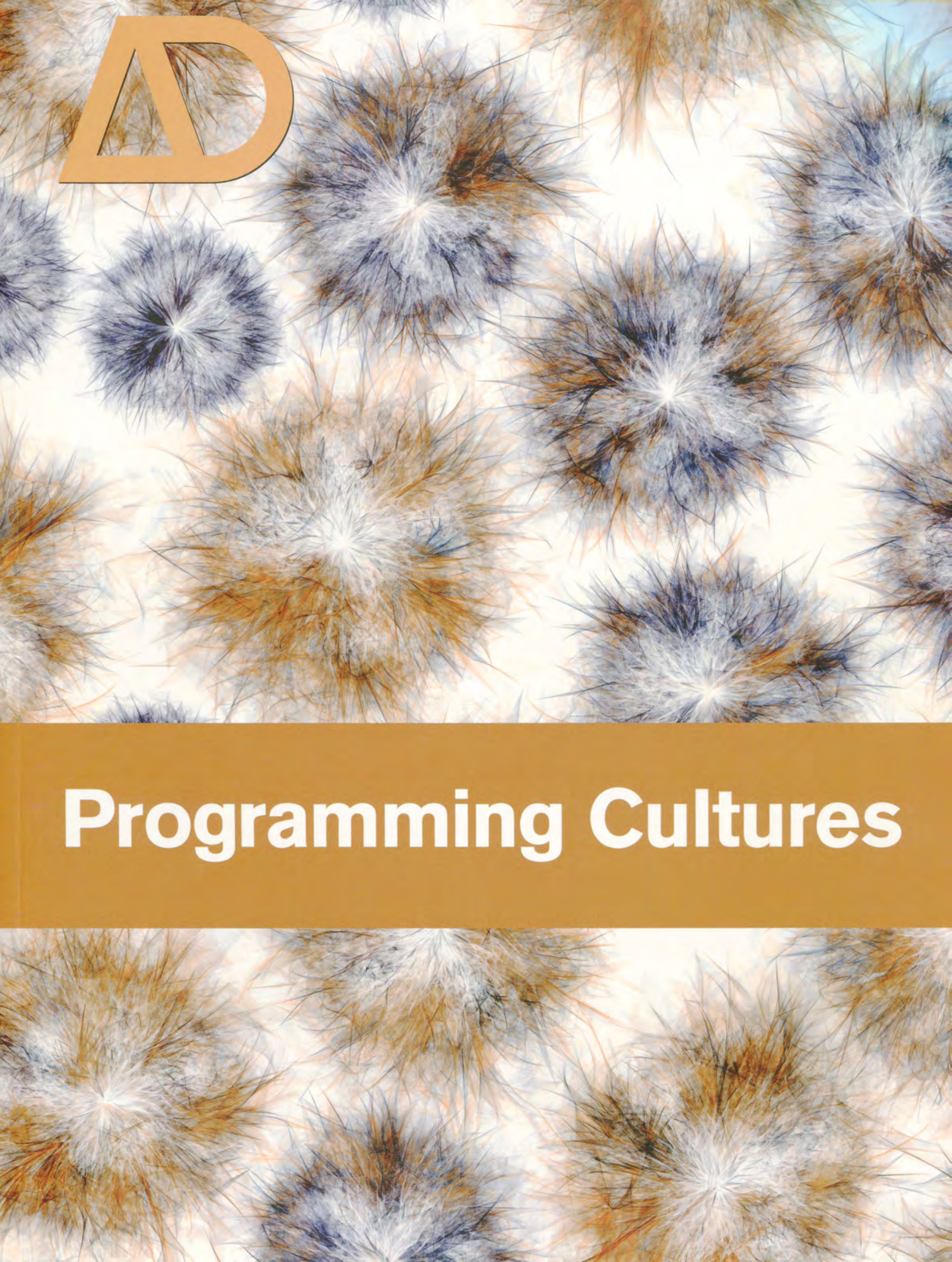
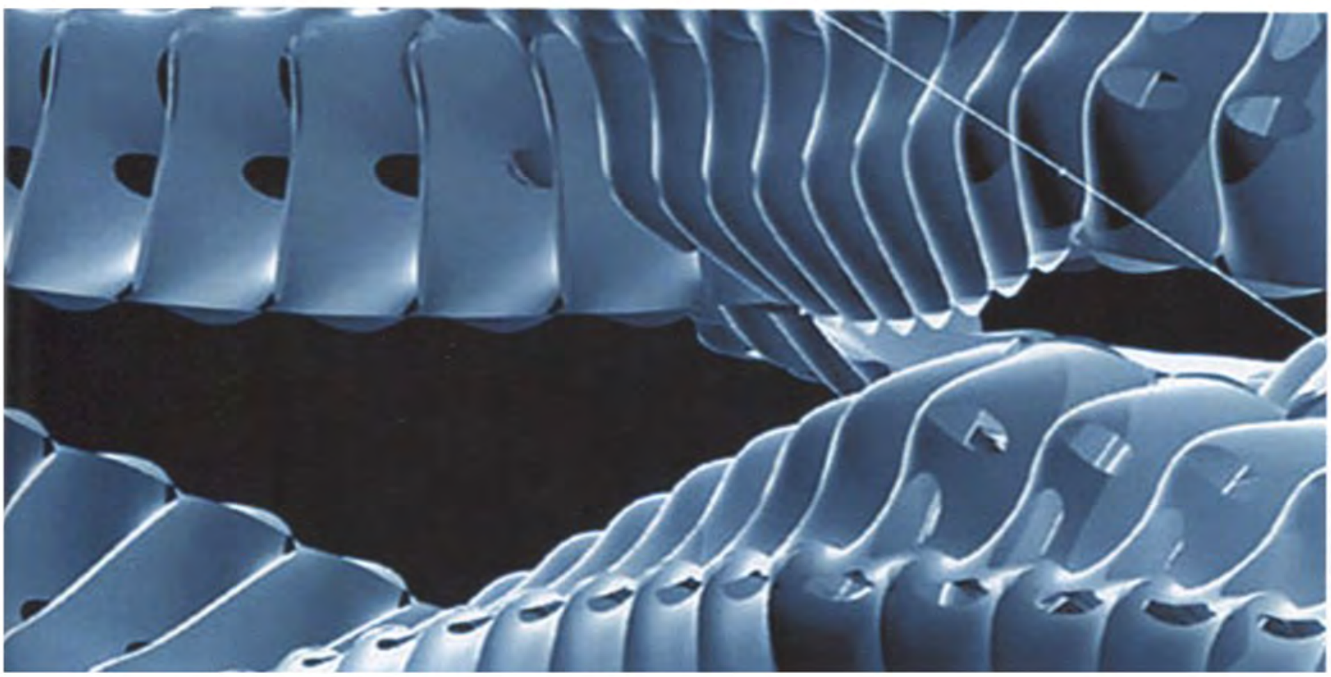


