEM (scanning electron microscope) imaging techniques were developed and implemented to analyse the organisational properties of silk textures across various length scales and species. SEM imaging techniques enabled micro-scale analysis of material property variation across the transversal and longitudinal sections of the cocoon.

(3) Template fibre-spinning experiments: it was observed that when spinning on a relatively flat environment, the silkworm generates a flat non-woven silk patch. Building on this observation, and coupled with previous research,[9] a suite of environments with varying morphological features was developed in order to explore the relationship between surface features and fibre organisation.[10]

Experimental results determined the following: (1) A 3D cocoon structure emerged only at a sectional height of 21 mm; below this, a tent-like structure in the form of a rectangular pyramid was spun. In the absence of this height, a non-enclosed surface patch was spun. (2) Fibre density typically varied as a function of the distance from the central vertical pole to the surface boundary. This may point to a local optimal condition requiring the least amount of energy for the construction of a strong stable structure within a given timeframe. (3) Boundary contours were typically denser. This is most likely due to the silkworm's constant search for a vertical pole tall enough to allow for cocoon construction.

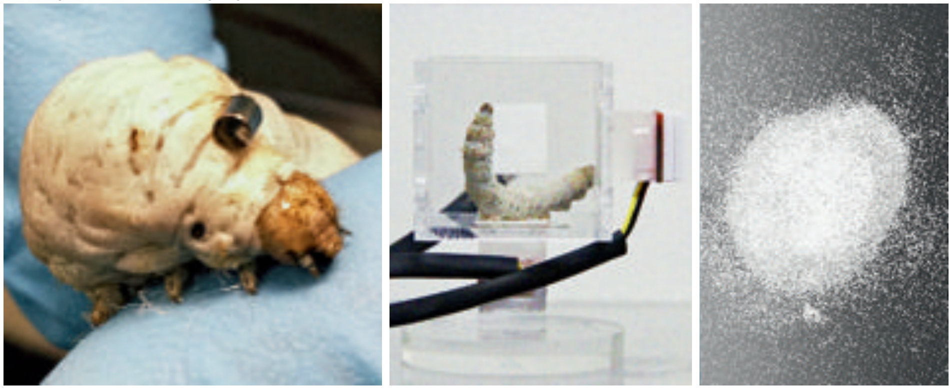
COMPUTATION AND DIGITAL FABRICATION

COMPUTATION

The pavilion was designed and constructed in two phases: the first phase consisted of digitally fabricating a scaffolding envelope made of silk fibres and the second phase consisted of deploying thousands of silkworms to spin a secondary silk envelope. A set of apertures built into the initial envelope capture light and heat, thus controlling the distribution of silkworms on the structure.

Overcoming current limitations of existing computer aided design (CAD) tools, a parametric environment was devel-

Fig. 3: a) Silkworm with attached magnet for motion tracking. b) A *Bombyx mori* silkworm positioned within a magnetometer testing rig. c) Point cloud visualisation based on magnetometer testing rig data.



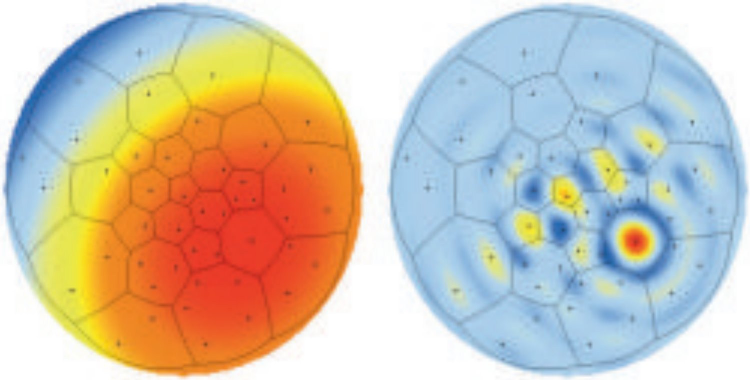


Fig. 4: a) Computational projection of panelled dome: solar mapping. b) Computational projection of panelled dome: aperture distribution mapping.

oped that facilitates the design and fabrication phases of the project, enabling continuous iteration between digital form-finding and physical fabrication processes. As such, this computational tool also served to mediate between environmental input, material properties and organisation as well as biological fabrication constraints. In addition, the tool enabled real-time evaluation of multiple design solutions.

The main goal was to develop a holistic computational design environment able to simultaneously capture and process multiple sets of complex constraints in real time. Most of these constraints are difficult or impossible to capture using current CAD tools. Amongst them is the ability to automatically determine for every digitally woven silk fibre what the conformal distance or space is within which the silkworm can spin, enabling the convergence between the digitally laid fibres and the biologically spun filaments.

A subsequent goal was to computationally embody the geometrical complexity and scalability of the Pavilion, as well as the scaffolding resolution and the range of fabrication tools used. The resulting tool informs the designer about overall material organisation as well as the effects of the biological parameters (such as silkworm motion range) on the final design.

The generative environment includes a new library designed on top of the RhinoCommon build that runs on the Grasshopper plug-in (in McNeel Rhinoceros 3D Modeler). The library comprises a set of routines that enable the shaping of a lightweight fibrous environment. The following data sets informed the algorithm for scaffolding thread geometry: the first set contains the fabrication constraints captured by the algorithm. These constraints are informed by the robotic manufacturing platform along with its prescribed gantry size and tool reach. This set generated the need for a spherical structure of the pavilion to be subdivided into a set of substructural patches. The patches conformed to a truncated icosahedron whose faces fit the robotic manufacturing bed. The second set of constraints originated in two data maps; the first map encoded the specific on-site solar trajectory and the second provided an opening radius multiplier to generate organisational fibre variation. Combined, these two maps informed the position and size of the pavilion apertures (fig. 4). The third set of constraints is linked to the silkworm's biological characteristics, with the goal of providing maximum silk deposit reach.

For each aperture, the position and size of which is determined by the site's light conditions, the computational protocol identifies a continuous tangent circle on the spherical geometry (fig. 5a). It is subsequently converted into tangent line segments, represented in 2D, matching the patch fabrication representation. For each such circle, a parameter controlling the resolution of the tangents relative to its geometry was assigned. This parameter determines the ratio between local fibre gradients to overall fibre distribution and organisation. The algorithm then checks each aperture to find out if it is contained within a prescribed patch, multiple patches or none, and classifies this information as data lists. For each patch containing a full or partial aperture, the algorithm computes the following: (1) Aperture formation in relation to the overall image of a continuous thread (fig. 5b). (2) Thread redistribution across apertures, providing balance between aperture distribution and continued thread allocation across the surface area of the overall volume. (3) Contour attachments for local continuous threads. (4) Scaffolding thread-spacing conformation to biological parameters of the silkworm weaving pattern (fig. 6a). (5) Robotic toolpath for fabrication (fig. 6b).

