The Computational Design: Practices, Histories, Infrastructures symposium is a two-day event at Carnegie Mellon University that examines computation as a subject of both scholarly and creative inquiry in architecture and other design fields. It accompanies the exhibition Designing the Computational Image, Imagining Computational Design at the Miller Gallery at Carnegie Mellon, which showcases rare photographs, film, high-quality reproductions, and interactive software reconstructions examining the formative period of numerical control and Computer-Aided Design technologies (1949-1976), along with a selection of experimental work by computational designers working today. Along with the exhibition, the symposium seeks to situate contemporary design methods in architecture and other creative fields in relation to broader histories, disciplinary frames, and technical infrastructures.

Speakers
Kristy Balliet, SCI-Arc/Ohio State;
Nathalie Bredella, Berlin University of the Arts, Germany;
Joseph Choma, Clemson U./U. of Cambridge, UK;
Dana Cupkova, Carnegie Mellon;
Jacob Gaboury, Berkeley;
Madeline Gannon, Carnegie Mellon;
Andrew Heumann, WeWork, NY;
Sean Keller, Illinois Institute of Technology;
Golan Levin, Carnegie Mellon;
Carl Lostritto, RISD;
Jonah Ross-Marrs, MIT;
Molly Wright Steenson, Carnegie Mellon;
Theodora Vardouli, McGill University.

Discussants
Felecia Davis, Penn State;
Molly Wright Steenson, Carnegie Mellon;
Olga Touloumi, Bard College;
Dan Taeyoung, Columbia.

Workshops by
Carl Lostritto; Joseph Choma; Atefeh Mahdavi and Scott Donaldson;
Jonah Ross-Marrs; Dan Taeyoung.

Demos by
Ben Snell
CMU Morphing Matter Laboratory
Qiaozhi Wang

Student Assistants
Scott Donaldson; Cecilia Ferrando; Liale OHMA Nijem; Chitika Vasudeva.

Administrative Support
Thomas Hughes; Linda Hague; David Koltas, Diana Martin.

Workshops coordination
Eddy Man Kim

Concept & Organization
Daniel Cardoso Llach
### Saturday October 7

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<td>Tour of the Designing the Computational Image/Imagining Computational Design exhibition</td>
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<td>11:00 – 11:15</td>
<td>Walk to the STUDIO (CFA111)</td>
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<td>G.L.O.: Graphic Line Object - Kristy Balliet, SCIarc/OSU;</td>
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<td>If these files could talk: Extracting Patterns from Digital Archives of CAD Drawings</td>
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<td>using Novel Forensic Techniques - Jonah Ross-Mars, MIT;</td>
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<td>Olympic Calculations: Computational Modeling for Munich ’72 - Sean Keller, IIT;</td>
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<td>Computational Visualization and Intermediation - Nathalie Bredella, University of the Arts,</td>
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<td>Berlin;</td>
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<td>Sketching with Mathematics: Variations of a Dancing Torus - Joseph Choma, Clemson U/U. of</td>
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<td>Beyond Nostalgia: drawing discipline from the brief pen-plotter era - Carl Lostritto, RISD;</td>
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<td>Picturing Structures</td>
<td>Structuring Pictures: Graph Manifestations in Christopher Alexander’s Architectural Theories (1961-1974) - Theodora Vardouli, McGill;</td>
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<td>Culling Vision: Depth, Distance, and the Limits of Perception in Graphical Simulation - Jacob Gaboury, Berkeley;</td>
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<td><strong>Computational Design Pedagogy Roundtable;</strong></td>
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<td>Interactive projects by the CMU Morphing Matter Lab (directed by Lining Yao); Benjamin Snell;</td>
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<td>George Wang; and more.</td>
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<td>19:30 – 21:00</td>
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### Sunday October 8

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<td>The present and future of architectural automation - Andrew Heumann, WeWork</td>
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<td>Indeterminate Set - Dana Cupkova, CMU</td>
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<td>Interpolation, A Social and Personal History, Golan Levin, CMU</td>
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<td>Reimagining Urban Intersections through Systems Thinking - Atefeh Mahdavi and Scott Donaldson</td>
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<td>Build a miniature CNC from e-waste - Jonah Ross-Mars, MIT</td>
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<td>Metatool: Seeing Spaces - Dan Taeyoung, Columbia</td>
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<td>Cutting Edge Nostalgia: Rhino-Controlled Vintage Pen Plotters - Carl Lostritto, MIT</td>
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<td><strong>Workshops Second Session</strong></td>
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### Code of Conduct

