**Computational Design and Fabrication: Bridging Architecture, Engineering and Computer Science**

**Application for the   
Project Week 2024/25**

**30.04.2024**

1. **Applicant**

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1. **Brief description of the project**

The proposed Computational Design and Fabrication project is designed to bring together Architecture, Civil Engineering, Mechanical Engineering, and Computer Science students. This initiative leverages the interdisciplinary knowledge base at TUM through a project-based educational approach. The overarching goal is to bridge theoretical knowledge with practical implementation and prepare students for advanced challenges in their respective fields. The project is structured into two key components: the seminar Computational Design and Fabrication 1 (CDF 1) and the Spring School Computational Design and Fabrication 2 (CDF 2), each offering 6 ECTS.

CDF 1 (Seminar) consists of a series of frontal lectures, tutorials, and interactive exercises that introduce students to the fundamentals of computational design, focusing on structural integrity, innovative use of materials, and digital fabrication techniques. It will take place in the winter semester of 2024/25 (October 2024 - January 2025). This module equips students with theoretical knowledge and prepares them with fundamental skills for practical applications.

Following the completion of CDF 1, CDF 2 (Spring School) takes place in March 2025 as an intensive one-week workshop. In this part, students engage directly with a comprehensive design-to-fabrication project, applying the principles and techniques learned in CDF 1. This hands-on experience encourages students to tackle complex design and fabrication challenges, fostering a deeper understanding of materials and manufacturing processes and promoting a synthesis of their multidisciplinary studies.

1. **Project description**

The proposed Computational Design and Fabrication project aims to integrate multiple scientific disciplines — mathematics, computer science, structural engineering, and architecture — to foster a symbiotic learning environment. The project targets Architecture, Civil Engineering, Engineering, Mechanical Engineering, and Computer Science master’s students. This interdisciplinary approach is taught through a combination of frontal lectures, tutorials, and exercises – i.e., teaching module Computational Design and Fabrication 1 (Seminar), 6 ECTS, October 2024 to January 2025 – and a one-week hands-on workshop – i.e., teaching module Computational Design and Fabrication 2 (Spring School), 6 ECTS, on 24-28 March 2025.

The overarching project goal is to offer students a thorough understanding of the following key topics, ensuring a holistic educational experience:

* Introduction to computational geometry, fostering algorithmic thinking and programming proficiency.
* Exploration of geometry processing, data structures, and interface intricacies crucial for effective computational design.
* Introduction to foundational concepts of structural- and fabrication-aware design, laying the groundwork for design solutions that integrate seamlessly into real-world applications.
* Familiarization with selected computational design tools and fabrication technologies.
* In-depth examination of domain-specific case studies, culminating in practical design and fabrication tasks.

Lectures and tutorials in the module CDF 1 (Seminar) will explore various facets of computational design, focusing on structural design and digital fabrication. Each session will focus on specific multidisciplinary approaches to complex problem-solving. Students will be engaged in interactive programming exercises featuring open-ended questions to reinforce these learning objectives. Several associated assignments will be designed to test students’ knowledge and stimulate creative thinking and playful engagement with the exercises. Students will work on these assignments in small groups, typically comprising three to four members from varying academic disciplines. This grouping strategy is intended to foster a collaborative learning environment where each member contributes distinct perspectives and expertise.

In the intensive one-week workshop, as part of CDF 2 (Spring School), students will confront themselves with a comprehensive design-to-fabrication project to apply the skills and knowledge acquired in CDF 1 in a practical setting. The Spring School will take place at the FIT AG / Additive Tectonics GmbH campus in Lupburg (Bayern), a worldwide leader in advanced additive manufacturing. In a specialized multidisciplinary environment bridging the competencies of academia and industry, students will leverage a spectrum of computational tools for structural design, shape optimization, and digital fabrication. A crucial aspect of their work will involve creating additively manufactured physical prototypes, allowing them to experience their digital designs materialize.

The project structure unfolds as follows:

* Theoretical Foundations: Through frontal lectures, students are introduced to the theoretical underpinnings of computational design, gaining insights into fundamental concepts and methodologies.
* Toolchain Exploration: Using real-world examples, a curated sequence of computational design tools is introduced and demonstrated. Students leverage these tools to complete assignments, gaining proficiency in software utilization while improving their design skills.
* Design Challenges: Students translate theoretical knowledge into practice through programming assignments, directly engaging with computational tools to implement and experiment with various design techniques.
* Practical Application: The culmination involves digitally fabricating physical prototypes across various scales to validate design proposals effectively.