A final overall visualisation of the pavilion, aluminium frame profiles for water jet manufacturing of the patches (visu-

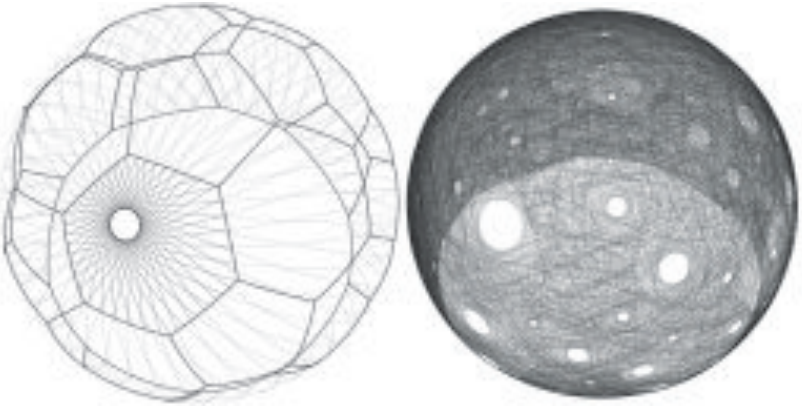


Fig. 5: a) Computational generation logic of single aperture.
b) Final computational path with global aperture distribution.

alised as the polygonal line segments), and unfolded toolpaths for CNC weaving are then generated as output (fig. 7).

DIGITAL FABRICATION

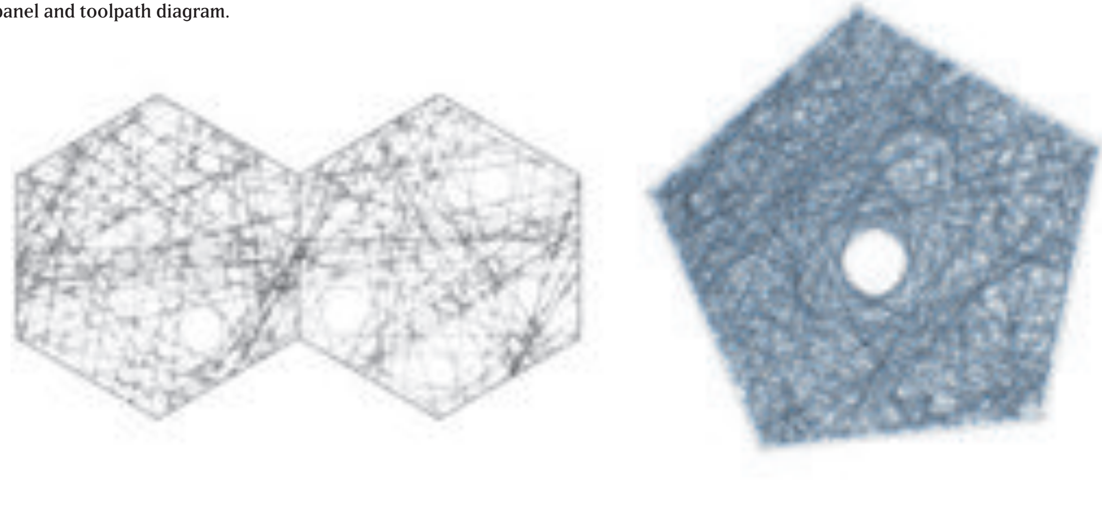
Based on the analytical protocols developed and reviewed above, a digital fabrication approach was developed that supported the findings with regard to the worm's possible range of motion and deposition behaviour, thus enabling the digital fabrication tools and biological construction to merge.

Initial toolpath development was tested with a three-axis CNC (Computer Numerically Controlled) machine. Initial computational paths were explored and implemented as traditional milling toolpaths without using the machine's spindle activation. These tests were originally developed as a drawing method prior to the development of the thread deposition tool (fig. 8).

Continued development of the CNC toolpath output (from the digital model to the machine) enabled the development of a basic tool that allowed for the deposition of thread as a spool or roll-based material. The gantry of the three-axis machine carried the rolls to be replaced as required based on the panel to be fabricated. A tool tip was developed that could be affixed into the normal collet design of the cutting head; the spindle would remain off and in a locked position. The spooled material could then be fed down through the tool tip inside a low friction HDPE (high-density polyethylene) tube. The tube ends in a custom-made press-fit bearing attached to a rotating shaft with a spring-loaded foot where the string could exit smoothly and in accordance with the direction of machine travel. The deposition of a lightweight material onto a temporary aluminium frame allowed the machine to run at higher velocities than normal cutting operations, thus aiding the speed of the fabrication process.

The perimeter of the unfolded 2D panels making up the overall form of the structure was designed as perimeter scaf-

Fig. 6: a) Computational silkworm spinning range calculation.
b) Computational unfolded panel and toolpath diagram.



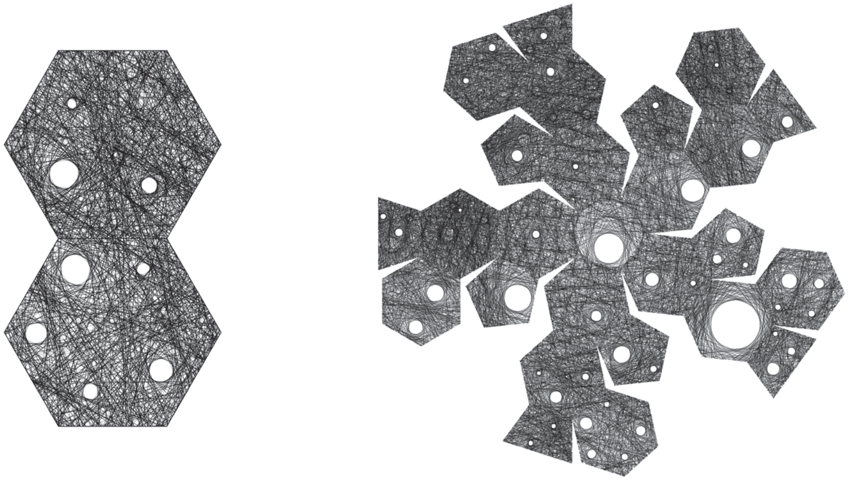


Fig. 7: a) Computational unfolded panel detail.
b) Computational unfolded overall panel layout for fabrication.

