ARCH7211: CONNECTIVE ENVIRONMENTS 2

DESIGN COMPUTATION STUDIO LAB
Tue/Thu 10:00am-12:30pm DARTS and studio space.
Course Instructor: Dr. Dimitris Papanikolaou / dpapanik@uncc.edu / Urban Synergetics Lab / Office: Storrs 146
Teaching Assistant: Atefeh Mahdavi Goloujeh / amahdavi@uncc.edu
Course website: TBD
Office Hours: Wed (by appointment).

PREMISE

The deeper information technology penetrates urban life, the more pressing is the urgency for architects, engineers, and planners not only to design more intelligent and participatory systems but also to understand their complex emerging behavior. During the past decades, the design of “smart” urban environments followed a command-and-control approach in which the city is seen as a commander for serving the needs of its users. Today, widespread expansion of computing, and simultaneous sharing of resources between people, makes this approach increasingly infeasible for the simple reason that the needs and wants of one individual may often conflict those of another.

The course investigates design, engineering, and empirical assessment of participatory cyberphysical systems of common pool resources. We will look at how information, human behavior, and physical constraints, shape the capabilities of cyberphysical sociotechnical systems, and how novel interactive technologies and design strategies may enhance them. We envision a future in which coordination emerges collectively from how humans interact with data, with and through the physical environment. Towards this goal, students will prototype enabling hardware and software technologies to connect humans, objects and places; they will design control mechanisms across scales to drive human behavior towards desired collective outcomes; and they will test these ideas through strategic game experiments.
Some provocative questions we will draw inspiration from (but we will not prove) are: Can self-governed MoD systems outperform autonomous centrally-controlled MoD systems? Is it possible to have low-tech intelligent MoD systems in which information propagates physically with the vehicles? Can the built environment manifest and communicate information physically in large participatory systems?

The studio lab will reimagine the future of shared urban mobility through the context of autonomous vehicles, complex human-in-the-loop systems, self-organization, social cooperation, and how in general, the design of urban form affects design and performance of the next generation of shared mobility systems. Moreover, we will brainstorm ideas for how shared mobility networks can be designed and used for other functions in cities, in addition to transporting people, to transporting goods.

This course is interdisciplinary. We will cover topics on information and communication technology, data visualization, systems theory, game theory, behavioral economics and mechanism design, ecology, and interaction design. You are expected to be highly motivated and find resources online on your own. We will not have the time to cover in depth all topics, tools and resources in class.

PREREQUISETS
Connective Environments 1 or prior experience with physical computing, sensors, and basics of server programming. If all these are new to you, you must team up with a student whose experience meets these requirements.

METHOD
The course combines lectures, discussions, lab assignments, readings, and student presentations, and is organized into four projects and one final paper. Each student will develop a website to document projects and weekly progress. Class meets twice per week and has one lab session (TBD). Lab assignments introduce core technologies. Final project integrates skills critically in a real architectural context that engages one or more individuals to interact with/through it. Final paper will be of publishable quality at the level of the ACM SIGCHI conferences.

TENTATIVE SCHEDULE
Weeks 01-02: Smart Cities, Mobile devices, User Interfaces, and Real Time Mapping
Weeks 03-05: Linking people, objects, and places: Creating a cyberphysical ecosystem
Weeks 06-09: Orchestrating Collective Behavior: Strategic Games, Game Theory, and Mechanism Design
Weeks 10-16: Project Development, Deployment, Experiment, and Analysis.

ASSIGNMENTS
Assignment 1 (5 days): Find and present a large-scale cyber physical participatory system. What are the components, who are the stakeholders, what are their interests, what is the feedback loop?
Assignment 2 (1 week): Create a real time map of UNCC campus or of Charlotte using real geolocation data from bikes.
Assignment 3 (3 weeks): Extend the provided network-based application platform and develop a human-device network that can exchange messages in any possible way (device-to-device, device-to-human, human-to-human, human-to-device). Implement a simple function in the microcontroller so that it updates a map and also informs users accordingly.

Assignment 4 (4 weeks): Design a participatory strategic game that involves people and places (such as a market mechanism) and its rules, such that once played iteratively by selfish individuals (each one unaware of the presence of the others), it converges to an equilibrium that you have already predefined.

Assignment 5 (8 weeks): Design, develop, implement, and test, a large scale multi-user cyberphysical participatory urban system. This can be a technology/system that helps people achieve something, a landscape-scale art installation, or anything you can imagine that connects humans, objects, landscapes, into an iterative feedback loop.

