UNCONVENTIONAL COMPUTING:

DESIGN METHODS FOR ADAPTIVE ARCHITECTURE

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/ edited by Rachel Armstrong and Simone Ferracina.

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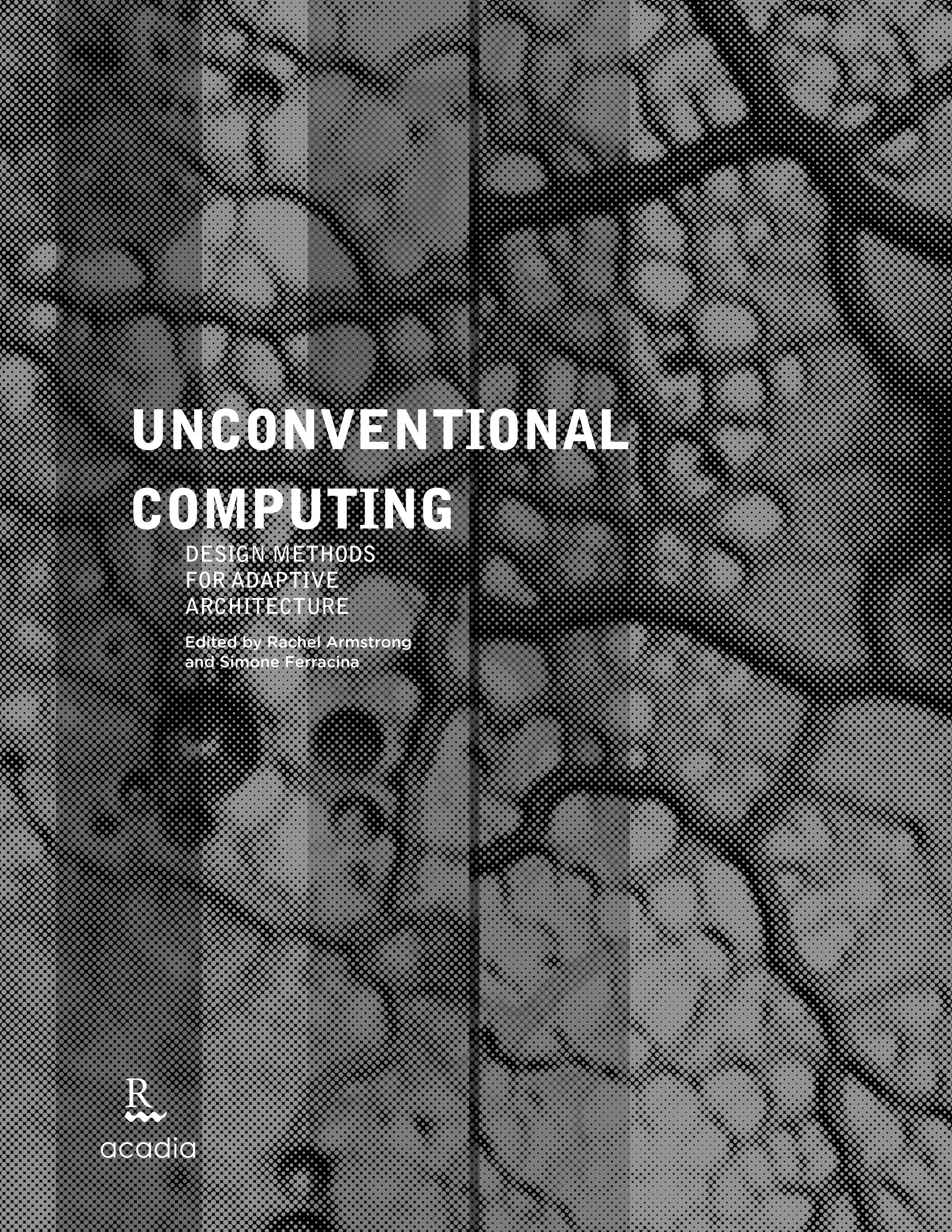