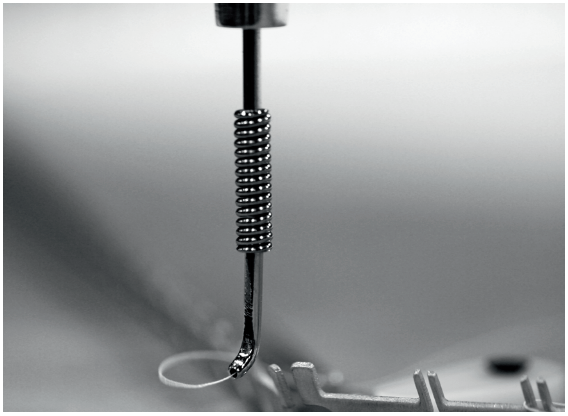


Fig. 8: Spring steel CNC threading tool and silk thread.

folding structures. They were cut from aluminium using water jets in order to maintain the deposited silk fibres during the fabrication process. The choice of a component-based assembly was dictated by the relatively large size of the overall structure and the limitations given by the gantry size of the CNC spinning tool. Designed as a temporary support, these panels could be reassembled after weaving to maintain the overall geometry of the system while installing it into a tensioned state in the atrium space of the Pavilion (fig. 9).

The frames were developed with small hook elements to allow the deposit of fibres. A release mechanism enabled the extraction of the frames once the panels were joined together and the structure was positioned in space. Between the joining edges of each frame was a small rubber-coated frame of piano wire to which the vertex nodes of the structure were affixed. The vertex nodes were to be used in attaching the tensile structure to its surrounding environment and the piano wire was the medium around which the edge of each panel was affixed (fig. 10).

Once the truncated icosahedron panels were assembled and knotted edge-to-edge, the overall structure was raised to its proper height and location, followed by the deployment of a series of tension lines. Each of the lines was affixed to a custom designed acrylic clip; each point location was calculated as part of the digital model of the vertex's normal intersection within the space. Tension cable lengths were measured, located and labelled. Once the structure was in place, the entire vertex and centroid tension lines were installed and tensioned to their marked lengths, suspending the metal frame and the structure in space. At this point, the frames were

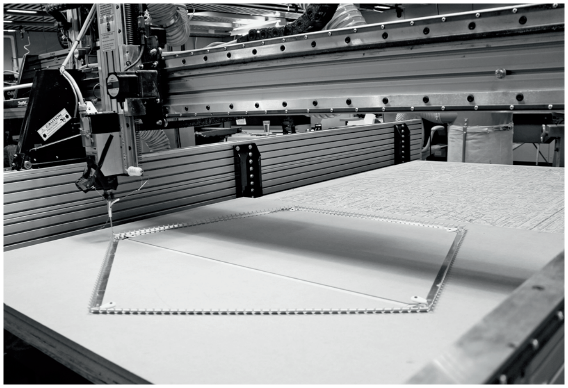


Fig. 9: Three-axis CNC machine adapted as CNC deposition tool. Custom threading tool, temporary aluminium scaffolding and MDF jig.

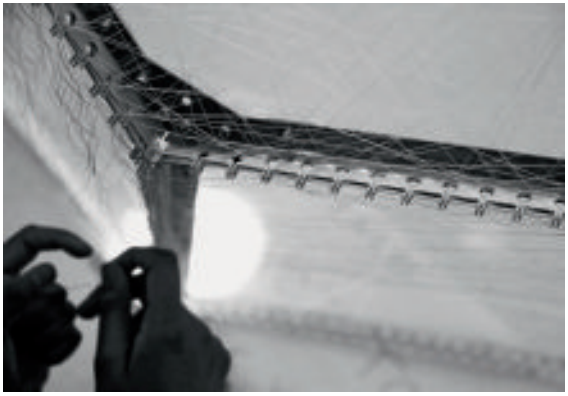


Fig. 10: Knotting of vertex connections of non-woven silk patches on temporary aluminium scaffolding structure.

removed, starting from the top of the structure and working down in circular fashion. Following the removal of the frame, some tension was lost that was recovered after the centroid suspension lines were tensioned. The bottom of the structure was affixed to a 25 mm thick MDF floor structure with a white vinyl covering.

BIOLOGICAL FABRICATION

Parallel to the digital fabrication of the primary structure, 6500 silkworms were raised through the remainder of their fifth instar feeding on a diet of mulberry leaves prior to the silk spinning phase (fig. 11). Reared in a light- and temperature-controlled room at the MIT Media Lab, the silkworms were fed and monitored over the course of several weeks. As the worms began spinning, they were transferred onto the tensioned silk structure with a protective fence and drop cloth in place.

Over a ten-day period, all silkworms were positioned on the scaffolding structure, typically initiating spinning from the bottom rim upwards (fig. 12).

Most silkworms were found to settle into a single space over the surface area of the structure, spinning flat patches in circular motion. In addition, most silkworms were found to migrate to the highest surface patch of the structure, possibly due to a combination of high temperature, low lighting conditions and decreased metabolic cost that is the result of horizontal movement (fig. 13).

Following two to three spinning days, the silkworms were released from the structure and collected on a drop cloth at the bottom of the dome. The silkworms were able to continue their cycle of metamorphosis into a silk moth, including egg laying and reproduction.

Fig. 11: Approximately 1000 *Bombyx mori* silkworms in their fifth instar upon arrival.

Fig. 12: View through pavilion apertures as the silkworms put a skin on the structure.

SUMMARY AND POTENTIAL APPLICATIONS

The Silk Pavilion explores the duality of digitally and biologically fabricated structures by proposing a template construction approach to fibre-based digital fabrication. In this approach, digital tools are implemented to deliver a highly differentiated scaffold, on top of which a biological system is deployed. The two systems are complimentary: while one provides the load-bearing paths of the structure, the other strengthens these trajectories and acts as a skin. Moreover, the biologically deposited silk embodies qualities associated with its scale that could not have been achieved using current digital fabrication tools. The silkworm-spun non-woven fibroin adheres to and wraps around the digitally deposited silk fibres and provides for a fibrous 'infill' due to the interaction between the two chemical agents deposited by the silkworm: the fibroin that acts as fibre and the sericin that acts as glue or connective tissue. The template construction approach can be implemented using other types of digital fabrication tools and biological systems. In this respect, the computational environment developed for this project is considered a generative one: it can address other similar problems across a range of scales and across an array of fabrication methods, environments and biological systems of choice.

Several potential applications may be considered as possible outcomes of this research. With regard to the direct potential for biological fabrication combined with digital fabrication, the experimental data affirming the relationship between scaffold surface morphology and biological fibre organisation can be considered the most valuable (fig. 1). Further research will explore various techniques for using templates in biological fabrication in order to generate highly controlled and tunable functional gradients of material properties. New types of high-performance textile composites may be designed in this way, not unlike the composites observed on the pavilion which combine internal and external natural-silk wrapping of the synthetic threads. In addition, direct silk fibre deposition onto a scaffolding structure not only bypasses the processing of silk cocoons into thread and textile, but also promotes a more sustainable silk harvesting cycle. Finally, with regard to decentralised swarm-like construction processes similar to the ones viewed in nature, future developments in the potential of collaborative construction behaviour will be further explored.