TOPICS
- Intelligent Shared Mobility Systems
- Intelligent Freight Transportation Systems
- Increasing awareness

LEARNING OBJECTIVES
By the end of the course you should:
- Practical knowledge of how to design, deploy, large-scale cyber-physical participatory network-based applications.
- Basic skills on urban sensing and urban computing
- Basic understanding of Game Theory and Mechanism Design
- Create online real-time maps
- Critically assess not only benefits but also limitations of intelligent systems

Also:
- Develop a strong thesis statement and be able to position it critically within the architecture/technology discourse
- Work independently by cultivating a learning-through-making approach to design
- Become comfortable working within unknown fields of knowledge
- Think out of the box and challenge pre-established notions about design and technology

Course Overview and Approach
The course combines lectures, discussions, and technical skill workshops. The course is organized into four thematic parts: The first part is a critical introduction to smart cities. The second part is a hands-on approach on developing networked technologies for connecting people, objects, and places. The third part introduces game theory and mechanism design (also called social engineering). The fourth part is the development of final projects.

Readings
All weekly assignments are due the beginning of next class.

CYBER PHYSICAL PARTICIPATORY SYSTEMS
A cyberphysical system (CPS) is a cybernetic system that links the physical and digital worlds. Cybernetic systems are feedback systems (e.g. systems that contain at least one control loop) that link information from past actions to drive decisions for future actions. A cyber physical participatory system (CPPS) is a CPS that involves participation of multiple humans.
NETWORK-BASED APPLICATION

Dynamic networked applications allow connected users to exchange information in real time. Working in teams you will learn, adopt, and extend, an online multi-user participatory cyber physical platform consisting of a server that can connect users and devices in a peer-to-peer manner. The platform will be provided by the Urban Synergetics Lab, and students are expected to expand it and adjust it according to their projects. The platform is based on web technologies Node.JS/Express.JS and Socket.IO. Node.JS and Express.JS is a No-SQL JavaScript-based template to build asynchronous servers. One of its benefits compared to SQL servers, besides the fact that is asynchronous, is that it uses the same programming language as the front-end side. This allows a developer (you) to use the same programming language for all components of a dynamic network application. In its simplest form, a cyberphysical participatory platform consists of a number of microcontrollers and a number of users that are all networked through a server and can exchange messages. From the point of view of the server, a client can be a human or a device with no difference between the two.

GAME THEORY AND MECHANISM DESIGN

Game Theory studies strategic situations between two or more individuals in which the decisions of one individual affect the options (and thus decisions) of the others. Game Theory asks the question: if all individuals involved in the strategic situation act selfishly, in what state will the system reach during equilibrium? Mechanism Design (or Inverse Game Theory) studies the opposite question: if we want a group of individuals to reach a predefined state of equilibrium, how should we design the rules or policies that affect their decisions and interactions?
Consider the two individuals in the above figure. Assume that each of them wants his tank to contain as much water as possible. Each individual can control only the outflow but not the inflow. Suppose initially, that each of them is unaware of the presence of the other; what will they do? Suppose next that each of them is aware of the presence of the other. What will they do now?

**CONTEXT/SITE/AREA OF STUDY**

The studio lab will use Charlotte’s North End Smart District (NESD) as an area of study. This will provide the context for your project. You are free to design any system within this area as long as it is a closed system. A closed system is a system whose components do not increase or decrease, over time, within its boundary. You are responsible to find the necessary data, drawings, any other contextual information for your site.

**GUEST TALKS (TBD)**

**COST**

You will be building in teams an interactive system consisting of Arduinos, RFID sensors, or other means of interaction. The cost of your project will depend on your decisions and the technical means you will choose.

**DOCUMENTATION**

You are expected to document your progress in the class’s blog and participate in the discussions. Make sure you cite the sources of your code, ideas, inspirations and techniques. Other people must be able to read your posts and find your resources.

**TEXTBOOK & ONLINE RESOURCES**

There is no required textbook. Most readings will come from the books “Networks, Crowds, and Markets: Reasoning about a Highly Connected World”, “Reinventing the Automobile”, and “ME++”. A list of individual readings and links is provided in the syllabus. Additional readings and links to online resources will be provided before each class.
### OFFICE HOURS
By appointment, Wednesdays.

