ENSAYOS / RESEÑAS

ESSAY / REVIEWS

BEHAVIOURAL MATTER

MATERIAL CONDUCTUAL

MArch. Robert Stuart-Smith. Architect

(INVITADO INTERNACIONAL)

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Architectural Association School of Architecture

Lecture at the School of Architecture, University of Costa Rica, 7th August 2011 / *Conferencia en la Escuela de Arquitectura, Universidad de Costa Rica, 7 de agosto 2011.*

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Presentation

In August 2011, architects Doreen Bernath (PhD in Histories and Theories of Architecture and Lecturer at the Architectural Association) and Robert Stuart-Smith (Studio Master at the Architectural Association (Design Research Laboratory) and founding partner of architectural studio Kokkugia) visited the School of Architecture of the University of Costa Rica (UCR) to teach the workshop *Recursive Space/Introjective Architecture*. The aim of the workshop was both to discuss the relationship between architecture and digital design and to explore the possibilities of the digital as a tool of design and a tool of analysis. This is an ongoing discussion in the discipline of architecture and has created as many supporters as adversaries. REVISTARQUIS is honoured to publish a written version of the lectures that Stuart-Smith and Bernath gave at the UCR School of Architecture in the context of the workshop. The diversity in their approach is a sign of the richness of the discussion that took place in our School.

Valeria Guzmán Verri

Presentación

*En agosto de 2011, los arquitectos Doreen Bernath (PhD. en Historias y Teorias de la Arquitectura y profesora de la Architectural Association) y Robert Stuart Smith (profesor de la Architectural Association (*Design Research Laboratory*) y cofundador del estudio de arquitectura Kokuggia) visitaron la Escuela de Arquitectura de la Universidad de Costa Rica para impartir el curso intensivo* Recursive Space/ Introjective Architecture*, el cual pretendía tanto introducir una discusión sobre la relación entre la arquitectura y el diseño digital, asi como explorar las posibilidades de lo digital como herramienta de diseño y como herramienta de análisis. Este es un tema que sigue en discusión en la disciplina de la arquitectura y que ha creado tanto adeptos como adversarios.*
REVISTARQUIS tiene el honor de publicar una versión escrita de la charla que ambos académicos realizaron en la Escuela de Arquitectura de la Universidad de Costa Rica en el contexto del mencionado curso. La diversidad de enfoques es signo de la riqueza de la discusión que se dio en nuestra Escuela.

Valeria Guzmán Verri

Abstract

I am a design director of Kokkugia, an architectural design practice based in London and New York. Kokkugia operates through design, research and teaching and specialises in self-organisational processes, developing algorithmic methodologies for each design project. Our work stems from the materialist philosophy of Gilles Deleuze and his idea of the "matter-function" where we are concerned with how design intent may be instantiated into matter. Thus the role of the architect is focused on orchestrating "becomings"; determining the conditions under which the formation of matter occurs. This essentially situates design as an organisational problem, whereby design intent is instrumentalised through negotiative processes that realise a solved state in matter.

