Subject Number(s)

4.570 (H) /4.550 (UG)

Subject Title and Subtitle

[Computation Design Lab]

Learning from design heritage: Research incubation workshop on data-driven method

Term offered

Spring 2026

Instructor(s)

Takehiko Nagakura

Guest speakers: Rohit Sanatani, Woongki Sung, Nikolaos Vlavianos, Taro Narahara

TA(s)

Xiaoyun Zhang

Credit Units

4.550: 2-2-8 Under grad : 4.570: 2-2-8 Grad

Level

4.570 (H) /4.550 (UG)

Prerequisites

There is no specific prerequisite, but students are expected to have a background in architectural design and computation, and be familiar with basic representational skills for image processing, drafting, modeling and scripting.

Schedule

Lecture/Review: Mon 11:00-2:00, Room 8-119

Lab and Seminar: Tue 7:00-8:30pm, Room 5-216

Subject Description

This class investigates recent information and visualization technologies that helps studying "design heritage", spatial designs that surround our lives. Design heritage broadly includes architecture, city and landscape; the built, demolished, and planned; and culturally important as well as the banal ones. We will look at various data-driven methods relevant to learn them, such as image/video feature detection, machine learning, physiological sensors, natural language processing, photogrammetric/gaussian splatting capture, augmented/virtual reality, and gamification. By examining how to collect data, how to process the raw data into forms useful for evaluation, and how to interpret and apply the findings, the students build a foundation for research projects bettering our understanding of the spatial designs around us.

Each week during the first half of the class, the class will invite a guest speaker, conduct a short hands-on exercise on a selected data processing tool, and read relevant literature from previous research projects in design heritage. The second half is run in a workshop format with desk critiques, where students are

expected to design and develop a small research project individually or in a group. There is no requirement for computational skills for this class, although familiarity with some scripting language is an advantage.

No fieldwork/field trip is planned for Spring 2026 class.

List of Subject Objectives

Understand and represent design heritage in architectural/landscape/urban space and historic places
Survey various data-driven approaches for analytical research of design heritage
Practice design of research method using data-driven approaches
Practice field methodology for collecting data of spatial forms and events
Explore means to deliver digitally enhanced architectural representation online, on-site, or in museum setting

Evaluation Criteria

Class participation: 25%
Short exercises (6 assignments): 30%
Final Project Development: 15%
Final review: 30% (Participation is required.)

Schedule of Exercises, Projects, Quizzes, Exams or Assignments

Weekly Schedule

Week 01	**Mon, Feb. 02**	Introduction
	+ Tue, Feb. 02	Using/analyzing image data: Scraping SNS, online crowd-sourcing
		Ex0 out: Q/A (Student selection)
		Guest Instructor: Rohit Sanatani
		Ex1 out: Learning through image data – image segmentation
		Google Colab, Segment Anything Model, Google Vision API
Week 02	**Mon, Feb. 09**	Recording spatial design and measruing human response in it
	+ Tue, Feb. 10	Structure for Motion, VR and AR, Physiological sensor
		Ex1 in: In-class review and discussion
		Tutorial: TN and XZ
		Ex2 out: Affective Computing - VR and physiological response
		Ex2 (part 1) Scanning a spatial design and editing 3d representation
		Gaussian Splatting, Photogrammetry, SuperSplat
Week 03	**Mon, Feb. 16**	***Presidents Day Holiday** (All Monday classes shift to Tuesday)*
	+ Tue, Feb. 17	**Ex 2 (part 1) in:** In-class review and discussion
		Tutorial: TN and XZ
		Ex2 (part 2): [in-class hands-on session]
		Meta Quest HMD**,** EEG/GSR, eye-tracking, Unity 3D
Week 04	**Mon, Feb. 23**	Pipeline tooling for online research – visual workflow editor
	+ Tue, Feb. 24	Mechanical Turk, RAG, dynamic website with LAMP
		Ex2 in: In-class review and discussion

Tutorial: XZ
Ex3 out: <mark>Designing a pipeline with subject-based test and ML model</mark>
Google Opal, LLM API call tools for Rhino/Blender/Unity 3D

