ARCH-582
A.I. in Sustainable Architecture Practice

Units: 3
Term—Day—Time: Fall 2024

Location:
TBD

Instructors: Joon-Ho Choi, Ph.D., LEED AP, Assoc. AIA
Associate Dean of Research and Creative Work
Associate Professor, Building Science
Affiliated Faculty, Information Sciences Institute
Director, Center for Wellness in the Built Environment

AC Martin Family Fund for Faculty Excellence in Architecture and Building Science

Office: Wat Hall room #318
Office Hours: By appointment
Contact Info: joonhoch@usc.edu
Class Assistant: TBD
Course Description
This course will provide students with a comprehensive understanding of how artificial intelligence (AI) algorithms can be integrated with various aspects of sustainable architecture, such as façade design, environmental performance, indoor environmental quality, and post-occupancy evaluation. The focus will be on applied machine learning and its role in enhancing the sustainability of the built environment through integrated design processes and environmental control mechanisms.

The course will emphasize the importance of user-centered design and the use of advanced computational algorithms without compromising any architectural or project resources. It will cover the building design process and the necessary steps to assure sustainability, user satisfaction, and environmental comfort and wellbeing.

The course content will include hands-on technical applications such as post-occupancy surveys, environmental data collection, design parameter surveys, and virtual reality. Students will also learn various artificial intelligence algorithms to aid in their coursework. By the end of the course, students will have a comprehensive understanding of how to integrate artificial intelligence algorithms into the building design process to enhance sustainability, user satisfaction, and building performance. They will be equipped with the skills to identify challenges and develop practical solutions by using artificial intelligence algorithms in the built environment.

Learning Objectives and Outcomes
After completing this course, a student should understand the following concepts and ideas:

- Understanding of AI and its applications in architecture and sustainability.
- Knowledge of sustainable design principles and their integration with AI.
- Ability to evaluate the impact of AI on the built environment and sustainability.
- Familiarity with AI tools and techniques for sustainable design and building performance analysis.
- Develop skills in designing AI-powered sustainable architecture solutions.
- Analyze the built environment and its sustainability performance by using AI algorithms.
- Apply sustainable design principles in AI-powered architecture solutions.

For technical outcomes, the course will help students to develop skills in analyzing data, building machine learning models, and presenting resulting effectively:

- Data collection and pre-processing: Understanding of data sources and techniques for collecting, cleaning, and preparing data for analysis.
- Exploratory Data Analysis (EDA): Use of visual and statistical methods to understand the relationships and patterns in data.
- Model selection and evaluation: Techniques for comparing and evaluating different machine learning models, including cross-validation and model performance metrics.
- Data visualization: Techniques for creating effective visualizations to communicate the results of data analysis and modeling.
- Big data: Overview of big data technologies and their applications in architecture and sustainability.

Prerequisite(s): N/A
Co-Requisite(s): N/A
Concurrent Enrollment: N/A
Recommended Preparation
Prior experience or preparation in indoor environmental quality systems, such as thermal, lighting, air quality, and acoustic systems, as well as architectural design and process and statistical analysis, is recommended for this course.

Course Notes
Lecture notes, a syllabus, handouts, reading assignments, and any other course materials will be posted on Blackboard. Practice with control hardware for homework or assignments will be incorporated in the course.

Teaching Method: This class will be conducted as a seminar and will mix lecture presentations by the instructor with student presentations, class demonstrations, slide presentation, project reviews, and guest speakers, as well as system construction with the application of acquired knowledge to a real built environment. An environmental chamber in Watt Hall will be used as a test bed and students will be required to complete their course projects and assignments using the facility in order to concurrently learn and put the acquired skills and knowledge into practice. Required texts and several reference books will be recommended to supplement coursework. Since the course is primarily for graduate-level students, course participants can choose any data type or source relative to their research interests or projects they are conducting.

Technological Proficiency and Hardware/Software Required
This course is based on a traditional classroom setting. In addition, students may need some software skills, but not required.

Description and Assessment of Assignments
• Assignment Overview: The assignments are designed to provide hands-on practice with software and tools discussed in the course. Each student will apply their expertise to a practical project, demonstrating their ability to effectively utilize these tools in the context of sustainable architecture.
• Learning Outcomes: Students will develop proficiency in using specific architectural and AI software and tools by completing these assignments. They will enhance their technical skills and demonstrate their ability to integrate technology into sustainable architectural design.
• Instructions: For each assignment, students are required to submit a detailed report or presentation that outlines their process, the challenges faced, and the outcomes achieved. Specific submission requirements will be provided for each assignment.
• Assessment Criteria: The assignments will be assessed based on both quality and quantity, with a focus on the following aspects:
  o Quality:
    ▪ Tool Usage: The effectiveness and appropriateness of the software and tools used in the project.
    ▪ Creativity: The originality and innovation demonstrated in applying AI technology to architectural design.
    ▪ Final Output: The completed project's overall quality, coherence, and presentation.
  o Quantity:
    ▪ Exploration: The extent to which the student has explored the capabilities of the software and tools.
    ▪ Utilization: The degree to which the student effectively utilizes the technical methods and resources available.
### Grading Breakdown

