Aegis Hyposurface©: The Bordering of University and Practice

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Abstract
Throughout history, profound technological shifts have been accompanied by significant cultural changes. The current shift from a technical paradigm based on physical, mechanical production to one based on electronic media impacts on forms of architectural practice in unexpected ways. The use of design software not only enhances graphic and modeling capacity but also reveals new possibilities for both form generation and fabrication. At a more subtle level it may influence the patterns of thought and creativity that have underpinned traditional forms of architectural practice. This paper examines the implications of the redefined praxis by considering the new role of 'town and gown' in the production of the interactive hypersurface: the AegisHypersurface©, the first working prototype of which was unveiled in March 2001.

Keywords
Real-Time Animation, Interactive Architecture, Hypersurface

1 Introduction: academe and praxis

If technology is the mechanism of cultural inscription, the traditional pen or pencil is the instrument of architectural design inscription producing a literal dent in the paper that is potentially determinate and inflexible. It engenders a linear development process through the gradual refinement of ever-approximate graphics. In electronic media, by contrast, the design process is both complex and hyper-precise from its initiation. Digital design is a potentially more mutable and open-ended generative process, in an environment in which parameters rather than fixed relationships are the currency, maintaining greater elasticity throughout the process.

This shift in base psychology needs qualification. It is a shift into non-linear creative processes and constantly changing methodologies. As such, universities as centres for research are the natural laboratories for experimentation and theoretical exploration. This brings about a reversal of relationship in architecture where practice becomes reliant on the universities to solve design methodology problems in contrast to the tradition of universities educating for the methodologies of practice.

2 AegisHyposurface©

Aegis, the first working prototype of which was unveiled in March 2001 [Figure 1], was first conceived as an interactive dynamically reconfigurable surface that would respond to stimuli from the environment in real time: architecture with a central nervous system [Figure 2]. At the outset, at the beginning of 1999, this was a highly speculative endeavour. The current stage of realization has only been achieved through the collaborative participation of a very large, diverse and globally dispersed group of specialists [Figure 3].

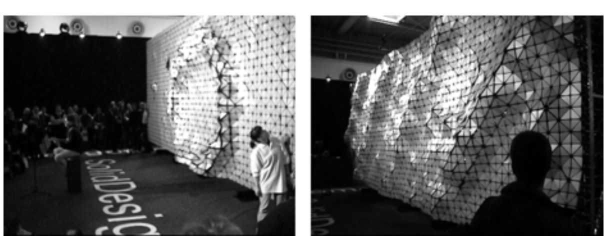

Figure 1. AegisHyposurface© in use

2.1 Conceptual Design:

A competition entry in the UK for an interactive art piece was developed over a period of weeks by a team comprising dECOi architects (France/UK), Deakin University's Prof Mark Burry and team in Australia, Dr Peter Wood, a programmer at Victoria University of Wellington in New Zealand and Dr Alex Scott, mathematician at UCL, London University. Together they devised the first interactive simulator, which allowed deployment of basic mathematical patterns across a surface through real time interface of the mouse and keyboard. This was presented to the competition jury as an interactive multimedia CD prepared by dECOi in France from the material assembled trans globally.

2.2 Hyposurface description

The project comprises two major components: a physical device and a control system. The physical device consists of a modular frame, a matrix of pneumatic pistons, a series of rubber 'squids', and

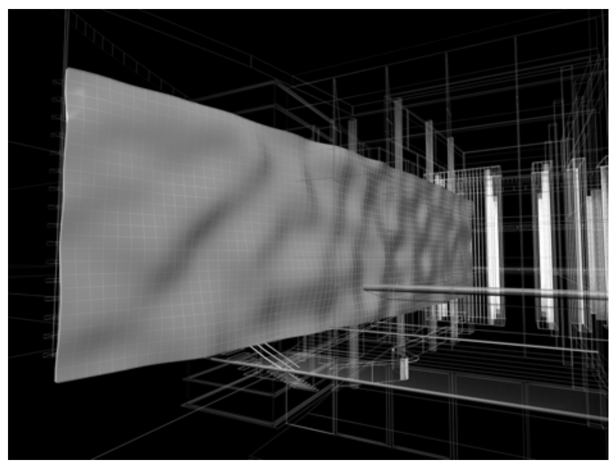

Figure 2. Early representation of the AegisHyposurface©

Figure 3. AegisHyposurface© project team and geographic distribution

a surface of bi-polar metallic facets [Figures 4 & 5]. The control system comprises a powerful computational device that connects to a bus system feeding the pistons with information. Commencement of the physical device development preceded that of the control system (in order that the actual operating constraints be fully understood), but the two aspects have essentially been developed simultaneously.

