DATA ECOLOGIES `07

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TIME`S UP
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http://www.timesup.org/laboratory/DataEcologies

Introduction

Here we enter the third version of Data Ecologies. A series of minisymposia that are bound together by a name that somehow manages to say a lot and nothing at the same time. But then what is the fun of having a name that explains the content from the beginning; there is no point in going to the meeting!
Data Ecologies investigates the way in which informational systems („Data") can be looked at in ways that we usually reserve for complex physical systems („Ecologies") and vice versa. Previous incarnations have concentrated upon the development of ideas in digital physics and artificial evolution, the interaction of aesthetics and information, the parallels of explanation across domains. There are many points of view with which we could interpret the ideas presented in the talks, perhaps some of them can be made clear in this introductory text.

This year we are investigating complexity in all its generality. Kirsty Kitto has recently finished a long and detailed investigation of several areas of complexity, the two main areas being artificial life and process physics, and has investigated the various models of and problems with definitions of complexity. Her investigation of complexity has led her to be interested in those problems that are defying the scientific method, in its traditional sense, and are forcing us towards new methods for investigation, modelling and analysis. One major area is the study of systems that are contextual, in that the systems adapt to behaviour in their context, or that depend upon their context for their interpretation. This is heavily related to the problems of open systems, systems that are interactive, systems that learn and adapt. How do we investigate such systems, how do we determine what a system can be, how do we limit our area of investigation so as to be able to find answers. It can be said that science, in particular the so-called „hard" sciences, are successful (in answering questions) because they choose to answer questions that are answerable. Kirsty is part of a movement within the sciences to begin to investigate questions that

are a bit outside the area of (easy, predictable, plannable,…) answers, questions where the methods to move towards an answer are not clear. She is, however, bringing along a strong arsenal of scientific tools with which these answers might be approached. One of these tools is the area of quantum mechanics, one of the major developments of the early 20th century and still a source of puzzlement, amazement and development. However the tools and techniques that have been developed are powerful and are being used on other problems, for instance the investigations of Peter Bruza into the structure of the subsymbolic layer(s) in cognitive systems. Coming from a background in nonstandard logics and cognitive science, Peter has noticed strong structural connections between the way that quantum mechanics and semantic space models behave and suggests that we may be able to investigate the development of learning in these semantic spaces at a subsymbolic level.

One point of view of importance at the meeting, though by no means central, is the recurring theme of the arts and the sciences and how they interrelate. Maja Kuzmanovic, Pix, Hans Diebner, Julie Tolmie and Time's Up in general fall within this area where the distinctions become harder to determine. After long working on the development of interrelations of the science and the arts at ZKM, Hans has developed the theories of Operational Hermeneutics and Performative Science that attempt to bridge this gap. Simultaneously Hans has been known to speak about the impossibility of bridging this gap, that the essential differences between the arts and the sciences, their motivations and techniques, cannot be broken down. One possible take on this is exemplified by Pix, a software engineer who has found himself being, on one side, a performer, an artists of sorts, while maintaining implementation/engineering skills and then finding himself confronted with the whole questions of meanings of his aesthetic investigations. The separation of engineering and technology from the two fields of the arts and the sciences is important here: too often artists think science is about algorithms and technology, scientists talk about the visuals that an

artist can produce to explain the abstract systems they are investigating. In these cases each are seeing the other in this technological corner of the triangle of arts-science-technology. Pix manages to maintain a position with both feet in technology whilst standing with one foot in the arenas of the arts and dabbling with a big toe in the sciences of complex systems (yes, he has four feet). Julie Tolmie, coming from a mathematical background, has spent considerable time investigating the communication of the complicated ideas from mathematics and other areas and has ended up coordinating part of the UK based VizNET network for visualisation. Julie's ideas about visualisation and her inclusion of the formality needed for scientific visualisation as opposed to the often beautiful but inaccurate „Artist's impression" offer another take on this bridging between the areas of sciences, arts and technologies. Maja Kuzmanovic, on the other hand, comes from a strong arts background but has no fear of the intricacies of physics and other sciences - whether she is juggling the balls of narrative or particle physics or mixed reality, the blending is smooth and coherent. This core area of interdisciplinarity is a strength of this meeting, however there will be communication problems and words with multiple, perhaps even contradictory meanings. The use of the word „interdisciplinarity" assumes the existence of disciplines as separate things in the first place; at Time's Up we like to think of ourselves an undisciplined, in the sense that we do not accept these boundaries upon the areas in which we choose to be active.

