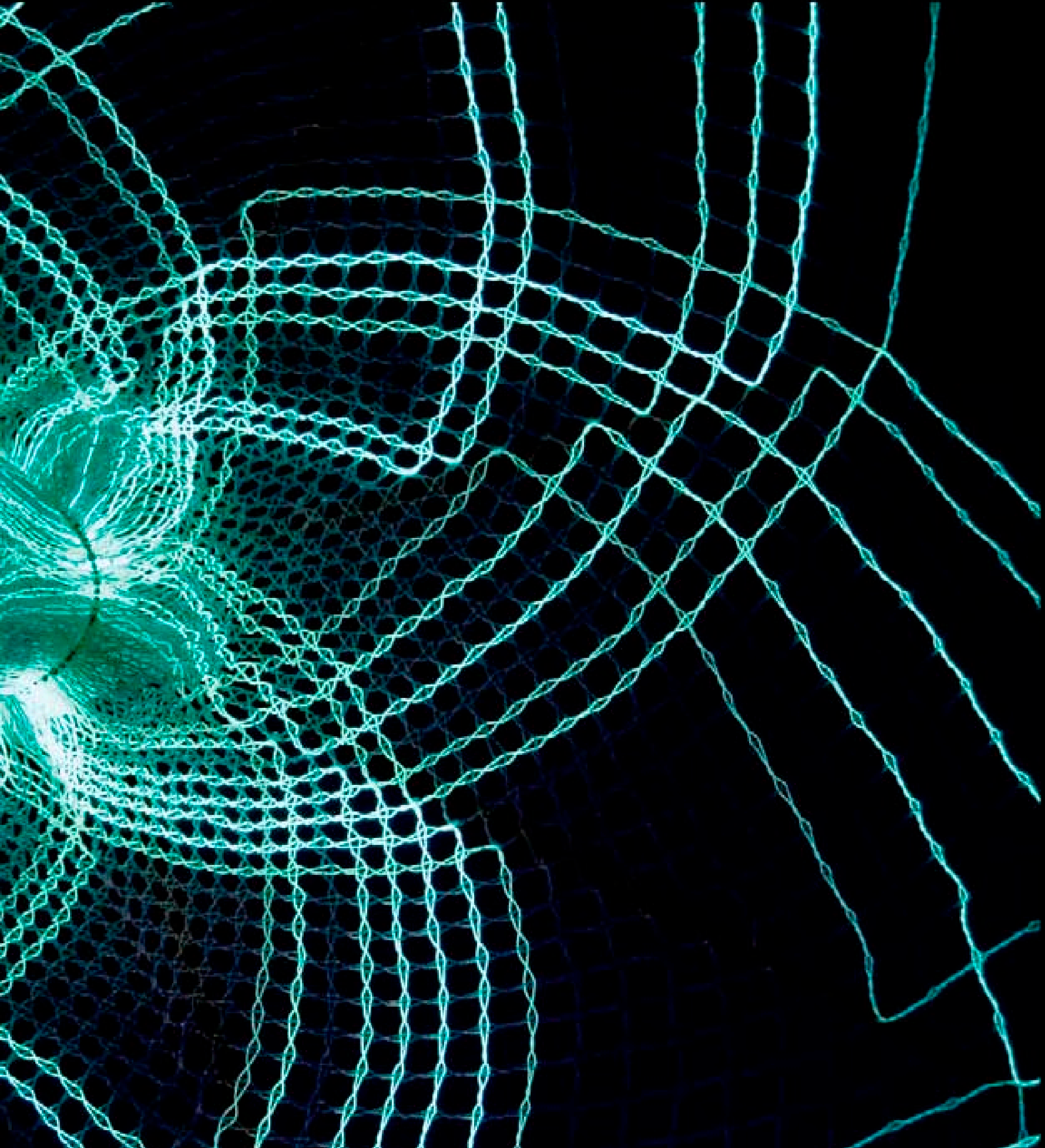
Responsive Textile Environments

Edited by Sarah Bonnemaison and Christine Macy



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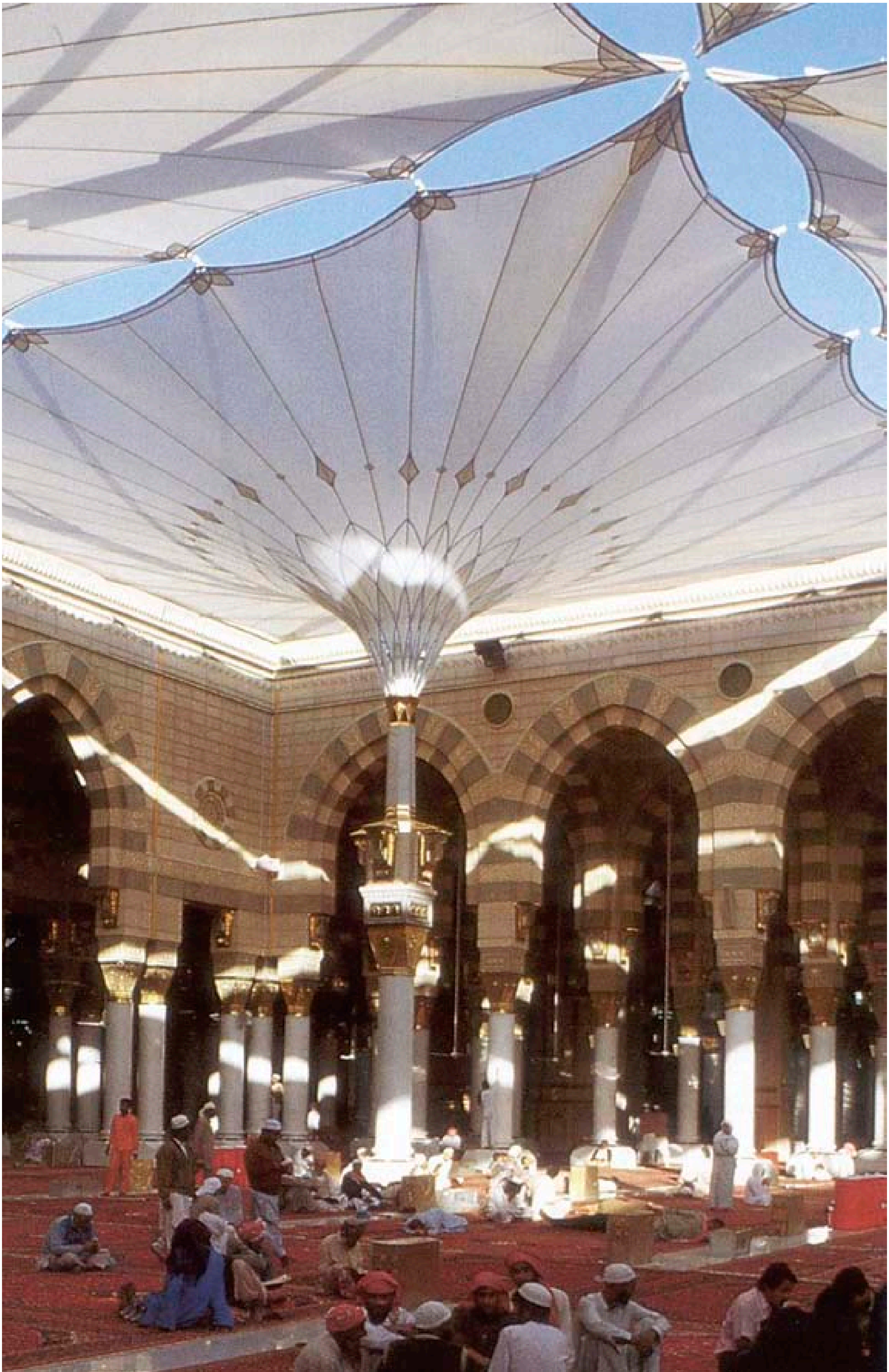


Responsive textile environments

Sarah Bonnemaison and Christine Macy
Dalhousie University

The world of textiles is the fastest growing field in architecture and design today. As Matilda McQuaid says in her catalogue essay for the *Extreme Textiles* exhibition, "What can be stronger than steel, faster than a world's record, lighter than air, safer than chain mail, and smarter than a doctor? Hint: it is in every part of our physical environment – lying under roadbeds, reinforcing concrete columns, or implanted into humans."[1] Textiles, of course is the answer to her riddle, especially technical, high-performance textiles.

Many designers, artists and architects are creating objects and environments that combine these new textiles with software, robotics and sensors. Whether their focus is clothing or immersive environments, their aim is to make textiles that interact with their users not only in visual or tactile terms, or even by being mobile, but which use digital interfaces to respond in all of these ways. According to Lucy Bullivant, the impact of these textiles "is phenomenological, meaning that the body is able to directly experience its environment in a very direct and personal way".[2] As a result, we are seeing a whole new area of avant-garde design — from clothing to large tensile structures that incorporate the event into the artifact — an approach that is valued by museums striving to engage their publics in ever-more interactive attractions and by manufacturers seeking new markets.

From the wearable interactive textile to architectural-scale tensile structures, new textiles are fundamentally changing the way we think about and relate to our environment. Textile-based buildings "range from flexible skeletons and meshworks skins to structures that move and respond to their occupants," says architect Philip Beesley.[3]

1 Convertible Umbrellas for the Courts of the Prophet's Holy Mosque, Mahdina, Saudi Arabia, 1992, Bodo Rasch
Six 17m x 18m convertible umbrellas provide shade in each of the two courtyards of the mosque.

2 *Vilkas* Dress
Joey Berzowska, Hanna Soder, Marcelo Coelho

Vilkas's kinetic hemline rises over a 30 second interval to reveal the knee and thigh. The wearer can wait for the hemline to fall, which can take several minutes, or actively pull it back down.

These new designs are the products of interdisciplinary collaborations. Clearly, a reactive or interactive garment or environment requires not just software specialists, designers of robotics, and electrical engineers, but often also materials scientists, chemists, specialists in nanotechnology and biomedical engineering. The *Am-I-Able* network for mobile and responsive environments is the result of one such interdisciplinary collaboration, with principal researchers from the Extra Soft Labs (XS Labs) at Concordia University (Joey Berzowska), the Banff New Media Institute (Sara Diamond), and the School of Interactive Arts and Technology at Simon Fraser University (Ron Wakkary). It explores the creative use of interactive technologies in the environment, through creating and adapting clothing, furniture, and the built environment to become communication devices that facilitate personal expression as well as multi-point communication between individuals and groups.[4]

A number of fiber artists are designing clothes that interact with their wearers. At the XS Labs, Berzowska and her research team have used interactive technology to create versatile electronic textiles that are animated, change their shape, augment the body's physical characteristics, and store memory.[5] Examples include the *Kukkia* dress, with its flowers that slowly open and close on their own, and the *Vilkas* dress, with a hemline that rises above the knee when electrically stimulated[6] (Fig. 2); and *Memory Rich Clothing* — a series of reactive body-worn artifacts that display their history of use, effectively communicating embodied memory.[7] The goal for these electronically enhanced garments is to promote touch, physical proximity, and interaction in social networks as well as intimate settings. Other artists are exploring the performative aspects of interactive technology with the environment, such as Thecla Schiphorst and Susan Kozel's *whisper* — a networked environment of input and output devices located in the clothing of participants and in the installation space. Devices "whisper" to, or "hear" the whispers of other devices in proximity.[8] Bullivant explains,

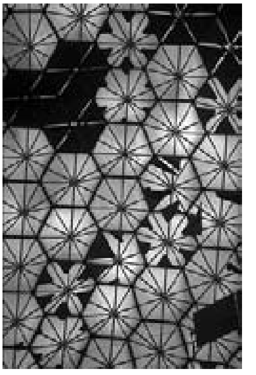
> The very nature of responsive environments, involving functioning through interfaces that facilitate interaction, is a form of mediation between inner world self and the outside world, and it presupposes some kind of event that is not wholly pre-programmed. Input from the real world received via sensors is essential, as are output devices in the form of actuators (mechanisms that transform an electrical input signal into motion), displays and other sensory phenomena to engage with users.[9]

The key point here is that the interaction is not pre-programmed but evolves according to the actions and responses of the people involved as well as input from the natural environment, such as sun, wind and changes in temperature. This kind of research continues designers long-standing value for the qualitative aspects of identity, memory, sociality, and quality of life that are central to human well-being. By considering environments and architectures as well as personal technologies, this incorporation of electronics into design emphasizes the link between individual wellness and social well-being — focusing on lifestyle and relationships, instead of focusing on biometric sensors with a quantitative approach to wellness, not to mention the issues of invasion of privacy and surveillance.

Architects have always collaborated with specialists. The creation of responsive textile environments furthers this type of research in the same spirit.

An early example of "responsive" a architectural environment was developed by the visionary thinker R. Buckminster Fuller in his *Garden of Eden* geodesic dome of 1955, which used two revolving geodesics inside each other, that opened to the outside. Fuller developed this idea further in his United States Pavilion at the Montreal Expo in 1967, designing automated retractable screens within the cellular framework of the geodesic that — triggered by a light sensor — selectively opened and closed as the sun moved across the sky (Fig. 3). Fuller used the analogy of a "breathing skin",

> anyone looking at the geodesic dome in Montreal saw a very beautiful piece of mechanics. It did all kinds of things to your intuition. You saw there were curtains that could articulate by photosynthesis [light sensors] and so forth, could let light in and out. It is possible, as in our own human skin [that] all of the cells organize, so that some are photo-sensitive and some are sound-sensitive, and they're heat-sensitive, and it would be perfectly possible to create a geodesic of a very high frequency where each of these pores could be circular tangencies, of the same size. One could be a screen, other breathing air, others letting light in, and the whole thing could articulate just as sensitively as a human being's skin.[10]



3 US Pavilion for Expo 67, Montreal, R. Buckminster Fuller and Shoji Sadao

Traditionally, tensile architecture has involved shelters built with posts and stretched fabric, from the age-old hand-woven woolen tents of desert nomads to modern PVC-coated membrane roofs for stadiums and inflated structures. Modern tensile architecture aims to clearly separate the elements working in compression (posts and columns) and those working solely in tension (membrane and cables).[11] One of the more recent development in this field is a possibility that the textile membrane might change over time, either through movement or in its properties.

The earliest example of a transforming high-tech tensile structure was a convertible roof designed by Frei Otto, the pioneer of lightweight structures, for an outdoor performing space in the courtyard of an abbey at Bad Herzfeld, Germany. A more recent example is a project by FTL Design Engineering for a transportable music pavilion used by the New York Philharmonic and Metropolitan Opera to bring concerts and operas to all parts of the city. This

4-5 Carlos Moseley Music Pavilion, New York City FTL Design and Engineering structure is deployed by what we could call large mechanical "actuators", in the form of extendable cranes on trucks that hold the membrane of the tent in place (Figs. 4-5).[12] With the advent of computer-controlled pneumatic and mechanical operators, solar cells, and an ever-increasing miniaturization of computerized control systems, the control and operation systems for tensile structures have become increasingly sophisticated. An outstanding example is Bodo Rasch's project for 300 umbrellas on the roof of the Great Mosque in Mecca, solar powered and free of cables (an essential feature because of their historically-sensitive location) due to a battery incorporated in the base of each. A smaller version of the project was realized in 1992 in two courtyards of the Prophet's Holy Mosque in Medina (Fig. 1).[13] In these projects, a computer chip triggers the umbrella to close under high winds, so that the delicate structures are not damaged. This is an example of tensile architecture in motion, exploring basic responsive capabilities to address environmental conditions (solar exposure, wind load).

The essays that follow present the work of a number of artists, designers and architects working with responsive textile environments, at multiple scales ranging from the most intimate scale of body and clothing to the most extended scale of a dispersed animated "architecture" that floats on the air over a large crowd of viewers. These essays present a radical addition to the traditional sense of textile design by incorporating communication devices such as mobile telephones, software programs, sensors and actuators in order to create a relationship between the physical, spatial and digital realms.

At the scale of the body and of personal space, Carole Collet's essay in this volume surveys a range of projects created by her students in the Textile Futures Course at Central Saint Martins College of Art and Design in London. These projects employ a wide range of technologies, some older (thermochromic inks, electroluminescent wire, photovoltaic cells) some more recently developed (shape-memory alloys). Responding to changes in temperature, wallpapers change their appearance when warmed by solar radiation, and wearable textiles when brought into contact with body heat. Miniaturization of mechanical actuators allows for small adjustments to shape and introduces motion at an intimate scale, as we see with one student's pillow that waves its tassels when stroked. Contemporary concerns with sustainability and ecology enter into this work as well, as students explore the intersection between cutting-edge technologies and recycling, and the marriage between organic textiles and synthetics.

6 Textile Futures students
Central Saint Martins College of Art and Design, London

7 Rachel Wingfield working on the *BioWall*

8 Silk-steel textile blend in installation by Mette Ramsgard Thomsen

A graduate of the Textile Futures course, Rachel Wingfield, has set up a design-research firm of her own in collaboration with her partner Mathias Gmachl. Their firm, Loop.pH has developed a number of notable installations that employ sensors to create animated surfaces and textiles. Employing both flat print-based techniques and more three dimensional technologies such as knitting, crocheting, and basket-like systems, their projects register input from human movement, weather conditions, and sunlight to "close the loop" between person, artifact and the larger — even global — environment. Wingfield and Gmachl's interest in pattern derives not only from the world of printed textiles, but from the insights of D'Arcy Wentworth Thompson and later Buckminster Fuller, who saw the perfection of natural forms, both organic and inorganic, as revealing essential truths about the physical world. In this sense, they are continuing a long history of designers working with geodesic, self-stable, and spiral geometries to express organic unity or (to use a contemporary term) sustainability.

