MSCD (){
Thesis Reviews 2020 (Spring, May 1st) {
Design Tools();
Data and Design();
Interactive and Immersive();
};
}

The **Master of Science in Computational Design** (MSCD) is a 2-year post-disciplinary research program at the School of Architecture at Carnegie Mellon University investigating critical questions and creative opportunities at the intersection of design, computation, and the built environment.

Schedule:

Session 1: Design Tools

Reviewers: Dimitris Papanikolaou (UNC Charlotte), Mary-Lou Arscott, Ardavan Bidgoli, Josh Bard, Dina El Zafaly

08:00 - 08:45 am	Toward Designing with Heterogeneous Values	Vincent Mai
08:45 - 09:30 am	A Mixed Modeling Environment Exploring Tangible and Digital Interactions for Iterative Design Modeling	Hongtao Ma
09:30 - 10:15 am	An inquiry into crowdsourcing for early-stage product design	Weixin Qiu
10:15 - 11:00 am	A Generative Design Application Development Workflow for Architecture	Siyu Guo
	15 min break (11-11:15am)	

Session 2: Data and Design

Reviewers: Andrew Heumann (Hypar), Ardavan Bidgoli, Ramesh Krishnamurti, Golan Levin, Molly Wright Steenson, Pedro Veloso

11:15 - noon	Towards Multi-Drone Autonomous Construction via Deep Reinforcement Learning	Zhihao Fang
noon - 12:45 pm	Data Processing in Using Machine Learning to Analyze Floor Layout Plan Design	Yufei Cheng
12:45 - 01:30 pm	Rethinking PropTech: Drawing insights about the real estate technology industry through technical experimentation	Ian Friedman
01:30 - 02:15 pm	Crafting the Weights of a Convolutional Neural Network to Make a Line Drawing	Erik Ulberg
	15 min break (11-11:15am)	

Session 3: Interactive and Immersive

Reviewers: Andres Burbano (Universidad de los Andes), Theodora Vardouli (McGill), Mary-Lou Arscott, Golan Levin, Dina El Zafaly, Larry Shea, Molly Wright Steenson

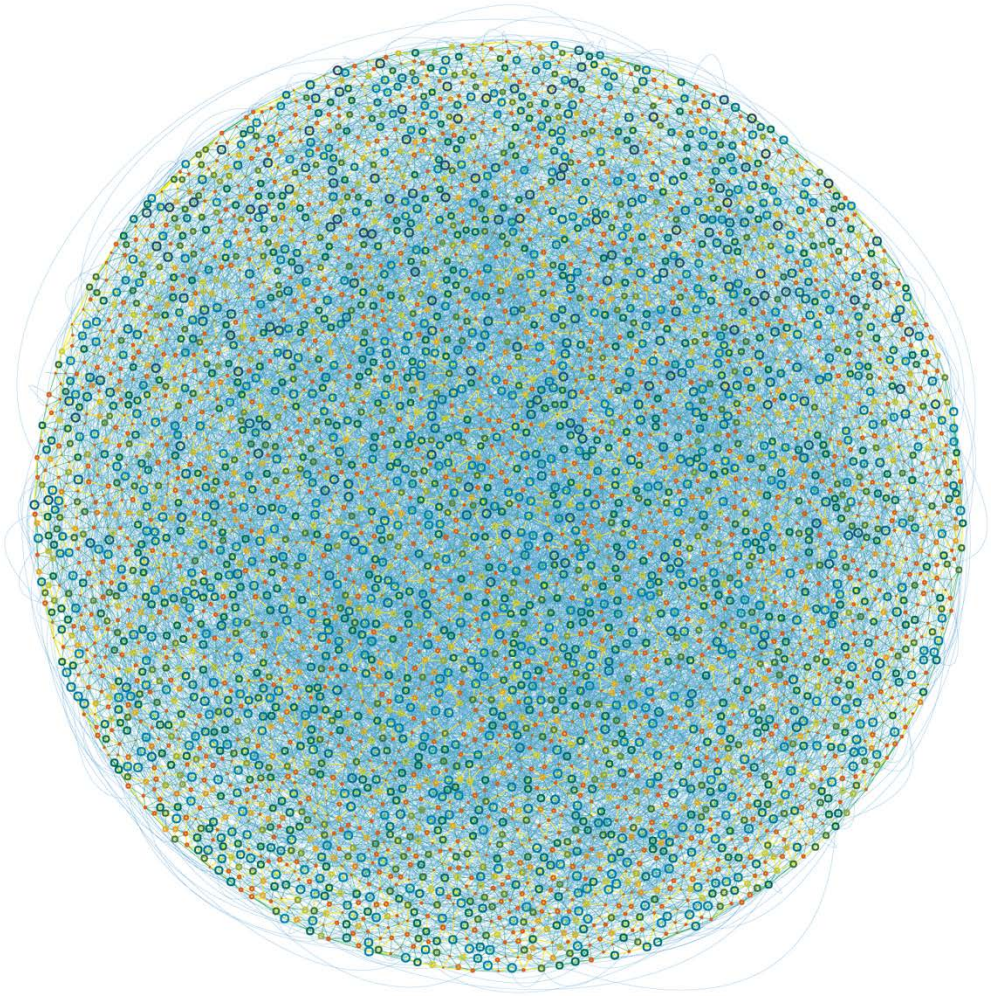
02:30 - 03:15 pm	Evoking Post-industrial Landscape Memories through Mixed Reality Soundscapes	Yixiao Fu
03:15 - 04:00 pm	The Responsive Layer: Towards a Self-expressed Physical World with Digital Augmentation	Yun Hao
04:00 - 04:45 pm	Hybrid Embroidery: Exploring Interactive Fabrication in Hand Crafts	Yi-Chin Lee
04:45 - 05:30 pm	Children's Exploration with Social Robots in Digital Art Making	Yaxin Hu

Advisors

Henny Admoni, Robotics Institute
Josh Bard, Architecture
Daragh Byrne, Architecture
Daniel Cardoso Llach, Architecture (Track Chair)
Ray Gastil, Architecture
Eddy Man Kim, Architecture
Eunsu Kang, Machine Learning
Ramesh Krishnamurti, Architecture
Golan Levin, Art
Josh Panknin, Engineering (Columbia U.)
Larry Shea, Drama
Molly Wright Steenson, Design
Valentina Vavasis, Architecture
Lining Yao, Human Computer Interaction

Session 1: Design Tools

Projects in this session reimagine the design process and its actors through new approaches to design participation, crowdsourcing, embodied virtuality, and generative design workflows.



