ARCHITECTURAL GEOMETRY 2

IE University
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Academic year: 22-23
Degree course: SECOND
Semester: 1º
Category: BASIC
Number of credits: 6.0
Language: English

PREREQUISITES
Architectural Geometry I.
Basic knowledge of Rhinoceros 3D and Grasshopper.

SUBJECT DESCRIPTION
Computation has a profound impact on a contemporary understanding of architectural form, space and structure. It shifts the way one perceives form, the way in which form is purposed, and the way in which form is produced. Computation has given architects new creative opportunities, it is a whole new spatial context for design that is free from the static Cartesian structure of the two dimensional drafting plane. The course establishes a conceptual framework of the digital in architecture and it goes beyond geometry and form applying the potential offered by computational tools in order to design a system, a recipe, which will take into consideration geometrical constrains to create not just one freezed solution but multiple simultaneous possibilities.

OBJECTIVES AND SKILLS
The course will provide a new method to explore spatial organization through geometry. Through the display of real models of contemporary architectural production, the course will provoke discuss about the epistemology of geometry. The students will activate a series of logical deformation of these geometry models, in this iterative process of modeling and remodeling, students will gain an understanding of geometry around them. The most effective way to improve seeing is by developing language that matches the richness and complexity of what we see. Students will be looking at buildings without drawing themselves but finding the code, the logic, the steps to reach that form.
This course aims to address the various natures of the relationship between mathematics, geometry, computation and architecture. The primary objective is to provide students with the tools to imagine and represent architecture and its forms through coding. We will begin but using parametric tools to examine existing architectural examples, with the intentions of understanding the logic behind a shape, exploring its logic to get acquainted with the growing landscapes of computational design practices. Through this analyzation, student will construct their own geometrical narrative to express parametric formal relationships. It will provide an opportunity for the students to enhance their knowledge about algorithms both in regards to gaining the practical scripting skills and understanding the relevant theoretical aspects of form generation and related mathematical principles underlying patterns in the physical world.

The second aim of the course is to communicate the principles of Building Information Modelling and its potential in a design process. With this methodology, students can create virtual architectural models, which, apart from the geometry, include other kinds of information. They will learn how to deal with data and hot to use it to inform their designs.

Throughout the course, students will use different software such as Rhinoceros/Grasshopper and Revit/Dynamo to create their own digital environment to develop their designs.


**BASIC AND GENERAL OBJECTIVES**

- **CB1**: Students have demonstrated knowledge and an understanding of a given area of study, building upon the foundation of secondary education, supported by advanced texts, and including aspects that engage the latest advances in their area of study.
- **CB2**: Students know how to apply their knowledge professionally to their work or vocation and possess the competencies that are often demonstrated through elaboration and defense of arguments and the resolution of problems within their area of study.
- **CB3**: Students can gather and interpret relevant facts (usually within their area of study) in order to make judgments that include reflection on relevant social, scientific, and ethical topics.
- **CB4**: Students can transmit information, ideas, problems, and solutions to both specialized and non-specialized audiences.
- **CB5**: Students have developed the necessary learning skills to continue their studies with a high degree of autonomy.
- **CG2**: Knowledge of the role of the fine arts as a factor that can influence the quality of architectural creation.
- **CG7**: An understanding of the relationship between people and buildings, and between buildings and their contexts, as well as the need to relate buildings and adjacent spaces to needs and to the human scale.

**SPECIFIC COMPETENCIES**

- **CE1**: Ability to apply graphic knowledge to the representation of spaces and objects.
- **CE3**: Adequate knowledge of systems of spatial representation, as applied to architecture and urbanism.
- **CE4**: Adequate knowledge of formal theory and analysis, and the laws of visual perception, as applied to architecture and urbanism.
- **CE5**: Adequate knowledge of metric and projective geometry, as applied to architecture and urbanism.

**TRANSVERSE COMPETENCIES OF THE UNIVERSITY**

- **CT2**: Ability to exercise professional behavior in accordance with constitutional principles and
ethical values of the respective profession.
- CT3: Manage unforeseen situations with the capacity to respond to changes within organizations. CT4: Use disciplinary knowledge to analyze and evaluate current situations.
- CT5: Integrate oneself into interdisciplinary and multicultural teams to achieve common goals in a context of diversity.
- CT6: Work actively in an international context.
- CE6: Adequate knowledge of graphic surveying techniques in all phases, from sketching to scientific restitution, as applied to architecture and urbanism.
- CE10: Adequate knowledge of the fundamentals of topography, hypsometry, cartography and site grading, as applied to architecture and urbanism.

METHODOLOGY
Each double session has a distinct theme, an exploration of a distinct aspect of computational geometry. The sessions begin with a lecture where the theory will be introduced and explained, but the bulk of our time is be spent actively working through a series of exercise to understand what we see out of us and implement the introduced concept within 3D modeling and parametric logics. Students will utilize both digital and physical media.