This year saw the passing away of Paul Watzlawick, one of the important members of the group that were responsible for what was called „Second Order Cybernetics." Strong interests here include the investigation of learning and how systems of learning take place, where systems adapt to situations and learn to manipulate them and, perhaps more importantly, to speak about them, to communicate. The Radical Constructivists, the group that we might put Watzlawick, Maturana and others into, talk about a nonexistence of an external reality and that all that we perceive being a

construction. These ideas have been extended by the investigations of a number of people and we are glad to welcome Bruno Marchal who has been central in the development of several ideas that formalise this so-called „Theory of Nothing" as opposed to the sought-after „Theory of Everything" in contemporary physics. Bruno's work merges with Peter's in the sense that they are dealing with the creation and development of descriptions of reality from an unstructured reality. Bruno's work ties in closely also with the process physics work of Kirsty, where she is using one particular process that produces a lot of structure including three dimensional space, while Bruno is investigating the plethora of processes that can arise and still give a coherent world, including three dimensional space.

The visualisation of processes becomes of importance here, where we attempt to get an idea of what it is that these highly abstract notions might look like, might mean. There are a large number of problems assosiated with representation. How can we even talk about the emergence of three dimensional space, how can we represent something in three dimensional space that allows the possibility of that representation not being three dimensional? A visual representation that does not allow that its image is not what we are trying to demonstrate is like a unfalsifiable statement; it doesn't really tell us anything. These problems plague the area of mixed reality, where we are taking large data sets with realtime dynamics and trying to talk about their structures. These problems are confronted again and again by groups like Time's Up and FoAM, Pix and Maja will have things to say about these problems, and this is also a major problem for visualisation in general. Kirsty has raised the point that this is possibly related to the difficulty of getting one's head around the ideas of quantum mechanics, where causality ceases to be so clear and one concentrates more upon correlations. In some sense visualisation brings together the core aspects of this meeting: how do we perceive, how do we build representations of abstract processes that utilise the perceptual facilities that we as humans have developed, how do we build representations that regard

the data set and processes not just as random number generators, how do we develop language and logics for complex semantic spaces, how can we model the intricacies of all these things?
There are a huge number of questions that arise and this meeting is by no means expecting to find answers. However the participants, all coming from highly mixed and „between the chairs" backgrounds, might be able to have several discussions that point to further developments of interest to them, to us, and to others.

I am looking forward to long and intricate discussions.

On the previous Data Ecologies `03 and `05

The original core of Data Ecologies was a plan to be able to speak about some of the subjects close to our hearts, this crossover between physical and media spaces, the virtual and the physical. In particular the ways that these things are similar without being planned to be similar, or how we build similar dynamics in a constructed environment that harmonise with the dynamics of the physical world. Simulations of physical systems, while by no means trivial, were and are not the idea we wish to follow. It has more to do with similarity of structures, partial homomorphisms if you like, between data systems and physical systems. Not just basic structures, we are interested in similarities between emergent structures based upon very different basis structures in physical and data systems.

DE03 was a small meeting with two very different days. The first day consisted of interesting talks that traced around some of the ideas of digital physics, the idea that our universe is, at the deepest level, a computational system. Karl Svozil, a theoretical physicist based in Vienna, gave a wonderful overview of the subject which helped to contextualise where these ideas arise. From the early work of Conrad Zuse, through Tom Toffoli and Ed Fredkin and including some of his own work on discrete systems with quantum properties, Karl's talk was clear and comprehensive. One of the implications in some digital physics theories is that there must be a basis structure within which these computations take place, for instance if the universe is a cellular automata, then these is a cellular structure which underlies space. Hartwig Thim, a physicist at the Johannes Kepler University here in Linz, gave a talk describing some of his work trying to observe certain properties that Einsteinian relativity, according to his calculations, should have. As a result of the nonobservation of these properties, Hartwig claims that there is evidence to suggest that there is a „preferred frame of reference" which would correspond to the basis structure within which such a cellular automata universe could run. Ross Rhodes, the person behind the digital physics website bottomLayer.com, gave a talk describing many

of his ideas about what is strange about the physical world and quantum strangeness and how this might all fit into a generally digital view of the world.