Toward Designing with Heterogeneous Values

Vincent Mai

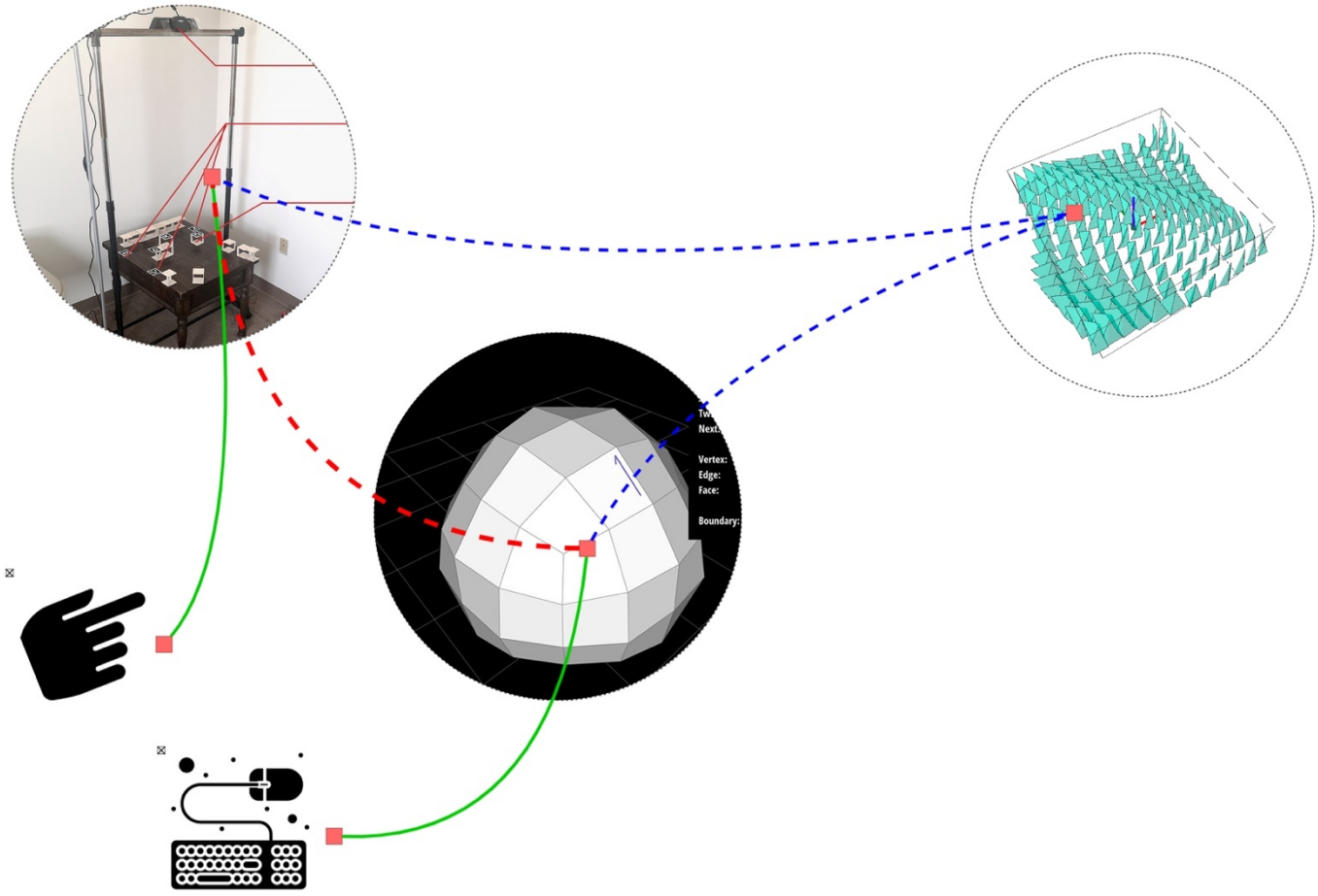
8:00 – 8:45 am

Advisors
D. Cardoso
R. Gastil

The process of urban design can be viewed as complex negotiations among heterogeneous value agendas representing different stakeholders. As a result, any urban design problem can yield a multitude of framings, each delineates a distinct set of considerations pertaining to its underlying objectives. Planners and designers frequently face the unwieldy challenge of the growing complexity of design problems, characterized by a large set of intertwined and often competing objectives.

Existing urban modeling approaches for policy analysis have been proven effective in simulating urban dynamics, they nonetheless model design as ‘black box’ processes within systems feedback loops. In contrast, systems modeling languages explicitly model the architectural and design variables of engineering systems. However, its effectiveness depends on the clarity of the design specifications while most urban issues are uncertain and ill-defined. Finally, multi-objective designs are often approached as optimization problems that presume fixed rules of objectives trade-offs, whereas design emphasizes designer’s ingenuity and creativity in coming up with novel solutions.

How can a design knowledge representation provide affordance and decision support when design problems are ill-defined and uncertain? The following thesis develops a graph design database for multi-objective street design. Integrating existing methods in system modeling, probabilistic inference, and property graph query, the database design explores a computational approach for discovering latent synergies and conflicts between different objectives and design strategies, facilitating the formulation of salient questions, and unveiling prudent design dimensions.