Programming Cultures

Architectural Design
July/August 2006

Programming Cultures:
Art and Architecture in the Age of Software

Guest-edited by
Mike Silver



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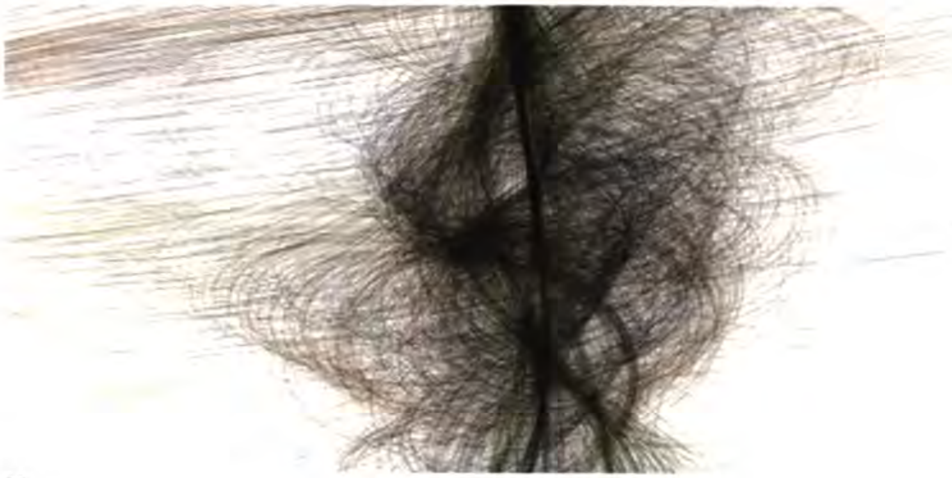

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b = bottom, c = centre, l = left, r = right

Front cover: Process 6 (Image 4), 28" x 28" inkjet print, 2005. Print derived from Process 6 (see 'Process/Drawing', pp 26–33). A dense surface of circles emanate from fixed points. The forms emerge as lines are drawn between their centre points as they expand outwards. Each circular element is the same software run with a different configuration. Each grows differently in response to its simulated environment. © CEB Reas.

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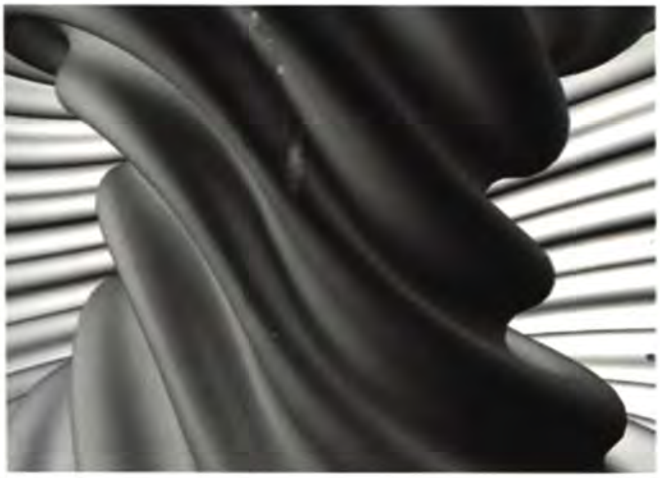

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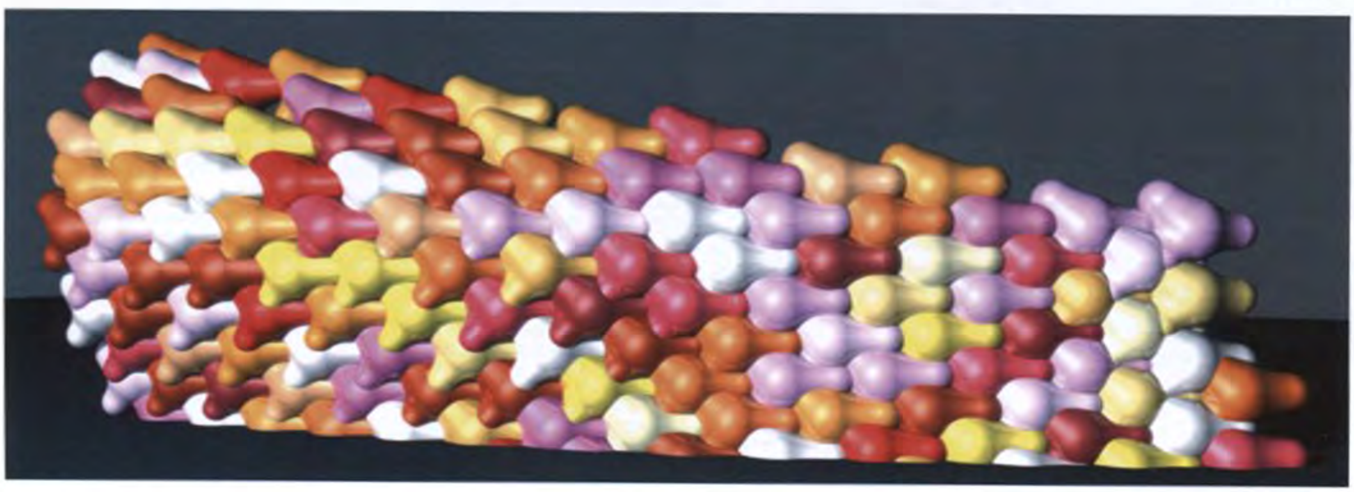
Editorial

