MAS ETH in Architecture and Digital Fabrication
Academic year 2015-2016

National Centre of Competence in Research Digital Fabrication
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Digital Fabrication

www.dfab.ch

MAS Programme Organisation
Prof. Fabio Gramazio, Prof. Matthias Kohler (Delegate Professors)
Philipp Eversmann (MAS Lead, NCCR Head of Education)
Luka Piskorec (MAS Scientific Research Assistant)

Affiliated NCCR Research Groups
BLOCK Research Group, Prof. Dr. Philippe Block
Agile and Dexterous Robotics Lab, Prof. Dr. Jonas Buchli
Institute for Dynamic Systems and Control, Prof. Dr. Raffaello D’Andrea
Institute for Building Materials, Prof. Dr. Robert J. Flatt
Chair of Sustainable Construction, Prof. Dr. Guillaume Habert
Chair of Architecture and Building Process, Prof. Sacha Menz
Automatic Control Laboratory, Prof. Dr. Manfred Morari, Prof. Dr. Roy Smith
Computer Graphics and Geometry Laboratory, Prof. Dr. Mark Pauly
Laboratory for Timber Constructions IBOIS, Prof. Dr. Yves Weinand
Digital fabrication promises to revolutionise architecture. The seamless combination of digital technologies with physical construction processes will pave the way for the realisation of radically new designs.
The new Master of Advanced Studies ETH in Architecture and Digital Fabrication is positioned within the Architecture Department (D-ARCH) of ETH Zurich. The MAS is the educational platform of the National Centre for Competence in Research (NCCR) Digital Fabrication. This large multidisciplinary research initiative provides an excellent environment for learning digital fabrication. Joint events and research laboratories allow students in the MAS programme to exchange and interact with NCCR researchers and principal investigators.

**Topics**

The MAS ETH in Architecture and Digital Fabrication will teach methods and technologies relating to digital design and fabrication and their implementation in architecture and construction. Projects and assignments will enable students to develop design concepts and realise large-scale prototypes using the NCCR Digital Fabrication’s unique robotic construction facilities. Courses will describe and exemplify how new technologies, materials and processes contribute to an advanced and sustainable construction culture.

**Professional perspectives**

Participants will develop strong competences in digital design and fabrication, enabling them to take leading positions in the field of architecture, construction, innovation development and production management. Knowledge of and experience with advanced fabrication equipment, as well as innovative design technologies, will position participants as cutting-edge practitioners in the field. The MAS programme will facilitate regular interactions with representatives from industry and practice, providing participants with insight and access to a network that will prepare them for practice or further studies in advanced research programmes.
Who we are

The MAS ETH in Architecture and Digital Fabrication is organised by the Gramazio Kohler Research group at ETH Zurich. Philipp Eversmann, the NCCR Digital Fabrication’s Head of Education, and Luka Piškorec, MAS Scientific Research Assistant, will conduct the MAS programme.

Fabio Gramazio and Matthias Kohler are architects with multi-disciplinary interests ranging from computational design and robotic control and fabrication to material innovation. In 2000, they founded the architecture practice Gramazio Kohler Architects, where numerous award-winning designs have been realised. Their built works include international exhibitions, private and public buildings, and large-scale urban interventions. As professors, Gramazio and Kohler developed the first architectural robotic laboratory at ETH Zurich. The ensuing research has been highly influential in the field of digital architecture, setting precedence and initiating a new research field focusing on the integration of industrial robots in architectural design and construction. They have contributed to numerous exhibitions around the world, such as the 2008 Architectural Biennial in Venice, the Storefront Gallery for Art and Architecture in New York in 2009 and Flight Assembled Architecture at the FRAC Centre Orléans in 2011. Their work has been widely published and is comprehensively documented in their recent publication “The Robotic Touch – How Robots Change Architecture”.