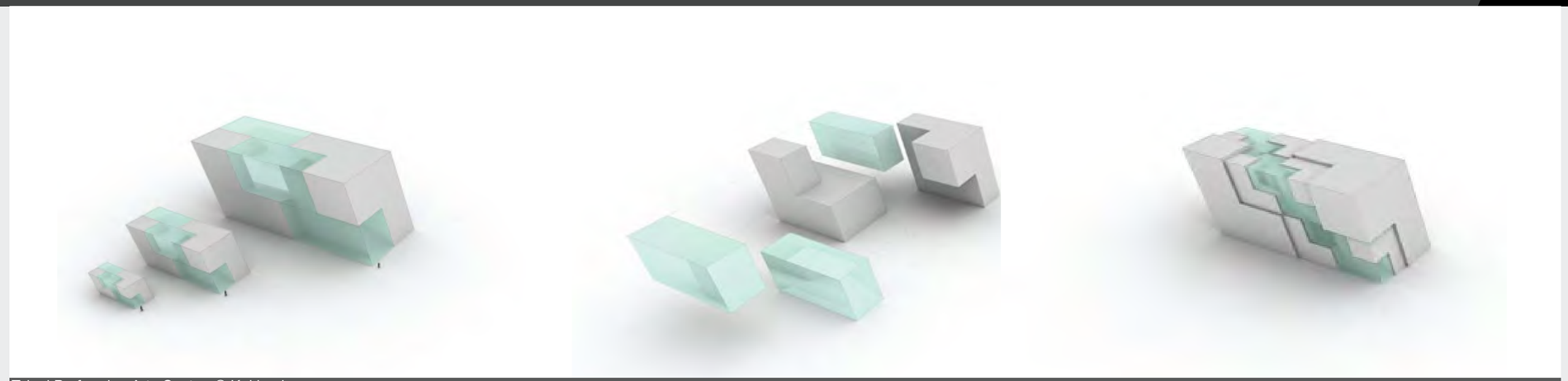
Keywords: algorithmic design, digital architecture, self-organisational design, non-linear algorithmic design methodology, body topologic.

Resumen

Soy director de diseño de Kokkugia, un estudio de diseño arquitectónico con base en Londres y Nueva York. Kokkuga opera a través del diseño, la investigación y la enseñanza. Se especializa en procesos auto-organizados, desarrollando metodologías algorítmicas para cada proyecto de diseño. Nuestro trabajo surge de la filosofía materialista de Gillles Deleuze y su idea de "función-materia," donde nos ocupamos de cómo el propósito de diseño puede hacerse materia. Así, el papel del arquitecto se centra en orquestar "devenires;" determinando las condiciones en las cuales ocurre la formación de la materia. Esto sitúa esencialmente al diseño en un problema de organización, según el cual el propósito de diseño se instrumentaliza a través de procesos de negociación que llevan a cabo un estado resuelto en materia. Así, el papel del arquitecto se centra en orquestar "devenires"; determinando las condiciones en las cuales ocurre la formación de la materia. Esto sitúa esencialmente al diseño en un problema de organización, según el cual el propósito de diseño se instrumentaliza a través de procesos de negociación que llevan a cabo un estado resuelto en materia.

I am a design director of Kokkugia, an architectural design practice based in London and New York. Kokkugia operates through design, research and teaching and specialises in self-organisational processes, developing algorithmic methodologies for each design project. Our work stems from the materialist philosophy of Gilles Deleuze and his idea of the "matter-function" where we're concerned with how design intent may be instantiated into matter. Thus the role of the architect is focused on orchestrating "becomings"; determining the conditions under which the formation of matter occurs. This essentially situates design as an organisational problem, whereby design intent is instrumentalised through negotiative processes that realise a solved state in matter.

The analogue models of Antonio Gaudi offer a precedent, as these models were more than representations of a finalised design: they were operative design models made in order to play out various design criteria within a material negotiation. The catenary curve formed by these suspended models creates optimal compression structural configurations when inverted. In these models Gaudi was able to negotiate his spatial, formal and compositional desires within a structurally operative model. This indirect design control offers even more potential today due to the development of the computer.



Taipei Performing Arts Centre, © Kokkugia

Following from some of the early pioneers of computation such as John Von Neuman and Stephen Wolfram developed simple algorithmic rules in cellular automata. These computational models demonstrate how simple rules, when played out in space, create a negotiated and unpredictable result. A lot of these rules produce periodic behaviour when run for a certain time; however some create unpredictable results, some of which are incredibly complex and rich in order. These emergent orders are non-linear, they can only be created by running the algorithm forwards, and there is no means to interpret the starting rules by looking at the results. Such algorithms may be understood as negotiative in nature, incorporating various criteria in a creative result. While the results may not be predictable, these algorithms are deterministic; containing no randomness, the same results are achieved each time the code is run, thus allowing for iterative improvement in the code, where the coder can learn from previous runs before amending and re-running the code.