Our symposium is dedicated to providing a harassment-free experience for everyone, regardless of gender, gender identity and expression, age, sexual orientation, disability, physical appearance, body size, race, ethnicity, religion (or lack thereof), or technology choices. We do not tolerate harassment of symposium or workshop participants in any form. Participants violating these rules may be expelled from the event at the discretion of the organizing team.
Session 1 Software Comes to Matter
Location: Frank-Ratchye STUDIO for Creative Inquiry - CFA 111
Time: Saturday October 7, 11:30 - 1:30

Participants
Kristy Balliet, SCI-Arc/Ohio State;
Nathalie Bredella, Berlin University of the Arts, Germany;
Sean Keller, Illinois Institute of Technology;
Jonah Ross-Mars, MIT.

Discussant
Molly Wright Steenson, Carnegie Mellon
G.L.O. / Graphic Line Object
G.L.O. / Graphic Line Object is a set of drawn models that explores the convergence of the virtual and physical of the drawn line. The pieces expose and challenge the visual tensions and expectations associated with the evolution of the computational image. The three physical models reference wall objects – a shelf, a plaque, a tapestry – while alternating roles between three distinct parts – a flat graphic, a thick drawn line, and an object. The role of what is modeled, drawn and displayed is explored in virtual reality and adapted for the physical realities of the gallery. It is a project that considers the gestures associated with drawing as a critical part of the computational process. The consequence of the combination of computational gestures with physical output offers new opportunities for material exploration.

Kristy Balliet is an architectural designer and co-founder of BairBalliet and principal of Balliet Studio. She is currently a design faculty member at SCI-Arc and an associate professor at The Ohio State University's Knowlton School of Architecture. Balliet is a graduate of Philadelphia University and the UCLA Department of Architecture and Urban Design. She is currently working on the forthcoming publication, The Possible Mediums Project to be published in 2018.

If these files could talk: Extracting Patterns from Digital Archives of CAD Drawings and 3D Models Using Novel Forensic Techniques
What can we learn from examining a given digital file of a drawing or 3D model? We could certainly open up the file in the appropriate software program and examine the drawing or model itself, but what more is hidden beneath this virtual representation? While a drawing or 3D model file appears to us on screen as a collection of parts existing at one and the same time in virtual space, the constituent lines, triangles or surfaces are actually represented in the software program as a sequence known as an index. By examining a file's element index, information can be gleaned about the designer's drawing or modeling process (the process of a file's becoming) and about the idiosyncrasies of the software program in which the file was created. Just as archaeologists have found hidden paintings concealed beneath famous works of art using radiography, is it possible to uncover another layer of information in our digital files lying just beneath the surface? Finding strategies of representing the sequence of elements in an index to uncover patterns is the subject of my research. This work requires building a toolbox of forensic methods to distinguish between user or algorithm-derived indexes across various file types and software platforms.

Jonah Ross-Marrs is a Master's of Science in Architecture Studies Candidate with the Computation Group at the Massachusetts Institute of Technology. Using novel visualization methods, Jonah seeks to reveal the hidden forms of the software tools which architects use today. Jonah was born in Oxfordshire, U.K. and grew up in Canada. He has worked as an Intern Architect in Berlin for Sauerbruch Hutton and as an Artist in Residence at Autodesk's Pier 9 in San Francisco.

Olympic Calculations: Computational Modeling for Munich '72
While, tragically, the 1972 Olympic Games in Munich came to be known best for the terrorist attack that took place there, the games were also the occasion for an important composition of architecture, landscape, art, and engineering that became a permanent addition to the city. At the center of the complex designed by Günter Behnisch was an ensemble of vast undulating tensile roofs covering the main athletic venues—roofs which were only, and only barely, made possible through major advancements in computational representation and analysis. Beginning with an image of one of the highlights of the design process—a purely computational model of portion of the roof—this talk will describe the emergence of new computational modeling techniques out of a hybrid design environment of physical models, drawing, photogrammetry, full-scale fabrication, machine plotting, and early computational form-finding.