2.3 Design development: Teamwork

The period between the competition and the commission of the completed eight by seven metre hyposurface was just over two years. During this period the original dECOi / Deakin University team has continued to expand. The definition and design of each aspect of the project has engaged particular expertise. The funding of the project as an art piece has generally required that such work be treated as research rather than consultancy[1], and be directed towards researchers in universities rather than commercial groups.

Figure 4. AegisHyposurface© – behind the interactive skin

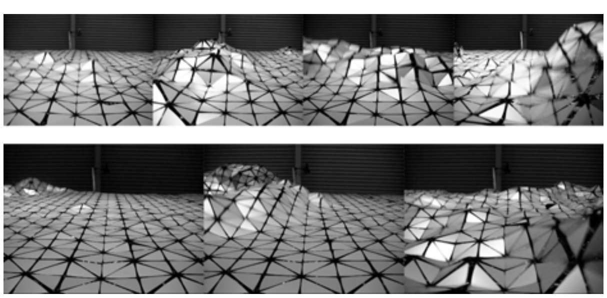

Figure 5. AegisHyposurface© – surface details

Specifically, the teamwork has required the following specialties:

2.3.1 Mathematicians

Dr Alex Scott, who first elucidated the potential and opportunities of mathematics for the project, and colleague Professor Keith Ball have contributed throughout the project, giving precision to the establishment of the base operative parameters of the system and contributing to the *esprit de corp* and narrative underpinning of the generative process [Figure 6].

Structural Engineers: Ove Arup & Partners, UK

David Glover at Group IV, Ove Arup & Partners and Sean Billings, as technical consultant were presented with the architects' brief for the dynamic surface. This called for 'considerable' deformation, a visceral effect of bodily scale, not merely surface patterning. Initially a potential displacement normal to the surface of 600mm was envisaged, later tempered to 500mm in response to the density of the pneumatic pistons allowed within the budget (currently a 250mm spacing, giving a total of 576 pistons). This precluded an elastic skin and translated to a surface that could hold its form and expand up to 200% of its planar area, suggesting a composite 'deep' surface acting like a three dimensional folded sheet. It is deformed by a matrix of actuators pressing against the valleys to open the ridges.

The problem of how such a dynamic system would behave, and how to devise a robust yet elastic sur-

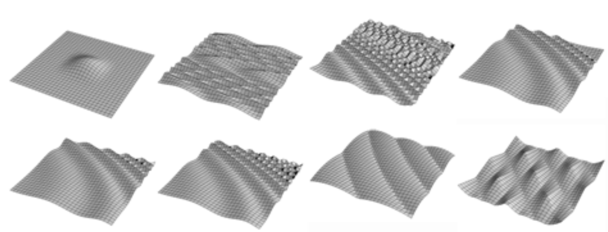

Figure 6. One of the original Mathematica surfaces/formulae

face capable of high-speed deformation stimulated a series of animated discussions and internet interrogations over a period of time. These culminated in a prototype with a facetted metallic skin, linked by a series of rubber 'squids' driven by a pneumatic piston capable of damped rotation about its base point.

By dividing the surface into the smallest possible facets, a relatively sparse grid of pistons could drive a 'fluid' metallic surface. Intermediate 'floating' facets were connected only to other facets and not to the pistons. The subsequent refinement of all aspects of the system started with a student-built full-scale prototype leading to a series of four successive piston-driven prototypes, none of which have altered the original basic arrangement. Sponsorship by a major software house has allowed development of a fifth full-scale and full size prototype for performance in a public arena.