In her work, the architect Mette Ramsgard Thomsen views "form" as a verb and morphogenesis as the process of biological systems organizing themselves in and in relation to their environment. She situates the "user" of the built environment in the midst of this process, developing their sense of self in the world through movement and interaction. Her *Strange Metabolisms* installation is a miniature world of scale models that she invests with metabolic qualities of movement by using film and video animation; while her other projects invite viewers to enter into the spaces enclosed by the textiles to manipulate and transform them. The inflated air sacs in her *Vivisection* piece recall the gently undulating fabric wave of Annette Messager's *Casino* that flowed silently from a portal in its installation at the Venice Biennale of 2005 to reveal a submerged world of animated creatures below. By working with a conductive silk and steel blend in her larger installations, Thomsen allows the architectural textile surface to power an interconnected matrix of sensors and actuators deployed in these projects.

Similarly, the architect Philip Beesley treats the textile matrix as a body for the dispersion of sensing and motor devices. Deriving his initial inspiration from geotextiles, Beesley has developed an evocative body of work that expands these fabrics literally and metaphorically to encompass earth and space. They also envelop their viewers in a gradual process of incorporation (although he prefers the term "digestion") so that one is never apart from, but

9 Digitally manufactured ‘breathing pore’ in textile installation, Philip Beesley

always in relation to the work. Like all the designers whose work is presented here, Beesley is interested in the interrelationship between person, textile and environment. He sees textiles as mediating — borrowing a phrase from the psychologist Donald Winnicott, he calls them “transitional objects” — between a personal sense of self and the larger environment. By incorporating sensors and actuators into his sculptural-scale textile pieces, he lends them an uncanny quality of being alive as they interact with their viewers. His collaborator Robert Gorbet has developed the networking systems that bring new complexity and subtlety to Beesley’s vision.

Lastly, Usman Haque’s work combines the personal technology of the mobile telephone with the most extended spatiality of the projects collected here, in his *Burbles* — aggregations of air-filled balloons that are lit and controlled by crowds far beneath them, who call in on their mobile phones to affect the sculpture. In all of his projects, Haque is fascinated by the unseen — from electromagnetic fields and invisible radiation on the spectrum, to scents and sounds. His projects draw out the visual potentials of these fields, making us more aware of our embeddedness in them. An as interaction designer, Haque is overt about his ethical perspective that people should have a constructive role in developing the shape and function of interactive systems, much in the same inclusionary vein that “participatory” architects such as Lucien Kroll developed in phsyical terms. In Haque’s words, people are then “more engaged with, and ultimately responsible for, the spaces that they inhabit.” This is surely a significant goal for responsive environments.

10 ‘Talking’ to the air-borne *Burble* with a mobile phone Usman Haque installation

Notes

1 Matilda McQuaid, *Extreme Textiles: Designing for High Performance*, New York: Princeton Architectural Press, 2005, p. 11.

2 Lucy Bullivant, “Introduction”, *Responsive Environments: Architecture, Art And Design*, London: V&A Publications, 2006, p. 7.

3 See Philip Beesley, Sachiko Hirosue, Jim Ruxton, Marion Tränkle and Camille Turner (eds.), *Responsive Architectures, Subtle Technologies*, Cambridge, ON: Riverside Architectural Press, 2004.

4 http://www.amiable.siat.sfu.ca/index.html

5 http://www.xslabs.net/intro.html

6 http://www.concordia.ca/clusters/textiles/ See also Joanna Berzowska and Marcelo Coelho, “Kukkia and Vilkas: kinetic electronic garments”, *Proceedings, Ninth IEEE International Symposium on Wearable Computers*, 18-21 (October) 2005, pp. 82-85.

7 Joanna Berzowska and Marcelo Coelho, “Memory Rich Clothing,” *Extended Abstracts, Conference on Human Factors in Computing Systems* 2006, ACM, Montreal, Canada; and Joanna Berzowska, “Memory Rich Clothing: Second Skins that Communicate Physical Memory,” *Proceedings of the 5th conference on Creativity and Cognition*, ACM Press, 2005, pp. 32-40.

8 http://www.fondation-langlois.org/html/e/page.php?NumPage=46

9 Bullivant, “Introduction”, p. 9.

10 Fuller quoted in Joachim Krausse and Claude Lichtenstein (eds.) *Your Private Sky: R. Buckminster Fuller, The Art of Design Science*, Baden: Lars Müller Publishers, 1999, p. 428.

11 See for example, Klaus-Michael Koch with Karl J. Habermann, *Membrane Structures: Innovative Building with Film and Fabric*, New York: Prestel, 2004; and Conrad Roland, *Frei Otto: Tension Structures*, New York: Praeger Publishers, 1970.

12 http://www.ftlstudio.com/ See also Robert Kronenburg, *FTL: Todd Dalland Nicholas Goldsmith, Softness Movement and Light*, Great Britain: Academy Editions, 1997. For other mobile and demountable tensile projects, see Oliver Herwig, *Featherweights: Light Mobile and Floating Architecture*, New York: Prestel. 2003; Robert Kronenburg, *Portable Architecture*. Oxford: Elsevier/ Architectural Press, 2003; and Robert Kronenburg (ed.), *Transportable Environments: Theory, Context, Design and Technology*, London: E & FN Spon, 1998.

13 http://www.sl-rasch.de/ See also Frei Otto and Bodo Rasch, *Finding Form: Towards an Architecture of the Minimal*, Stuttgart: Edition Axel Menges, 1995.

The next textile revolution

Carole Collet
Director, MA Textile Futures Course
Central Saint Martins College of Art and Design

The textile industry played a central role in the industrial revolution and pioneered cutting-edge developments in areas such as space travel, medicine, fashion sportswear and architecture. Yet textile designers have often worked in the shadow of higher-profile design disciplines, such as fashion, and are rarely recognized for their leading roles in designing and shaping much of what we wear and how we live. In recent years, the industry has undergone dramatic changes — not only has the bulk of textile production shifted to Asia, but new scientific and technological developments have emerged that are rapidly changing the nature of textile design and opening fresh horizons for designers.

Since the beginning of the 21st century, as environmental issues have become a central concern for populations across the globe, designers in many fields have begun to re-think their role in the production and consumption of consumer goods. Textile designers are no exception. As they embrace new technologies and materials, they need to address the ecological design impacts of their designs as well, to shape a more sustainable future. This century marks the beginning of a new textile revolution and we believe it is smart, invisible, sustainable, ethical and poetic. This paper highlights the potential for new textile design and is informed by the research and practice taking place in the MA Textile Futures Course[1] at Central Saint Martins College of Art and Design in London, UK.

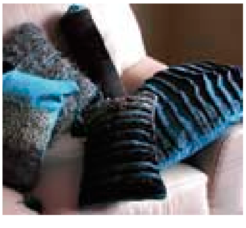
1 The making of intelligent textiles, MA Textile Futures Studio, 2005

Smart textiles, new design scenarios?

The emergence of technologies such as conductive textiles, electronic inks, photovoltaic materials, biomaterials and nanotechnology demands greater collaboration between scientists and designers to transform textile processes and products. Some of these new technologies offer tremendous potential for the development of new textile products — such as conductive textiles made of silver or carbon fibres that allow textile components to be integrated into computerized systems,[2] and textiles that act as sensors or actuators. Companies such as ElekTex[3] and IFM[4] have produced innovative products using these technologies. Technology transfer has also stretched the boundaries of the discipline — for example, the use of Shape Memory Alloys in the medical industry has enabled new textile products to be created, such as Corpo Nove's "smart" shirt with sleeves that roll up as the ambient temperature increases.[5]

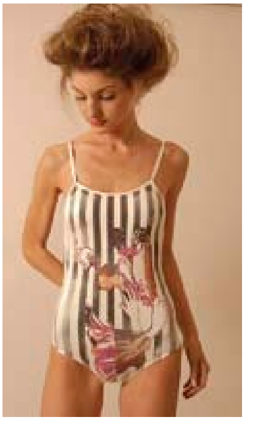
Within this context, the growing challenge of energy consumption has stimulated a great deal of research into lighter and more efficient batteries. Konarka, a high-tech company based in Japan, has produced a range of "power plastic" nanomaterials to charge portable electronic devices such as MP3 players, mobile phones and computers. This flexible photovoltaic material converts light into energy in a similar way to the photosynthesis process.[6] Because such technologies are still in development, it is a challenge for textile designers to integrate them without compromising the design values of their product. Dina Elsabahi and Yun Ding are two designers who challenged their practice by embracing new scenarios to create responsive textile designs.

"Can woven textiles exploit principles found within biomimicry to produce living animated objects for the home?" was the question Dina Elsabahi asked as she developed her final collection in June 2007.[7] Her project explored 'biomimicry' to develop a collection of domestic furnishings — more specifically, cushions that behave like cats. Using ethnographic research methods, Elsabahi studied and filmed the behaviour of three people and their cats as case studies. She then translated cat behaviours into design principles to create cushions that react to the way they are held. The flick of a tail is transformed into the flip of a tassel, and the cushion purrs when it is gently squeezed. "Dina is using organic behaviour and texture as a muse to transform the common sofa cushion into a moving object possessing pet-like qualities, giving the consumer aesthetic and emotive reward based on the attention given".[8] This work explored the language of craft in symbiosis with smart technologies such as sensors, conductive textiles and shape memory alloys. (Figs. 2 and 3)



2-3 Pet Cushions
Dina Elsabahi, 2007
The tassels twist and flip when the cushion is squeezed

In a more straightforward project, Yun Ding explored photochromic, thermochromic, and water-reactive inks to reconceptualize the swimsuit. These 'smart' materials are not so new anymore, but Yun Ding was interested in exploring their changing aesthetic qualities for a very specific and focused market. The swimsuits change appearance in the sun, in water and in different ambient temperatures.



4 Aqua Chameleon Collection
Yun Ding, 2007
The black stripes of this swimsuit disappear on contact with water.

Sustainable textiles?

According to sustainability analysts William McDonough and Michael Braungart, "the industry that launched the Industrial Revolution has long illustrated some of its most notorious design failures. About one half of the world's wastewater problems are linked to the production of textile goods, and many of the chemicals used to dye and finish fabrics are known to harm human health. Often, the clippings from carpet or fabric mills are so loaded with dangerous chemicals they are handled like toxic waste, while the products made from these materials are considered safe for use in the home."[9] Global pollution, over-population, and increasing pressures to augment the production of raw materials are all issues that directly affect the textile industry. There is no such thing as an ecological textile when it comes to mass production, but there are measures that can make a positive change. Alternative ways of addressing issues of design, production, consumption and waste can open up new opportunities for textile designers.

If "people, profit and planet" must be considered equally in the quest for sustainability, the textile industry has a long way to go in cleaning up its act. Research into new and less damaging textile production has led to the development of fibres such as the Fox Fibre[10], a naturally coloured grown cotton, or *Tencel*, an artificial fibre produced in a closed loop system with no water or air pollution. More recently, research into biomaterials has led to the production of *Ingeo* made from corn.[11] Ingeo is the world's first man-made fibre entirely derived from annually renewable resources. Other biomaterials include *Soy silk* made out of waste from the tofu manufacturing process.

Still, tackling sustainability from the designer's perspective is a huge challenge — asking designers to develop new ways of working and to imagine new aesthetics that push beyond the "eco-design" standard of "natural"-looking, unbleached, undyed and all-too-often, undesirable product. While the continuing popularity of natural fibres may appear to be a positive sign, the production of both cotton and wool is highly polluting and environmentally damaging. Cotton cultivation for example, uses one fourth of the world's production of pesticides. More and more our designers are willing to respond to the sustainable challenge by producing exciting textile collections, here are a few examples:

Neda Niaraki investigated the concept of rapid recycling for fast fashion consumption. Her collection of 100% *Tyvek* garments allows the customer to wear their clothing items up to 12 times before returning them for recycling in the original packaging of a pre-paid envelope. Niaraki argues that western consumers are addicted to rapidly changing fashions and consume more than ever. *Well Dressed*, a recent report published in 2006 by the University of Cambridge Institute for Manufacturing, established that "waste volumes from

the sector are high and growing in the UK with the advent of fast fashion. On average, UK consumers send 30kg of clothing and textiles per capita to landfill each year."[x] Niaraki's collection is more provocation than solution, her objective being to make the stream of consumption more visible by emphasizing the potential of post-consumption (Fig. 5).

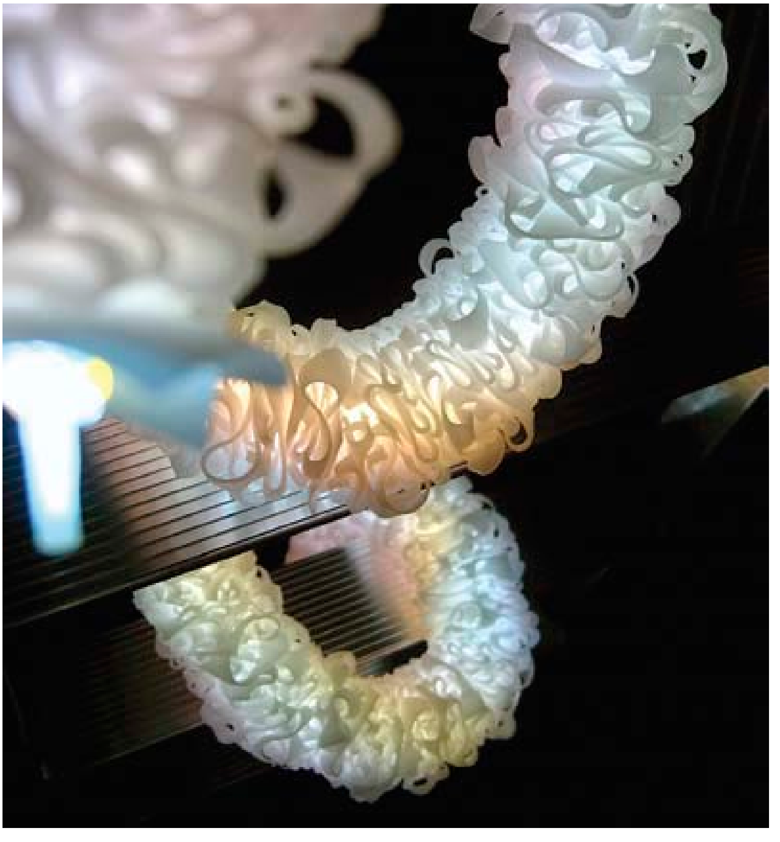
Jenny White dedicated her Masters degree to designing a sustainable collection of luxury furnishings. Calling it the *Eco-boudoir*, she has targeted the market niche of a well-to-do clientele with a conscience. A carefully selected range of fabrics — including wild silks, bamboo fabric, organic cottons and wools, chrome-free leather and recycled furs — are combined with new technologies such as laser etching and digital printing to create an innovative luxury range. This is by no means a fully sustainable collection but it is a good example where each fabric and technology has been sourced to design out ecological issues[12] (Figs. 6 and 7).

5 'Fast Food' Fashion Collection
Neda Niaraki, 2007
The range is made from recyclable Tyvek

6 Eco-Boudoir Collection
using wild silk and bamboo fibres,
Jenny White, 2007

7 Detail of laser etched chrome-free leather

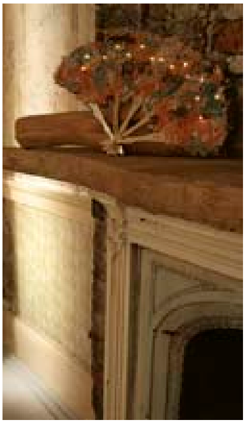
Too often, valuable raw materials end up in landfill without even entering the consumption chain. Lucy Fergus has focused on such waste material to create a number of lighting products. In collaboration with the UK based *Silex* silicone rubber product manufacturer, Fergus exploits the translucency of the material used in conjunction with electroluminescent wires to design a range of ambient lighting products. These lace-like light-emitting boas reuse material that would have otherwise ended up in landfill (Figs. 8 and 9).



8-9 Lighting Collection
Lucy Fergus, 2007

Can 'smart' materials and technologies meet sustainable design principles?

In designing with intelligent technologies and smart materials, designers are immediately confronted with the energy consumption and the longevity of the product. The development of wearable computing for instance, has been seriously hindered by the need for batteries to power the garment. Until this issue is addressed by technologists and designers, such products run the risk of being short-lived electronic gadgets.



Elena Corchero and Kate Deacon have explored the intersection of sustainability and intelligent technology in their work. In *Solar Vintage*, Elena Corchero designs a range of fashion accessories that explore the functional and aesthetic qualities of flexible photovoltaic panels (Figs. 10 and 11).