### CALENDAR

<table>
<thead>
<tr>
<th>WEEK</th>
<th>Theme</th>
<th>Date</th>
<th>Discussion</th>
<th>Lab</th>
<th>Notes</th>
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<tbody>
<tr>
<td>1</td>
<td>Synergetic Cities</td>
<td>Thu Jan 10</td>
<td>Course Introduction From Smart Cities to Cybernetic Cities</td>
<td>Assignment 1 Out</td>
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<tr>
<td>2</td>
<td>Synergetic Cities</td>
<td>Tue Jan 15</td>
<td>Cybernetics Feedback Centralized and distributed systems</td>
<td>Collecting &amp; cleaning data Visualizing data on maps</td>
<td>Assignment 1 Presentations Assignment 2 Out</td>
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<td></td>
<td></td>
<td>Thu Jan 17</td>
<td>Moving and Sharing Intelligent mobility systems</td>
<td>Visualizing data on maps</td>
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<td>3</td>
<td>Connecting people, objects, and places</td>
<td>Tue Jan 22</td>
<td>Cyberphysical systems Human-in-the-Loop systems Anatomy of a cyberphysical system</td>
<td>Designing a Front-End User Interface Assignment 2 Presentations Assignment 3 Out</td>
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<td>Thu Jan 24</td>
<td>Building a server in Node.JS</td>
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<td>4</td>
<td>Connecting people, objects, and places</td>
<td>Tue Jan 29</td>
<td>Interacting with a Database in MongoDB</td>
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<td>Thu Jan 31</td>
<td>Chat Room Application using Socket.IO</td>
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<td>5</td>
<td>Connecting people, objects, and places</td>
<td>Tue Feb 05</td>
<td>Sending/Receiving Socket Messages with a Microcontroller</td>
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<td>Thu Feb 07</td>
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<td>6</td>
<td>Orchestrating Collective Behavior</td>
<td>Tue Feb 12</td>
<td>Social Networks Cellular Automata Self Organization Common Pool Resources Causal Loop Analysis</td>
<td>Emergent patterns in multi-agent systems Representing Social Networks Assignment 3 Presentations Assignment 4 Out</td>
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<td>Thu Feb 14</td>
<td>Game Theory Strategic Games Prisoner's Dilemma The Tragedy of the Commons</td>
<td>Examples in NetLogo First Course Evaluation</td>
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<td>Orchestrating Collective Behavior</td>
<td>Tue Feb 19</td>
<td>Game Theory Zero Sum Games Market Equilibrium</td>
<td>Market Lab in class</td>
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<td>Thu Feb 21</td>
<td>Mechanism Design (Inverse Game Theory)</td>
<td>Examples in NetLogo</td>
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<tr>
<td>8</td>
<td>Orchestrating Collective Behavior</td>
<td>Tue Feb 26</td>
<td>Mechanism Design (Inverse Game Theory)</td>
<td>Examples in NetLogo</td>
<td>Assignment 4 Presentations Assignment 5 Out</td>
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<td>Thu Feb 28</td>
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<td>9</td>
<td>Spring Break</td>
<td>Tue Mar 05</td>
<td>No Class</td>
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<td>Thu Mar 07</td>
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<td>10</td>
<td>Project Development</td>
<td>Tue Mar 12</td>
<td>Field Trip NESD</td>
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<td>Final Project Proposal Presentations</td>
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<td>11</td>
<td>Project Development</td>
<td>Tue Mar 19</td>
<td>Desk Crits</td>
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<td>Thu Mar 21</td>
<td>Desk Crits</td>
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<td>12</td>
<td>Project Development</td>
<td>Tue Mar 26</td>
<td>Desk Crits</td>
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<td>Thu Mar 28</td>
<td>Desk Crits</td>
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<td>13</td>
<td>Project Development</td>
<td>Tue Apr 02</td>
<td>Desk Crits</td>
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<td>Thu Apr 04</td>
<td>Desk Crits</td>
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<td>Project Deployment</td>
<td>Tue Apr 09</td>
<td>Desk Crits</td>
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<td>Thu Apr 11</td>
<td>Project Deployment</td>
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<td>Project Development</td>
<td>Tue Apr 16</td>
<td>Project Deployment</td>
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<td>Thu Apr 18</td>
<td>Experiment</td>
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<td>16</td>
<td>Project Development</td>
<td>Tue Apr 23</td>
<td>Experiment</td>
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<td>Thu Apr 25</td>
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<td>17</td>
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<td>Tue Apr 30</td>
<td>Final Reviews</td>
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<td>Thu May 02</td>
<td>Final Papers</td>
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### General Required Readings

**Readings**


### Weekly Readings

**WEEK 1**
The Anatomy of a Smart City: People, Things, and Bits
The first 3 weeks overview predominant definitions of ‘smart cities’ in academia and industry focusing on the question: what is intelligent behavior in an architectural/urban context, what components constitute an intelligent system and how does the role of organization, structure, and stakeholder interests affect behavior?

