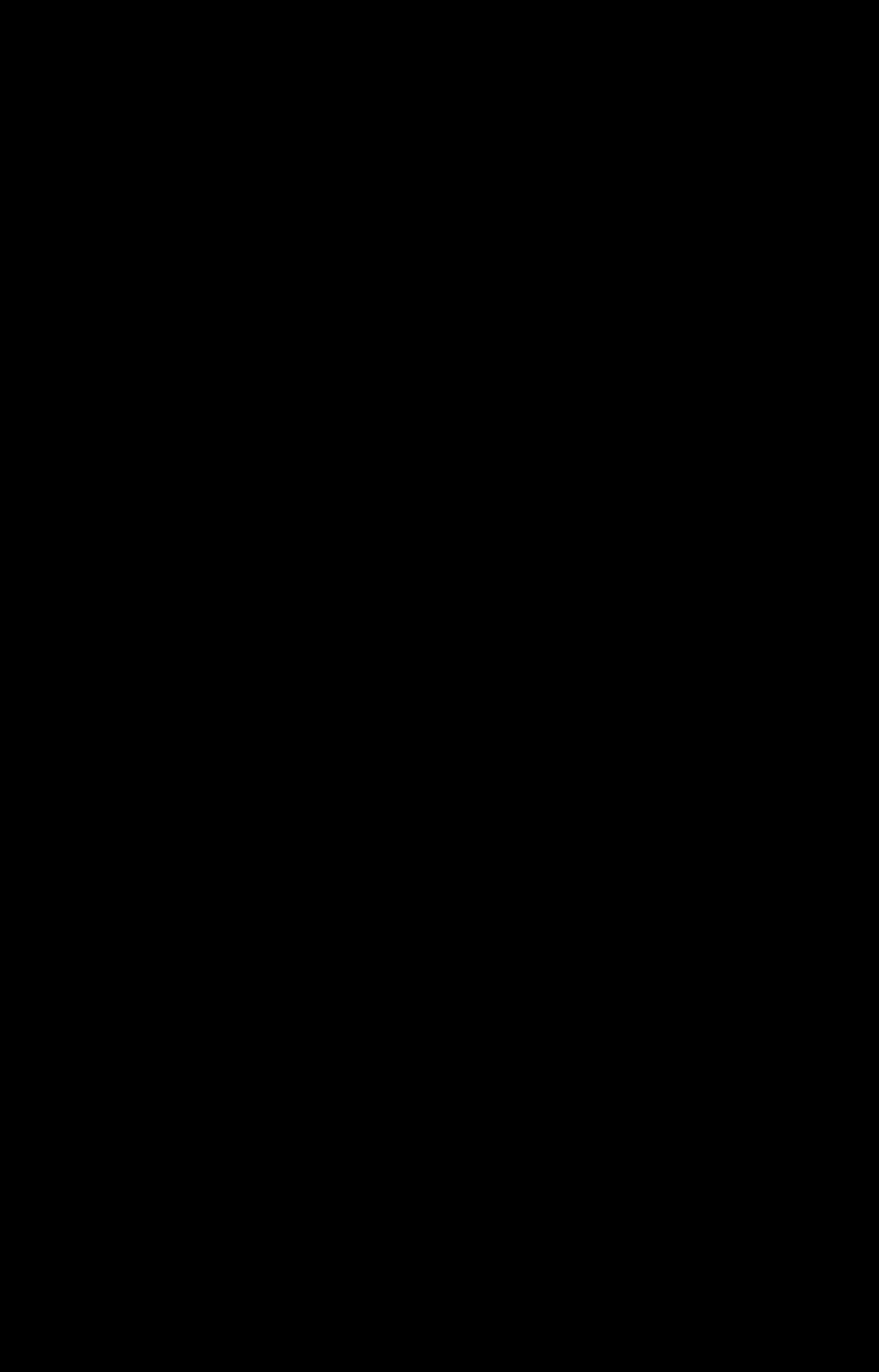


DESIGNING THE COMPUTATIONAL IMAGE IMAGINING COMPUTATIONAL DESIGN

Sep 23–Nov 12, 2017
Miller Gallery at Carnegie Mellon University

Curated by Daniel Cardoso Llach



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Designing the Computational Image, Imagining Computational Design
is an exhibition showcasing rare photographs, film, high-quality reproductions, and interactive software reconstructions examining the formative period of numerical control and Computer-Aided Design technologies, along with a selection of experimental work by computational designers working today.

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Sponsors
This exhibition received generous support from the Graham Foundation for Advanced Studies in the Fine Arts; and from the College of Fine Arts, the School of Architecture, and the Frank-Ratchye STUDIO for Creative Inquiry at Carnegie Mellon University.

Contemporary works by
Kristy Baillet & Kelly Bair, Daragh Byrne, Joseph Choma, Dana Cupkova, Andrew Heumann, Jürg Lehni, Golan Levin, Zach Lieberman, Carl Lostrutto, Jonah Ross-Mars, Kyuha Shim, and Benjamin Snell.

Archives
The Carnegie Mellon University Archives; the Computer History Museum; the Martin Centre for Architectural and Urban Studies, University of Cambridge, UK; the MIT Libraries, Institute Archives and Special Collections; the MIT Museum; SFMOMA; Charles Eastman; Robin Forrest; Timothy E. Johnson; Nicholas Negroponte; Paul Pangaro; George Stiny; Rachel Strickland; and Christos Yessios.

Designing the Computational Image

Imagining Computational Design

By Daniel Cardoso Llach

During the three decades following the Second World War, government investment in university research funded multidisciplinary projects to investigate the use of computers for manufacturing and design. Designing the Computational Image, Imagining Computational Design explores this period of remarkable inventiveness, and traces its repercussions through the work of a selection of computational designers working today.