> Creating fashion accessories that incorporates this technologies, emphasizing their aesthetic qualities, can start a dialogue about fashion, energy and sustainability highlighting the importance of making these technologies be part of our daily life. I would like to add the dimension of sustainability to the fast growing wearable computing market and at the same time challenge the stereotypically minimal, sporty and masculine look of these devices.[13]

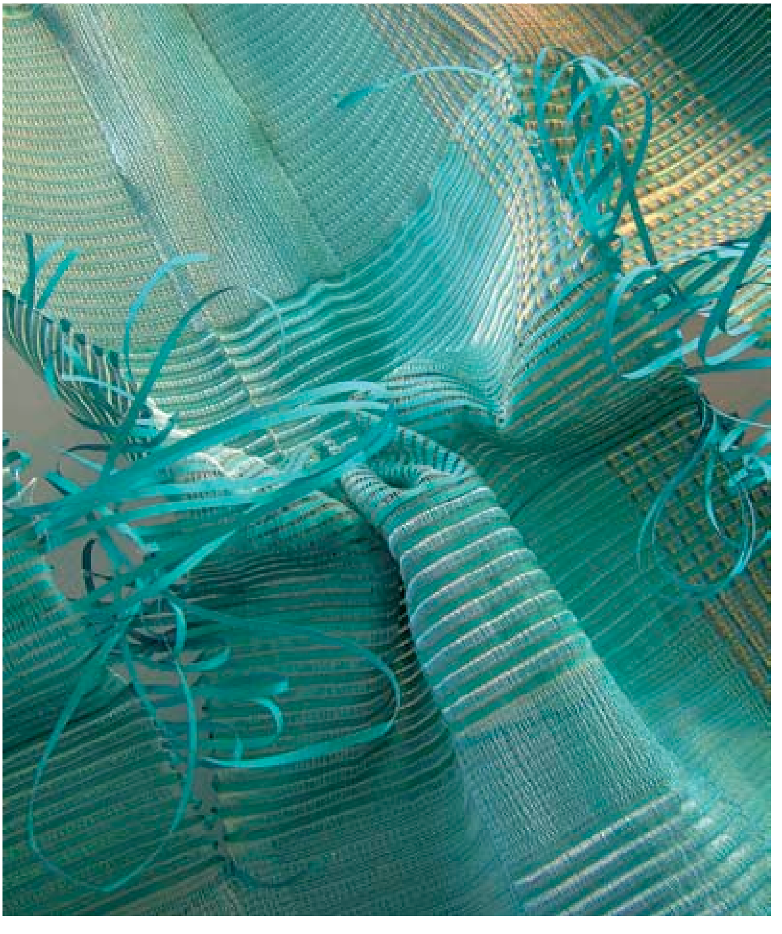
10-11 Solar Vintage Collection
Elena Corchero, 2007

Kate Deacon's work questions the role and function of woven textiles for smart homes. By designing scenarios which build on future technologies such as solar fibres, she has produced a collection of intelligent interactive furnishings: blinds that light up as you stroke them, and that open up and close in response to the daylight (Fig. 12).[14]

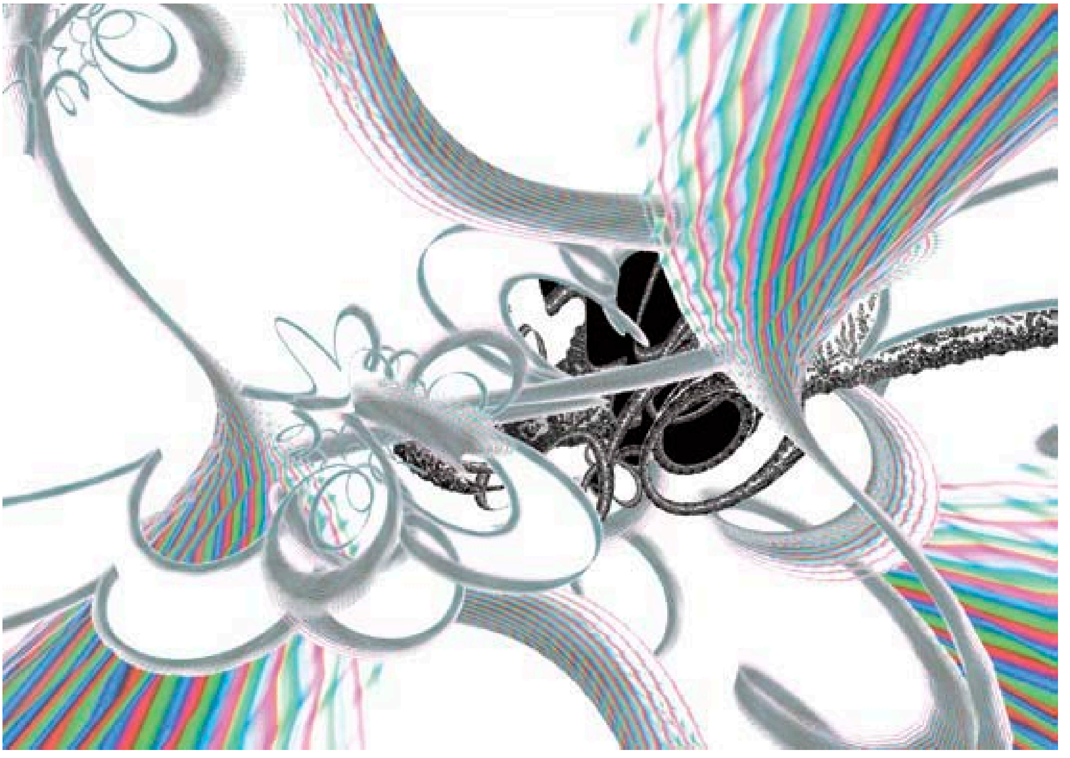
> Imagine a window blind that stores energy, which it then slowly released to power and light the home. I utilize smart technology to generate organic movements in light-reactive interior textiles. I combine functionality with aesthetics and sustainability, which is a primary issue in my creative process in textiles.[15]

Will new materials and technologies challenge the ethics of textile design?

Sustainability raises the debate when it comes to ethics. The textile industry is known to be highly responsible for labour exploitation and use of underage workforce. Perhaps less widely acknowledged, recent technologies, whether still in research laboratories, or already exploited, can pose serious ethical questions. For instance new processes emerging from biotechnologies enable



12 Shape Memory Blinds
Kate Deacon, 2005
Sections open and close according to the level of daylight.



13 Design for flexible display screen
Rainer Stolle, 2005

us to exploit genetic manipulation to produce new fibres, such as *Bio Steel*™, a spider silk derived from the genetic engineering of goats.[16]

In another sector, the current race for patenting efficient flexible colour display technologies is as exciting as it is cause for concern. In his postgraduate collection from 2005, Rainer Stolle chose to question how much technology can control us, and how much future textiles can be a part of such a techno-control society (Fig. 13). Stolle investigated the potential of innovative designs for textile based flexible display technologies as a way to question the ethical usage of such a device. What will happen when any flexible materials, any fabric can become a digital screen? Will we turn into moving advertising boards, controlled by brands and technologies? What happens to the body, what becomes of fashion when the wearable screen is a ubiquitous technology? How many fashion corporations will want to be big brother? Illustrated very much by the film "Minority Report"[17], one can fear that fashion brands and advertising would jump on such a technology without questioning issues of private space and public surveillance. Who would truly be in control?

What can be the role of aesthetics and poetics in a consumerist and technology-driven society ?

The human need for inspiring aesthetics and comforting materials is more relevant than ever in a high-tech, high-speed consumer culture. In the past few years we have seen a regained interest in crafted materials from hand knitted bohemian fashion, to lace ceramics and tactile buildings. Designers are looking

14 Wear and tear wallpaper
Linda Florence, 2005

at new relationships with products and are more and more concerned with the emotional qualities and experience gained from textile products.

Linda Florence's work deals with our relationship to products and time. She designs flooring concepts and wallpapers that become more colourful with time. Wear and tear becomes added value as the user discovers new layers of colours and new patterns. Her work was recently at the Victoria and Albert Museum, in London as part of the "Touch Me" exhibition in 2005.[18] (Fig. 14)

Our relationship to nature has long influenced textile designers. Heather Smith, inspired by the poetic of her natural habitat proposed to co-design with nature to create a new aesthetic. In a process that involves weather conditions (rain or sun) Heather produced a range of garden surfaces that evolve with time, water and exposure to ultraviolet light. Her *Come Rain, Come Shine* Collection relies on natural decay to fully reveal their patterns and unfold a constantly changing aesthetic (Fig. 15).

A new kind of textile designer?

The fast development of materials, technologies and design methods makes it more difficult than ever for textile designers to not only innovate but also to understand a new landscape of possibilities. Yet we have reached a very exiting time for textile design and the future of the discipline. Not only we can ground new and innovative work in our textile craft rich history, but we can now embark on inventing new design scenarios, which only a few years ago, would have belonged to the realm of magic.

I believe that the key to the future of textile design lays in multidisciplinary collaborations. We can no longer contemplate design innovations without a true understanding of other disciplines such as material science, electronics and interaction design, ethnography, sociology, and environmentalism amongst others. The interaction between science and design in particular will help bringing new concepts to life. Designers can challenge science as much as scientists can inform design. This is the principle behind *Nobel Textiles*, a current research project at Central Saint Martins College of Art and Design. Five leading textile and fashion designers have been paired up with five Nobel-prize winning scientists with the aim of producing a textile design concept based on scientific discovery. The project, still in its infancy, has already enabled the designers to explore and pursue new approaches and design methods in response to specific scientific discoveries.[19]

So have we truly embraced the next textile revolution? What is the future for textile design? I believe there is not one future, but many. Smart materials, sustainable design, scientific development open up new territories and foster new challenges for textile designers. But above all, knowing how to remain connected to who we are and what we need will become even more crucial in a world with an ever growing population and ever decreasing resources.

Notes

1 http://www.textilefutures.co.uk
2 http://www.gorix.com
3 http://www.electex.com
4 http://www.ifmachines.com
5 http://www.corponove.it
6 http://www.konarka.com
7 http://textilefutures.co.uk/exchange/bin/view/TextileFutures/DinaElsabahi#
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9 William McDonough and Michael Braungart, "Transforming the textile industry: Victor Innovatex, Eco-intelligent polyester and the next industrial revolution", green@work (May-June) 2002 http://www.mcdonough.com/writings/transforming_textile.htm
10 http://www.foxfibre.com
11 http://www.ingeofibers.com
x Julian M Allwood, Søren Ellebæk Laursen, Cecilia Malvido de Rodríguez and Nancy M P Bocken, Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom, University of Cambridge Institute for Manufacturing., 2006. http://www.ifm.eng.cam.ac.uk/sustainability/projects/mass/UK_textiles.pdf
12 http://www.eco-boudoir.com
13 http://textilefutures.co.uk/exchange/bin/view/TextileFutures/ElenaCorchero#Final_Project_solar_Vintage
14 http://www.katedeacon.com
15 Kate Deacon, Textile Futures Degree Show Catalogue 2005
16 http://www.nexiabiotech.com
17 Minority Report is a 2002 science fiction film directed by Steven Spielberg
18 http//:www.lindaflorence.com
19 see http://textilefutures.co.uk/exchange/bin/view/TextileFutures/NobelTextiles, http://epigenome.eu/en/3,47,0

15 Come Rain, Come Shine Collection
Heather Smith 2007.
A wooden fence embellished with iron nails reveals rhythmic harmonies as rain continues the design process.

Auspicious tangents

1 and 2 Droog Design showroom, Amsterdam
Date: 13/03/2006
Time: 20:43:19

Loop.pH
Mathias Gmachl
Rachel Wingfield

Loop.pH is a multidisciplinary partnership established in 2002 by designer Rachel Wingfield and artist Mathias Gmachl, specializing in the design, construction and fabrication of environmentally responsive textiles and structures for the built environment. Their work aims to provide a more intuitive understanding of our natural environment and mediates between craft, technology and nature. Loop.pH has completed a number of significant commissions, including *Sonumbra*, a play structure in Mowbray Park in Sunderland, UK (2006) and *Weather Patterns*, a temporary installation on the facade of the York Art Gallery (2005); as well as the *Chlorophyll / Jabberwocky* exhibition in Vienna (2005); *Botanical Scan* in the Design Museum, London (2004); and *Buried Light* at the V&A Museum (2004). In addition to their commissioned projects, Loop.pH is actively engaged in research activities, collaborates with industry, consults on research design projects, and runs workshops in the field of responsive textiles and digital media.

3 Royal Botanical Gardens
Kew, London, UK
Date: 13/03/2006
Time: 20:43:19

Loop.pH going off on tangents

On the following pages you will find a number of images from our archive, some well-known and others unpublished. We have tried to provide extended captions to illustrate the intertwingled web of interests we find ourselves in. Each image takes a different angle to give you a glimpse of all that is growing in our garden.

4 Loop.pH studio
London, UK
Date: 10/04/2007
Time: 22:12:39

Familiar domestics

Most living spaces use textiles as membranes and interfaces. When we sleep at night we inhabit an almost entirely textile place. We imagine extending familiar textile applications into the built environment to create fully integrated textile architecture inspired by biological systems.

One of the domestic textiles we have been focusing on is a window covering. Making such a design responsive allows it to grow, metabolize and synthesize with qualities in its immediate surroundings. It can be light-emitting, temperature-regulating, structural and adaptive.

Following along this trajectory is a world of materials that truly facilitate the relationship between the inside and the outside. They are no longer inert matter, but active and able to respond to stimuli such as light, heat, water and electrical energy.

5 illumine Exhibition
Brussels, Begium
Date: 12/12/2003
Time: 17:46:18

6 illumine Exhibition
Brussels, Begium
Date: 13/12/2003
Time: 13:24:02

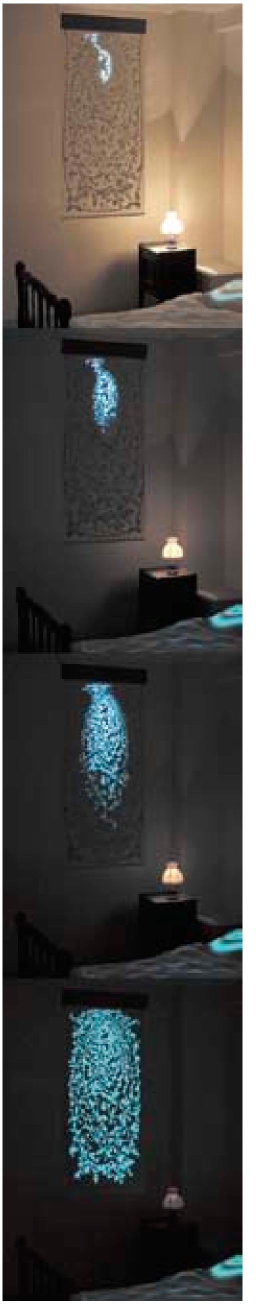


Photo synthesis

DigitalDawn is a reactive window blind with a surface that is in constant flux, growing in luminosity in response to its surroundings. It digitally emulates the process of photosynthesis using printed electroluminescent technology. the darker a space becomes the brighter the blind will glow maintaining a balance in luminosity. A natural, botanical environment appears to grow and evolve on the window lamp. Light sensors monitor the changing light levels of the space triggering the growth of the foliage on the blind. The piece explores how changing light levels within a space can have a profound and physiological impact on our sense of well being. It also explores the ability and potential of fabric to flirt on the boundary of physical and virtual spaces as it plays with the ethereal quality of light in a continuous dialogue with its environment.

Digital Dawn was conceived to mimic the ability of plants to photosynthesize, utilizing the natural energy of the sun in the day and storing electricity that will be used later to illuminate the blind.

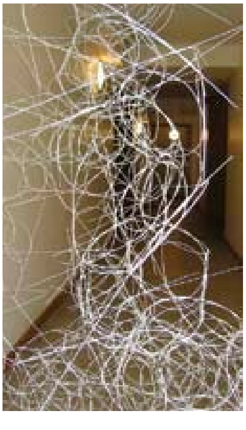
7 Loop.pH studio terrace garden, London, UK
Date: 18/03/2007
Time: 12:37:55

Energy storage

Looking at plants spinning, weaving and knotting themselves around features in their environment, we cannot but think how they inspired humans to manipulate fiber and thread. It is the nature of many plants to climb and attach themselves tangentially to establish a structurally stable and energetically efficient link. The image above shows a knotted end of a tentacle that a passion flower uses to anchor itself in space. The two black rods are a fibre composite that is part of a woven space-frame — the *BioWall* — we are developing for plants to grow into and consume. The space-frame relies exclusively on tangential joints and can easily be scaled to fit many the requirements of many life-forms.

When the rod is bent into a circular shape to be woven into the BioWall, it is like a charge being sent into a battery. The structural energy in each circle is put into a pattern that distributes individual forces to make a powerful whole. The total energy in the wall can be considerable, and it is stored as potential for a long time — at least until the material used cannot sustain the forces involved. The image to the left shows the BioWall slowly releasing its energy over time because of the low quality of its fiber composite. While this might be exciting to look at, it is a nightmare for a person preparing a showcase! Biological organisms use a similar principle to store and transport chemical energy within cells for metabolism. The molecule ATP (adenosine triphosphate) is produced as an energy source during photosynthesis, fermentation and cellular respiration and consumed by a multitude of cellular processes; its energy is released when a chemical bond in the molecule's structure is broken. Because the materials used are of a very high quality (atoms), the principle is extremely reliable.

8 Loop.pH studio
London, UK
Date: 15/09/2006
Time: 14:53:40



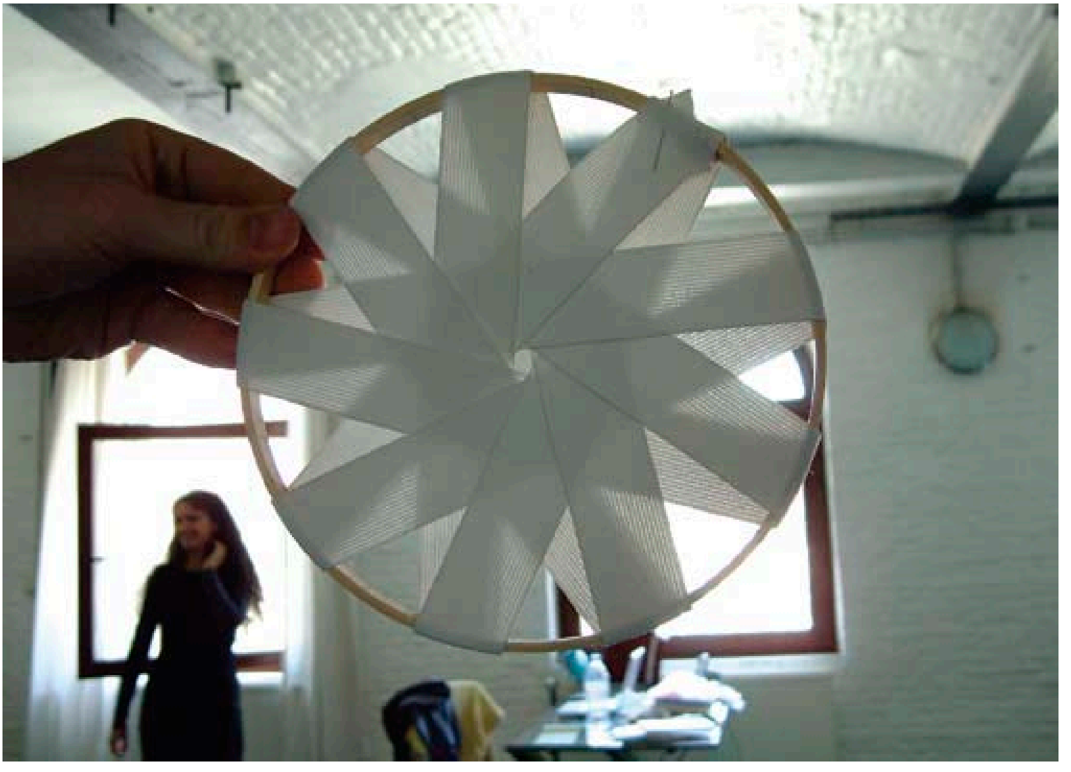
9 Ghent, Belgium
Date: 14/02/2004
Time: 22:31:12

Practitioners in intertwingularity

Pattern can be understood as a universal language to recognize and apply interconnectedness. Many craft disciplines rely on pattern. It is interesting to experience how the meditative quality of making can allow us to extend a way of thinking into the act of making and vice versa.

