

## AUGMENTING PUBLIC SPACES WITH LIVE FORMS AND FABRICS

*Integrating mechatronics and textiles to provoke social interactions  
in public spaces*

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**Abstract.** The research reported in this paper aims to investigate the potential of integrating live forms and fabrics to enable social interactions at existing public sites as a brief for a transdisciplinary student design project. Through the use of flexible and modular design and fabrication methods, mechatronics, and smart materials and textiles, existing public sites were augmented with interactive installations by groups of students coming together from multiple cognate design disciplines spanning public art to engineering and including textile design.

**Keywords.** Interactive architecture; textiles; microelectronics; full-scale prototyping; public space.

### 1. Introduction

*“Each person, withdrawn into himself, behaves as though he is a stranger to the destiny of all the others. His children and his good friends constitute for him the whole of the human species...And if on these terms there remains in his mind a sense of family, there no longer remains a sense of society”* (de Tocqueville, 1840).

The problem of the ‘Fall of Public Man’ (Sennett, 1976), linked particularly to the competitive, status-anxious, capitalism of the new world was the social contextual problem presented to stimulate experimental intervention in the public space by students. Combining textile and information technology we sought to make this representative of the hybrid nature of contemporary public meeting ground. In the world today, there is a new public space that is substantially virtual – Facebook,

internet blogging, Twitter but still significantly dominated by individualism and projection of the self. But there is potential to turn the same technology to more collective ends, confronting issues such as carbon and climate change that demand a broader basis for collective interaction.

As social networking and its relationship to recent political events in the world show, ubiquitous computing offers some new opportunities for linking people to one another and linking people to all sorts of data. This could be gathered aggregated data, or real time local data collected through sensing technology, or crowd-sourced social data input via mobile devices etc. The advent of cheap and easily accessible microelectronics that no longer require specialist knowledge or expertise to deploy them, smart-materials, from light and heat responsive pigments to embedded electronics, and new textile design technologies present an interesting palette to novice designers looking at the potential to augment the social space in virtual and material ways. Textile practitioners are combining digitised techniques with traditional 'analogue' versions, and using new materials to create pattern and form that are beyond the merely decorative (Braddock Clark and Harris, 2012).

We targeted the design and development of prototypes, which are innovative, functional, interactive, and responsive, in order to retrofit and reactivate existing sites that were considered "dead". The project, delivered in an 8-week intensive studio that addressed the interaction between people sharing public space, their interaction with the wider community and with concealed activity such as ambient and artificial flows and events within the city. It posed the question of how textiles, computing, communication, sensing and actuation could be retrofitted to the visionary city of the immediate past to foster concurrent interaction in physical and virtual public space.

The investigations were performed through a studio, involving 35 students from six different design disciplines – architecture, landscape architecture, interior design, industrial design, textile design, and public arts – and a team of teaching staff and tutors with backgrounds in architecture, computer science, arts, textile design, and mechatronics. Students learned to design and construct architectural models using digitally fabricated models and woven, knitted, or printed textiles, embedded with smart materials. Integrated with sensors and actuators connected to embedded microelectronics, these architectural models were to respond to or interact with the changing environment or users.

This paper presents a discussion of three of the seven different prototypes that were proposed and tested during the studio. The public were given the opportunity to test the prototypes in the street over several days.

## **2. Methodology**

The methodology sought to engender a genuinely trans-disciplinary design research space. The fundamental components were generative design, mechatronics, textile

design and smart (use of) materials. There was a broader aim to locate the design activity socially, historically and in the contemporary application of technology in design.