Despite AD's long-standing association with the digital in design, this is the first issue with any reference to programming or software in the title. This says much about architecture's previous relationship with the computer. At the end of the 1990s when I first started editing AD, I was often confounded by the gap between design process and text. Why was everyone generating amorphous Maya-inspired blobs, but talking about Derrida? *Programming Cultures* hails the way for a new generation of work that comes out of a pure, unadulterated passion for software. For a young designer like CEB Reas, who has been playing with script since childhood, it is an entirely natural creative impulse. For experienced designers like Malcolm McCullough and Greg Lynn, it has come out of decades of pioneering work on computer-aided design. McCullough, one of the first architecture managers for Autodesk, exhorts us that 'all you need is the will to improvise'; Lynn enthuses 'I love the moment when I discover some new potential in software.' This is all constructive play which, as described by Ingeborg M Rocker in her interview with Lynn, adds up to 'exhaustive exploration'. It is a not insignificant shift, which moves architects away from being mere consumers of software towards becoming knowledgeable adapters, crafters and, ultimately, producers. So much more than a development of architects' technical skill bases, it is set to have a huge impact on the culture of architecture. Could the deftness with scripting that educators and designers like Mike Silver, the guest-editor of this issue, is encouraging in his students at New York's Pratt Institute of Architecture become commonplace? Could scripting become the new drawing? The potential aesthetic impact of this way of working is anticipated by Pia Ednie-Brown's discussion of the new compositional principles spearheaded in the work of Alisa Andrasek of biothing. For, as Ednie-Brown points out: 'Working with computational algorithms as primary generative material offers a different bent to, for example, the mathematical ratios of the Renaissance or the flow diagrams of Modernism.' At such a nascent stage, the ultimate cultural repercussions of a new programming era are only to be guessed at. The implications are that we could be at the brink of an entirely new period of culture and knowledge; if so, could Stephen Wolfram be set to become the next Isaac Newton, and Gehry Technologies' software be about to eclipse the pattern-books of Palladio?

Helen Castle

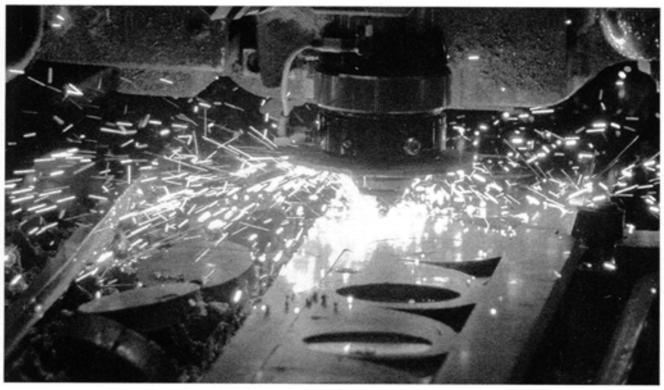


Greg Lynn, Slavin House, Venice, California, due for completion 2007
In this project, Lynn is testing the limits of Gehry Technologies' software. As Lynn states in his interview with Ingeborg M Rocker (page 88), the use of the software is 'provocative at many levels and is having a pretty significant effect on my work'.

The Milgo Experiment: An Interview with Haresh Lalvani

For just less than a decade, Haresh Lalvani has been working on a series of projects with Milgo/Bufkin, a leading architectural metal-fabrication company, seeking to economically integrate the shaping and making of metal surfaces into elements that create a seamless whole. Here, **John Lobell** interviews Lalvani about his pioneering work with computer-aided design and manufacturing and how it has been informed by his development of the Morphological Genome, a universal code for mapping and manipulating form, whether natural or man-made.

Soft AlgoRhythms, surfaces with softer, rounded bends as morphological extensions of bent-surface AlgoRhythms.



Milgo's laser-cutter, one of the several digital-fabrication devices used for different Milgo experiments.

'The dilemma posed to all scientific explanation is this: magic or geometry.

Rene Thom, 1972[1]

A more important set of instruction books will never be found by human beings.

James D Watson (on the human genome), 2003[2]

In recent decades there has been an increase in the use of curved surfaces in architecture, although to date more often in computer simulations than in realised projects. The most common use of curved surfaces is cylindrical column covers that are created from sheet metal on press brakes, with skilled workers continually moving the sheet of metal under the machine's blade by hand. This process curves the metal without warping or deforming it.

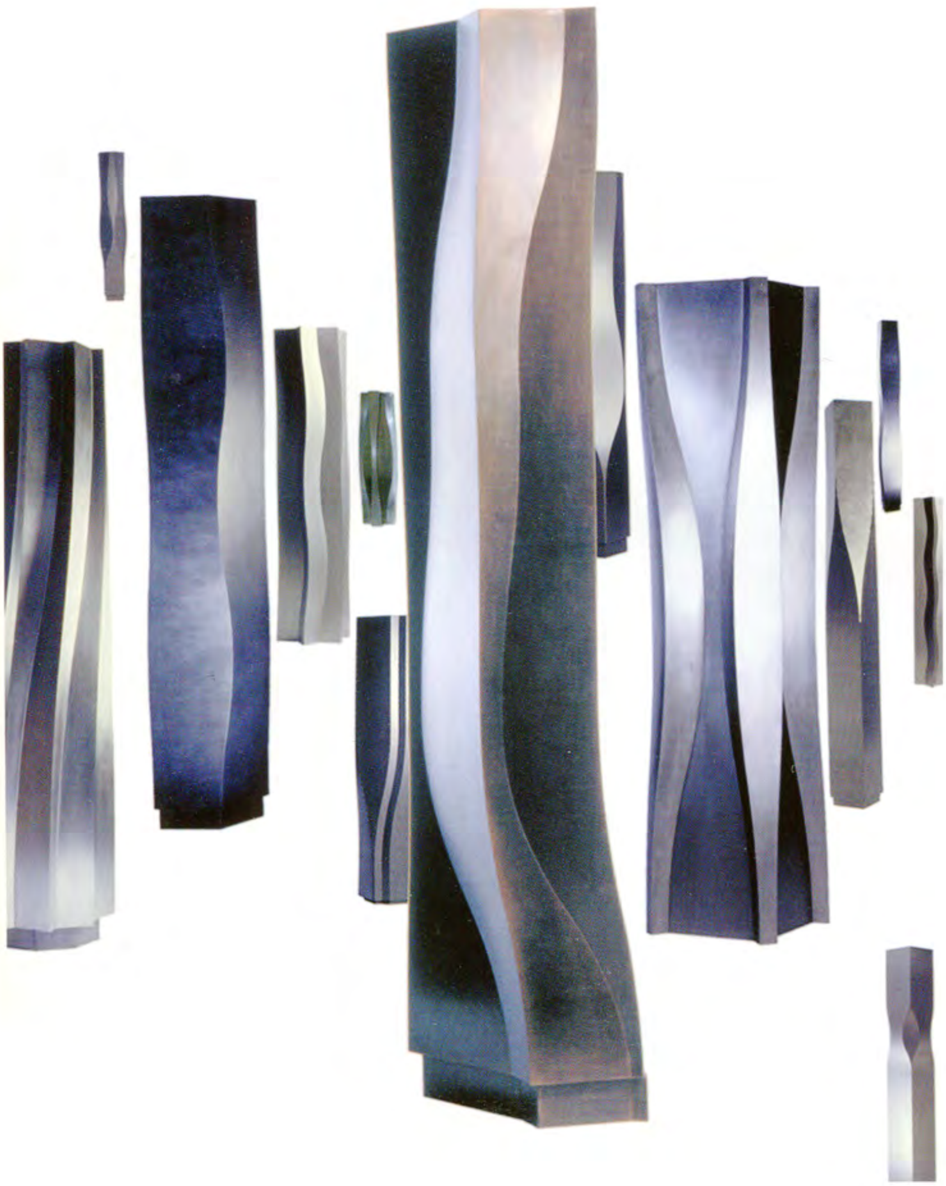
Compound curves, along which one cannot place a straight edge in any direction (for example, a bowl), are far more difficult to fabricate for architecture. They are commonly used in the automobile industry, where they are created by pressing the metal between curved male and female dies, which stretches and deforms the metal. However, such dies are expensive – a cost that can be justified only by making large quantities of identical pieces. Compound curves in sheet metal can also be created by hand, for example with an English wheel, though this technique is also expensive and it would thus be impractical to make an entire building using this method.