Such ideas challenge the linear thought processes so predominant in contemporary society, and the concept clear dichotomies: such as past and future, material and spiritual — enabling us to approach complex situations from multiple perspectives and to assimilate knowledge found throughout history.

Nik Gaffney, a long-term friend and collaborator, is deeply intertwingled into this early synectic structure, built as part of a public performance in Ghent.



10 Foam Lab
Brussels, Belgium
Date: 30/06/2004
Time: 13:01:19

Pattern and recognition

The circle is the breadth of this creation. It is so highly symmetrical, it appears uniform and featureless to us. Many patterns we see are the result of such absolute symmetries breaking into recognizable subsets.

The woven pattern of the elastic band in this image is arrayed in a 9-fold symmetry. The sunlight shining through the material exposes more patterns within patterns. Faced with the absolute of the circle, pattern is a way of coping, a suggestion for survival in the manifest physical world. The pattern describes the joy of birth and all creation from the undifferentiated ocean of the first time.

Standing by the window is Maja Kuzmanovic, a long-term friend and collaborator. Together we grow our own worlds, as she likes to put it.

Making visible

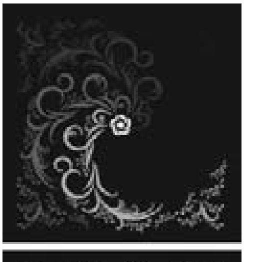
Weather Patterns is a permanent light installation created for the York Art Gallery. Five weather-proof window displays set in recessed niches emit light at night and reflect sunlight during the day, using electroluminescent panels sandwiched between toughened glass and a mirror. Data from a dedicated weather station on the site is used to animate the digital pattern.

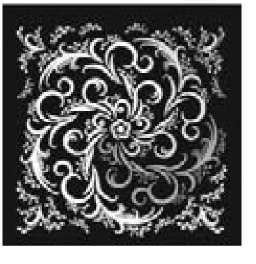
This project is part of an ongoing exploration dealing with the effects humans have on the environment. Scientific and technological progress has given us powerful tools to expand our knowledge, but they have also allowed us to work on a scale far beyond human. The whole world has become a laboratory and it becomes increasingly difficult to judge whether our experiments are well or badly designed. Within this area of research global climate change is one of the most prominent and widely understood. With our installation we want to offer a tool that allows people to experience changes in our weather and to rethink their relationship with a very fragile and highly interconnected atmosphere that secures life on this planet.

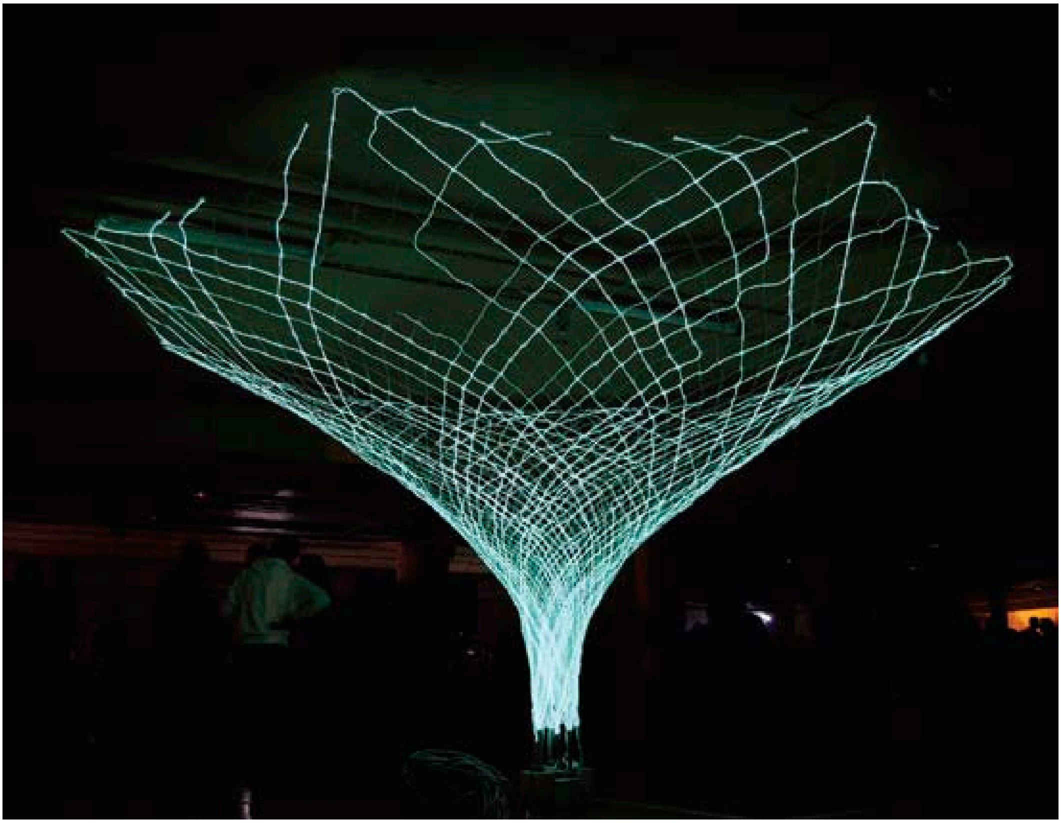
In our design for *Weather Patterns* we have reworked the classic dot-matrix display, creating a spiral based matrix capable of reproducing basic movement, rotation and growth patterns.

11 York Art Gallery, UK
Date: 30/12/2005
Time: 22:05:29

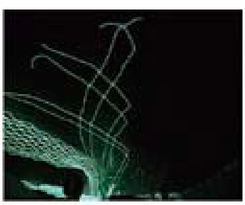
12 Loop.pH studio
Date: 02/05/2005
Time: 15:21:55

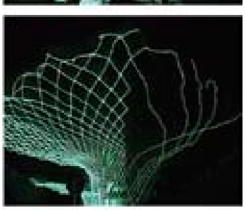


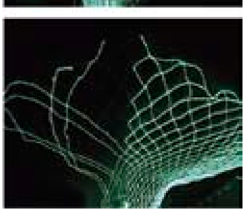




13 Madrid, Spain
Date: 16/06/2007
Time: 23:11:13







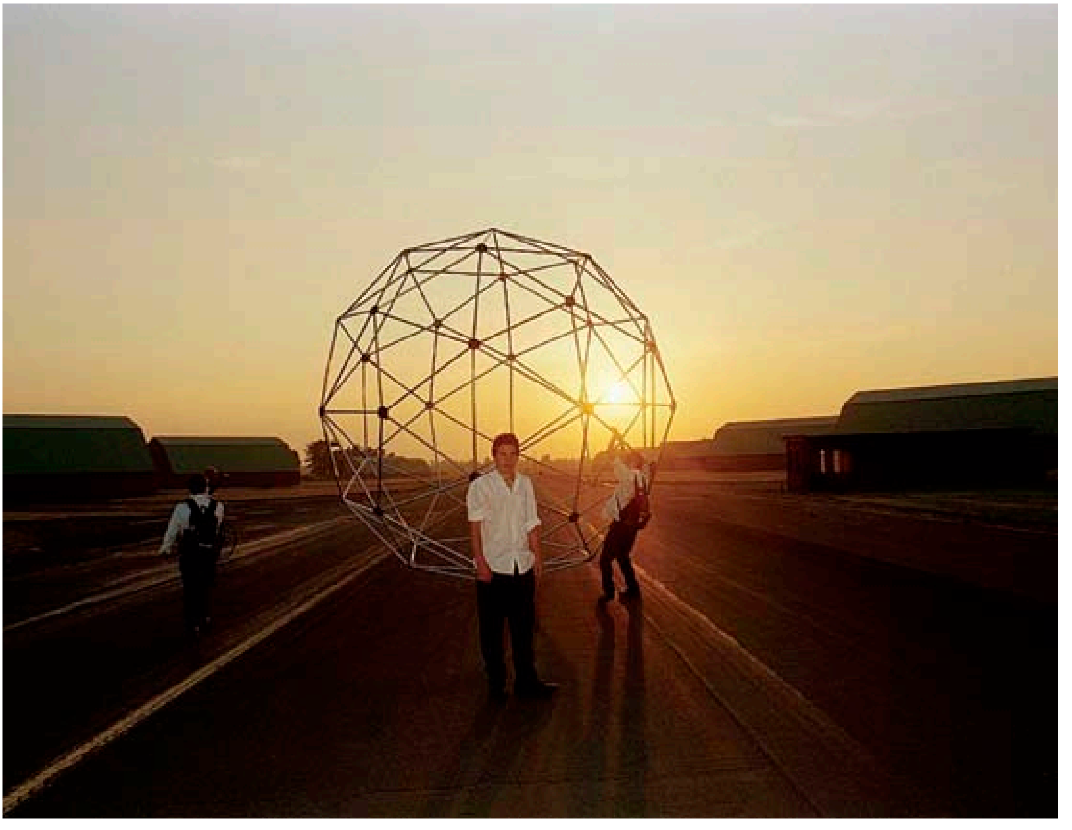
14 Loop.pH studio
Date: 20/11/2006
Time: 20:32:20

The material is the machine

The Digital Revolution has greatly expanded our possibilities to share ideas. Open-source software and collaboratively created encyclopedias involve many minds working together on complex problems. Likewise in the craft community, a network of skilled people share knowledge they have discovered through individual experience.

The act of making stimulates thought; it allows one to reflect and contemplate, which is greatly needed in a time of continuous acceleration. The objects created in the process have an emotional durability and reflect diversity. Making not only supports our individual needs — much more than 'retail therapy' ever could — it also deepens awareness of our immediate surroundings, the networks of people, resources and environments.

This image shows *Sonumbra*, an animated architectural-sized piece of lace developed in close collaboration with two outstanding members of our local lace community. Initially designed for a responsive play space, it responds to the activity of the people orbiting the umbrella by casting a sonic shade of light.The atmosphere of musical rhythms, harmonies and luminous patterns are composed by the visitors' movements. Wandering unaware or actively gravitating towards *Sonumbra*, each person plays a part and becomes a note in a unique composition of light, sound and space.



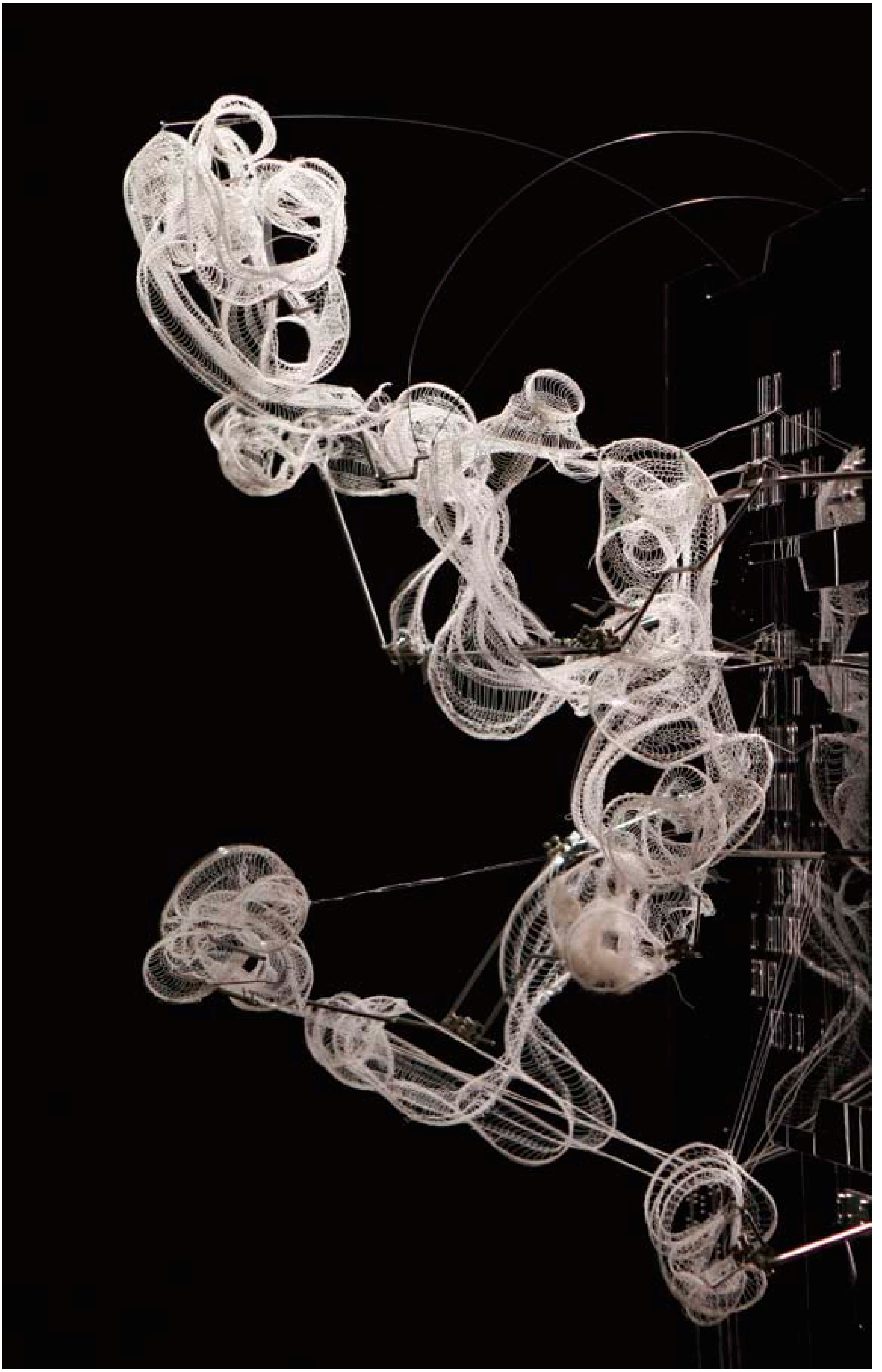
Geodesic distance

15 Aldeburgh, UK
Date: 24/06/2006
Time: 21:46:33

For some of us, school can be a difficult experience. Many subjects might appear rich in detail, but poor in meaning. Having to narrow your thinking to produce "right" or "wrong" answers can be an alienating experience, when your head is spinning from a multitude of intertwingled possibilities.

Hierarchies, categories and statistics provide a comfort zone for the modern mind when things get too entangled with their context. But both living and learning are dynamic processes, in which everything is changing and in a constant state of becoming. We need to teach a holistic systems thinking recognizing interdependence and interconnectedness. Observing natural ecologies is a key element in life-long learning. Without respect for all living things, respect for human life is unsustainable.

The schoolchildren in this image are physically experiencing order in space, where the whole is greater than the sum of its parts.



Metabolistic architectures

Mette Ramsgard Thomsen
Centre for IT and Architecture
Royal Danish Academy of Fine Arts

The concept of morphogenesis is informing a growing set of research fields. Contemporary thinking in biology, artificial intelligence, cognitive science and robotics has given rise to a notion of form as a consequence of the self-organization of complex systems, where iterative processes generate not only responsive behaviours but physical manifestations of them. In this case, the morphology of the organism or dynamic system is understood as emerging from its internal logic and continual adjustment to changes in its environment. Form is thus a result of behaviour, a calcification of habit, a shaping taking place through learnt responses to a context. As such, form retains its openness, fluidity and instability: assembling, dissolving, and flexing with the curvatures of action and reaction.

The research investigations collected here under the name *Robotic Membranes* — *Strange Metabolisms*, *Breathing Wall* and *Vivisection* — seek to imagine an architecture of behaviours. Exploring the built environment as a dynamic place of exchange and communication, these projects explore how architecture can be conceived of, designed and realized as a responsive system that connects the behaviour of walls, floors and ceilings to changes in the external and internal environments. Using the notion of a metabolistic architecture, these projects investigate the idea of an architecture moving not merely to reflect user optimization, but rather according to its own rhythms of folding and unfolding, closing and opening to inhabitation.