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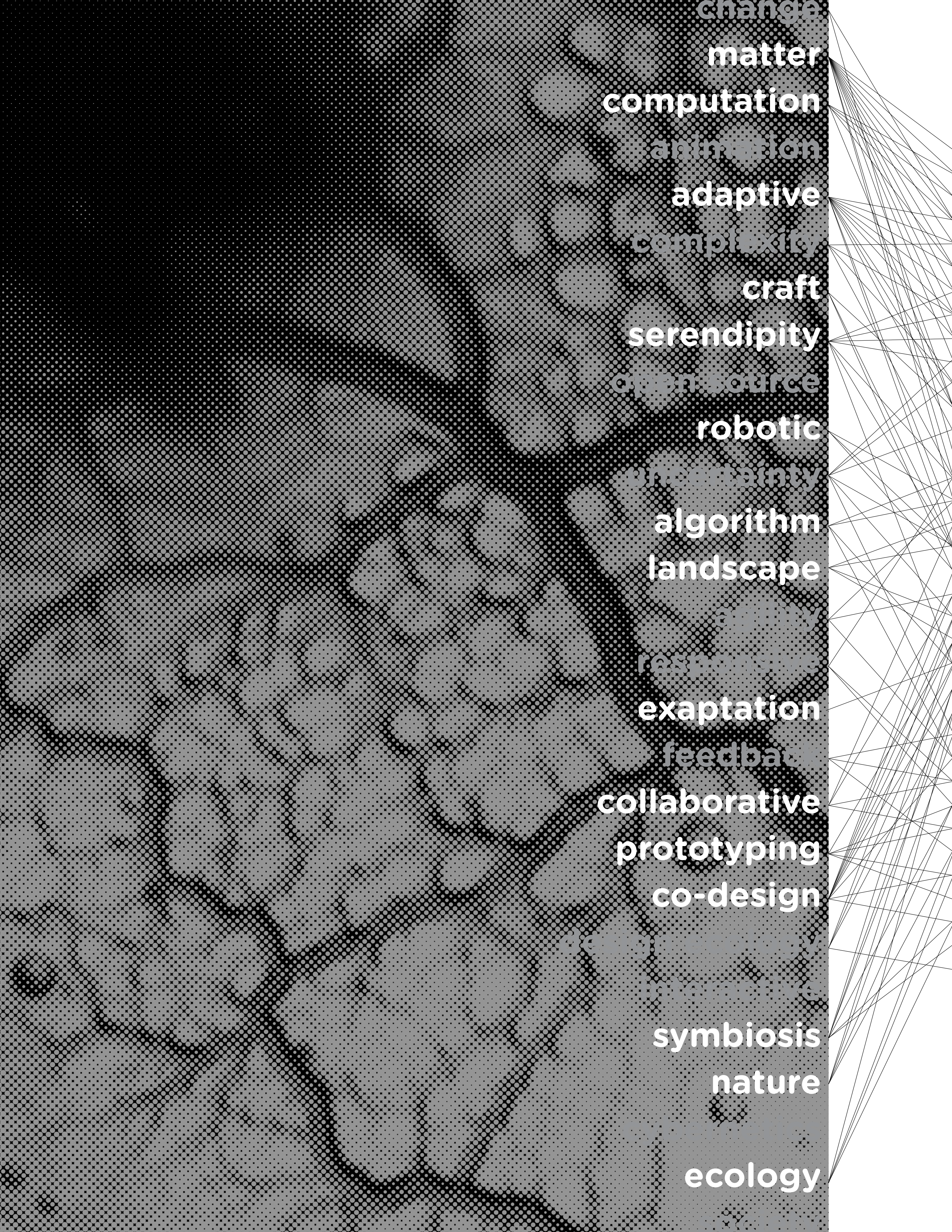