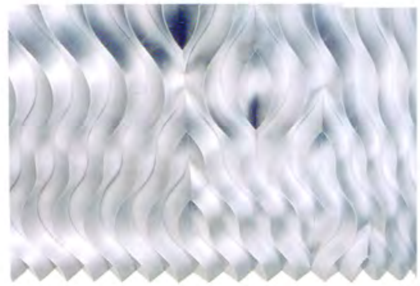
In 1997 Haresh Lalvani began working with Milgo/Bufkin, a leading metal-fabrication company, to find a way of creating developable curved sheet-metal surfaces using an economical process that recognises both the characteristics of sheet metal and the digital capabilities of metal fabrication, such as laser cutting, water-jet cutting, press braking, digital punching. The fabrication of sheet metal at a scale economical for architecture inhibits compound curves and requires developable surfaces – curved surfaces that can be folded or bent from a flat sheet without deforming the material. This work launched the AlgoRhythms project that Lalvani terms the 'Milgo experiment' According to Lalvani:

'There is more than one Milgo experiment in progress, AlgoRhythms being the first. All relate to genomic architecture.[3] The objective of these experiments is to integrate shaping (morphology) and making (fabrication) into a seamless whole. In nature, the two aren't separate. In these projects, I am interested in architecture as surface, not mass. Mass focuses on material performance (strength of material), while surface depends on its geometry (strength of form). This approach has several motivations. First, it is deeply connected with sustainability, as limited resources require us to maximise performance. Second, the bulk of the morphological universe (morphoverse) is inhabited by curved forms that need to be discovered, mapped and accessed. Straight lines and flat planes are in a minority within this universe. Third, new building technologies closer to those found in and beyond nature need to be invented to deal with these new vocabularies.

'We focused on metal because Milgo is a metal-fabrication company though our experiments extend to other materials and forms. The question was as follows: Using sheet metal as it is used in architectural metal fabrication, could we form surfaces to define architectural space using techniques available at Milgo? We wanted to modulate the stiff metal surface to make rigid curved surfaces without deforming the metal. This way the sheet metal would preserve its integrity and become what "it wants to be" to borrow Kahn's words. It would also become stronger Strength "emerges" from curvature when 2-D becomes 3-D during the forming process. We have called this new kind of forming "nondeformational bending" By comparison, standard methods of forming sheet metal, for example stamping, deep drawing and so on, yield stronger 3-D surfaces by deforming the metal sheet as, for example, in the making of automobile bodies.

As we proceeded with these projects, three things happened. First, on a more practical level, we found that we could bend sheet material in a new way We produced AlgoRhythms, a line of architectural products, column covers, wall panels and ceilings, and proposed other products.





The first line of AlgoRhythm products – columns, walls and ceilings – using nondeformational bending of sheet metal.

Second, it was satisfying to demonstrate that theoretical ideas could be translated into practice. The Milgo experiment is an application of the "Structures on Hyper-Structures" work I did in 1981[4] and establishes that metastructural thinking can lead to real products. My work at NASA-Langley from 1989 to 1990 had touched on this in the context of structures for outer space. Third, this experiment has opened a window in the morphoverse where process is added to form. This is the universe of form I have been mapping. Thus the project-within-project became mapping the family of AlgoRhythmic forms as an example of forms generated by a physical process and not a computational one. The Milgo experiments attempt to marry software (morph genome) with hardware (fabrication genome!) in the making of physical objects.

'It is important that the products we produce have an intellectual integrity throughout the process, from the mathematics of surfaces to fabrication techniques, to the detailing we use in installation. Working with Neil Katz, we derived AlgoRhythms through a computational algorithm based on my generalised morphological model that defined new families of surfaces from "solid" forms. The result allowed infinite variations of form, as one iteration could continually morph into another

There is currently much 'computer architecture' around – exotic curved forms on the screen that may not be buildable. Lalvani's work with AlgoRhythms, although based on higher mathematics, is more rooted in the realities of construction than many other approaches:

'The interesting question is whether there is a fundamental link between form and form-making. I assume there is. The form of a seashell or a bone, though based on different growth principles, is intimately connected with its process of growth. Form *is* process.[5] In AlgoRhythms we linked the approaches to form and fabrication from the very beginning. Our approach leads to a new kind of mass-customisation that should eventually make it possible for us to make many units, each one different, as efficiently as we can make them all identical.

'We have installed AlgoRhythms in various buildings and showrooms. Most prominently we have an iteration of AlgoRhythm columns in folded titanium in the permanent design collection of the Museum of Modern Art (MoMA). And in March and April 2004, at an exhibition at the Municipal Art Society in New York, we showed the Hyperwall system, an AlgoRhythms beam and an AlgoRhythms structural truss to extend the concept into forming structural shapes.