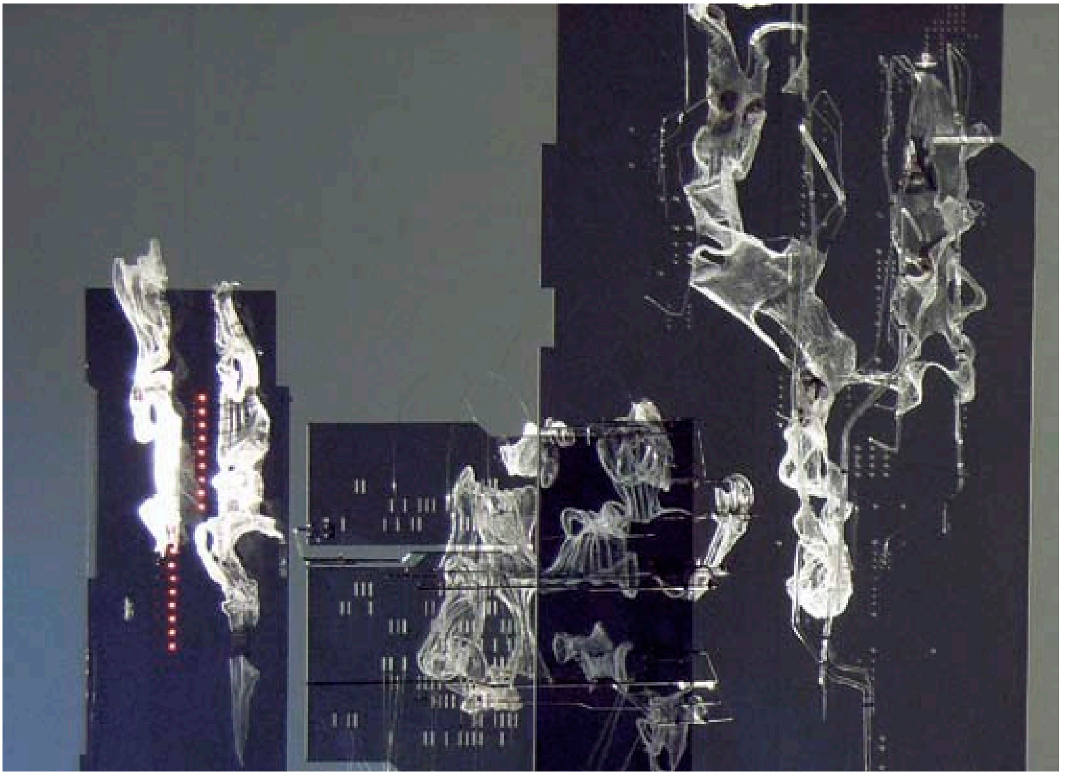
1 Strange Metabolisms
Polyurethane monofilament, carbon loaded fiber, wool, perspex, steel and wood. Exhibited at *Robotic Membranes* exhibition, Grand Parade Gallery, Brighton, UK, 2007

Flows

The city is formed through its occupation. As an event it takes place through the moment of its occupation, shaping itself continuously as we move through it. To imagine the city as a constant, as something we return to, or visit, situates it outside our own participation. Here, the built edifice, the artifact of its structures is emphasized and their stability seen as that which contains our own fleeting presence. But buildings move. The pull of gravity that sinks us into the ground tenses structures continuously as they slowly fall down. The wood is rotting, steel rusting and concrete cracking. The windows and doors are opening and closing, air conditioning switching on and off, heating and electricity passing through the structures that contain us. So in spite its apparent stability, the built environment is in a constant state of flux.

Imagine if a city could become a place where its fabric — walls, floors, and façades — became dynamic, where life would be reflected into the built world, and spaces could shift and change with the rhythms of the day and the seasons of the year. The projects explore how the built environment can be programmed to have its own idiosyncratic behaviours. Rather than programming it to realize a preconceived moment of inhabitation, these projects seek to find their own breath and own sensory apertures by which they can be affected.

2 Strange Metabolisms

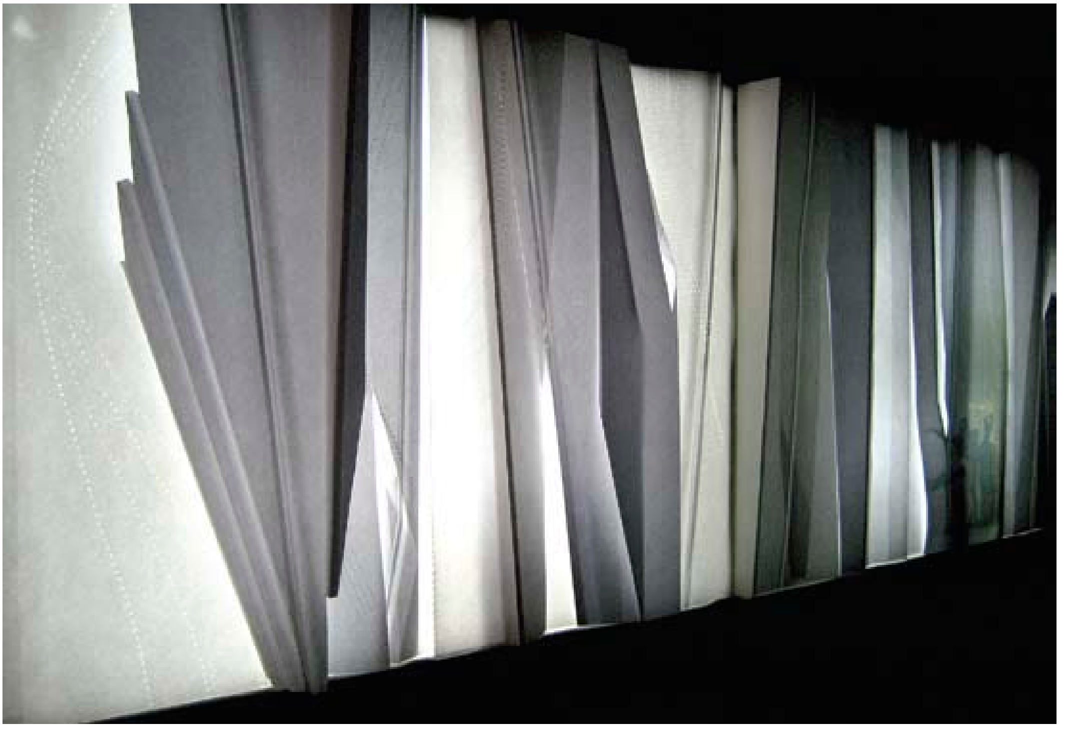


3 **Strange Metabolisms**
Models assembled in the exhibition space

Strange Metabolisms

Strange Metabolisms is the imagination of a performing city, developed in collaboration with textile artist Toni Hicks.[1] As a utopia, the project imagines the making of a textile architecture, a knitted skin — wrapping, folding and pleating as it links the inside to the outside, the intimate to the public. The models in this installation are machine-knit structures that explore the design and manufacture of complex skins. Made from synthetic and natural fibers such as plastic, silk, steel and wool, the models use the strength and qualities of these fibers to create custom-designed "skins" that change according to their site and occupation.

Strange Metabolisms is an abstract world. Exhibited in their box-like packing cases, these textile models mimic Manhattan-like plots coming together through blind neighbourship. In contrast to the other full-scale projects discussed in this essay, which are robotic membranes that move on their own, Strange Metabolisms are scaled models which come to life through simple stop frame animation — revealing the life of the city, its actions and reactions, expansions and contractions over time.



4 Breathing Room
Paper model

5 Breathing Room
Rendered drawing

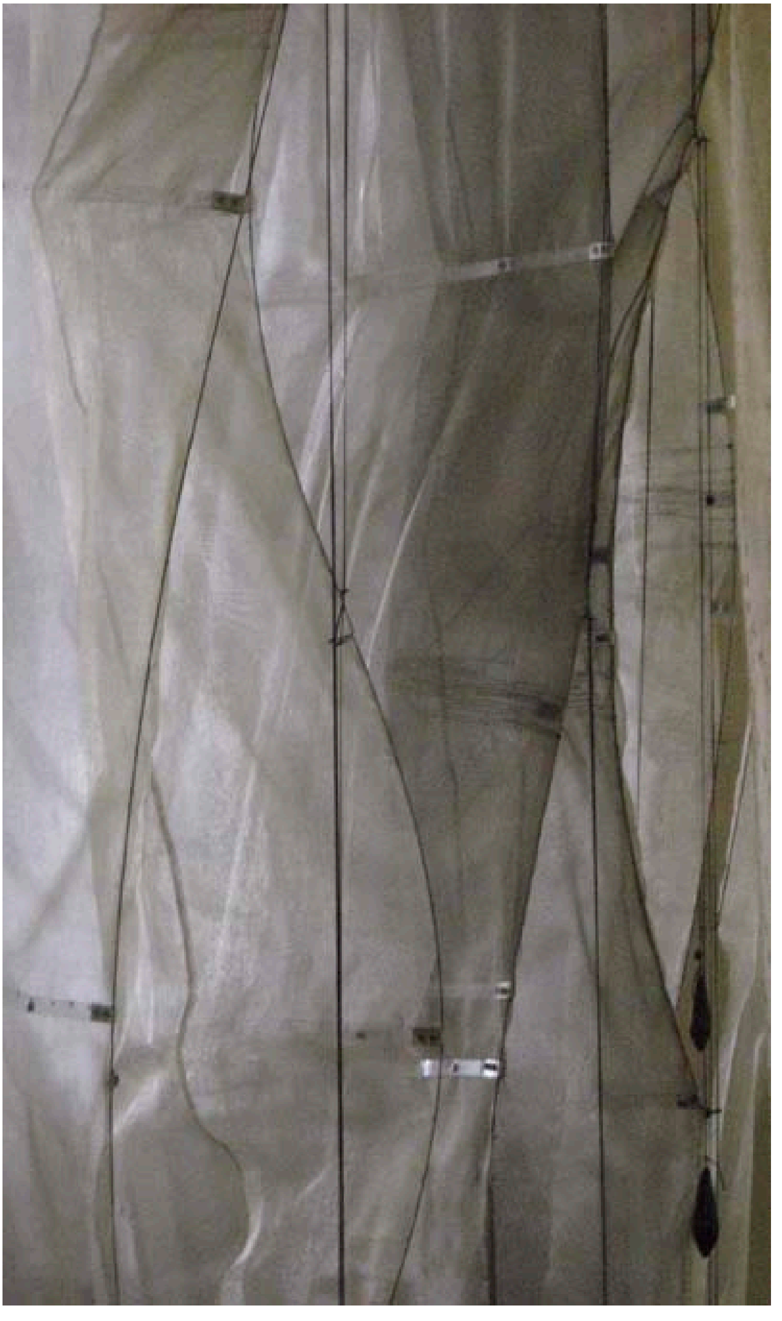
Breathing Room

Breathing Room is an interactive installation developed and realized in collaboration with Karin Bech.[2] A diaphanous textile surface that is simultaneously object and enclosure, it adapts its contours and depths in response to the actions of the people who view and are invited to interact with it. By pulling lines attached to fishing weights, users can change and move the spaces it envelopes. The response of the textile is subtle — a slight inhalation, an increase of pulse, as the membrane breathes, opening and closing itself according to its own internal physiognomy. These rhythmic oscillations are counteracted, shaped and changed by users' adjustments.

Breathing Room is a responsive textile architecture. Imagined as a scenographic element for a performance, the space is conceived as a three dimensional backdrop which encloses pockets and eddies of space that can be entered, occupied and further transformed by the performers (dancers). In the interval between movement and stasis, Breathing Room offers a moment of pause, a secret site within and without the gaze of the spectator.

Finding structure and gaining habit

Robotic membranes use textile as a technology as well as a material. As the former, textiles involve assemblage and can be employed to create complex composites. Knitting, weaving, lacing or felting are pliable technologies of assemblage which bring fibers together to engineer a material with particular properties. In the textile investigations presented here, the textiles' properties combine the architectural requirement for structural strength and the



6 Breathing Room
Silk-steel fabric, microprocessors, sensors, fans.
Exhibited at Charlottenborg, Denmark, 2006 and Grand Parade Gallery, Brighton, UK, 2007

robotic "organism's" need for motility. The outcome is a membrane that gains the possibility of structure and movement, allowing for the realization of a dynamic architecture.

With the integration of conductive fibers, the textile can become a matrix for computation, allowing the material capabilities for sensing and actuation. Steel thread or carbon-loaded fiber allow electricity (or data) to pass through

7 Vivisection
As installed in the Charlottenborg, Copenhagen, 2006

the material, making the textile the wiring that enables independent micro-controllers to communicate. In this way, the membrane becomes an intelligent tissue "aware" of its state and capable of sensing its larger setting and the space or activity it encloses.

How does the built artifact gain "habits"? How might these textile constructions generate their own particular movement scores by which they may shape themselves? Because these robotic membranes employ a distributed computational system, the structures are aggregates of individual cells that can act or react independently to changes to their environment. Each cell or micro-controller bridges between input and action, creating the basis for a simple interaction. The rhythm of the organism is the collective breath of each cell, generating complexity through overlay.

Vivisection

Vivisection, a collaboration with designer Simon Løvind[3], is the making of a live section, a sensing skin that acts and reacts to its inhabitation. It investigates the making of a tectonic surface that embeds a capability for sensing and actuation. The conductive silk-steel blend of the fabric allows for passage of electronic signals. When coupled with antenna-equipped sensor chips, the entire fabric works as a sensor, which can feel the presence of viewers. The sensors inform a network of distributed micro-computers, that in turn control fans which inflate and deflate internal bladders in the structure.

8-9 Vivisection

10 Strange Metabolisms

Diversions

The human eye generally perceives the physical world as stable. As we grow through childhood evolving into our adult selves, we tend to (despite age and illness) conceive of ourselves as beings, formed and finite in our manner of being and acting in the world. We conceptualize our relationship to the world as a constant, and our language and semantics depends upon this sense of continuity. Even when we accept that our interpretation and understanding of the world has changed, we trust that the world itself remains unchanged.

The last decades have seen a challenge to this cultural certainty. Rather than finding ourselves outside a stable world of recognizable objects, we now increasingly see ourselves as imbedded within the environment. Departing from a Cartesian segregation of subject and object, the concept of embodied cognition sites the self as an integral part of its containing environment.[4] The organism is a dynamic system which constructs its form through ability to sense and its actions and reactions. It also constructs the environment in a way that is particular to it as an organism. Form, in this sense, emerges from self-organization in interaction with the environment.

It is through the interactions of this dynamic system, and its "leakage" towards its environment, that an organism comes to define its own recursive rules of engagement. The biologist Humberto Maturana describes a self-organized — or what he calls "autopoietic" system — in this way:

> a dynamic system that is defined as a composite unity is a network of productions of components that (a) through their interactions recursively regenerate the network of productions that produced them, and (b) realize this network as a unity in the space in which they exist by constituting and specifying its boundaries as surfaces of cleavage from the background

through their preferential interactions within the network, is an autopoietic system.[5]

Maturana here is describing a system of emergent behaviours. An organism comes into being through interactions with the space in which it exists. As we learn to act and be within our environment, we form our knowledge about it and about ourselves. We are constantly learning, adapting and adjusting to the continual changes that take place in our own complex biologies and in the environments we occupy. Our physical presence or embodiment is necessarily fluid, shifting and becoming, relearning how to be and act in an unstable world. This sense of learning becomes a means of understanding ourselves in the world. As Katherine Hayles argues in her book *How we became Posthuman*, learning is a means of constructing meaning with respect to a world that doesn't appear to us completely, but through which we explore both ourselves and the environment in which we exist.[6] Pointing back to the work of Varela, Thompson and Rosch[7], she suggests that the closer one comes to the flux of embodiment the more one is aware that the coherent self is a fiction. Habit is an enculturing of the body, a state that forms us but also reforms us, constantly changing with the inscribing and incorporating practices that shift as technologies change.

The robotic membranes presented here speculate on whether a material might be described through a similar construct of habit-making. Might the density of a floor or the porosity of a wall shift and form not through an over-determined program (based on ergonomics or another form of user optimization) that aims to predict and prescribe potential functionality, but through the emergence of a "habit" that results from a dynamic interaction between a material and the way it is inhabited? Using "habit" as metaphor and blueprint, these Robotic Membranes seek to engage the flux and instability of "the embodied" as it shapes form through behaviour.

Notes

1 *Strange Metabolisms* was developed and realized as a collaboration between Mette Ramsgard Thomsen, Centre for IT and Architecture and Toni Hicks, Head of Constructed Textiles, University of Brighton, December 2006.

2 *Breathing Room* was developed and realized by Mette Ramsgard Thomsen with Karin Bech, Centre for IT and Architecture August 2006.

3 *Vivisection* was developed and realized as a collaboration between Mette Ramsgard Thomsen, Centre for IT and Architecture and Simon Løvind, Danmarck Design Skole, October 2006.

4 Hubert L. Dreyfus, *What computers still can't do, a critique of artificial reason*, Cambridge, Mass.: MIT Press, 1972, 1993; Terry Winograd and Fernando Flores, *Understanding computers and cognition: a new foundation for design*, Norwood, NJ: Ablex Publishing Co., 1986; Pavel Zahorik and Rick L. Jenison, "Presence as Being-in-the-World", in *Presence: teleoperators and virtual environments*, vol. 7, no. 1 (Feb) 1998: 78 - 89; and Katherine Hayles, *How we became Posthuman: virtual bodies in cybernetics, literature and informatics*, Chicago: University of Chicago Press, 1999.

5 Humberto R. Maturana, "Man and Society", in F. Benseler, P. M. Hejl and W.K. Koch (eds), *Autopoiesis, Communication and Society*, Frankfurt-am-Main; Campus Verlag,1981. See also Humberto R. Maturana and Francisco Varela, *Autopoiesis and cognition: rhe realization of the living*, Dordrecht, Holland and Boston: D. Reidel Publishing Co., 1980.

6 Katherine Hayles, *How we became Posthuman: virtual bodies in cybernetics, literature and informatics*, Chicago: University of Chicago Press, 1999.

7 Francisco Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind: Cognitive Science and Human Experience*, Cambridge, MA: MIT Press, 1991.