Philipp Eversmann is an architect with broad interdisciplinary experience and a professional focus on digital technologies and their implementation in practice. Professionally he has been involved in the design, development and construction of large-scale projects in Germany, the United States and France, most notably the “La Canopée” renovation of Forum les Halles (Patrick Berger & Jacques Anziutti) and the new Ministry of Defence (Nicolas Michelin & Associés) in Paris. In his independent practice he has explored digital design principles in a range of different projects, competitions and small scale pavilions. He has held visiting professorships at the EPF Lausanne and Technical University Munich and has been a lecturer at the Ecole Spéciale d’Architecture in Paris.

Luka Piškorec studied architecture at the University of Zagreb in Croatia and worked in architectural offices in Croatia and Switzerland. He continued his studies at the ETH in Zurich and received his Master of Science in Architecture (MSc ETH Arch) in 2011. From 2011 to 2014, he has been research assistant for the Gramazio Kohler Research Group, running the chair’s elective course and elective thesis workshop.

Exchange with cutting-edge research

The programme’s content and teaching have been developed as an integral part of the NCCR. It will be taught by leveraging the centre’s experts, research innovations and broader potential for external networking.

The NCCR Digital Fabrication is a research initiative of the Swiss National Science Foundation (SNSF) which, together with ETH Zurich, has supported this partnership designed to research how architecture and construction can be advanced. Well-known researchers in the fields of architecture, engineering, materials science, computer science and robotics from leading Swiss research institutions have come together to work within the NCCR Digital Fabrication. The goal is to develop new methods of design and construction that can give rise to ground-breaking technological solutions, thereby fostering advances in Swiss building culture. Overall, the NCCR Digital Fabrication will be home to a community of over 70 MAS, PhD, post-doctoral and professorial researchers. The centre will use its leading position to engage public, private and industrial partners in the advancement of digital fabrication and the development of innovative architectural building processes.
Performance
How can we evaluate a spatial configuration and how can we integrate the information into a digital model? Concepts and tools for the analysis of parameters such as light, acoustics and material properties will be investigated. When integrated into a parametrical model, the extracted information can function as design-driving criteria.

Collaboration
Digital design and fabrication provides a common platform and set of data for projects while also generating new issues that can be jointly examined by larger teams. At the same time, the interaction of and borders between conception, engineering and fabrication become blurred and must constantly be redefined. This MAS module will address new collaborative design strategies, both for the execution and management of projects.

MATERIAL AND CONSTRUCTIVE SYSTEMS

Material processing
The relationship between basic materials, material production and advanced material processing are vital to the creation of material-informed design processes. Through a deeper understanding of material capacities, synergies between multiple materials can be created. Material performance will thus be analysed through the extraction of material data.

Structures
Digital simulation tools are becoming increasingly accurate and useful in the development and analysis of design. Real-time physics simulation enables accurate predictions of how materials and assemblies will respond to loads and assembly behaviours. Through the exploration of these technologies and the underlying science and engineering, physical simulation will be used in the development of processes and projects. At the same time, structural principles and assembly systems will be inves-
tigated with specific emphasis on additive processes. Structural systems will be developed from a multitude of components, with a focus on employing specific material capacities to gain overall strength.

**Envelopes**
As the main interface between exterior and interior conditions and requirements, the building envelope has to fulfil a complex set of communicative parameters, both physical and visual. Materials and components interact, forming a highly adapted skin. Basic knowledge of building physics, climatology and sustainability gives rise to integral concepts for building envelopes.

**DIGITAL CONTROL AND FABRICATION**

**Robotic fabrication**
Industrial robots will be used as the principal teaching platform and will therefore be the key to understanding the relevant technologies and how they work. Unlike a manual fabrication process, an extremely precise sequence has to be defined for each step of the fabrication and assembly processes, and for controlling tools, movements and the factors that ensure the stability of each step needed to create the structure. Most of this information can be included in a parametric model, such as the sequence and elements needed for forming a brick wall.

