Course Outline Form

Year: 2014-2015  
Course Number: ARCH5231C  
Course Title: TOPOLOGICAL STUDIES IN COMPUTATIONAL DESIGN  
Course sub-title: The Man-Machine: Mass Customisation  
Instructor: Kristof Crolla (Email: kristof.crolla@cuhk.edu.hk)  
Schedule: Semester 2, Monday, 9.30am -12.15pm, computer lab  
Enrolment / Quota: 10/10

Images: (top left) Pavilion with 3D-printed nodes, by CUHK Students IP Tsz Man Vincent, CHAN Chi Yan, LO Man Kiu Albert, NG Kei Yiu Alex, as part of this elective in 2013-2014, (top right) Evolutionary optimised 3D metal printed node from a tensegrity structure, ARUP, 2014, (bottom-left) Makerbot 3D Printer, (bottom - middle) CNC router, (bottom-right) metal laser cutter

1. Course Description

Today's available computational power is unprecedented, and the speed at which information can be processed increases constantly. The production of architecture is process based and thus these information processing abilities are radically reshaping the profession. As advanced digital and information-based design methods and production techniques become more easily accessible, it is essential for architects to not only explore their architectural application but to also gain a critical understanding of these new modes of operation.

This research seminar investigates how latest technology is creating a paradigm shift in the conceptual stages of architectural design. It entails the practical exploration of contemporary architectural design techniques and the impact these have on the theoretical discourse. The question at hand is how responsive virtual design environments (such as real-time physics simulators), and advances in computer controlled fabrication allow for a paradigm shift in architectural design. This we no longer perceive as being “static”, now that real-time feedback loops, and algorithmic design set-ups throughout the entire architectural process allow for meaningful responsive adaptation during, pre- or post-construction.
The course consists of two parts: 1. tools exploration and 2. critical application. A series of hands-on introductory software tutorials (from a customized course manual) will form the starting point, to which following seminars on contemporary architecture will provide a theoretical backdrop. Students will firstly be introduced to recent developments in 3D-NURBS modelling (Rhino) and procedural modelling (Grasshopper), followed by experiments with the latest add-ons and plug-ins, such as Kangaroo (real-time physics), Millipede (topological optimisation), and HoopSnake (recursive scripting). Following this, students are asked to critically apply gained skills in a small-scale architectural design project.

During semester 2 we will work on the topic of Mass Customisation vs. Standardisation of component based structures, using CNC milling technology, vacuum forming, 3D printing, mould-making, and casting. Part of the task involves the design exploration of the extensive opportunities the fabrication tools provide for integrated patterning and ornament.

To guarantee practical applicability we will work with both digital geometry set-ups and physical output throughout all stages of the project. Group discussions of seminar’s content and selected readings will frame the work in a broader contemporary architectural discourse.

2. OBJECTIVES

This course will provide students with rigorous expertise in procedural design techniques, digital fabrication, and their use in architectural design. It will introduce participants to the ongoing international debate on architectural applications for algorithmic design tools.

3. LEARNING OUTCOMES

At the end of this course students
1. will be able to demonstrate architectural applications of recently developed digital design and fabrication tools; develop an ability to use the technical tools associated with contemporary architectural practice; extend and advance the use of new tools and technologies into architectural design; remain technologically agile in order to adapt to and capitalize upon changes in technology.
2. will be able to critically investigate and evaluate theoretical concepts and drivers behind evolving architectural design and construction technology; tackle novel situation and ill-defined problems; understand design as an ongoing process, not as a product; develop a comprehensive understanding of contemporary theoretical discourse
3. will have explored through team work new ways of representing architectural concepts verbally, graphically and by means of physical models; develop and propose new ways of representing architectural concepts verbally, textually and graphically.

4. ASSESSMENT SCHEME

1. Individual weekly homework + class participation (10%)
   • Task: Students will frequently receive small homework exercises on covered computational design tools to assist them in understanding the various topics covered in class.
   • Evaluation criteria: correctness and quality of the submission.
   • Submission requirements will be communicated via Blackboard.

2. Material Research (20%)
   • Task: In order to get a better understanding of the state of the art of latest digital design and fabrication techniques, an encyclopaedic knowledge overview will be compiled and shared.
Groups of students will investigate various forms of digital fabrication technology, covering methodology, applicability, flexibility, etc.

- Evaluation criteria: Quality, rigor and completeness of the research, quality of the presentation & report.
- Presentation: Public presentation through digital media and panels

3. Critical application (60%)
- Task: Design in group of max. 3 students an architecture intervention for the CUHK Architecture School Building Atrium that critically applies the explored tools + build a large-scale physical model / working prototype.
- Evaluation criteria: Explorative nature of the project, complexity and difficulty of the chosen task, quality of the presentation & report.
- Presentation: Public presentation through digital media, panels and physical models.

4. Final Course Portfolio (10%)
- Task: Bundle all material from exercise 1, 2 and 3 in a comprehensive portfolio following the provided template.
- Submission via Blackboard and hard copy:
  - Report: A4 landscape booklet
  - All produced digital files & physical models

Submission requirements will be communicated via the Blackboard online teaching system. No late submissions will be accepted or graded. According to the University Policies, the overall performance of the class will be distributed and adjusted with the ‘Gaussian Normal Distribution’.

5. COURSE FORMAT
seminars and tutorials.

6. REQUIRED READING

Software:
- CROLLA, Kristof and Sebastien Delagrange, International Workshop Series: Grasshopper Course Notes v.6.0, Hong Kong, 2014
- PIKER, Daniel, Kangaroo Live Physics for Rhino and Grasshopper (draft), 2011 (available online)
- PAYNE, Andrew & Issa Rajaa, The Grasshopper Primer, Second Edition – for version 0.6.0007, 2009 (available online)

7. RECOMMENDED READING

Theory:
- CORSER, Robert, Fabricating ARCHITECTURE, Selected Readings in Digital Design and Manufacturing, Princeton Architectural Press, 2010
- KOLAREVIC, Branko, Architecture in the Digital Age: Design and Manufacturing, Spon, 2003
8. SCHEDULE

The Schedule of Teaching consists of weekly seminars and group tutorials with additional individual tutorials possible on demand. A Blackboard page will be used for communication of course material, video tutorials, submissions and forums.

- Week 1 – Introduction + Rhino: Basic Modelling Techniques
- Week 2 – Rhino: Advanced Modelling Techniques 1+ Grasshopper: Introduction
- Week 3 – Grasshopper: Volatile Data Inheritance, Data Management
- Week 4 – Grasshopper: List & Data Management
- Week 5 – Grasshopper: Real-Time Physics (Kangaroo)
- Week 6 – Grasshopper: Real-Time Physics (Kangaroo)
- Week 7 – Grasshopper: Evolutionary Optimisation(Millipede)
- Week 8 – Grasshopper: Evolutionary Optimisation(Millipede)
- Week 9 – Presentation material research
- Week 10 – Individual tutorials
- Week 12 – Individual tutorials
- Week 13 – Individual tutorials
- Final Presentation

9. FIELD TRIP: None

10. PREREQUISITES: None

IMPORTANT NOTE TO STUDENTS:
Attention is drawn to University policy and regulations on honesty in academic work, and to the disciplinary guidelines and procedures applicable to breaches of such policy and regulations. Details may be found at http://www.cuhk.edu.hk/policy/academichonesty/ . With each assignment, students will be required to submit a statement that they are aware of these policies, regulations, guidelines and procedures.