The historical portion of the exhibition showcases previously unseen or little known photographs, high-quality reproductions, and films exploring the formative period of numerical control and computer graphics technologies between 1949 and 1976. It draws from archives and personal collections including those of the numerical control and Computer-Aided Design projects at MIT, The Architecture Machine group, the Computer History Museum, the Mathematical Laboratory at the University of Cambridge, UK, and the Institute for Physical Planning at Carnegie Mellon University, among others. It is organized in three sections. Software comes to matter shows how at the root of Computer-Aided Design research were concerns about machine automation and material production rather than concerns about representation, as is often understood; Structured images shows how the numerical structure of computational images enabled new kinds of formal manipulation in design, elicited new knowledge claims about the relationship between objects and their representations, and fostered visions for a realignment of the design disciplines around computational descriptions; finally, Interaction and intelligence shows how ideas about computation in design developed alongside contemporary discourses about cybernetics and Artificial Intelligence, re-imagining

design as a collaborative endeavor between humans and machines. Further, interactive reconstructions of pioneering computational design systems and algorithms, such as Ivan Sutherland's 'Sketchpad' and the 'Coons patch,' offer access to material and sensual aspects of these methods.

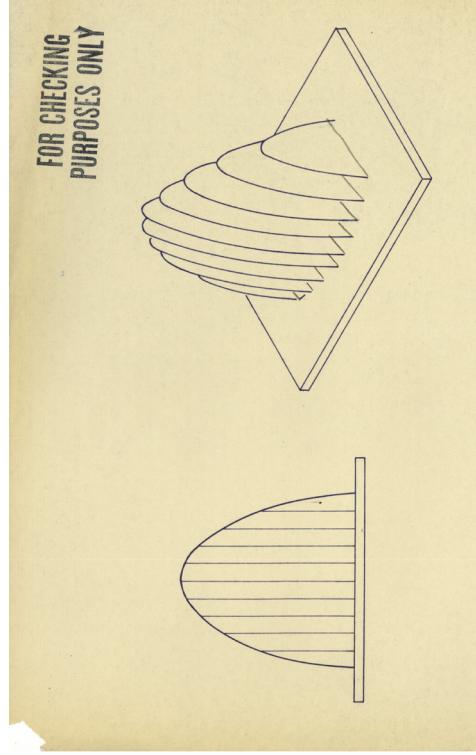
The contemporary portion of the exhibition puts present-day experiments in computational design in conversation with these traditions. Shared strategies across projects include the creation of algorithms for the manipulation of matter and form; new interfaces for spatial capture; responsive artifacts; and approaches to designing and making where robots are imagined as agents of visual or tectonic exploration. Produced by a selection of architects and other designers working today, these pieces blur disciplinary distinctions; challenge the separation between 'image' and 'object'; circumscribe new arenas for creative practice; and illustrate how the concept of design itself is in a state of flux, constantly re-imagined against its socio-material and technological substrates.

Prior attempts to outline histories of the digital in architecture have usefully traced the adoption of these technologies by a subset of prominent architects during the 1980s and 90s. Contrasting with these discipline-specific accounts, this exhibition illuminates computational design method's multidisciplinary roots in postwar technology projects and explores their political, material, and aesthetic specificity. Situating contemporary design languages in relation to these broader historical and disciplinary frames, the exhibition showcases the confluence, during the second half of the twentieth century, of publicly funded technical innovations in software, geometry, and hardware with a cultural imaginary of design endowing computer-generated images with both geometric plasticity and a new type of agency as operative architectural artifacts.

From the playful and exploratory to the utilitarian and technical –and from historical archives to present-day practices– the materials on display illustrate how the expressive and functional possibilities of a new medium challenged disciplinary boundaries, as well as dominant views on drawing, design, and creativity ushering new and ongoing formal languages, and intellectual debates. Highlighting shared practices, histories, and infrastructures that so far have remained distinct, they offer a perspective from which we might critically reconstruct the visual and intellectual histories of computation in design –and re-imagine their future.

Software comes to matter

In their effort to automate machine tools, numerical control researchers had to develop efficient notations to encode geometric, as well as material and mechanical, constraints. Drawing chiefly from the archives of the numerical control project at MIT, and from the Cambridge CAD Group in the UK, this section shows how these early software projects inscribed an impulse to conceptualize design in relation to both material and symbolic economies,



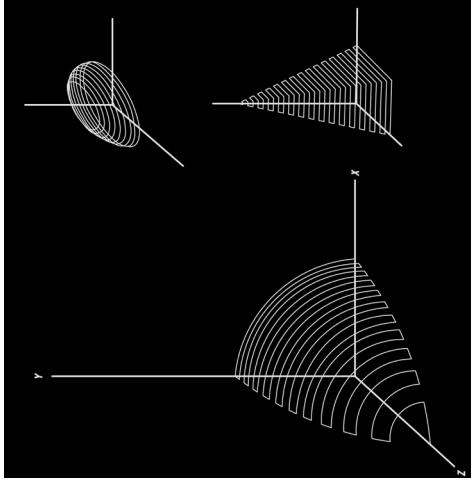
Drawings of a 3-D volume subdivided into discrete parts, Donald F. Clements 1953,

Courtesy of the MIT Libraries, Institute Archives and Special Collections

This diagram illustrates how engineers at the Servomechanisms Laboratory worked to rationalize the process of subdividing a geometric shape into discrete components suitable for fabrication.

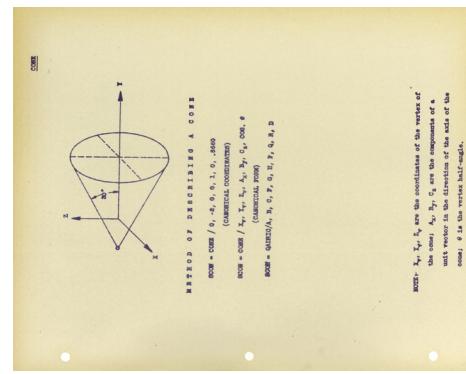
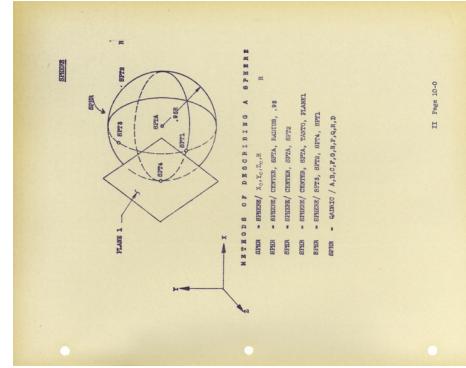
and illustrates the confluence of materials, machines, and geometry in the abstract languages of computation—showing how software, literally, came to matter.

