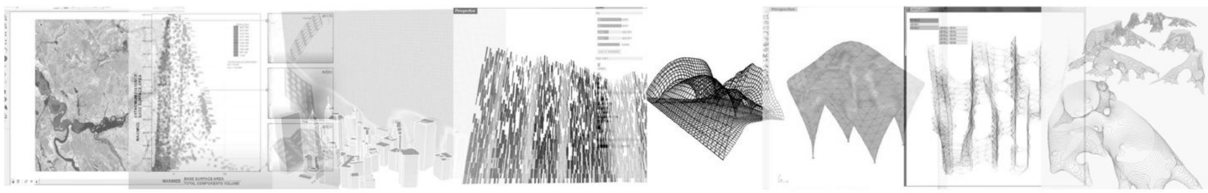
TOOLS AS AUGMENTATIONS: AN INTRODUCTION TO COMPUTATIONAL DESIGN



Architects -as mediators between immaterial and material, human and technology- are often confronted with complex projects that require many levels of inquiry and exploration. For this purpose, architects are armed with an array of tools to facilitate the processes of observation, research, and analysis to define the field of possibilities in terms of space, event, and movement. Other tools allow the architect to sketch, improvise, represent, modify, analyze, critique, and explore various fields. After a long process of deliberation, introspection, and collaboration, the architect arrives at a singular decision in order to create new forms of contextual relationships. Therefore, it goes without saying that the architect's tools are the most prized possessions. They are similar to bodily prostheses and new augmentations that not only alter what can be done, but what can be represented and conceptualized. It could even be said that the architect is indelibly influenced by the logic and agency of those tools.
In this context, it is important for the architect to develop a critical view and ask the following questions: Where does the tool come from? What does the tool want to do? What new tools can be created? Should not every process of design be one that reinvents new methods of thinking, and new tools for creation? How does the architect's subjectivity influence various properties of the tools? This course stems from the assumption that architects should not only be able to use various tools, but should have the ability to create new critical and experimental design tools that respond to specific design-questions. In this course, we will aim at the generation of design-question oriented customized digital workflows. These customized workflows will explore the potential of breaking down a design problem into several questions in order to approach architectural and urban research through a bottom-up method. This technique will allow us to experiment with converging varied inter-operational platforms in order to develop custom toolsets for each proposed design question. The process of workflow customization will amplify our ability to explore options and achieve depth and speed of analysis. In this course we will use Rhino/Grasshopper as meta-tools which enable the creation of other tools. However, the course is not about software itself, but about experimental design processes. Using a series of custom scripts, techniques and workflows, Rhino/Grasshopper will be used to create new interfaces that disappear and become part of the Rhino environment or even part of the physical world. External input devices (cameras and sensors) will be used to create new relationships with 3d modeling, data will become incorporated into new forms of tools, and representation will be explored as a way to design the behavior of the user. Technology will not be used as calculators, but as augmentations of the designer that alters their design process. The point of the course is to develop computational design thinking in order to acquire a critical lens for the evaluation of digital tools. Through a closer look at the relationship between computational design theories and methods, we will engage in an experimental feedback loop where new ideas can generate new design techniques, and new design techniques can thus generate new ideas.

LEARNING OBJECTIVES

- **Develop computational thinking**

The current transition from Computer Aided Design (CAD) to Computational Design in architecture represents a profound shift in design thinking and methods. Computational thinking is a problem solving process that includes a number of characteristics, such as logically ordering and analyzing data and creating solutions using a series of ordered steps (or algorithms), and dispositions, such as the ability to confidently deal with complexity and open-ended problems. While there is a particular history of such an approach in architecture, its relative newness requires the continued progression of novel modes of design thinking for architects. This course will introduce the fundamentals of computational thinking in order to encourage designer-authored computational processes.

- **Knowledge of computational design theories**

Through lectures and discussions, we will focus on the “digital turn” in architecture since 1992 as coined by architectural historian Mario Carpo. He argued that computational design has emerged from the discipline of architecture and is forcing it into a field of “architectures”. Therefore, computational design theory is situated in between three practice-orientated teaching trajectories, which are place and technology, form and experience, space and documentation; and, links them together through a theoretical and conceptual understanding developed by thinking and working through theory and practice.

- **Knowledge of computational design methods**

Through lectures, discussions, and hands-on tutorials, the students will be introduced to number of fundamental algorithmic structures, computational analysis methods, data structures and data management platforms applicable to designer-authored computational design processes.

