ARCH 607
ADVANCED COMPUTATION:
DIGITAL TOOL DEVELOPMENT


CATALOG DESCRIPTION

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 tool sets 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/C# 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.

LOCATION

Waite Phillips Hall (WPH) B36 (Map)
COURSE DESCRIPTION

“Geometry is still geometry, regardless of the machines that process it - compass or computers.”

From Alberti’s perspective methods, to Borromini’s geometric diagrams, and as recently as Luigi Moretti’s parametric algorithms, the architectural discipline continues to develop numerous processes for design through the framework of systems. Cameron Wu’s "Of Circles and Lines" and Baroque Machinations continues this systemic tradition by means of a new instrument for architectural generation: the animated parametric plan. By using Baroque church plans as compositions for constructing a set of parametric relationships, Wu’s animations reveal these projects’ latent formal possibilities that transcend any aesthetic tropes associated with computational design. These instantiated plans are derived from geometric relationships, which are parameterized and reimagined in various states to produce a “higher mode of transformational thinking about architectural and geometric part-to-whole relationships that is not dependent solely on attributes of material plasticity for its legibility.”

In “Building with Geometry, Drawing with Numbers,” Mario Carpo outlines the “transition from classical and medieval geometry to modern number-based calculations” that took place during the Renaissance and influenced Borromini’s aforementioned geometric system for Sant’Ivo alla Sapienza. He posits our digital era is bookended by two factors: the shift towards numbers on one end and spline-modeling software on the other. With the emergence of the spline that has ushered a “revival of [pure] geometry as a tool for design,” designers are afforded new opportunities to interact with geometry that can address conditions of irregularity with formal continuity. Whereas Borromini’s compass facilitates parametric relationships with fixed geometric primitives, splines permit geometric flexibility at the expense of coherent and systemic parameters. By combining these instruments through custom software, architects can develop bespoke computational compasses for creating reciprocal relationships between systems and the contexts with which they engage. While a traditional compass’s only parameter is its radius, by leveraging software as a design tool we can make combinatory instruments that manage multiple design ambitions for balancing interior relationships with exterior contexts. While existing digital modeling software allows us new degrees of interaction, custom computing permits us a new state of control.

With increasing software ubiquity and literacy, it is difficult to separate the design process from the software itself. The emergence of accessible software has collapsed the traditional flow of creativity, to the extent that, as Mario Carpo puts it, “digital tools are no longer the tools for making: they are primarily tools for thinking.” This seminar takes on the premise that software is an ingrained part of the contemporary creative process where scripting literacy is critical for future architecture production.

ASSIGNMENTS

Project Description:
https://docs.google.com/document/d/19RCbSQdcG0EWLhkm0yFVmBYRHlmgUG6O_rCoCyr_tswg/edit?usp=sharing

LEARNING OBJECTIVES

This course is designed to introduce advanced computational design using Rhinoceros 3D—a NURBS surface modeling program—and Grasshopper3D—visual programming language and associative modeling environment—and C#—An object oriented coding language. The course will focus on fundamental concepts and techniques in computational design, an ad hoc set of methods borrowed from computer science, computational geometry, animation, and video games, and adapted to specific design problems. The first half of the semester will be spent developing scripting literacy and understanding coding syntax. The second half of the semester will translate this literacy to architectural tool suites. The students are expected to acquire some hands-on experience in programming as this is the craft that underpins computational design. An intuitive and critical understanding of programming as it applies to our digital instruments is valuable for evaluating them and their results. Therefore, evaluation of the assignments will not be based solely on technical complexity or accomplishment, but the computational design integrity and the ability to take advantage of limitations and even "bugs" in your assignments will be equally important.

1. Develop coding language literacy and read and write basic syntax.
2. Understand fundamental programming concepts and theories.
3. Develop knowledge around data types and data structures.
4. Learn to translate scripting to architectural production.
5. Produce deployable tools for architectural production.

COURSE NOTES

The semester will be conducted in meetings on Tuesdays. Each meeting will encompass a short lecture on a theme and associated precedent, concluding with a longer technique workshop where students will follow an in class tutorial to develop their technical skillset related to the theme. Project updates are frequent to include incremental advancement in the aforementioned technical skills and thematic understanding.

Every other week there will be a git commit. The purpose of the bi-weekly git commits will be to see if you can conceptualize through programming what has been presented in your reading and the lecture. Scripting, therefore, becomes a way of thinking. Thus, each week there will be three aspects to your work: tutorial project application, project development, and attendance at the lecture and interactive representation review.
SOFTWARE REQUIRED

All tutorials and templates will be given using the following software: Rhino 7, Grasshopper, Visual Studio 2019, (optional) Revit 2022, (optional) Unity3d 2021. Tutorials will be given on Windows OS, however Mac OS may be used as well. Tutorial instructions may differ slightly on Mac OS. Students will be required to look into solutions if their software differs from those used in demos. Mice are required at all times.

