Computer Architectures

Computer Architectures is a collection of multidisciplinary historical works unearthing sites, concepts, and concerns that catalyzed the cross-contamination of computers and architecture in the mid-20th century.

Weaving together intellectual, social, cultural, and material histories, this book paints the landscape that brought computing into the imagination, production, and management of the built environment, whilst foregrounding the impact of architecture in shaping technological development. The book is organized into sections corresponding to the classic von Neumann diagram for computer architecture: program (control unit), storage (memory), input/output and computation (arithmetic/logic unit), each acting as a quasi-material category for parsing debates among architects, engineers, mathematicians, and technologists. Collectively, authors bring forth the striking homologies between a computer program and an architectural program, a wall and an interface, computer memory and storage architectures, structures of mathematics and structures of things. The collection initiates new histories of knowledge and technology production that turn an eye toward disciplinary fusions and their institutional and intellectual drives.

Constructing the common ground between design and computing, this collection addresses audiences working at the nexus of design, technology, and society, including historians and practitioners of design and architecture, science and technology scholars, and media studies scholars.

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Series Foreword

Enabled by increasingly multilayered systems comprising software, simulations, algorithms, and other sociotechnical infrastructures, design practices today resist analysis through conventional disciplinary and methodological lenses. Their study — which is essential to address the new formations (of labor, of cities, of artifacts) unfolding in conjunction with technological change — demands new scholarly sensibilities: towards emerging technical conditions and capacities, and towards new sites of historical and sociotechnical inquiry. The *Design, Technology and Society* series nurtures these sensibilities by bringing together innovative scholarship drawing from fields including architecture, design, media, human-computer interaction, software studies, and science and technology studies (STS). Deliberately embracing the conceptual diversity of the word "design," the series outlines the boundaries of a new multidisciplinary field of inquiry focusing on the technological imagination and production of human-made environments.

If scholars have recently called for a radical re-imagining of design as a *political technology* for re-communalizing life,[i] the series' admittedly more modest aim is to make visible the *technological politics* of design, so often hidden by boosterism or mystification. As software, simulations, digital fabrication, robotics, big data, artificial intelligence, and machine learning configure new imaginaries of designing and making across fields, the series creates a space for works that approach these subjects critically from enriched sociotechnical, material, and historical perspectives. With these expanded accounts, it aims to reveal the seams, the uneven distributions, and the messy encounters that dominant narratives of technological prowess tend to obscure. Further, by offering works that situate design in relation to particular sociotechnical histories and substrates, the series seeks

to lend specificity to and help chart design's heterogeneous territories.

Works in the series include historical studies examining the roles of university laboratories, government sponsored research, public policies, or technology companies in shaping ideas, systems and practices of design; accounts of specific computational design artifacts, formal languages, algorithms, or software systems which examine their material and cultural histories, and their role in enabling new design practices and discourses; ethnographic studies exploring how technological ideas or methods have shaped conceptual or practical aspects of design; research projects examining the agencies — both human and non-human — involved in the design, operation of, and interaction with computational design systems; accounts of non-traditional or overlooked design-technological subjects; and studies reporting on speculative or critical technologies addressing questions about the design process, envisioning alternative modes of design participation or engagement with traditions, materials, and the body, or probing innovative theories and practices of design.

Daniel Cardoso Llach and Terry Knight
Editors, *Routledge Research in Design, Technology, and Society* Series

Note

i Escobar, Arturo. "Autonomous Design and the Emergent Transnational Critical Design Studies Field." *Strategic Design Research Journal* 2, no. 11 (August 2018): 139–46.

Preface and Acknowledgments

This book started with one conference and closed with another. In November 2013, fourteen scholars in architectural history, science and technology studies (STS), media studies, and the history of science assembled at the MIT Media Lab top floor for a three day excavation of human-machine systems in design and architecture post-1945. Punctuating their presentations were live interviews with key figures in research efforts to develop such systems. *Futures Past: Design and the Machine*, as we titled the conference, was the outcome of year-long conversations among the two of us and our co-organizer Duks Koschitz. One of our motivations behind that conference was the need to come to terms with the multivalent nature of "the digital" and to challenge the silos that we saw morphing around computational design and digital architecture, both of which seemed to gradually acquire their own histories, set of actors and debates, in relative isolation from one another. Aiming for a productively destabilizing confrontation, we structured the panels as encounters between first-hand accounts and historical scholarship on early touchpoints between architecture and computation.