After attending the course, students will be able to:

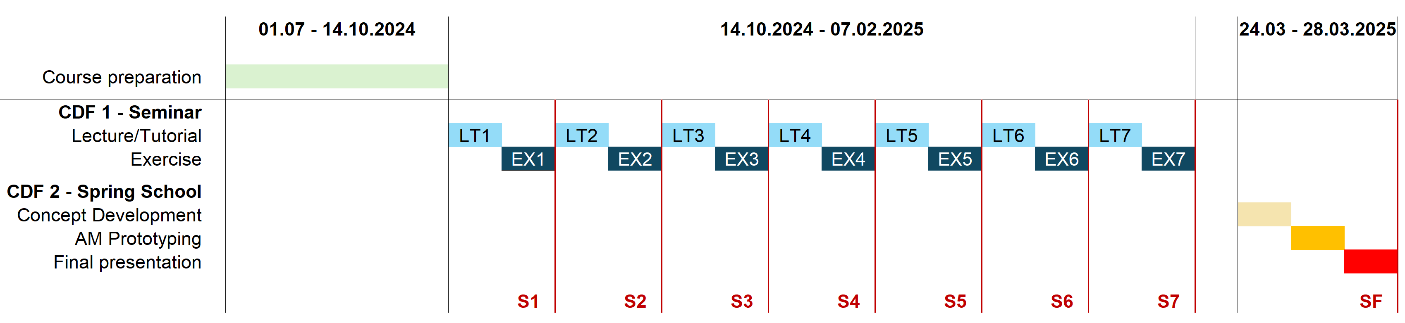
* Understand the scope and relevance of computational methods for design in academic research and professional practice.
* Gain proficiency in implementing fundamental versions of algorithms pertinent to architectural geometry, structural design, and digital fabrication.
* Acquire competence in using mainstream CAD tools and programming as conduits to self-implemented design solutions.
* Gain practical expertise in computational design through immersive, hands-on experiences.

The fulfillment of the learning goals will be assessed by:

* Evaluating the quality of the solutions submitted by the students in relation to the assigned exercises throughout the CDF 1 (Seminar) teaching module.
* Evaluating the quality of the design project developed by students during the intensive design workshop in the CDF 2 (Spring School) teaching module.

1. **Project procedure**

The project includes two teaching modules: CDF 1 – Seminar (Master, 6 ECTS) and CDF 2 – Spring School (Master, 6 ECTS). The structure of the project is shown in the table below (LT – lecture/tutorial, EX – exercise, S – student submission/milestone).



1. **Financial efforts**

As outlined in the attached financial plan, the following personnel and material costs are expected for the successful implementation of the proposed project:

* One academic staff, 10% E13/3 position (extension of an existing contract) for the period 01.07.2024 -31.03.2025 with the following tasks:
  + Conceive and prepare materials for lectures, tutorials, and exercises.
  + Provide tutorials to students on the use of specific software.
  + Provide guidance to students in the fulfillment of the assigned exercises.
  + Provide personalized tutoring to help students grasp complex topics.
  + Organize the one-week workshop (24-28 March 2025), coordinate logistics, and ensure all necessary materials and resources are available.
* One student assistant, Master level, 4 hours/week for 15.08.2024-30.10.2024. The student will support the teaching team in the following tasks:
  + Prepare materials for lectures, tutorials, and exercises.
  + Organize the Moodle platform and the online repository to share teaching material and interact with students.
  + Organize the lecture hall for lectures, tutorials, and exercises.
* Travel and accommodation for 15 students and 5 tutors for the one-week Spring School (24-28 March 2025) at FIT / Additive Tectonics in Lupburg (Bayern).
* Material (ABS, PLA plastic, resin) for producing various additively manufactured prototypes by students during the one-week Spring School.

1. **Signatures**

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Prof. Dr. Pierluigi D’Acunto Prof. Dr. Mark Michaeli

Professorship of Structural Design Vice Dean of Studies

TUM School of Engineering and Design TUM School of Engineering and Design

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Chair of Structural Analysis

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