As we scale up AlgoRhythms and apply our theories to more building components – for example, to curtain-wall systems and glass envelopes, to beams and trusses and, eventually to entire buildings – we encounter real structural problems. We have designed the entire exterior and lobby of a 12-storey apartment building in Chelsea, New York. The

HyperWall system, an irregular modular wall system using AlgoRhythmic principles (exhibited at the Municipal Art Society, New York, 23 March to 30 April 2004).

important next step is to go beyond surfaces and begin investigating entire building systems, especially structures. We are now working on a residential building we are calling Project X that is AlgoRhythmic from the structural system out to the facade.[6] Since the late 1990s I had been thinking of AlgoRhythmic skins (such as in glass) for tall buildings,[7] so when Stanley Perelman asked me to design a 25-storey apartment building in Manhattan, here was an opportunity to mine the universe of columnar forms we had been developing at Milgo for a completely different application.

'We are interested in developing Soft AlgoRhythms, where the hard edges of the folded surfaces disappear, but here the fabrication technologies are in the way We are looking into Kinetic AlgoRhythms as well, but here we need some bright ideas, as we don't know how to proceed without making the continuous into discrete.

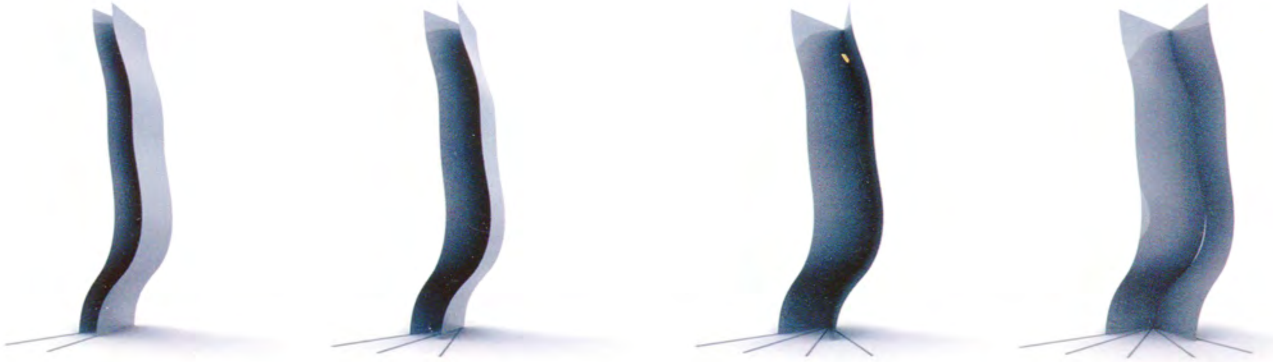
The approach behind AlgoRhythms began with Lalvani's work on the Morphological Genome, a universal code for mapping and manipulating all form: natural, man-made and artificial. By conceiving the morphological universe as a hyper-universe, and by using higher dimensional geometry, we gain the power to understand and manipulate it. Lalvani says:

'The morphological universe is infinite and open-ended, with a fractal hierarchy composed of recursive levels within levels through which one can access and navigate in a number of ways from any level. This is a universe where each structure (and each type of architecture) can transform from one to another in a continuum of space and time, within and between levels. This hyper-universe map provides the basis for the Morphological Genome.

Project X, an apartment building in Manhattan, designed for Stanley Perelman. The morphology of the building skin and structure are derived from AlgoRhythm columns.

An AlgoRhythm truss, a NYSTAR project, inspired by the flow of milk and derived from AlgoRhythm columns. Photo taken at Milgo in the factory setting.

Soft AlgoRhythms, surfaces with softer, rounded bends as morphological extensions of bent-surface AlgoRhythms. Their forming technology is yet to be determined.



The computer sequence shows an example of Kinetic AlgoRhythms, a kinetic version of the HyperWall system folding dynamically. This is another example where the forming technology is yet to be invented.

'The Morphological Genome is a direct inspiration from biology, something I began wondering about in the mid-1970s. In biological terms, it is an epigenetic code[8] that lies outside the biological genome. I have always wondered if there is a "shape gene" in nature and, as far as I understand, the answer today is still "no" If the answer were to become "yes" it would be easy to reverse-engineer biology and construct every shape in nature through genetic engineering. The absence of a shape code in nature provides the need to invent a shape genome. This is the agenda of the Morphological Genome[9] project.

'The Morphological Genome is a model experiment for mapping other genomes. It is composed of morphological genes (morph genes), where each gene specifies a family of related parameters, and each parameter is controlled by a single variable of form equivalent to a "base" in DNA. We are working on this universal structure of form, similar to Crick and Watson's structure of DNA, and mapping and manipulating it at this genetic level.

In deriving AlgoRhythms from the Morphological Genome, Lalvani and his associates took a series of algorithmic steps:

At the first level is the genomic concept, a meta-algorithm, which defines a family of interrelated, intertransforming shapes tied to a fabrication process. At the second level is a computational algorithm of developable surfaces, surfaces that can be formed from flat sheets by bending without deforming.

'I want to point out that the issue of mapping all form is like counting to infinity, many times over, since there are infinite infinities within the morphological universe. So as a practical matter the morphoverse is not mappable. However, what is possible is to provide a framework and show the workings within it with some examples. The expedient way is to identify the morph genes. The key idea here is that the infinity of possible forms can be specified by a finite number of morph genes. I am expecting this to be a small number.[10] Besides the difficulty of identifying these as universal morph genes, you run into unsolved mathematical problems. Only a few years ago I discovered that there exist topological surfaces that violate Euler's famous equation that relates the number of topological elements.[11] The fact that new morphologies (which lead to new mathematics, and new architecture) are possible, is a feature of the morphoverse. This makes mapping the morphoverse more challenging to accomplish.

Interestingly, several architects now refer to their work as 'genetic' Lalvani speculates:

All these genetic and algorithmic approaches to architecture, including our genome project, mark an evolving path in our relationship with the computer – from a labour-saving device to an intelligent problem-solving machine, to an autonomous entity capable of independent creativity. We hold the latter as sacredly human, but this may change.[12] The point I want to make is that as we pass on our skills, knowledge and intelligence to the computer we must be prepared to pass on creativity as well. This trajectory inevitably leads to architecture without architects, in a different sense from Rudofsky,[13] of course. In "Meta Architecture" [14] I had referred to this as the end of architecture (as we define it presently), an architecture liberated from the architect.