Materials in this section include, among others:



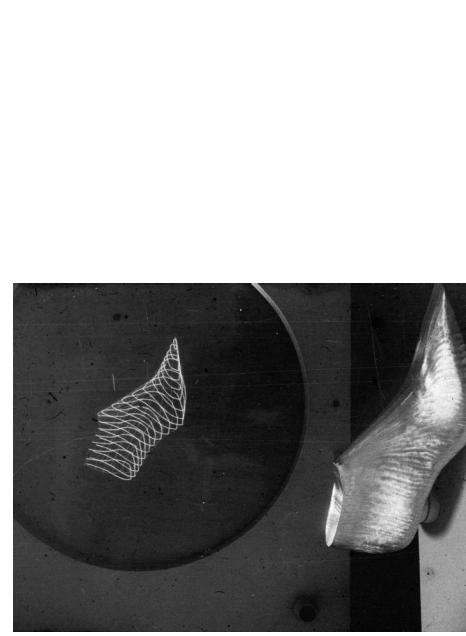
Pictures Drawn by the Whirlwind Computer APT II and APT III programs, Douglas T. Ross, Digital Print [reconstruction], 2014 [1958]

Some of the earliest 3-D computer graphics were representations of the path of milling machines. This specific drawing was calculated with the Whirlwind computer to visualize the path of a milling tool in 3-D space during fabrication. The curved shapes likely describe airplane parts.



Method of Describing a Cone; Methods of Describing a Sphere, Douglas T. Ross, Digital Print, 1960. Courtesy of the MIT Libraries, Institute Archives and Special Collections

Researchers at the MIT Servomechanisms Laboratory developed computer subroutines and programming languages—crucially APT—for numerical control. The difficulties of preparing the information for manufacturing prompted them to ponder whether the computer could assist the design process. These two images are items in the APT Language Dictionary describing 'Vector' and 'Plane' elements.



Multipatch model and numerically machined metal last, A.P. Amit and A.G. Flutter, Cambridge CAD Group, Digital Print, 1971. Courtesy of Robin Forrest

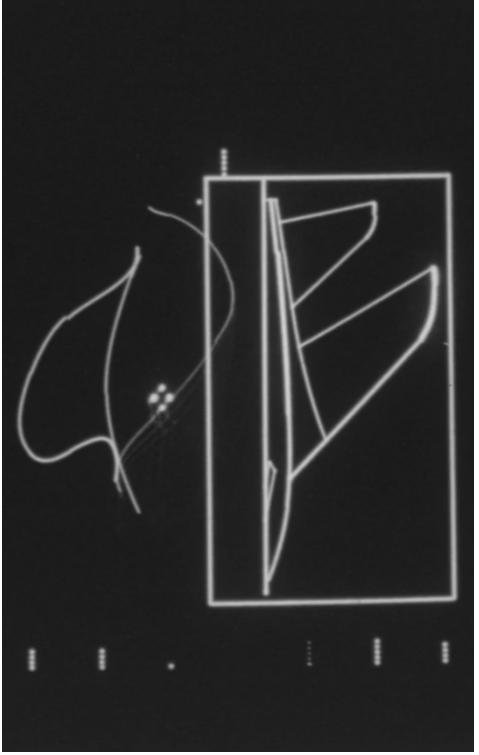
An object produced using numerically controlled machines exhibits a new kind of resemblance with its description. This picture, showing a metal shoe last and its computational model, illustrates an early disclosure of this association. Courtesy of Robin Forrest.

Structured images

Unlike pictures drawn by hand, computational images are enlivened (and constrained) by their numerical definition, and by the architecture of their data structures –both of which are ciphered in the non-pictorial language of computers: code. Exploring materials from the US Air Force funded MIT CAD Project, the SRC funded CAD Project at the University of Cambridge, and the Institute for Physical Planning at Carnegie Mellon, works in

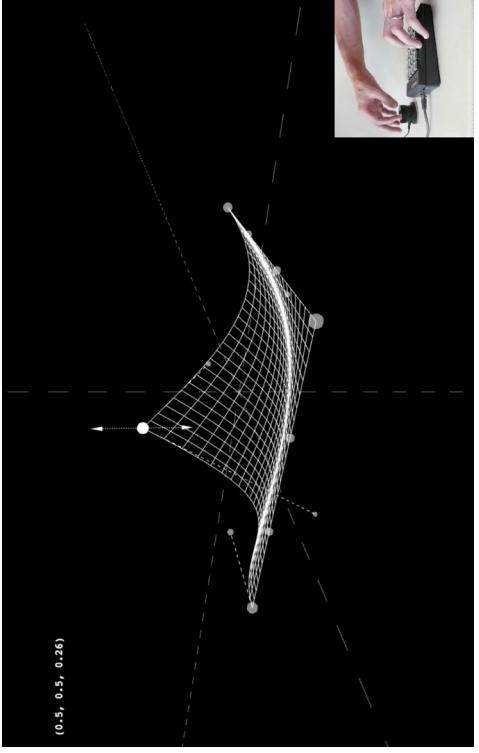
this section explore early disclosures of the structured image, and the beginnings of its progression from elemental geometric skeletons into the data rich semantic models common in architecture and engineering today.

