ARCH-499
Artificial Intelligence in the Sustainable Architecture Context

Units: 3
Term—Day—Time: Fall

Location:
TBD

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Associate Professor, Building Science
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Office Hours: TBD
Contact Info: joonhoch@usc.edu
Class Assistant: TBD

(Source: commonedge.org)
Course Description
This course will provide undergraduate 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-Prerequisite(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
Provide enough information about an assignment so a student or reviewer can tell what kind of work is to be done and how it should be completed, i.e. how the learning outcome will be assessed. Include any assessment and grading rubrics that will be used.

Grading Breakdown

<table>
<thead>
<tr>
<th>Assignments</th>
<th>Points</th>
<th>% of Grade</th>
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<tbody>
<tr>
<td>Mid-term project</td>
<td>200</td>
<td>20%</td>
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<tr>
<td>Final project</td>
<td>400</td>
<td>40%</td>
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<tr>
<td>Assignment and quizzes</td>
<td>300</td>
<td>30%</td>
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<tr>
<td>Class participations</td>
<td>100</td>
<td>10%</td>
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<tr>
<td>TOTAL</td>
<td>1000</td>
<td>100%</td>
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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+
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.
Statement for Students with Disabilities
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. Website and contact information for DSP: http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html, (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu.

Statement on Academic Integrity
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, (www.usc.edu/scampus or http://scampus.usc.edu) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A.

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/. Information on intellectual property at USC is available at: http://usc.edu/academe/acsen/issues/ipr/index.html.

Discrimination, Sexual Assault and Harassment
Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity http://equity.usc.edu/ or to the Department of Public Safety http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

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.

(Source: dezeen.com)
Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call engemannshc.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086 equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421 studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776 dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.
USC Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
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
dps.usc.edu, emergency.usc.edu
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) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.

(Source: KDnuggets.com)
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<thead>
<tr>
<th>Week</th>
<th>Lecture Description</th>
<th>Project / Assignment</th>
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<tbody>
<tr>
<td>1</td>
<td>• Introduction to Artificial Intelligence and Machine Learning</td>
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<tr>
<td></td>
<td>o Overview of AI and ML</td>
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<td></td>
<td>o Key concepts and terminologies</td>
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<td></td>
<td>o Historical background and current state of AI in the built environment</td>
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<td></td>
<td>o AI design principles</td>
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<td>2</td>
<td>• Design Process and Environmental Control</td>
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<td></td>
<td>o Overview of building design process</td>
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<td>o Environmental control mechanisms</td>
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<td>o Building information modeling (BIM)</td>
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<td></td>
<td>o Environmental simulation software</td>
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<td>Project I (handout)</td>
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<td>3</td>
<td>• Post-Occupancy Evaluation and Indoor Environmental Quality</td>
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<tr>
<td></td>
<td>o Overview of post-occupancy evaluation</td>
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<td>o Indoor environmental quality</td>
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<td>o Thermal comfort, lighting, air quality, and acoustic systems</td>
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<td>4</td>
<td>• Façade Design and Environmental Performance</td>
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<td></td>
<td>o Overview of façade design</td>
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<td>o Environmental performance of building envelopes</td>
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<td>o Building energy analysis and simulation</td>
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<td>o Building-integrated photovoltaics (BIPV)</td>
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<td>Project II (handout)</td>
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<td>5</td>
<td>• Machine Learning Fundamentals</td>
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<td></td>
<td>o Overview of machine learning algorithms</td>
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<td>o Supervised and unsupervised learning</td>
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<td>o Linear regression, decision trees, and neural networks</td>
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<td>6</td>
<td>• Applied Machine Learning in Architecture</td>
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<td>o Data selection, collection and preprocessing</td>
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<td>7</td>
<td>• Applied Machine Learning in Architecture</td>
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<td></td>
<td>o Model selection and training</td>
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<td>8</td>
<td>• Applied Machine Learning in Architecture</td>
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<td></td>
<td>• Model evaluation and optimization</td>
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<td></td>
<td>o Applications of machine learning in building design, environmental control, and</td>
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<td>post-occupancy evaluation</td>
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<td>9</td>
<td>• Mid-term Presentation</td>
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<td>Project 1 due &amp; presentation</td>
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| 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 presentations  
|    | 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