Teaching throughout the course will be based on learning through exploration and experimentation with algorithmic principles. Students will be asked to maintain a digital diary, catalogue of experiments explored, chronicles and reflects on the digital workflows to which they have been introduced. They will be expected to experiment with these workflows in a self-directed manner beyond what is introduced in class. Thereafter, these geometrical narratives will be translated into physicals models. Every double session, students must submit the diary chapter of the previous double session.

Assignments will be started and developed in class and are to be completed at home. During the sessions the professor will make corrections and answer questions both individually and to the whole group.

There will be an exam at the end of the semester that will include all the concepts studied in class. Out of the 30 sessions:

- 14 sessions are dedicated to lectures and tutorials. Students are asked to follow along the tutorials on their own computers.
- 2 sessions are dedicated to the final exam.
- 14 sessions are dedicated to in class applications of concepts learned during the course.

<table>
<thead>
<tr>
<th>Teaching methodology</th>
<th>Weighting</th>
<th>Estimated time a student should dedicate to prepare for and participate in</th>
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</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>36.67 %</td>
<td>55 hours</td>
</tr>
<tr>
<td>Discussions</td>
<td>13.33 %</td>
<td>20 hours</td>
</tr>
<tr>
<td>Exercises</td>
<td>36.67 %</td>
<td>55 hours</td>
</tr>
<tr>
<td>Group work</td>
<td>0.0 %</td>
<td>0 hours</td>
</tr>
<tr>
<td>Other individual studying</td>
<td>13.33 %</td>
<td>20 hours</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0 %</td>
<td>150 hours</td>
</tr>
</tbody>
</table>

PROGRAM

SESSIONS 1 - 2 (LIVE IN-PERSON)
Introduction to Computational Design

SESSIONS 3 - 4 (LIVE IN-PERSON)

Packing
Produce stability through adjacency.
\ Space Grids, Space Filling Shapes, Filtering Logics.

SESSIONS 5 - 6 (LIVE IN-PERSON)

Stacking
Assemble a Tectonic Shape.
\ Reciprocal Structure, Stacked Geometry, 3D printing logics.
Assignment 1 OUT – Parametric Walls (20% of the grade).

SESSIONS 7 - 8 (LIVE IN-PERSON)

Sectioning
Approximate a Free-from Shape using Planar Objects.
\ Physical intersections of Curves, Surfaces, Solids.

SESSIONS 9 - 10 (LIVE IN-PERSON)

Membranes
Physical Digital Engines (Particle-Spring Systems).
\ Mesh Relaxation and Hanging models. Collisions. Smoothing meshes.
Assignment 1 DUE – Parametric Walls (20% of the grade).

SESSIONS 11 - 12 (LIVE IN-PERSON)

Adaptive Components
Sharing a Logic Being Different.
\ Parametric Variations. Surface Paneling and Tessellation. Graph Theory.
Assignment 2 OUT – Surface Tessellation (20% of the grade).

SESSIONS 13 - 14 (LIVE IN-PERSON)

BIM Technology

SESSIONS 15 - 16 (LIVE IN-PERSON)

Architectural BIM
Modelling Constructive Elements: Walls, Floors, Stairs, Beams and Columns, Roofs.
Assignment 2 DUE – Surface Tessellation (20% of the grade).
SESSIONS 17 - 18 (LIVE IN-PERSON)
Architectural Digital Workflows
Connecting Different Tools creating Customizable Workflows. Introduction to Rhino-Inside.

SESSIONS 19 - 20 (LIVE IN-PERSON)
Modularity
\ Wave Function Collapse.
Assignment 3 OUT – Growing Agglomeration (20% of the grade).

SESSIONS 21 - 22 (LIVE IN-PERSON)
Generative Design
Principles and Techniques. Applying Generative Design to Architecture.
\ Case Study: Energy Analysis and Optimization.

SESSIONS 23 - 24 (LIVE IN-PERSON)
Assignment Review
Students are expected to explain the concept they want to develop, bringing drawings and diagrams. References and guidance will be given based on the needs and directions of each proposal. Peer-reviews will take place at the end of the session.

SESSIONS 25 - 26 (LIVE IN-PERSON)
Loops
Develop the rule of self-similarity.
\ Aesthetics of Repetitions, Fractal Geometry, Branching.

SESSIONS 27 - 28 (LIVE IN-PERSON)
Informed Drawings
Views, Plans and Managing the Design Information.
Assignment 3 DUE – Growing Agglomeration (20% of the grade)

SESSIONS 29 - 30 (LIVE IN-PERSON)
Final Exam
Students will be asked to code the shape of a building showed to them (30% of the grade).