On the one hand we had key figures who facilitated the introduction of computers and computation in architectural research and practice. On the other hand, we had scholars of architectural history, STS and media studies juxtaposing these first-hand narratives with historical framing of sociotechnical networks contemporaneously at work. There was an awareness that somehow these histories were important in unpacking architectural practices around computers, but there was no desire to directly provide one singular genealogy. During the six years that have passed since *Futures Past*, "method" (as historiographic attitude and tactic) has been a sustained topic of debate and conversation between us, especially in developing this book

project. Our conversations crystallized with a presentation at the symposium *Other Histories of the Digital* at the Harvard Graduate School of Design in April 2018, where we articulated a methodological intervention and called for a move toward a polyglot space.

Projects like ours are social animals that only grow in the presence of others. This book would have never happened if Duks Koschitz had not brought us all together to organize *Futures Past*. Our profuse thanks should go to Terry Knight and George Stiny, who indulged our conference proposal and offered us critical feedback throughout. We also thank Nicholas Negroponte for helping make this ambitious undertaking possible.

For their invaluable first-hand personal accounts, we would like to thank the MIT Architecture Machine Group — Nicholas Negroponte, Steven Gregory, Christopher Herot, Andrew Lippman, Masanori Nagashima, Paul Pangaro, and Guy Weinzapfel — the late Lionel March, Charles (Chuck) Eastman, Alan Kay, Edward Hoskins, Paul Richens, and John Gero. Their stories and retrospections shed new light on the main debates of the first postwar decades, allowing us to peek into the motivations and aspirations that shaped their research and practice.

The historical accounts by scholars were organized in four sessions: *Designing Futures, Systems Thinking, Modeling Information,* and *Mediating Interfaces*. For the vibrant terrain of interpretations, we are grateful to John Blakinger, Larry Busbea, Moa Carlsson, Carlotta Daro, Britt Eversole, Jacob Gaboury, Nikos Katsikis, David Mindell, Gabrielle Schaad, Molly Wright Steenson, Ksenia Tatarchenko, David Theodore, and Alise Upitis.

For expertly chairing and productively framing our panels, we thank the late Edith Ackermann, Arindam Dutta, Peter Galison, John Harwood, Axel Kilian, Daniel Cardoso Llach, Jennifer Light, Yanni Loukissas, João Magalhães Rocha, and Felicity Scott. Our dialogue and conversations with these scholars informed our thinking, and helped us clarify the structure of our edited volume. Interpretations and translations of their input are entirely our own.

A special thank you goes to Masanori Nagashima, whose financial support allowed us to bring together such a unique

constellation of actors in Cambridge, MA. We are thankful for his sponsorship that allowed us to issue this book in paperback.

This book project grew and transformed through the years. We are grateful to the authors who adapted conference papers from *Futures Past* for this book and to those who contributed new work. Our editor Grace Harrison, with her patience and diligence, guided us wisely throughout the publication process. We would like to acknowledge George-Étienne Adam for his hard work with organizing the manuscript material.

In closing we are also thankful to Matthew Allen, Phillip Denny, and Christina Shivers, whose provocation to think about "other histories" of the digital from a media perspective arrived at a crucial moment and offered us the opportunity to reflect on our editorial collaboration. Antoine Picon, John May, Andrew Holder, Michael Osman, Sean Keller, Daniel Cardoso Llach, and Andrew Witt indulged our reflections, engaging us in a conversation over the status of scholarship in architecture, as well as practice(s), while challenging us to envision the future we want to see materialize with this protean, polyphonic field of scholarship on architecture and computing that we put forward.

Our most important interlocutors during this intellectual journey have been Terry Knight and Daniel Cardoso Llach. Our project would be nowhere close to where it is without their continuous support and critical input. Thank you both for making sure our project comes to fruition.

1 Introduction

Toward a polyglot space

Olga Touloumi and Theodora Vardouli

In the decades following the end of World War II, the fields of architecture and computing became conceptually and operationally entangled. Emerging computational concepts and practices inflected design discourse, while design methods and spatial concepts influenced theories and practices of computing. Making sense of this intimate intertwining requires a move away from narratives of unidirectional transfer between computing and architecture, and towards a systematic interrogation of their intellectual and institutional common ground.