The second day of DE03 was dedicated to a workshop using the system Framsticks for artificial evolution. Framsticks, which has been developed by a small team in Poland, extends many of the ideas initiated by Karl Sims in his early evolutionary software developments, adding the capacity to look into, analyse and modify the development of the creatures in the Framsticks world. The workshop, which was mostly hands-on, investigated the various properties and capacities of Framsticks and looked at some of the options that would be available for a further development of Framsticks for its use in complex situations with, e.g. interactions with physical space.

Data Ecologies 05 was concentrated upon the 100 year anniversary of the publication of Einstein's papers that essentially overthrew the then-current consensus physical understanding. We benefited from the special RevComp session on reversible computation at the „Computing Frontiers" conference in Italy, which was immediately before DE05. We were able to attract Ed Fredkin, Tom Toffoli and Dan Miller to come directly from Italy and give their ideas on digital physics and how the whole interfacing between computational and physical worlds might be. Tom opened the meeting with an eloquent talk demonstrating ways that behaviour that we know to be very physical, e.g. thermodynamics, relativistic effects, can be found is common, everyday structures such as simple computer programs or flocks of sheep. Ed spoke about his development of the SALT model, where he has been working for many years on a general philosophy of digital systems and how they underlie our universe, and the SALT model is a description of the necessary structures needed in order to obtain physics-like behaviour in a three dimensional cellular automata. The bugbear of a preferred frame of reference and the impossibility to even discuss such a thing once again raised its head. Dan Miller presented his results where

one possible SALT model was explicitly described, but more importantly, he managed to summarise the ideas and raise the issues of how these digital physics ideas relate to gaming environments, especially those environments where the games go on indefinitely and not everything can or should be planned in advance.

We also managed to get Karl Svozil to return, he gave a completely different talk upon a subject very dear to his heart, on the question of aesthetics and algorithmics, how information theory and scarcity interrelate to inform certain ideas about what is regarded as beautiful. This talk might be regarded as one of the kicking-off points for some of the threads that inform this year's meeting, where we are interested in complexity and comprehension, perception of systems and design that associates with nature. Hartwig Thim returned and gave a similar talk as in 2003, unfortunately with less enthusiasm as he had hurt his foot. Nik Gaffney gave a talk outlining FoAM's approach to using ideas from physics as the basis for their mixed reality environment „trg" which, at that point, had been recently presented at KIBLA in Slovenia. Jürgen Schmidhuber, based at IDSIA in Switzerland, has a long standing interest in digital physics as well as various implication in robotics, artificial intelligence and related areas. His „Algorithmic Theory of Everything" is based upon the idea that there is no limit on what a computational basis for the universe might compute, so it might be thought to compute everything. Given that everything is there, what do we get? Well, somehow (and that is the tricky part) we get the result that most things do not happen, that somehow consistency and a bunch of other aspects fit together in order to give, for us at least, this universe with its regularities.

We see an increase in the complexity and density of the talks given at the two previous Data Ecologies meetings, and look forward to a further deepening this time around.

Program

Friday 20th July

10:30 Welcome and Introduction

11:15 Peter Bruza - The Quantum Mechanics of Semantic Space

13:00 Lunch

14:00 Kirsty Kitto - Complexity of Systems, Systems of Complexity

15:15 Sophia Bustorff

15:45 Hans Diebner - Data ecology or operational hermeneutics

Saturday 21st July

10:30 Maja Kuzmanovic - On growing of worlds: whole systems in turbulent environments

11:45 Pix - „What am I doing rendering fractals?"

13:00 Lunch

14:00 Bruno Marchal - The consequence of the computationalist hypothesis in the physical sciences

15:15 Julie Tolmie - Applying Multimodal Mapping, Notation and Formalism in Mathematical Microcosms

Peter Bruza

The Quantum Mechanics of Semantic Space

Recently a serendipitous and potentially far reaching connection was made: The formalisation of Quantum Mechanics (QM) shows curious similarities to a class of semantic model emerging from cognitive science. Such models have an impressive track record of replicating aspects of human information processing such as word association norms.

This talk aims to provide some initial steps to explore this intriguing connection with the goal of producing a new genre of formal and operational models of human sub-symbolic reasoning related to
information processing and retrieval. The general thrust of the underlying research is to provide the groundwork for technology, which can genuinely and reliably enhance human awareness in complex information environments.

Kirsty Kitto

Complexity of Systems, Systems of Complexity

Many of the systems in which science is currently interested can be classified as complex, and they appear to be defying the scientific method. Despite this, little work is currently being done to investigate general reasons for this failure.