The trans-disciplinary design learning was first organised around introducing textile design and responsive materials. Textile fibres offer a variety of unique appearances and qualities such as translucency, colour, patterning effects, and surface texture and tactility (Salim et al., 2012). With the development of new textile fibres, such as blended fibres, microfibers, and nanofibres with high strength, low weight, and better performance than conventional materials (Horrocks and Anand, 2000), it is now possible to use a textile to achieve a structural function as well as aesthetic quality. In addition, by combining textile materials with non-textile such as sensors, actuators, processors, and microsystems (Jayaraman et al., 2006), and hybrid materials, such as microelectronic components and conductive substrates, fabrics may no longer be passive, but instead have the capacity to monitor and interact with individuals and their environment. This suggests that surface, structure and form are becoming more interconnected, interdependent and interactive, and for innovative design solutions to emerge, designers need to work beyond the traditional boundaries of their disciplinary areas (Underwood et al., 2009).

Therefore, to enable trans-disciplinary design learning in this studio, the lectures were wide ranging, from introduction to textile design and smart materials, responsive and interactive architecture and design engaging mixed reality to theoretical introduction to the history of the utopian city, the specific social and architectural history of the site. Guest lecturers introduced mechatronics, multi-criteria optimisation for performance design (the design and prototyping of the electric racing car), interactive architecture (the design and prototyping of the Aegis Hyposurface). The skills offerings were equally catholic with the expectation that the group members would naturally specialise within the group and self select which activities to focus on. Thus most participants were given support to learn parametric modelling using Grasshopper ([www.grasshopper3d.com](http://www.grasshopper3d.com)) and Yeti ([www.yeti3d.com](http://www.yeti3d.com)), to work with Arduinos ([arduino.cc](http://arduino.cc)) and Firefly ([www.grasshopper3d.com/profile/firefly](http://www.grasshopper3d.com/profile/firefly)), and other simple programming protocols while the textile participants focused specifically on textile based technologies.

Following the first week when the students developed individual conceptual proposals in order to 'market' their ideas to the whole group, the design was carried out in groups, each with a representative from every discipline. The textile representatives led many of the early concept discussions. They brought samples of novel two and three-dimensional textile weaves and knits to the class along with precedents for smart material development. This extended the group thinking in terms of the material performance component of their designs. To accommodate the focus of and demands of all the disciplines engaged, the groups were also

briefed to consider the project from a top-down perspective and develop a master plan for the whole of the streetscape to be engaged as the site. The material-driven bottom-up thinking and top-down master planning were engaged in parallel.

### 3. Projects

In this paper we explore three of the seven projects in greater detail as the basis for evaluation of the success of introducing textiles as a tactile medium with which to achieve the social interaction ends through a digitally enhanced public space.

#### 3.1. GROUP 3: "IN-BETWEEN" ORGANIC ROBOTICS

The "*In-between*" *organic robotics* project examined the integration of textiles and technology as a platform to encourage social interaction through a sensory experience. It used soft shell architectural membrane to create a sense of protective intimacy and encourage the user to actively engage with their surrounds through touch and sight. The space represented "our lived memories, imagination, fantasies and dreams" (Group 3 et al., 2011).

The skin of the space is made up of multi-layered materials. The outer surface is a highly elastic fabric, printed with a pattern of organic line-work referencing a biological system. The fabric's fine gauge jersey knit construction enables a high degree of stretch and recovery, semi transparency when stretched, creating a dimensionality of shadows cast by the opaque line-work and the fine lace-like lattices that were laser cut from the same flexible knitted material and layered within the structure's walls. The pattern was printed on both sides of the fabric, so that the pattern appears to float across and through the surface moving in and out of focus. The sensory experience is further heightened through the use of thermo-chromic pigments. At 30 degrees and above, these heat-sensitive pigments lose their colour, so when the user touches the surface the pattern dissolves and leaves a momentary imprint of their presence. As the temperature decreases, the pattern again returns. Embedded in the surface are sensors that detect the users' presence and activate coloured lighting in the space through the use of arduinos.

The prototype was tested at street level (Figure 1) but conceived for an underground passage under one of the road intersections on the site (Figure 2).