Materials in this section include, among others:



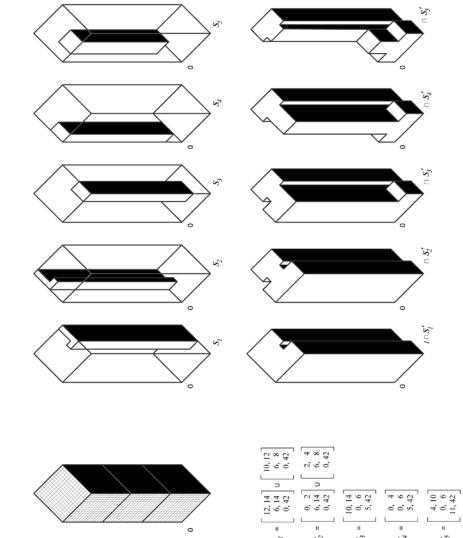
Feehand Curve Sketching at MIT Lincoln Labs, Digitized 16mm film, 1967. Courtesy of Timothy E. Johnson

The exhibition showcases a selection of rare films illustrating the alignment of industry, military and academia with design concerns. With the DARPA funded MIT Lincoln Labs as a common thread, they show how computer graphics served a variety of purposes, including airplane design [pictured here], car design for Ford Motors, and scientific visualization for research at Syracuse and Johns Hopkins Universities.



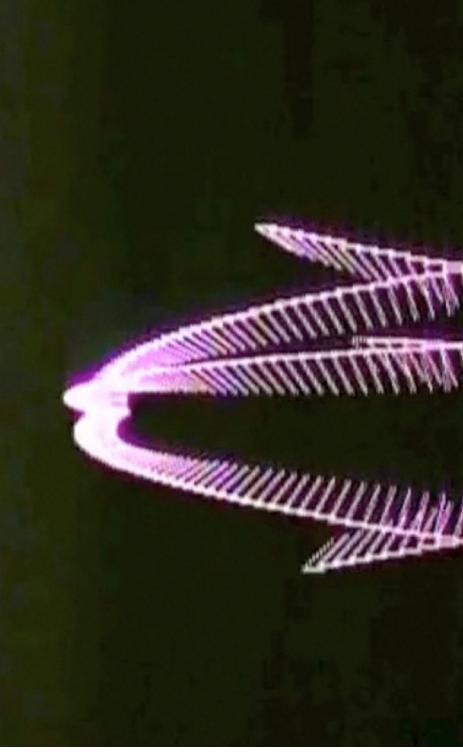
Interactive software reconstruction of the 'Coons Patch'; Steven A. Coons, Software, 2017 [1967] Reconstruction by D. Cardoso Lach in collaboration with S. Donaldson

A resourceful (and self-taught) mathematician and designer, Steven A. Coons pioneered a mathematical technique to describe curved surfaces, which first demonstrated the formal possibilities of combining Computer-Aided Design and numerically controlled machinery. The 'Coons patch' instantly attracted the attention of aircraft, car and ship industries. This software reconstruction, developed specially for this exhibition, allows visitors to manipulate a 'Coons patch' by editing the coordinates of the points in cubic curves.



The development of the block form of the Seagram Building by the subtraction of volumes from a notional building envelope, Lionel March and Philip Steadman, Digital Print, Reconstruction 2017 [1971]

Collaborations between mathematicians, engineers, and architects were not uncommon in research universities during the postwar years. At Cambridge, the Mathematical Laboratory was a point of contact between architects from the center for Land Use and Built Form Studies (LUBFS) –the research unit of the Cambridge Architecture department— and the mathematicians and engineers from the CAD Group started by Maurice Wilkes, and led by Charles Lang. This image, a mathematically defined diagram of Mies van der Rohe's Seagram Building in New York, is an example of such collaborations. The underlying mathematical model was produced by CAD Group member (and former student of Steven A. Coons) Robin Forrest for one of the chapters of a volume edited by two mathematically-inclined architects at LUBFS: Lionel March (the center's director), and Philip Steadman.



'Stick Models'; Paul Pangaro at The Architecture Machine group, MIT, Digital Video, 1975, Courtesy of Paul Pangaro

The numerical structure of computer-generated images made new types of formal manipulation possible. The two films featured here show early explorations into this new plasticity. 'Stick Models' by Paul Pangaro animates series of digital elements, which playfully occupy the screen following a programmed logic. 'Color tests', possibly a film from Bell Labs, enlivens geometric patterns by creating organic transitions between a-periodic tilings, random configurations, and parametrically defined geometries.



'Mess', Zach Lieberman, 2017. Openframeworks. Courtesy of the artist

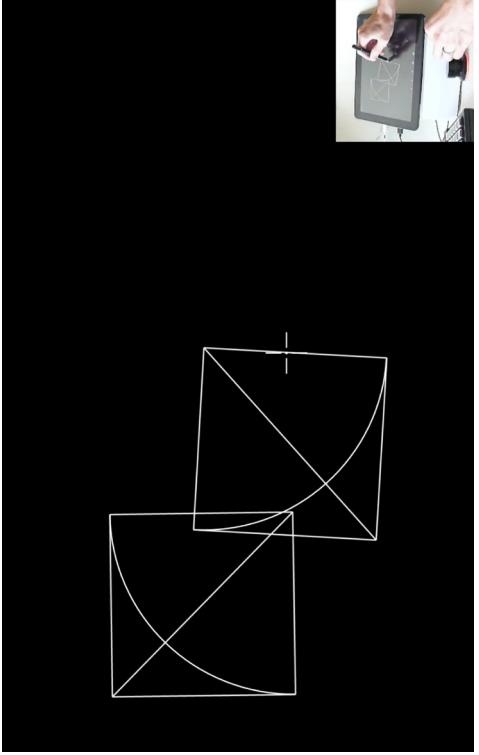
One of the United States' foremost new media artists and educators, Zach Lieberman combines the development of new programming tools for creative exploration, with playful experimentation of time-based and interactive systems. The exhibition features a selection of Lieberman's recent works developed using Open Frameworks —a C++ library he co-initiated and continues to develop—which illustrate his sophisticated understanding of (and playful engagement with) computational form, color, and geometry.