One proposal, that many complex systems are in fact contextual in their responses to interaction and therefore stymie the reductive techniques of the scientific method, will be investigated. A work-in-progress interpretation of quantum theory, that it in fact describes nonseparable and contextual complex systems, will be presented, and some ways in which this might be used to model complexity explored.

Sophia Bustorff

It is a basic property of waves to create connections. Through antennas we get access to Hertzian space. One could therefore use electromagnetic waves to create wave-sculptures, real-time connections in space[time, or portals of the imaginary or liminal, that function as portals, allowing one to enter another space. Those connections can go both ways from formlessness to form and structure and back – the materialisation of the inconcrete and its opposite.

Hans Diebner

Data ecology or operational hermeneutics

To optimize society has been an early vision of cybernetics as historical examples like the CyberSyn project in Allende's Chile show. Still, or nowadays even more, a democratizing tendency is attributed to the cybernetic achievements, above all, of course, the internet and related techniques. Some people even speak of a second renaissance, indicating above all that art and science converge through the unifying power of cybernetics. No doubt, the new techniques open undreamt-of possibilities for creativity. At the same time, the goldfish bowl blogosphere, for example, with its data presented on a silver platter, is a source for system theoreticians to model the „creative processes" in society. This is not only used in new marketing strategies like viral marketing, but also utilized by artists within the fields of „Guerilla art," for example.

Interestingly, almost parallel to the evolution of cybernetics, the arts tended to integrate itself into a systemic entity. Boris Groys writes in the Modern Tate catalog on „Open Systems" (2005): „... it was precisely the radicalisation of the notion of creativity by the revolutionary avant-garde that has historically led to its integration into the 'system'. The avant-garde art saw itself as the embodiment of the pure negativity, as the medium of destruction and annulment of all traditional, mimetic, naturalistic art forms." Recent activities in system theory are the systemic description of how innovations emerge through the counter-acting influence of art. Groys' suspicion that art becomes part of the system holds in a literal way. This is why I want to promote the revival of a allegedly out-fashioned opinion by Heidegger, put into a timely expression: Cybernetics tends to Verdinglichung (reification), whereas art has the potential to twist out from Verdinglichung. In my conception derived from this point of view, „data ecology" means a negotiating practice between cybernetics and hermeneutics which I like to call „operational hermeneutics."

Maja Kuzmanovic

On growing of worlds: whole systems in turbulent environments

We can perceive the universe around us as composed of many overlapping, simultaneous realities, interconnected ecologies of worlds, in which we constantly influence their patterns and are influenced by their connections. By acknowledging this interdependence, we minimise the predominance of rigidly hierarchical, reductionist or exclusive world-views - from finding alternatives to technocratic ‚security theatre' or homogenous global consumerist culture, to proliferating biological and cultural diversity.
Whatever their shape or flavour, many of today's Earth-bound realities are slowly and often imperceptibly sliding towards pervasive environmental and social instability. In order to be able to perceive, experience, or act with these instabilities in mind, human-scale endeavours should become more in tune with ecological-scale transformations. This requires a shift from short-term, mechanistic ‚action-response' driven tactics, to long-term, systemic and environmental reflection. Thinking which enables an integrated approach to engaging with complex issues. Moving from objects to relationships, from collections to communities, from structure to process and from contents to patterns, whole systems thinking can provide fresh perspectives to current problems. This approach is based on the assumption that inclusive and participatory cultures can generate systems, actions and behaviours that are better suited to an existence in turbulent situations.

At [foam], we research the potentials for fertile ‚design ecologies' based on whole systems thinking. These ecologies should be able to entangle physical environments and digital simulations, traditional crafts and emerging technologies, artistic and scientific endeavours. They encourage proactive engagement and problem-solving from multiple perspectives. They integrate thinking and making, ethics and aesthetics, aiming to generate and integrate realities, where the ‚built' and the ‚grown' are interdependent aspects of diverse and abundant patterns of life.

pix (Steven Pickles)

„What am I doing rendering fractals?“

I will be presenting the results of my aesthetically driven investigations into polynomial strange attractors, particularly the number spaces they occupy. Existing investigations into this area tend to treat the attractors as discrete points in a vast number space, resulting in a wonderfully varied but ultimately disparate collection of bizarre shapes. My investigations suggest that these shapes exist in a continuum of smooth transitions.