BIBLIOGRAPHY
Recommended

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EVALUATION CRITERIA

A. CLASS PARTICIPATION
Three main criteria will be used in reaching judgment about your class participation:

Depth and Quality of Contribution: the comments and questions must be relevant to the topic discussed in class. Students are encouraged to ask questions when something remains unclear to them. It is appreciated if students attempt to respond the questions of their peers and help them move forward.

Frequency: Frequency refers to the attainment of a threshold quantity of contributions that is sufficient for making a reliable assessment of comment quality. Your attempts at participation should not be such that the instructor has to “go looking for you”. You should be attempting to get into the debate on a regular basis.

B. ASSIGNMENTS
The course relies on three assignments that require the student to work outside the class. The details of what these submissions imply will be discussed in detail in class and are mention above in the course program. The assignments are mandatory and make up the 60% of the final grade. Students will be asked to keep a digital diary. Every couple session will be a chapter in this diary, explaining and exploring with the process learnt. The digital diary is mandatory.

C. FINAL EXAM
The last two sessions will be dedicated to the final exam which makes up 30% of the final grade. The final exam will be based on everything studied from session 1 to 28 and the details will be discussed previously in class. Students are allowed to bring their own notes and support material, so they are encouraged to take notes throughout the course.

D. FINAL GRADE
The final grade breakdown:

• Sobresaliente/Outstanding: 9.0-10.0 (A to A+)
  Consistently produces work of the highest quality and craft; exhibits notable progress and development over the course of the semester; meets all course objectives at highest level; attendance is near-perfect, and contributions to course discussions are extremely valuable.

• Notable: 7.0-8.9 (B to B+)
  Completes all assignments with work of above-average quality and craft; exhibits significant progress and development; meets most course objectives; attendance and participation are very good.
Each student has 4 chances to pass any given course distributed in two consecutive academic years (regular period and July period).

Students who do not comply with the 70% attendance rule will lose their 1st and 2nd chance, and go directly to the 3rd one (they will need to enrol again in this course next academic year).

Grading for retakes will be subject to the following rules: Students failing the course in the first regular period will have to do a retake in June (except those not complying with the attendance rules, which are banned from this possibility). Dates and location of the June retakes will be posted in advance and will not be changed. Please take this into consideration when planning your summer. The maximum grade that a student may obtain in any type of retake will be 8 out of 10.

The retakes will consist on a comprehensive exam. The grade will depend on the performance in this exam and the submission of all the assignments; continuous evaluation over the semester will not be taken into account. This exam will be designed bearing in mind that the passing grade is 5 and the maximum grade that can be attained is 8.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Percentage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Exam</td>
<td>30 %</td>
<td></td>
</tr>
<tr>
<td>Assignments</td>
<td>60 %</td>
<td></td>
</tr>
<tr>
<td>Class Participation</td>
<td>10 %</td>
<td></td>
</tr>
</tbody>
</table>

E. RETAKE POLICY

- Each student has 4 chances to pass any given course distributed in two consecutive academic years (regular period and July period).
- Students who do not comply with the 70% attendance rule will lose their 1st and 2nd chance, and go directly to the 3rd one (they will need to enrol again in this course next academic year).
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PROFESSOR BIO

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Alessandro is a co-founder of 50SuperReal studio, where he focuses on applying coding to the automatisation of design and technical processes, as well as playing the role of BIM Manager and computational expert.

He is currently an adjunct professor at IE School of Architecture and Design where he teaches Mathematics and Computational Geometry, Co-Director at Structuralia in the Master “BIM and Smart Buildings” as well as professor in the “Programming applied to BIM” Master program.
Alessandro spends a lot of his time in educational processes, giving lectures, workshops and corporate training programs. Previously, he has been teaching in ETSAM as part of the Masters in Advanced Infographics, and you can find his online classes on several different educational and professional platforms. He has also been a researcher in the Institute of Advanced Architecture of Catalonia, focusing on urban scale projects, and part of MargenLab team designing and building architectural prototypes based on energy modelling and sustainable strategies.

Currently he is focusing his career in pushing the boundaries of the Building Information Modelling methodology. Processes as advanced modelling, automatisation and data informed geometry are his main topics of research, mixing programming and drafting to explore the digital capabilities of architecture and design.

Alessandro graduated cum laude in 2015 from the Faculty of Engineer in Pisa with a master degree in “Building Engineering and Architecture”, presenting a project that studied the intersection between vernacular architecture and information technologies, which can be found in several publications. Through exchange programs, he has also studied at the Technical University of Riga and the Institute of Advanced Architecture of Catalonia (IAAC). In 2016 he enrolled the International Master BIM Manager from Zigurat, Global Institute of Technology.

OTHER INFORMATION
Students are required to bring their own laptop with a mouse and a sketchbook to each class. Students who fail to do so will be marked as “Absent”.
All students must have Rhinoceros 3d and the Grasshopper plug-in pre-installed, before the course starts.