DEA 6210: Architectural Robotics
MW 8:40-9:55

- 3 credits; letter grade only; no final exam; priority given to DEA students.
- Encouraged to enroll: students from MAE, IS, CS, ECE, PSYCH, COGSCI, FSAD, ARCH, ART, COMM.
- Recommended prerequisite: permission of instructor (15 student cap)
- course webpage: (linked from https://arl.human.cornell.edu/academics.htm).

Keith Evan Green, RA, Phd, Professor, DEA & MAE, keg95@cornell.edu, office hr. tbd in MVR 2421.

NOTE: This pdf file for the syllabus is comprehensive; however, the active and most complete documentation for this course is found in the course guide provided online at https://arl.human.cornell.edu/DEA6210_Arch_Robotics.htm. Here, you will find all the information contained in this pdf file, links to most all required readings, and additional supporting documents.

1. Course Description (50 words max.)
Embedding robotics into the fabric of architecture fosters a more interactive and potentially more intimate relationship between the built environment and us, and represents a new frontier for design, computing, and psychology. Part-seminar, part-lab, this course considers the design, technical, social, ecological, and ethical challenges and opportunities of architectural robotics.

2. Course Objectives and Learning Outcomes
- To understand the design, technical, social, ecological, and ethical challenges and opportunities of architectural robotics, and demonstrate this understanding in written form and presentations.
- To conceptualize and evaluate design alternatives responsive to the challenges and opportunities of an ecosystem that is biological, artificial, and increasingly digital, using a variety of design strategies.
- To demonstrate an ability to iterate, in design prototypes, an architectural robotic artifact (from furniture to the metropolis in scale).
- To demonstrate the ability to communicates the motivations for, iterative development of, and expected use of the Architectural Robotic artifact that was prototyped, as well as assessing its shortcomings (through the vehicle of a video).

3. Background and Definitions
While Information Technology [IT] can control digital bits on the display-screen surfaces of buildings, or temperature in building interiors, IT also has the capacity to move physical mass to create interactive, and adaptive cyber-physical, built environments—Architectural Robotics. The prospect of this kind of environment was anticipated by Nicholas Negroponte, an MIT Media Lab founder, some forty years ago in his vision of “a man-made environment that responds to and is ‘meaningful’ for him or her” [5].

Wired editor Kevin Kelly has since imagined a “world of mutating buildings” and “rooms stuffed with co-evolutionary furniture” [3]. And while Bill Gates envisions “a robot in every home,” [2] the late William Mitchell, former Dean of MIT’s School of Architecture and Planning, envisioned homes “as robots for living in” [4].
Architectural Robotics meanwhile raises such critical questions as:

- How will we program the built environment, from furniture to cities?
- How will Architectural Robotics recognize activities taking place inside and surrounding them?
- How will designers (which may include end-users) associate particular human and ecological conditions with desired built environment configurations?
- How to design cross-operability and collective interactivity/intelligence of multiple Architectural Robotic artifacts (furnishings, furniture, rooms, buildings, cities) operating together as cyber-physical “ecosystems”?
- What are the safety, security and privacy issues related to Architectural Robotics, and how do designers design Architectural Robotics to protect property and living things from hackers, operating failures, and other harmful impacts?

In the act of designing, designers typically anticipate in the form and function of their artifacts how people will use them and how these artifacts will respond to a range of possible, local conditions. In designing Architectural Robotics, however, there is a fundamental difference: investigators are engineering a responsive system that actively engages and interacts with inhabitants and local conditions in real time. So, unlike a conventional building that has a limited range of responses to dynamic, changing conditions, Architectural Robotics artifacts are intimately bound together with its users and local conditions in a designed performance.

Architectural Robotics must go beyond simplistic formal achievements; they must instead explore ways for improving life, enhancing existing places, and supporting human interaction. This is no utopian dream in which technology or design transforms completely our everyday reality. Instead, design and technology together – a cyber-physical hybrid – supports human activity, responds naturally, and performs according to our needs and wants. Architectural Robotics, when employed, must also complement and redefine our urban living patterns. Answers to life problems and opportunities will come not from computational or design solutions alone, but through the way computation, embedded in the physical, built environment, helps support and enhance the interactions across people and their surroundings to create places of social and psychological significance.

For philosopher Andrew Feenberg, “technology is not simply a means but has become an environment, a way of life” [1]. Architectural Robotics is more than an aesthetic search, a stylistic possibility, or a technological quest; it is, instead, a way to develop new spatial patterns in support of human activities. This course, “Architectural Robotics,” aims to cultivate new vocabularies of design and new, complex realms of understanding towards novel, computational and bio-centric design propositions.