Required Readings

Case studies / videos

Assignment 1
Find and present a network participatory project. What does the system do? How does it do it? Who are the key participants and what are their motivations? What is the conflict about? What is a possible solution to the problem?

WEEK 2
Real Time Cities / Moving and Sharing
This week explores the role of information transparency and real time feedback. This week also explores the concept of resource sharing, the evolution of on-demand mobility, its challenges, and how novel autonomous technologies and design strategies may help overcome them. Come prepared to discuss at least one of the following:

Required Readings
Optional Readings


Green eld, A. (2013) Against the Smart City (The City Is Here for You To Use). 1.3 edn. Amazon Digital Services, Inc.: Do Projects.


Lab

- Maps, latitude, longitude coordinates
- Leaflet.JS
- MapBox.JS

Assignment 2

Create a real-time map visualization of Charlotte or UNCC on a topic of your choice
WEEK 3

Closing the Loop: Feedback, Control, and Self-Regulation
This week explores the concept of information feedback in cybernetic systems and its role in creating self-regulating behavior. Every self-regulating system contains a control feedback loop. Understanding the components of the loop is important for understanding the behavior of the system: how does the loop close? Who makes the decisions and who takes the actions? Come prepared to discuss at least one of the following:

Required Readings

Optional Readings

WEEKS 4-5
Lab sessions. No reading assignments other than necessary tutorials.

WEEK 6
Crowds and Emergence: From individuals to Masses
This week focuses on the topic of modeling and simulation of complex urban systems, asking the question: how can we study emergence of systems by replicating their behavior through computer simulations? how does macro-behavior of large ecosystems depend on micro-behavior of individuals? Come prepared to discuss at least one of the following:
**Required Readings**
http://ccl.northwestern.edu/papers/gridlock/Wilensky-Stroup.html

**Optional Readings**

**Workshop**
Agent based simulations with NetLogo

**WEEK 7**

**Game Theory: Scarcity, Individualism, and Collective Outcome**
This week explores the concept of equilibrium in strategic situations, asking the question: if every individual acts selfishly, where will the system go? What happens when goals and interests of some individuals conflict those of other individuals? Come prepared to discuss at least one of the following:

**Required Readings**
Hardin, Garrett James, 1915. The Tragedy of the Commons.

**Optional Readings**

**Guest Talk: TBD**

**WEEK 8**
Mechanism Design (Inverse Game Theory)
This week explores the concept of mechanism design, asking the question: how should we determine rules, payoffs, and platforms if we want a group of selfish individuals converge to a desired outcome? Come prepared to discuss at least one of the following:

**Required Readings**

**Optional Readings**

**WEEK 9**
Spring break: No class

**WEEKS 10-16**
Project development. No reading assignments other than necessary tutorials.

**PRESENTATION FORMAT**
All printed project presentations will follow specific guidelines regarding style, layout, and dimensions. These guidelines will be announced ahead of time.
STUDIO LAB CULTURE & ATTENDANCE

The course combines studio culture with research lab culture and seminar culture. It consists of desk crits and lectures, discussions, presentations, demos, workshops, and reading assignments. Attendance and participation is required. You are expected to be in the studio at your desk before class begins. Two (2) unexcused absences automatically lower your final grade one letter grade. More than two (2) unexcused absences will constitute grounds for automatic failure of this course. Documentation of excused absences must be submitted in writing and show evidence of the medical or family emergency. If you must be late or absent, notify me as early as possible in advance. The workload expected to be invested in the course is significantly high. If you took Connective Environments 1, expect this course to have more workload.