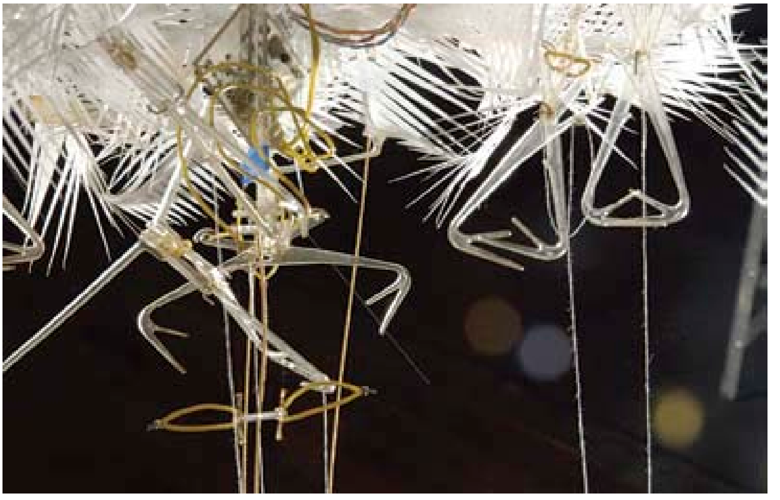
Hylozoic Soil Control System

Robert Gorbet and Philip Beesley
University of Waterloo

1 Hylozoic Soil, 2007

Hylozoic Soil is one of a series of large-scale textile installations that pursue reflexive, kinetic architectural environments. Recent generations of this work have employed sensing and actuator mechanisms, and this essay focuses on the control system developed for these actions. The microprocessor-controlled system includes open-source 'Arduino' hardware extended by new control boards, shape-memory alloy actuators and space sensors arranged in a distributed interactive system.

The textiles in these installations feature collective patterns of movement by mechanical components that respond to viewers' movements in the exhibition gallery or space. The structural matrix which supports these components — and gives shape to the textile — is formed out of lightweight lattice scaffoldings that are digitally fabricated to precise tolerances and assembled in 'geodesic' organizations. This matrix also houses distributed networks of sensors and actuators. The structures are designed at multiple scales, from the very fine and intricate moving components, to the intermediate tessellations (tilings) of component arrays and, at the largest scale, the general structural systems. The most recent projects in this series of installations focus on integrating control systems with decentralized responsive intelligence. The work is based on a program of gradual development moving from individual figures composed of complex hybrid organisms toward immersive architectural environments that include lightweight interior-linings and durable exterior shading and filtering assemblies.

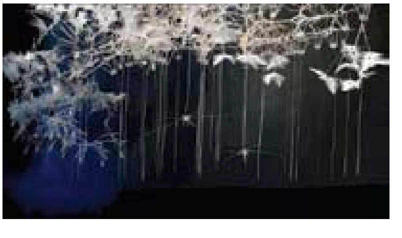


2 Implant Matrix, 2006

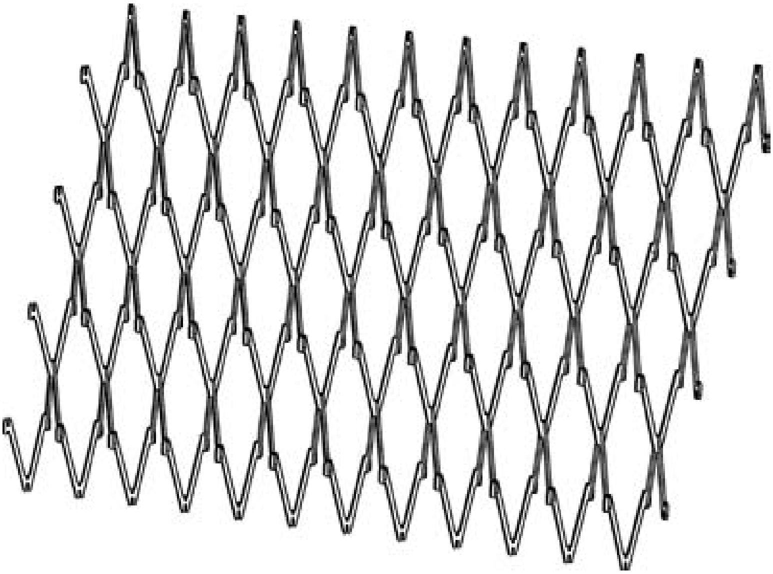
Preceding the latest work, a temporary gallery installation erected this past year in Toronto titled *Implant Matrix* was an experimental building skin equipped with layers of miniature valves and clamping mechanisms that might convert surrounding material into a living wall. By accreting and digesting surrounding matter, the matrix was designed to accumulate a new kind of living turf. The work used simple interactive systems controlled by distributed Peripheral Interface Controller (PIC) microprocessors. These systems supported a primitive intelligence that animated the structure, pursuing a kind of mechanical empathy in which the components reacted to human occupants as prey. The elements were structured using an aperiodic tessellation of rhombic cells with slender acrylic armatures that flexed perforated sheets of Mylar. Capacitance 'whisker' sensors, shape-memory alloy (SMA) muscle-wire actuators and toothed Mylar filtering valves were included within its lightweight polymer skeleton. The Implant Matrix installation included distributed sensing and actuation while retaining centralized power, intelligence, and communications.

Hylozoic Soil is a generation that builds upon work done within Implant Matrix, developing a decentralized structure where much of the system is distributed and extensible, based on localized intelligence. Occupants move within the Hylozoic Soil structure as they would through a dense thicket within a forest. Microprocessor-controlled sensors embedded within the environment signal the presence of occupants, and motion ripples through the system in response, pulling trickles of air through the mesh and drawing stray organic matter through arrays of filters.

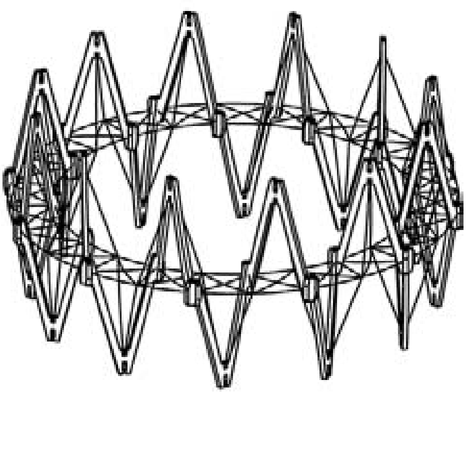
3 Hungry Soil, 2000



4 Reflexive Membrane, 2004



5 Meshwork field



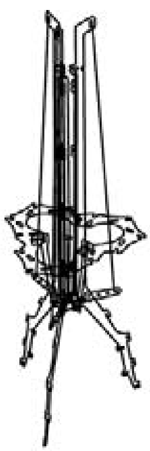
6 Meshwork 'column'

The structural core of Hylozoic Soil is a flexible meshwork assembled from small acrylic chevron-shaped tiles that clip together in tetrahedral forms. These units are arrayed into a resilient, self-bracing diagonally organized space-truss. Curving and expanding this truss work creates a flexible grid-shell topology. Columnar elements extend out from this membrane, reaching upward and downward to create tapering suspension and mounting points. Fitted into this flexible structure are hundreds of small mechanisms that function in ways akin to pores and hair follicles within the skin of an organism.

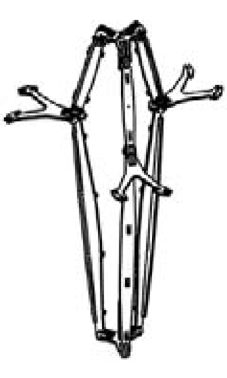
7 'Breathing' pore

'Breathing' pores are composed of thin sheets shaped into outward-branching serrated membranes, each containing flexible acrylic tongue stiffeners fitted with monofilament tendons. The tendons pull along the surface of each tongue, producing upward curling motions that sweep through the surrounding air. 'Kissing' pores are a cousin of this mechanism. These use a similar mechanics fitted with a fleshy latex membrane and offer cupping, pulling motions. A second kind of 'swallowing' pore occurs in a triangular layout that creates a dense series of openings running throughout the meshwork. These openings contain pivoting arms in triangular arrays that push out radially against the surrounding mesh, producing expanding and contracting movements. Yellow LED lights are fitted within lower surfaces of these elements, configured to pulse in synchronization with swallowing motions. 'Whisker' wound-wire pendants are arranged in dense colonies within this environment, supported by acrylic outriggers with rotating bearings. Tensile mounts for the whiskers encourage cascades of rippling, spinning motion that amplify swelling waves of motion within the mesh structure.

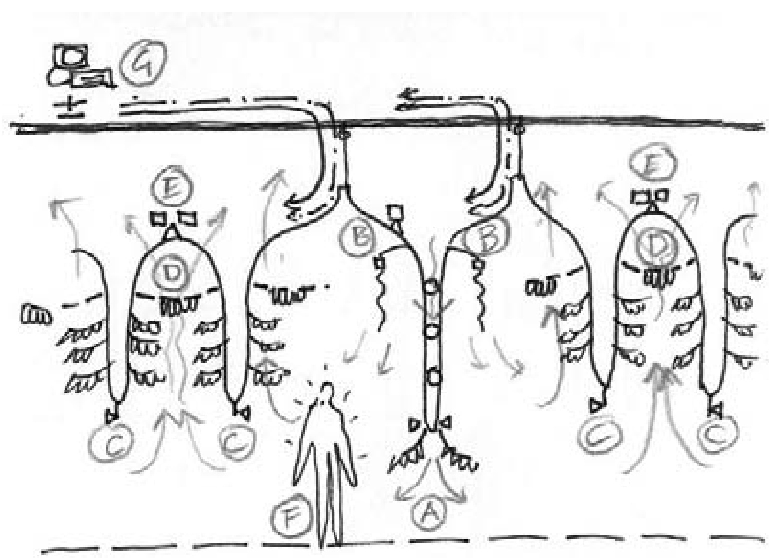
Processing for this system is based on Arduino (www.arduino.cc), an open-source platform that was designed to make tools for software-controlled interactivity accessible to non-specialists. The palm-sized Arduino microcontroller board can read sensors, make simple decisions, and control devices. The microcontroller used in the platform is an Atmel ATmega168, a tiny computer-on-a-chip that contains specialized hardware to process digital signals, read analog inputs and communicate over a serial connection, based on user-designed software that resides in its memory. The first developers- Massimo Banzi, David Cuartielles, David Mellis, and Nicholas Zambetti- ran



8 'Kissing' pore

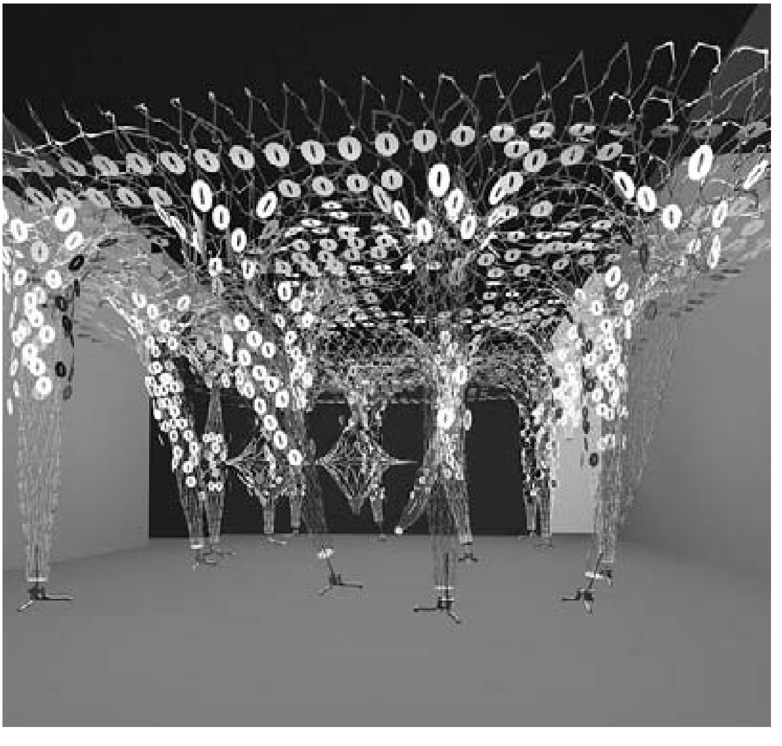


9 'Swallowing' pore

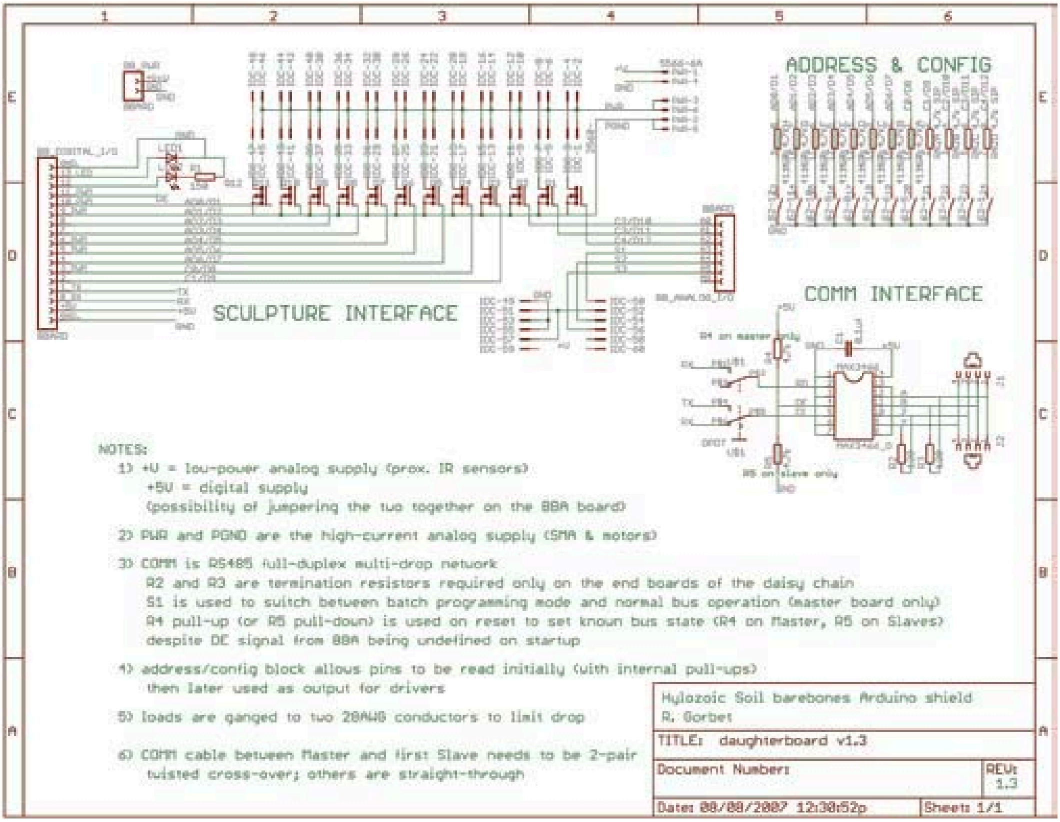


workshops that demonstrated assembly of the microprocessors and gave the board away to stimulate development. A community of developers and users now provide cooperative support, and the programming environment and documentation is written with the neophyte in mind. The version of Arduino used for Hylozoic Soil is the Bare-Bones Board, Revision C, developed by Paul Badger (www.moderndevice.com). This inexpensive implementation of the platform has a small (40mm x 60mm) footprint, and is provided fully-assembled or in kit form. It includes power regulation, timing, and external components for digital inputs and outputs that can control a range of interactive devices.

In Hylozoic Soil, each Bare-Bones Board is paired with a custom 'daughter board' to form a robust integrated unit. The daughter board provides three key additional elements to extend the function of the main board: a high-current output stage, configuration switches, and a communication interface. Twelve high-current output channels permit digital control of devices at currents of up to 1 amp per circuit at voltages up to 50 volts. Twelve switches are read by the software during initialization of the boards and can be used for functions such as configuring individual board addresses and specifying configuration data to control individual board behavior. The communication interface converts serial communication signals from the Arduino and supports distribution at high speed to a network of boards using the RS485 standard. The daughter board also provides a 60-pin ribbon cable interface for connecting actuator and sensing devices, and a two-channel power connector to distribute high currents to actuators as well as a lower current 'electronics' supply.



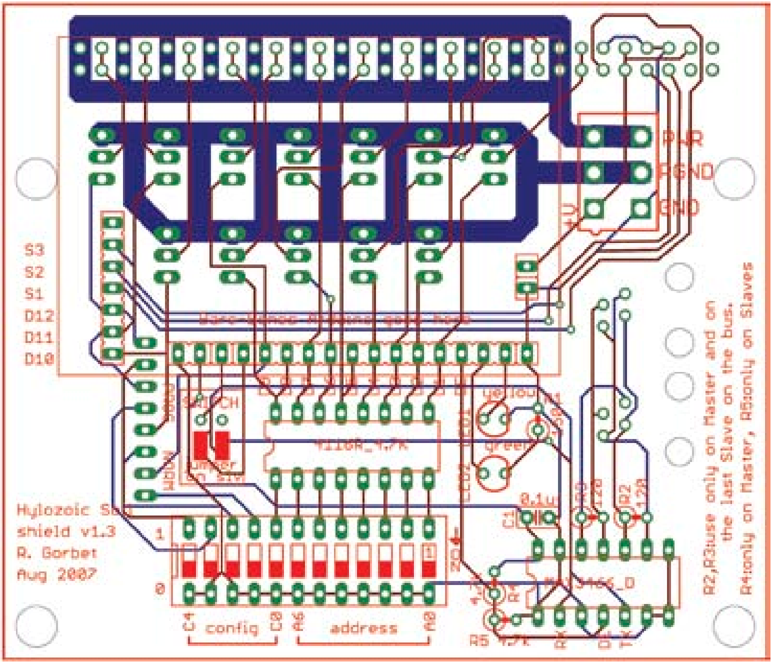
11 Hylozoic Soil, 2007



12 Hylozoic Soil, 2007

The Hylozoic Soil sculpture includes three kinds of actuator elements: 'breathing' and 'kissing' pore mechanisms actuated by shape-memory alloy 'muscle' wires, 'whisker' elements driven by small direct-current motors, and miniature LED lights. Each mechanism is designed to operate at five volts. Under software control, the output drive channels switch current from the high-current five volt supply to each of the individual actuator elements. The SMA-actuated pores are driven by ten-inch lengths of 300 micron-diameter Flexinol wire that contract when an electrical current runs through them. Mechanical leverage amplifies the 1/2" contraction that occurs in each wire and translates this into a curling motion. Whisker elements are composed of flexible wound wire strings extending from the shaft of a small three-pole motor. LED lights are combined with current-limiting resistors to form a visual actuator configured for the five volt power supply.