A Mixed Modeling Environment Exploring Tangible and Digital Interactions for Iterative Design Modeling

Hongtao Ma

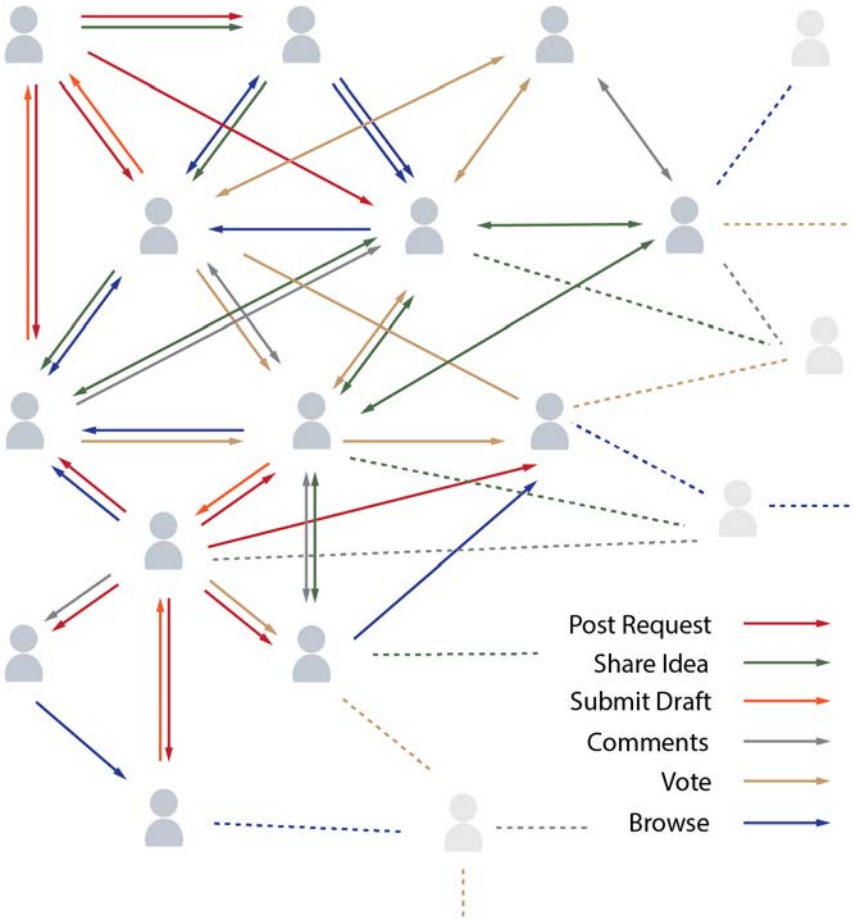
8:45 – 9:30 am

Advisor
D. Cardoso

Reader
E. Man Kim

This thesis explores the concept of embodied virtuality in design modeling, where there is no clear separation between interaction with the physical and virtual world. Inspired by researchers' effort to explore the interaction patterns for 3D modeling, the idea of taking advantage of both physical and virtual worlds is emerging: the physical space supports embodied interaction, while the digital interface offers parametric editing operations as well as some post-processing functions. Based on an analysis of previous researches, this thesis argues that by combining a specific mesh data structure with a physical encoding of geometries in voxels, we can merge the gap between tangible and digital interfaces and leverage the strengths of both, which will bring out a new way of working for designers and enable more agency of designers, not just professional ones.

In this thesis, a mixed modeling system is built as a processing API to be used as a tool for an animation design task. The system enables concurrent interaction with both the tangible cubes and the digital model and makes it convenient to iterate the design in both worlds. The project aims to set up a mixed modeling framework that is extendable, so successors can extend either the TUI or the GUI (e.g. designing something that is different from a voxel representation for the TUI or adding more edit operations for the GUI).