An early experimental project of ours is quite a clear example of how such negotiations may be involved in design. The Mars project was conceived in order to test a design methodology that would allow a character of surface to be developed in negotiation with spatial organisation, environmental and structural forces. Intended for the first human mission to Mars, an inflatable was proposed due to its small cargo size and weight relative to its inflated size. With Mars' gravity and air pressure being less than earth's there is also an added advantage due to pressure differences, as the internal pressure would be stronger than Mars's. Following Frei Otto's experiments with soap films, the project attempted to minimise the surface tension of the inflatable and at the same time pull the envelope in various directions to fix it on the site.

The resulting surface has internal and external conditions, and embodies both the pressure difference, and surface tension it is negotiating. We could not draw or model such a result, conceptually yes, but its formation necessitated a process of negotiation algorithmically.

While the Mars experiment contained one generative process, the **Taipei Performing Arts Centre** competition utilised numerous algorithms in order to achieve the end design. The proposal utilises a podium to house the back of house and retail program, and is eroded to provide public space adjacent to a neighbouring night market. The auditoria are embedded within this and a semi-enclosed roof provides environmental regulation to the public spaces. The podium is designed through a fractal organisation that allows for a local condition of diagonal movement both in plan and section. This is implemented through a set of interlocking volumes of glass and concrete. The figure/void relationship created by the two materials is reminiscent of Dick Von Gamaren's studies of English castles and their void-void relationship that offers different spatial perceptions as an alternative to a figure-void. Safe-guarding this spatial relationship the geometry proliferates across the site at various fractal scales. As one approaches the public spaces, the large fractal scales are subdivided by smaller fractals. The auditoria interiors are designed in a similar fashion, where local subdivisions of geometry can be adjusted for acoustic performance.

The roof is developed utilising a swarm system - whose connected nodes are attached to adjacent ones with springs. Some of these are fixed to the site and podium while the rest develop a near-equilibrium rest in order to arrive at a roof formation.

Much of Kokkugia's algorithmic research has been pursued through the development of software that behaves as a swarm system, where design intent is assigned to individual autonomous agents' decisions, and their collective behaviour drives a material formation.

There are three main ways we tend to work with swarms.

Dynamic agent formations

Through agent formation, the movement of a collective, such as the flocking of birds. Craig Reynolds described how birds operate on very simple rules that govern an emergent collective behaviour. Movement here is a calculated negotiation.

Assembly

The aggregation of behavioural geometric elements in order to arrive at larger organised assemblies. Parallels could be drawn with ant bridges, etc.

