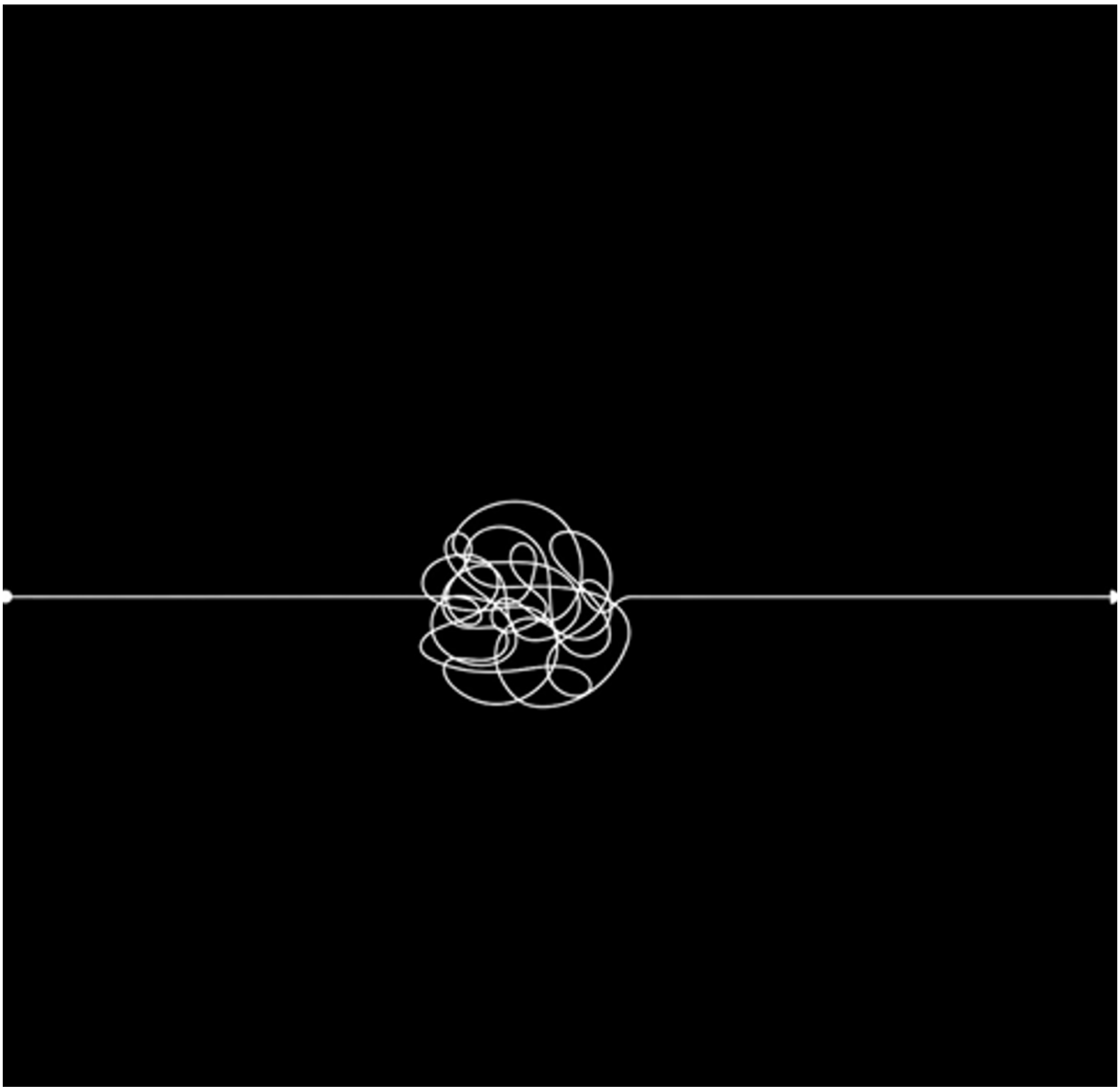

Advanced Computational Design

INSTRUCTOR
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ISSUE

What are the digital and post-digital paradigms? How can we gain literacy in computational methods, explore, and apply to our architectural design?

DESCRIPTION

This CORE course exposes students to an iterative approach for design problem solving with computation and automation tools. Students will gain exposure to computational design methods, applications, and hardware systems in the context of contemporary and future approaches to architectural design. The course has two key phases:

01_HISTORY, THEORY, AND LITERACY
Students will be exposed to the broader context of computing technology, development of computer aided design (CAD) tools, their use within design for contemporary and future practice. They will also gain computational literacy, with exposure to different types of computer languages for controlling and performing analysis on design geometry.