Each daughter board accommodates up to three analog sensors. Sharp infrared proximity sensors with varying detection ranges provide feedback that allows the sculpture to respond to occupant motion occurring near the boards. Powered by the five-volt electronics supply, the sensors emit an infrared signal and receive reflected signals from nearby objects, registering the distance of the reflecting surface and feeding that information back to an input on the Arduino board.



13 Hylozoic Soil, 2007

The Hylozoic Soil distributed system consists of 38 controller boards, all with identical hardware. Specialized functions are assigned by software setups in groups of boards, and one board assumes a supervisory role for the entire system. This 'bus controller' board manages messaging by means of a 'full-duplex, differential multi-drop' communication bus. A full-duplex implementation uses two pairs of wires: one pair for incoming information and the other for outgoing data. This allows for simultaneous communication in both directions along the bus. Each board constitutes one 'drop' of the multi-drop system. The communication system uses an RS485 communication standard protocol. In this standard, information is transferred on pairs of wires that carry differing voltages. Communication signals are detected by measuring the differential in the paired wires. This scheme, along with the use of twisted-pair cabling, makes the system less prone to noise-induced communication errors.

Individual boards all 'talk' on the bus controller's receive lines, and listen to the controller's instructions on the parallel send lines. Information is transferred from board to board via the controller. A typical message may consist of several bytes of information, and includes addressing information to route the message. The bus controller forwards messages it receives on its outgoing lines, and individual boards are programmed to ignore messages which are not for them.

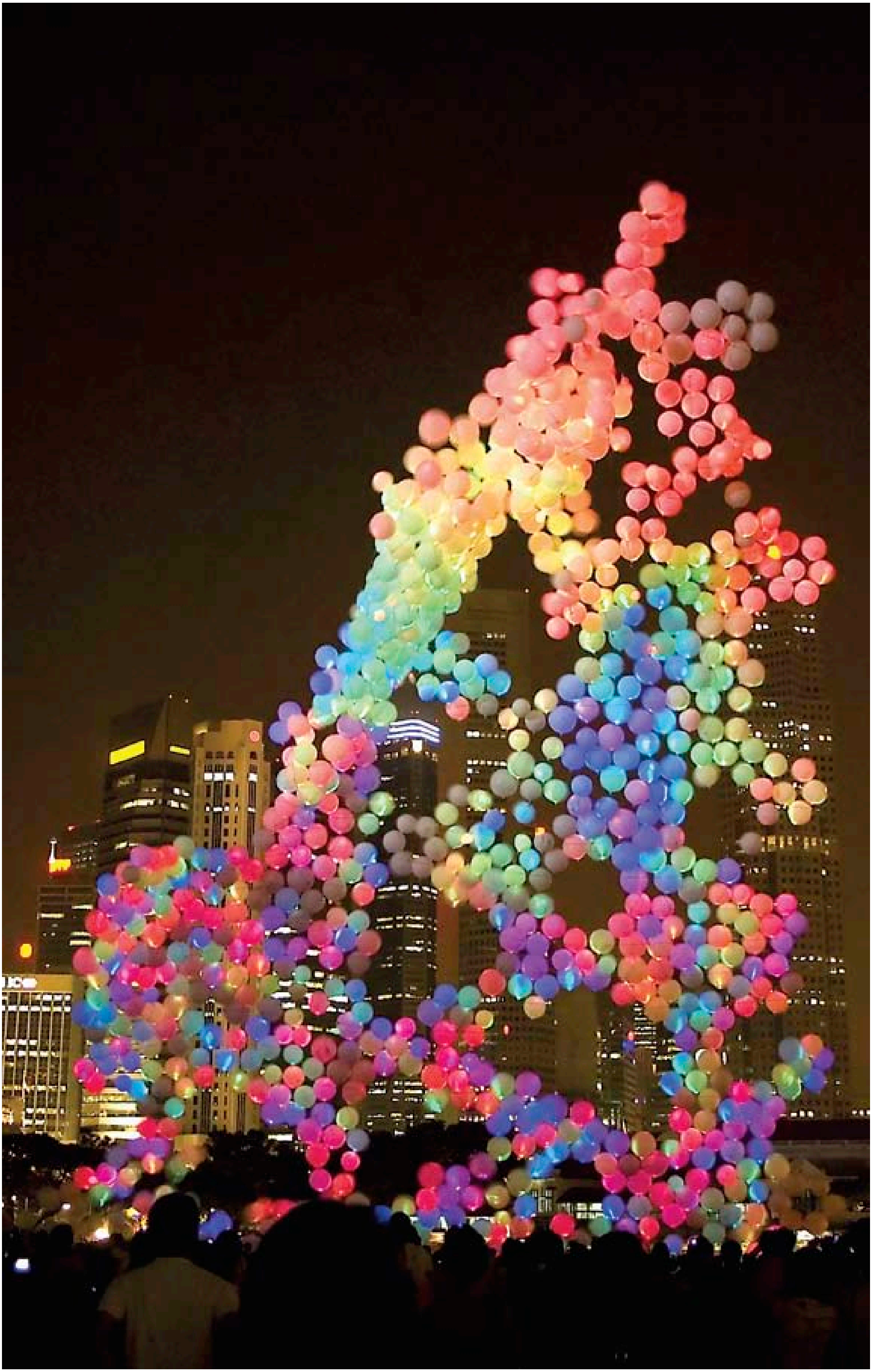
This organization means that there is the potential for communication conflicts if multiple boards try to send messages simultaneously, so each board needs a way to know when it is safe to talk on the bus. In order to accomplish this without using up scarce hardware resources, Hylozoic Soil uses a 'challenge-response' model. The bus controller periodically asks each individual board if it has something to say, and the board responds. If that response needs to be retransmitted to the other boards, the controller relays it. In this way, a given board emits signals on the bus only if it has been asked to do so by the bus controller. The messaging protocol has been designed to use primarily one-byte messages, meaning that at the slowest bus speed of 9600 bits per second, the bus controller can poll the entire installation in a tenth of a second.

Several levels of behavior are programmed into the sculpture in order to encourage coordinated spatial behaviour to emerge. Software is organized into local behavior affecting isolated groups of devices, coordinated behavior between neighboring groups, and global behavior running throughout the whole system. Each board produces its own response to local sensor activity. The bus controller polls the board, and if the board's sensors have fired the board transmits sensor information to the bus controller when polled, using an 'information message'. An information message is composed of six bits containing the address of the originating board, and two bits containing sensor status information. When a board's sensors have fired, the bus controller will forward that information message on its outgoing bus. Each board listens for messages from neighbouring boards, identified by means of an address map of the devices within the installation, encoded into the software. The bus controller has information about sensor activity from all of the individual boards and is

able to control a third level of 'global' behaviour with this information. For example, if excessive activity is detected it may send out a special message to all boards to quiet down the sculpture. Similarly, it may send out a message instructing a low-level background behaviour if it detects that sensors have not fired in a while. Six bits are available for addressing, leaving substantial capacity for special messages. Messages with unassigned addresses are used for these special functions to avoid confusion with information messages originating from individual boards.

Simplicity and economy are prevailing qualities that have guided design of the system, supporting massive repetition and efficient mass-manufacturing of the assemblies. Consumption of materials is reduced to a radical minimum by employing optimized form-finding design methods. Strategies include use of efficient tensile forces and textile systems in mesh and shell forms and derivation of three-dimensional forms from thin, two-dimensional sheets of material. Space-filling tesselations and rigorously nested components derived from sheet goods contribute to this hybrid economy. Some eight cubic feet of acrylic polymer, fifty pounds of copper wire, aluminum sheet and handfuls of specialized alloys are expended, while the expanded space formed from these materials occupies some eight thousand cubic feet.

Similarly, the control system offers considerable complexity in its behaviour while avoiding large centralized computing. The distributed arrays of inexpensive miniature microprocessors achieve coherent behaviours through their distributed communication network. The intensive repetition of small information packets in the communication network and mass-manufacture of miniature physical components in the physical sculpture are similar in their approach, offering a resilient, heterogeneous whole.



Architecture, interaction, systems

Usman Haque
Haque Design + Research Ltd.

1 ***Open Burble***
An immense rippling, glowing 'Burble' sways in the evening sky, responding to the crowd interacting with it below. Singapore Biennale 2006.

> "I go up", said the elevator, "or down."
> "Good," said Zaphod, "We're going up."
> "Or down," the elevator reminded him.
> "Yeah, OK, up please."
> There was a moment of silence.
> "Down's very nice," suggested the elevator hopefully.
> "Oh yeah?"
> "Super."
> "Good," said Zaphod, "Now will you take us up?"
> "May I ask you," inquired the elevator in its sweetest, most reasonable voice, "if you've considered all the possibilities that down might offer you?"
> *Conversation with an elevator designed by the Sirius Cybernetics Corporation in The Restaurant at the End of the Universe by Douglas Adams*

The word "interactive" is found everywhere these days. It may be worth considering what this word means and whether things presented to us as interactive actually are so, before moving on to consider why we might want our designed objects and spaces to be interactive. We should keep in mind that while interactive objects are not necessarily hi-tech and hi-tech ones not necessarily interactive, technological advances may make certain aspects of interaction easier to achieve — in part because they compress temporal, spatial or interpersonal scales. Rather than provide from the outset a fixed definition for "interactivity", I would like to discuss it from a few different angles, hoping that the sketched-in boundaries enable us to converge on a particularly useful conception of the word.

To turn to an architectural context, let us imagine a brick wall that crumbles over years under the impact of rain. Is the wall interacting with its environment? I would argue it is not — rather, it is merely reacting, because the wall has no effect on the environment affecting it (other than at a molecular level). The environment does not change its behaviour as a result of the wall's gradual collapse. The causality is entirely in one direction. Similarly, when louvers track the circuit of the sun in order to direct sunlight into a building or prevent its entry, they are merely responding to certain input conditions and thus should not be described as interactive, but as reactive. Interaction, by contrast, concerns an exchange of information between two systems (two people for example, two machines, or a person and a machine). What is crucial to the definition is that this exchange should be in some sense circular — otherwise it is merely a reaction.

Single and multiple loop interactions

When you withdraw money from a cash machine, is that interactive? After all, you key in some numbers and currency notes are returned – closing a circle. To answer this question, let us step back for a moment and consider what occurs when we withdraw money from a real live human teller at the counter inside a bank. We step up to the desk, furnish our identification, wait a few moments, and then receive from the teller the quantity of money requested. Although it has been a simple transaction, it involved a two-way exchange of information: we provided our identification and explained how much cash we wanted, and the teller handed it over. The key here is that we received what we expected, both us and the teller: we provided the teller with information they expected to hear (distinguishing us from other customer accounts), and they furnished us with the desired sum of money. This was an *interaction*, in the sense that instructions were transmitted across a boundary and we received something in exchange. It was not, however, a very interesting form of interaction because we each operated within a predetermined set of boundaries. In the same way, withdrawing money from an automatic teller, each participant in the transaction selects from a fixed set of possibilities and responds with a fixed set of possible outcomes. Input and output criteria alike were predetermined by the designer of the system.

In another example of the same sort, what happens when you enter an art installation that presents you with a visual effect that is the result of your movements in space? Would you call this interactive? Although you might not, on entering the gallery, be expecting particular visual effects to be triggered by your movements in the space, it is likely that the artist had already decided which visual outputs would be associated by certain inputs – either knowingly, by filtering for the aesthetics desired, or unknowingly but just as deterministically, through the complex but unchanging structure of the computer program. Let us call this a *single-loop interaction*.

As a contrast to these types of interactions, let us consider exchanges in which we actually enter into a conversation with the other participant. With the bank teller for example, we might discuss recent news, or have a conversation about a particular financial issue that requires further appointments, or have a conversation about a personal matter (more likely once we get to know a teller from repeated visits to the bank). What is critical key here is that the domain of our interactions is open, and through conversation we maintain a relationship that is productive and engaging.

We will probably discover new and unexpected information; we may benefit from this or simply from our interactions, that will encourage related interactions in the future. It is, perhaps, our propensity to encourage on-going, iterative, and evolving interactions and conversations that makes us human. Note, however, that it isn't merely the unexpectedness that makes this a constructive form of interaction; if it were too unexpected (for example, if the teller started yelling at us for no apparent reason) then the interaction would break down.

In such *multiple-loop* interactive systems, causality is much more difficult to ascribe than in reactive systems: A provokes B, but B affected A in the first place, in an ever-continuing loop. Note that complex thermostat systems such as those that take into account other environment input data are not, in their complexity, necessarily multiple-loop interactive systems. Multiple-loop interaction does not depend upon complexity, it depends upon the openness and continuation of cycles of response. It also depends on the ability of each system, while interacting, to have access to and to modify each other's goals. This is the kind of interaction that is just not present in a cash machine (or many art installations); it is not, however, an interaction that I believe is impossible to achieve with machines!

Conversation theory

We have discussed three different scenarios: one in which I claimed there was no interaction; a second in which there was interaction, in quite unsophisticated terms; and a third in which there was a constructive and continual interaction. It is my contention that the third scenario is most interesting and also the most productive in the context of designed spaces and architecture.

Within human-machine relationships, the single-loop interaction provides us with a situation where a person is at the mercy of the machine and its inherent logical constructs. We may get unexpected results — for example, the machine tells us that it is out of cash — but because the machine can only select from a predetermined set of responses there can be no constructive interaction. The third scenario by contrast, relies on the creativity of the person and the machine as they negotiate across an interface, and it is this "conversational" creativity, I will argue, that makes these interactions the most desirable.

I recognize that reactive single-loop devices are useful for functional goals like satisfying our creature comforts (I am thinking here of Bill Gates' technologically-saturated mansion; building management systems that aim to optimize sunlight distribution; and thermostats that regulate temperature). Such systems satisfy particular efficiency criteria that are determined during, and limited by, a design process. However, if one wants the inhabitants of a building to feel in control of their environment or take responsibility for its organization, then the most stimulating and potentially productive system would be one in which people hold "conversations" with the environment —

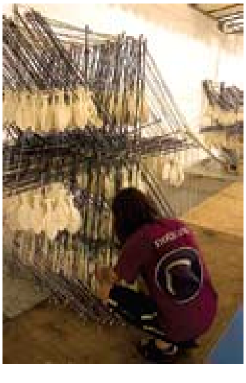
with the history of such interactions building new possibilities for sharing goals and sharing outcomes. In such architectural systems, the building's inhabitants would be able to determine efficiency criteria.

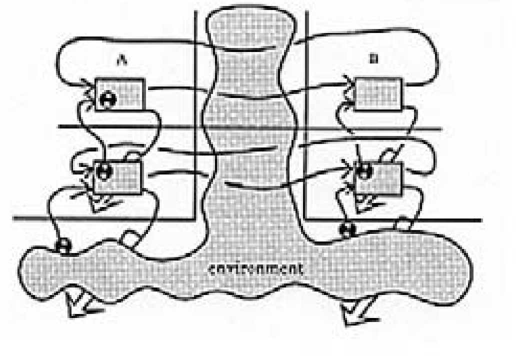
The cybernetician Gordon Pask, who collaborated with architects in the 1970s and 80s at the Architecture Association in London, provides us with rigorous guidance on how to develop such systems. His "Conversation Theory"[1] gives us a clear framework for designing interactions in which systems such as humans, machines or environments may engage in the constructive exchange of information without needing to rely on perfect communication with each other (without, for example, requiring an environment to talk to us with the emotionally-inflected yet clearly robotic voice of Star Trek's onboard computer!). Ahead of its time, Pask's work was not fully grasped by the architectural community. But now that technological developments have altered our relationship to machines, and conceptual developments have enabled us to understand the constructive role that participants (formerly construed as mere "users") may have in an open system, it is possible to consider how Pask's Conversation Theory may help us to build complex, dynamic interactive environments.

In such systems, there may be an environmental sensor/actuator device which monitors a space and is able to alter it. However, rather than simply doing exactly what we tell it (which relies on us knowing exactly what we want within the terms of the machine, i.e. within the terms of the original designer) or alternatively it telling us exactly what it thinks we need (which relies on the machine interpreting our desires, leading to the usual human-machine inequality, or, as some would say, mistreatment), a Paskian system would provide us with a method for comparing our conception of spatial conditions with the designed machine's conception of the space.