An inquiry into crowdsourcing for early-stage product design

Weixin Qiu

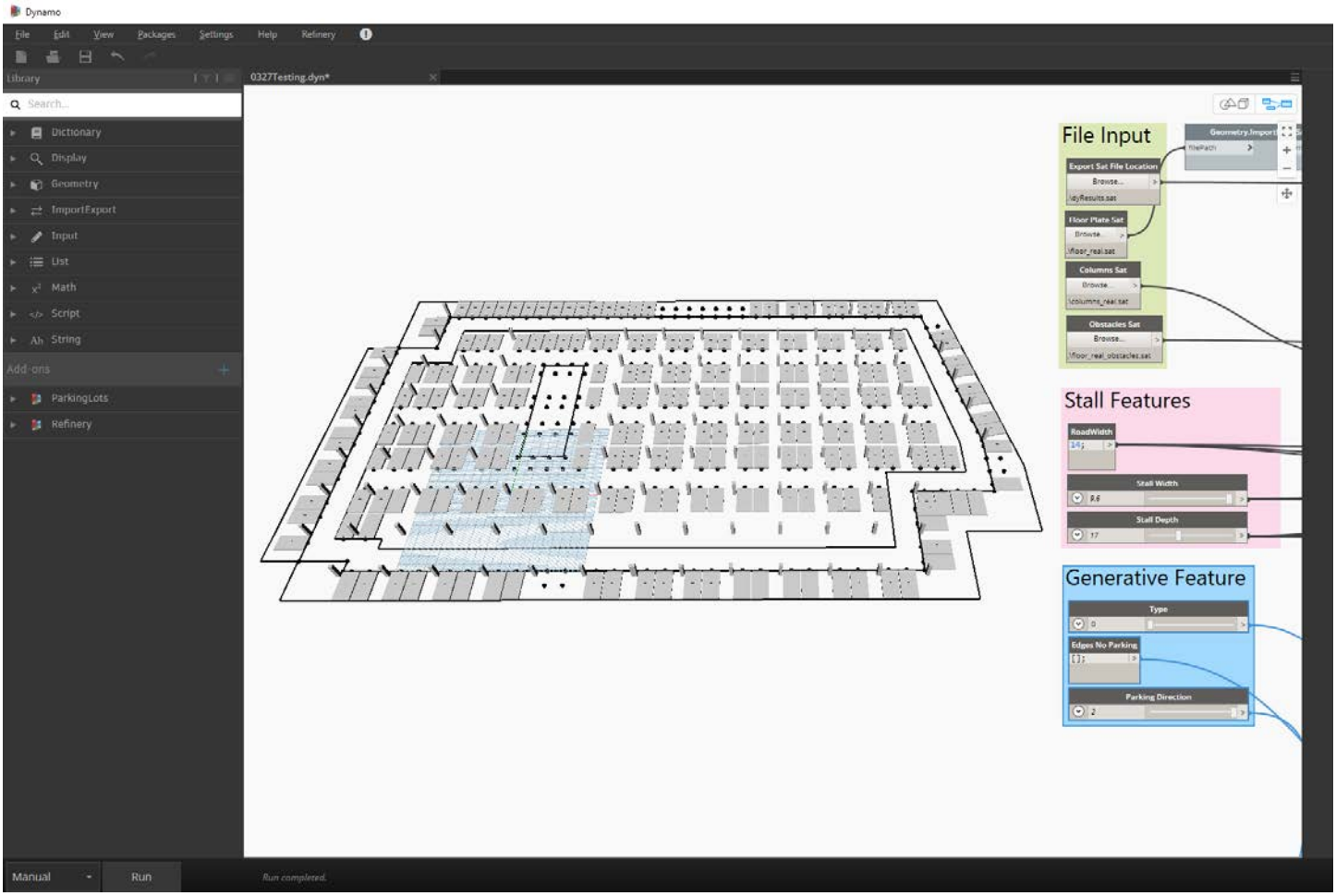
9:30 – 10:15 am

Advisor
D. Cardoso

Reader
E. Man Kim

The maturing of internet technologies has changed dramatically the way people work and, under the impact of the current health crisis, online collaboration and communication seem to demand increased attention.

In this research, I investigate and review the concepts of crowdsourcing workflow and the pros and cons of some existing design tools that support crowdsourcing — a kind of workflow that uses the internet to collect work from multiple actors. Based on the analysis of these, I explore the potential of applying it to the field of design, and implement a web-based design tool that combines the characteristics of crowdsourcing workflow and collaborative design. Some relevant issues of crowdsourcing are also discussed, such as compensation mechanism and user engagement.



A Generative Design Application Development Workflow for Architecture

Siyu Guo

10:15 - 11:00 am

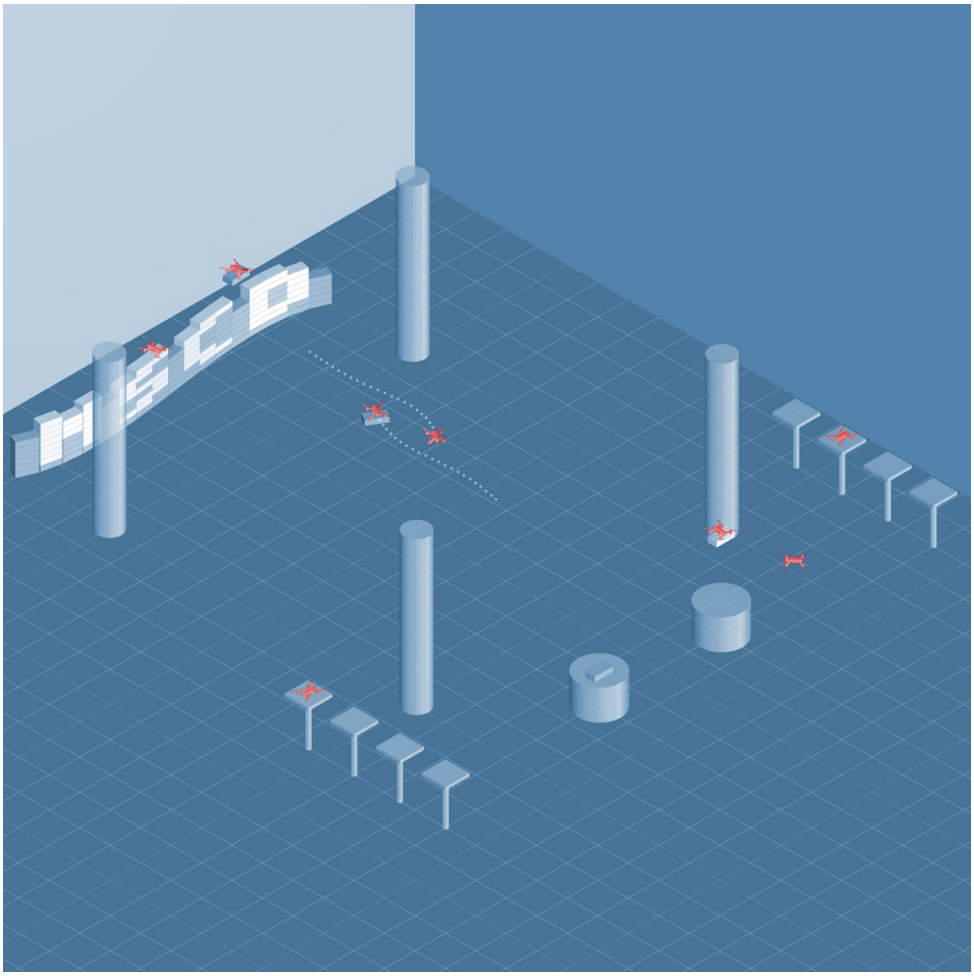
Advisor
D. Cardoso

Reader
J. Bard

This thesis explores the feasibility of using generative design techniques to improve the efficiency of architectural tasks. Through research on traditional case studies, contemporary case studies, user interviews, I found scenarios that are suitable for using generative design techniques in architecture: the design quality can be quantified, the task is boring and repetitive, there is rich data to measure the design results. Based on the findings, I proposed a new development process for derivative design tools. Using this process, I developed a prototype of a parking garage generative design tool. Through a demo with architects, their feedback demonstrates that the prototype has practical value for improving the design efficiency. In the end, I will release both the development workflow and the associate prototype on the dynamo forum.

Session 2:
Data and Design

Projects in this session mobilize datasets large and small in conjunction with machine learning algorithms to generate, analyze, or build design.