The course will utilize Slack for communication and coordination and Github and Google Drive for submissions.

DESCRIPTION AND ASSESSMENT OF ASSIGNMENTS

An intuitive and critical understanding of programming as it applies to our digital instruments is valuable for evaluating them and their results. Therefore, evaluation of the assignments will not be based solely on technical complexity or accomplishment, but the computational design integrity and the ability to take advantage of limitations and even “bugs” in your assignments will be equally important. Assignments will be assessed based on the following Rubric:

<table>
<thead>
<tr>
<th>Rubric</th>
<th>100%</th>
<th>75%</th>
<th>50%</th>
<th>25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological Proficiency</td>
<td>Exceptional scripting functions, operations, and techniques.</td>
<td>General scripting functions, operations, and techniques.</td>
<td>Basic scripting functions, operations, and techniques.</td>
<td>Bad scripting functions, operations, and techniques.</td>
</tr>
<tr>
<td>Scripting Legibility</td>
<td>Script is exceptionally legible and organized.</td>
<td>Script is generally legible and organized.</td>
<td>Script is somewhat legible and organized.</td>
<td>Script is not legible and organized.</td>
</tr>
<tr>
<td>Design Development</td>
<td>Work is exceptionally unique and interesting. Exceptional understanding and application of design principles.</td>
<td>Work is generally unique and interesting. Good understanding and application of design principles.</td>
<td>Work is somewhat unique and interesting. Minimal understanding and application of design principles.</td>
<td>Work is not unique and interesting. Lack of understanding and application of design principles.</td>
</tr>
<tr>
<td>Representation</td>
<td>Communicates design exceptionally using architectural presentation materials and techniques.</td>
<td>Communicates design generally using architectural presentation materials and techniques.</td>
<td>Communicates design somewhat using architectural presentation materials and techniques.</td>
<td>Does not communicate design using architectural presentation materials and techniques.</td>
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</table>

GRADING BREAKDOWN

<table>
<thead>
<tr>
<th>###</th>
<th>Assignment Title</th>
<th>Points</th>
<th>% of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>001.A</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>002</td>
<td>001.B</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>003</td>
<td>001.C</td>
<td>10</td>
<td>10%</td>
</tr>
</tbody>
</table>
ASSIGNMENT SUBMISSION POLICY

Each assignment will be submitted to Github or Google Drive as specified in the Project Description, meeting the deadlines and protocols specified by assignment briefs and Schedule. Each student must be prepared to discuss their assignment in class. If in a group, only one student needs to submit the assignment with their group name (not both names).

SCHEDULE

<table>
<thead>
<tr>
<th>Date</th>
<th>W</th>
<th>Time</th>
<th>Theme</th>
<th>Technique Workshop</th>
<th>Precedent</th>
<th>Project</th>
<th>Due</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022.08.23</td>
<td>0</td>
<td>6:00-7:50</td>
<td>Programming Syntax</td>
<td>C#: Component: variables, types (string, int, double, boolean), operators, conditional statements, loops, parallel loop, Rhino API</td>
<td>Digital Project, Gehry Technologies</td>
<td>001</td>
<td></td>
<td>Formulations, Andrew Witt; Grayboxing (Log 43), Andrew Witt</td>
</tr>
<tr>
<td>2022.08.30</td>
<td>0</td>
<td>6:00-7:50</td>
<td>Data Structures</td>
<td>C#: Lists, Arrays, Dictionaries, Tuples, DataTree: Flatten, Graft, Simplify, Path Mapper, Relative Item, Split Tree,</td>
<td>Lewis Residence, FOGA</td>
<td></td>
<td>-</td>
<td>Post Digital Quitters: Why the Shift Toward Collage is Worrying, Mario Carpo</td>
</tr>
<tr>
<td>2022.09.06</td>
<td>0</td>
<td>6:00-7:50</td>
<td>Functions</td>
<td>C#: Functions, Recursion, Point3d, Vector3d, Plane, Line, Polyline, Curve, PolyCurve, Nested Looping</td>
<td>Baroque Machinations, Cameron Wu; Tempietto Inversum, Iman Fayyad</td>
<td>-</td>
<td>001.A</td>
<td>Of Circles and Lines (Log, no. 31), Cameron Wu</td>
</tr>
<tr>
<td>2022.09.13</td>
<td>0</td>
<td>6:00-7:50</td>
<td>Geometry</td>
<td>C#: Breps, Faces, Edges, IDE (Visual Studio 2019)</td>
<td>Kasita Placement; Certain Measures; Form Maps; Certain Measures</td>
<td>-</td>
<td>-</td>
<td>Building with Geometry, Drawing with Numbers (When Is the Digital in Architecture?), Mario Carpo</td>
</tr>
<tr>
<td>2022.09.20</td>
<td>0</td>
<td>6:00-7:50</td>
<td>Transforms</td>
<td>C#: Transform, Translation, Rotation, Projection, Scaling, Quaternions, non-euclidean space</td>
<td>Stadium N, Luigi Moretti</td>
<td>-</td>
<td>001.B</td>
<td>Exhibition of Parametric Architecture and of Mathematical and Operational Research in Town-Planning, Luigi Moretti</td>
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<tr>
<td>2022.09.27</td>
<td>0</td>
<td>ASY NC</td>
<td>Object Oriented Programming 1</td>
<td>C#: Objects, Classes, Namespace, Inheritance, Unity3D API</td>
<td>Embryological House, Greg Lynn, Cardiff Bay Opera Houses (Reiser + Umemoto, Greg Lynn)</td>
<td>-</td>
<td>-</td>
<td>Animate Form, Greg Lynn; Embryological Housing, Greg Lynn; Probable Geometries: The Architecture of Writing in Bodies, Greg Lynn; Beautiful Monsters, Greg Lynn, The Mathematics of the Ideal Villa, Collin Rowe: New Variations on the Rowe Complex, Greg Lynn, Computer Animisms: Two Designs for the Cardiff Bay Opera House, Greg Lynn, Jesse Resier, Nanako Umemoto</td>
</tr>
</tbody>
</table>