The computer's transformative effects upon architecture have often been addressed in recent scholarship. Perspectives on digital cultures or turns in architecture (Picon 2010; Carpo 2017) or lineages of "the digital" (Lynn 2014; Goodhouse 2017) have proliferated in the last decade and a half. These histories, however, have focused mainly upon the production of radically innovative architectural forms, the new digital instruments used to produce them, or the ways in which these instruments changed architectural production. In recent years, scholars have begun to unearth architects' roles as co-producers of the "digital landscape" (Steenson 2017). In such histories, academic, industrial, and military research centers have formed a productive site of scrutiny because they enabled and promoted encounters between architecture, the mathematical sciences, engineering, and computers (Light 2005; Dutta 2013; Cardoso Llach 2015; Keller

2018). Architects were not passive adopters of computational techniques and computer technologies. Instead, they actively engaged in their construction—a construction that unfolded against a backdrop of large discipline-wide debates and within the constraints of specific epistemic and technical contexts.

It is also not possible to think about computers and computation without design and architecture: computing technologies acquired bodies through design choices (Harwood 2011) and presence in the world within specific architectural sites. They also transformed the production of architecture, creating new working protocols and alliances between building industries and designers, and between designers and "users." This is too vast a history to capture in a single account or through a single lens. As a prelude to, and reflection on, the essays hosted in this volume, we use the first part of this introduction to advance a methodological intervention that reimagines scholarship on computers and architecture in terms of a "polyglot space," a space where a multitude of methods coexist and co-produce. In the essays of *Computer Architectures*, this polyglot space is calibrated against four conditions: the medium, field, obsolescence, and conversation. We call for a historiographic modality that speaks many languages (is multilingual); can only exist as a multitude of voices (is polyphonic), shifts scales of examination (is scalar), and changes form (is protean).

Medium

In a 1984 article in *Scientific American* titled "Computer Software," Alan Kay, the computer scientist often attributed with the invention of object-oriented programming, cast computers as meta-media:

> The protean nature of the computer is such that it can act like a machine or like a language to be shaped and exploited. It is a medium that can dynamically simulate the details of any other medium, including media that cannot exist physically. It is not a tool, although it can act like many tools. It is the first metamedium.
>
> (Kay 1984: 59)

As scholars such as Matthew Fuller and Andrew Goffey (2017) or Casey Alt (2011) have shown among others, this media rhetoric cannot be severed from the particular technical development of object oriented programming, namely the shift from writing programs as procedures, sequences of step-by-step instructions, to building ontologies of abstract entities that exchange data. Built upon Ivan Sutherland's landmark work on SKETCHPAD and systematized in SMALLTALK (developed by Alan Kay, Adele Goldberg, and Dan Ingalls), object orientation transformed programming by centering the design of a program on relations of objects and not on processes. Object orientation made it possible to conceive of, and promote through articles such as "Computer Software," the computer as a medium. The computer, the executor of programs, would turn from a tool for performing a rote process to something that could have an internal life and an architecture: an instrument for creating new and possibly unprecedented ontologies. Speaking about computers in terms of "media" is a historical construct (Manovich 2001; Murray 2003, 2011; Chun 2004; Hagen 2005) that could be approached both analytically and critically. The question we ask here is not whether computers are or are not "media," but what can we learn about "digital architecture" once we consider it from a "media" perspective.

A "medium" is not a stable category with definite characteristics and predilections. A medium can be a tool, but it also can be useless. It can be an object, but also an infrastructure. What a media approach does to the study of digital architecture is to provoke a change of focus: it shifts attention from the interpretation of buildings or artifacts made using digital instruments to the study of the technics, instruments, and processes that mediated their making. Or to recall literary theorist Hans Ulrich Gumbrecht, a media focus shifts attention away from "hegemonies of meaning" and interpretation to the "materialities of communication," the channels, infrastructures and protocols that participate in the construction of meanings (Gumbrecht and Pfeiffer, 1994). Paradoxically, although a media focus on digital architecture foregrounds materialities of computing, it can also push the computer itself off-center. In fact, expanding "the digital" "before" and "beyond" computers is the premise

animating much of current literature (Goodhouse 2017; Bottazzi 2018). In accounts such as these, "the digital" is a larger category that orbits around technological applications but is seldom about them. In such accounts, the computer, the machine performing computations, often becomes the elephant in the room.