Sean Keller is a historian and critic of modern and contemporary architecture. He is the author of Automatic Architecture: Motivating Form After Modernism (University of Chicago Press, 2017) and has written for numerous anthologies and journals, including Artforum, Grey Room, Perspecta, and the Journal of Architectural Education. His work has been recognized by a Warhol Foundation Grant and a Winterhouse Award for Design Writing and Criticism. Keller is Associate Professor, Associate Dean of Research, and Director of the M.S. program in architecture at the IIT College of Architecture. He has taught at the University of Chicago, Yale University, and Harvard University.

Computational Visualizations and Intermediation
At the beginning of the 1990s, NOX, an architectural firm headed by Lars Spuybroek and Maurice Nio created the H2Oexpo, a pavilion designed for the artificial island Neeltje Jans, in order to explore interactions between man and technology. In my talk, I will focus on a CAD drawing depicting the H2Oexpo and ask how the drawing unfolds its operative agency within the context of the design and building process, as well as within the ecological setting of the project. When examining how H2Oexpo grapples with issues of interaction between architecture and electronic media, I will also focus on the subject of computational images and materiality, in order to address the following questions: How were intermediation relationships introduced during design and construction? How did information technology permeate the architectural structures of the pavilion? How did the building’s immersive capacities communicate the dynamics of water management to the public? And finally, to what extent was embodied interaction part of the design concept, and how did it bring forth the potentiality of space?

Nathalie Bredella is a visiting professor of architectural history at the University of Arts Berlin (UdK). Before joining the faculty, she led the DFG-funded research project “Architecture and New Media” at the UdK. Prior to that, she held fellowships at the DFG research group Media Cultures of Computer Simulation (MECS) at the Leuphana University in Lüneburg and at the International Research Institute for Cultural Technologies and Media Philosophy (IKKM) at the Bauhaus University in Weimar. After studying architecture at the Technical University Berlin and the Cooper Union New York she received a PhD in architectural theory for her study on architecture and film, published as Architekturen des Zuschauens.
Session 2 Structured Images
Location: Frank-Ratchye STUDIO for Creative Inquiry - CFA 111
Time: Saturday October 7, 14:30 - 16:30

Participants
Joseph Choma, Clemson U./U. of Cambridge, UK;
Jacob Gaboury, Berkeley;
Carl Lostritto, RISD;
Theodora Vardouli, McGill University.

Discussant
Olga Touloumi, Bard College
Beyond Nostalgia: drawing discipline from the brief pen-plotter era
Colette Stuebe Bangert and Charles Jeffrey Bangert together created Large Landscape: Ochre and Black, which is an unusually perfect representation of the ‘60s computer drawing zeitgeist. This drawing was made by writing code to control a pen-plotter. Analysis of the drawing and available technology at the time suggests that there were no 3-D models, no representation of the drawing on a computer screen, and no pre-articulated compositional agenda involved in the making of the work. The drawing is not the output of a digital image. The drawing is the image. Unlike the very earliest computer art, however, the aesthetics were no accident. The Bengert team were reflective, analytical, iterative and purposeful. This talk will cover why the limitations of the “pen plotter era” are interesting from an historical perspective; why these limitations are valuable given today’s pedagogical challenges; why these limitations are applicable to 21st century creative spatial practice.

Culling Vision: Depth, Distance, and the Limits of Perception in Graphical Simulation
Distance has always posed a unique challenge for computer graphics, as it requires a negotiation with the limits of what is seen and may therefore be simulated. For over forty years this problem was solved through the use of a hardware object known as a z-buffer, responsible for the storage and manipulation of depth information for any given simulation. A deceptively simple technology, the z-buffer forms the basis for a wide range of technical practices in visual rendering today, yet the images it produces are never meant to be seen – one of many backend “visual passes” hidden from the user. An examination of these “depth map” images reveals a great deal about the material function of digital images today and their relationship to the history of visual media and indeed vision itself. This talk examines the history of the z-buffer concept through an investigation of one such image. Drawing on original archival research I look to identify the modes of simulation that inform the z-axis as a vector for the simulation of vision, asking what a historical examination of depth and distance in computer simulation can tell us about the ways we computationally produce and restrict visual knowledge today. Image: Screenshot taken from “Z” by Alan Warburton (2012)