This enables us to converge, agree on and thereby share each others' conceptual models of the space and what alterations we decide it requires. With this shared conception we are better able to act upon the space, in

2 Assembling the *Burble*





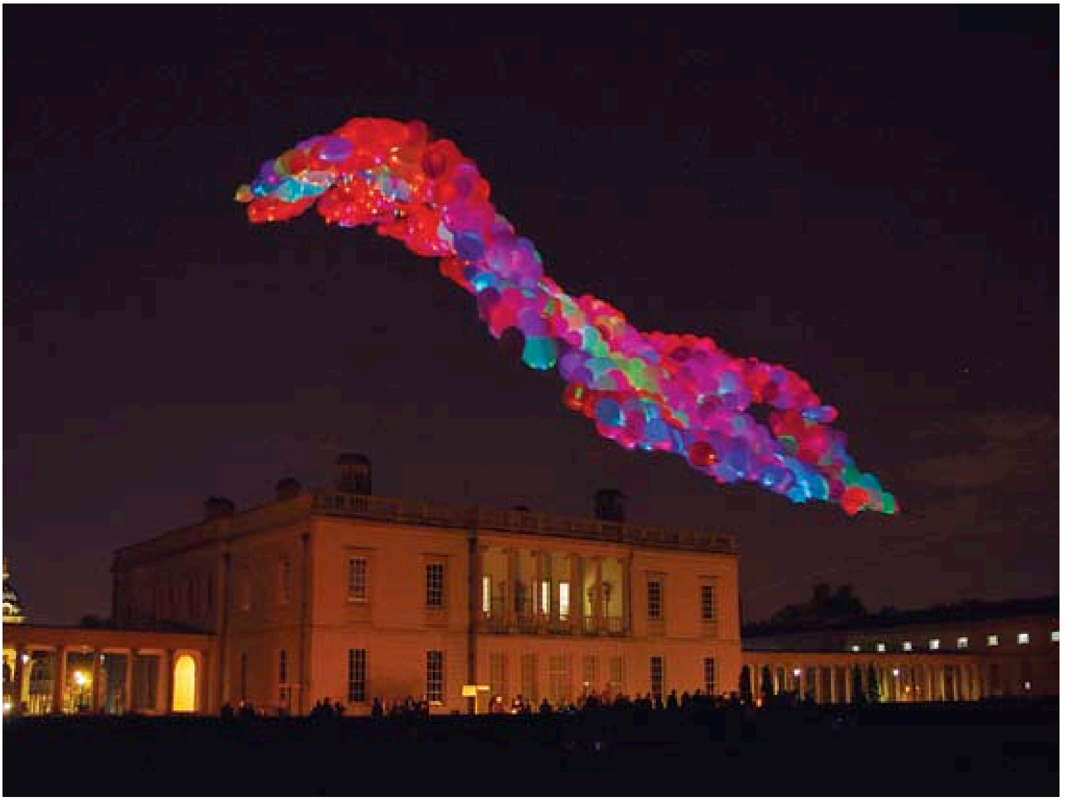
3 Circular interaction-modeling by Gordon Pask

4 Inflating the *Burble*

conjunction with an artifact, in a constructive, engaging and ultimately satisfying manner. Such systems would operate with "underspecified" sensors; i.e. either a whole collection of them, each individual sensor of which may or may not eventually be determined as useful in calculating its output; or better yet, it may evolve its own sensors, dependent on dynamically determined input criteria (Pask built such a system in the 1950s, which evolved its own sound receptors).

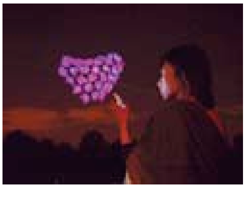
For example, building on the rather prosaic model of the thermostat, an authentically interactive implementation would enable a person to add inputs to the temperature-regulating system as desired. These might range from "energy consumption over the last month" to "the exterior temperature for this day last year" to "the colour of my clothes today" to "the fifth letter of the second paragraph on the front page of today's newspaper". The system would evolve weightings for each of these input criteria in order to provide satisfactory output, again according to criteria determined dynamically with the person. Output criteria might include "increasing thermal comfort", "keeping my energy bills down", "keeping my neighbour's energy bills down", "minimizing my hot chocolate drinking", "maximizing the number of friends who come to visit". In all cases, both input and output criteria are dynamically constructed.

These systems allow us to challenge the traditional architectural model of production and consumption that places firm distinctions between designer, client, owner, and mere occupant. We can consider instead architectural systems in which the occupant takes prime role in configuring the space s/he inhabits, a bottom-up approach which would result in a more productive relationship to our spaces and to each other. This way of thinking about interactive systems is not necessarily technological: it is not about making your online shopping experience more efficient. Nor is it about making another nice piece of hi-tech lobby art that responds to people flows through the space (which is just as representational, metaphor-

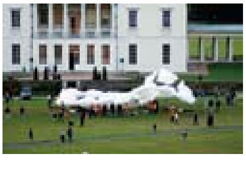


5 Sky Ear
Greenwich, UK, 2004
A glowing cloud embedded with mobile phones listens for electromagnetic waves in the sky.

encumbered and unchallenging as a polite watercolour landscape). It is about designing tools that people themselves may use to construct (in the widest sense) their environments and thus to build their own sense of agency. It is about developing ways to make people themselves more engaged with, and ultimately responsible for, the spaces that they inhabit. It is about investing the production of architecture with the poetries of its inhabitants.



6 Calling Sky Ear
A spectator calls in.

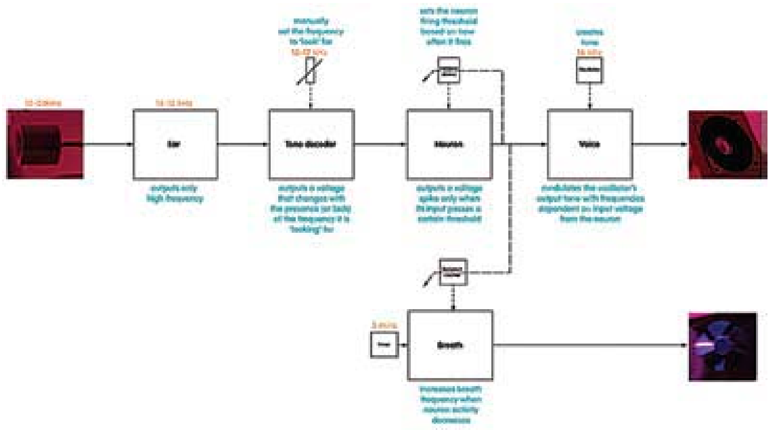


7 Before the launch

Haque Design + Research

To this end, I briefly discuss below some architectural experiments by Haque Design + Research concerned with some of these ideas.

Sky Ear was an experiment to develop a system that responded in realtime to input from people, from the environment and from electronic devices. It consisted of a floating carbon fibre cloud of 1000 helium balloons, electromagnetic sensors and mobile phones that drifted above a park in London, in 2004 <http://www.haque.co.uk/skyear.php>. The purpose of the cloud was twofold: first, to provide a complex network of distributed sensors responding to electromagnetic fields, and second to explore how an "audience" might explicitly become a creative "participant" in the event by being encouraged collaboratively to affect the sensors that they would otherwise be merely observing. The cloud was both a sensor system, responding to electromagnetic waves generated by mobile phone calls, and an actuator, producing electromagnetic fields itself.



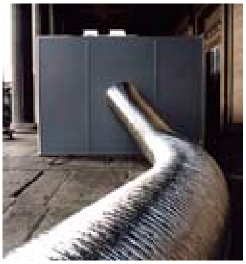
8 Evolving Sonic Environment Diagram

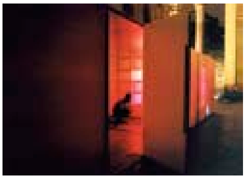
9 Evolving Sonic Environment
An interactive environment that builds up a representation of its ihabitants through a network of autonomous communicating sensors. Presented at Threshold '06, E:vent, London; Emocao Art. ficial - Cybernetic Interfaces, Sao Paulo, Brazil; and NTT Intercommunication Centre, 2006.

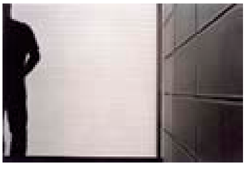
Next is a pair of projects undertaken to understand perception: while the first explores how we perceive space, the second explores how a space might perceive us. *Haunt* (a collaboration with anomalistic psychologist Professor Chris French) involved measuring electromagnetic patterns, infrasonic frequencies and temperature and light conditions in supposedly "haunted" spaces and then recreating these phenomena in a "neutral" space in order to determine how people constructed, psychologically, a haunted space from these given phenomena <http://www.haque.co.uk/haunt.php>.

Taking the opposite approach, in *Evolving Sonic Environment* (a collaboration with Robert Davis, specialist in artificial neural networks) we built a "spatialized" neural net into which people could actually enter, walk around and affect through their movements and occupancy patterns <http://www.haque.co.uk/evolvingsonicenvironment.php>. The system was composed of a society of autonomous devices, functioning analogously to the neurons in our brains - not intelligent in isolation, but behaving collectively in such a way that we can begin to infer different properties in their outputs. Learning circuits in each device enabled them to adapt over the long term to different patterns of occupancy so that after a while the society of devices collectively developed their own perceptual categories of "occupancy" that were not explicitly programmed, and which therefore did not necessarily correspond to human-determined patterns of occupancy.

Finally, *Paskian Environments*, a collaboration with cybernetician Dr.





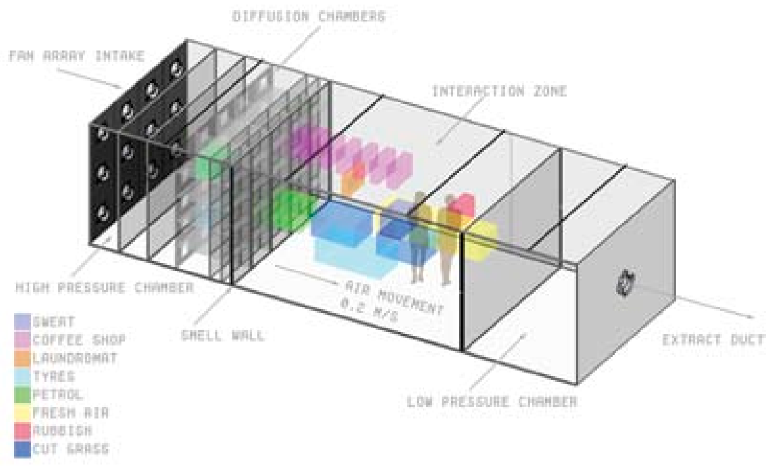


10 Extract duct

11 View through the entrance

12 Scent diffusion wall

13 Olfactory-visual coordination



14 Diagram, *Scents of Space* Installation, with Josephine Pletts and Dr. Luca Turin

Paul Pangaro, will consolidate the approaches of *Haunt*, *Evolving Sonic Environments* and *Sky Ear* (i.e. it will build upon what we now understand about humans perceiving environments, environments perceiving humans as well as the participative role for non-designers in designed systems) and broadly explore Gordon Pask's Conversation Theory in the context of architectural constructs. The intention in this project is to take interaction algorithms from Pask's past projects (which importantly are context-independent) and apply them to the construction of a dynamic large-scale environment. Sited in a building in London, England, the Paskian Environment will be partly multi-modal installation, partly event-oriented performance and partly interactive environmental construct, encompassing both internal and exterior spaces. We are particularly interested in working with existing systems of the building (facade, internal/external lighting, information management, wayfinding) and unused spaces (dead-end corridors, locked courtyards).

With these projects we hope to get closer to the goal of authentic multi-loop interaction in actual built architectural projects, forsaking the easier route of creating merely "reactive" works.

Notes

I would like to thank Dr. Paul Pangaro for his comments during the preparation of this article. This article was first developed for publication in *AU: Arquitetura & Urbanismo*, no. 149 (August) 2006, Brazil.

1 Pask, Gordon (1976). *Conversation Theory, Applications in Education and Epistemology*, New York: Elsevier.

15 Sky Ear

Contributor biographies

Philip Beesley
University of Waterloo

Philip Beesley maintains an experimental practice that combines architecture, sculpture and performance. His hybrid art-architecture installations have developed a distinctive body of work involving geotextile fields and interactive environments, while his built works include a series of schools, theatres and community facilities. His creative work has been recognized by the Prix de Rome for Architecture (Canada), a Governor-General's award, a number of Ontario Architects Association Awards of Excellence, and two Dora Mavor Moore Awards. In parallel with his practice, he is an Associate Professor at the University of Waterloo School of Architecture as well as the Fabrication theme leader for the Canada Design Research Network and co-director of the Waterloo Integrated Centre for Visualization, Design and Manufacturing (ICVDM), a high performance computing centre. Publications include *Fabrication: examining the digital practice of architecture* (AIA/ACADIA 2004), *Responsive Architectures: Subtle Technologies* (Riverside Toronto 2006), *Future Wood* (Riverside, 2006), *Mobile Nation* (Riverside 2007), and the forthcoming *On Growth and Form: organic architecture and beyond* (Tuns Press 2007).

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Sarah Bonnemaison
Dalhousie University

Sarah Bonnemaison holds architectural degrees from Pratt Institute and Massachusetts Institute of Technology, and a Ph.D. in human geography from the University of British Columbia, with a thesis on the bicentennial commemoration of the French Revolution in Paris. An associate professor of architecture at Dalhousie University in Canada, her research areas include cultural landscapes, temporary urbanism, lightweight and tensile structures and experimental form-finding. Her book, *Architecture and nature: creating the American landscape* (Routledge 2003), won the 2005 Alice Davis Hitchcock Award from the Society of Architectural Historians. She is currently working on a co-edited book about installations as a form of architectural inquiry.

http://architectureandplanning.dal.ca/architecture/visitors/faculty/bonnemaison.shtml

Carole Collet
Course Director, MA Textile Futures, Central Saint Martins College of Art and Design
Associate Director of the University of the Arts Textile Futures Research Unit

Carole Collet is trained as a textile designer and is a consultant in the area of textile print, R&D, sustainable design, and intelligent textiles. Her current research *Poetic Textiles For Smart Homes* explores the new technologies of intelligent textiles and new materials, together with more traditional and low-tech methods of textile production to generate new hybrid designs in which sustainable values underpin both the design process and the design outcomes. The project aims to map out new possibilities for textile to take a leading role in redefining our intimate and emotional relationship with "smart homes". Carole is currently leading the Nobel Textiles project (sponsored by MRC UK) which links Nobel laureates to leading textiles and fashion designers. Her work has been exhibited at the Science Museum and the V&A in London and she has contributed to conferences worldwide.

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Robert B. Gorbet
University of Waterloo

Robert Gorbet is an Assistant Professor of Electrical and Computer Engineering at the University of Waterloo, with cross-appointments to Mechanical Engineering and the School of Architecture. He holds BASc (1992), MASc (1994) and PhD (1997) degrees from the University of Waterloo. He is also a practicing technology artist, and has exhibited technology-mediated works internationally since 2002, in collaboration with artists, designers and architects. He is an award-winning instructor, teaching courses in professionalism and ethics, microcontroller interfacing, robotics. In 2004 he helped develop Technology Art Studio, a course combining engineering and sculpture students in interdisciplinary project groups to create technology-mediated sculptural works.

http://ece.uwaterloo.ca/People/faculty/gorbet.html
www.gorbetdesign.com

Usman Haque

Director, Haque Design + Research

Usman Haque creates responsive environments, interactive installations, digital interface devices and mass-participation performances – encompassing the design of physical spaces and the software and systems that bring them to life. Until 2005, he was a teacher in the Interactive Architecture Workshop at the Bartlett School of Architecture in London. The recipient of numerous awards and prizes, he has been an invited researcher at the Interaction Design Institute Ivrea, Italy, and an artist-in-residence at the International Academy of Media Arts and Sciences, Japan. He is a recipient of a Wellcome Trust Sciart Award, a grant from the Daniel Langlois Foundation for Art, Science and Technology, the Swiss Creation Prize, Belluard Bollwerk International, the Japan Media Arts Festival Excellence prize and the Grand Prize Asia Digital Art Award. Haque Design + Research specialises in the design and research of interactive architecture systems. Architecture is no longer considered something static and immutable; instead it is seen as dynamic, responsive and conversant.

www.haque.co.uk

Loop.pH

Rachel Wingfield and Mathias Gmachl

Loop.pH is a design and research group that aims to bridge the gap between design and the natural sciences. They specialise in the conception, construction and fabrication of environmentally responsive textiles for the built environment. It is directed by Rachel Wingfield and Mathias Gmachl. Rachel is also a Senior Lecturer with the MA Design for Textile Futures and a Research Fellow at Central Saint Martins College of Art and Design in London. Mathias is a Research Associate at the Royal College of Art in London. Loop.pH belong to an emerging generation of designers redefining conventions of how, why and with what things are made. Emphasis is placed on learning from both traditional craft based practices alongside the cutting edge of scientific and technological discovery. With a deep understanding of the complexity of ecological systems and natural cycles their approach to design and fabrication values the physical process of making as much as new and established research methodologies and theories. Rachel and Mathias are currently working on a residency at the Royal Botanical Gardens Kew and Queen Elisabeth Hospital in London. They will exhibit at the Museum of Modern Art, New York, in early 2008 and continue collaborating with Nobel Laureate John Walker on the project *Metabolic Media*.

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Christine Macy

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Christine Macy is a professor of architecture at Dalhousie University in Canada. Her research work focuses on the representation of cultural identity in architecture, civic infrastructure, and ephemeral architecture. A graduate of UC Berkeley and MIT, she practiced for a number of years before establishing Filum in 1990, a research-based design office focusing on the form-finding and fabrication of ephemeral and tensile structures. A frequent contributor to *Canadian Architect*, her books include *Architecture and nature: creating the American Landscape* (Routledge 2003) which received Alice Davis Hitchcock Award from the Society of Architectural Historians in 2005; and the forthcoming *Festival Architecture* (Routledge 2007), and *Dams* (Norton 2008).

http://architectureandplanning.dal.ca/architecture/visitors/faculty/macy.shtml

Mette Ramsgard Thomsen

Royal Academy of Fine Arts

Mette Ramsgard Thomsen is an architect working with interactive technologies and an Associate Professor at the Royal Academy of Fine Arts in Copenhagen, where she leads the Centre for Interactive Technology and Architecture [CITA]. Her research focuses on the conceptualization, design and realization of spaces defined by physical and digital dimensions. Her work has received funding from the Arts and Humanities Research Board of The Arts Council, UK; and the Research Academy and Arts Foundation, Denmark. She has been a research affiliate at the Fraunhofer Institute, Germany; the Human Interface Technology Lab, University of Washington; and taught at the Bartlett School of Architecture and the Department of Computer Science of University College London and at University of Brighton, School of Architecture and Design. She has led workshops in Ahmedabad, Amsterdam, Aarhus, Barcelona, Bonn, Braunschweig, Calcutta, Copenhagen and Seoul.

http://cita.karch.dk

Conference credits

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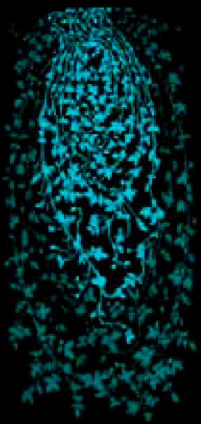

With essays by

Philip Beesley and Robert Gorbet
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