References

4. Nota bene:
- This course is the “next chapter” of a course that I taught for many years that was cross-listed in Architecture and Electrical & Computer Engineering under the same title. The course pedagogy
has been the subject of a paper presented at ICRA (the IEEE International Conference on Robotics and Automation), and a paper published in RAS (IEEE Robotics and Automation).

- On the course webpage, in the upper-left corner, “Documents” links to a webpage of downloadable readings supporting this course. To enter this “Documents” page, you will need to enter the case-sensitive password, ARDUINO, when prompted.
- This syllabus is subject to revision; revisions will be dated and distributed online.

5. Assessment of Student Performance and Grading Policies

Students will receive a grade in response to the work presented and documented, weighted as follows:

- [20%] ideated design concept(s) and formative paper (4 pages—research question/lit review).
- [20%] prototype(s)—functional; aesthetically refined; responsive to stated purpose.
- [20%] video, as per ACM CHI Video Showcase conference requirements
- [20%] paper, as per ACM or IEEE conference full paper requirements using ACM CHI template.
- [20%] participation and upload of all documents to the class Box file strictly adhering to all formatting requirement and specifications detailed here, on the course webpage, and in the ACM conference website.

The prototype can be in the form of any of the following:

- a working (i.e. functioning) prototype at full scale
- a working (i.e. functioning) prototype to-scale (e.g. 1:10 scale)
- a “Wizard of Oz” prototype (i.e. one manually operated to simulate full-functionality)
- other forms of digital and analog media (negotiated with instructor)

The above video and paper will be completed to meet the (full) paper submission requirements for one of the following conferences (selection of which is negotiated with instructor): an ACM conference (e.g. HRI Human-Robot Interaction, DIS Designing Interactive Systems, TEI Tangible, Embedded and Embodied Interaction, IDC Interaction Design and Children, or CHI Human-Computer Interaction) or an IEEE conference (e.g. ICRA Robots & Automation, IROS Intelligent Robots & Systems, RO-MAN Robot-Man-Systems.) Each paper will include a research question focused on a challenge or opportunity considered in class, and will clearly communicate the design development and any testing of the prototype. For each project, the student designer(s) will be designated first authors and the professor and TA will designated as last authors for any conference submission, as the professor and TA will be integral to the success of the submission. (Students are encouraged to join the ACM SIGCHI mailing lists (including the one for job postings) and also become a student member of SIGCHI which brings you a 1-year subscription to interactions magazine [print] and discounts on ACM conferences. See the course webpage for more information.) Throughout this course—an intimate and intensive “conversation” between students and faculty members—students will have ample opportunity to receive feedback on their work.

6. Materials

- Sketchbook like this one or a comparable one found in our bookstore.
- Prototyping materials. You may elect to build hardware to partly satisfy the requirements for this course. A list of materials for building hardware and an extensive guide to building hardware can be found at my DEA 5210 course page.
7. Reading List
One book is required for this course:
Additional reading materials for this course are listed and downloadable from the on-line course page,
https://arl.human.cornell.edu/academics.htm. Key titles include:

8. Topical Outline By Week

Week 01 TYPES | Reconfigurable, Distributed, Transfigurable
Week 02 PATTERNS | Compressed Patterns (Alexander), Heat Maps, Typology, Motion Tracking
Week 03 INTERACTIONS | All around us (Benjamin); Robots for Living in (Mitchell)
Week 04 CONTROLS | I/Os; User, Interactive, and Autonomous Control; Mechatronic and Intelligent
Week 05 I ROBOT | Who are we?; Organic/Mechanic (Rykwert); Prosthetic (J. Hale); Dismembered
Week 06 I ROBOT | Who are we?; Pygmalion (Ovid, de Meun); Protean (Lifton); Posthuman (Hayles)
Week 07 HABIT-ATIONS | Homes, Classrooms, Hospitals, Theaters, Offices, Cars, Space
Week 08 LIVING ROOMS | Cells and Palaces (J. K. Huysmans, A. Breton, C. Mollino)
Week 09 FORMS | Physical Forms & Forms of Speech; Striated and Smooth (Deleuze)
Week 10 LINES AND SURFACES | Rigid, continuum, soft, modular; Kinematics
Week 11 MEASURES | Evaluation Strategies and Metrics; Scalability; Wicked Problems
Week 12 COGNITION | Distributed Cognition, Cognitive Rooms (E. Hutchins, N. K. Hayles)
Week 13 NETWORKS | The Digital Oligarchy; Weak Architecture (G. Vattimo) and Mesh Networks
Week 14 ETHOS AND ECOSYSTEMS | Bits, Bytes and Biology; The Garden of Technology (J. Cage)
Final Class DEMOS | Presentation of Prototypes and Videos; Conclusions, Lessons Learned