Picturing Structures | Structuring Pictures: Graph Manifestations in Christopher Alexander’s Architectural Theories (1961-1974)
In 1961 architect and mathematician Christopher Alexander presented an audience of building scientists with a figure consisting of points and lines. This figure was not a geometric shape, but a mathematical entity that Alexander identified as a “linear graph.” Alexander enlisted the graph to picture the abstract structure that he saw as undergirding a “design problem” – a set of requirements to be met by a designer. He then presented a method for transforming what was a disordered entanglement of requirements into a neatly ordered “tree.” In this talk, I track pictures of graphs in Alexander’s body of work from 1958 to 1974. Taking these pictures as instantiations of a mathematical entity with broader symbolic and operational attributes, I discuss the changing status of graph theory in the 1960s. Ultimately, I interrogate the forces that brought graphs into Alexander’s work as a way of concretely practicing structural abstraction — the lingua franca of architectural and mathematical modernism in the Postwar.

Theodora Vardouli is Assistant Professor in the McGill University School of Architecture. She holds a PhD and SMArchS in Design and Computation from the MIT Department of Architecture, and a professional and post-professional Diploma from the National Technical University of Athens. Theodora’s scholarship interrogates techniques of calculating, modeling, and representing that underlie contemporary digital media, their symbolic meanings for architectural cultures, and operational implications for creative design. She is co-editor of Computational Making (Design Studies, 2015) and Computer Architectures: Constructing the Common Ground (Routledge, forthcoming 2018) — a collection of essays that rethinks the history and historiography of architecture and the computer.
Session 3 Interaction and Intelligence
Location: Frank-Ratchye STUDIO for Creative Inquiry - CFA 111
Time: Sunday, October 8, 08:30 - 10:50

Participants
Dana Cupkova, Carnegie Mellon;
Madeline Gannon, Carnegie Mellon;
Andrew Heumann, WeWork, NY;
Golan Levin, Carnegie Mellon;
Molly Wright Steenson, Carnegie Mellon.

Discussant
Felecia Davis, Penn State
Human-Centered Automation

Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) systems have radically transformed how our world is digitally conceived and physically produced. Although CAD/CAM processes have become more computationally sophisticated, the way a designer communicates an idea to a CNC machine has remained relatively unchanged for over the last 50 years. In this talk, Madeline Gannon discusses how this technology can be appropriated to facilitate broader streams of human-machine communication and interaction. She shares her own work imbuing fabrication machines with a sense of spatial intelligence, and discusses how these human-centered interaction techniques can reconfigure fabrication machines to expand, augment, and amplify human capabilities.

The Present and Future of Architectural Automation

Despite widespread hand-wringing about the massive coming loss of jobs to automation, architects, reports say, can relax, since our complex and creative industry has only a 1.8% chance of being automated in the next 20 years. However, architecture firms and technology companies are scrambling to build platforms that facilitate automating much of architecture, all in the name of productivity and profit. This talk will investigate the reality of architectural automation -- to the extent that it is currently possible -- through the lens of "The 11-House," a composite drawing produced using various automation techniques in popular architectural software platforms. This will provide a jumping off point to interrogate the "automatic" as it relates to form and aesthetics in the present and future of creative work.

Indeterminate Set

Computation is typically a prompt to the illusion of determinacy. This talk will describe a set of pieces shown in the Designing the Computational Image, Imagining Computational Design exhibition. The set plays with the indeterminate expression of a singular piece of code. The three individual objects, originating from it express a variety of formal and aesthetic effects. Represented in these different forms, code becomes ambiguous —overwritten by the expression of each singular identity. Interactivity between this ‘Sentient Object’ and human perception explores, and challenges, the division between humans and their environment. All three pieces were produced collectively, through collaboration —overlaying multiple design sensibilities across the set— but the same code underlies all the pieces.