My background as a computer scientist will bring two notable qualities to my talk. Firstly, a profound lack of understanding of the mathematical relevance (if any) of my discoveries. And secondly, the emphasis on the seemingly irrelevant implementation details of the software i developed to perform these investigations.

Bruno Marchal

The consequence of the computationalist hypothesis in the physical sciences

The computationalist hypothesis is the postulate that there is a level of description of myself such that „I" am unable to detect a functional substitution made at that level. I will present a simple, informal, but thoroughly deductive argument showing that IF „I" am a machine (whatever „I" means except we suppose „I" is different from the „whole physical universe", if that exists) then the observable universe, whatever that is, cannot be the result of a computational process. If time remains, I can show how to extract some empirical verifiability criterion for testing the computationalist hypothesis, and explain why quantum mechanics, without wave collapse, confirms it up to now.

Julie Tolmie

Applying Multimodal Mapping, Notation, and Formalism in Mathematical Microcosms

Mathematical microcosms are created by expressing mathematical structures or processes as multimodal objects. Not surprisingly, the resultant systems reveal structures not explicitly encoded in the mapping. This is not unlike deducing relationships from axioms; the choice of mapping creates (visual) primitives from which more complex structures can be constructed or recognised or 'deduced'.

Diverse mappings create diverse microcosms. Interrelationships between these microcosms are necessarily tight, either being explicitly defined in the multimodal mappings themselves, for example the same parameter to colour vs space vs time, or being implicitly induced across the multiple representations of the 'same' mathematics, for example between a local and global view, or a minimum dimension vs higher dimension phase space.

Notations and multimodal formalisms are required to 'read' the space. To some extent they evolve along with it and are not independent of its content. But there is also a generic element; just as reading mathematical equations is taught, reading and moving between different levels of the mappings becomes the modus operandi of the space. This is not unlike navigating and making sense of diverse game environments without explicit instructions.

The example considered is rational numbers mod 1, with a focus on the interplay between the algebraic (group structure) and geometric viewpoints. The microcosms thus created can be used to rethink anything (and any data) expressed in these number systems.

Speakers Biographies

Peter Bruza

http://homepage.mac.com/pbruza/blogsite/personal/personal.html

Peter Bruza is a professor of information technology at Queensland University of Technology, Brisbane, Australia Peter's research spans the fields of information retrieval, cognitive science, applied logic and quantum mechanics (QM). Peter Bruza was a pioneer in applying logic to information retrieval via his PhD thesis in 1993. Since then he has made theoretical contributions to information retrieval and applied logic, for example, by developing an inductive theory for information retrieval evaluation, and operational models attempting to replicate aspects of human abductive reasoning to drive semi-automated scientific discovery. In the last five years, Peter Bruza has been pioneering a line of research into sub-symbolic reasoning using semantic space models, which are models emerging out of cognitive science. In recognition of this ground breaking work he was appointed to the editorial board of the Journal of Applied Logic (Elsevier) in the area of „human reasoning". More recently he has been exploring the intriguing connection between semantic space models and QM. Together with Professors William Lawless (Paine College), Keith van Rijsbergen (University of Glasgow) and Don Sofge (Navy Center for Applied Research in AI), he is helping establish a new field „Quantum Interaction", the aim of which is to advance and apply the methods and structures of QM to non-quantum domains such as cognition, economics, artificial intelligence, information retrieval and complex systems.

Kirsty Kitto

http://www.scieng.flinders.edu.au/cpes/postgrad/kitto_k/index.html

Kirsty Kitto was awarded her PhD by The Flinders University of South Australia in 2006. Her current research interests include models of contextuality and complexity, the dynamical generation of open ended evolutionary and hierarchical behavior, and using quantum theory to model nonseparable systems. She is currently working in the School of Chemistry Physics and Earth Sciences at Flinders University as an Associate Lecturer.

Hans Diebner
http://diebner.de/

Hans H. Diebner studied physics in Tübingen. He graduated in 1994 with a thesis on exactly reversible molecular dynamics simulations. His final year project as well as the subsequent post-grad project has been supervised by the chaos research pioneer Prof. Otto E. Rössler. In 1999 he received his PhD with a doctoral thesis on „Time-dependent deterministic entropies and dissipative structures in exactly-reversible Newtonian molecular-dynamics universes." During the doctoral studies and thereafter Diebner has been research assistant and postdoc, respectively, at the Institute for Medical Biometry, University of Tübingen, with Prof. Klaus Dietz, involved in immuno-epidemiological modeling.