Towards Multi-Drone Autonomous Construction via Deep Reinforcement Learning

Zhihao Fang

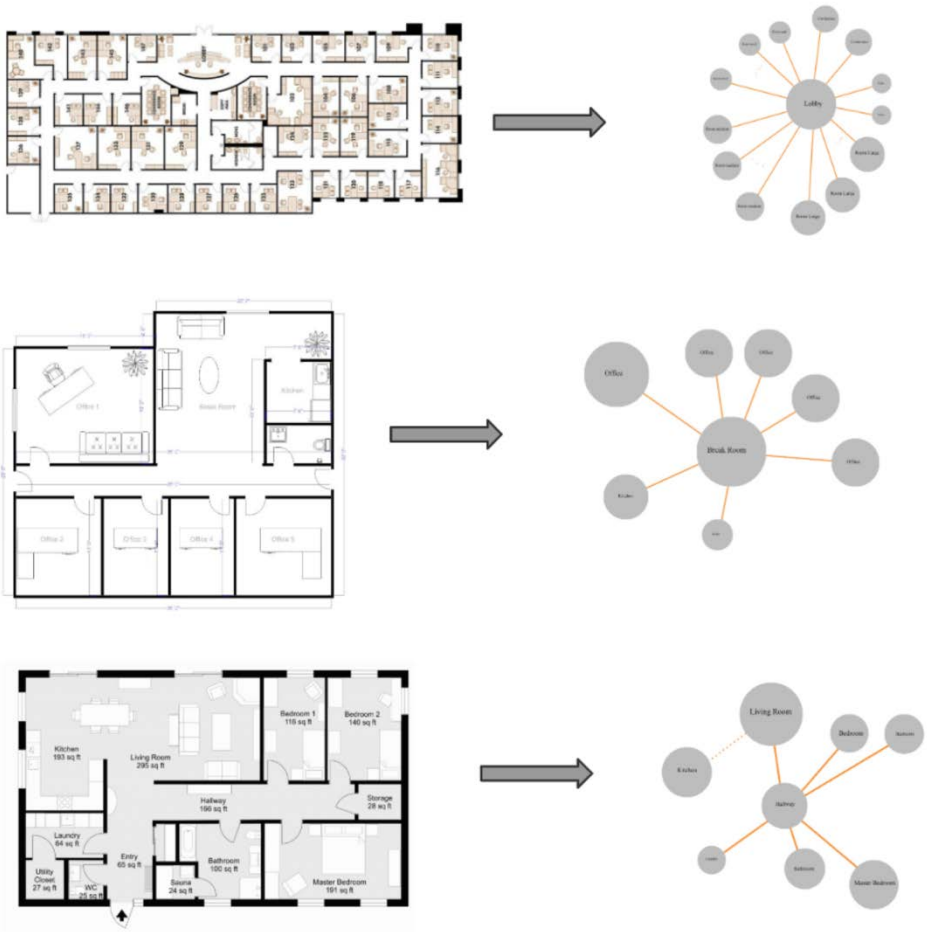
11:15 - noon

Advisor
D. Cardoso

Readers
J. Bard,
A. Bidgoli,
R. Krishnamurti,

Autonomous construction has been an active research topic for engineers and designers for many years. Meanwhile, technological advancements in the drone industry are pushing the extending their capabilities, increasing the probability of drones actively participating in additive construction in the near future. However, there is no technical framework that can control a scalable number of drones for autonomous construction in a dynamic, continuous environment.

This thesis aims to develop a simulator system for autonomous multi-drone additive construction using deep reinforcement learning based algorithm. First, the process of multi-drone additive construction is modeled in a computer simulation. Then state-of-art deep reinforcement learning algorithm is applied to achieve collision avoidance in navigation. Finally, a software package is developed and able to be integrated into a 3D modeling software, Rhinoceros, for future use and development for researchers and designers.



Data Processing in Using Machine Learning to Analyze Floor Layout Plan Design

Yufei Chen

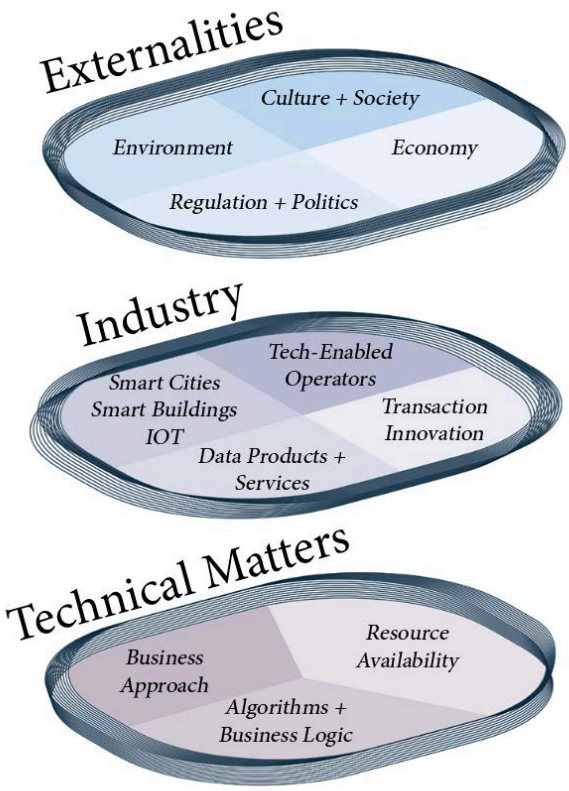
Noon – 12:45 pm

Advisor
D. Cardoso

Readers
R. Krishnamurti
A. Bidgoli

As the study of machine learning becomes more mature, more and more people begin to think about applying this technology to help research on problems long existed and generate a new outcome, and using machine learning to help research on the analysis of architecture layout plan is a popular one. Among the machine learning techniques rising in recent years, the deep neural network is the most significant and the newest one. And the most important part of the machine learning process, data processing, is missed and hasn't been touched in a research perspective in the relative papers.

To reveal the inner logic of how we design the layout plan, the approach based on using graph theory and focus on the interior space's topological relationship is chosen for this research. During the research, various data structures are chosen to represent the same raw graph data extracted from the floor layout design. As different data inputs, they are examined under the same universal machine learning process to find out the influence of various data representation forms. Thus some universal machine learning frameworks are examined and created an adapted version for floor layout plan analysis.