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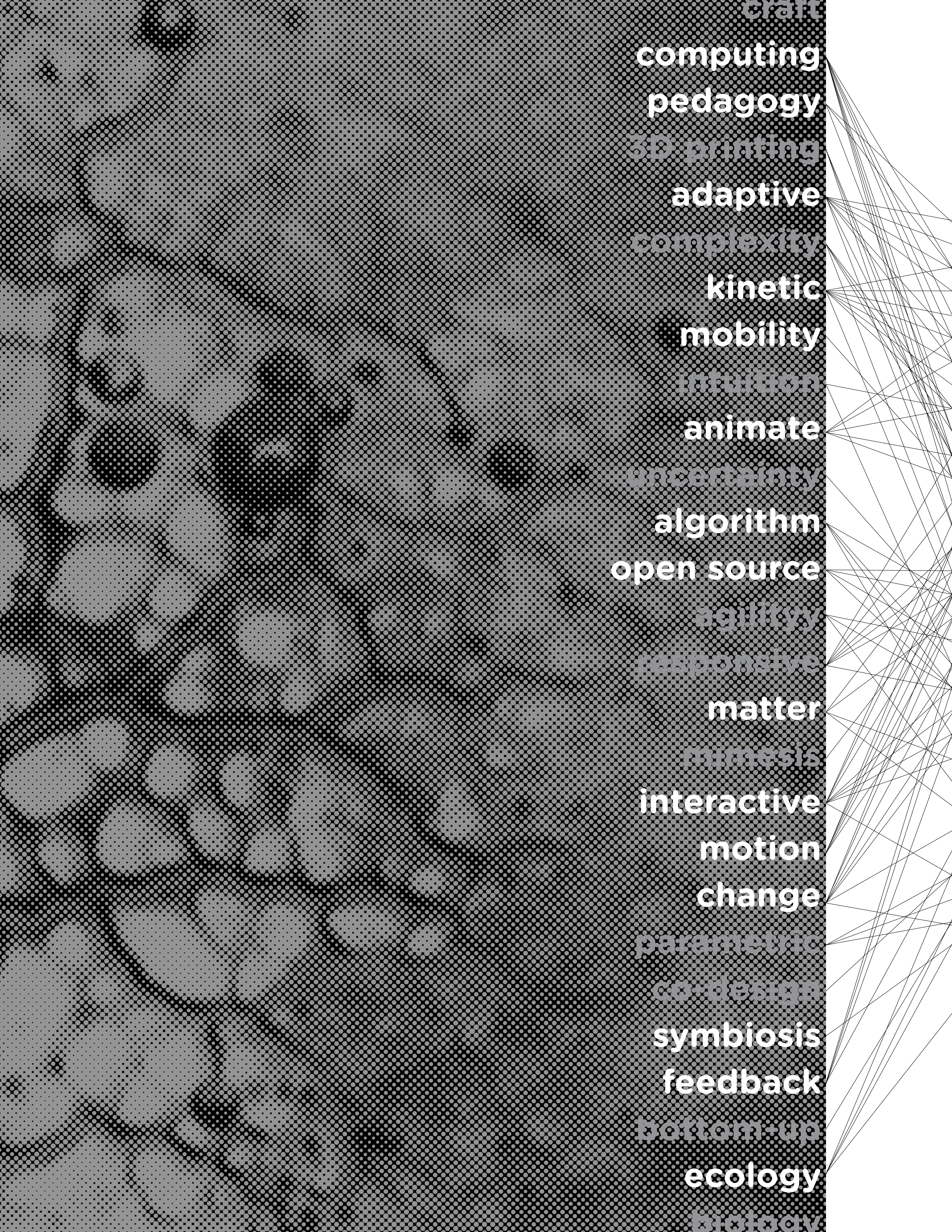
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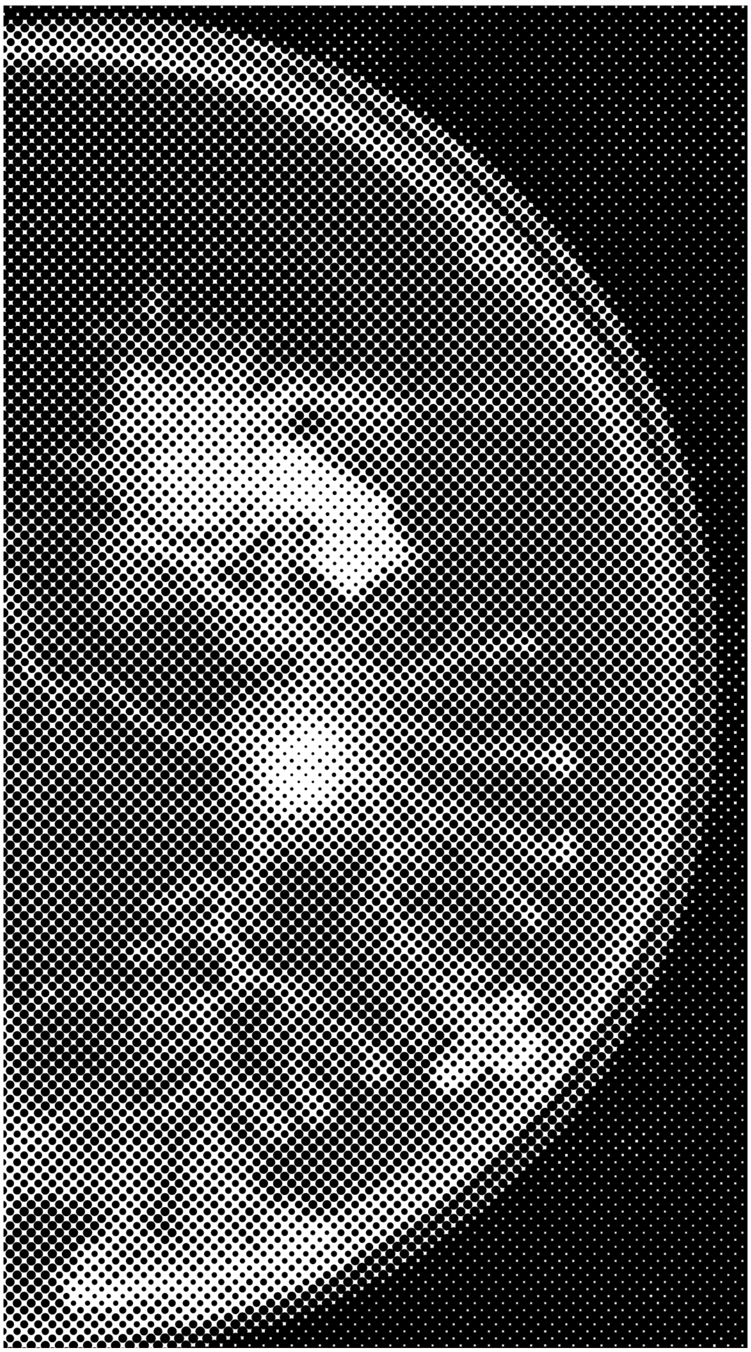
INTRODUCTION