In 1999 he founded the Institute for Basic Research at the Center for Art and Media (ZKM), Karlsruhe, commissioned by the ZKM's CEO Prof. Peter Weibel. At the ZKM, he conceived „performative science", a methodological discourse on the inter-relationship of artistic and scientific methods as well as practical implementations in the fields of complex systems reseach based on the new performative scientific episteme. The achievements of the ZKM-period have been published in 2006 by Springer-Verlag Wien, entitled „Performative Science and Beyond - Involving the Process in Research." Since 2006 Hans Diebner continues with performative science at the Institute for New Media, Frankfurt am Main. He is deeply committed with education and endeavours to establish performative science as a (really) interdisciplinary area of studies.

Maja Kuzmanovic
http://fo.am/

Maja Kuzmanovic is a generalist interested in inciting small miracles in everyday life. She received her BA in Design Forecasting (HKU) and MA in Interactive Multimedia (University of Portsmouth). Throughout the 1990s she collaborated with scientific institutes, as well as roamed the field as an independent artist-researcher. She worked in MR, VR and online, infusing digital technologies with physical movement, narrative alchemy and audiovisual poetry. For her works, Maja was elected one of the Top 100 Young Innovators by MIT's Technology Review in 1999. She founded FoAM in 2000 and has since functioned as FoAM 's PI, eco+media artist and head chef. Her leadership skills have been recognised by the World Economic Forum, awarding Maja with the title 'Young Global Leader' in 2006.

pix (Steven Pickles)
http://pix.test.at

pix (Steven Pickles) is an Australian artist, programmer and free software developer currently based in Berlin. He has collaborated on numerous projects with groups such as farmersmanual, FoAM, selectparks and meso. pix completed his B.Sc in Computer Science at the University of Adelaide in 1999 and his generalist approach has lead to research and experimentation in numerous technical fields including sound synthesis, computer animation, visual programming, physical interfaces and embedded programming.

Bruno Marchal
http://iridia.ulb.ac.be/~marchal/

Ph.D. in Computer Science, 1998, at the french university of Lille. I'm currently a research fellow at IRIDIA, the AI lab of the Université Libre de Bruxelles. My main research interests are in the Foundation of the Cognitive Sciences, the Foundation of the Physical Sciences, and the Mind-Body Problem.

Julie Tolmie
http://www.sfu.ca/~jatolmie/index1.html

Dr. Julie Tolmie is a member of King's Visualisation Lab at the Centre for Computing in the Humanities, King's College London, where she represents 3DVisA, the 3D Visualisation in the Arts Network within vizNET, the UK Visualization Support Network. Active in the UK visualization community, Julie recently convened an expert workshop, From Abstract Data Mapping to 3D Photorealism: Understanding Emerging Intersections in Visualisation Practices and Techniques (June 2007), funded by the AHRC ICT Methods Network, as a follow up to vizNET 2007 (www.viznet.ac.uk/viznet2007/). During 2006, she initiated a joint KCL/ACL project, combining the TimeMap/Heurist environments to map visualisation research networks, and subsequently refined this approach to map FP6 EU projects in cultural heritage across different calls and funding programmes. In 2005, Julie extensively mapped and analysed the relationships between more than 300 game design patterns identifying trends that were not apparent to their authors. Julie holds a PhD in Mathematical Sciences from the Australian National University (2001) with a focus on abstract visual notation in mathematics. Prior to moving to Europe, she held a faculty position in the School of Interactive Arts and Technology at Simon Fraser University in Vancouver (2002-2005) where she focused on 3D stereo visualisation of particle systems. This research direction had begun in Paris where she worked at Institut Henri Poincaré (2000-2001) making mathematical images and animations for MathImage, Université en Ligne and Centre Emile Borel. In the 1990s she spent almost 10 years working at the Australian National University as a mathematics and statistics adviser as a result of which she developed exceptional expertise in explaining and translating research questions and models across all disciplines. During this period she also taught in a graduate seminar on mathematical structures for computer art and computer music composition at the Australian Centre for the Arts and Technology and her subsequent work has been exhibited in Australia, Canada, France, Hungary and the Netherlands.

This symposium is a part of gRig, the Guild for Reality Integration and Generation, a project supported by the European Union as a part of the Culture 2000 Program.

http://grig.info