02_EXPLORATION, APPLICATION, AND TRANSLATION
Students will explore contemporary and novel methods for integrating computational design, digital tools, for digitization, design geometry manipulation, and synthesis. Using a Problem-Based Learning (PBL) method, they will learn to iteratively solve explore, develop, and test design geometry problems that can be applied and integrated into architecture.

Each lesson will be framed with three types of language literacy and development skills: 1) human language; 2) high level computer language (scripting); 3) graphical (node-based) coding. We will explore the potential for all three to impact developable, repeatable, design geometry for architecture.

The topics in this course refer to issues in architectural design, theory, and practice methods underpinned by contemporary and emerging technologies with computational design, artificial intelligence, computer numerically controlled (CNC) fabrication, robotics, and others. The course will provide students with skills to understand complex forces that shape architectural design, critical methods, fabrication, and technologies to synthesize architectural design works. Using a design thinking approach, students will gain computational literacy and familiarity with technologies to articulate the relationship between design abstraction and physical translation, engage in an iterative approach toward design that navigates observation, analysis, ideation, prototyping, testing, and reflection with design tools.

IMPACT AND SUSTAINABILITY

As we navigate from the digital, post-digital, and into the AI paradigm, emerging architecture graduates more-than-ever need exposure, and experience engaging with powerful tools and technologies to apply to their design work. This begins with computational literacy, and an understanding of critical methods, functions, and terminology used to translate their design ideas (human language) into directives and instructions for automatic processing. This will prepare students with awareness, engagement, and ability to operate computing tools into the future as part of their academic and future professional work in the field.

METHODS

PHASE 01 – HISTORY, THEORY, AND LITERACY

Week 1_Computational Design

Overview / Questions

- What is computational design?
- What is the history of computing technology?
- What are some important theoretical ideas associated with computing and design?
- What is serialism? What do computers do well and badly?

Activity

- Install 3D Tools
- Get acclimated to the basics of the environment / interface
- Learn to draw points, curves, primitives.
- Discuss "responsible and efficient modeling methods"
- Define Non-Uniform-B-Spline workflows vs. (Smooth) Mesh modelling, advantages, and tradeoffs.

Week 2_Computer Languages

Overview / Questions

- Understanding high level computing languages. What are they?
- Where are they situated between human language, poetry, metaphor, and high-low voltage signals as 1s and 0s.
- What is a syllogism?
- Understanding high level computing languages – what are they?
- What is a scripted language?
- What is a graphical computer language?

Activity

- Install GH toolkit / Interface
- Understand the relationship between GH and 3D environment
- Integrating and Separating objects

Week 3_Variables and Operators

Overview / Questions

- What are variables and operators (English, math, geometry, etc.)
- How do we instantiate and control variables?
- How do we apply operators to variables to create change?
- How can we perform analysis on geometry to learn about its attributes?
- How can we impose, pick, select and then use areas of geometrical interest?

Activity

- Developing Points, Vectors, Curves
- Manipulating geometry with operators and transformations
- Geometry Analysis Tools and Applications

Week 4_Data and Lists

Overview / Questions

- What is data?
- What are data types?
- How do we collect data?
- How do we find our data later?
- How can we extract / integrate data into design?

Activity
- Understanding "garbage in garbage out" and how to cleanse data.
- Simple List Management
- Data typology and inheritance
- Importing and exporting lists; linking to geometry and operators.

Week 5_Patterns
Overview / Questions
- What are patterns and how do we express them?
- What is Boolean logic and how does it work?
- How can we understand truth, falsehood, equivalence?
- What is conjunction and disjunction?

Activity
- Understanding and applying Boolean Variables (true/false).
- Using Truth Tables
- Using Boolean operations (conjunction, disjunction)
- Understanding how to apply / dispatch Boolean states to geometry.

Week 6_Loops and Conditional Statements
Overview / Questions
- How can we generate complex lists?
- What are conditional statements?
- What are loops, how do they work, and what do they represent?
- What is recursion?
- How can loops and conditional statements benefit geometry?

Activity
- Sequence and series
- Existential and Universal Quantification
- Applied patterns to geometry generation and analysis
- Weaving and Dispatching Data
- NURBS Surface analysis (U/V)
- Surface division / subdivision / reconstruction

Week 7_Midterm-Exam

PHASE 02 – EXPLORATION, APPLICATION, AND TRANSLATION

Exploring Tools and Applications (Week 8)
Overview / Questions (Week 8)
- What specific tools are being developed to streamline design processes?
- What is emergent design?
- What is a bottom-up vs. top-down approach to design in architecture?
- How can tools help with design optimization?