**Tooling**
Innovative construction techniques require advanced tools. Robotic end-effectors are the tools that enable robots to build the design; the production and refinement of tools and end-effectors are therefore fundamental steps in integrating robotics in processes and assembly. Development can be accelerated thanks to digital modelling and rapid-prototyping techniques, since they allow prototypes to be created and tested quickly. These new opportunities expand the role of the designer into that of a toolmaker, and the tools developed free the architect to use standard robotics in new and innovative ways. Tool development will be taught concurrently with construction processes and material research. These three topics reinforce each other, providing a foundation for the understanding of physical processes in digital fabrication.

**Sensing and control**
Industrial robotic arms can position building material very precisely at a desired location and with a given orientation. Robotic control techniques must therefore be developed that allow a robotic arm to steadily manipulate building materials to specific target points. This predetermined approach has clear limits, however, as it cannot account for uncertainties in the assembly process. It is therefore necessary to implement adaptive (and robust) control strategies that use information gained during the material build-up. Separate components for measuring, control, trajectory generation and fault handling can interact in real-time during the assembly, ensuring the structure's integrity. Participants will therefore become familiar with robot interfaces, different programming languages and possible man-machine interaction techniques.
The MAS in Architecture and Digital Fabrication provides 60 credit points according to the European Credit Transfer and Accumulation System (ECTS), a standard for comparing university studies within Europe. This corresponds to one academic year or 1,500–1,800 hours of study. The credit points are attributed as follows:

**Teaching modules (20 ECTS)**
- Computational Design Processes
- Material and Constructive Systems
- Digital Control and Fabrication

**Design-studio modules (20 ECTS)**
- Design Project I and II

**Master's thesis module (15 ECTS)**
- Master’s Thesis

**Theory lecture series (5 ECTS)**
- Analysis of underlying theories and paradigms of digital fabrication and its wider implications, including historical contextualisation and contemporary discourse.
Activities

MAS / PhD workshops
Joint workshops with MAS and PhD students will be organised twice a year. Each workshop will focus on a topic or theme related to digital fabrication in architecture, and will be supported by external specialists from industry and by leading practitioners. These workshops will foster exchange between individuals whose interests range from pragmatic and technological approaches to more conceptual or intellectually driven investigations. The goal is to engage a wider audience of experienced participants and thereby encourage the mutual learning of skills and the development of knowledge across a range of diverse participants.

PhD mentoring
MAS participants will be supported by the broader community of NCCR researchers throughout the course of study. Doctoral researchers working within the NCCR Digital Fabrication bring a wide range of expertise and interdisciplinary knowledge to the programme and will be highly valuable for MAS students. When complimentary topics or interests are identified, PhD researchers may take on a mentoring role for MAS students or projects. Such an exchange is intended to be mutually beneficial, with MAS students helping with research and the doctoral students supporting the advancement of MAS learning and skills development.

Lecture series and symposium
A series of regular lectures featuring leaders from practice, industry and research will provide important external input and a forum for discussion within the MAS, but also for the broader NCCR research community. In addition to the regular lecture series, a larger NCCR symposium will be organised once a year to bring experts together for discourse and exchange on topics pertinent to digital fabrication in architecture.

NCCR excursions and events
Investigative excursions will be organised to visit architectural and industrial sites and external institutes. These events will be a fundamental part of the curriculum and are designed to broaden participants’ experience, inform their course work and provide opportunities for networking and collaboration.

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The MAS Digital Fabrication has access to a diverse range of study- and fabrication-related resources.

NCCR Digital Fabrication facilities
As part of the NCCR Digital Fabrication, participants in the MAS programme will have access to many of the facilities and much of the equipment assembled by the research institute. The NCCR has a wide range of industrial and prototypical robots at its disposal, thereby offering immediate and regular access to equipment and the opportunity to rapidly prototype experiments at scale before moving on to the full-scale production facilities.