Rethinking PropTech: Drawing Insights about the Real Estate Technology Industry through Technical Experimentation

Ian Friedman

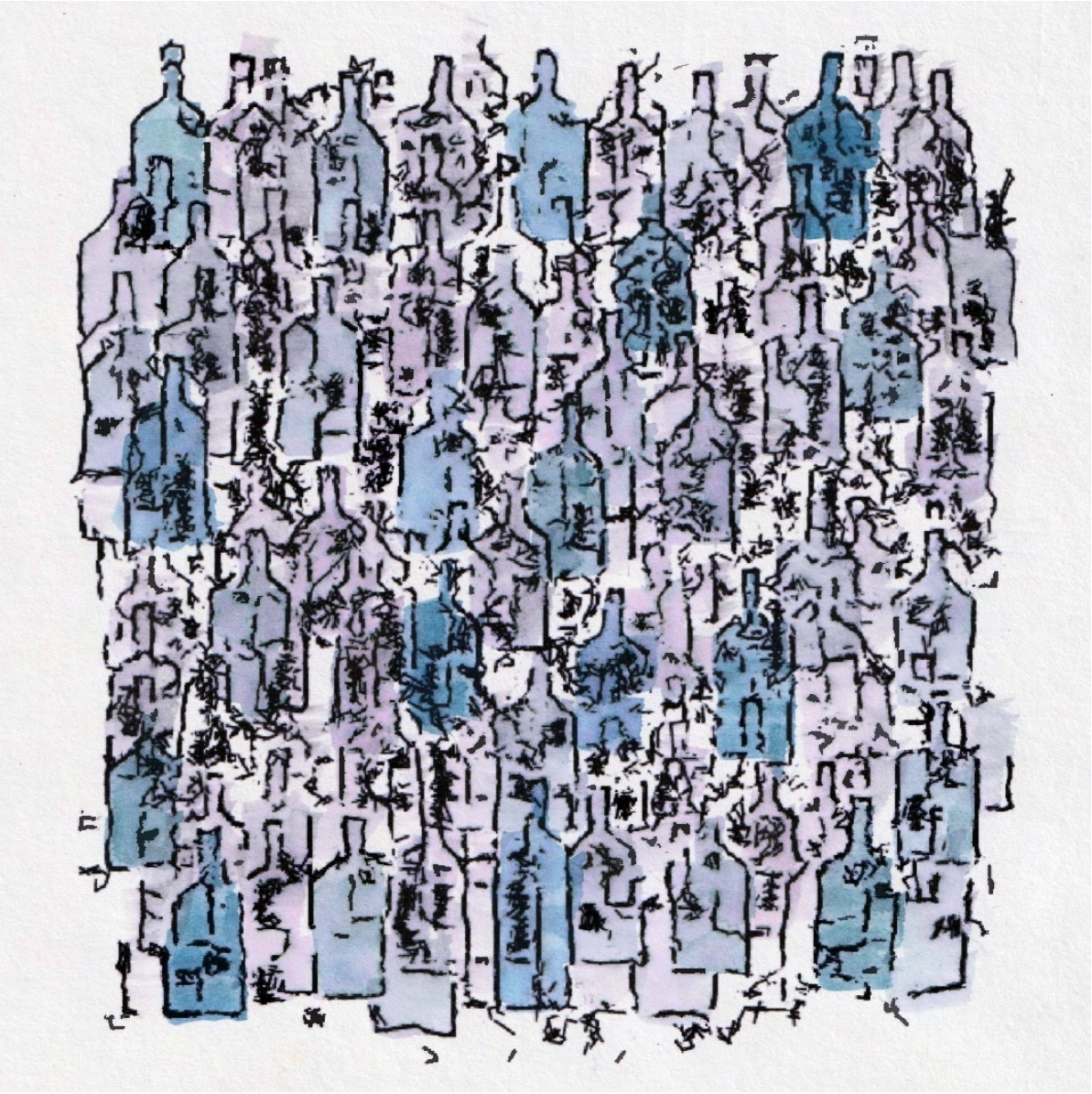
12:45 – 1:30 pm

Advisors
E. Man Kim
V. Vavasis
D. Cardoso
J. Panknin

Over the past ten years, the real estate technology industry, also known as PropTech, has undergone a massive expansion. This rapid expansion, fueled by a >140x growth in venture capital funding over the past decade, has propelled PropTech startups to actively shape the ways in which we engage with the built environment; physically, digitally, financially, and otherwise.

This rapid change calls for rigorous inquiries into the nature and mechanics of PropTech. Prior work that attempts to understand PropTech has focused on establishing broad definitions of the industry, occasionally scoping down to highlight a few issues at play at a technical level. While these approaches have been incredibly useful in defining an otherwise nebulous industry, they do not examine how the technical issues of PropTech relate to and inform the structures at play within industry, an important perspective to take on an industry that is fundamentally driven by technology.

This thesis draws insights about PropTech by taking a decidedly different approach; one which uses technical experimentation, data analysis, and industry immersion as a basis of examining the broader industry from the inside. In doing so, new insights emerge and a different mode of thought arises - one which is hierarchical, contextualizing technical issues within areas of industry and highlighting their relationship to the much broader phenomena of macroeconomics, regulation and politics, culture and society, and the physical environment.



Crafting the Weights of a Convolutional Neural Network to Make a Line Drawing

Erik Ulberg

1:30 – 2:15 pm

Advisors
D. Cardoso
D. Byrne

Readers
G. Levin
M. Steenson

A growing number of visual artists use convolutional neural networks (CNNs) in their practice. While CNNs show promise as a form of representation in art, the lack of interpretability of CNNs limits creative control to high level decisions around datasets, algorithms, and hyperparameters. As an alternative, the field of computer vision presents a more immediate paradigm of control through the hand-crafting of convolutional kernels.

This thesis investigates the hand-crafted approach as an additional creative lever for artists working with CNNs. It reimagines network weights as a continuous, spatial, and computational material supporting direct human interaction. Two experimental tools are proposed: one for parametrically generating first layer kernels and the other for editing multiple layers. These tools attempt to transform the hand-crafting of features into “crafting” in a truer sense by bringing CNNs and visual materials into a close feedback loop. The author serves as a case study to examine the affordances and artistic use cases of hand-crafted CNNs. The results suggest that hand-crafted CNNs can be a viable form of representation for artists seeking to build simple, bespoke feature detectors, but that more complex CNNs would likely require a hybrid approach integrating data-driven methods.