Activities
- Explore various applications and plugins for design exploration and optimization.
- Explore tools for conducting analysis on site and building performance.

Week 9_Digitization

Overview / Questions

- What is digitization?
- What are potential objects and phenomena that can stream from the environment into a computational model?
- How do we query, modify, manipulate, physical phenomena once digitized?
- How can scanned information direct, inform, and inspire design geometry?

Activities

- Explore microcomputers, sensors, and digitization methods.
- Understand the philosophy behind (R, G, B) -> (X, Y, Z).
- Explore scanning technologies and image mapping tools.
- Realtime (streaming data) vs. Data in Memory (files & sequences)
- Review surveying tools vs. design tools.
- Understand file-types and data storage methods.

Week 10_Synthesis

Overview / Questions

- What is Synthesis?
- How do we translate our abstract digital models into physical objects?
- What are the differences and realities that we often encounter when undergoing translation from digital to physical?
- How can translation and synthesis direct, inform, refine, and inspire design geometry?
- What is a computer numerically controlled device?

Activities

- Explore how CNC machines work (printers, 3D printers, cutters).
- Additive vs reductive fabrication and construction methods.
- Understand edge conditions.
- Understand the limits of translation from pure/primitive geometry and the realities of built environment.
- Physical properties and realities of material, fabrication, assembly, and how they can inform design and construction setups.
- Understanding computational tools can enhance, refine, and inform translation and synthesis.

Week 11_Automation Technology / Robotics

Overview / Questions

- What are robotics? How are they different to CNC machines?
- What are multi-axis machines and how do they work?
- What control systems exist to connect architects with robotic technologies?
- How to link robotics with sensors, digitization, and synthesis methods?

- *Activities*
- Explore uses for robotics in fabrication, assembly, and on-site construction.
- Develop an end effector and robotic system based on specific workflows.
- Understand different types of robots and their specific or general usage cases.

Week 12_ Artificial Intelligence

Overview / Questions

- What is Artificial Intelligence?
- What types of AI can be applied to design and architecture?
- What are the strengths and limitations of AI for design and architecture?

- What ethical concerns are raised with AI?

Activities
- Understand large language models and data-driven design.
- Understand image segmentation and how it can be applied to language models.
- Explore image-based AI tools and reflect on value to Architecture and design.
- Explore large language-based AI models, and how they may inform or misinform design data?

Week 13_Final Exam

LEARNING OUTCOMES

The goal of this course is to develop student confidence in the practical applications computation for the digital design environment. Students will become conversant in the rudiments of high-level computer language (syntax and semantics), gain confidence in defining an architectural problem, developing a response based on original procedural logic and presenting outcomes and knowledge gained through the process.

1. Ability to collaborate and participate in architectural research.
2. Ability to demonstrate verbal and written communication skills.
3. Ability to explore and develop graphic skills developed through novel technologies.
4. Ability to research drawing and geometry problems for architecture.
5. Ability to demonstrate critical thinking skills.
6. Ability to develop a problem-solving approach to challenges faced in architecture and design.
7. Awareness and literacy of computational languages in the context of architectural design and development of 3D modeling techniques.
8. Awareness of mathematical concepts such as sets, and series as applied to geometry and surface analysis.
9. Awareness of mathematical concepts such as disjunctive and conjunctive syllogisms, universal and existential quantification, and predicate calculus as an approach to practical architectural design.
10. Ability to develop and execute digitization, design, and synthesis methods
11. Awareness of the history and theory and future of digital technologies in the architecture and design field.

ASSESSMENT SCHEME

SPECIFIC ASSESSMENT

1_ Midterm Exam: **20%**
2_ Group Assignment: 40%
3_ Final Exam: 40%

Total: 100%

COURSE FORMAT

1_Teaching Days
1. Students must attend F2F teaching during these teaching hours.
2. Schedule: T2 – Thursdays 9:30AM

3. Lecture Hall: YASUMOTO INT'L ACADEMIC PARK LT6.

2_Group Work

1. Students will work in groups on a major assignment requiring one presentation.
2. Students are encouraged to share references, and collaborate on problem solving efforts, however, individual literacy and knowledge retention is required for examinations.

3_Written Exams

3. There are two written examinations over the course. These will be a mix of written (essay style questions) and "fill in the blank" that demonstrate computational literacy across different formats and languages (human/python/grasshopper/others).
4. Exams will be based on assigned readings, assignments, and material covered within course lectures/demonstrations.