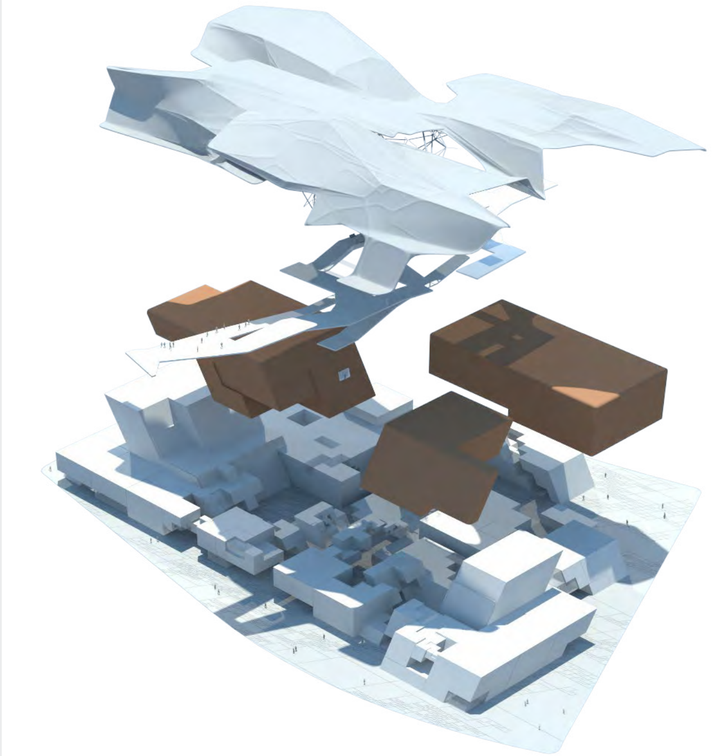
Construction

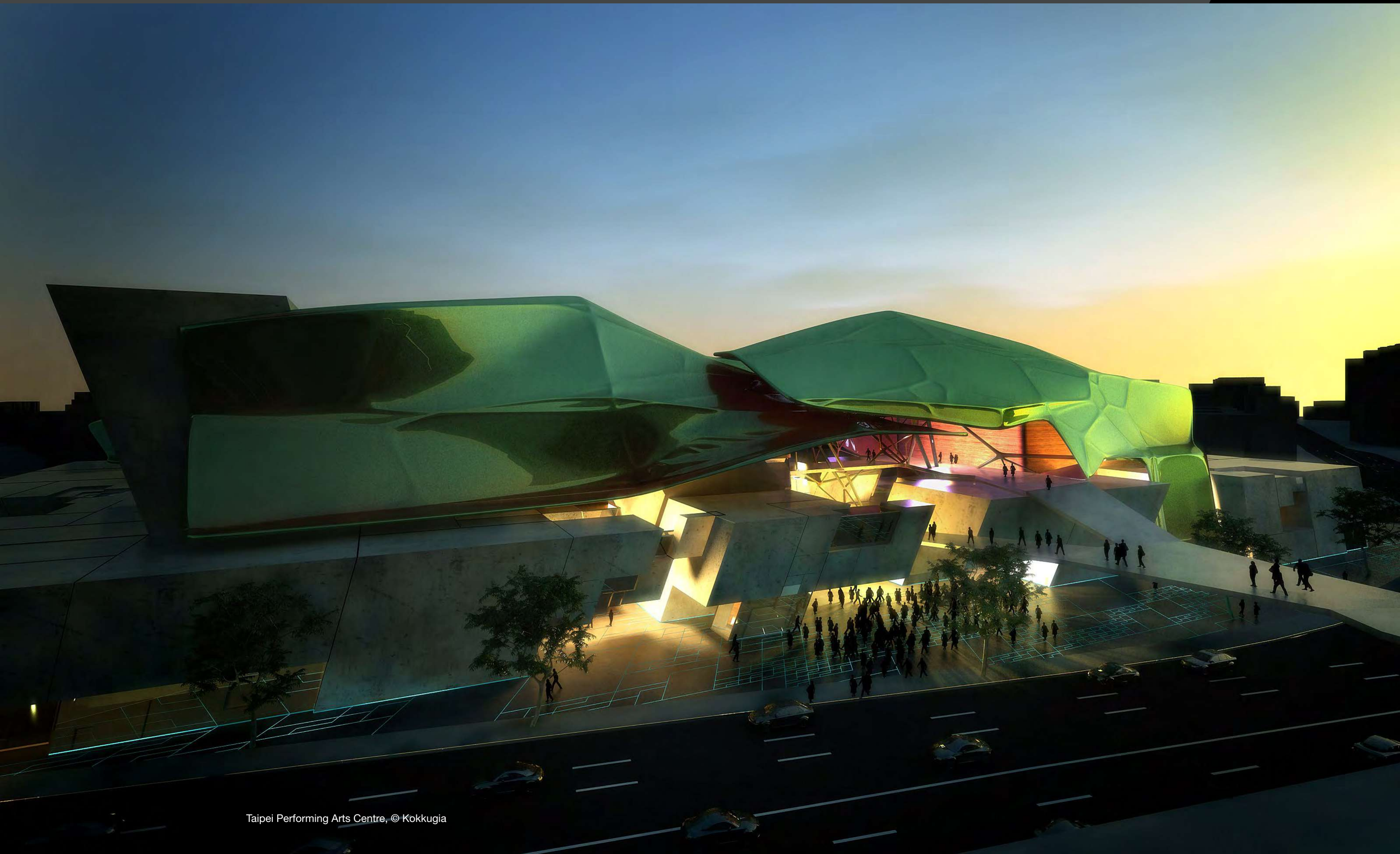
The use of agency for determining where and how matter is placed. (material (Re)distribution) This stems from the study of pheromones by such scientists as Guy Theraulaz and Eric Bonabeau. Termites are particularly famous for building sophisticated structures through simple local information. Pheromones in deposited material help inform behavioural decisions on what to build next.