Interaction and Intelligence

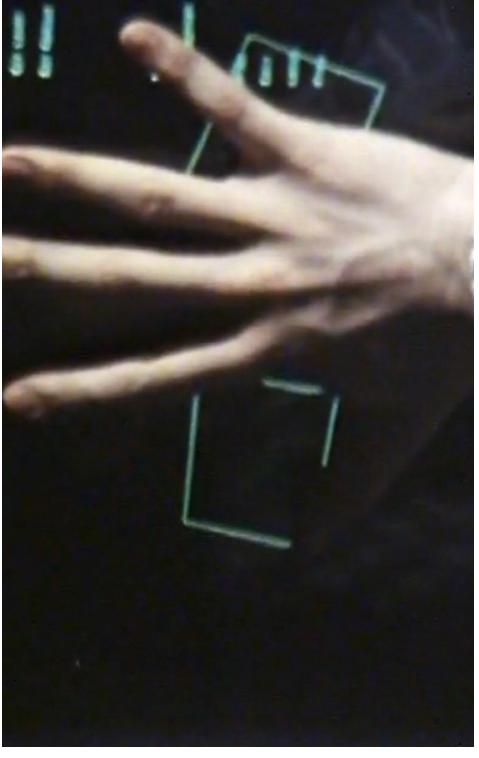
Alongside the development of numerically controlled machines and interactive computers and displays, new theorizations of the design process emerged. Drawn from archives at Carnegie Mellon, MIT, and Cambridge, materials in this section explore early visions of design as a cybernetic feedback loop between humans and machines. Ramifications in architectural research include attempts to codify or automate aspects of the

planning process with managerial, aesthetic, or social intents. The section also features documents from news and popular media illustrating how computational design researchers were not only confined to their laboratories, but rather actively sharing their theories and seeking to capture the imagination of the public with their visions of design.

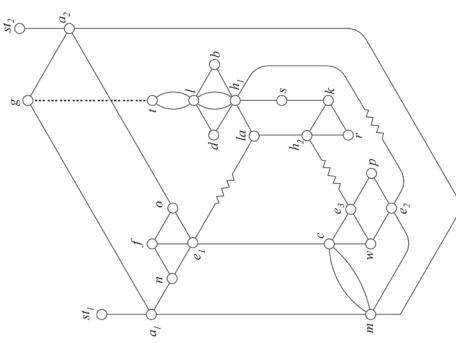
Materials in this section include, among others:



Interactive software reconstruction of 'Sketchpad'; Ivan Sutherland, Software and Hardware 2017 [1963] Reconstruction by D. Cardoso Llach in collaboration with S. Donaldson
Origin stories of CAD routinely point at 'Sketchpad' as the first example of interactive computer graphics. This interactive software reconstruction uses modern programming languages and hardware to evoke some of the visual, tactile, and ergonomic aspects of the experience of using 'Sketchpad' in the TX-2 computer at Lincoln Labs in the early 1960s.



FINGER FILM, Rachel Strickland, digitized Super 8 film, 1976, Courtesy of Rachel Strickland
'FINGER FILM' is a cinema vérité style short film documenting early research on interactive displays at The Architecture Machine Group at MIT. The film's original approach to "narrating" technologies —paying attention to their tactility, their materiality, and their sometimes unexpected behavior— stands uniquely among the pieces in this show, and also among present-day discourses about technology.



'Adjacency graph' for Frank Lloyd Wright's Devin House project; Lionel March and Philip Steadman, Digital Print, 2017 [1974] Reconstruction
Graphs offered mathematically-inclined architects a language to describe a building's functional arrangement, without explicit commitment to a specific form or style. This graph of a house designed by Frank Lloyd Wright describes the adjacencies between the different spaces in the house. According to its authors, Land Use and Built Form Studies director Lionel March and researcher Phillip Steadman, "Tadjacencies on both floors are shown in a single graph, with the staircases denoted by zig zag lines. The graph is not planar."

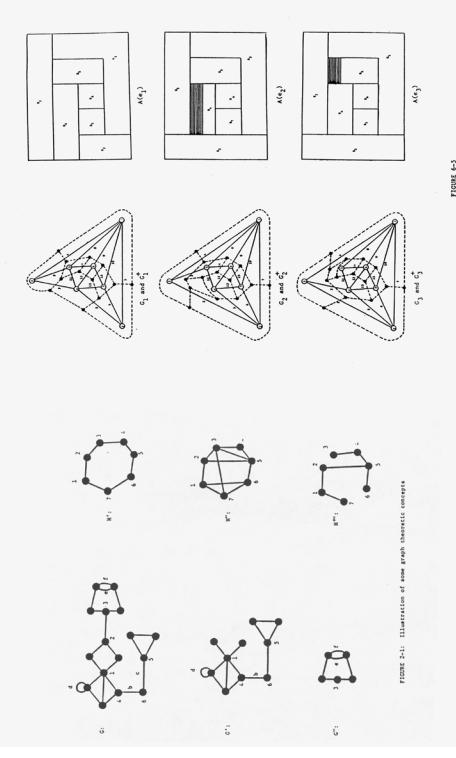


FIGURE 4-5

Illustrations of graph theoretic concepts and architectural arrangements, Charles Eastman, Digital Print, 1980, Courtesy of the Carnegie Mellon University Archives
As the Carnegie Institute of Technology became Carnegie Mellon University, collaborations between architects, urban planners, social scientists, and computer experts started to take place under the newly formed School of Urban and Public Affairs (SUPA) —the predecessor to the Heinz School. Architecture and Computer Science faculty member Charles M. Eastman was tasked, in 1968, with the creation of a joint Ph.D. program between the College of Fine Arts (CFA) and SUPA with the goal of developing "rigorous methods in architecture." Works in this section illustrate some of the concerns Eastman and his students addressed, including experiments in layout generation for automated spatial planning; graph-theoretical representations of buildings; exhaustive enumeration of architectural plans; and research into data structures for managing building design. These evoke contemporary developments in mathematics, and also work done at centers of architectural research —such as those at Cambridge and MIT— whose work is also on display.