Rachel Armstrong

Simone Ferracina



As digital counters reset to rows of gaping zeroes at the turn of the millennium, the world held its breath and waited to see what followed.

Eyes were glued to time displays on microwaves, computers, clocks and household appliances, and we were spellbound by the as-yet unknown impacts of the so-called millennium bug. This apocalyptic-sounding hardware and software design oversight, meant that computer systems using only the last two digits of the year—rather than all four—were thought to be vulnerable to error as the digits "99" changed to "00." It was said that some appliances would interpret the new millennium as the year 1900 and simply stop working. While this might have caused minor irritation at a local level, these small disturbances could have potentially summated and resulted in a global meltdown. Yet as the digits flickered and the counters clicked into the reset position, it became clear that we had escaped digital doomsday.

In the following decade we have become increasingly aware of a much more insidious kind of millennial malevolence stemming from material causes—one we had long been trying to ignore.

Perhaps we had been glamoured away from earthly matters by the endless promises of the digital domain. This weightless realm, which is enlivened by energized specks of matter, has come to represent possibilities that far exceed the heavier reality of atoms, and to suggest that it is possible to embrace lifestyles that are seemingly unencumbered by material consequences. Yet, although the world of electrons is massless, when coupled to brute machines, it is far from inconsequential. With software as the machine "mind" instructed by humans, it appeared that we could subdue the fickle natural world into submission and effortlessly build impossible Escher-esque geometries.

In an uncertain world, digital technologies offer stability by positing that existence is finite, that everything is calculable and that the course of events can be managed. This deterministic worldview, according to which human beings are literally in control, originates in the "natural laws" formulated during the Enlightenment. These laws describe the world in mathematical terms—as objects, hierarchies, and geometries—and provide, coupled with specialized instruments, the means to make predictions. Van Neumann's architectures and Turing's codes have enabled us to take these models to new dimensions, representing mathematical concepts using algorithms that replicate like living things. With the advent of the graphical user interface, a new level of mathematical complexity was layered over our growing skill-base in the visualization of complex data. The arrival of desktop 3D modeling software in the early 1990s further exploded the architectural portfolio of possibilities through the production of new forms that were previously barely imaginable. Strange shapes could be bred like the artificial life forms designed by Karl Sims[1] and William Latham,[2] which could be copied and pasted in their multiples without being encumbered by the obsolescent notion of matter. Reality was not only mathematically fluid but could now also be sculptured at scales of "one to whatever."

1 Sims, Karl. 1987-2013. "Karl Sims." http://www.karlsims.com.

2 Latham, William. No date. "William Latham." http://www.doc.gold.ac.uk/~mas01whl/.

We have always inhabited a restless earth, whose many personalities are shaped by global shifts of matter—weather, oceans, soils and ecosystems. However, in the last 150 years our global-scale use of increasingly powerful machines has exacerbated these exchanges in ways that provoke exceptional material instability. Indeed, in the third millennium we have realized that our species collectively wields a geological-scale force that is shaping global events. As authors of the Anthropocene, our influences to date have been largely unintended. Yet, we are beginning to design our planetary systems by provoking geoengineering-scale events to dampen unwanted material turbulence such as sea level rises or climate change. Mega industrial-style approaches such as building the Moses gates, a series of giant mechanical barriers to stop the city of Venice from flooding; seeding the oceans with iron; spraying the atmosphere with sulphate-aerosol; turning biomass into char or launching a cloud of mirrors into space to deflect the sun's rays, may be equally as likely to tip our planetary systems into further disarray. We need a subtler and more distributed form of engagement with matter than the centralized, top-down control systems that characterized the industrial age.