Session 3: Interactive and Immersive

Projects in this session explore embodied, material, and social aspects of computation to speculate about memory, pedagogy, and craft.

Evoking Post-industrial Landscape Memories through Mixed Reality Soundscape

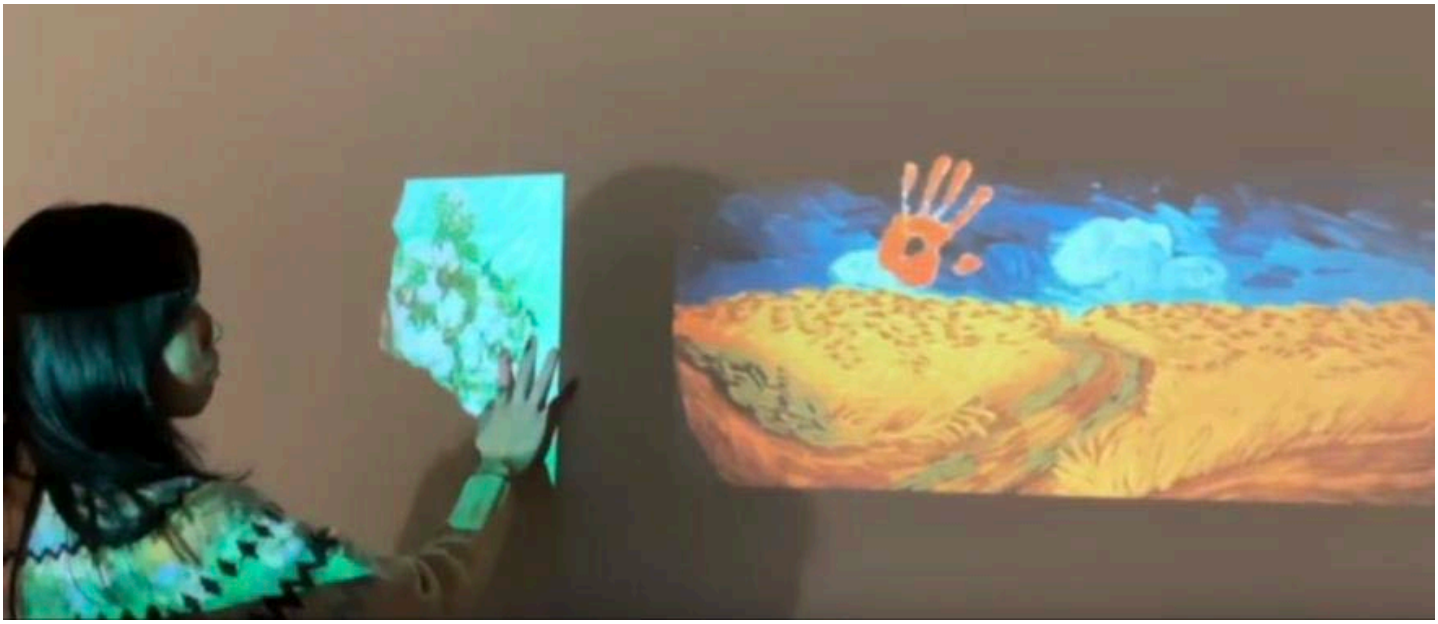
Yixiao Fu

2:30 – 3:15 pm

Advisors
D. Byrne
D. Cardoso
L. Shea

Landscape and memory are entangled concepts when discussing the relationship between the geography (space) and history(time). By evoking the memories in the landscape, there is a temporal and ontological disjunction which suggests the spectrality of the space. Sound, a physically unconstrained and invisible medium, is perfect for presenting such spectral presence in a form of absence.

Located at the interface between the post-industrial landscape, spectral memory, sound and contemporary media technology, this thesis asks how can a spatialized soundscape serves as a medium to evoke the spectral memories of the landscape? An audio walk “Spectral Memory of the Post-Industry” is proposed at Pittsburgh’s historical landmark - Carrie Furnace as a proof of concept. While taking the form of an audio walk, the thesis challenges the linear narrative structure that is commonly found in traditional audio walks (constrained, guided) and proposes a space-driven auditory wandering (open-ended, unguided). Mobile mixed reality is utilized to support the sound localization and spatialization and offers a more flexible and immersive way of exploring the landscape. The spectral memories of the landscape are realized through a virtual soundscape combing the environment sound effects and oral history recordings. Using the post-industrial landscape’s distinctive aesthetics and spatial complexity as the stage for soundscape design, this thesis also explores the juxtaposition between a multi-sensory visual and sonic experience and how it allows people to empathize with historical events and reinterpret the landscape identity. Building upon the technical set up for audio-based mixed reality, this thesis also introduces the workflow of designing the spatialized soundscape for landscape on visually-based design platforms.



The Responsive Layer: Towards a Self-expressed Physical World with Digital Augmentation

Yun Hao

3:15 – 4:00 pm

Advisor
D. Cardoso

Reader
D. Byrne

The Internet of Things (IoT) enables physical objects to use built-in hardware and software to acquire and transform data over the Internet and respond to humans. Each IoT device has its own unique application and interface for users to use and control. However, in an environment where IoT devices are continuously working together, it is difficult for users to control and interact with it in this way. In addition, the ideal smart environment is supposed to consist of everyday objects that can also capture information and respond like IoT devices.

This thesis proposes an interactive system called the Responsive Layer that enables everyday objects to express information about objects themselves or previous interactions with users without the need for additional embedded sensors and interactive devices. The system combines projection mapping and computer vision technology to perceive the interaction between users and the physical world and respond with images and text through projection. The thesis discusses the intentions of the system, its design concepts, implementation details, and prototypes used to evaluate and improve the system. It introduces an easy-to-operate system architecture that uses digital augmentation to interact with the physical world and proves its feasibility and wide application prospect through the development and observation of prototypes.