For an extended discussion of the works in the historical section (with a focus on MIT), see Cardoso Llach, Daniel. *Builders of the Vision: Software and the Imagination of Design*. Routledge, 2015.

Contemporary works

This section showcases works by a selection of artists, architects, and designers from other fields using computation as a vehicle to investigate new formal, spatial, and tectonic languages. Rather than representing practices widely adopted by industry, they delineate a variety of experimental approaches which evoke the spirit of exploration and discovery of the earlier works on display. They offer insight into how computation has

helped designers depart from the strictures of architectural modernism and standardized industrial production, fostering new materialities and visualities—as well as new types of material responsiveness. Further, the pieces on display show how computational methods have been used to create new types of engagement with audience—where time, motion, and participation become themselves devices of aesthetic expression.

Materials include, among others:



BairBallet / Kelly Bair & Kristy Ballett | **Production Team: Yosphine Ang, Chao Chen,**
G.L.O. / Graphic Line Object 2017, Drawn models, Courtesy of BairBallet

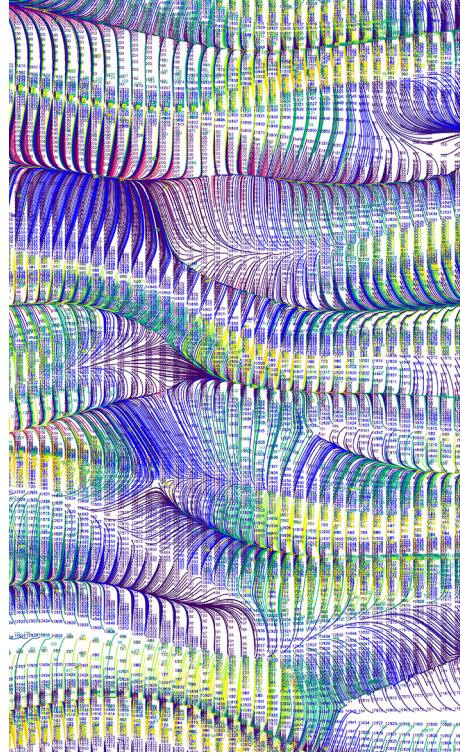
A set of drawn models exploring the convergence of the virtual and physical of the drawn line. The three physical models reference wall objects—a shelf, a plaque, a tapestry—while alternating roles between three distinct parts—a flat graphic, a thick line drawing, and an object. The role of what is modeled, 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.



Joseph Choma, Untitled, Robotically carved Indiana Limestone (29" x 19" x 15"), 2016,
Courtesy of Joseph Choma

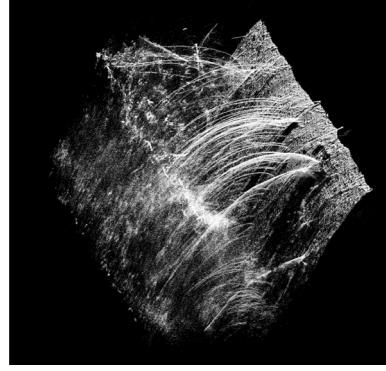
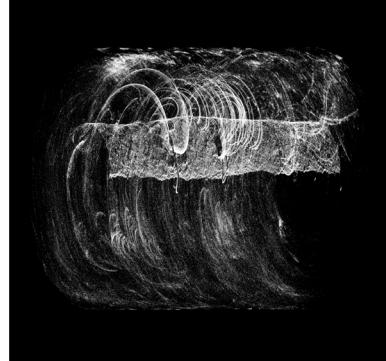
Choma's work investigates the production of formal and material effects through mathematical methods. Illustrating this approach, this artifact is a full-scale physical mock-up of a small portion of a mathematically derived sculpture ($12 \times 7 \times 6$) entirely defined by the following equation:

$$\begin{cases} (uy) | (9/4)P \leq u \leq (15/4)P, |Pl| \leq v \leq (7/4)P \\ x = u(\sin(u+v)\cos(u)); y = u(\sin(u+v)\sin(u)); z = v(\cos(u+v)) \end{cases}$$



Dana Cupkova, Indeterminate Set 003, Design and Production team: Maranatha Dawkins, Collen Clifford, 2017, Courtesy of Dana Cupkova

This ‘topographical flow’ image is color-coded according to each line’s unique identifier in the software. Making the underlying data an argument for visual exploration, Cupkova operates on the numerical structure of the image as an aesthetic device. The layering of lines of varying tones works to highlight the drawing’s analytical value, and its geographical accuracy, while making a new landscape visible.



Ben Snell, Untitled, Two photographs 2017, Courtesy of Ben Snell

LIDAR is a range-sensing technology typically employed by the government and military to survey land from above. By measuring the time of flight of modulated pulses of light, depth can be extracted from a scene, often to very high precision. Here, Snell brings this device deep within a bamboo forest in the Blue Ridge Mountains of Northern Virginia. A single capture elicits a myriad interpretations of the same scene. Some resemble the world as we know it; others are unfamiliar, distorted. Together, they configure a space of multiple optics. As seen through this technology, two different forests appear similar—composed of the same raw material. The ravine between these forms is a space where the tension between these new vantage points is resolved.