9. Classroom Policies, including Attendance and Late Work
- Switch off your mobile phone.
- Arrive on time, engage, and participate.
- Ask if there is something you don’t understand.
- Offer an insightful remark (when you find a natural break in our class activity).
- Check your email address and the online course page for timely information about this course.
- Don’t plagiarize; cite the work of others (https://plagiarism.arts.cornell.edu/tutorial/index.cfm).

Required: attendance, timely arrival to class, participation, and the uploading of all documents to the course Box or Google Drive folder strictly adhering to all formatting requirement and specifications detailed here, on the course webpage, and in the ACM conference website(s). Failure to fulfill these requirements will reduce your grade up to 10% of the total grade at the discretion of the instructors. Attendance at the start of class will be taken for some class sessions without advanced notice. For each absence or late arrival, email the professor and TA with an explanation, attaching supporting documentation (e.g. doctor’s note); these will be considered as a valid excuse (hardship, medical appointment) without penalty, or not. It is your education, so you should take responsibility for yourself in attending all class sessions on time.
**Late submissions will NOT be accepted**, except with a doctor’s note or other proof of personal crisis or hardship. Failure to submit the printed documents and digital files on-time will reduce your final assignment grade 10 points.

**Grading for this course is carefully determined** by the professor (and TA, if any) with thoughtful consideration of student grading by your peers. If you believe the grade for any component of this class including the final grade is incorrect, you may submit a written argument along with the component-in-question for reassessment. The written argument must reference a specific issue with the graded component of the course and must be thoroughly substantiated. The professor (and TA, if any) will together consider the request, potentially with the assistance of other faculty with expertise in the area. The reassessment will result in any of the following outcomes: no change of grade, a change of grade for the better, or a change of grade for the worse. You understand that the grade for work submitted for reassessment may result in a grade lower than originally assigned.

**10. Consent**
To prepare the required paper and video for this course, enrolled students may conduct peer-to-peer participant studies using their peers, enrolled in the same course, as participants. These studies will use methods considered in my course DEA 2370, Human-Centered Design Methods, the new core course for all DEA students. These methods may include interviews, observations, surveys, co-design activity, heuristic evaluations, and cognitive walkthroughs. As part of this design research activity, students conducting these studies may take written notes, photographs, and/or video as a means of documentation. This documentation may be reproduced in the papers and videos for submission to CHI or a like conference, and may be presented at the conference. Student will not be identified by name in such submissions/presentations, and no aspect of these studies should cause discomfort or risk to participants; nevertheless, should any student in the class chose not to participate in any aspect of the study, or have questions about her/his participation, please make this known to the instructor prior to the start of such study. Non-participation will not impact your grade for this course in any way.

**11. You are encouraged to join ACM SIGCHI and DRN**
Students enrolled in this course are encouraged to join email postings (aka listservs) for ACM SIGCHI ANNOUNCEMENTS and DESIGN RESEARCH NEWS (both of these for design opportunities) and also ACM SIGCHI JOBS. Students are also encouraged to become a student member of SIGCHI which brings you a 1-year subscription to interactions magazine [print] and discounts on ACM conferences. [Directions for joining these](#).

**12. University Statement on Academic Integrity and Honesty**
Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work, except in the cases of projects that are specifically structured as group endeavors. In compliance with the Cornell University policy and equal access laws, the faculty, teaching assistants, and teaching associates for this course are available to discuss appropriate academic accommodations that may be required for students with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances, so that arrangements can be made. Students are encouraged to register with Student Disability Services to verify their eligibility for appropriate accommodations.
13. DEA Statement

DEA is dedicated to fostering a respectful and accepting learning community in which individuals from various backgrounds, experiences, and perspectives can embrace and respect diversity. Everyone in this community is empowered to participate in meaningful learning and discussion, regardless of an individual’s self-identified gender, sexual orientation, race, ethnicity, religion, or political ideology. We encourage students to share their uniqueness; be open to the views of others; honor and learn from their colleagues; communicate in a respectful manner; and create an inclusive environment.