In all of the above, agency develops solutions to conflicting design criteria through the emergence of a dynamic stability or a near-equilibrium condition. The non-linearity of these algorithms does not limit the number of design criteria incorporated into the solution and is adaptable to on-going inputs. The biological examples enable the explanation to be easy to perceive, but it should be clarified that our algorithms do not behave like biological systems, they are written to achieve architectural design goals - not biological simulations!

An art project called **Swarm Matter** explored how ornamental design criteria could be seeded within agency. A swarm of autonomous agents connect to each other in order to develop a heterogeneous field. The heterogeneity is not surprising, but rather the local hierarchies of scale, and symmetry that occur. The field contains continuities and singularities, and suggests the locally rich and adaptive nature of swarm systems.

Taipei Performing Arts Centre, © Kokkugia





Taipei Performing Arts Centre, © Kokkugia

These qualities offer an alternative to the modernist tectonic canon, a syntax of elements such as in Maison Domino, and point towards a more integral tectonic, where differentiation in material organisation provides possibilities at small and large scales.

A project that was to be constructed in China, **Fibrous tower**, investigated how such a material organisation could negotiate structural, environmental and ornamental design criteria within its formation. As a networked structure, the concrete exoskeleton relies on an excess of connections in order to deal with structural loading, rather than direct paths of force. The skin is topologically complex, similar in concept to an Erwin Hauer screen, allowing daylight but minimal heat gain on the facade. The structure is rather economically competitive except at key locations where the facade delaminates, creating exterior voids for outdoor break-out spaces.

A study into composite fibre structures further progressed this idea within monolithic material fabrications while KDF explored bundled assembly logics. The **Yeosu Pavillion**, undertaken as a collaboration with Tom Wiscombe's office (Emergent), dealt with how multiple materials interface and maintain their own characteristics. The composite shell structure is locally stiffened through ridges that then continue as air beams across the ETFE transparent envelope. The continuation of articulation contains its own hierarchy and is almost gothic in appearance.

Babiy yar, a Kiev memorial gallery space to the Holocaust, failed a little in these material transitions but offers a tight project by other means. Located at the end of a very sober avenue in Kiev, a monolith provides a cold heavy moment for contemplation and a strong presence. A swarm system was developed to re-territorialise the site, carving ground and flying up to carve out an atrium/void through the gallery. The monument is inverted, becoming an architectural space one can experience more so than an object. Constructed in bronze, its excess of elements reminds us of the multitude that makes up Ukraine's Jewish history and future.