Checklist	001D Four Fights, Andrew Heumann, 2017, Digital drawing (12" x 12"), Courtesy of the Andrew Heumann	Courtesy of Dana Cupkova and Daragh Byrne	1023 Photograph of Steven A. Coons and Douglas T. Ross (II), Photographer unknown, Digital Print, c. 1960	Laboratory, MIT, Digital Print, 1950-1952	Products Tomorrow," Steel, The Metalworking Weekly, January 6, 1964	unknown, Digital Print, c. 1970	1080 Simple pocket design, BUILD solid modelling system, Ian C. Braid, Cambridge CAD Group, Digital Print, 1973
Contemporary Works				<u>Structured Images</u>		Cambridge CAD Group*	
010 Clickspace, Machine Drawing Series, Jonah Ross-Mars, 2015, Courtesy of Jonah Ross-Mars	008 Curves Created in Two Dimensions, Unrelated on Paper, Carl Lostritto, 2017, Ink on paper, Gel pen and vintage Hewlett Packard 7475A plotter (11" x 11"), Courtesy of Carl Lostritto	006 10x10 cubes with random lines, Cube with curves, Icosphere ink, Ink sphere, 3d blob / contour travelers add energy, 3d blob / movement study, Puffball, More trails, 2016-2017, Zach Lieberman, Digital videos and images, Courtesy of Zach Lieberman	1030 Proposal for the Investigations in Computer-Aided Design for Numerically Controlled Manufacturing Processes, Servomechanisms Laboratory, Digital Image, 1959	1018 A house, and cubes, drawn using Sketchpad III, "Timothy E. Johnson, MIT CAD Group", Digital Print, 1963	1039 "Instant Design Latest Gadget by MIT Men", Record American, Digital Print, 1963 . Press Clipping: "Instant Design Latest Gadget by MIT Men", Record-American (Boston, May 24, 1963)	Software comes to matter	1047r Representation of a hyper-cube, Janet Tomlinson, Digital Print, 1975, Models and Systems in Architecture and Building –LUBFS Conference Proceedings Number 2, edited by Dean Hawkes, The Construction Press Ltd
011 Formations in Bodoni Bauer, Kyuha Shim, Video projection, Processing code, 2017, Courtesy of Kyuha Shim	009 Sketching with Mathematics: Variations of a dancing torus, Joseph Choma, 2017, Six 16" x 12" printed drawings, Courtesy of Joseph Choma	007 Otto, Jürg Lehni, 2014, Video documentation of Otto: Brushless DC motors, chalk tool head, sprung steel reels, cables, custom made controller and software, Courtesy of Jürg Lehni	004 Meshy, Golan Levin, 1998 [revised 2017], Software on interactive tablet. Courtesy of Golan Levin	1032 Draft of the first Computer-Aided Design funding Proposal to the US Air Force, Douglas Ross, Digital Image, 1959	1012 "Flying Carpet", MIT CAD Project researchers, Original, 1963	1041 A user of an early CAD system using the 'ESL console', Photographer unknown, Digital Print, c. 1965	1089 Multipatch model and numerically machined metal last, A.P. Armit and A.G. Flutter, Cambridge CAD Group, Digital Print, 1971
012 Untitled, Joseph Choma (designer) and Quarra Stone Company (fabricator), 2016, Robotically carved Indiana Limestone (29" x 19" x 25"), Courtesy of Joseph Choma	013 A Taxonomy of Communication, Jürg Lehni in collaboration with Jenny Hiron, 2016, Robotic chalk wall-drawings of variable scale, Courtesy of the SFMOMA	MIT Libraries, Institute Archives, and Special Collections	1024 Handwritten notes about design by Steve A. Coons, Steven A. Coons, c. 1964	1011 Handwritten draft of "Surfaces" article, Steven A. Coons, Digital Prints, c. 1963	1042 The ESL Console at the MIT Project MAC, Photographer unknown, Digital Print, c. 1965	<u>Structured Images</u>	1075 General view of Type 340 display with PDP7 and Titan teletypes. Photographer unknown, Digital Print, 1968
002 G.L.O. / Graphic Line Object , BairBalliet / Kelly Bair & Kristy Balliet (Production Team: Yosphine Ang, Chao Chen), 2017, Drawn models, Courtesy of BairBalliet / Kelly Bair & Kristy Balliet	003A Indeterminate Set 003: Information, Effect, Interaction. 003.1 Flow Duration, Dana Cupkova, 2017, Lenticular Print. Design and Production team: Maranatha Dawkins, Collen Clifford, Courtesy of Dana Cupkova	<u>Software comes to matter</u>	1027 Draft of the article 'Design and the Computer', Steven A. Coons, 1962	Computer History Museum	1072 Cubes with different parameter settings and depth-modulated intensity, Cambridge CAD Group Digital Print, 1972	*Courtesy of Robin Forrest	Interactive software reconstructions
005 Untitled, Ben Snell, 2017, Two photographs, Courtesy of Ben Snell	003B Indeterminate Set 003: Information, Effect, Interaction. 003.2 Object Landscape, Dana Cupkova, 2017, Inject Print. Design and Production team: Collen Clifford, Thomas Sterling, Courtesy of Dana Cupkova	1005 Methods of Describing Cutting Tools, Douglas T. Ross, Digital Print, 1960	1028 Handwritten notes by Steven A. Coons to Robert Mann on music, automation, and authorship, Steven A. Coons, c. 1962	<u>Structured Images</u>	1053 Response of a Resonant System to a Frequency Step	1073 Spherical patches with parameter lines and surface normal, Cambridge CAD Group, Digital Print, c. 1970	<u>Structured Images</u>
001A Abstraction II (Unsmooth), Andrew Heumann, 2011, Digital drawing (12" x 12"), Courtesy of the Andrew Heumann	001B The 11-House / 1.8%, Andrew Heumann, 2016, Digital drawing (12" x 12"), Courtesy of the Andrew Heumann	1001 Drawings of a 3-D volume subdivided into discrete parts, Unknown author (possibly Donald F. Clements), Digital Print, c. 1953	1029 Handwritten notes by Steven A. Coons on Computer-Aided Design, Steven A. Coons, 1960	1016 "Fluent' Language Held Vital to Computer-Aided Design", Steven A. Coons, Digital Print, c. 1963	1055 Metamorphosis, Lillian Schwartz and Ken Knowlton, Digital Video, date nd	1090 Interactive software reconstruction of the 'Coons Patch', Steven A. Coons, Software, 2017, Reconstruction by Daniel Cardoso Llach in collaboration with Scott Donaldson	<u>Interaction and Intelligence</u>
001C Ayo, Andrew Heumann, 2017, Digital drawing (12" x 12"), Courtesy of the Andrew Heumann	003C Dana Cupkova + Daragh Byrne, Indeterminate Set 003: Information, Effect, Interaction. 003.3 Sentient Object, 2017, Concrete cast, Electro-mechanical hardware, Thermochromic paint. Design and Production team: Dan Cascaval Josh Gy Kim, Ammani Nair,	1002 APT Drawings, Donald F. Clements, Digital Print, c. 1953	1006 and 1008 "Modifiers-Minor Section" (left); "Geometric Definitions" (right)", Douglas T. Ross, Digital Prints, 1960	1038 Ivan Sutherland using 'Sketchpad'; Photographer unknown, Digital Print, c. 1963	1056 Cybernetik, Digital Video, date nd	1076 Patch visualisations using parameter lines and surface normal, P.J. Payne using Multipatch written by A.P. Armit, Cambridge CAD Group, Digital Print, 1972	<u>Interaction and Intelligence</u>
	1022 Photograph of Steven A. Coons and Douglas T. Ross, Photographer unknown, Digital Print, c. 1960	1003 Handwritten notes on the Parsons Milling Machine proposal, Unknown (likely authors: Robert Marsh, William Pease, or Gordon Brown), Digital Image, 1949	1010 Roll of punched paper tape stored in a small box labeled "Main Program", Douglas T. Ross, Facsimile (object), c. 1948	1043 View of the room housing the TX-2 computer at Lincoln Labs, Photographer unknown, Digital Print, c. 1964	1057 Pixillation, Digital Video, date nd	Interactive software reconstruction of 'Sketchpad' by Ivan Sutherland. 2017 [1963]. Reconstruction by Daniel Cardoso Llach in collaboration with Scott Donaldson	<u>Interaction and Intelligence</u>
		1017 Innovations in Manufacturing, "Electronic Systems Laboratory", Digital Print, 1963	1012 Innovations in Manufacturing, "Electronic Systems Laboratory", Digital Print, 1963	1044 View of the TX-2 computer terminal at Lincoln Labs, Photographer unknown, Digital Video, c. 1975c	1062 The Utah teapot (wireframe), Unknown (likely Martin Newell), Digital Print, c. 1974	1078 Joining surface patches using Multipatch , A.P. Armit, Cambridge CAD Group, Digital Print, c. 1970	2-D reconstructions
		1087 and 1088 Diagram (left) and Photograph (right) of the MIT Parsons Milling Machine, Servomechanisms	1087 and 1088 Diagram (left) and Photograph (right) of the MIT Parsons Milling Machine, Servomechanisms	1045 Color tests, Unknown (possibly Ken Knowlton at Bell Labs), Digital Video, c. 1975c	1061 Early CAD system in a PDP display with a light pen, Photographer	1079 Primitive solids and test part, BUILD solid modelling system, Ian C. Braid, Cambridge CAD Group, Digital Print, 1973	<u>Software comes to matter</u>
			1037 "How We'll Design Products Tomorrow", Digital Print, 1964 . Source: "How We'll Design	1046 Color tests, Unknown (possibly Ken Knowlton at Bell Labs), Digital Video, c. 1975c	1062 The Utah teapot (wireframe), Unknown (likely Martin Newell), Digital Print, c. 1974	1080 Pictures Drawn by the Whirlwind Computer APT II and APT III programs , Douglas T. Ross, Digital Print, 2017 [1958], Reconstruction	