To begin this conversation with the material world, we need to identify a common language and develop technologies that enable meaningful exchanges between humans and the natural world. Alan Turing identified the computational power of nature as a programming platform and considered its ability to express matter in many rich and diverse combinations as being a specific form of computing. Its language is expressed in the laws of physics and chemistry, while its poetry is recited in the multitude of sonnets we recognize as biology. Nature's unique rule sets provide alternatives to the computational potential of the digital platform, and architecture has begun to readjust to the new cultural, technological, material and environmental conditions that constitute the natural world in the twenty-first century. This "millennial nature" possesses a kind of agency that is different from the untouched wildernesses, or picturesque landscape vistas that Romantics have swooned upon. Millennial nature is not an Enlightenment "standing reserve"[3] that awaits mechanical instruction, nor is it an anti-modern, vengeful force that seeks to usurp humankind.[4] Instead, it is native to twenty-first century challenges, having been deconstructed and stripped of aestheticisms to expose a raw, relentlessly material character.[5] Its assemblages not only exist in unsettled areas of the planet but also inhabit our power stations and garbage dumps.[6] Millennial nature is a force to be reckoned with—continually forged through the horizontal coupling of different species of lively material agents, which negotiate many difficult relationships through the production of assemblages. Millennial nature is a shape-shifting transformer that does not produce utopian fabrics but weaves fluctuating terrains that are composed of paradoxes and contradictions. It seeks a new relationship with humanity where work is carried out in equal partnership, and should therefore be engaged and nurtured, not tamed or subdued. Indeed, millennial nature does not prioritize life over nonliving systems, but embraces many different substrates such as inorganic agents,[7] biology, weather, geological forces, soils, oceans, atmosphere, gravity, light, star systems, black holes and humans. "Millennial nature" refers not only to an alternative way of observing the environment but to a whole new production platform for the synthesis of systems and fabrics that perform work equivalent to that of machines. Architects have already begun to explore the opportunities presented by such a technologically integrated natural ordering system, by raising the status of matter in design practice and integrating physical and chemical processes to the production of architecture. These works include *Gravity Screen* by Omar Khan[8] and *Hylozoic Ground* by Philip Beesley.[9] In these instances, the practice of architecture is no longer about the fabrication of a building object but about the development of post-natural fabrics where the architect's role is to develop a spatial program that shapes the interactions and exchanges of the various participating bodies.

Post-natural fabrics are an expression of millennial nature. They emerge from the convergence and complex interplay between artificial and natural systems—as continuous fields of activity with diffusive bodies that are intimately entangled within their infrastructures and yet open and ready to adapt and evolve. Post-natural fabrics are not finite geometries or polished products, but generative fields of material fertility in which new events may occur—potentially indefinitely. The fluctuating chemical exchanges within post-natural landscapes are invisible to their inhabitants, who consider these synthetic fabrics as everyday experiences. Post-natural natives are culturally entangled with their environments and expect them to be lively and tangibly interactive—an attitude analogous to that of post-digital revolution children who poke at paper expecting it to converse with them.[10] Within these convergent terrains there is a spectrum of conditions and experiences—as varied as the configuration of life itself—all of which may be regarded as post-natural. Examples of emerging post-natural landscapes include the transformation of native biomes by industrial toxins[11] and the more strategic entangling of artificial and natural systems as explored in Liam Young and Kate Davies's *Unknown Fields Division*.[12, 13, 14]

3 Heidegger, Martin. 1993. "The Question Concerning Technology." In *Martin Heidegger: Basic Writings*, edited by William Lovitt and David Farrell Krell, 287-311. New York: Harper & Row.

4 Koolhaas, Rem. No date. "Sustainability: advancement vs. apocalypse." *OMA*. http://oma.eu/lectures/sustainability-advancement-vs-apocalypse.

5 Morton, Timothy. 2007. *Ecology Without Nature: Rethinking Environmental Aesthetics*. Cambridge: Harvard University Press.

6 Bennett, Jane. 2010. *Vibrant Matter: A Political Ecology of Things*. Durham: Duke University Press.

7 Williams Goldhagen, Sarah. 27 January 2012. "A tree is a tree is a … building?" in *Lebbeus Wood's blog* http://lebbeuswoods.wordpress.com/2012/01/27/a-tree-is-a-tree-is-a-building/.

8 Firmin, Sandra Q. 2010. "'Architecture in motion' in UB gallery." *UB Reporter*, February 3 http://www.buffalo.edu/ubreporter/archive/2010_02_03/reflexive_machines.html.