Swarm Matter, © Kokkugia

Yeosu Pavillion, © Kokkugia

Yeosu Pavillion, © Kokkugia

Babiy yar, Kiev memorial© Kokkugia

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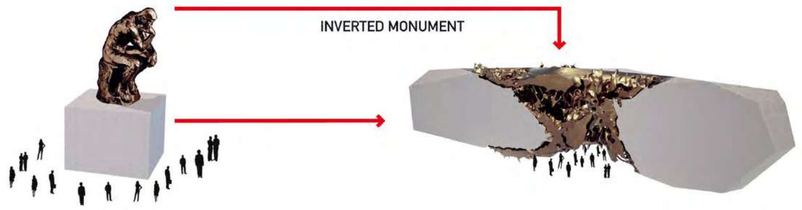
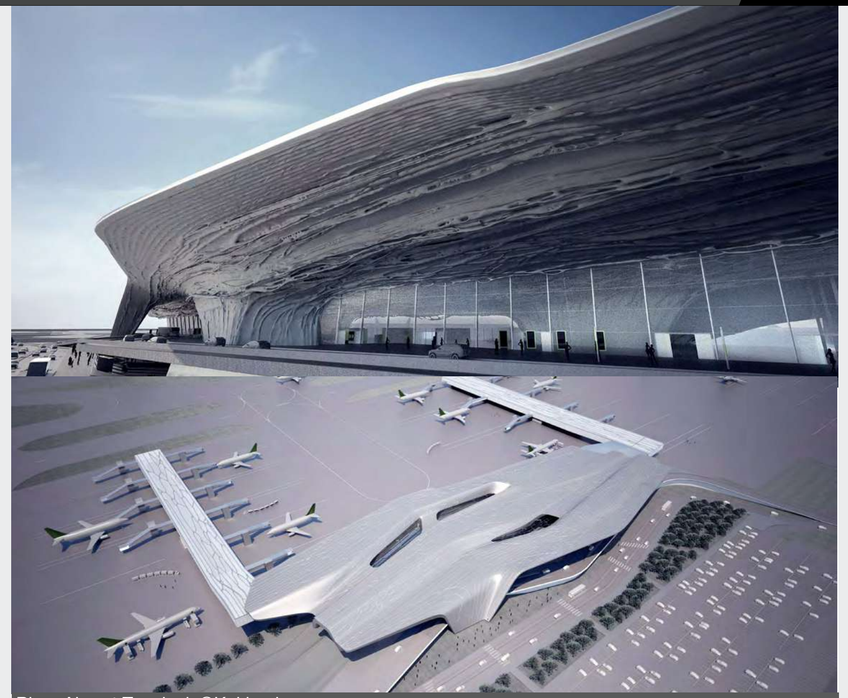
While **Babiy yar** is more ornamental in nature, the **Rigar Airport Terminal** focused on structural and programmatic issues. The terminal dedicated to Air Baltic proposed an alternative to the architectural tradition of emphasising the roof as the dominant feature of an airport. While the airport roof often receives a decent portion of the architects design energy and construction budget, it is often only experienced by those departing, and the unfortunate arriving passengers have a far less lustrous experience. Therefore, we proposed to place the design emphasis on a ceiling that could mediate these two levels. Arrival and departing passengers both enjoy the architectural features. Check-in is placed on level with arrival, and passengers then "ascend" through the ceiling in order to arrive at departures level. The project heightens the sense of the event of flying.

Collaborating with Buro Happold, the ceiling was conceived of as fibrous swarm systems that increased their number of connections in response to structural feedback. Each autonomous node knew nothing of overall structural performance, only of their individual structural analysis. By each node locally correcting itself in relation to other nodes, the roof reduced its structural performance and created a heterogeneous roof that shifts from shell structure, to truss or waffle slab configurations due to local changes in structural requirements.

We were invited to collaborate with Studio Pei Zhu for the **National Art Museum of China** competition recently. The scale of the project - a building 250m long-led us to develop a turbulent system that would evoke difference and variation in order to break the scale down and evoke Chinese cultural

Babiy yar, Kiev memorial, © Kokkugia





Rigar Airport Terminal, ©Kokkugia

references of clouds that Pei Zhu had requested. Topological manifold holes allow light down onto the podium below where public events are held. We developed an agent-based methodology that allowed for a turbulent set of movements to be created around the gallery volumes, in order to create a glazed facade and glazing structure. This same methodology also creates the landscape. In both cases, the eye registers different orders of magnitude varying distances away from the site. A chaotic order is achieved that is perceived at numerous scales. It is most identifiable in the landscape tiling.