This project succeeded well at engendering both intimacy and user fascination at the level of detailed interaction where the heat sensitive textile and motion sensitive lighting proved robust forms of actuation. The challenge of integrating this highly interior architecture into the public realm and tensions between public and private forms of movement and behaviour were less easy to resolve.



Figure 1. “In between” organic robotic project prototype being tested on the public street by day and by night.

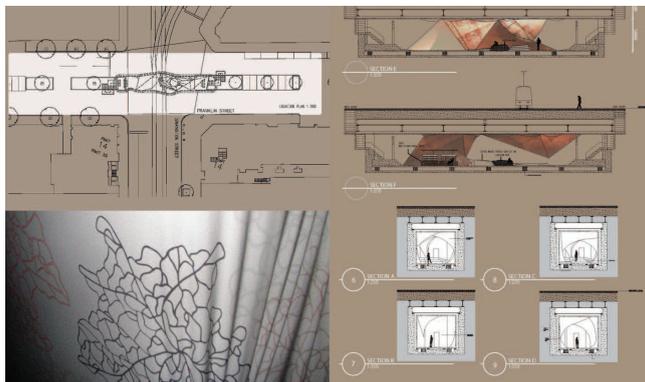


Figure 2. “In between” organic robotic project – site plan and sections showing the intention to create an underground linking tunnel to be lined in this way; heat sensitive print on surface that dissolves on contact.

### 3.2. GROUP 4: BIOMIMICRY

The *Biomimicry* project investigated the potential of a textile to act as both a form-building device and a flexible, sensor-driven model to communicate ambient environmental states.

For the installation, the initial inspiration was drawn from coral patterns and geometries, as a means of achieving an organic structure with kinetic qualities. These structures act as an agent, highlighting and distinguishing the levels of complexity within the overall system (Group 4 et al., 2011).

Initial experimentation by the textile design student developed a system of weft knitted peaks and cut-outs (voids), utilising various 3D shape knitting techniques,

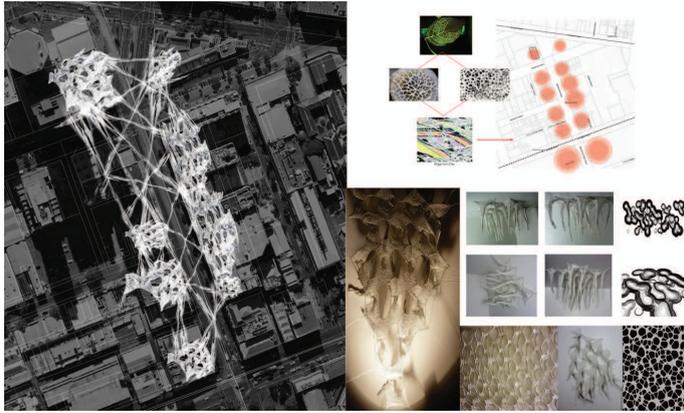


Figure 3. Biomimicry – masterplan , installation sites and textile experiments.

such as holding stitches and short row patterning (Figure 3). Being an additive fabrication process, weft knitting offers the advantage of being able to tailor (shape), through the deliberate placement of stitches and holding of stitches, complex surfaces and 3D forms using one continual thread. Such an approach enables the opportunity to explore electronics such as feeding light or fluid through a tubular “thread” in the knit.

From these knitted samples, the group then developed a series of small physical and digital models to examine the responsive potential of the knitted samples. Real time data on carbon dioxide levels and levels of other pollutants were fed to the system and calibrated to trigger the release of different coloured fluids into the tubes so that the whole knitted ‘organism’ would alter its spectral state in a way drawing on the metaphor of coral bleaching or adaptive colouring in frogs or polychrotidae.

Hand knitted, using packaging tubes as giant 50mm diameter needles, the full scale piece was knitted from one continuous length of clear plastic tubing that was both flexible and stable. The ends of the tubing were then connected to the pump to circulate the fluorescent fluid through the piece as a continuous system. A system of kiragami inspired peaks, made from lycra were laser cut in a pattern derived from self-organisation. Conceptually while the knit would festoon identified locations throughout the site it was also conceived as a social environmental statement that could grow and recede over time, inspired in part by the Croquet Coral Reef (Wertheim, 2009).