The New New Economy

The first thing you notice in the Three-Dimensional Trading Floor (3DTF) are the rainbow-colored ribbons, their peaks and valleys rendered in Virtual Reality Modeling Language (VRML). They run from the foreground to the back of the NYSE logo (“the world puts its stock in us”), just in reach of the left hand, maybe skirting the left side of the face. The facets and polygons of the ribbons, of the kiosks behind, display numbers and letters, a periodic table of the stock exchange. It’s a juicy palette produced by an SGI machine that might also churn out special effects in a blockbuster, if it were left running overnight. All the lights are on. All the data are on. As Hani Rashid and Lise-Anne Couture, the principals of Asymptote Architecture wrote in 2002, “The three-dimensional trading floor (3DTF) supplements the main trading floor, allowing users to enter a parallel ‘reality’ and exist in an entirely different space.” (1) In the 3DTF, Asymptote Architecture presents the New New Economy, the movement of capital manifested in vectors and pixels—indeed, an entirely different space, weaving straw into gold, or rainbow-colored ribbons into capital.
Interpolation, a Social and Personal History
A brief history of attempts to transform one thing into another, with code.

Golan Levin develops artifacts and experiences which explore the expressive use of computation. His work focuses on the design of systems for the creation, manipulation and performance of simultaneous image and sound, as part of a more general inquiry into the formal language of interactivity, and of nonverbal communications protocols in cybernetic systems. Through performances, digital artifacts, and virtual environments, often created with a variety of collaborators, Levin applies creative twists to digital technologies that highlight our relationship with machines, make visible our ways of interacting with each other, and explore the intersection of abstract communication and interactivity. Levin has exhibited widely in Europe, America and Asia.

Computational Design Pedagogy Roundtable
A roundtable for sharing methods and tactics to incorporate computation as a subject of creative and scholarly inquiry into syllabi and curricula in architecture and other design fields. Participants are expected to contribute their experiences as computational design educators or students—from sharing ideas about exercises, syllabi, or curricula, to discussing their engagement with different technical or conceptual frameworks, platforms, and themes. While this roundtable chiefly targets educators, everyone is welcome.

Moderated by Dan Taeyoung, Columbia University
Location: Frank-Ratchye STUDIO for Creative Inquiry - CFA 111
Time: Saturday October 7, 17:00 - 18:30
Enrollment limit: 12

Demo Session
Projects by
CMU Morphing Matter Lab, Directed by Lining Yao
Printed Paper Actuator
Thermorph

Ben Snell
LIDAR capture experiment

Qiaozhi Wang
Project HADEN (a VR design environment)

Location: CFA Main Hall
Time: Saturday October 7, 16:00 - 19:00
Enrollment limit: 12
Workshops
Location: Frank-Ratchye STUDIO for Creative Inquiry - CFA 111; CFA 214; Margaret Morrison Carnegie Hall 107 and 403 (Code Lab);
Time: Sunday, October 8, 11:30 - 17:30 (with lunch break)

Tutors
Joseph Choma, Clemson U., U. of Cambridge, UK;
Carl Lostritto, RISD;
Atefeh Mahdavi and Scott Donaldson, CMU;
Jonah Ross-Mars, MIT;
Dan Taeyoung, Columbia.

Workshops coordinator
Eddy Man Kim
Introduction to Mathematical Form-Making

Instructor: Joseph Choma

Date/Time: Sunday, October 8th 11:30 am - 3:30 pm

Location: CFA214

Prerequisites: Basic knowledge of Rhinoceros and Adobe Illustrator is a plus, but not essential.

Equipment: Participants should bring laptops with Rhinoceros.

Enrollment: 30

Description: Cylinders, spheres and cubes are a small handful of shapes that can be defined by a single word. However, most shapes cannot be found in a dictionary. They belong to an alternative plastic world defined by trigonometry: a mathematical world where all shapes can be described under one systematic language and where any shape can transform into another. This workshop systematically lays out a basic foundation for using mathematical transformations as design tools. It is intended for architects, designers, and anyone with the curiosity to understand the link between shapes and the equations behind them.

Cutting Edge Nostalgia: Rhino-Controlled Vintage Pen Plotters

Instructor: Carl Lostritto

Date/Time: Sunday, October 8th 11:30 pm - 3:30 pm

Location: MMCH403 (Code Lab)

Prerequisites: Familiarity with Rhino/Grasshopper

Equipment: Participants should bring laptops with Rhinoceros.