Lalvani's morphogenomic model seems to imply continuity, but at the moment there appears to be a bias towards seeing the universe in terms of binary discreteness. On whether reality is continuous or discrete, Lalvani comments:

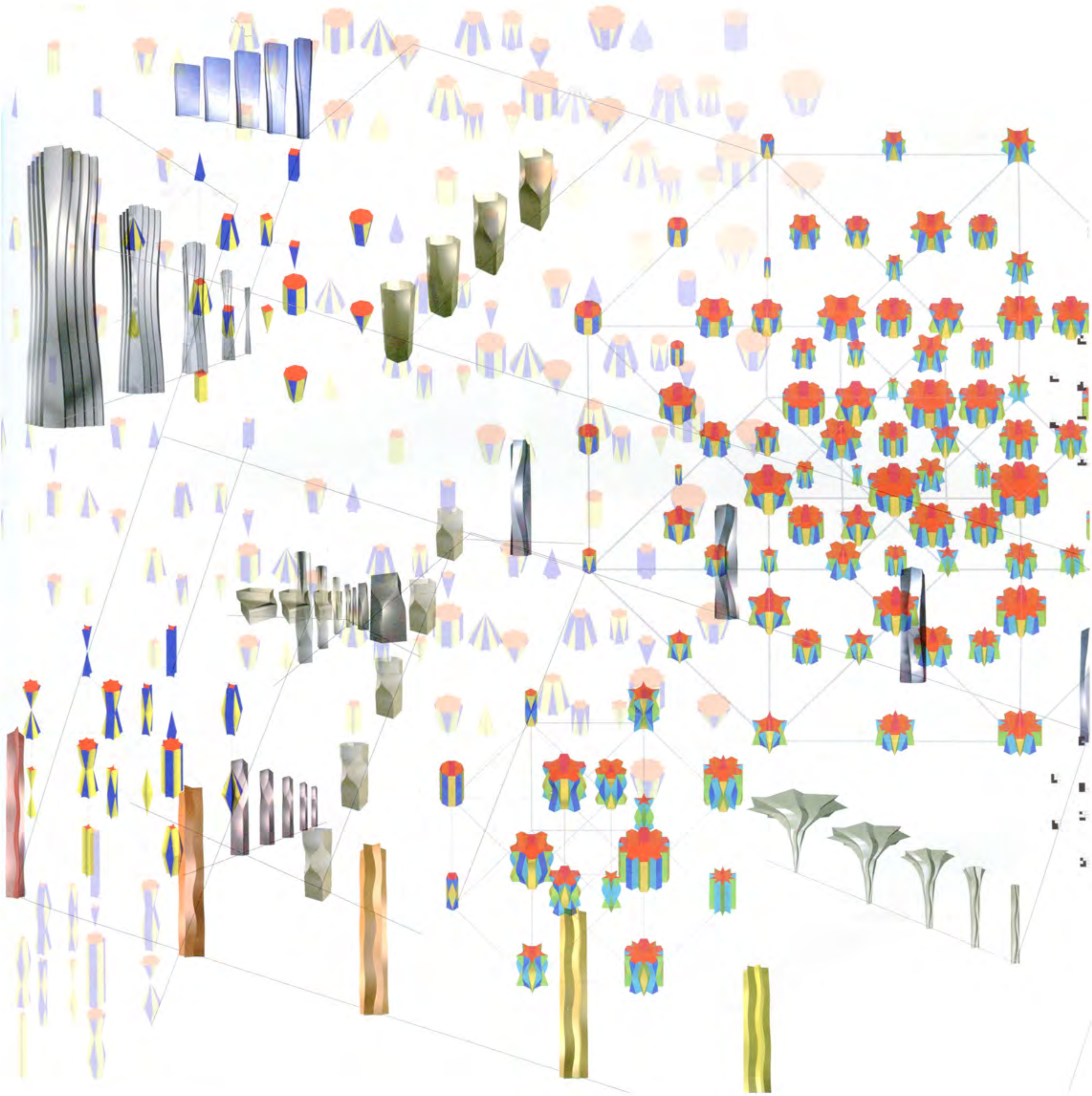
'The binary view of the universe, exemplified by discrete computational sequences of 0s and 1s, does not appear to capture the continuum we see in life. In my morphological model, there is a continuum, infinite states between 0 and 1. Yet I am unable to carry this through to all aspects of form. I would like to believe that all topology, the bottom-most level of form, is a continuum and it is also emergent. But the quantum nature of integers that describe many topological features makes it discrete. For example, the number of sides of a polygon is, say either three or four, both discrete states. Yet a few years ago I discovered that the space between three and four is filled with fractional regular polygons with sides in between these two numbers. So what appears discrete may be hiding a continuum.

'However, there are clear instances, like cellular automata, that resist the continuum.[15] Additionally, when you apply the bottom-up cellular automata rules, a one-gene phenomenon in the morph genome, to smooth topological surfaces we need to impose a top-down topology from a completely different gene.[16] The emergence of top-down from bottom-up is an intriguing idea. Nonetheless, the coexistence of discrete and continuous systems leads me to think that the universe may have a variable dial that can be set to binary or continuous states, or any state in between. After all, movies, which have 24 discrete frames per second, appear continuous when we run them. Physical reality may have a discrete basis at the root level, though at the experiential level it appears perfectly continuous.'[17]