<table>
<thead>
<tr>
<th>Assignments</th>
<th>Points</th>
<th>% of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term project</td>
<td>200</td>
<td>20%</td>
</tr>
<tr>
<td>Final project</td>
<td>400</td>
<td>40%</td>
</tr>
<tr>
<td>Assignment and quizzes</td>
<td>300</td>
<td>30%</td>
</tr>
<tr>
<td>Class participations</td>
<td>100</td>
<td>10%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1000</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
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* A final grade shall be awarded using the following guidelines:
  
  General rule:
  
  a. 97.0 - 100 = A+ Students in this range will get an A and commendation (the university does not give A+)
  
  b. 93.0 - 96.9 = A
  
  c. 90.0 - 92.9 = A-
  
  d. 87.0 - 89.9 = B+
  
  e. 83.0 - 86.9 = B
  
  f. 80.0 - 92.9 = B-
  
  g. 77.0 - 79.9 = C+
  
  h. 73.0 - 76.9 = C
  
  i. 70.0 - 72.9 = C-
  
  j. 67.0 - 69.9 = D+
  
  k. 63.0 - 66.9 = D
  
  l. 60.0 - 62.9 = D-
  
  m. <60.0 = F

### Assignment Submission Policy

Deliverables are defined as any work required from the student that was assigned for acquisition or preparation outside of the regular classroom, e.g. web-based reference documents, homework, take-home quizzes, and projects. All deliverables are mandatory and due at the beginning of class on the required due date. Failure to submit a deliverable on-time and reasonably well attempted shall result in a deduction of 50% of the assigned point value, with an additional 10% deducted for each full-day late until such work is delivered into the instructor’s possession, properly completed. Any deliverable not properly submitted within one calendar week of a required due date may result in a failing grade to the student in this course. Any student who may be absent from class on the due date may submit their work beforehand directly to the instructor, or, on the due date via another student. Exceptions to this policy shall be considered with adequate justification.

### Grading Timeline

All of the submitted assignment/homework/take-home quizzes will be graded within 7 days and returned during class in the following week.

### Additional Policies

- **Quality:** All deliverables shall be graded for quality and content, 60% and 40% respectively. Chaotic, illegible, disorganized deliverables shall negatively impact the course grade.

- **Attendance:** On-time attendance is expected in this course as is required in professional practice. Late arrival and repeated absences shall negatively impact the course grade.

### Additional Notes

- **Student Assignments**
This course is hands-on and project-based, requiring students to complete both individual and group assignments in a timely manner. These assignments will focus on applying artificial intelligence algorithms to building design and sustainability performance. Students will gain experience in data analytics and will have the opportunity to develop an AI model that can be applied to real-world
sustainable building design projects. The assignments can be tailored to align with the students’ specific areas of interest within the course content and project scope.

Students will be given five plus assignments and two projects during the course that will help them gain a deeper understanding of the technical approaches being taught. In addition, students will have reading assignments based on articles handed out in class or available on the web.

The assignments will include:
   1) Developing proficiency in analyzing architectural design and performance data.
   2) Establishing an AI model to explore key technical features of sustainable architecture
   3) Building a diagnostic tool using advanced problem-solving skills using AI algorithms.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University’s educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Academic Integrity:

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, compromises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university’s mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or “recycle” work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity’s website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.
My priority as your professor is to ensure a safe, respectful education environment where all students can learn and thrive. The University does not tolerate any form of discrimination or harassment (including sexual assault, dating and domestic violence, stalking) based on protected characteristics (e.g., race, disability, ethnicity, sex, gender identity, sexual orientation, religion, pregnancy, etc.) or related retaliation (i.e., Prohibited Conduct). All faculty and Teaching Assistants are considered Designated Employees by the University, which means that if they observe or learn of Prohibited Conduct, they are obligated to immediately share that information with the University’s Office for Equity, Equal Opportunity, and Title IX (EEO-TIX). This obligation, grounded in law and policy, is designed to protect the safety of students and the broader USC community, as well as ensure that students receive information about available supportive measures and resolution options to enable them to make informed choices. Supportive measures include reasonable academic accommodations available with or without the filing of a Formal Complaint.

If you need academic accommodations due to protected class discrimination, harassment, or related retaliation, you may:

- Contact EEO-TIX directly (eeotix@usc.edu or 213-740-5086), without sharing any personal information with me.
- If you would like to speak with a confidential counselor about sexual misconduct, Relationship and Sexual Violence Prevention Services (RSVP) provides 24/7 confidential support for students (213-740-WELL 9355), or 213-740-4900 and press 0 after hours).
- If you are pregnant, have recently experienced childbirth, and/or have medical needs related to childbirth, please contact OSAS or EEO-TIX for assistance.
- Finally, if you need reasonable accommodations for a religious observance, please submit a request to me by email as far in advance as possible.