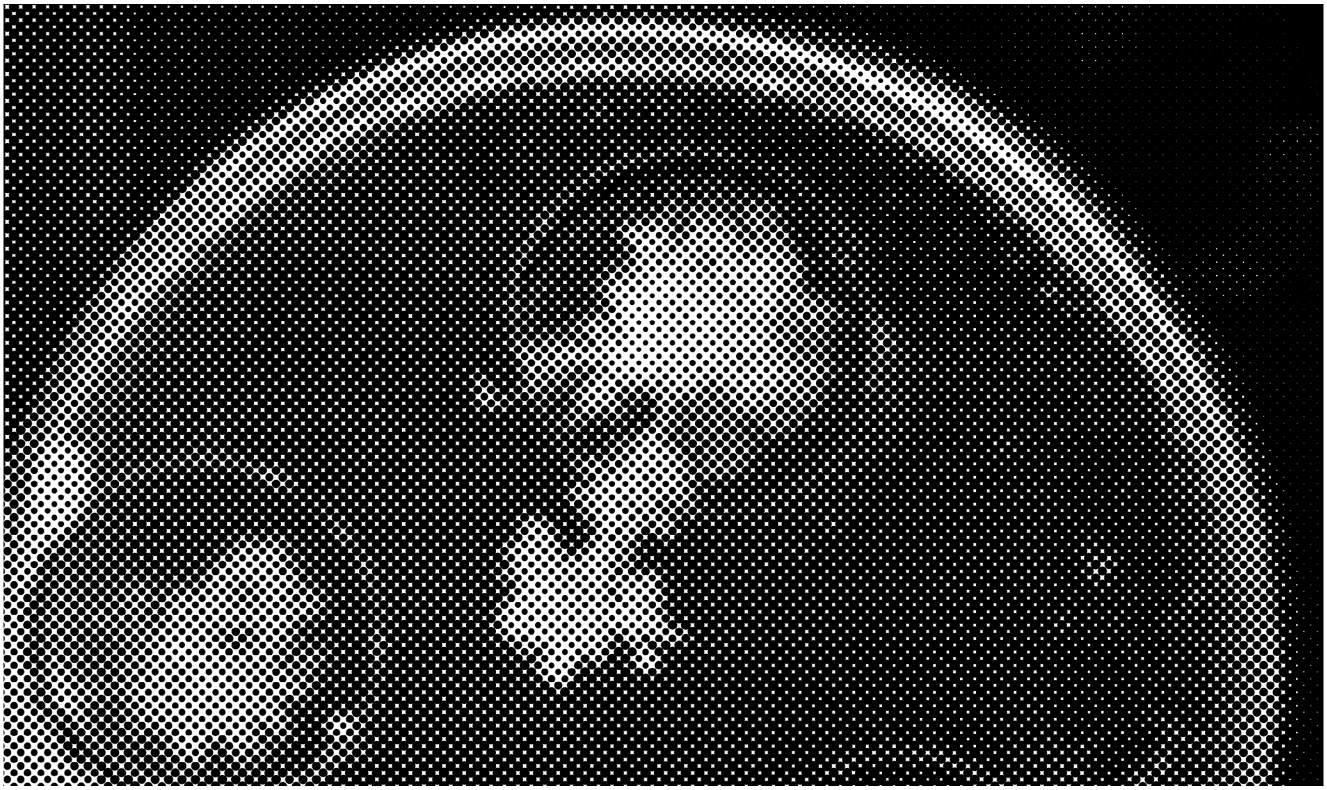
9 Armstrong, Rachel, and Philip Beesley. 2011. "Soil and Protoplasm: The Hylozoic Ground Project." *Architectural Design* 81(2):78-89.

10 UserExperiencesWorks. 2011. "A Magazine Is an iPad That Does Not Work." *YouTube* video. http://www.youtube.com/watch?v=aXV-yaFmQNk.

11 Paul, Rebecca. 2011. "SPURSE and the BMW Guggenheim Lab Explore NY's Most Astonishing Post-Natural Landscape." *Inhabitat*, September 9. http://inhabitat.com/nyc/spurse-the-guggenheim-bmw-lab-explore-nys-most-astonishing-post-natural-landscape/2/.

12 Phillips, Alexander. 2012. "Back to the Futurist: Liam Young." *URBNFUTR*, February 13. http://urbnfutr.theurbn.com/2012/02/back-to-the-futurist-liam-young/.

13 Meier, Allison. 2013. "Emerging: Artist Sterling Wells Creates Post Natural Landscapes." *Inhabitat*, January 17. http://www.artinfo.com/news/story/857655/emerging-miniature-landscapes-are-painting-subjects-and.



Unconventional Computing: Design Methods for Adaptive Architecture is an exploration of this emerging terrain of negotiated acts of co-design between humans, nonhumans and matter, where spatial programs are regarded as acts of persuasion, cooperation and symbiosis. These practices may be considered as various species of unconventional, or nature-based, computing which aims to develop novel non-standard algorithms and computing architectures.[15, 16, 17] These acts of design and production are not artificial or at odds with nature, but seamlessly entwined with its processes. Unconventional computing offers a platform for coupling information and matter so that, rather than being an afterthought to geometry, materials may participate directly in the design solution.