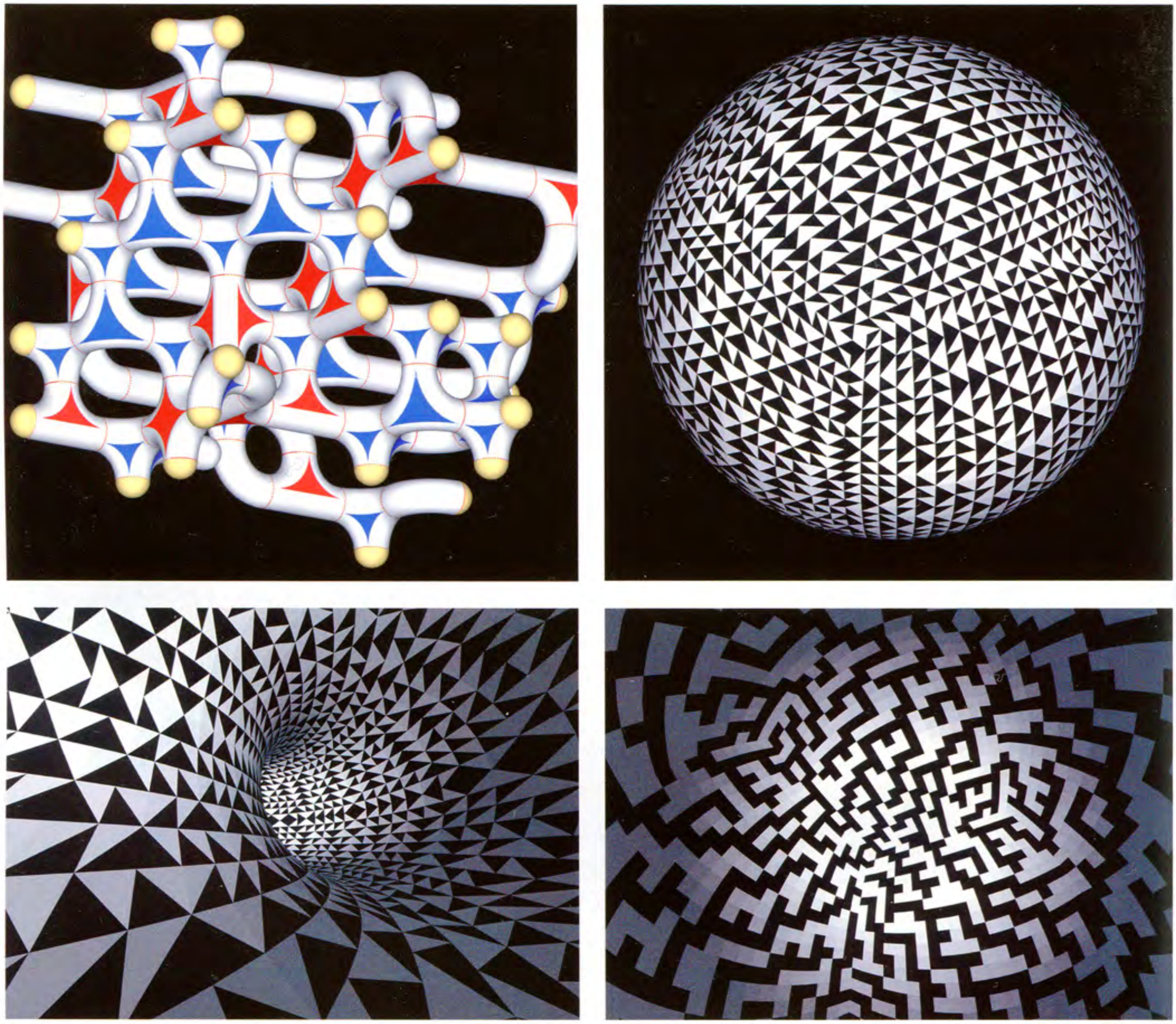
Lalvani's work seems to have broader implications for architecture:

At the very least it would be satisfying to show that the "alphabet" of form is not restricted to simple shapes like the cube, cylinder, cone and sphere, but that it is an extensive family of intertransforming alphabets embedded in an integrated framework. This framework, an open-ended, expansive, continually extendable higher-dimensional periodic table of all forms, is an interesting idea. You are no longer limited to existing architectural vocabularies, you can generate your own vocabularies, morph any vocabulary to any other, or existing vocabularies (architectural contexts) to new ones. Any language becomes an instance of the other. Here is a universe where the particular and the universal coexist, as do complexity and diversity in a dual relationship to one another. This understanding can be liberating, and empowering.

'The known issues of architecture, programmatic, structural, poetic, visual and spiritual, will not go away. The challenge is to



A portion of the morphoverse suggesting a continuum of AlgoRhythm columns. These columns, fabricated from single metal sheets, are genetically coded and are based on one algorithm, one material and one method of forming. Adding process to form opens a new window in the morphoverse and requires the expression of 'fabrication genes' in addition to selected 'form genes'.



Wolfram's cellular automata rule 30 applied to a sponge-like surface (top left), a sphere (top and bottom right) and torus (bottom left). Such surfaces require the activation of at least two morphological genes.

infuse new formal vocabularies with meaning. The morphology of meaning (and hence of language and thought) is one of the most interesting unsolved problems. A coherent mapping of form and meaning is our challenge and architecture is the best experimental medium for that.

And his Morphological Genome appears to have implications that go far beyond architecture. He has been applying this approach to dance, chemistry metrics in physics, and so on:

'The Morphological Genome could impact how we approach different areas of knowledge. At this time we are pressing forward in several areas outside architecture. The challenges are enormous. Each new area has its own knowledge base and to overlay an extrinsic model would be naive. The challenge is to find the intrinsic structure of native knowledge.

'However, the Morphological Genome does have significant ramifications in all areas of shaping and making. It can be embedded in a morph chip and linked with new fabrication techniques including nanotechnology (for example, in Drexler's "assembler" at the nano level),[18] or in some universal forming machines (that do not exist) at the architectural level. This forming ability must include the integration of bottom-up and top-down mentioned earlier. Think of this in terms of the stem cell, a universal cell that differentiates into different specialised cells that perform completely different functions in a co-coordinated manner. At the purely formal level, the Morphological Genome has the same intent, a universal code that can produce the infinite variety of forms we find in nature, technology and beyond. At this point we are far from realising this. The genome is in progress, and Milgo's experiment is just one case study The goal is auto-morphogenesis, human products (including architecture) that design themselves physically not just virtually[19] out of encoded forms, processes, materials – something the biologists are likely to achieve first as a neat counterpoint to artificial life' [20] ∆

Acknowledgements

School of Architecture, Pratt Institute, for its support of the Center for Experimental Structures; Bruce Gitlin, Alex Kveton and Robert Wrazen of Milgo/Bufkin; Neil Katz, Ajmal Aqtash, Che-wei Wang and John Gulliford for computer-modelling/rendering as members of Lalvani's studio team; NYSTAR grant (2002–04) to experiment with AlgoRhythms Structures involving Pratt students at Milgo.[21] Some ideas in this paper were first published in notes 3 and 7 below.