Questions about how the elephant entered the room, where it sat, how big it was, and what color it had, have proved generative for historians such as John Harwood (2011) and, in this book, AnnMarie Brennan, Rachel Plotnick, and David Theodore, who talk about the presence of these massive (or not so massive) instruments in old and new architectural types (factories, clean rooms, offices, houses, hospitals). Seeing the elephant becomes more challenging when talking about the computer as a design medium—a medium for performing the complex web of acts that count as *doing* architecture. Where, when, and how then is the computer: is it the algorithms? Their implications for practice and labor? Their outputs? The cultural, political, economic, discursive effects of these outputs? Does the computer dissolve under a history of cultural techniques (Siegert 2015)? Or can a history of "the digital" not include computers at all?

Field

We see digital architecture as a field of practices, operations, and techniques built around computers, broadly construed (looms and rooms, women calculators, desktops and laptops, programmable materials and synthetic bacteria and the list goes on). Talking about media necessitates consideration of the field they modulate, the infrastructure that supports them, the industries that produce them, the anthropo-technical conduits around them, the older media before them, and the techniques and theories embedded in them.

There may indeed be "eight million stories of the origins of the digital in architecture" (Goodhouse 2017). Yet each of these eight million stories assumes a specific vantage point toward the computer: it either fetishizes it or dissolves it. How about operationalizing this observation to willfully produce an oscillating field: one that ties the digital with the computer, in its

socio-technical specificities, but allows the computer to move in and out of focus? What are the implications of a scholar adopting a mobile vantage point toward the computer: tactically centering and decentering it to illuminate negotiations between different modes of agency?

We vouch for histories that are attuned to resonances between wide-lens views of epistemic and cultural phenomena and the micro-operations of making and using technical artifacts. We argue for histories that oscillate between *longue durée* epistemic transformations and situated acts from designers and users. Looking at the embodied and material contingencies beyond the deliberations of auteur architect-technologists and auteur architect-users is our way of venturing to *other* histories of digital architecture.

Obsolescence

It is common for architects involved with digital media to return to early work on computers and design in search of unrealized potential. Common are also stories of anticipation and forecasting, where technologies tangled up in narratives of newness are confronted with their historical echoes. Yet, instead of simply saying "this is not new" one needs to look with some specificity at how these echoes operate, at the conditions by which they persist, and at the kinds of disciplinary and epistemic modes they are reflected on. Cutting against the grain of retro-techno-projections is a critical project that centers on obsolescence: on things discarded and things embedded in every shift and update.

Digital innovation comes with digital obsolescence. One device, one programming language, one software, gives way to another, slowly necessitating updates and new equipment. Obsolescence challenges archival modalities. This is not new for the library and information sciences, which often need to simulate the environments of operating systems and amass obsolete media, from slide scanners to floppy discs. Work on the preservation of digital objects, some of which has sprung out of the *Archaeologies of the Digital* program at the Canadian Centre of Architecture, tackles digital obsolescence: they come to terms with unreadable files,

inactive versions of computer programs, and defunct hard drives.

But there is also another form of obsolescence that does not come from a condition of being defunct, but from a condition of being forgotten, sidetracked, and overthrown. It is an obsolescence of meanings, discourses, practices projected upon techniques. History writing as a construction of both memory and obsolescence plays its part here. Despite stated attempts to resist it, stories of digital architecture gravitate towards breaks, shifts, and turns of various kinds. Innovation carries cultural capital and cultural currency; narratives of innovation structure historiographical fields and their cathectic power can produce obsolescence (of makers, old media, and techniques). To grapple with obsolescence, both in history writing and digital production, we need more stories of continuity than of break. We also need to become more attentive to stories of techniques, to reveal processes of naturalization and embeddedness that render them ubiquitous and/or invisible, and to trace these techniques' lives as they traverse intellectual, institutional, cultural, and practical settings. We need more histories of banality and failure. And we need to come to terms with delivering dry histories that do not climax or break ground, but rather shape ground.

Conversation

Can a single, all-inclusive and comprehensive historical narrative describe and explain phenomena as multivalent and complex as those surrounding the concatenation of "digital" and "architecture"? The social construction of epistemic value often demands that a scholar makes with an argument an almost territorial claim toward an entire field. Can we move beyond a competitive, "free-market" logic of argumentation and declare that history writing (as history making) occupies a conversational space?