Week 05	**Mon, Mar. 02**	Finding patterns through Machine Learning
	+ Tue, Mar. 03	Spatial layout, sketches, photos
		Ex3 in: In-class review and discussion
		Guest Instructor: XZ + Woongki Sung
		Ex4 out: <mark>Finding and generating patterns by machine learning</mark>
		GAN (pix2pix), One-shot/zero-shot learning, Stable Diffusion
Week 06	**Mon, Mar. 09**	Examining literature on spatial designs
	+ Tue, Mar. 10	Natural language processing, sentiment study of heritage places
		Ex4 in: In-class review and discussion
		Instructor: DT
		Ex5 out: <mark>Design Analysis through text</mark>
Week 07	**Mon, Mar. 16**	**Ex5 in:** In-class review and discussion
		Final project guideline (Title, idea, method, deliverable, resource)
		[in-class session] **Brainstorming: Final project topic and method**
	+ Tue, Mar. 17	Workshop/ desk critique by sign-up

Week 08	*Mar. 23 – Mar. 27*	*MIT Spring Break*

Week 09	**Mon, Mar. 30**	**Presentation: Final project proposal + initial progress**
	+ Tue, Mar. 31	Tutorial: Training Image Segmentation (Yolo 11)
		Lab: desk critic by sign-up
Week 10 gamification	**Mon, Apr. 06**	Human-subject study in cognitive psychology, COUHES,
	+ Tue, Apr. 07	Guest talks: Daniel Tsai + Xiaoyun Zhang
		on Analysis of Palladio's Four Books using NLP
		Tutorial: Customizing Multi-modal network (Yolo-world)
		Lab: desk critic by sign-up
Week 11	**Mon, Apr. 13**	**Interim review: Final project**
	+ Tue, Apr. 14	**Lab**: desk critic by sign-up
Week 11	*Mon, Apr. 20*	*Patriots Day Holiday*
	+ Tue, Apr. 21	No class
Week 13	**Mon, Apr. 27**	(Data-driven) AI tools for design generation
	+ Tue, Apr. 28	Guest talks: Rohit Sanatani + TBA (Taro/Nik/Tracy)
		on Analysis of Urban Data Matrix by Deploying Analogy
		Lab: desk critic by sign-up

Week 14 exhibition	Mon, May 04	Cultural heritage practice for preservation and online/museum
	+ Tue, May 05	Guest talks: TN + Woongki Sung on Generation of Architectural Site Plan through Bayesian Network Lab: desk critic by sign-up
Week 15	Mon, May 11	Final presentation * Submit your presentation package ready for online archive (ppt/pdf)
	Tue, May 12	Reserved for backup *(MIT Last day of class)*
	May 16-21	*MIT Final Exam period*
	May 22	*MIT Grade deadline*
	May 27-29	*MIT Commencement*

Textbooks and Reading Sources

All materials are provided online from the resource section of the class home page as links to text, video, and interactive media. The following is a snapshot of the reference literature.

Machine Learning + Image/Video/3D models

[ML]   (architecture) W. Peng, F. Zhang, T. Nagakura   2017 paper   2018 Smarchs Thesis
Machines' Perception of Space: Employing 3D Isovist Methods and a Convolutional Neural Network in Architectural Space Classification

[ML]   (architecture) W. Peng   2023 PhD Thesis   demo video
Visual Experience in Temporal Situational Context: Method of Matching and Modeling in Design

[ML]   (architecture) C. Cheng   2024 Smarchs Thesis
Alive Scene: Participatory Multimodal AI Framework for Collective Narratives in Dynamic 3D Scene

[ML]   (architecture) C. Cheng, T. Nagakura, D. Tsai   2023 conference
A Synergy of AI Observation and Design Tool: Leveraging Multifaceted AI Techniques for Encoding Human Behaviors and Stories in Space

[ML]   (architecture) S. Miao, T. Nagakura, D. Tsai   2024 conference
Deep Spatial Memory: Quantifying Architectural Spatial Experiences through Agent-driven Simulations and Deep Learning

[ML]   (architecture) C. Wu   2020 March thesis
Machine learning in housing design : exploration of generative adversarial network in site plan / floorplan generation