SOFTWARE REQUIRED

Base modeling:	Rhino3D
Workflow automation and customization:	Grasshopper plug-ins + GHPython for the followings: GIS import/export, environmental simulation, structural analysis, population simulation, image analysis, etc.
Documentation production:	Adobe Photoshop + Adobe Illustartor
Video construction + Editing:	Adobe After Effects

HARDWARE REQUIRED

You would require an Arduino UNO starter kit from Amazon for the in-class and homework assignments of Week 5th, June 13th.

DESCRIPTION AND ASSESSMENT OF ASSIGNMENTS

I. Tutorial Assignments (35%): Tooling up

Eight tutorials will be scheduled throughout the semester and will test your understanding of the technical topics covered in class. These tutorials will require you to follow and work through tutorial videos that will be given to you during the weeks they are assigned. To demonstrate that you have completed each tutorial, you will turn in a copy of your digital outputs from the final part of the exercise. At the end of the course, seven highest grades will be considered.

II. Presentation (20%): Computational Design Theories and Methods

This assignment will require you to work in teams of two to research one of the following topics commonly used in computational design:

- Object-oriented design
- Computer vision as design input
- Physics engines
- Evolutionary solvers
- Network theory
- Physical computing
- Topological optimization
- Environmental simulation
- Crowd simulation
- Branching process / algorithm
- Ubiquitous computing / Internet of things (IOT)

You will present your research results with the help of a PowerPoint slideshow. You will be able to download a PowerPoint template from the course Blackboard page. You are required to summarize all your findings in the minimum of 10 and maximum of 15 slides. You have 5 minutes to present all your slides.

These are some of the questions you should consider when preparing your presentation: What is the definition of your topic? What problem can it solve? What is the background of the field? How has the field evolved over time? What are some of the state of the art practices? What are some of the software utilized in the field? How can this topic inform architectural design? What are some architectural examples of the topic?

III. Final Project (35%): Computational Workflow Development

Part 1 (10%): Students will work in teams (2 people) to choose one of the weekly topics and propose a design problem to address with a devised workflow.

Part 2 (10%): Workflow is a sequence of operations for human-to-machine information processing. Building from an initial design hypothesis, one could break down the required sequence of steps to assign each to a software or programming language that will prove most suitable for the execution of the desired outcome, with data linkages serving as the primary substance activating each sequential step. In this exercise, you are asked to map the ingredients of your proposal in a sequence diagram that demonstrates all the input variables, tools, and intended output of your proposed system. This diagram may use icons, text, or geometry, and could also include future predictions/assumption for your proposed project. This assignment will assist you in developing a custom workflow for your proposal. You will be able to download a workflow template from the course Blackboard page.

Part 3 (15%): The goal of this final assignment is to realize the full extent of the research workflow proposed in part 2. Students will build custom, cross-platform workflows to formalize research and generate data-driven geometry and/or systems within Grasshopper. The ultimate objective is to develop and document an innovative approach to the realization of construct and workflow as a dynamic/unified/interoperable system.
The working methodology advocated in this course enables the designer to quickly arrive at many design variations, addressing design goals established at the outset and reinterpreted in process. By creating a matrix of design possibilities from all outcomes, one can showcase variability in the tested workflow and study the range of possibilities in the proposed design problem. Your matrix of possibilities could focus on various parameter testing (population, duration, geometry construction, optimization, etc.). Studying this taxonomy becomes a way for us to test the flexibility and extendibility of the conducted experiment and insert moments of control into the process.

GRADING BREAKDOWN

Course assignments will be graded according to quality, clarity, intricacy, creativity and depth of operations. Careful planning and a serious, consistent commitment will be required for you to successfully navigate the various deliverables in this course. As we aim for a richly interactive course, participants will be required to present both progress and final work (per assignment) to the group at large at periods throughout the semester. As such, consistent and interactive attendance is required. Attendance and participation will be reflected in final grades. The table below summarizes the ARCH607 course assignments and their point distribution:

Assignments	Number	Points Per Assignment	Total Points
Participation	-	-	10
Assignments	8 (7 highest grades will be considered)	5	35
Presentation	1	20	20
Final Project_Part 1	1	10	10
Final Project_Part 2	1	10	10
Final Project_Part 3	1	15	15
Total	-	-	**100**

SCHEDULE BREAKDOWN

Date	Topics/Daily Activities	Homework Assigned	Deliverables/ Due Dates
Week1: 5/16	*Class cancelled due to the incoming students' orientation*	*N/A*	*N/A*
Week2: 5/21	**COURSE OVERVIEW** ● Course methodology presentation: Tools as Augmentations ● Introduction to Grasshopper as a metatool	★ **Assignment 1**: Digital Work Samples	N/A
Week2: 5/23	**INTRODUCTION TO RHINO + EXPLICIT HISTORY** ● Interface ● Geometry Types	★ **Assignment 2**: Introduction to Grasshopper	★ **Assignment 1**: Digital Work Samples
Week3: 5/28	*Memorial Day - No Class Meeting*	N/A	N/A
Week3: 5/30	**COMPUTATION OF GEOSPATIAL DATA** ● Introduction to Lists ● Introduction to GIS data ● Raster vs. Vector data ● How to acquire GIS data ● Introduction to Gh-Meerkat	★ **Assignment 3**: Introduction to data management in Grasshopper ❖ **Presentation**: Introduction to computational methods ❏ **Final Project_ Part 1:** Group forming + topic explorations	★ **Assignment 2**: Introduction to Grasshopper (See class Blackboard for submission guidelines) ★ **Assignment 1**: Portfolio
Week4: 6/04	**GIS DATA VISUALIZATION** ● Introduction to Gh-Elk ● Introduction to data plotting ● Introduction to GH-Animation ● Introduction to Gh-Human + ● Gh-Heteroptera + Gh-Horster	★ **Assignment 4.1**: Working with OSM GIS data ★ **Assignment 4.2**: Data Visualization + Animation in GIS	★ **Assignment 3**: Introduction to data management in Grasshopper (See class Blackboard for submission guidelines)
Week4: 6/06	**STRUCTURE GENERATION + ANALYSIS** ● Introduction to structural analysis parameters ● Introduction to Gh-Kangaroo live physics engine ● Introduction to Gh-Millipede for topological optimization ● Introduction to Gh-Karamba for finite element analysis	★ **Assignment 5**: Kangaroo + Weaverbird exploration ❏ **Final Project_ Part 2**: Workflow proposal	★ **Assignment 4.1**: Working with OSM GIS data ★ **Assignment 4.2**: Data Visualization + Animation in GIS ★ **Final Project_ Part 1:** Group forming + topic explorations
Week5: 6/11	**ENVIRONMENTAL ANALYSIS** ● Introduction to environmental analysis parameters ● Introduction to Gh-Diva for solar analysis ● Introduction to Gh-Ladybug + HoneyBee for environmental analysis	★ **Assignment 6**: Environmental analysis with Ladybug + HoneyBee	★ **Assignment 5**: Kangaroo + Weaverbird exploration ❖ **Presentation**: Introduction to computational methods
Week5: 6/13	**PHYSICAL COMPUTING** ● Introduction to physical computing parameters ● Introduction to Arduino hardware ● Introduction to Gh-Firefly ● Introduction to analog + digital sensors	● **Assignment 7**: Environmental analysis ❏ **Final Project_ Part 3**: Workflow execution	★ **Assignment 6**: Environmental Analysis with Ladybug + HoneyBee ❏ **Final Project_ Part 2**: Workflow proposal
Week6: 6/18	**COMPUTER VISION** ● Introduction to vision tools w/ GH-Firefly ● Introduction to image and video classification techniques	● **Assignment 8**: Image + video classification	● **Assignment 7**: Environmental Analysis
Week6: 6/20	**IN-CLASS WORK SESSION**	N/A	● **Assignment 8**: Image + video classification
Week7: 6/25	**ASSIGNMENT 2 PRESENTATION + DISCUSSION**	N/A	❏ **Final Project_ Part 3**: Workflow execution

OFFICE HOURS

My office is located at the USC School of Cinematic Arts, SCI 211. I am available Mondays and Wednesdays 12:30-2:00 pm, Thursdays, 12:30 - 4:30 pm, or by appointment at other times.
Due to the short nature of the course and the vast amount of material involved, I encourage you to take advantage of my office hours. I am always available asynchronously via email. I am also available for synchronous chats via Skype. Just get in touch!

ATTENDANCE

This course adheres to the School of Architecture attendance policies. Because of the concentrated nature of foreign studies course offerings, consistent attendance is a critical aspect of the course. Absence from class can not easily be "made up" when the class experience involves unique exposure to resources not otherwise available to the students. As such absence from field studies activities can have significant impact on the evaluation of student and may result in an unsatisfactory grade.

STUDENTS WITH DISABILITIES

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

ACCREDITATION STATEMENT

The USC School of Architecture’s Master of Architecture degree is an accredited professional architectural degree program. All students can access and review the NAAB Conditions of Accreditation (including the Student Performance Criteria) on the NAAB
Website: http://www.naab.org/accreditation/2009_Conditions.aspx