ACADEMIC INTEGRITY

As a UNC Charlotte student, each of you have the responsibility to be familiar with and observe the requirements of the UNC Code of Student Academic Integrity. This code and policies will be strictly followed. All written and graphic materials, in-class presentations, and other academic tasks should be your individual and original work unless specifically noted as group work. The studio is a public space. Please be sensitive to images and other materials around your desk, including your computer, which might be offensive to others. In addition, all students are required to abide by the spirit and letter of the UNC Charlotte Sexual Harassment Policy, which can be found online at: http://www.legal.uncc.edu/policies/ps-61.html

GRADING (TBD)

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<thead>
<tr>
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<td>First review</td>
<td>25%</td>
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<td>Second review</td>
<td>25%</td>
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<td>Final review</td>
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<td>Weekly deliverables</td>
<td>10%</td>
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<td>Attendance and participation</td>
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</table>

Late weekly submissions as well as poor attendance will count negatively towards your grade. All courses in the SoA are governed by the rules and regulations of UNC Charlotte as stated in the University Undergraduate and Graduate Catalogs. For more information about these polices, please refer to the appropriate catalog, which can be found online at: http://www.uncc.edu/gradmiss(gs_catalog.html (grad). Grading of courses conform to the following grading scales and values:

Graduate Scale & Values

<table>
<thead>
<tr>
<th>Grade</th>
<th>Range</th>
<th>Description</th>
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<tbody>
<tr>
<td>A</td>
<td>90-100</td>
<td>Commendable</td>
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<tr>
<td>B</td>
<td>80-89</td>
<td>Satisfactory</td>
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<tr>
<td>C</td>
<td>70-79</td>
<td>Marginal</td>
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<tr>
<td>U</td>
<td>69 &amp; Below</td>
<td>Unsatisfactory</td>
</tr>
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</table>

These grades are determined according to the following criteria:

A (Excellent / Commendable): Meets or exceeds stated requirements of the course; exhibits significant improvement, development, and/or intellectual growth over the course of the term; exhibits research efforts from which both the instructor and students may learn; all work turned in on time and presented in a professional manner.

B (Good / Satisfactory): Meets the stated requirements of the course; exhibits good improvement, development, and/or intellectual growth over the semester; provides a measure for student emulation; and all work is turned in on time and well presented.

Grad C (Marginal): Fails to meet most requirements of the course (the work is incomplete to a significant degree); exhibits little or no improvement, development, and/or intellectual growth over the semester; and/or work is of a caliber only marginally acceptable at the graduate level.

Grad U (Unsatisfactory): Fails to meet the requirements of the course; and/or the work is incomplete or of a caliber unacceptable at the graduate level. A grade of U will affect eligibility for continued enrollment and will not apply towards degree requirements.

RESOURCES
For information about writing style, use the UNCC standard guide for student research, writing, and citation style: Kate Turabian, et al. *A Manual for writers of Research Papers, Theses, and Dissertations*, 7th ed (Chicago: University of Chicago Press, 2007)

For assistance with research, students are encouraged to contact Art and Architectural Research Librarian, Jenna Rinalducci. You can also contact her via email at jraldu@uncc.edu ask questions or make an appointment to talk in person.

For assistance with writing, students are encouraged to contact the UNC Charlotte Writing Resource Center for free, individual consultations on all stages of the research paper and presentation process. You can reach them by email at wrchelp@uncc.edu.

Additional information about the WRC can be found online at http://writing.uncc.edu/writing-resources-center.

**SOA POLICIES**

Academic Integrity: All written and graphic submittals, in-class presentation, and other academic tasks should be your individual and original work unless specifically noted as group projects. No cheating. No plagiarism. It is assumed that you are aware of and will comply with the spirit and specifics of the UNC Charlotte Code of Student Academic Integrity, which is available online at: http://legal.uncc.edu/policies/ps-105.html.

Disability: If you have a diagnosed disability which influences your ability to learn or have your work assessed in the classroom, please provide a copy of the Letter of Accommodation from the UNC Charlotte Office of Disability Services by the end of the second week of classes. All efforts will be made to accommodate your needs and this information will remain confidential.

Inclusiveness: All perspectives and opinions are welcomed and will be respected in this university classroom as long as they are presented in manner that is respectful. Intolerance will not be tolerated. If you feel personally uncomfortable or alienated, or that diversity in general is any way stifled in this class, please let the professor know so that the situation can be remedied.

Culture: Students and instructors alike share responsibility for collective culture of all SoA course, all participants are expected to enhance its intellectual life by being present, pro-active, and respectful. All courses actively comply with and promote the SoA and CoAA culture policies with which it is assumed you are aware. The SoA culture policy is available online at http://www.coaa.uncc.edu/Academics/School-of-Architecture/About.

Electronics: At all time during class cell phones, computers and other devices should be switched off and put away, unless permission to use those devices has been explicitly given by the instructor. All students are required to abide by the UNC Charlotte policy on responsible Use of University Computing and Electronic Communication Resources, which can be found online at http://www.legal.uncc.edu/policies/ps-66.html.