Accommodations do not relieve you of the responsibility for completion of any part of the coursework you miss as the result of a religious observance. If you have questions or concerns about your request, you may contact EEO-TIX.

**Religious Holidays**

The University of Southern California recognizes the diversity of our community and the potential for conflicts involving academic activities and personal religious observation. The University provides a guide to such observances for reference and suggests that any concerns about lack of attendance or inability to participate fully in the course activity be fully aired at the start of the term. As a general principle, students should be excused from class for these events if properly documented and if provisions can be made to accommodate the absence and make up the lost work. Constraints on participation that conflict with adequate participation in the course and cannot be resolved to the satisfaction of the faculty and the student need to be identified prior to the drop/add date for registration. After the drop/add date the University and the School of Architecture shall be the sole arbiter of what constitutes appropriate attendance and participation in a given course.

**Respect for Diversity**

It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students’ learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated.
Support Systems:

**Counseling and Mental Health** - (213) 740-9355 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

**988 Suicide and Crisis Lifeline** - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

**Relationship and Sexual Violence Prevention Services (RSVP)** - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

**Office for Equity, Equal Opportunity, and Title IX (EEO-TIX)** - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

**Reporting Incidents of Bias or Harassment** - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

**The Office of Student Accessibility Services (OSAS)** - (213) 740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

**USC Campus Support and Intervention** - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

**Diversity, Equity and Inclusion** - (213) 740-2101
Information on events, programs and training, the Provost’s Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

**USC Emergency** - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

**USC Department of Public Safety** - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

**Office of the Ombuds** - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

**Occupational Therapy Faculty Practice** - (323) 442-2850 or [otfp@med.usc.edu](mailto:otfp@med.usc.edu)
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.

(Source: KDnuggets.com)
<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Description</th>
<th>Project / Assignment</th>
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</table>
| 1    | • Introduction to Artificial Intelligence and Machine Learning  
       o Overview of AI and ML  
       o Key concepts and terminologies  
       o Historical background and current state of AI in the built environment  
       o AI design principles | |
| 2    | • Design Process and Environmental Control  
       o Overview of building design process  
       o Environmental control mechanisms  
       o Building information modeling (BIM)  
       o Environmental simulation software | Project I (handout) |
| 3    | • Post-Occupancy Evaluation and Indoor Environmental Quality  
       o Overview of post-occupancy evaluation  
       o Indoor environmental quality  
       o Thermal comfort, lighting, air quality, and acoustic systems | |
| 4    | • Façade Design and Environmental Performance  
       o Overview of façade design  
       o Environmental performance of building envelopes  
       o Building energy analysis and simulation  
       o Building-integrated photovoltaics (BIPV) | |
| 5    | • Machine Learning Fundamentals  
       o Overview of machine learning algorithms  
       o Supervised and unsupervised learning  
       o Linear regression, decision trees, and neural networks | |
| 6    | • Applied Machine Learning in Architecture  
       o Data selection, collection and preprocessing | |
| 7    | • Applied Machine Learning in Architecture  
       o Model selection and training | Project II (handout) |
| 8    | • Applied Machine Learning in Architecture  
       • Model evaluation and optimization  
       o Applications of machine learning in building design, environmental control, and post-occupancy evaluation | |
| 9    | • Mid-term *Presentation* | Project 1 due & presentation |
| 10   | • User/Client Centered Design Approaches  
       o Overview of user/client centered design  
       o Human comfort and well-being  
       o Building performance and user satisfaction | |
| 11  | • Virtual Reality and Simulation  
|     |   o Overview of virtual reality and simulation  
|     |   o Virtual reality software and hardware  
|     |   o Applications of virtual reality in building design and post-occupancy evaluation  
|     |   o User-centered design and VR-based building performance evaluation  |
| 12  | • Building Performance Analysis  
|     |   o Overview of building performance analysis  
|     |   o Energy, environmental, and user satisfaction analysis  
|     |   o Building-level performance evaluation and optimization  |
| 13  | • Case Studies  
|     |   o Overview of case studies  
|     |   o Applications of AI in sustainable architecture  
|     |   o Analysis of building performance and design optimization  
|     |   o Discussion of ethical and technical challenges  |
| 14  | • Thanksgiving Break  |
| 15  | • Final Project and Conclusion  
|     |   o Final project presentation and evaluation  
|     |   o Recap of key concepts and takeaways  
|     |   o Discussion of future developments and applications in AI and sustainable architecture  
|     |   o Conclusion of the course.  |
| 16  | • Final project submission  |
| TBD | Project III due & presentation  |
Reading Materials / References

- The Routledge Companion to Artificial Intelligence in Architecture, 2021, Routledge
- Artificial Intelligence and Architecture
- From Research to Practice, 2022, Walter de Gruyter GmbH
- Sustainable Design: HCI, Usability and Environmental Concerns, 2022, Springer
- Data-driven Analytics for Sustainable Buildings and Cities, 2022, Springer
- Sustainable Architecture Design: An Overview, 2015, Routledge
- Sustainable Design for Built Environment, 2019, Taylor & Francis