2.3.2 Rubber Research Engineers: RAPRA & Burton Rubber, UK

dECOi architect(e)s approached RAPRA (UK), the rubber research group with their first design for the squid. This is the rubber device conceived during the initial discussions with Ove Arup engineers, by which the 2-dimensional thrust of the pistons is translated to the 3-dimensional 'fluidity' of the metallic surface. RAPRA made a series of design-developed prototypes for physical testing. This was done by injection-moulding rubber into custom-built, heavy steel moulds under high pressure. Different specifications of rubber were tested for flexibility and durability. Having determined the basic specification, the rubber moulding was taken over by a commercial group, Burton Rubber and a series of different moulds have been developed that not only allow flexible movement to the facets but also protect them from clashing with one another by protecting their edges.. The current 'squid' is the fourth prototype.

2.3.3 Adhesive Research Engineers: Locktite (Spanwall & Univer)

The most vulnerable aspect of the device is the connection between the rubber squids and the metallic facets as this requires a joint between anomalous materials that is malleable in three-dimensions and subject to quite severe tensile stress. Metallic-veneered rubber facets allowing for a rubber-to-rubber connection were discounted for reasons of cost and weight.

In the early prototypes a mechanical connection was attempted by stud-welding a connecting rod to the rear of the facets, which crimped over a metal pin cast into the tips of the rubber legs of the 'squids'. This produced difficulty in manufacture, giving inaccuracies that caused the facets to clash during operation. The welds failed before the rubber.

The solution adopted as a result of the research of first Spanwall, the facet manufacturer, and subsequently Univer, was to use specialist superglue to adhere the metal directly to the rubber. In this instance the rubber failed before the glue joint in testing to destruction. Locktite (UK) experimented to establish the most effective adhesive and surface preparation. Their research also led to modification of the squids and facets to increase the contact area and reduce build-up of local stresses.

2.3.4 Pneumatic Engineers

Electronic actuators were the first idea for a system to drive the hyposurface, attractive for the precision with which they can be controlled. However, the robust reliability, speed and relatively low cost of a pneumatic system made the latter the final choice. Univer Ltd as a manufacturer of high quality pneumatic systems with expertise in automated control systems has been instrumental in developing all aspects of the basic mechanical operating system. They assembled the series of prototypes of the physical device and orchestrated lengthy empirical testing to establish performance potential at every stage. Each increase in scale was accompanied by a huge jump in the demands placed on the system inputs. At present there is capacity to operate up to 1800 pistons at a frequency of about 3hz, waves propagating at speeds of up to 25m/sec.

2.3.5 Electronic Engineer

Essential to the vision, the piece must operate as a real-time calculating device, responding to events happening in the immediate surroundings by triggering an open-ended series of mathematical formulae. The device demanded a sophisticated control and bus system, surpassing the capacity of standard program control units, to be able to operate at all. The demand for real-time calculation added a further requirement for high-performance number crunching.

2.3.6 Mechatronics Engineers

Saeid Nahavandi and Dr Abbas Kouzani at The School of Engineering and Technology, Deakin University (Australia) brought their knowledge of information systems in robotics to bear on the design of the control system. They have designed the system to a performance specification that demanded information be supplied to each piston every 10 milliseconds. Initially they were not certain that this could be achieved, but they have attained a final operating speed of between 10 and 14 milliseconds. Most remarkably, this has been achieved within a highly constrained budget. The control system weighs 750kg, which gives some idea as to the sheer physical size of the device providing the required computational power.

Our goal had been to devise 3 operating potentials – mathematic, visual and manual – to feed information to the surface. Manual operation would allow a direct interface with the mouse and keyboard of a computer, such that one can draw or cause effects on the surface by direct interference. Mathematically based operations formulaically calculate the position of pistons, allowing complex patterns to be deployed in a highly controlled manner, which seems to offer more sophisticated control. Both of these operating methods have been attained by the control system, but Saeid Nahavandi's expertise in video recognition systems has also allowed images from a video camera to be visualized in 3D. What is at this point quite a crude 3-dimensional image nonetheless hints at the potential of fully 3-dimensional methods of representation. The control system has been devised to be open-ended anticipating the continual addition of further enhanced electronic inputs that can be harnessed to create high-speed movement [Figure 7].