The Silk Pavilion was developed by the Mediated Matter Group at the MIT Media Lab in collaboration with James Weaver of the Wyss Institute (Harvard) and Prof. Fiorenzo Omenetto of Tufts University. The project was developed as part of ongoing research investigating fibre-based digital fabrication methods[11] combined with relevant cases found in nature. The construction stage explored the relationship between digital and biological fabrication on product and architectural scales.

Fig. 13: Top view of the Silk Pavilion as approximately 6500 silkworms construct the fibrous composite.

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MARK BURRY has published internationally on two main themes: the life and work of the architect Antoni Gaudí in Barcelona, and putting theory into practice with regard to 'challenging' architecture; he has also published widely on broader issues of design, construction and the use of computers in design theory and practice. As Consultant Architect to the Temple Sagrada Família since 1979, Mark Burry has been a key member within the small team, untangling the mysteries of Gaudí's compositional strategies for the Sagrada Família, especially those coming from his later years, the implications of which are only now becoming fully apparent as they are resolved for building purposes. In February 2004, in recognition of his contribution to this project, he was given the prestigious award *'Diploma I la insignia a l'acadèmic corresponent'* and the title Senyor Illustre by la Reial Acadèmia Catalana de Belles Arts de Sant Jordi and he was recently awarded an Australian Research Council Federation Fellowship. Mark is director of RMIT's state-of-the-art Spatial Information Architecture Laboratory, which has been established as a holistic interdisciplinary research environment dedicated to almost all aspects of contemporary design activity. The laboratory focuses on collocated design research and undergraduate and postgraduate teaching with associated advanced computer applications and the rapid prototyping of ideas. The laboratory has a design-practice emphasis and acts as a creative think-tank accessible to both local and international practices, including ARUP in Melbourne and London, dECOi in Paris and Gehry Partners in Los Angeles.

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ENRICO DINI graduated in Civil Engineering from the University of Pisa, and has spent most of his career on the implementation of robotic automation of shoe manufacturing. During these years, Enrico came across rapid prototyping technology, which he made his sole focus from 2004 onwards. Since then, he has developed a large-scale 3D printer using inorganic binders. In 2008, his first large-scale 300-nozzle 6 × 6 meter 3D printer became operational. His technology has been used since then to make 3D print sculptures and architectural mock-ups. Recently, he has been working on a 'maritime' printer suitable for printing artificial reefs for coastal protection.

JORGE DURO-ROYO, born in Barcelona, graduated as an architect from the Polytechnic University of Catalonia School of Architecture and as a mechanical engineer from the Polytechnic University of Catalonia School of Industrial and Aeronautic Engineering, where he graduated with honours. In 2006, he spent a year in Paris on an Erasmus Scholarship at the École Nationale Supérieure Paris-La Villette. From 2009 to 2010, he co-taught Introduction to Parametric Architecture for 4th and 5th year students with the Coda Group. In 2010, he attended the master's degree programme in Advanced Design and Digital Architecture at the Pompeu Fabra University. In 2010–11, he completed a master's degree in Architecture, Energy and Environment at UPC-ETSAB. He has worked in Europe in international offices such as Dominique Perrault DPA and Duro Architecture and Engineering. Jorge co-founded DumoLab in 2008, a young architecture, engineering and research studio that focuses on experimental design, data management in architecture, innovative material systems and programming of new design tools. He has spent the last two years in Cambridge MA, collaborating with MIT professors on multiple innovative research subjects. In 2013, he joined the Mediated Matter Research Group as a Research Assistant.

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AMMAR KALO recently received a Master in Science in Architecture with a concentration in Digital Technologies from the University of Michigan Taubman College of Architecture and Urban Planning (2013). Prior to pursuing his post-professional studies, he has held professional posts in architecture and design in Dubai and worked on international projects of various scales. At Taubman College, his work focused on digital fabrication and computational design methodologies. His current research interests include synthesizing conventional materials and digital technologies into hybrid material systems. Ammar holds a bachelor's degree in Architecture from the American University of Sharjah (2008).

MARKUS KAYSER studied 3D Furniture and Product Design at London Metropolitan University and continued on in 2009 with the study of Product Design at the Royal College of Art. Currently, Markus is a PhD candidate at the MIT Media Lab, where he has joined the Mediated Matter Group. Before joining the group, he started his own studio, engaging in discussions about opportunities in the production of design involving new as well as forgotten processes and technologies. Now, as then, his research draws on science, art and engineering and aims to blur the gaps between seemingly separate fields. Experimentation plays a central part in developing his research. Markus's recent work demonstrates the exploration of hybrid solutions linking technology and natural energy to show opportunities, question current methodologies in manufacturing and test new scenarios of production. His work has been widely publicised around the world in exhibitions, broadcasting and web-based media.

OLIVER DAVID KRIEG is a doctoral candidate at the Institute for Computational Design at the University of Stuttgart. With the completion of his Diploma thesis in 2012, he also received the faculty's Diploma Prize. Prior to that, he worked as a Graduate Assistant at the Institute's robotic prototype laboratory, RoboLab, from the beginning of 2010. With a profound interest in computational design processes and digital fabrication in architecture, he has participated in several award-winning and internationally published projects. In the context of computational design, his research aims to investigate the architectural potential of robotic fabrication in wood constructions.

DIRK KROLIKOWSKI has been the architect and associate in charge of the design, development and delivery of the unique external structure (the Megaframe) of the Leadenhall Building, a 51-storey office development in the city of London. Dirk also heads the Digital Research Cluster of Rogers Stirk Harbour + Partners and led the implementation of advanced modelling strategies for Leadenhall, an award-winning project that has received international recognition for its integrated use of digital technology. In 2011, Dirk was appointed Lecturer for Innovative Technology and Design at the Bartlett School of Architecture (UCL).

JORIS LAARMAN is a Dutch designer, artist and entrepreneur best known for experimental designs inspired by upcoming technology. He attended the Design Academy Eindhoven in 1998 and graduated cum laude in 2003. He founded Joris Laarman Lab together with his partner Anita Star. His critically acclaimed work has been added to the permanent collections of many renowned international museums such as MoMA in New York, V&A in London, Centre Pompidou in Paris and the Rijksmuseum in Amsterdam. He has contributed articles and seminars for *Domus* magazine and was a guest teacher at European universities such as the Architectural Association London, Rietveld Academy Amsterdam and the Design Academy Eindhoven. In 2011 he received one of the eight Innovators of the Year awards by the *Wall Street Journal*.