[ML]   (architecture)H. Tu, G. Varinlioglu, L. Gao, B. Chen, T. Nagakura 2023 conference

Feeling Like Humans: Low-cost wearable sensors for design research in the age of AI

[ML]   (urbanism)   R. Sanatani, T. Nagakura   2023 conference
The Many Faces of the Metropolis: Unsupervised Clustering of Urban Environments in Mumbai Based on Visual Features As Captured in City-Wide Street-View Imagery

[ML]   (urbanism)   R. Sanatani, T. Nagakura, D. Tsai   2022 conference
       Presentation Video (SIGraDi)
The Tourist's Image of the City: A comparative analysis of the visual features and textual themes of interest across three global metropolises

[ML]   (heritage)   P. Gonzalez, T. Nagakura   2020 paper   2021 PhD thesis (not for distribution)
AI Visitor: Tracking and simulating pedestrian trajectories in Machu Picchu

[ML]   (architecture) R. Villalon   2017 PhD Thesis
Data mining, inference, and predictive analytics for the built environment with images, text, and WiFi data

[ML]   (architecture)   X. Zhang   2021 Smarchs Thesis
Envisage: Investigating Design Intentions, Visual Perception through Eye Tracking of Architectural Sketches

[ML]   (architecture)   J. Park 2015 PhD Thesis
Synthetic tutor : profiling students and mass-customizing learning processes dynamically in design scripting education

[ML]   (urbanism)   Q. Liang, M. Wang, T. Nagakura   2020 paper   2020 Smarchs Thesis   Video
Urban Immersion: A Web-based Crowdsourcing Platform for Collecting Urban Space Perception Data.

[ML]   (architecture)   J. Peraino   2020 March thesis
Architectural epidemiology : a computational framework

[ML]   (architecture) Y. Liu 2020 Smarchs Thesis
Measuring the immeasurable : an experiment for a machine to map low-level features to high-level semantic representation of architectural space using a single view photo

[ML]   (urbanism)   T. Sun 2020 Smarchs Thesis
Synthesizing 3D morphology from a collection of urban design concepts

Data Mining/Visualization/Analysis (for reference)
[crowd-sourcing](urbanism)   Y. Yoshimura, S. He, G Hack, T Nagakura, C Ratti   2020 paper   2014 Smarchs Thesis
Quantifying Memories: Mapping Urban Perception

[data mining]   (urbanism)   X. Chen   2011 Smarchs Thesis   demo video (Singapore)   demo video (Paris)
Seeing differently : cartography for subjective maps based on dynamic urban data

[data mining]   (urbanism)   N. Chen   2016 Smarchs Thesis
Urban data mining : social media data analysis as a complementary tool for urban design

[data mining]   (architecture)   S. Zhang   2020 March thesis
Value in design? Features, pricing, and design strategies

Other Projects (for reference)
[ML]   (toolkit)   Chin-Yi Cheng   2017 Smarchs Thesis
Interactive design process based on augmented intelligence : a framework and toolkit for designers to interact and collaborate with AI algorithms

[Measurment]   (handcraft)   G. Bernal   2014 Smarchs Thesis
Learning from master's muscles : EMG-based bio-feedback tool for augmenting manual fabrication and crafting

[BIM]   (architecture) T. Nagakura and W. Sung   2017 paper
Spatial Typology for BIM - Preassembling for Synthetic Architectural Design

[Participatory]   (architecture)   J. Choi 2014 March Thesis
Democratic Play : crowd-sourcing through games for architectural design

[Participatory]   (architecture) Y. Hou 2016 March Thesis
Engaging public voice in big data society : an on-line participatory design experiment

AI Platform Tools (for reference)
[ai tool]   (image-based GAN) Pix2Pix   toolkit

[ai tool]   (image/video-based)   Google Vision AI   toolkit

[ai tool]   (comprehensive)   Microsoft Azure Cognitive Services toolkit

[ai tool]   (video-based)   Moments in Time Dataset   toolkit

[ai tool]   (video-based) STAR toolkit

[ai tool]   (Agent-based)   Unity ML-Agents Toolkit   toolkit

[ai tool]   (Reinforcement Learning)   Gym   toolkit

Lab Fees (if any)

None