In our book, we use the idea of a *common ground* as an analytic and as a program of action. The common ground pays tribute to a key-phrase that animated the intellectual landscape in which architecture was imagined as computation and computers were imagined architecturally. The "common ground" was an exciting

slogan in postwar intellectual life (Spillers 1974; Galison 1998), tangled up with visions of unification of multiple modes of knowledge and action. The rhetoric of a common ground, be it a common "bedrock," a common "language," or a common communication channel, played a key role in challenging disciplinary boundaries and formations, and in institutionalizing unlikely collaborations.

In a spirit of sustained reflexivity, we also adopt the common ground as a methodological heuristic. Grappling with the variety of technical languages and epistemic cultures that configured relationships between architecture and computers requires active and curious listening for inflections, translations, and transmutations of words and technics. It also entails coming to terms with metaphor, evocation, and imagination as constituents of technological development. It requires a polyglot space of historical inquiry that is:

- *Multilingual*—this space is contingent upon multiple forms of literacy. It requires speaking, with some degree of interactional expertise, architectural, mathematical, programming, and engineering languages. It also crucially requires listening to the languages of multiple epistemic communities: technologists, architects, designers, mathematicians and paying attention to the many valencies and expressions of ideas, practices, and techniques.
- *Polyphonic*—it seeks and produces the conditions for a multiplicity of scholarly perspectives and methods. It is generative rather than definitive, expansive rather than convergent. It is reflexive and resonant.
- *Scalar*—actors, practices, discourses, institutions, and objects co-exist in a plane of interrogation and can be centered or decentered in the process of history writing. Thick descriptions and wide-lens readings alternate, and reveal new assemblages at work.
- *Protean*—the field itself changes shape. It is temporal.

Yesteryear's "othering" of dominant narratives and approaches to digital architecture provides the conditions for its change.

Architecture of *computer architectures*

These categories are an attitude rather than a framework. Readers may recognize them in the polyphony of methods and approaches reflected in the book, rather than in the structure of the chapters. The chapters are grouped according to four keywords that we gave to the authors, one of which they each tackled with their essays. The keywords came from the classic Von Neumann diagram for a computer architecture. To create resonances and productive dissonances, we grouped our essays according to its main constituents, turning *program* (control unit), *storage* (memory), *input/output*, and *computation* (arithmetic/logic unit) into props for historical inquiry. The authors' essay-responses enacted a diversity of methods and concerns, weaving fortuitous lateral connections. Instead of a methodological proposal, this organizational move acts as a suggestion of what is possible once key-terms move beyond disciplinary definitions. In other words, using Von Neumann's diagram as an organizational tactic provisionally shapes a field of possibility stabilized around four quasi-material objects. Positioned as both technological and cultural constructs, "program," "storage," "input/output," and "computation" provide categories for parsing designers' and technologists' debates around the computer. Collectively, authors bring forth the striking homologies between a computer program and an architectural program, a wall and an interface, computer memory and storage architectures, structures of mathematics and structures of things.

Program

Peder Anker takes on a close examination of environmental design and its history, illuminating one important episode around computers entering architectural culture. He follows the émigré architect Serge Chermayeff from his conservation campaign for

If Peder Anker and AnnMarie Brennan investigate "program" as a metaphor through which designers, modernist elites, and workers expressed their aspirations for more freedom and control, Theodora Vardouli shows us its conception as a vehicle for "order" and a "method." Her essay traces the intellectual, institutional, and technical contexts that shaped Alexander's proposition for a logico-mathematical foundation for design. Vardouli focuses on the work that led up to Alexander's landmark publication *Notes on the Synthesis of Form*, which included an application of HIDECS 2: a computer program based on a hierarchical graph theory-based decomposition algorithm aiming to assist "rational" design decision-making. Her essay traces shifting meanings of "rationality," reading not only Alexander's texts but also the mathematical techniques that he mobilized in their cultural and material dimensions. The mathematical object of the graph, Vardouli argues, allowed Alexander to move between structural and procedural understandings of "program," as both representing logical structures and delineating "order" of steps.