Enrollment: 14

Description: This workshop will introduce Python Programming with the Rhinoscript Library to control a vintage pen plotter. All participants will work individually or in small groups to produce an original one of a kind drawing. We will focus on crafting lines in terms of material, speed and geometry. No programming experience is necessary, but a working knowledge of Rhino basics will be helpful.

Reimagining Urban Intersections through Systems Thinking

Instructors: Atefeh Mahdavi and Scott Donaldson

Date/Time: Sunday, October 8th 11:30 am - 3:30 pm

Location: MMCH103

Prerequisites: A willingness to experiment and usher desirable futures.

Equipment: Participants should bring laptops with Rhinoceros.

Enrollment: 12

Description: How do we negotiate the world around us? This workshop will use systems thinking and simulation methods to explore, experiment, and propose interventions around urban intersections. Whether you drive, bike, walk, take the bus, or are driven by an autonomous vehicle, you’ll be invited to participate in an experimental framework for designing and thinking about intersections. This workshop will involve human-centered design methods such as affinity diagramming to examine our beliefs about traffic, society, and technology. We will use Nicky Case’s Loopy, a tool for thinking in systems, to model and explore the various factors at play. Then, with Dutch traffic engineer Hans Monderman’s notion of ‘negotiation’ and Donella Meadows’ theory of ‘leverage points’ as frameworks, groups will consider their simulations and propose interventions for urban intersections.

Build a miniature CNC machine from e-waste

Instructor: Jonah Ross-Marrs

Date/Time: Sunday, October 8th 11:30 pm - 3:30 pm

Location: STUDIO for Creative Inquiry (CFA 111)

Prerequisites: Familiarity with Rhino/Grasshopper

Equipment: Participants should bring laptops with Rhinoceros.

Enrollment: 14

Description: Learn to build a CNC machine from e-waste and understand the link between virtual files and machined objects at a low-level. This workshop will walk participants through the building of a small computer-numerically-controlled (CNC) machine to draw or cut foam. The workshop will begin by extracting stepper motor-controlled linear actuators from e-waste. The linear actuators will then be assembled in such a way to cut foam or make drawings. After downloading Grbl (a CNC software which works with Arduino) we will move on to control our found stepper motors based on a computer vector file. The participants will leave with a prototype of a working CNC machine with all the necessary software and hardware.
**Metatool: Seeing Spaces**

**Instructor**  
Dan Taeyoung

**Date/Time**  
Sunday, October 8th 11:30 am - 3:30 pm

**Location**  
CFA214

**Prerequisites**  
Basic knowledge of Rhinoceros and Grasshopper

**Equipment**  
A computer equipped with Rhino and Grasshopper (v 0.9.0076)

**Enrollment**  
30

**Description**  
In this workshop, visual representation will be used to construct playful ‘seeing spaces’ for computational design. We will be creating the ‘sandboxes,’ ‘shovels,’ and ‘sand’—environments in which designers can interact and play. How may we craft the design process by shaping the designer’s environment? Grasshopper will be used to create playful interfaces that disappear, becoming part of the Rhino environment. Mouse and keyboards will be used to create new relationships with 3d modeling, data will be incorporated into new types of tools, and representation will be explored as a way to design the behavior of the user. Advanced participants will experiment with incorporating data analysis/ML tools such as regression, k-means clustering, T-SNE, and principal component analysis. However, as this will primarily be a critical/creative workshop about creating tools and environments, the goal will not be to learn specific technical skills, but to adopt and test out a stance towards computation that involves altering the designer’s behavior.

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**Computational Design: Practices, Histories, Infrastructures** is a two-day symposium at the Carnegie Mellon University School of Architecture, College of Fine Arts, hosted by the Frank Ratchye STUDIO for Creative Inquiry, and conceptualized and organized by Daniel Cardoso Llach.

The symposium is aligned with the exhibition *Designing the Computational Image, Imagining Computational Design* at the Miller Gallery of Contemporary Art at Carnegie Mellon. With the support of the Graham Foundation for Advanced Studies in the Fine Arts, a forthcoming reasoned catalogue will record the symposium and the exhibition, and offer additional context through interviews and essays.

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