SILKE LANGENBERG is a senior researcher at the Chair of Architecture and Digital Fabrication, Institute of Technology in Architecture at ETH Zurich. Between 2011 and 2013 she was based in Singapore several times to research at the Singapore ETH Centre for Global Environmental Sustainability. From 2006 to 2011 she was Researcher at the Institute of Historic Building Research and Conservation of ETH Zurich. Silke has studied architecture at the Universities of Dortmund and Venice. She received a Scholarship for extraordinary achievements for her PhD in Engineering Sciences about *Buildings of the Boom Years. Architectural Concepts and Planning Theories of the 60s and 70s* (finished 2006). In 2013, Silke was appointed as Full Professor for Design and Construction in Existing Contexts, Conservation and Building Research at the University of Applied Sciences in Munich.

JARED LAUCKS is a trained maker, architect, designer and fabrication specialist. He is currently a Research Assistant in the Mediated Matter Group at the MIT Media Lab, where he is interested in developing novel methods of digital fabrication for design research. Jared graduated from Philadelphia University with a bachelor's degree in Architecture, focused on digital technologies. As an extension of this research, he launched j_laucks; initially a platform for experimental design and fabrication, it has since grown into a multifaceted research agenda exploring avenues from architecture and design to computation, material systems, and fabrication. In parallel to working as an architect, he was appointed Adjunct Professor at Philadelphia University, developing a new advanced modelling curriculum. Jared has exhibited work in cities across the globe, including Philadelphia, Berlin, Frankfurt, NYC, Valparaiso, Lyon, Paris, Miami, Sao Paulo, London and Munich.

WILLI VIKTOR LAUER is a research assistant at the Future Cities Laboratory, Singapore ETH Centre for Global Environmental Sustainability, Module II Architecture and Digital Fabrication, led by Fabio Gramazio and Matthias Kohler, where he has implemented a research facility for investigating robotic fabrication methods for high-rise buildings. Between 2009 and 2011, he worked as a Scientific Assistant at the Chair of Building Realization and Robotics at the Technical University of Munich, where he gained in-depth knowledge of the young history of robotic construction technologies and the forerunners in building industrialization. In the context of his master's thesis in 2009, he reconstructed the first architectural robotic arm: the Location Orientation Manipulator by Konrad Wachsmann.

DIETER LINKE is experienced in development and inventions for membrane structures and their details, merging architectural and pragmatic requirements. Following his carpentry apprenticeship, he was awarded a Civil Engineering Diploma from the Munich Technical University in 1991. Key projects are Mina Tent City (PTFE, Medinah), Masoala Rainforest Hall (ETFE cushions, Zurich), AWD Arena (single layer ETFE, Hanover), Allianz Arena (ETFE cushions, Munich), National Stadium (Birdnest, single layer ETFE, Beijing), Sports and Concert Complex, (plane PVC, Baku). Further, the benefits of using ETFE film in modern greenhouse culture and sustainable energy technologies currently hold his interest.

MARTA MALÉ-ALEMANY is an architect, researcher, and educator from Barcelona. Since 1997, she has combined her professional practice with teaching experimental design studios and research seminars in architecture schools from the US (MIT, UPenn, UCLA, SCI-ARC among others) and Europe (AA, IaaC, UIC), in combination with directing several master's degree programmes in architecture. Following many years of exploration in using digital technologies for the production of architecture, her current research agenda focuses on developing innovative material and construction solutions using customised robotic devices, with a particular interest in additive manufacturing for architecture. Marta graduated from ETSAB-UPC (Barcelona) in architecture, holds a master's degree in Advanced Architectural Design from Columbia University (New York), and is currently a PhD candidate at the ETSAB-UPC (Barcelona), investigating the potential of large-scale additive manufacturing technologies to innovate building construction.

ARETI MARKOPOULOU is a Greek architect and educator whose research and practice design explores new architectural models where applications of ICT, energy and fabrication allow built and public space to dynamically adapt to behavioural and environmental changes over time. She holds an MArch by IaaC in the field of 'Prototypes of Urbanity: from Bits to Geography' and a Fab Academy diploma on Digital Fabrication offered by the MIT Center for Bits and Atoms and the Fab Lab Network. She is permanent faculty at IaaC with several published articles internationally. Co-founder of the Mycity-me nonprofit organization, her practice includes project collaborations with multidisciplinary offices and institutions and she has participated in R + D projects ranging from intelligent cities (such as 'Smart BCN' with City Hall Barcelona, 2013), self-sufficient buildings (such as 'Fab Lab House' at Solar Decathlon Europe, 2010), digital fabrication (such as 'Fabrication Laboratory' at DHUB, 2010) and Internet of things (such as 'Hyperhabitat' at the XI Venice Biennale, 2008). She is currently the Director of the Masters in Advanced Architecture at IaaC in Barcelona and initiator and partner of Fab lab Athens in Greece.

KEVIN MCCLELLAN is a designer, artist and founder of Architecturebureau, a design research office exploring complex systems and their material effects on form. After receiving his master's degree in Architecture and Urbanism from the DRL at the Architectural Association School of Architecture with a Project Distinction in 2005, he subsequently worked in New York for Kevin Kennon and in London with Zaha Hadid Architects. In 2011, he co-founded the UK-based Dsigndot, an online marketplace for the sale of unique and collectable designs.

WES MCGEE is an Assistant Professor in Architecture and Director of the Fab lab at the University of Michigan, Taubman College of Architecture and Urban Planning. As a founding partner and senior designer in the studio Matter Design, his work spans a broad range of scales and materials, always dedicated to re-imagining the role of the designer in the digital era. In 2013, Matter Design was awarded the Architectural League Prize for Young Architects & Designers. Wes has presented his work at many national and international conferences on design and fabrication. He is Chair of the Conference Robotic Fabrication in Architecture, Art, and Design, hosted at the University of Michigan in 2014.

ACHIM MENGES is a registered architect and professor at the University of Stuttgart, where he is the founding director of the Institute for Computational Design (since 2008). In addition, he has been Visiting Professor in Architecture at Harvard University's Graduate School of Design (2009–10), at the AA School of Architecture in London (2009–current) and at Rice University in Houston (2004). Achim Menges graduated with honours from the AA School of Architecture in London (2002), where he subsequently taught as Studio Master of the Emergent Technologies and Design Graduate Program (2002–09) and as Unit Master of Diploma Unit 4 (2003–06). Achim's practice and research focuses on the development of integral design processes at the intersection of morphogenetic design computation, biomimetic engineering and computer-aided manufacturing that enables a highly articulated, performative built environment. His work is based on an interdisciplinary approach in collaboration with structural engineers, material scientists and biologists. He has published several books on this work and related fields of design research, and is the author/co-author of numerous articles and scientific papers. His projects and design research have received many international awards, has been published and exhibited worldwide, and form parts of several renowned museum collections.