REQUIRED/ RECOMMENDED READINGS

McNeel Python Wiki: http://wiki.mcneel.com/developer/python
Rhinoceros Tutorials: http://www.rhino3d.com/learn
Lyons, John. (1977) Semantics. Cambridge: Cambridge UP, 1977. Print.
ISSA, Rajaa, Essential Mathematics for Computational Design
Bandur, Markus. Aesthetics of Total Serialism: Contemporary Research from Music to Architecture.
Lynn, Greg. Animate Form. New York: Princeton Architectural, 1999. Print.
Gramophone, Film, Typewriter: Friedrich Kittler
Here/There: Telepresence, Touch, and Art at the Interface: Kris Paulsen
Programmed Visions: Software and Memory: Wendy Hui Kyong Chun

IMPORTANT NOTE TO STUDENTS

Expectations for Professional Conduct
The motto of The Chinese University of Hong Kong (CUHK) is "Through learning and temperance to virtue". This motto places equal emphasis on the intellectual and moral education of students. In addition to pursuing academic excellence, students of CUHK are expected to maintain and uphold the highest standard of integrity and honesty in their academic and personal lives, respect the rights of others and abide by the law. More information on Postgraduate studies can be found in the PG Student Handbook. https://www.gs.cuhk.edu.hk/

Attendance
Class attendance is required in all courses. For an excused absence, the instructor must be notified and presented with documentation of illness or personal matter. Please note: **Three (3)** or more unexcused absences may result in a failing grade for the course.

Academic Honesty
The Chinese University of Hong Kong places very high importance on honesty in academic work submitted by students and adopts a policy of zero tolerance on academic dishonesty

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 may be required to submit a statement that they are aware of these policies, regulations, guidelines and procedures.

Third-Party Assistance
All intellectual work essential to the design project must be completed by the student and cannot, under any circumstance, be outsourced to a third party (including, but not limited to a company, consultant, alumni, and/or friend).

In the design studio context, students may utilize external resources, such as printing services for presentation materials, and/or laser cutting and 3D printing services for prototyping purposes. Use of such third-party services constitutes non-intellectual work done by others. It is only permitted with prior written consent from the studio tutor and acknowledgment of such work done by the third party.

Assistance from other students or friends for aspects of project production also constitutes non-intellectual work done by others; this is allowed only if declared and acknowledged in a written statement attached to any such work that has received assistance.

Under all circumstances, students must declare all work done by others by completing the school's designated form before assessment. This form must include a detailed explanation of the third party's identity (name and relationship to the student), when and how they were utilized, and the specific tasks they performed in the project. The completed form, signed by the student, must be endorsed by the tutor and presented during the final review. The school will collect and retain this form for record-keeping purposes.

Failure to follow this code of conduct may be considered a case of academic dishonesty, to be reviewed by a disciplinary board, and possible failure of the course.

Artificial Intelligence
Unless approved by the Programme or School Director, any use of AI tools such as ChatGPT or image generation tools (Midjourney) etc. is strictly prohibited and may result in disciplinary action in accordance with university policy on academic honesty. Students may refer to the CUHK 'Use of Artificial Intelligence tools in Teaching, Learning and Assessments' – A Guide for Students.

Student Work
Submission of studio documentation must be complete and correctly formatted. Missing or incomplete submission of the documentation folder will result in the grade for the course being withheld. This will prevent registration for the following term or delay graduation. In addition, a grade deduction of *one letter grade* will be made.

GRADE DESCRIPTOR

Grade	Descriptor	Criteria	Points
A	Excellent	Outstanding performance on all learning outcomes.	4
A-	Very Good	Generally outstanding performance on all (or almost all) learning outcomes.	3.7
B+	Good	Substantial performance on all learning outcomes, OR high performance on some learning outcomes which compensates for	3.3
B			3

B-		less satisfactory performance on others, resulting in overall substantial performance.	2.7
C+	Fair	Satisfactory performance on the majority of learning outcomes, possibly with a few weaknesses.	2.3
C			2
C-			1.7
D+	Pass	Barely satisfactory performance on a number of learning outcomes.	1.3
D			1
F	Failure	Unsatisfactory performance on a number of learning outcomes, OR failure to meet specified assessment requirements.	0

Written Feedback to Students

Term: ________________________________ **Grade:** ________________________

Course: ______________________________ Date: ___________________________

Assignment: ___________________________ Student Name: ___________________

Studio Tutor: __________________________ Student ID: _____________________

Feedback from Studio Tutor:

Achievements:

Challenges: