ITECH

Integrative Technologies & Architectural Design Research

M.Sc. Programme, Faculty of Architecture and Urban Planning, University of Stuttgart

2020/21

ICD Institute for Computational Design and Construction

itke Institute for Building Structures and Structural Design

University of Stuttgart

Coordinating Institutes:
ICD- Institute for Computational Design and Construction
Prof. AA Dipl.(Hons.) Arch. Achim Menges

ITKE- Institute of Building Structures and Structural Design
Prof. Dr.-Ing. Jan Knippers

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INTRODUCTION

IMAGE ON COVER: ICD/ITKE Research Demonstrator 2018-19, 2019. © ICD/ITKE University of Stuttgart.

IMAGE: ICD/ITKE Research Pavilion 2016/2017, 2017. © ICD/ITKE University of Stuttgart.

AGENDA - Why ITECH?

The Integrative Technologies & Architectural Design Research M.Sc. Programme is an interdisciplinary, research-oriented, experiment-based programme shaped around contemporary aspects of the built environment and practice.
The goal of the ITECH programme is to prepare a new generation of students from different disciplines for the continuing advancement of technological and computational processes in development of the built environment through merging the fields of design, engineering, construction and natural sciences. Combining an intensive, critical and analytical approach to computational design, simulation and fabrication processes, the ITECH programme is focusing on challenging the design space boundaries of current contemporary architectural and engineering practice. It seeks to provoke a re-examination of techniques, methods and theories of design in relation to the fields of engineering, robotics, digital manufacturing, material science and biology.

The programme is open to students with a recognized bachelor's degree in architecture (or architectural science), civil / structural engineering, urban planning, biology or biomimetics, environmental engineering or similar engineering or natural science degrees.

All programme courses are instructed in English. The modules of the core ITECH programme are taught by researchers at ICD and ITKE with oversight of Professor Menges and Professor Knippers and input from visiting researchers and scientists.
The programme is structured as a 2 year professional master's degree for students with a 3 year bachelor's degree. However, students with a suitable 4 years bachelor's degree or students who already hold a master's degree may apply for advanced standing after enrolment– subject to the review by the university. Such applicants will be considered for placement in the third semester of the programme.

IMAGE: ICD/ITKE Research Pavilion 2013/14, 2014.

AGENDA - Why ITECH?

Technological progress has always been a catalyst for design innovation in architecture and construction. Today, technological advancements across multiple disciplines suggest a profound transformation of the way the future built environment is conceived, designed and materialized. New alliances are being forged between the fields of design, engineering and natural sciences, leading to novel interdisciplinary and multifaceted design cultures. Design plays a critical role in this transformation: Here, the notion of design is extended beyond the design of space, surface and structure to the design of processes, systems and reciprocities.

The ITECH programme investigates the realm of integrative technological advancements as novel potentials in architecture and construction. It seeks to prepare students for the complex contemporary conditions found in the building industry, which is facing stringent environmental and economic challenges while experiencing the emergence of new technical opportunities at an unprecedented speed. Thus, the master's programme is inquiry-oriented, experiment-based and shaped around contemporary aspects of design research. Students will engage in cutting-edge computational architectural design techniques, structural and climate engineering and advanced fabrication and construction technologies. The interrelation of such topics will be exposed both as a technical and an intellectual venture.

The programme offers the opportunity to study with one of the leading teams for technological and computational design research. As a team, the partner institutes strive to present students with a cutting-edge educational experience that fosters the development of one's individual interests in architectural design, structures, technology and computation.

If you are an architect, engineer, materials scientist, biologist, or other with a deep interest in how the design and fabrication of our built environment will develop alongside increasingly powerful computation and fabrication technology, the ITECH M.Sc. Programme is for you. The course considers how known and experimental computational systems, materials and fabrication techniques might be applied within the context of architecture and the wider AEC (architecture, engineering, construction) industry. The programme seeks to foster collaboration between students, researchers and industry professionals from multiple compatible fields within this area.

IMAGE: ICD/ITKE Research Pavilion 2014/15, 2015.

TEAM

The M.Sc. Programme Integrative Technologies & Architectural Design Research is coordinated by ICD (Institute for Computational Design and Construction) and ITKE (Institute of Building Structures and Structural Design) in collaboration with IBK2 (Institute of Building Structures).

ICD - The Institute for Computational Design and Construction provides expertise in advanced computational design processes and the integral use of computer-controlled manufacturing processes with a particular focus on robotic fabrication. Prof. Achim Menges, director of the ICD, is internationally renowned for his design work and research with visiting professorships at both Harvard University and the Architectural Association. He is author of numerous books and scientific papers and his design research and projects have received multiple international awards, been exhibited worldwide and form parts of several renowned museum collections. The ICD's researchers have studied in world renowned schools of architecture and/or have worked for leading architectural practices around the globe.

http://icd.uni-stuttgart.de (link)

ITKE - The Institute of Building Structures and Structural Design focuses on the development of building structures as an essential and form-giving aspect of architecture and considers how to extend the boundaries of engineering design and material science towards new and non-standard applications in the field of architecture. Prof. Jan Knippers, director of the ITKE, is the author of numerous books and publications in the fields of engineering, architecture and biomimetics, co-founded an international engineering firm and is collaborating with renowned architects from around the globe. The multidisciplinary team of ITKE research associates bring together competencies from a wide range of fields focused on advanced building technologies.

http://www.itke.uni-stuttgart.de (link)

IBK2 - Institute of Building Technology, Construction and Design stands for an approach towards sustainable design and the use of new materials and methods in construction. The integration of diverging aspects of technical, ecological, economical and aesthetic nature communicates the holistic design approach of the IBK2 team.

http://www.uni-stuttgart.de/ibk2 (link)

The interdisciplinary and research-oriented character of the ITECH programme has been developed to provide students with the opportunity to take full benefit of the larger international network of interdisciplinary research and expertise available through the partner institutes, the university and its related external industry collaborators. The programme has the unique advantage of being situated within the heartland of technological innovation in Germany. The ITECH programme is aimed at furthering long-standing relationships with industry networks that the institutes have already established.

Stuttgart University is recognized internationally for education and research in technology and garners significant research funds in a vast array of fields. The Faculty of Architecture consistently ranks among the top schools in Germany, and is supported by extensive research through both private industry and publicly funded projects. The University of Stuttgart is also renowned for creatively engaging the rigour and insights of engineering science in architectural design. High level of research exposure is reflected directly in the quality of the school's faculty and curriculum.

CONTENT

The programme is structured in two parts: the group Design Research Project (first year, see p. 10) and an individual Master Thesis (second year, see p. 11). Both projects take advantage of the extensive collaboration among the partner institutes and are supported by a diverse range of seminar modules and expert colloquia, offered by the three institutes.
The seminar modules provide the technical and conceptual foundation necessary for the successful development of research projects while allowing students to explore individual areas of interest.

The main fields of investigation for the Design Research and Master Thesis Projects include:

- Morphogenetic computational design processes
- Bottom-up design and engineering of material systems and hybrid structures
- Investigation of novel production paradigms enabled by robotics and generative manufacturing
- Integration of biomimetic strategies for the design and engineering of performance-oriented architectural morphology and ecologically embedded architectural physiology
- Exploration of novel architectural tectonics and related performance capacities
- Integrative testing through full-scale prototypes and mock-ups

IMAGE: ICD/ITKE Research Pavilion 2013/14, 2014.

PROGRAMME STRUCTURE

Requirements
The ITECH programme is a 2 year Master of Science programme for students who hold a 3 year bachelor's degree (minimum) in one of the following fields:

- architecture

- civil / structural engineering

- biology or bionics

- urban planning

- environmental engineering

- similar engineering or natural science degrees

Advanced Standing
Students who hold a suitable 4 year bachelor's degree or a master's degree may apply for advanced standing after enrolment. Such applicants will be considered for placement in the third semester of the programme (see details: p. 14).

Language
All programme courses are fully instructed and evaluated in English.

Tuition and Fees
All ITECH M.Sc. Students are required to pay a semester fee, which is currently EUR 180. From the winter semester 2017/18 onwards, higher education institutions in Baden-Württemberg will be charging tuition fees for international students and for students taking up a second study programme. International students who are not citizens of an EU/EEA country and who are taking up a consecutive study programme, are required to pay tuition fees of EUR 1,500.00 per semester in addition to the general semester fees of the University of Stuttgart. here are no tuition fees for German and EU citizens attending the ITECH programme at the University of Stuttgart. For more information, please visit the tuition overview on the website of the University of Stuttgart.

Degree
The programme leads to an internationally accredited master's degree and is offered as a two-year full time programme (equivalent to 120 ECTS). For students with a bachelor's degree in architecture, the completion of the full two year M.Sc. programme (120 ECTS) provides an internationally accredited degree in architecture.

What are ECTS?
European Credit Transfer and Accumulation System (ECTS) is a European standard for comparing study attainment credits. One academic year requires 60 ECTS credits, which is equivalent to 1800 hours of study. One ECTS credit is equivalent to 30 hours of study.

IMAGE: ICD/ITKE Research Pavilion 2015/16, 2016.
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CURRICULUM

The curriculum is based on the German semester system: the winter semester typically takes place between mid-October and mid-February with a two week Christmas break, while the summer semester takes place between mid-April and mid-July. It is important to note that this is a full-time programme and course work and studio submissions may also take place outside the semester times. The intensive learning and research environment coupled with the fabrication and prototyping nature of the programme requires a full-time commitment.

Vacation Period
There are four holiday periods throughout the academic year: 2 weeks at Christmas, 3 weeks in the winter semester, 1 week at Pentecost and 3 weeks in the summer semester.

IMAGE: ICD/ITKE Research Pavilion 2012, 2012.

CURRICULUM

First Year

During this first year, the curriculum is led by two design research rrojects that are developed as a collaborative undertaking between the involved institutes. The two Design Research Studios operate consecutively and culminate with the development of a full scale research architectural prototype. During this year, the students work collectively in studio under the close supervision of tutors and supervisors. The introduction to relevant topics in computational design, engineering and construction is provided through two supplementary seminar modules (6 ECTS, each) per semester. In addition, a series of regular colloquia (3 ECTS) will expose the students to presentations in cutting edge research by leading experts in the related fields. Both, seminar modules and expert colloquium are structured to provide relevant support for the research project development.

Within the winter semester Design Research Project the focus will be on investigating biological structures and abstracting studied principles into an architectural system. Based on initial studies of the performative morphologies of natural structures, new material-based fabrication concepts and their resulting morphospaces will be explored. By the end of the semester, students are expected to produce a series of biomimetically-informed fabrication concepts with proposals for their application as architectural systems. The most promising concepts developed during the design studio will be the starting point for the development and fabrication of the Design Research Project within the summer semester.

This explorative and comparative process will be supplemented by the closely related seminar 'Architectural Biomimetics', which will enable students to investigate related biologic role models in interdisciplinary teams.

In the summer semester, students will work as a group on the Design Research Project. Throughout the semester students develop the project starting with conceptual system development up to fabrication and construction of the design research project.

IMAGE: ICD/ITKE Research Pavilion 2010, 2010.

CURRICULUM

Second Year

The third and fourth semesters of the programme are designated for the preparation and development of the master's thesis dissertation. The third semester is aimed at laying the foundation for a promising master's thesis through a Thesis Preparation Project (15 ECTS) supported by an integrated Master Thesis Preparation Seminar (3 ECTS) and two supplementary Seminar modules (6 ECTS each).

The thesis preparation project engages the students in the selection and development of a suitable master's thesis research proposal. The entire fourth semester is dedicated to the development of the master's thesis.

Thesis research topics can be developed from a wide range of starting points within the context of Integrative Technologies and Architectural Design Research. Each year a number of specialized topics and research areas are offered by the participating institutes, which are directly related to the topics being developed by the institutes at the time (for further details please visit ICD, ITKE). Additionally, students are also encouraged and supported in the development of their own research interest.

Students are responsible for conceptualizing, framing and developing their own thesis topic under the supervision of the tutors and supervisors. For more information on possible areas of research focus or examples of past thesis projects, please visit the institute´s websites.

IMAGE: ICD/ITKE Research Pavilion 2011, 2011.

CURRICULUM

Given the interdisciplinary and research-based nature of the programme, each student must select a supervising professor (ICD or ITKE), two suitable tutors and any additional supporting resources that may be required (technical equipment, additional supervisors, etc). To better address different research directions, there are currently three thesis track options possible:

A Semester 3+4: Research Thesis
Track A is aimed at engaging research through a scientific and highly methodological approach. Students may expand on current methods, systems, and methodologies, or it may form the basis for the development of a new functional principle. This option offers the ability to engage a research interest over two semesters. Track A concludes with a comprehensive research document.

B Semester 3+4: Design Research Thesis
Track B is aimed at engaging an architectural system or processes by expanding both its technical development as well as its design space. Track B concludes with a spatial or structural design study or application enabled by the research subject (material system/ fabrication process/etc…) and a related research document.

C Semester 3+4: Design Studio and Research Extension of Design Studio
Track C incorporates a design studio in ITECH / Faculty of Architecture / exchange semester, etc. in semester 3 and a research extension as a short version of (A) or (B). The ITECH design studios are offered directly by the corresponding institutes and their specific focus is in line with the institutes particular research interest.

Exchange semesters of external design studios

Exchange semesters of external design studios are a great opportunity to gain additional technical experience or expertise that may contribute to the development of the master's thesis. In order to ensure that these external options are feasible within the programme and pertain to the overall goal of the thesis, students must obtain prior approval from the examination committee.

Note: Students that obtained credits through advanced standing can only take the ITECH design studios – exchange semester or external studios are not possible.

IMAGE: ICD/ITKE Research Pavilion 2012, 2012.
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RESOURCES

In addition to the centrally located studio space in the downtown campus, the ITECH programme offers access to both the specialized resources of the partner institutes, as well as the extensive resources of the Faculty of Architecture and the University of Stuttgart as a whole. These resources include:

- Robotic Laboratory (RoboLab, 6-axis KUKA KR 125/2 industrial robot and a vertical turn table as the 7th external-axis)

- Material Testing Laboratory (various testing facilities for static and dynamic loading up to 400kN)

- Model Workshop (three laser cutters, one cutting plotter and two 3-axis CNC milling machines)

- Computer Laboratory (Casino IT, Faculty of Architecture computer laboratory, 3D printer and plot service)

- Wood Workshop, Metal Workshop

- Photography Studio

These primary resources are available to all students in the ITECH programme after passing a formal instruction by the workshop manager. Additional access to workspaces of other institutes and external bodies has also been arranged during the course of previous ITECH projects. Access to additional equipment or workspaces is dependent on project details and availability in any given year.

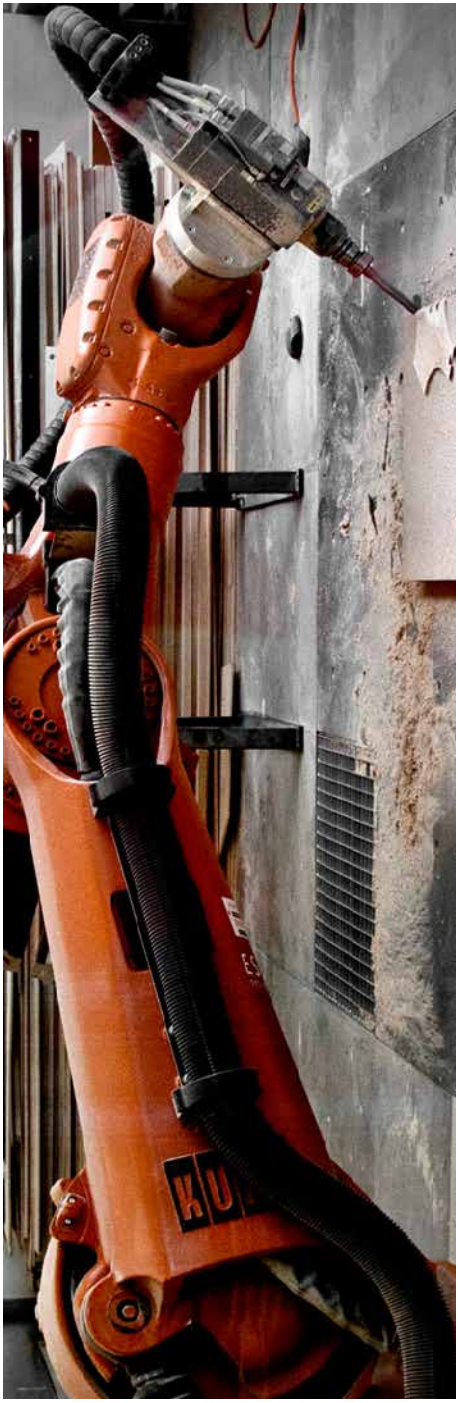

IMAGE: RoboLAB, University of Stuttgart, 2011.

ADVANCED STANDING

All applicants will initially be offered acceptance to the first semester and are highly encouraged to pursue the full two-year programme.

Students who have completed at least a 4 year bachelor's or master's programme (equivalent to a minimum of 240 ECTS) are eligible to apply for advanced standing based on their ability to provide proof of equivalent credits of up to 60 ECTS . These credits must be from courses that are part of their previous education, and equivalent to modules offered as part of the first year curriculum of the ITECH programme.

Please note, that advanced standing applicants might receive advanced standing on some or none of the course credits based on the committee's assessment. Equivalent credits must be analogous to the course of study of the first year of the ITECH programme curriculum and must also demonstrate high level of academic performance and design proficiency.

Please note: Due to the professionally accredited status of the programme, all international applicant's degrees will undergo an equivalence check to confirm eligibility within the German academic system.

Students holding degree qualifications that differ from the list provided above (p. 8) will be assessed on an individual basis.

IMAGE: ICD/ITKE Research Pavilion 2015/16, 2016.

ITECH MODULES

Project/Design Studio Modules

25990 Integrative Technologies and Architectural Design Research Project 1

26020 Integrative Technologies and Architectural Design Research Project 2

Master Thesis Preparation Modules

49760 Integrative Technologies and Architectural Design Research- Thesis Preparation Project

49870 Thesis Preparation- Seminar Module

Seminar Modules

49770 Computational Design

49780 Computational Design and Digital Fabrication

49790 Form and Structure

49800 Material and Structure

49810 Building Systems

49820 Building Envelopes

49830 Computational Design and Simulation

49840 Architectural Biomimetics

Colloquia Modules

49850 Expert Colloquium 1

49860 Expert Colloquium 2

Master Thesis Module

40970 Master's Thesis Integrative Technologies and Architectural Design Research

Subject to the prior approval of the ITECH examination committee, students can take courses up to 30 ECTS from other M.Sc. programmes of the University of Stuttgart (for example COMMAS, see website).

IMAGE: ICD/ITKE Research Pavilion 2011, 2011.
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1st YEAR

1st semester

PROJECT MODULES

Integrative Technologies and Architectural Design Research Project 1
15 ECTS

SEMINAR MODULES

Seminar Module
6 ECTS

Seminar Module
6 ECTS

COLLOQUIA MODULES

Expert Colloquium 1
3 ECTS

30 ECTS

2nd semester

PROJECT MODULES

Integrative Technologies and Architectural Design Research Project 2
15 ECTS

SEMINAR MODULES

Seminar Module
6 ECTS

Seminar Module
6 ECTS

COLLOQUIA MODULES

Expert Colloquium 2
3 ECTS

30 ECTS

60 ECTS

Advanced Placement

2nd YEAR

3rd semester

PROJECT MODULES

Integrative Technologies and Architectural Design Research Thesis Preparation Project
15 ECTS

SEMINAR MODULES

Seminar Module
6 ECTS

Seminar Module
6 ECTS

COLLOQUIA MODULES

Thesis Prep. Seminar
3 ECTS

30 ECTS

4th semester

PROJECT MODULES

Integrative Technologies and Architectural Design Research

Master Thesis

30 ECTS

30 ECTS

60 ECTS

120 ECTS

ITECH MODULES

Integrative Technologies and Architectural Design Research Project 1

Module 25990 (15 ECTS)
Term: Winter

Biological structures in nature are characterized by highly differentiated geometries with local variation of material properties. These performative morphologies are able to negotiate between multiple, potentially even contrary fitness criteria through their material organization strategies. Such structures are thereby able to achieve a higher level of functional integration than current technical approaches to architectural fabrication. Recent developments in computational design methods, material science and fabrication techniques open up new possibilities to transfer functional principles of these natural systems into architectural applications.

Students will investigate computational design strategies and fabrication techniques for natural structures in order to identify potential future trajectories while positioning analysed precedents within the larger disciplinary context.

Based on these initial studies new material-based fabrication concepts and resulting morphospaces will be explored. This explorative and comparative process will be supplemented by the the closely related seminars Architectural Biomimetics, Computational Design Techniques and Design Thinking, and Form and Structure, which will enable students to investigate related biologic role models in interdisciplinary teams as well as developing suitable computational design tools for this process. The outcome of these investigations will be an overview of the topic in the context of the discipline and a series of biomimetically informed fabrication concepts and proposals for their application as proto architectural systems. The most promising concept developed during the design studio will be the starting point for the development and fabrication of the Design Research Project within the summer term.

Menges, A. 2012. Material Computation – Higher Integration in Morphogenetic Design. Architectural Design, Vol. 82 No. 2.

Menges, A. 2012. "Morphospaces of Robotic Fabrication – From theoretical morphology to design computation and digital fabrication in architecture". In Proceedings of the RobArch Conference 2012, edited by S. Brell-Çokcan, J. Braumann, Vienna, 28-47.

La Magna, R., Gabler, M., Reichert, S., Schwinn, T., Waimer, F., Menges, A. and Knippers, J. 2013. "From Nature to Fabrication: Biomimetic Design Principles for the Production of Complex Spatial Structures". International Journal of Spatial Structures 28(1): 27- 40.

IMAGE: Landesgartenschau Exhibition Hall, 2014.

Integrative Technologies and Architectural Design Research Project 2

Module 26020 (15 ECTS)
Term: Summer

Following the Integrative Technologies and Architectural Design Research Project 1 and Architectural Biomimetics Seminar, the focus of this studio is the design development and fabrication of a biomimetic design research project, which will be constructed on the university campus. The seminar offers the opportunity to apply computer-based design, planning, simulation and production methods in an integrated design process on a full scale architectural project. The students will develop experience on all phases of project development, from computational design, planning application, structural design through to digital fabrication and assembly on site.

The design of the research project will be based on design principles that have been derived from the investigation of biological role models in the context of the Architectural Biomimetics seminar course in the previous semester. Particular attention will be directed on the examination of construction and material distribution principles as well as on geometrical formulation as found in the biological role models and on the potentials to transfer those principles into technical applications for large-scale architectural applications. To generate a coherent system from the fundamental biomimetic research to fabrication, the integration of the technical production parameters in an automated robotic manufacturing process represents a further core focus for the studio.

A team of students with support from the academic staff will develop a computational design system, which incorporates material, fabrication, structural and design constraints. In parallel, the students will participate in the co-requisite research seminar Computational Design and Digital Fabrication, to get an advanced understanding of robotic fabrication.

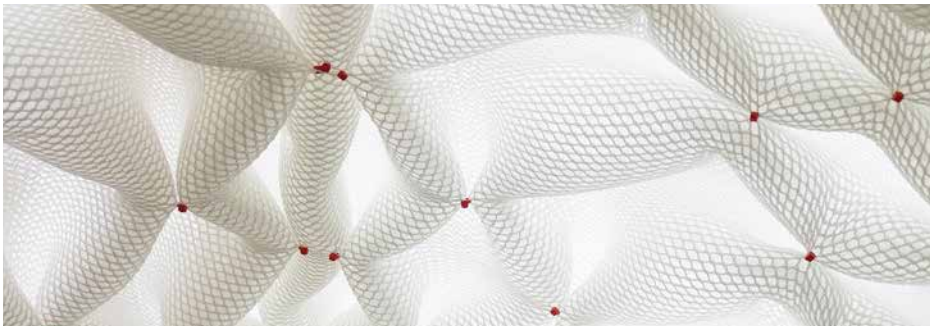
Knippers, J., Speck, T.: 2012, Design and Construction Principles, in: Nature and Architecture, Bioinspiration and Biomimetics, Vol 7.

Menges, A. (ed.), 2012. Material Computation – Higher Integration in Morphogenetic Design. Architectural Design, Vol. 82 No. 2.

Menges, A. 2012. Morphospaces of Robotic Fabrication – From theoretical morphology to design computation and digital fabrication in architecture, in Proceedings of the RobArch Conference 2012, eds. S. Brell Cokcan, J. Braumann, Vienna, pp. 28-47.

La Magna, R., Gabler, M., Reichert, S., Schwinn, T., Waimer, F., Menges, A. and Knippers, J. 2013. From Nature to Fabrication: Biomimetic Design Principles for the Production of Complex Spatial Structures, International Journal of Spatial Structures, Vol. 28 No. 01, pp. 27- 40.

IMAGE: ICD/ITKE Research Pavilion 2011, 2011.



Integrative Technologies and Architectural Design Research Thesis Preparation Project

Module 49760 (15 ECTS)
Term: Winter/Summer

The second year of the programme is designated for the development of the master's thesis. The third semester aims at laying the foundation for a promising master's thesis through a Thesis Preparation Project supported by an integrated Master Thesis Preparation Seminar and two supplementary seminar modules.

The thesis preparation project engages the students in selection and development of a suitable master's thesis research proposal within a wide range of topics within contemporary architectural design research. Each year a number of specialized topic areas are offered by the participating institutes. These research areas are directly supported by expert researchers and open up the possibility for students to directly engage, through their thesis, in state of the art design research questions. Additionally, students are also encouraged and supported in the development of their own architectural design research interest. Areas of research focus can include: computational design and fabrication, morphological differentiation, material assembly, as well as material behaviour-driven system performance. The aim is for each sub-topic to be investigated in the context of full-scale architectural prototyping. In this regard, each research subtopic can be explored as an individual aspect of a larger common project to be developed throughout the master's thesis phase.

Students are responsible for conceptualizing, framing and developing their own thesis topic under the supervision of their tutors and supervisors. Given the interdisciplinary and research-based nature of the programme, each student must select a supervising professor from one of the institutes involved, suitable tutors and any additional supporting resources that may be required.

IMAGE: ITECH Master Thesis Project, 2014.
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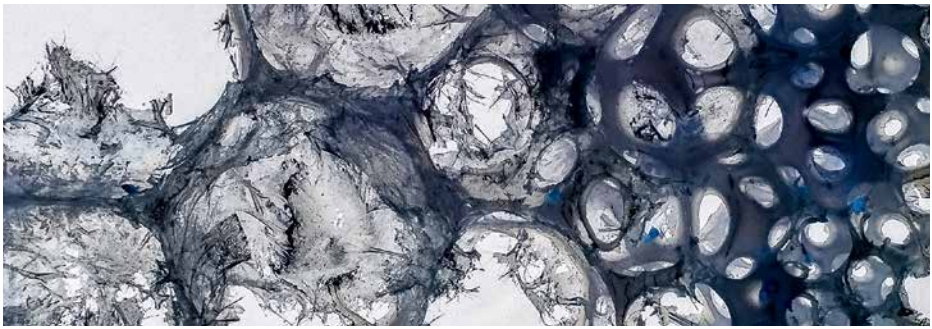