I teach in the Architectural Association School of Architecture's Design Research Laboratory (AADRL) where I have been introducing students to the idea of agency as a topological condition of surface. **Body Topologic** ran as a five week workshop and planted the groundwork for the algorithmic logic I wanted the students to have in order to approach the studio brief.

Looking back through a number of key moments in architecture's recent history, it is clear that a number of architects seized tectonic invention for spatial design potential. A lot of Frank Lloyd Wrights' seminal work can be understood as a strategic exploration of structural cantilevers made possible

through steel and reinforced concrete construction.

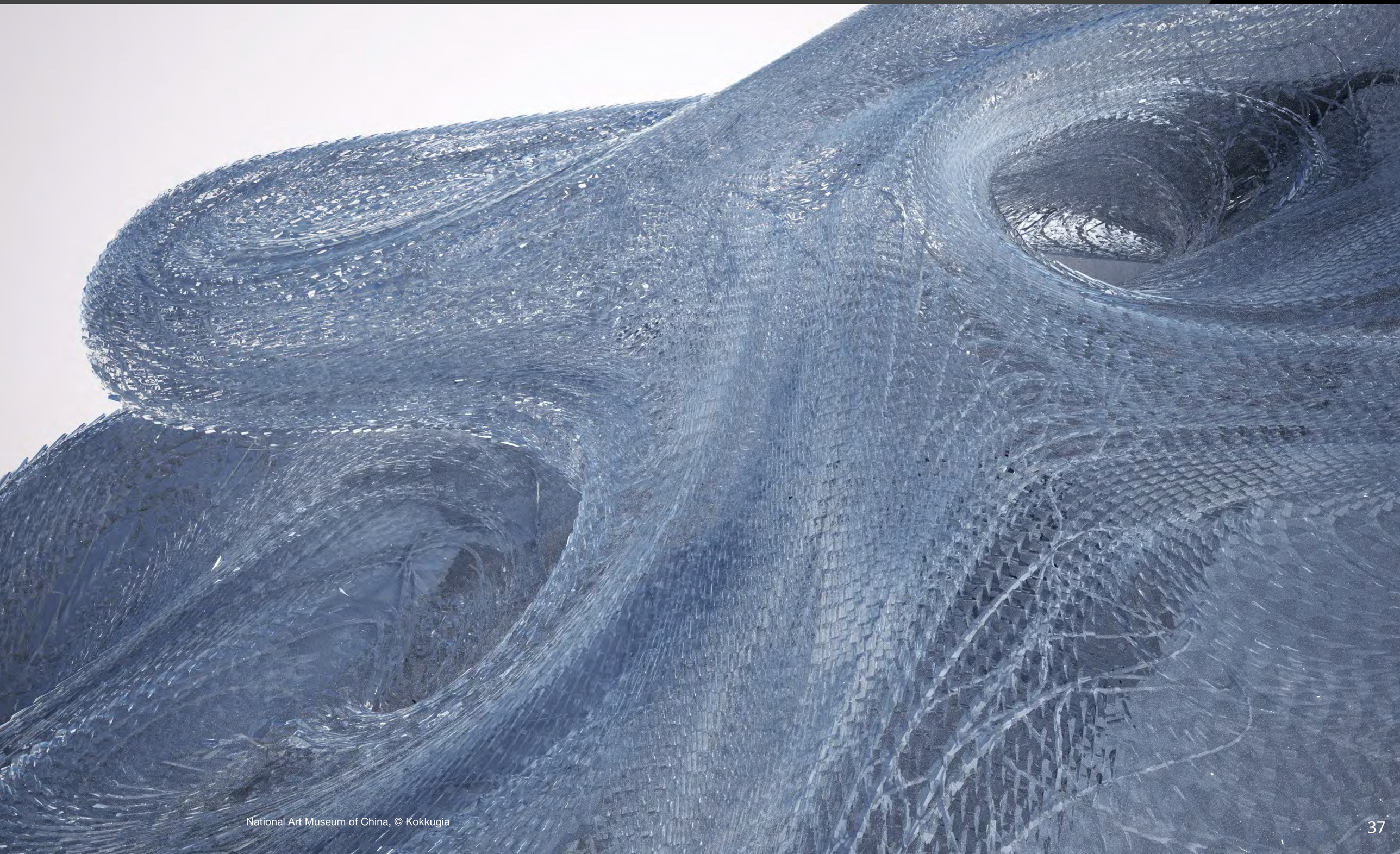
In *Behavioural Matter;* a design studio I run in the Design Research Laboratory Master Programme, we have been exploring qualitative aspects of building life-cycles through the development of non-linear processes of material organisation and temporal design affects that embrace an ethical attitude to environmental sustainability.