This is not a new idea. Iterative exchanges between body and systems already informed the interactive architectures imagined by cyberneticists, where objects and space were capable of responding to the influences of people, communities and environments, such as in Cedric Price's *Fun Palace*.[18] Such adaptive paradigms were even embodied in non-mechanical systems in the living experiments of Gordon Pask's chemical ear,[19] which responded to the sounds of the street, as well as in Stafford Beer's pond life experiments.[20] Unconventional computing techniques differ from these approaches since, in the wake of thirty years of biotechnology, it is now possible to manipulate embodied processes with such precision and at such small scales that architects have access to a technological portfolio that actually begins to behave in lifelike ways. For example, Gabriel Villar and colleagues are using vesicles distributed using 3D printing systems to form microscale structures[21] and Klaus-Peter Zauner's group is using dynamic vesicle systems in microfluidic devices to provoke artificial nerve and muscle-like behavior in chemical assemblages.[22, 23] Indeed, the parallel

14 Sterling, Bruce. 2013. "Architecture Fiction: Future Perfect and Lisbon Architecture Triennale." *Wired*, February 4. http://www.wired.com/beyond_the_beyond/2013/02/architecture-fiction-future-perfect-and-lisbon-architecture-triennale/.

15 Calude, Christian S., John Casti, and Michael Dinneen, eds. 1998. *Unconventional Models of Computation*. Singapore: Springer-Verlag.

16 Calude Christian S., Masami Hagiya, Kenichi Morita, and Grzegorz Rozenberg, eds. 2010. *Proc. 9th International Conference Unconventional Computation, Lecture Notes Comput. Sci. 6079*. Heidelberg: Springer.

17 Adamatzky, Andrew, Larry Bull, Benjamin De Lacy Costello, and Susan Stepney, eds. 2007. *Unconventional Computing*. Luniver Press.

18 Mathews, Stanley. 2006. "The Fun Palace as Virtual Architecture: Cedric Price and the Practices of Indeterminacy." *Journal of Architectural Education* 59(3):39-48.

19 Bird, Jon, and Ezequiel Di Paolo. 2008. *Gordon Pask and His Maverick Machines*. Cambridge: MIT Press. 185-212.

20 Beer, Stafford. 1994. "A Progress Note on Research into a Cybernetic Analogue of Fabric." In *How Many Grapes Went into the Wine: Stafford Beer on the Art and Science of Holistic Management*, edited by Roger Harnden and Allenna Leonard, 29. New York: Wiley.

21 Villar, Gabriel, Alexander D. Graham, and Hagan Bayley. 2013. "A tissue-like printed material." *Science* 340(6128):48-52.

22 University of Southampton. No date. "Artificial Wet Neuronal Networks from Compartmentalised Excitable Chemical Media." *Electronics and Computer Science (ECS)*, http://www.ecs.soton.ac.uk/research/projects/735.

23 Palmer, Jason. 11 January 2010. "Chemical Computer that Mimics Neurons to Be Created." *BBC News*. http://news.bbc.co.uk/1/hi/8452196.stm.

24 Deutsch, David. 1997. *The Fabric of Reality: The Science of Parallel Universes–and Its Implications*. London: Penguin Books.

25 O'Connell, Aaron. 2011. "Aaron O'Connell: Making sense of a visible quantum object." *TED*, March. http://www.ted.com/talks/aaron_o_connell_making_sense_of_a_visible_quantum_object.html.

26 Gissen, David. 2011. "Thoughts on a Heap of Rubble." *Kerb* 19:50-52.

27 Adamatzky, Andrew, ed. *International Journal of Uncoventional Computing*. 2006-2013.

28 Turner, Scott, and Rupert Soar. 2011. "Conversations - Termite Mounds: a Real Example of Agent-based Architecture." *YouTube*, February 2. https://www.youtube.com/watch?v=0a2GXjS9Cao.

processing powers of matter can deal with the dynamic nature of these systems and resolve overlapping and often contradictory spatial paradigms to produce complex and engaging experiences. For example, architectural programs may demand the convergence of processes and objects, quantum and classical physics, nanoscales and megascales. Through the parallel processing power of atoms, nature-based computation does not treat different qualities as binary opposites or mutually exclusive states, but as coexistent realities or parallel worlds—perhaps in a way similar to light being both a field and a particle[24] or an object simultaneously vibrating and not vibrating.[25] Unconventional computing does not propose to have any one solution to these new possibilities, but deals with probabilities as yet-undetermined expressions of matter and spaces. In fact, it aims to suggest that many new species are possible from an evolutionary soup of what Gissen[26] calls "pre-natures," which are primordial material agencies. These raw ingredients respond to spatial programs using a range of tactics that diversify possibilities such as fusions, recombinations and adaptive changes. Their interactions suggest new configurations and possibilities that may not have previously existed and may extend our knowledge sets. However, this emerging field that aims to work directly with nature-based processes to develop material solutions, is predominantly occupied by theoretical research, with only a handful of experimental prototypes currently being explored.[27] Such explorations invite multidisciplinary partnership, as in Rupert Soar's work on modeling termite mounds by interweaving disciplines and crafts from zoology, architectural space analysis, and mechanical engineering. His work reveals a new spatial "reticulum" paradigm that is informed by the movement of bodies in relationship to fine-grained oscillating chemical and thermal operations.[28]