Input/output

Molly Wright Steenson tackles one of the most elastic and influential keywords that permeated research around interactive computing in 1960s North America: the interface. Languages and metaphor take on a key structuring and analytical role in Steenson's essay, and are acknowledged as ways of constructing technological imaginations. Spatial metaphors (scale, boundary, and surface) become crucial in conceptualizing the interface, and conceptualizing architecture as an interface. Architecture-as-interface both reinforced ergonomic mandates ("cognitive ergonomics") and exploded the architectural object within a relational, dialogic web of actions and reactions. Interface-as-architecture allowed the computer to move beyond the confines of an object and become an environment, to reach ever-expanding scales. Interfaces, Steenson argues, are embodied, but in their embodiment they virtualize the entities that they are installed to connect. Interfaces, she also argues, are successful when they disappear. Disappearance and occlusion then become suggestive

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11 The axiomatic aesthetic

Alma Steingart

In 1958, *Scientific American* published a special issue on "The Creative Process" dedicated to innovation in science (Bronowski 1958: 58–65). Edited by Jacob Bronowski, the volume included articles on the physiology and psychology of the imagination, as well as the role of innovation in mathematics, physics, and biology. Bronowski, who would later become famous for his work on the BBC television series *The Ascent of Man*, was committed to the idea that the sciences and the arts were not, as C. P. Snow would famously declare the following year, opposed to one another. Rather, they were parallel activities united by their creativity and innovation.[1] Bronowski was not alone in trying to bridge the gap between the sciences and the arts. Other intellectuals such as metallurgist-turned-historian of technology and art Cyril Stanley Smith, developmental biologist and philosopher Conrad H. Waddington, and designer and artist Gyorgy Kepes were similarly committed to a mid-century scientific humanism that emphasized creativity and aesthetic considerations as qualities shared by the sciences and the arts (Waddington 1970; Smith 1980, 1983). Whereas Bronowski's vision was an all-encompassing one that treated the sciences and the arts as unified wholes, his writings are inflected by his personal training in mathematics. His notion of creativity clearly bears the marks of the high modernist mathematical epistemology in which he was steeped. Bronowski's creative mind reflected values held in common by many modern mathematicians, who conceived of their field as a self-contained and autonomous body of knowledge.[2]

Bronowski held that in both art and science, creativity was fundamentally a question of *identification*, meaning the ability to recognize common features across separate spheres:

> a man becomes creative, whether he is an artist or a scientist, when he finds a new unity in the variety of nature. He does so by finding the likeness between things which were not thought alike before, and this gives him a sense both of the richness and of understanding. The creative mind is a mind that looks for unexpected likeness.
>
> (Bronowski 1958: 63)

Bronowski's description of creativity as the recognition of "unexpected likeness" in the search for unification and understanding is a testimony to the structural conception of mathematics that dominated mathematical research at the time. Mathematicians postulated that diverse mathematical subfields could be analyzed and approached from a unified perspective by turning their attention to the study of abstract mathematical structures. They sought universal theories that would enable them to describe mathematics as one unified whole. As historian Leo Corry has noted, by the mid-1940s "the idea soon arose that mathematical structures are the actual subject matter of mathematical knowledge in general" (Corry 2004: 10).

Bronowski directly identified structuralist mathematics as a shared model for both scientists and artists.

> Science is pictured as preoccupied less with facts than with relations, less with numbers than with arrangements. This new vision, the search for structure ... is also marked in modern art. Abstract sculpture often looks like an exercise in topology, exactly because the sculpture shares the vision of the topologist.
>
> (Bronowski 1958: 64)

That is, it was not simply that the nature of creativity operated similarly in both science and art. More fundamentally, they shared an underlying approach, "the search for structure." It is thus not

surprising that Bronowski called upon topology, as opposed to geometry, to unite the sciences and the arts. By mid-century, topology was concerned more with the arrangement of an object than with its metrical qualities, and thus became symbolic of structuralist methods writ large.

Surveying the twentieth-century literature on science and art, Linda Henderson has noted that "by mid-century a focus on structure and form had become a more fundamental means to compare the two realms" (Henderson 2004: 426). Bronowski was not alone in identifying structure as a common denominator. One of the best examples of the attention to structure as a uniting concept in both science and arts is Kepes's 1965 edited volume *Structure in Art and in Science*.[3] Its cover, graced by the names of the preeminent artists, scientists, and architects who contributed essays, from Pier Luigi Nervi to Buckminster Fuller, gestures toward Kepes's definition of structuralism in its distribution of rectangles suggestive of decussating lines: "structure, in its basic sense, is the created unity of the parts and joints of entities. It is a pattern ... of interacting forces perceived as a single spatio-temporal entity" (Figure 11.1). It was the product of several seminars Kepes organized at MIT in which he hoped to foster interdisciplinary discussions around the notion of structure.[4] It serves as such as an uncommonly rich source with which to interrogate the structuralist vision that undergirded mid-century scientific humanism and as a testimony to its prevalence.

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