A new Robotic Fabrication Lab (RFL) is currently in construction at the ETH. This very large fabrication hall will feature one of the world’s largest and most versatile construction robots. The result will be a unique environment that allows for leading international research in the field of robotic fabrication in architecture and construction. It is as an integral part of the new Institute of Technology in Architecture (ITA) building, located on the Science City Campus of the ETH Zurich.

ETH Zurich RAPLAB
The ETH RAPLAB is the basic fabrication facility of the Department of Architecture (DARCH). It houses laser cutters, a Zund cutting plotter, a vacuum former, a 3-axis CNC mill, cement and wood workshops, and access to professional specialists. The facilities and equipment are available to all ETH Architecture students, including participants in the MAS Architecture and Digital Fabrication programme.
Requirements

Target group
The MAS Architecture and Digital Fabrication programme is designed for university graduates from Switzerland and abroad. The MAS will accept qualified applicants who are specifically interested in improving their skills and gaining experience in the areas of advanced digital design methods, digital fabrication and the application of robotics within construction and architecture.

Requirements
A master’s degree in architecture or engineering recognised by ETH, or an equivalent educational qualification (i.e. a bachelor’s degree and a minimum of two years of professional experience in a directly related field) is required. Also required are proof of creative design skills and technological capabilities. Documents submitted with the application and a portfolio review will be used to assess a candidate’s qualification.

Language
All instruction will occur in English. All applicants are expected to be highly proficient in English (spoken, written and reading). Interviews may be requested to evaluate a candidate’s language abilities.

Tuition fees
Tuition for the course is CHF 12,000. Fees and administrative costs are CHF 1,160 for two semesters. The total for the programme is CHF 13,160.

Accreditation
Students who successfully complete the programme receive their Master of Advanced Studies ETH in Architecture and Digital Fabrication (MAS ETH DFAB). A diploma supplement is issued together with the MAS certificate according to the guidelines laid out by the Rector Conference of Swiss Universities.
Application

The Centre for Continuing Education is responsible for all applications for admission to MAS programmes.

The application process consists of two steps:
1. Submit your application via the online platform Eapply (www.lehrbetrieb.ethz.ch/eApply) and pay the application and handling fee using your credit card.
2. After submitting your application online, print the confirmation and send a signed copy by post together with all required supporting documents to the Centre for Continuing Education. The portfolio, letter describing why you would like to participate and letters of recommendation should be sent separately to admission@dfab.ch.

Candidates will be informed of their acceptance by mid-May. In case of acceptance, the candidate has 30 days to provide a final response.

Deadlines for submitting documents
The application deadline for the MAS ETH in Architecture and Digital Fabrication is 30 April 2015. This deadline applies to the printed application and the required documents as well as the online application. The documents must have been sent by the deadline (the date on the postmark) and must have reached the Centre for Continuing Education eight days thereafter.

Portfolio requirements
The portfolio should feature three projects which you feel demonstrate your design capabilities as well as your technical knowledge. Layout quality will also be evaluated and should emphasise images and design diagrams. The portfolio is to be sent in PDF format and should not exceed 10MB. Please include a letter explaining why you would like to participate in the programme and three letters of recommendation.

Late applications
Late applications may be considered if places are still available. The programme accepts a maximum of 18 students per year.

Scholarships
ETH Zurich offers various scholarships. For more information please contact the ETH Scholarship Office or the Geisendorf Foundation for Architecture.
Links

MAS Programme:
www.dfab.ch/mas

Online Application:
deadline: 30.4.2015

Housing Office of University and ETH Zurich

Arriving in Switzerland for international students:

Information on general living cost in Switzerland:

Scholarships
ETH Scholarship Office

Geisendorf Foundation for Architecture
www.geisendorf.org
Contact

For questions concerning the application, please contact:

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The MAS administration reserves the right to change any content stated in this document without further notice.

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