This publication therefore aims to apply and expand the tools, approaches, materials and platforms of unconventional computing to shape more direct, responsive and adaptable methods of architectural production. While this publication does not propose to be a scientific project, it seeks to begin multi disciplinary conversations that may lead to the production of many new species of unconventional computing that are accessible to architectural design practice. An interest in the methodological approach to these challenges runs strongly through the presented works to help establish its research-based foundations and has been encouraged to support the exploratory nature of this publication. In their proposals, contributors investigate a wide variety of computing and designing practices that invoke the material world. The voices in this publication suggest that unconventional computing is a synergetic practice, which works alongside established methods such as parametrics, digital prototyping, landscape design and cybernetics. The possibilities that these methodological convergences may produce, are still emerging and indeed, this book serves as part of the toolset through which new material practices may be shaped.

This publication does not propose unconventional computing as a cure-all for our ecological malaise, nor a new paradigm to replace an "outmoded" digital platform. Rather it intends to diversify the opportunities available for a richer design portfolio, and to establish a more "complete" architectural design system by extending the range of possible material solutions that integrate with and inform ecological networks. The importance of using a nature-based form of computation resides in the ecological impact of architecture, as our civilization becomes more resource-constrained. While conservation of energy and frugal use of natural reserves may buy us time to develop new paradigms to underpin human development, they are not sustainable in the long term, as they continue to operate according to the laws of resource consumption.[29] By the middle of this century there will be another two billion people on the planet, who will need housing, food and a humane quality of life. Industrial austerity alone will not be enough to achieve this goal.

29 Armstrong, Rachel. 2012. "Lawless Sustainability." *Architecture Norway*, December 5. http://www.architecturenorway.no/questions/cities-sustainability/armstrong/.

A nature-based production platform could potentially transform the practice of architecture into a system of ecological regeneration[30] and potency—into post-natural fabrics expressed through effusive, decorative and ecstatic exchanges. These vibrant terrains could become sites for possible further acts of production, and would be valued for their fertility and powers of transformation, rather than their square footage. Whether we like the idea or not, with the advent of the Anthropocene all acts of architecture can be understood as forms of geoengineering that are collectively changing the environment, since the production of buildings depletes natural resources, reduces land fertility and currently accounts for 40 per cent of our carbon footprint. Yet geoengineering is not just an industrial event, it is also a natural, spontaneous process. The earth's atmosphere was transformed from being a noxious "reducing" atmosphere into one that is oxygen-rich through the collective action of primitive life forms called cyanobacteria. However, such changes do not sustainably occur through a single imperial act of control, but through many consensual acts carried out by distributed agencies. Over time, their local effects collectively shape the behaviour of ecosystems through continual, varied, convivial and negotiated acts of design.

30 Armstrong, Rachel. 2012. "Soft Cities." In *Organs Everywhere No.4 Material Shifts*, edited by Simone Ferracina. http://organseverywhere.com/past/issue4/.

The millennial moment has passed, and we have survived. We are traveling the *Long Now*[31] of human development in the company of millennial nature, and the prosperity of this relationship will be expressed through a different kind of geoengineering, one whose success will be measured in biorhythms and through the material potency of the earth. There is still time to recover from our industrial jet lag and re-synchronize human development with natural processes. Yet, these transitions must be made urgently and must be more sustained than an architectural fashion—and last longer than a jolly green sustainability song. If not, our species will simply grind to an entropic halt while millennial nature marches on without us. However, we are making progress. The move to unconventional computing is a step toward developing many different conversations with the material world and establishing new modes of design practice that may sire diverse architectural species. Mutually beneficial exchanges between humans and the natural world require generational thinking and are likely to be expressed through a great variety of architectural types and post-natural fabrics. Perhaps these architectures will be as rich and varied as life itself—but we are far from 'there' yet. Indeed, it is possible that we have just arrived at the beginning of a new relationship with millennial nature. The essays in this publication provide us with a primordial soup of exciting possibilities that may begin to consummate these composite new partnerships between humans and the material world.

31 The Long Now Foundation. 1996. "The Long Now." http://longnow.org.

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