Notes

1 From Rene Thom, *Morphogenesis and Structural Stability*, WA Benjamin (New York), 1972.
2 From James D Watson, *DNA: The Secret of Life*, Alfred Knopf (New York), 2003.
3 Haresh Lalvani, 'Genomic Architecture', in Deborah Gans and Zehra Kuz (eds), *The Organic Approach to Architecture*, Wiley-Academy (Chichester), 2003, pp 115–26.
4 Haresh Lalvani, *Structures on Hyper-Structures*, Haresh Lalvani (New York), 1982; based on author's doctoral dissertation entitled 'Multi-Dimensional Periodic Arrangements of Transforming Space Structures', University of Pennsylvania, 1981.
5 In nature, process results from force. D'Arcy Thompson's dictum 'Form is a diagram of forces' is another way of saying the same thing.
6 This project began in September 2004. Vince DeSimone has analysed the structure and proposed a method of construction, and Israel Berger has been advising Milgo/Bufkin on the exterior skin construction. Che-wei Wang, working in Lalvani's studio, has been assisting with the modelling and visualisations shown here.
7 The first example, called 'Fractal High-Rise', was published in Haresh Lalvani, 'Meta Architecture', in Giuseppa di Christina (ed), *Architecture and Science*, Wiley-Academy (Chichester), 2001; article reprinted from ∆ *HyperSurface Architecture*, Sept/Oct 2000.
8 D'Arcy Thompson, in his classic *On Growth and Form*, has already pointed out physical forces and mathematics as the guiding principles of form lying outside genetics. See D'Arcy Wentworth Thompson, *On Growth and Form*, Cambridge University Press (Cambridge, UK), 1942. Dr Loren Day, a structural biophysicist in New York working on the structure of viruses, who reviewed this text, sent Lalvani the following remark on this speculation of his: 'I think "mathematics and physical forces" do, in fact, guide genetics. It's more than a possibility.'
9 The Morphological Genome defines just one chromosome of architecture and other chromosomes of architecture could be added through genomes of materials, processes and so on, and the most complex of all, the genome of meaning to complete the entire architectural genome.
10 At present, Lalvani is focusing on a dozen or so genes. Several of these genes are infinite-dimensional, yet rounding that off to a small manageable number gives an exact count of the number of dimensions active in the morph genome.
11 The simplest of these surfaces is one with a singularity (ie, with a single vertix at the centre) where all edges and faces meet. This is an infinite class of surfaces obtained by taking all Eulerian structures (like a cube, tetrahedron, dihedron, and so on that satisfy the Euler relation Vertices – Edges + Faces = 2) and collapsing the vertex to its neighbours or to a common centre. The resulting structures violate Euler's equation. Adding holes to these generates an additional infinite class of new topologies not defined by the more general Euler relation where the 2 on the right-hand side of the equation is replaced by $2 - 2g$, where g is the number of holes.
12 For the exponential change in the power of the machine and its ramifications for society see, for example, Ray Kurtzweil, *The Singularity is Near*, Viking (New York), 2005. Kurtzweil argues that 'We won't experience the 100 years of progress in the 21st century – it will be more like 20,000 years of progress [at today's rate] ... Within a few decades, machine intelligence will surpass human intelligence, leading to The Singularity ... [that will include] the merger of biological and non-biological intelligence.'
13 Rudofsky used this term for indigenous architecture: Bernard Rudofsky, *Architecture without Architects*, University of New Mexico Press (Albuquerque, New Mexico), 1987 (reprint).
14 Haresh Lalvani, 'Meta Architecture', op cit.
15 Lalvani asked Neil Katz (who modelled the CA surfaces for him) to take Wolfram's one-dimensional cellular automata (see Stephen Wolfram, *A New Kind of Science*, Wolfram Media (Champaign, IL), 2002), index his 256 rules in an 8-dimensional cube as part of the morphoverse so that each vertex is one rule, and check for a continuum between any two adjacent rules. Surprisingly, the result showed no such continuum.
16 This top-down component comes from the topology of the surface, for example the surface of the cube has six squares with three squares meeting at every corner, a rule that is independent of cellular automata rules and is specified by a different morph gene. This gene is the same gene that establishes the square grid of the cellular automata, an a priori grid that has to be 'imported' to demonstrate the bottom-up nature of a cellular automaton. A fully bottom-up phenomenon requires the emergence of (primary) topologies as well. This means a minimum of two genes is required for a cellular automaton.
17 Loop Quantum Gravity theory suggests something similar for physics. See, for example, Lee Smolin's article 'Atoms of space and time', *A Matter of Time*, special edition of *Scientific American*, Vol 16, No 1, 2006.
18 Eric Drexler, *Engines of Creation*, Anchor Books (New York), 1986.
19 This is related to the idea of growing architecture. For the origins of this idea see William Katavolos, *Organics*, Steendrukkirj de Jong & Co (Hilversum), 1961; Vittorio Giorgini, 'Early experiments in architecture using nature's building technology', in H Lalvani (guest-editor), *The International Journal of Space Structures*, 11:1 & 2, Multi-Science, 1997. Lalvani's own ideas were proposed in an unpublished article 'Towards Automorphogenesis: Building with Bacteria', 1974. For more recent work, see John Johansen's *Nanoarchitecture: A New Species of Architecture*, Princeton Architectural Press (Princeton, NJ), 2002.
20 The genomics pioneer Craig Venter foresees creating life in the laboratory from gene sequences in 10 years. On a related note, earlier, in the 1990s, the idea of originating 'from nothing' had led the physicist Alan Guth to suggest the possibility of creating a 'universe' in the laboratory.
21 NYSTAR, New York State Office of Science, Technology and Academic Research, gave Milgo/Bufkin a two-year grant to experiment with two different AlgoRhythm structures: AlgoRhythm glass-panel systems and the AlgoRhythm truss system. The following participated in the various prototyping experiments at Milgo: Henry Harrison and Jenny Lee (production managers), Neil Katz (consultant) and Pratt students Ori Adiri, Ezra Ardolino, Ajmal Aqtash, Daniel Barone, Christopher Devine, Thorsten Foerster, Brandon Gill, Gershon Gottlieb, Seo Kiwon, Jeff Mitcheltree, Matthew Peterson, Sabrina Schollmeyer, Reza Shricker, Jarrett Shamlain, Che-wei Wang, Hiroshi Yamamoto and Albert Zuger.

Programming Cultures

Art and Architecture in the Age of Software

Guest-edited by Mike Silver

An exploration of the relationship between software engineering and the various disciplines that benefit from new tools, *Programming Cultures* focuses on how designers are writing new codes to solve visualisation and data-processing problems. Taking its cue from a symposium organised by Mike Silver at Pratt Institute in New York, it extends the potential of programming for architecture far beyond the scope of popular, appropriated systems such as Form-Z, Maya and 3D Studio MAX. Here programming is advocated as a discipline central to the development of design and a key to unlocking new ways of working rather than as a mere service to generative design and construction. Scripting becomes the inspiration and driving force behind a new aesthetic and new wave of design. This title of AD features the work of seminal figures such as Greg Lynn and Haresh Lalvani, while also presenting the important new work of designers like biothing, Evan Douglis and CEB Reas. It also encompasses the writing of architectural thinkers, such as Karl Chu and Ingeborg M Rocker, and includes contributions by influential mathematician Stephen Wolfram, Dennis R Shelden of Gehry Technologies and the veteran of architectural programming Malcolm McCullough.

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