AMMAR MIRJAN is an architect with a background in automation engineering. He studied at the Berne University of Applied Sciences and at the Bartlett School of Architecture in London. He has worked for different architecture studios in New York, Tokyo and London. In 2011, he joined ETH Zurich, where he is currently pursuing his PhD at the Chair for Architecture and Digital Fabrication. His research focuses generally on the relationship between design and construction with intelligent machines and specifically on architectural fabrication processes with flying robots.

MICHAEL JAKE NEWSUM is the Robotics Lab Coordinator at the Southern California Institute of Architecture. His work currently focuses on the development of computational tools for the integration of design and fabrication through new robotic workflows. He received a Master of Science in Architecture with a concentration in Digital Technologies from the University of Michigan, Taubman College of Architecture and Urban Planning. Additionally, he earned a bachelor's degree in Architecture from the University of Arkansas, Fay Jones School of Architecture.

PETR NOVIKOV holds a master's degree in Architecture from Moscow Architectural Institute and a master's degree in Advanced Architecture from IaaC. Petr is co-inventor of the Stone Spray technology, which was created during a digital tectonics course at IaaC. The project received the Golden Prize of Spark Awards 2012. During the Open Thesis Fabrication program of IaaC in 2012, he and Saša Jokić worked on the new 3D printing technology Mataerial. Petr has given numerous lectures on the use of robotics in architecture. In 2013, he was featured in *ICON* magazine as one of 50 people pushing the boundaries of architecture.

NERI OXMAN is the Sony Corporation Career Development Professor and the Director of the Mediated Matter Research Group at the MIT Media Lab. Her group conducts research at the intersection of computational design, digital fabrication, and materials science, applying that knowledge to design across scales from the micro-scale to the building scale. Neri coined the term 'material ecology' to describe her work, applying the science of ecology to the world of the artificial. A leader in the field of biologically inspired digital fabrication, her research and design work have been acquired for permanent collections and exhibited at the Museum of Modern Art (NY), Centre Georges Pompidou (Paris), the Museum of Fine Arts (Boston), and the Smithsonian Institute, among others. Neri was named in ICON's list of the top 20 most influential architects to shape our future (2009), selected as one of the 100 most creative people by FASTCOMPANY (2009) and awarded the Earth Award (2009), a METROPOLIS Next Generation Award (2009) and the 40 Under 40 Building Design + Construction Award (2012) amongst many others. She publishes and lectures worldwide.

LAURENT PAMBAGUIAN obtained his PhD in Material Science in 1994 from Paris XI University for the work he did at ONERA, the French Aerospace Lab. Over the last 20 years, he has developed expertise in several advanced materials and processes topics, including metal matrix composites for structures, thermal management and lubrication, cellular materials and carbon nanotube-based materials. He joined the Materials Technology Section of ESA in 1999 and for the last eight years has been involved in the development of additive manufacturing technologies for space use.

BRIAN PETERS is an architect and designer who specialises in emergent design and fabrication techniques. He received a Master's of Architecture from the University of Illinois at Chicago and worked for several years as an architect in Chicago. In 2009, Brian moved to Barcelona, where he received a Master of Advanced Architecture with an emphasis on digital tectonics from the Institute of Advanced Architecture in Catalonia. More recently, Brian was based in Amsterdam, where he started several projects investigating the role of 3D printing in architecture, including Building Bytes and the KamerMaker with DUS Architects. As of the fall of 2013, Brian is teaching and conducting research at Kent State University in the College of Architecture and Environmental Design.

DAVE PIGRAM is a designer, researcher and educator and holds a Master of Science in Advanced Architecture from Columbia University. As co-director of the international, award-winning architecture and innovation practice supermanoeuvre, his research focuses on the use of computation to increase the number and quality of feedback loops between design and fabrication. Dave is currently the Director of the Master of Advanced Architecture programme at the University of Technology, Sydney (UTS) and co-directs research into robotic fabrication at the University of Michigan and is a Research Affiliate at MIT's Media Lab.

JORDI PORTELL is a practising registered architect who has become increasingly dedicated to research as a result of being a master's level student, and later a faculty assistant at the FABbots Research Studio directed by Marta Malé-Alemany. He holds a professional degree in architecture from the ETSAB UPC-Barcelona and a Master's in Advanced Architecture from the IaaC Barcelona. His research is focused on the application of additive manufacturing techniques in architecture, with a special interest in multi-material systems and complex material networks.

JONATHAN RABAGLIATI is an artist whose field of practice extends across architecture, art, design and curation. He is one of the longest-serving members of the Specialist Modelling Group at Foster + Partners. Recent projects include the design and delivery of Canary Wharf Crossrail Station roof, a hypotrochoidal staircase for Bloomberg and defining geometry for the National Bank of Kuwait tower. He engages primarily through sculpting with code, and wrestling with design systems to seek out simplexity, the other side of complexity. In the interstices, he regularly collaborates with Julie Kim, where graphic design meets in a critical dialogue with conceptual art and computational experimentation.

METTE RAMSGAARD THOMSEN is an architect working with digital technologies. Her research centres on the relationship between crafts and technology framed through 'digital crafting' as a way of questioning how computation, code and fabrication challenge architectural thinking and material practices. Mette is a Professor at the Royal Danish Academy of Fine Arts, School of Architecture in Copenhagen, where she heads the Centre for Information Technology and Architecture (CITA).

STEFFEN REICHERT is a research associate and doctoral candidate at the Institute for Computational Design at the University of Stuttgart, Germany. He received a Master of Science in Architecture Studies in the field of design and computation from the Massachusetts Institute of Technology (MIT) and a diploma degree with distinction in product design from the Academy of Arts and Design in Offenbach. His research focuses on the relationship of form, fabrication and performance in responsive, biologically inspired systems based on anisotropic material behaviour.

KATJA RINDERSPACHER is a doctoral candidate at the Institute for Computational Design at the University of Stuttgart and a registered architect. She holds an engineering degree from the Fachhochschule Mainz and a Master of Science in Architecture with honours from Pratt Institute, New York. Her work was distinguished by scholarships (e.g. Fulbright Scholarship, DAAD/German Academic Exchange Service) and awards (e.g. Excellence in Academic Achievement Award). As an architect and project manager, she worked in New York, Switzerland and Germany, including Studio Daniel Libeskind. Her current research involves the integration of geomorphological processes in computational design and digital fabrication for the construction of complex structures.

JEAN ROULIER was trained as joiner, carpenter and wood building engineer. Having accumulated extensive experience in CAD in practice, he co-founded the company Lignocam SA in 2006 in order to develop CAM software for the wood industry. Since then, the homonymous software Lignocam has become the leading CAM software interpreting BTL files. Its objective is the promotion of wood in construction – even the most daring ideas – as well as the realisation of a smooth digital chain in the construction and fabrication process.