Hybrid Embroidery: Exploring Interactive Fabrication in Hand Crafts

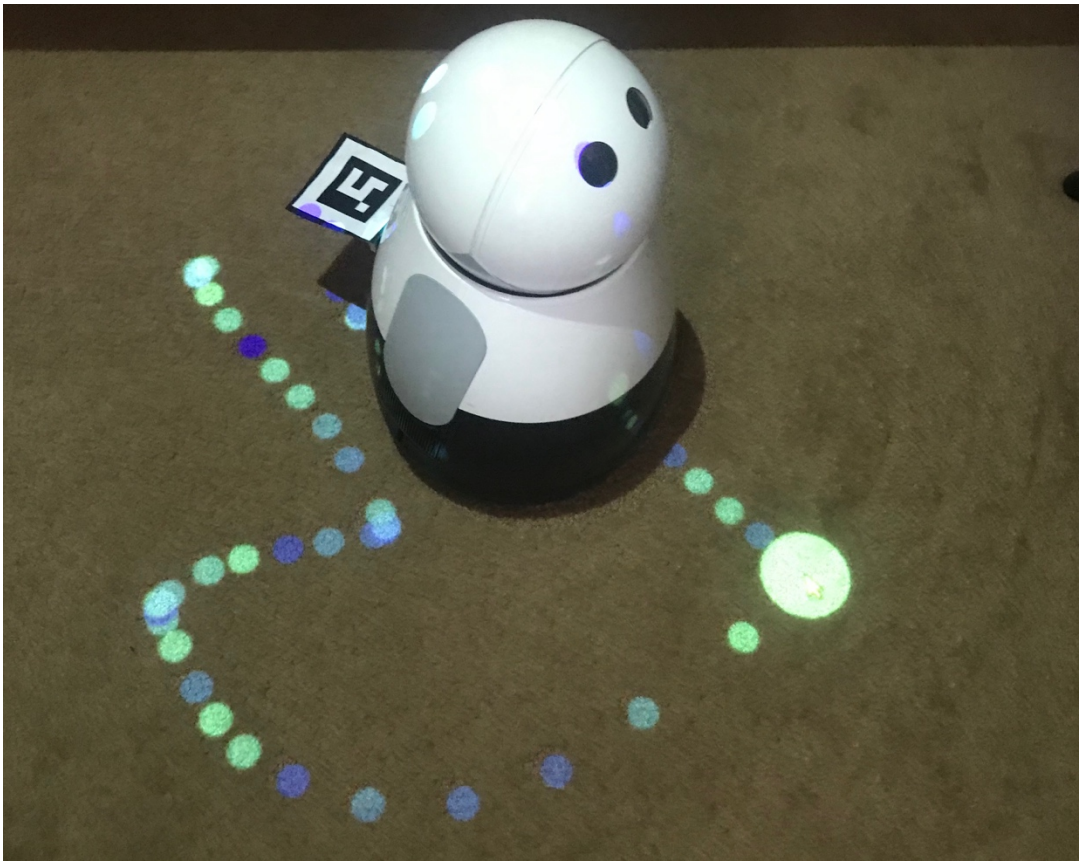
Yi-Chin Lee

4:00 – 4:45 pm

Advisors
D. Cardoso
J. Bard
E. Kang

This research presents Hybrid Embroidery, a framework for interactive fabrication that leverages the potential of computation to broaden the possibilities of the craft of embroidery. Combining traditional crafting techniques of embroidery, computational design methods, computer vision, and computer numerical control (CNC), the research shows how this framework elicits a variety of innovative fabrication experiences that emphasize open-ended exploration, improvisation, and play.

Interacting with the system's algorithms in a conversational, turn-based fashion, users create generative embroidery stitching paths that result in unique embroidery pieces. Further, there each embroidery piece acts as a module of the bigger picture in the game of exquisite corpse in response to the inherent communal nature in textile crafting. Hybrid embroidery thus offers an example of how computational methods may enrich craft and other creative practices. It further highlights its implications for supporting creative exploration through real-time and direct manipulation of materials and close human-machine interaction. This thesis documents this framework, a series of sample results, challenges, and how to position this framework to the larger picture.



Children's Exploration with Social Robot in Digital Art Making

Yaxin Hu

4:45 – 5:30 pm

Advisors
D. Cardoso
H. Admoni

Exploration is an essential way for children to make sense of the world and reflect on self-identity in the view of constructionism. With materials provided by culture and environment, children explore and understand the unknowns through acting in them. Nowadays, the digital age has created a larger variety of technical artifacts that children interact with and provided new environments for them to explore and learn.

This thesis presents an interactive system with an autonomous mobile robot Kuri, where children engage in digital art making activities and explore the underlying mechanisms of robot behaviors and graphics generation. Further, the thesis investigates robot social behaviors that are exhibited with facial expression, body movement, sound and light, and designs experiments to evaluate their effects on children’s willingness to explore different palettes in the interactive system.

The **Master of Science in Computational Design** (MSCD) is a 2-year post-disciplinary research program at the School of Architecture at Carnegie Mellon University investigating critical questions and creative opportunities at the intersection of design, computation, and the built environment.

Contacts

MSCD Track Chair

Daniel Cardoso Llach
Associate Professor, Architecture
dcardoso@cmu.edu

Graduate Programs Coordinator

Darlene Covington-Davis
dc1e@andrew.cmu.edu

Admissions Coordinator

Alexis McCune
amccune@andrew.cmu.edu

Information for Applicants
https://soa.cmu.edu/cd-application-requirements

Website:
http://code.arc.cmu.edu

Faculty Advisors

Josh Bard
Associate Professor, Architecture
jdbard@cmu.edu

Daragh Byrne
Associate Teaching Professor, Architecture
daraghb@cmu.edu

Dana Cupkova
Associate Professor, Architecture
dcupkova@andrew.cmu.edu

Eddy Man Kim
Associate Teaching Professor, Architecture
eddymankim@cmu.edu

Ramesh Krishnamurti
Professor, Architecture
ramesh@andrew.cmu.edu

Golan Levin
Professor, Art
golan@cmu.edu

Larry Shea
Professor, Drama
lshea@cmu.edu

Molly Wright Steenson
Associate Professor, Design
steenson@cmu.edu