ARCH 607 / Spring 2022 / COURSE SYLLABUS / 2021.08.02 / P. 5/11
### ADDITIONAL POLICIES

#### ATTENDANCE

It is essential and required for all students to be on time and present for all seminar meetings, class lectures, and reviews. Lateness and absences will be recorded and can seriously affect course grades. Dates called out in the syllabus as review dates are considered examination periods. Absences on project review dates may lead to automatic failure of the assignment unless pre-approved by the instructor. Such an absence may only be due to personal illness, family emergency, or religious observance. Additionally, it is important that students have read the readings prior to class and participate in class discussions.

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<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Title</th>
<th>Content</th>
</tr>
</thead>
</table>
| 2022.10.04 | 6:00-7:50 | **Object Oriented Programming** 2 | C#: Objects, Classes, Namespace, Inheritance, Revit API
Conway's Game Of Life, John Conway; Flatwriter, Yona Friedman |
| 2022.10.11 | 6:00-7:50 | Mesh                                       | C#: meshes, faces, edges, vertices, subdivision
Software, No.4, Software, No. 14, MOS Architects |
| 2022.10.18 | 6:00-7:50 | Optimization                               | C#: Parallel Processing, Optimization, Memory
ArchiGAN, Stanislas Chaillou |
| 2022.10.25 | 6:00-7:50 | Individual Crits                          | -                                                                       |
| 2022.11.01 | 6:00-7:50 | Individual Crits                          | -                                                                       |
| 2022.11.08 | 6:00-7:50 | Individual Crits                          | -                                                                       |
| 2022.11.15 | 6:00-7:50 | Final Demo                                 | -                                                                       |
| 2022.11.22 | 6:00-7:50 | Holiday                                    | -                                                                       |
| 2022.11.29 | 6:00-7:50 | Guest Lecture (Gehry Technologies)        | -                                                                       |
| 2022.11.22 | 6:00-7:50 | Holiday                                    | -                                                                       |

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ACADEMIC INTEGRITY

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Campus, the Student Guidebook, contains the Student Conduct Code in Part B, while the recommended sanctions are located in Appendix A: https://policy.usc.edu/scampus-part-b/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The review process can be found at: https://sjacs.usc.edu/.

RELIGIOUS OBSERVANCES

The University recognizes the diversity of our community and the potential for conflicts involving academic activities and personal religious observation. The University provides a guide to such observances for reference and suggests that any concerns about lack of attendance or inability to participate fully in the course activity be fully aired at the start of the term. As a general principle students should be excused from class for these events if properly documented and if provisions can be made to accommodate the absence and make up the lost work. Constraints on participation that conflict with adequate participation in the course and cannot be resolved to the satisfaction of the faculty and the student need to be identified prior to the drop/add date for registration. After the drop/add date the University and the School of Architecture shall be the sole arbiter of what constitutes appropriate attendance and participation in a given course. Any student concerned about missing class for a recognized religious holiday should bring this matter up with your instructor in the first week of classes. A list of recognized religious holy days may be found at: http://orl.usc.edu/life/calendar/.