VIRGINIA SAN FRATELLO and **RONALD RAEL** are architects, artists and educators. They are partners at Rael San Fratello and in Emerging Objects, which is a pioneering design and research company that specializes in 3D-printed materials and objects for the built environment based in Oakland, California. Ronald is Associate Professor at the University of California Berkeley and Virginia is Assistant Professor in the area of Design at San Jose State University. They both hold Master of Architecture degrees from Columbia University in the City of New York. Their research focuses on the convergence of digital, ecological, and creative material explorations. The research is applied through the design and fabrication of innovative buildings and their components, furniture elements and site-specific installations that often look at inherent material resources and have embedded political consequences. Rael San Fratello was the recipient of Metropolis Magazine's Next Generation Design Award for their Hydro Wall concept, a finalist in the WPA 2.0 design competition and winner of the Van Alen Institute's Life at the Speed of Rail competition. Rael San Fratello was voted one of '10 to watch' by *California Home and Design* magazine. Their work has been published in *Metropolis* magazine, *L'Arca*, *DOMUS*, the *NY Times*, *Interior Design* magazine, the *Praxis Journal of Writing and Building*, *Make* magazine and *MARK* magazine.

JOSE SANCHEZ is an architect/programmer/game developer based in Los Angeles, California. He obtained his licence at Universidad de Chile, in Santiago and his Master in Architecture at the Architectural Association's Design Research Lab, London. He is a partner at Bloom Games, a start-up built upon the BLOOM project, winner of the WONDER SERIES hosted by the City of London for the London 2012 Olympics. He is the director of the Plethora Project, a research-based practice investing in the future of on-line open-source knowledge propagation. The project has over 150 videos and an open-source library of code with over 700,000 completed video sessions since 2011. His background in computational design and digital manufacturing is linked to the practice Biothing, were he has been one of the principal designers in numerous projects and exhibitions since 2009. In 2012 he founded the Plexus talks at the Bartlett School of Architecture, bringing together designers from different disciplines speculating on the role of computational design and new media in the practice of the discipline. Today, he is Assistant Professor at USC School of Architecture in Los Angeles and Co-Chair of ACADIA Conference 2014, to be hosted at USC. His research 'Gamescapes' explores generative interfaces in the form of video games, speculating on modes of intelligence augmentation, combinatorics and open systems as a design medium.

FABIAN SCHEURER is founding partner of designtoproduction and leads the company's office in Zurich. He graduated from the Technical University of Munich with a diploma in computer science and architecture. In 2005, designtoproduction was founded as a research group at ETH to explore the connections between digital design and fabrication. At the end of 2006, designtoproduction teamed up with architect Arnold Walz and became a commercial consulting practice, since then having implemented digital planning and production chains for projects like the Hungerburg-Funicular in Innsbruck (by Zaha Hadid), the Rolex Learning Center in Lausanne (by SANAA), or the Centre Pompidou in Metz (by Shigeru Ban) among others. Fabian Scheurer has taught as guest lecturer/tutor at the AA in London and the IaaC in Barcelona. Since 2012, he has been a lecturer for Digital Modelling and Production at HTW Chur.

TIM SCHORK is co-director of MESNE Design Studio and a lecturer in the Department of Architecture at Monash Art Design & Architecture (MADA). His integrated design-based practice, research and teaching investigate the relationship between architecture and divergent domains of knowledge through the use of computation in order to create innovative design strategies for novel spatial structure. His work is trans-disciplinary and fosters connections between and across disciplinary domains such as architecture, other art and design disciplines, engineering and science in order to innovate in design, often challenging the operative boundaries as well as formal and conceptual aesthetics of what is regarded as standard architectural practice.

TOBIAS SCHWINN is a research associate and doctoral candidate at the Institute for Computational Design at the University of Stuttgart. His research focuses on the integration of robotic fabrication and computational design processes. Prior to joining the ICD, he worked as a Senior Designer for Skidmore, Owings and Merrill in New York and London applying computational design at various planning stages. Tobias studied architecture at the Bauhaus University in Weimar and at the University of Pennsylvania in Philadelphia as part of the US-EU Joint Consortium for Higher Education. He received his engineering degree in 2005.

MATTHEW SHAW is an architect, maker and educator based in London. His work is driven by the speculative use of digital technologies, the impact these technologies will have on our lives and the way they shape our architecture. Matthew is co-founder of ScanLAB Projects, tutor at the Bartlett School of Architecture, University College London, and Director of Graticule Architecture.

BOB SHEIL is an architect, Professor in Architecture and Design through Production, and Director of Technology at the Bartlett School of Architecture, where he also runs MArch Unit 23 with Emmanuel Vercruysse and Kate Davies. He is a founding partner of sixteen*(makers), whose work in collaboration with Stahlbogen GmbH '55/02' won a RIBA award for design in 2010, and also includes a ten-year catalogue of experimental projects both internationally published and exhibited. He is an educator, critic, researcher, collaborator and practitioner, as well as an experimental designer who is fascinated by transgression between making, craft, and technology, in architectural design practice. As Director of Technology, he has been responsible for the School's significant acceleration of investment in digital technologies, which led to the establishment of the Digital Manufacturing Centre (2009) and more recently, the Bartlett Manufacturing and Design Exchange (B-MADE). In 2011, he chaired the highly acclaimed inaugural conference FABRICATE with Ruairi Glynn.

MIKE SILVER is an architect, researcher and educator. He is currently on the faculty of the Department of Architecture at the University of Buffalo. Mike directs a multidisciplinary design laboratory that explores emerging technologies such as humanoid robotics, automated fibre placement and mobile design apps for on-site construction. His work has been exhibited at the New Museum of Contemporary Art in New York, the International Design Center Nagoya, the National Building Museum in Washington, DC, the Architecture League in New York and the Cooper-Hewitt National Design Museum, also in New York. He built his first working robot out of Scotch tape and spirograph parts at the age of 12.

ASBJØRN SØNDERGAARD is an architectural researcher working in the field of digital fabrication in relation to architectural design. He is coordinator of Digital Experimentation at the Aarhus School of Architecture, Chief Development Officer and founding partner of Odico Formwork Robotics, a high-technology enterprise framing architectural design experimentation and fabrication in the field of industrial robotics. As the academic project manager of several interdisciplinary research projects, he heads investigations into structural design and architectural robotics. His doctoral research focuses on morphogenetic processes and the development of novel structural logics in relation to numerical fabrication techniques.

DAVID STASIUK is an architect and PhD Fellow at the Centre for Information Technology and Architecture in Copenhagen. His research investigating development strategies for emergent parameterisation is a component of the Centre's larger, multi-pronged Complex Modelling project. His own work is focused on investigating the development of emergent parameter spaces through the integration of simulation systems with topological transformation. His professional work has focused on bespoke detailing for advanced architectural geometries, computational design implementation, and the use of digital fabrication and documentation techniques, some of which was presented at the ACADIA 2012 conference.