2.3.7 Further Programming

Xavier Robataille has been operating between the mathematicians and the mechatronics engineers to develop a number of simulators that can be user-controlled or programmed to respond characteristically to an array of sensory devices to allow efficient and highly variable generation.

2.3.8 Method of collaboration

Given the diversity of the group and their global distribution, the Internet has remained the essential working medium allowing all manner of information in different formats to be distributed and received in real-time. This has accelerated the development of the project, and has allowed for a seamless collaboration of hitherto discrete and unassociated technical fields. This appears to be the most innovative aspect of the project, allowing a greatly expanded development potential while also highlighting the linguistic distinctions between disciplines.

3 Concluding comments

dECOi, as a practice and Aegis, as a real life avant-garde practice project have benefited from a particular university-based approach to research into digital design methodologies. From the practice point of view, 'the University' has appeared both reassured and at the same time driven to extremes of productivity by firstly, the realism of the project and secondly the presumed commercialism stemming from this. 'The Practice' has drawn reciprocal reassurance from the apparent rigour of research work and technical possibility driven beyond previously known territory. But perhaps the essential stimulant and emollient in the collaboration has been the 'otherness' of the project with all the immeasurable potential and instability that this carries.

Figure 7. Image showing the video capture system in operation

It is unlikely that this project could have eventuated within the constraints of traditional working practices. It has revealed not only something of the digital revolution's re-qualification of praxis but also the radically shifting border between practice and academe.

The geographically dispersed specialist researchers and practitioners from diverse fields whose input has been called upon, have found it relatively easy to work together through a common electronic medium, communicating through compatible software or real time video of the system in operation, for instance.

So, perhaps the most innovative aspect of the device, which certainly opens a highly original perspective on the dynamic formal possibilities enabled by information systems, is simply the revolution in creative process that it celebrates. A group of 'local' thinkers have come to understand the value and kinship of interdisciplinary partnership through the development of a kinetic art / architecture project which has invited not only exploration of the technique of art, but finally also the art of technique.

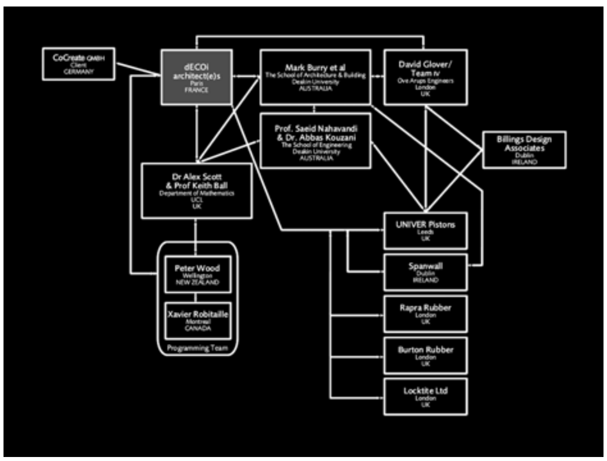

Figure 8. AegisHyposurface© project team

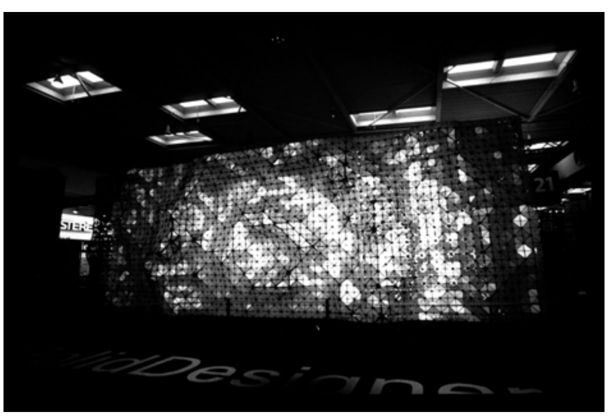

Figure 9. AegisHyposurface© – in use

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Notes

1. dECOi secured funding in 2000 from NESTA (UK) – National Endowment for Science, Technology and Arts.