DISABILITY ACCOMMODATIONS

The University of Southern California is committed to full compliance with the Rehabilitation Act (Section 504) and the Americans with Disabilities Act (ADA). As part of the implementation of this law, the University will continue to provide reasonable accommodation of academically qualified students with disabilities so those students can participate fully in the University's educational programs and activities. Although USC is not required by law to change the “fundamental nature of essential curricular components of its programs in order to accommodate the needs of disabled students,” the University will provide reasonable academic accommodations. The specific responsibility of the University administration and all faculty serving in a teaching capacity is to ensure the University's compliance with this policy.

The general definition of a student with a disability is any person who has “a physical or mental impairment which substantially limits one or more of such person's major life activities,” and any person who has “a history of, or is regarded as having, such an impairment.” Reasonable academic and physical
accommodations include but are not limited to: extended time on examinations; substitution of similar or related work for a non-fundamental program requirement; time extensions on papers and projects; special testing procedures; advance notice regarding book lists for visually impaired and some learning disabled students; use of academic aides in the classroom such as note takers and sign language interpreters; early advisement and assistance with registration; accessibility for students who use wheelchairs and those with mobility impairments; and need for special classroom furniture or special equipment in the classroom.

Obtaining Accommodations:
General: 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 your studio instructor 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. Physical Accommodations: DSP will work with classroom scheduling, the course instructors and their departments, and the students to arrange for reasonable accommodations.

Academic Accommodations: Students seeking academic accommodations due to a physical or learning disability should make the request to the course instructor prior to or during the first week of class attendance, as well as registering with DSP as early in the semester as possible. Course instructors will require that a student present verification of documentation when academic accommodations are being requested.

WRITING CENTER

For assistance with academic writing, students may wish to take advantage of the Writing Center maintained by USC. Evaluation of paper clarity, organization, syntax and grammar is available by appointment, free of charge. If you’d like to improve your writing and your ability to communicate your ideas, consider using this valuable resource. See their website at http://dornsife.usc.edu/writingcenter/ for more information.

SUSTAINABILITY INITIATIVE

The School of Architecture has adopted the 2010 Initiative for Sustainability, which includes the following language: “The design should engage the environment in a way that dramatically reduces or eliminates the need for fossil fuel.” This intention impacts our design process in a number of ways, including: orientation of buildings and site development to minimize negative environmental force impacts and take advantage of positive ones building modestly: providing the minimum space necessary to handle required programmatic needs maximum practical use of daylighting; careful use of orientation and provision of control/shading mechanisms to handle associated heat loads maximum practical use of passive solar techniques for heating and cooling maximum practical use of natural ventilation techniques; selection of hybrid systems for ventilation, heating and cooling which permit this.

No school can lay a claim to Sustainability sensitivity that does not institute and vigorously pursue a recycling program. This recycling program is in force at all times. We pledge to provide adequate,
well-marked recycling containers for each section and to provide a posted, printed recycling protocol so you know what goes where.

ACCREDITATION STATEMENT

The USC School of Architecture’s five-year Bachelor of Architecture program and the two-year Master of Architecture program are accredited professional architectural degree programs. 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/.

STATEMENT ON ACADEMIC CONDUCT AND SUPPORT SYSTEMS

Academic Conduct:
Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b.

Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:
Counseling and Mental Health
(213) 740-9355 – 24/7
on call studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. National Suicide Prevention Lifeline 1 (800) 273-8255 – 24/7 on call suicidepreventionlifeline.org Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention and Services (RSVP)
(213) 740-9355(WELL), press “0” after hours – 24/7
on call studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)
(213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault,
non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious
dissuasion, retaliation, and violation of interim measures.

Reporting Incidents of Bias or Harassment
(213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity
Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs
(213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing
readers/notetakers/interpreters, special accommodations for test taking needs, assistance with
architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy
(213) 821-4710
uscsa.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely
affecting their success as a student.

Diversity at USC
(213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity
Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency
UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7
on call dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in
which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety
UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7
on call dps.usc.edu
Non-emergency assistance or information.

**NETIQUETTE**

Netiquette refers to etiquette on computer networks. Students are expected to treat the online class
community as a safe, engaging, and professional space. Netiquette expectations are as follows:
- Use course content to support responses
- Strive for clarity
- Exercise professionalism on camera and in all assignments
• Think and reflect before responding
• Stay on point
• Avoid shorthand (e.g., IDK)
• Avoid sarcasm
• Avoid yelling (e.g., ALL CAPS!!!)
• Strive for quality over quantity

BEST PRACTICES

Since the class will meet on Zoom, please follow this protocol to maximize your ability to concentrate and participate with minimal distractions:
• Participate in class with web camera on, if possible
• Clear background of any visual distractions (or use designated virtual backgrounds, as requested)
• Keep microphone on mute unless speaking
• Use a headset to limit outside noises
• Alert others in their household not to disturb
• Follow established class norms for contributing to class discussion (e.g., raising hand; using chat; unmuting / muting when called upon; collaborating with small groups; presenting original work)