HANNO STEHLING is consultant for digital fabrication and parametric modelling at the digital fabrication consultancy designtoproduction in Zurich. He graduated with a diploma in architecture from University of Kassel, where he studied under Prof. Manfred Grohmann (Bollinger + Grohmann) and Prof. Frank Stepper (Coop Himelb(l)au) and is Dipl.-Ing. Architekt SIA. He has a strong background in computer programming and gradually focused his studies on the intersection between architecture and computer science. He worked as a freelance programmer and as computational designer for renowned architects such as Bernhard Franken before joining designtoproduction in 2009. Hanno Stehling is co-founder of the online platform RhinoScript.org and gives modelling and scripting classes to both academic and professional audiences.

KASPER STOY is a robotics and embodied artificial intelligence researcher holding an Associate Professor position at the Software and Systems Section of the IT University of Copenhagen. He has published more than sixty papers in international conference proceedings or journals and is the author of *Self-Reconfigurable Robots: an Introduction*, published by MIT Press. He holds an MSc degree in computer science and physics from the University of Aarhus, Denmark (1999) and a PhD in computer system engineering from the University of Southern Denmark (2003), where he also worked as Assistant Professor (2003–6) and Associate Professor (2006–13).

MARTIN TAMKE is an architect pursuing design-led research on the interface and implications of computational design and its materialisation. His special focus is on the methods and consequences of digital fabrication and the integration of simulation and feedback in the process of architectural design and production. Martin is a founding member and Associate Professor at the Centre for Information Technology and Architecture (CITA) at the Royal Danish Academy of Fine Arts, School of Architecture in Copenhagen.

KADRI TAMRE is an architect, currently working as a Teaching and Research Associate at the Institute for Experimental Architecture, Hochbau at the University of Innsbruck. She holds a master's degree in Architecture from the University of Applied Arts Vienna / Studio Wolf D. Prix and has working experience in architectural practices in Austria, Estonia, Spain and China, receiving several awards and scholarships. She has been teaching various international parametric design and robotic fabrication workshops. Her current research focuses on the development of novel interface and material processes and she is co-running the University of Innsbruck's robotic laboratory.

LAVENDER TESSMER is a designer, fabricator and musician. Currently a lecturer at Washington University of St. Louis, she is teaching courses in architectural representation and digital fabrication. Since 2010, Lavender has worked with Yogiaman Tracy Design (yo_cy) on a variety of installations and residential and commercial projects. Her specialisations include parametric design, steel fabrication, connection design, visualisation and material testing. As a recent graduate of Washington University in St. Louis, she received the 2011 Laskey Award, a Fall 2011 Degree Project Award, and was nominated for the Frederick Widmann Prize in Architecture.

SKYLAR TIBBITS is a trained architect and computer scientist whose research focuses on self-assembly technologies for industrial applications in a built environment. Skylar was recently awarded a 2013 Architectural League Prize, the Next Idea Award at Ars Electronica 2013, the Visionary Innovation Award at the Manufacturing Leadership Summit, a 2012 TED Senior Fellowship and was named a Revolutionary Mind in *SEED* magazine's 2008 Design Issue. He has designed and built large-scale installations around the world and exhibited at the Guggenheim Museum NY, the Beijing Biennale and lectured at MoMA and SEED Media Group's MIND08 Conference. Skylar is the Director of the Self-Assembly Lab at MIT and the founder of a multidisciplinary research-based practice, SJET LLC. Skylar is also on the faculty of MIT's Department of Architecture, teaching master's and undergraduate-level Design Studios and co-teaching How to Make (Almost) Anything at MIT's Media Lab.

KENNETH TRACY teaches architectural design at the American University of Sharjah, United Arab Emirates, where he is an Assistant Professor of Architecture. Kenneth has taught at the Pratt Institute, Columbia University, the New Jersey Institute of Technology, and Washington University, where he established the Digital Initiative Fabrication Research Lab in 2009. He holds a master's degree in Architecture from Columbia University and a bachelor's degree in Design from the University of Florida. In 2005, he co-founded Associated Fabrication, a digital fabrication shop in Brooklyn, New York. Currently, Kenneth co-directs Yogiaman Tracy Design, whose research includes designs, lectures and writing related to digital techniques and culturally resonant craft practices.

WILLIAM TROSSELL graduated from the Bartlett School of Architecture, University College London, in 2009. Since completing a master's degree in Architecture, he has created structures, sculptures and events that draw on an extensive understanding of digital fabrication. Will is co-founder of ScanLAB Projects and tutor at the Bartlett School of Architecture.

ERIK VERBOON is an Associate with Buro Happold New York, drawing upon more than seven years' experience developing computational solutions to advance the Buro's Complex Building Envelope Design practice. His research areas include parametric modelling, object-oriented methodologies, performance- and algorithmic-driven design, environmental and thermal analysis, and rapid prototyping (3D printing). Erik collaborated on the winning entry to the 2007 PS1 Young Architects Program. He has also presented at numerous academic institutions and professional conferences and published in accompanying journals and books. A graduate of the Stevens Institute of Technology's Product Architecture Lab in Hoboken, NJ, he teaches courses there in environmental analysis and design.

ANDREW VRANA is a Principal Architect at Metalab, based in Houston, which integrates expertise in digital media and fabrication with architecture, product development and civic art, from concept through construction. Recent projects include collaborations with artists for turnkey designs and CMservices, including development, optimisation and installation of large-scale civic art. Metalab's product design work has successfully incubated and launched several businesses and product lines through its partnerships. As Assistant Professor at the University of Houston's College of Architecture, Andrew has co-taught the Digital Fabrication seminar since 2005, which has realised numerous award-winning and published works.

ALLISON WEILER is currently working as a Teaching and Research Associate at the Institute for Experimental Architecture, Hochbau at the University of Innsbruck. She also works with LAAC Architekten/Austria in the realm of sustainable Alpine infrastructure development, as well as collaborating with [uto]. She graduated with honours from the University of Pennsylvania, and holds a master's degree in Architecture. Her current research focuses on the development of novel interface and material processes, and she is currently pursuing this work with the REX|LAB, an experimental architectural robotics lab based in Innsbruck.

CHRISTINE YOGIAMAN is an Assistant Professor at the American University of Sharjah in the United Arab Emirates, where she teaches architectural design. Integrating digital technologies into all levels of architecture design education, Christine has coordinated the Graduate Core Studio sequence in conjunction with her development of a digital curriculum in Washington University in St Louis. She directs Yogiaman Tracy Design, whose current projects in Indonesia focus on the utilisation of digital techniques along with contextual influences to create culturally embedded, affective work. She received third place for the 2012 Steedman Fellowship in International Design, and has won the 2012 TEX-FAB APPLIED: Research through Fabrication competition.

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