By writing custom software we have been able to design material organisations that offer interesting architectural design opportunities. For example, a temporal eco-resort design utilised local sand and salt in both formative and degrading processes to provide a seasonal architecture that arose from its site on the Red Sea coast, only to return to it eight months later through weathering with no external resources required - only the ability to numerically control and simulate possibilities.

Similarly, a mushroom farm was designed which seasonally produced both mushrooms and its own architecture - rendering architecture as both factory and product (possible due to phase changes that take place in the mushroom funghi - mycelia). These seasonal proposals undergo change in their design affects throughout their life-cycle. A current proposal for a thermal bath and urban park complex, utilises water erosion to transform the organisation of space, whilst creating formal, material, and ornamental changes in time. There is a constant feedback between erosion and a network of water routes creating a continuously changing micro environment that facilitates local fluctuations in building use.

Modes of production enter the domain of design via the understanding that machinic behaviour is a design opportunity - and one that must be tamed to work with pragmatic and creative criteria. One project in the studio investigates the material organisation of 3d printed bioplastics - where algorithmic investigations into topological structural optimisation facilitates spatial and material definitions of topology, grain, threshold and density for architectural affect. The project demonstrates algorithmic formative processes being utilised to negotiate the worlds of architecture, environment, and material production within one design methodology. The digital generative process which involves structural optimisation also informs algorithmic behaviours that direct the printing process in order to

National Art Museum of China, © Kokkugia



National Art Museum of China, © Kokkugia

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Such material affects also embody ornamental criteria intrinsic to the material outcome.

In Kokkugia's projects and academia, the design task focuses on organisational logics that determine spatial relationships, form and material order. Formation is seen as a the process of organising matter, at increasingly smaller scales with increasing levels of control. My academic research and teaching pursues this through the development of material fabrication systems and time-based simulations of life cycles, while Kokkugia engages in the commercial and public demands of architecture today by seeding numerous design criteria within architectural designs that are generated through non-linear algorithmic processes. These two streams operate together and I believe point to a bright future for architecture, where we engage in ever increasing dimensions of design in order to create richer architectural effects that are intrinsic to their formal and material becomings.

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Robert Stuart-Smith

Robert is a Design Director and a Founding Partner of Kokkugia. He holds a Masters in Architecture + Urbanism from the Architectural Association (AA) School of Architecture's Design Research Laboratory (AA.DRL). Robert teaches at the AA where he is a Studio Master in the AA.DRL and co-coordinator of Digital Design. He has previously taught at RMIT University (Australia), the University of East London (UK), and is an internationally invited lecturer and critic.

Robert has extensive experience in cultural, commercial and infrastructural projects, gained from working in the offices of Lab Architecture Studio and Sir Nicholas Grimshaw & Partners prior to co-founding Kokkugia. During this period he worked on projects such as the Southern Cross Station (Melbourne), Federation Square (Melbourne), Museo Del Acero (Monterrey), and Fulton St Transit Centre (New York City).

His research focuses on self-organisational systems and developmental growth, pursuing qualitative building life cycle design effects that are polyvalent and environmentally responsive. He also leads Kokkugia's consultation to Cecil Balmond on non-linear algorithmic design research.

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