ARCHITECTURAL GEOMETRY 2

Bachelor in Architectural Studies BAS SEP-2023 AG2-AS.2.S.A

Area Architecture and Design

Number of sessions: 30

Academic year: 23-24

Degree course: SECOND

Number of credits: 6.0

Semester: 1º

Category: BASIC

Language: English

Professor: **ALESSANDRO MATTOCCIA**

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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 programe.

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 profesional 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. Trough 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.

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SUBJECT DESCRIPTION

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. These ruled-based systems create a collection of recipes not to create a unmutable design shape but rather the computation process to produce multiple simultaneous possibilities.

LEARNING OBJECTIVES

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 how to use it to inform their designs.

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

(according to Ministerial Decree EDU/2075/2010, 29 of July, and the official accreditation request for the Bachelor in Architectural Studies, July 2015; see BOCYL, 14 March p. 10477-10481).

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.

TEACHING METHODOLOGY

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.

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.

IE University teaching method is defined by its collaborative, active, and applied nature. Students actively participate in the whole process to build their knowledge and sharpen their skills. Professor's main role is to lead and guide students to achieve the learning objectives of the course. This is done by engaging in a diverse range of teaching techniques and different types of learning activities such as the following:

Learning Activity	**Weighting**	**Estimated time a student should dedicate to prepare for and participate in**
Lectures	20.0 %	30.0 hours
Discussions	6.67 %	10.0 hours

Exercises in class, Asynchronous sessions, Field Work	20.0 %	30.0 hours
Group work	0.0 %	0.0 hours
Individual studying	53.33 %	80.0 hours
TOTAL	100.0 %	150.0 hours

PROGRAM

SESSIONS 1 - 2 (LIVE IN-PERSON)

Introduction to Computational Design

Historical Introduction. Digital Feedback Loop and Variations. Pattern and Systems Thinking.

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.

Assignment 1 OUT (20% of the grade)

SESSIONS 7 - 8 (LIVE IN-PERSON)

Finding Form 01

Arches, Vaults and Shells

\\ Introduction to Particle-Spring Systems. Mesh Relaxation and Hanging models.

SESSIONS 9 - 10 (LIVE IN-PERSON)

Finding Form 02

Tent Structures, Membranes and Net Constructions.

\\ Tensioning & Smoothing meshes. Minimal Surfaces.

SESSIONS 11 - 12 (LIVE IN-PERSON)

BIM Technology

History. Geometric vs non-Geometric Information. N-dimensional Models.

Assignment 1 DUE (20% of the grade)

Assignment 2 OUT (20% of the grade)

SESSIONS 13 - 14 (LIVE IN-PERSON)

Architectural BIM 01

Modelling Constructive Elements: Walls, Floors, Stairs, Beams and Columns, Roofs.

SESSIONS 15 - 16 (LIVE IN-PERSON)

Architectural BIM 02

Introduction to Families. How to create and manage Families.

SESSIONS 17 - 18 (LIVE IN-PERSON)

Adaptive Components

Sharing a Logic Being Different.

\\ Parametric Variations. Surface Paneling and Tessellation. Graph Theory.

SESSIONS 19 - 20 (LIVE IN-PERSON)

Branced Structures

A geometric system that expands through bifurcation.

\\ L-System. Three-dimensional supporting systems.

Assignment 2 DUE (20% of the grade)

Assignment 3 OUT (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)

Loops

Develop the rule of self-similarity.

\\ Aesthetics of Repetitions, Fractal Geometry.

SESSIONS 25 - 26 (LIVE IN-PERSON)

Autonomous Agents

Introduction to Complex Systems and Group Behaviors.

//Flocking. Cellular Automata and its Variations.

SESSIONS 27 - 28 (LIVE IN-PERSON)

In-class Exercises

A series of exercises to practice for the final exam.

Assignment 3 DUE (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).

EVALUATION CRITERIA

A. 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 makes up the 60% of the final grade.

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.

B. 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 in the course 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.

C. 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.
- Aprobado: 6.0-7.0 (C to C+). Completes all assignments with work of acceptable quality and craft; exhibits some progress and development; meets a majority of course objectives. Attendance and participation are acceptable.
- Aprobado: 5.0-6.0 (D). Assignments are delivered but are incomplete and/or of low quality and craft; exhibits little progress and development; meets few course objectives. Attendance and participation are poor, but absences do not total more than 30%
- Suspenso: 0-4.9 (F). Work is incomplete, missing, or does not meet course objectives. Attendance and participation are poor.
- Automatic Failure/Suspenso: 0 (F). Please note that a student who misses 30% or more of the scheduled sessions receives an automatic 0.0, and loses his or her right to the second “convocatoria.”

criteria	percentage	Learning Objectives	Comments
Final Exam	30 %		
Assignments	60 %		
Class Participation	10 %		

RE-SIT / RE-TAKE 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).

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.

BIBLIOGRAPHY

Recommended

- Helmutt Pottmann, Andreas Asperl, Michael Hofer, Axel Kilian. *Architectural Geometry.* ISBN 9781934493045 (Printed)
- Sigrid Adriaenssens, Philippe Block, Diederik Veenendaal, Chris Williams.. *BIM Design: Realising the Creative Potential of Building Information Modelling.* ISBN 9781934493045 (Printed)
- Benjamin Aranda, Chris Lasch. *Pamphlet Architecture 27: Tooling.* ISBN 9781568985473 (Printed)
- Frei Otto, Bodo Rasch. *Finding Form: Towards an Architecture of the Minimal.* ISBN 97839306986 (Printed)

BEHAVIOR RULES

Please, check the University's Code of Conduct here. The Program Director may provide further indications.

ATTENDANCE POLICY

Please, check the University's Attendance Policy here. The Program Director may provide further indications.

ETHICAL POLICY

Please, check the University's Ethics Code here. The Program Director may provide further indications.