Thesis Preparation Seminar

Module 49870 (3 ECTS)
Term: Winter

The ITECH Master Thesis Preparation Seminar investigates the logical argument required to make a sound 'intellectual proposition'- a thesis. In other words, it is concerned in 'how to' conduct and structure research rather than 'what' specific subject matter you intend to research. The seminar, introduces the core aspects required to undertake scientific research independent of the field or the contents of the work. These structures are widely accepted across multiple disciplines and not only form part of presenting academic and scientific research but are also fundamental to conducting the research itself. The basic parts or chapters of such a research document will be introduced in general and with regards to the research field of architecture. Emphasis is laid on developing a mode of thinking and researching rather than presenting, thus turning the research methods into an operative tool of design. The Master Thesis Preparation Seminar aims at aiding the ITECH master's candidates to both build their thesis in a scientific manner and to identify further research resources that need to be incorporated into the proposal. It is thus not a contents-specific seminar but rather methodological in nature. The seminar will address both the structural requirements to properly develop a successful Thesis proposal but it will do so under the larger framework of the overall thesis dissertation. For this purpose, the three Thesis Tracks of the ITECH programme will be addressed individually, specifying how the overall Scientific Research Structure needs to be formulated to account for each track's focus. The seminar is centered around a two-day workshop with an introductory lecture on research structure and its modifications to suit a specific research track. A common workshop and individual tutorials will help to kick-start each student's formulation of their research document. As the seminar functions in support to the ongoing academic research work of the thesis candidates, the content of the document is to be developed by the candidates over the course of the term with the support of the thesis tutors. An intermediate progress review with the thesis tutors will take place prior to final submission.

Ecco, U. 2015. How to Write a Thesis. Cambridge, Massachusetts: MIT Press.

IMAGE: ITECH Master Thesis Project, 2015.
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ITECH MODULES

Integrative Technologies and Architectural Design Research Master Thesis

Module 80970 (30 ECTS)
Term: Winter/Summer

Thesis is a process of critical engagement with the research topic. It begins during the Thesis Preparation project (or before) and culminates with a cohesive argument, or proposition, that clearly articulates the students' individual contribution within the research field. The 4th semester provides the students with the opportunity to consolidate their gained academic knowledge, personal design perspective, research interest, technical expertise and contextual understanding of architecture through an Integrated Technologies and Architectural Design Research Master Thesis (30 ECTS).
The ITECH programme's interdisciplinary framework, coupled with a critical and analytical approach to computational design, simulation and fabrication, offers a unique space for inquiry within architectural design and practice. The thesis presents itself at the forefront of this inquiry as it may foster, develop and test many kinds of understandings, both technical and theoretical.
As a process of critical engagement, thesis is not only assessed by its final output but through a series of development stages marked by key review points. The student's objectives, the academic objectives of the programme, as well as the student's progress within the overall process will all be considered at each development stage.
To better address different research directions, there are currently three thesis track options possible:

A Semester 3+4: Research Thesis
Track A is aimed at engaging architectural research through a scientific and highly methodological approach. Students may expand on current methods, systems, and methodologies, or it may form the basis for the development of a new functional principle. In all cases, this option offers the ability to engage a research interest over two semesters. Track A concludes with a comprehensive research document.

B Semester 3+4: Design Research Thesis
Track B is aimed at engaging an architectural system or processes by expanding both its technical development as well as its design space. Track B concludes with a spatial or structural design study or application enabled by the research subject (material system/fabrication process/etc…) and a related research document.

IMAGE: ITECH Master Thesis Project, 2015.
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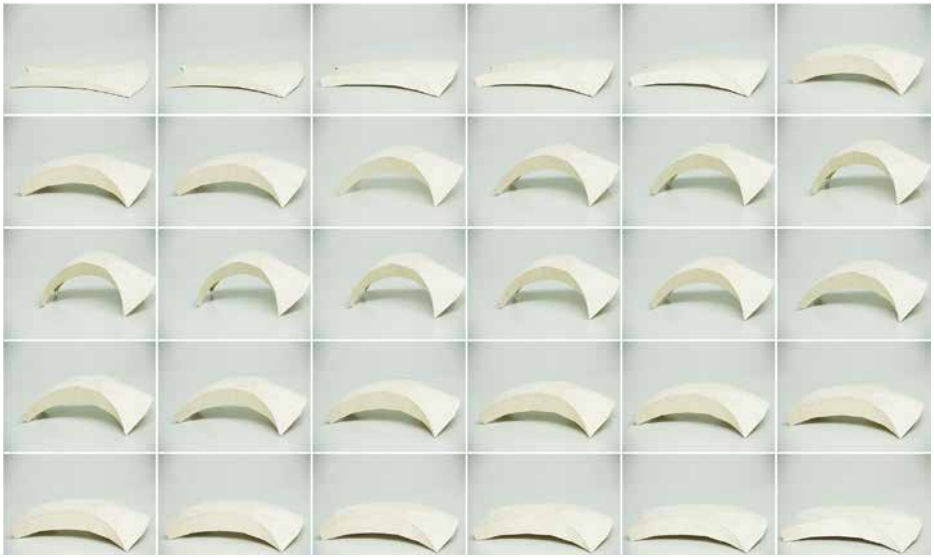
ITECH MODULES



C Semester 3+4: Design Studio and Research Extension of Design Studio
Track C incorporates a Design Studio in ITECH / Faculty of Architecture / Exchange Semester, etc. in Semester 3 and a research extension as a short version of (A) or (B). The ITECH design studios are offered directly by the corresponding partner institutes (ICD & ITKE) and their specific focus is in line with the institutes particular research interest.

Exchange semesters of external design studios are a great opportunity to gain additional technical experience or expertise that may contribute to the development of your Thesis. In order to ensure that these external options are feasible within the programme and pertain to the overall goal of your Thesis you must obtain prior approval from the examination committee.

NOTE: Students that obtained credits through advanced standing can only take the ITECH design studios – exchange semester or external studios are not possible. Independent Thesis Topics can be pursued only by prior agreement with the supervisors if excellent proposals are submitted.

IMAGE: ITECH Master Thesis Project, 2014.
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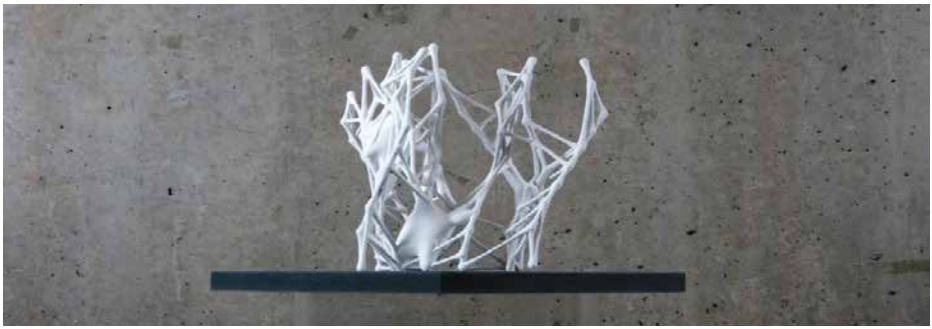

Computational Design

Module : 49770 (6 ECTS)
Term: Winter

An algorithm is a finite sequence of explicit, elementary instructions described in an exact and complete, yet general manner. The application and execution of algorithms on a computer happens through programming languages, which enable computing procedures. This is a fundamental property of computation as a technical achievement, but also as a theoretical framework for design. Computation has a profound impact on a contemporary understanding of architectural form, space and structure. It shifts the way one perceives form, the way in which form is purposed, and the way in which form is produced.

The fundamental concepts which underlie computational theory and techniques expose form as a subsidiary component of environment, and environment as a complex web of influences.

This seminar investigates the potentials of algorithmic procedures for architectural design. It provides an opportunity for the students to enhance their knowledge of algorithms by developing practical scripting skills, understanding theoretically relevant aspects of form generation and exploring mathematical principles and underlying patterns in the physical world. Based on the investigation of related mathematics, relatively simple algorithms will be developed to produce complex systems within an architectural context.

Menges, A., and Ahlquist S., eds. 2011. Computational Design Thinking. Chichester: John Wiley & Sons.

Burry, M. 2011. Scripting cultures: Architectural design and programming. Chichester: John Wiley & Sons.

Coate, P.S. 2010. Programming Architecture. London: Routledge.

Flake, G.W. 1998. The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation. Cambridge: MIT Press.

IMAGE: Student Project Computational Design, 2013.

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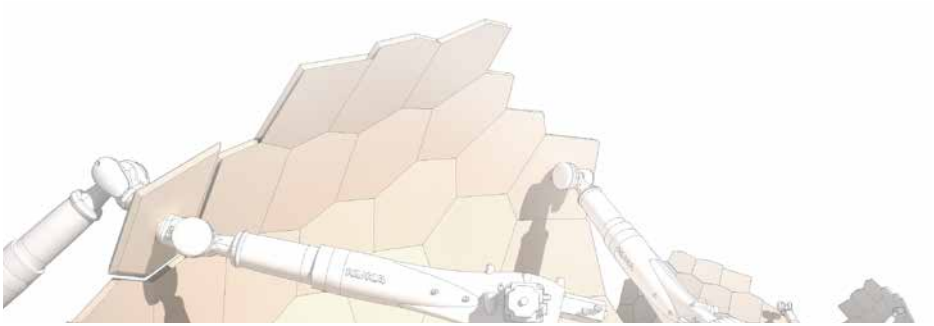


Computational Design and Digital Fabrication

Module 49780 (6 ECTS)
Term: Summer

Recent developments in computational design methods, fabrication techniques and robotic control open up new possibilities for materialization in architecture. Beyond the automation of traditional fabrication techniques, robotic tools create the opportunity to explore adaptive, interactive and responsive manufacturing methods. Students will develop skills and understanding for robotic fabrication, explore experimental robotic techniques (i.e. robotic interface, drone control, sensing, data processing, live streaming control and input/output signals), investigate computational design strategies and advanced robotic control for digital fabrication.

Based on these studies, new computation-based fabrication concepts will be explored. This explorative process will be closely related to the ITECH Integrative Technologies and Architectural Design Research Project, which will enable students to investigate fabrication techniques in interdisciplinary teams as well as developing suitable computational design tools for this process.
The result of these investigations will be an overview of robotic fabrication within the context of an architectural discipline, deeper understanding of technologies for advanced fabrication of architectural systems, and the development of computational tools, experimental fabrication techniques and prototype architectural demonstrators.
Prerequisite is previous participation in one of the computational design seminars or experience with Grasshopper or Python programming.

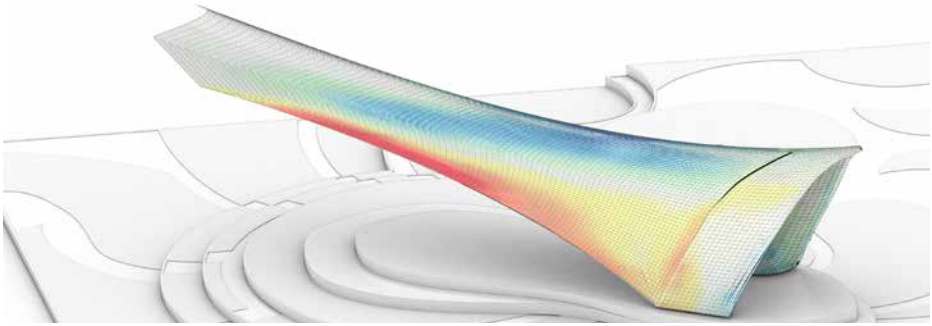
Bechthold, M. 2010. "The Return of the Future: A Second Go at Robotic Construction". Architectural Design 80(4): 116–121.

Biggs, G., Macdonald, B. 2003. "A Survey of Robot Programming Systems". In Proceedings of the Australasian Conference on Robotics and Automation Brisbane, edited by J. Roberts and G. Wyeth(eds.), 1-10.

Brell-Çokcan, S., Braumann, J. 2010. "A New Parametric Design Tool for Robot Milling". In Proceedings of the 30th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA), 357–363.

Schwinn, T., Krieg, O., Menges, A. 2012. "Robotically Fabricated Wood Plate Morphologies". In Robotic Fabrication in Architecture, Art and Design: Proceedings of the Robots in Architecture Conference 2012, edited by S. Brell-Çokcan and J. Braumann, 48-61. Wien New York: Springer.

IMAGE: ITECH Master Thesis Project, 2015.



Form Finding - Form and Structure

Module 49790 (6 ECTS)
Term: Winter

The seminar provides a thorough overview of structural systems, such as form-active and surface-active structures, and their relationship between form and structural behaviour. Furthermore the module covers design strategies for those structural systems focusing specifically on compression shells and tensile structures such as membrane structures. Prerequisite for the design and construction of such structural types is a solid knowledge of their structural behaviour that will be taught during the seminar.

To design and evaluate spatial structural systems, a range of digital modelling, scripting and analysis tools are introduced and digital form finding procedures are explained and applied on practical examples. With the introduction of Finite Element programmes and Particle Spring Systems the understanding of the form – structure relationship is intensified. To be able to critically evaluate and compare the results of the used methods, an overview of the mathematical background of the used tools is provided.
The seminar will conclude in the submission of a design project of a small scale architectural application using the introduced form-finding and analysis tools. The students should be familiar with the architectural and spatial potentials of shell and membrane structures in order to explore their possibilities within their projects. Prerequisites for attending the course are good Rhinoceros skills and basic Grasshopper and Python knowledge.

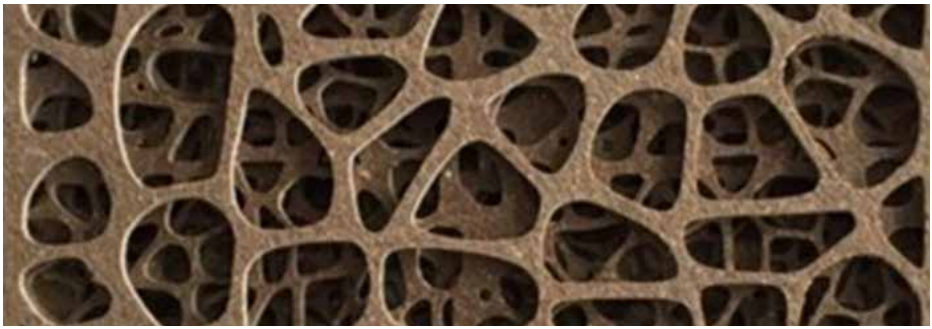
Edward Allen and Waclaw Zalewski, Form and Forces – Designing Efficient, Expressive Structures (Hoboken: John Wiley & Sons, 2009).

Heine Engel. Tragwerksysteme – Structure Systems (Ostfildern: Hatje Cantz, 2007).

Jan Knippers, Jan Cremers, Markus Gabler and Julian Lienhard, Construction Manual for Polymers + Membranes (Basel: Birkäuser, 2011).

Helmut Pottmann, Andreas Asperl, Michael Hofer and Axel Kilian, Architectural Geometry (Exton: Bentley Institute Press, 2007).

IMAGE: ICD/ITKE Research Pavilion 2016/17, Process, 2017.

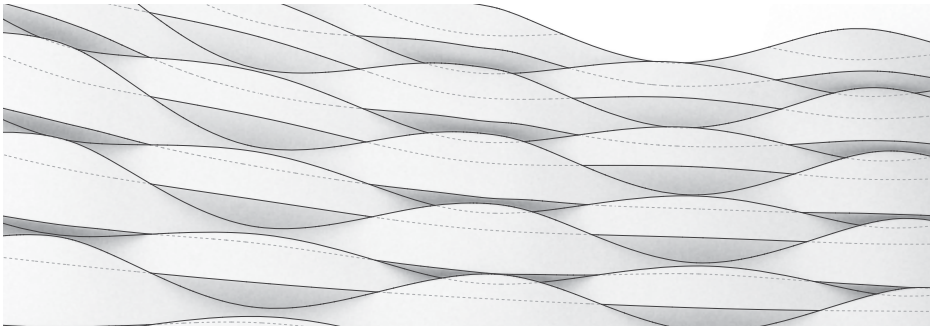


Material and Structure

Module 49800 (6 ECTS)
Term: Winter

The seminar is intended to prepare students for the application of complex construction materials in load-bearing structures, building envelopes as well as in other diverse architectural contexts.
The seminar covers a wide range of different materials going from traditional materials, i.e. concrete, steel, wood and glass, to nowadays lightweight materials, i.e. bio materials, composites, textiles and polymers.
Furthermore, understanding of the properties, characteristics and structural behaviour of these materials and related knowledge of compounds, layered elements as well as fibre reinforcement possibilities shall allow proper and intentional usage in architectural and structural applications.
A number of concepts of applying these materials in different design/structural and interactive contexts will be tackled in details throughout an experimental approach.
The students will actively work in groups, with real materials and will have the chance to integrate an interactive system in their prototype.
Architectural students will design and explore the structural functionality and the responsiveness of their materials' systems in one of four different folding concepts that will be integrated in this course framework.
This is considered an experimental approach towards design, how to integrate materiality, structure and responsiveness in a new format.

IMAGE: 3D-cladding module with integrated acoustic absorption function, 2015/2016. © BioMat at ITKE University of Stuttgart.



Building Systems

Module 49810 (6 ECTS)
Term: Winter/Summer

Geometrically complex architectures and structures require an increasing understanding of joint assembly and joining technology of building systems. In coherence with design approach and the technological parameters, organisational principles coordinate and enhance the design conclusion. To realize complex generated building systems, the seminar introduces solutions for an architectural implementation based on requirement profile, joining sequence, and materiality.
Beyond clarifying design and technology specifics, the seminar initiates the development of multi-layered, integrative components and subsystems. Technological requirements and design parameters, the investigation of joining sequence and joint assembly are essential for an architectural implementation and its performance.
This seminar focuses on an integrative design approach for building structure, building envelopes, and building systems.

Set as a 2-phase course, student works include the architectural and technological analysis of innovative building systems. Based on the results of this examination, the second part of the course transfers gained knowledge developing a prototypical building component and building system.

Gilbert, H. 1984. The Dream of the Factory Made Home. Cambridge, Massachusetts: MIT Press.

Nerdinger, W., Barthel, R., Junge, R., Krippner, R., and Petzold, F. 2010. Wendepunkte im Bauen - Von der seriellen zur digitalen Architektur. München: DETAIL Verlag.

Lass, E., Pottmann, H., Asperl, A., Hofer, M., and Kilian, A. 2007. Architekturgeometrie. Wien /New York: Springer Verlag.

Bergdoll, B., and Christensen, P. 2008. Home Delivery: Fabricating the Modern Dwelling. New York: Museum of Modern Art.

IMAGE: ITECH Master Thesis Project, 2015.

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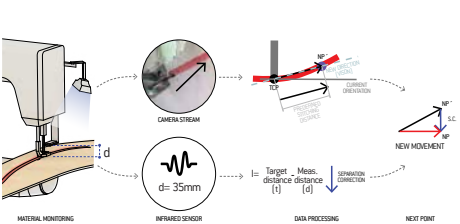
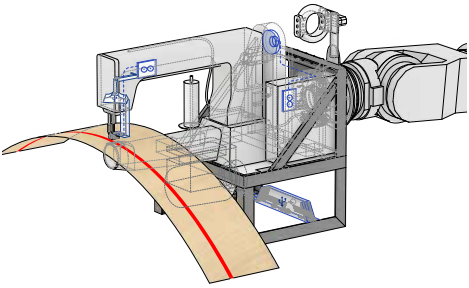




Computational Design and Simulation

Module 49830 (6 ECTS)
Term: Winter

The course introduces a new methodology for digital design and fabrication; contrary to traditional notions of design, behavioural strategies for fabrication are not based on the execution of a priori defined abstract plans, such as detailed digital design models, but are based on the concept of execution of tasks. Tasks represent design intention and unfold in a nondeterministic way based on the constant interaction of the machine/robot/agent with the material and its environment through sensor-actuator feedback.
The course introduces students to the topic of behavioural fabrication and related computational techniques including: (i) Agent-based and behavioural models, (ii) Sensor feedback and machine vision, (iii) Online robotic control methods, (iv) Methods for environmental analysis and mapping.
At the core of the research lie the analysis, abstraction, translation and implementation of fabrication-oriented behaviours for the production of physical prototypes.

Students are expected a high degree of proficiency in computer programming (either in C# or in python), and are also are expected to be familiar with industrial robotics from the previous seminar courses offered by ICD in computation and robotic fabrication.

Brooks, Rodney A. 1990. Elephants Don't Play Chess. Robotics and Autonomous Systems 6 (1-2): 3–15.

Dörfler K, Rist F, Rust R. 2012. Interlacing: an experimental approach to integrating digital and physical design methods. In Rob|Arch 2012: Robotic fabrication in architecture, art and industrial design. Springer, Vienna, 2013, pp. 82–91

Johns, Ryan Luke, Axel Kilian, and Nicholas Foley. 2014. Design Approaches Through Augmented Materiality and Embodied Computation. In Robotic Fabrication in Architecture, Art and Design 2014, edited by Wes McGee and Monica Ponce de Leon, 319–332. Springer International Publishing.

Menges, A., 2008. Integral formation and materialisation: Computational form and material gestalt. In K. R. Klinger & B. Kolarevic (Eds.), Manufacturing Material Effects: Rethinking Design and Making in Architecture, pp. 195–210. New York: Routledge.

IMAGE: Behavioral Fabrication Project, 2016.

Architectural Biomimetics

Module 49840 (6 ECTS)
Term: Winter

The seminar focuses on the investigation, abstraction and transfer of biological strategies into technical applications. Students will work in interdisciplinary teams to investigate biological role models within a bottom up process and will be searching for solution strategies towards specific aspects by exploring biological role models within a top down process. Computational simulation and analysis tools are used to find model representations for biologic processes and investigate functional principles.

Evolutionary processes in nature generated manifold solutions in respond to environmental and performative demands, where various functional and form generative aspects have to be integrated in a coherent system. While a number of those aspects can be easily transferred to architectural aspects, natural organisms are working radically different from today's construction and planning practice. While nature evolved highly energy and material efficient solutions, based on geometrical and material differentiation, today's construction industry and design processes are mostly based on the standardization of elements and the addition of mono functional subsystems. Recent developments of computational design and digital fabrication processes have initiated a fundamental paradigm shift from industrial production of standardized elements towards an integrated design processes. This development opens up the possibilities to create architectural systems which are characterized by multifunctional geometrically differentiated structures, which can match the capacity of nature's performative morphologies, and thereby enables us to transfer functional principles of natural organisms into architectural applications.

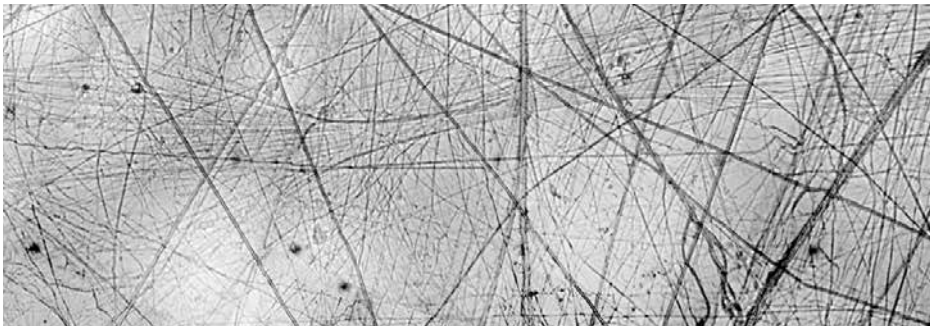
John W.C. Dunlop and Peter Fratzl. "Biological Composites," Annual Review of Materials Research 40(1) (2010): 1.

Helge Otto Fabritius, C. Sachs, Dierk Raabe, Svetoslav Nikolov, Martin Friak, J. Neugebauer. „Chitin in the exoskeletons of arthropoda: From ancient design to novel materials science." In Chitin, ed. Neal S. Gupta. (Berlin: Springer, 2011), 35.

Petra Gruber, Biomimetics in Architecture, (Wien, Springer, 2010).

Jan Knippers and Thomas Speck, 2012. "Design and construction principles in nature and architecture," Bioinspiration & Biomimetics 7(1) (2012).

IMAGE: ICD/ITKE Research Pavilion 2014/2015, Biomimetic Research, 2015. © ICD/ITKE University of Stuttgart.



Expert Colloquium 1 and 2

Module 49850 and 49860 (3 ECTS)
Term: Winter and Summer

The seminar modules of the ITECH programme are accompanied with Expert Colloquia, which will take place in the Winter Semester (Expert Colloquium 1) and Summer Semester (Expert Colloquium 2).

The Expert Colloquia are presented in a flexible format to introduce research and new technology development from outside the involved institutes and to foster the collaboration with industry and academic partners. The module introduces knowledge about the current state of integrative technologies in practice and research, presenting the work of experts ranging from design architects, engineering consultants to manufacturers and scientists. It offers students the possibility to discuss their own work with external experts as a base for further development.

The aim of the Expert Colloquia is to integrate the interdisciplinary expertise from cutting edge researchers in industry as well as from other academic institutions and universities into the ITECH programme.

The open format of this module includes a lecture series in the Winter Semester with invited guest speakers who will provide an insight into their professional and academic work as well as excursions to academic institutions and industry partners in the Summer Semester.

The specific schedule, contents and collaborating institutions will vary from year to year and will be announced and defined according to specific ITECH topics during the corresponding academic year.

IMAGE: ICD/ITKE Research Pavilion 2014/2015, Biological Role Model Research, 2015. © ICD/ITKE University of Stuttgart.

APPLICATION PROCEDURE

In order to apply for the ITECH programme, the following documents are required:

- portfolio: max. 10 pages (DIN A4 format, single pages), max. 10 MB
- letter of motivation
- additional form (Ergänzungsformular des Zulassungsausschusses)
- curriculum vitae
- copy of high school diploma or equivalent
- copy of your university degree(s)
- copy of your university transcript(s)
- proof of English proficiency:
  IELTS certificate (overall band score 6) or
  TOEFL certificate (minimum score: 550 paper based, 213 computer based, 79 internet based) or
  CAE- Cambridge Advanced Certificate in English or
  CPE- Cambridge Proficiency Certificate in English
  (Native Speaker and students who passed the entirety of their undergraduate studies in Australia, Canada, Ireland, New Zealand, the US or the UK are exempt from this rule)
- applicants from China, Mongolia, and Vietnam must submit a certificate from the "Akademische Prüfstelle (APS) des Kulturreferats der Deutschen Botschaft".

Please note that all copies need to be officially authenticated and English or German translations are required.

A full application consists of the documents listed above. You will be able to submit all documents and fill out your application form in the University of Stuttgart C@MPUS portal. The C@MPUS portal will open for ITECH applications in mid-December.

The application deadline is February 15th, 2020.

IMAGE: ICD/ITKE Research Pavilion 2015-16, 2016.

ITECH

Integrative Technologies & Architectural Design Research

M.Sc. Programme, Faculty of Architecture and Urban Planning, University of Stuttgart

ICD Institute for Computational Design and Construction

itke Institute for Building Structures and Structural Design

University of Stuttgart

Contact: info@itech.uni-stuttgart.de

IMAGE: ICD/ITKE Research Pavilion 2018-19, 2019.