1014 "Parameterization of cutting tools and materials", Douglas T. Ross, Digital Print, 1958, Reconstruction

1086 Blooms Day, George Stiny, Acrylic on Canvases (12), 1969, Courtesy of George Stiny

Structured Images

1067 The development of the block form of the Seagram Building (architect: Mies van der Rohe), by the subtraction of volumes from a notional building envelope, I, made out of three cubes. Lionel March and Philip Steadman, Digital Print, 1971, Reconstruction

1049 First page of 'The Use of Computers Instead of Drawings in Building Design,' Charles M. Eastman, Original printed media, 1975, Courtesy of Charles M. Eastman

1045 FINGER FILM, Rachel Strickland, Digitized 16 mm film, 1976, Courtesy of Rachel Strickland

Interaction and Intelligence

1048 Adjacency graph for Frank Lloyd Wright's Devin House project, Lionel March and Philip Steadman, Digital Print, 1974, Reconstruction

1050 Nicholas Negroponte sketching on a touch sensitive display, Photographer unknown, Digital Print, c.1978, Courtesy of Nicholas Negroponte

Personal Collections

Structured Images

1034A Freehand Curve Sketching, Timothy E. Johnson at MIT Lincoln Labs, Digitized 16mm film, 1967, Courtesy of Timothy Johnson

1034B Surface Generation by Computer, Ford Motors Product Research at MIT Lincoln Labs, 1967, Courtesy of Timothy Johnson

1046 Stick Models, Paul Pangaro at The Architecture Machine group, Digital Video, 1975, Courtesy of Paul Pangaro

Interaction and Intelligence

1035 Space Planning Experiment, Timothy E. Johnson and Guy Weinzapfel, Digitized 16mm film, c. 1972, Courtesy of Timothy E. Johnson

Designing the Computational Image Imagining Computational Design

is an exhibition conceptualized and curated by Daniel Cardoso Llach, and coordinated at the Miller Gallery at Carnegie Mellon University by Margaret Cox and Kara Skylling.

The exhibition draws from several years of archival research by the curator, and is accompanied by a two-day conference titled 'Computational Design: Practices, Histories, Infrastructures' on October 7-8, 2017 at the Frank-Ratchye STUDIO for Creative Inquiry at Carnegie Mellon. With the support of the Graham Foundation for Advanced Studies in the Fine Arts, a forthcoming reasoned catalogue will record the exhibition and the event, and offer additional context through interviews and essays.

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Daniel Cardoso Llach, 2017