This project exhibited conceptual strength as an environmental barometer and interesting opportunities to adapt textile formats but was very challenging to realise as a full-scale prototype (Figure 4), using materials that do not conform to

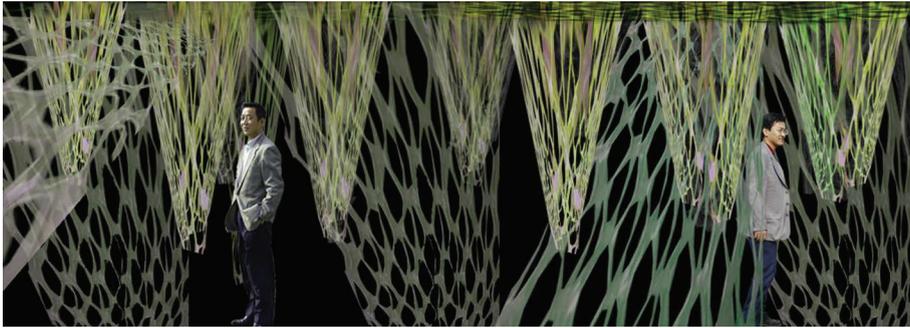


Figure 4. *Biomimicry – concept render for the full scale installation.*

existing textile technologies and missible fluids with unpredictable characteristics. It was also more difficult to evaluate public impact without installing a robust long-term intervention.

### 3.3. GROUP 7: THE TUNNEL VISION EXPERIMENT

The *Tunnel Vision* group's initial response was to collect a body of detailed information from the site. Through discussions, in the context of their precedent topics of translucency and blur, the group asked themselves 'how do we set up a public responsive intervention to blur the boundaries between sets of users?' (Group 7 et al., 2011). These discussions led the group to focus on human movement and the idea of layered, adaptive translucency. An installation was proposed with multiple layers of translucent screens that would be fixed to a minimal frame.

The patterning and graphics for the fabric panels drew inspiration from the surroundings of the site, specifically the Swanston Street Axis (the principal central axis through Melbourne) central to the site. The patterning used a geometric abstraction referencing the on-axis Shrine of Remembrance and the circular disc motif of the facing on-axis Design Hub building. The simplified geometric patterns provided an added detail to the surface, and a sense of depth and transition through the play of light and casting of shadows.

The panels being of a lightweight semi-transparent thermoplastic fabric were digitally printed, heat set and laser cut and then layered. Within the floor of the installation a system of pressure sensors were embedded using arduinos to activate servo motors to swing the translucent screens open in a 'Mexican wave' along the tunnel in response to passing footfall (Figure 5). This enabled the screens to adjust automatically to human motion detected beneath it through tracking movement. The printed patterns on the screens animate in the manner of a flipbook (Figure 6).



*Figure 5. Tunnel Vision – render of the tunnel in use.*



*Figure 6. Tunnel Vision – large scale prototype on the street showing the flip book use of printing on the fabric. Top right insert early experiments with translucent fabric.*

The challenge of actuating large swinging screens in response to pedestrian foot fall was much greater than in some of the other projects. The integration of textile printing was a powerful communication idea in the site.

#### 4. Conclusion

The challenging combination of novel textile applications with microelectronics to link ambient and external data to interactive prototypes was a very successful vehicle for a transdisciplinary design studio that engaged all the participants fully. It was also found to succeed at the level of activating the public space and engaging public participation, although the novelty of a short-term occupation and engagement may have contributed to this aspect. The students included ethnographic film studies and records of participant interaction in their research before, during and after the installation of the prototypes in the public space. The focus on textiles was a key component in the studio which drew the students from disciplines other than textiles in through early tactile concrete engagement with material systems, form and performance properties.

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