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Brad KLIGERMAN and Jamil MEHDAOUI

## Genetically Modified Spaces

Art, Architecture and Territory  
The Fabrication of a Wave in Venice's Lagoon

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**Abstract** The invention and deployment of an experimental infrastructure for the fabrication of tangible, interactive spaces built from *immaterials* and confronting a territorial multiplicity, Venice's Lagoon. Influenced by innovations in persuasive computing and transitive materials, they inform its development and offer it credibility as a sustainable and interactive alternative for the contemporary built environment. a *wave* in

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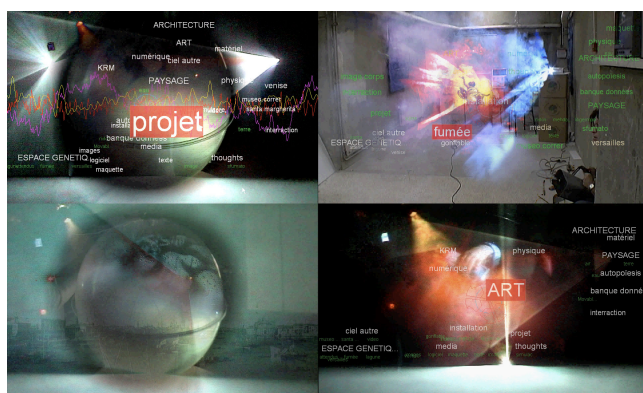
### 1 THE PROJECT AS A THEORETICAL MODEL

*The project begins by questioning* the topicality of three terms which form the basis of the postulate “*art imitates nature*” –*techné, phusis, mimesis*. [2] Positioned to lend meaning and context to the inherent confrontation between nature and technology, artifice and edifice, objectivity and representation, its methodology is neither strictly theoretical nor practical, but a combination of the two that results in the critical elaboration of a project concerning the role of mimesis as an inventive, creative process, capable of engaging a synthesis of art, nature, science and technology.

A collaboration between architects: research commissioned by the French Ministry of Culture as part of the program, “Art, Architecture and Landscapes.” [3] But also,

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Brad KLIGERMAN, assistant professor  
Ecole Nationale Supérieure d'Architecture Paris-Malaquais  
14 rue Bonaparte, Paris 75006 France  
Portable phone: +33.6.87.76.20.62  
E-mail: bkligerman@gmail.com  
work: brackligerman.info  
blog: metaverseterritories.com  
Contact address: 8, rue Bucourt, Saint-Cloud 92210 France



**Fig. 1** Installations aimed at developing an experimental platform to work with space and *immaterials*. Color and light, surface and form, tension and compression are construed as its primary structure and not as background noise. Images are captured from the video, *Radical Materiality*[1] generated using Pure Data.

a *project*, the invention and deployment of an experimental infrastructure for the fabrication of tangible, interactive spaces from *immaterials*: a *wave* transmitted in Venice's Lagoon. [4] By describing its core as a project, and with certain audacity, an architectural project, it is open to the exploration of a way of thinking, leading directly towards its theoretical stature. That an architectural project can become, by rights or by interpretation, a body of research, is another question. What we are aiming for is an experimental research, one that defines its own protocols of existence, as well as the procedures for its evaluation, and by encouraging the accumulation of the diverse layers that incarnate a project, serves as the fabrication of its own theory.

This project focuses on the invention and deployment of responsive materials as the physical and computational bridge between form and function, location and environment, structure and representation. Neither aimed at applied technical innovation, nor simply the demonstration of a specific technology, it is positioned at the critical in-



**Fig. 2** A North-South cross-section (looking West) taken near the island Sant'Erasmus, showing a *wave* in Venice's lagoon as simulated using Blender3D, based on data received from the project's stream, synthesized using Pure Data.

tersection between the two. Its stature as a *project* could complicate its relevance; the complex collage of intuitive and rational decision employed to treat diverse themes (nature, technology, art, architecture, history, media...) using multiple, hybrid models of representation (images, video, text, waves, signals, streaming...) demands a synthesis of scientific and cultural methods justifiable only through the realization of a project.

## 2 PROJECT DESCRIPTION

*The project* consists of the hardware and software necessary for the creation of a *wave* in Venice's lagoon. A data stream is produced from the project's infocloud, whose composition is the basis for defining the form, scale, proportions and material qualities of a complex, but tangible, space. Upon confronting its natural and man-made milieu, it must act and react in order to proliferate. This infrastructure is composed from four *machines*:

1/ *DATA SERVER*, providing the raw material for fabricating the project's infocloud. There are two distinct databases types: a) a subjective, contextual collection of digitally archived images, video, sound and text, defining the project's **cultural context**; and, b) tables of statistical data describing the project's **natural context**, in this case, Venice's lagoon.

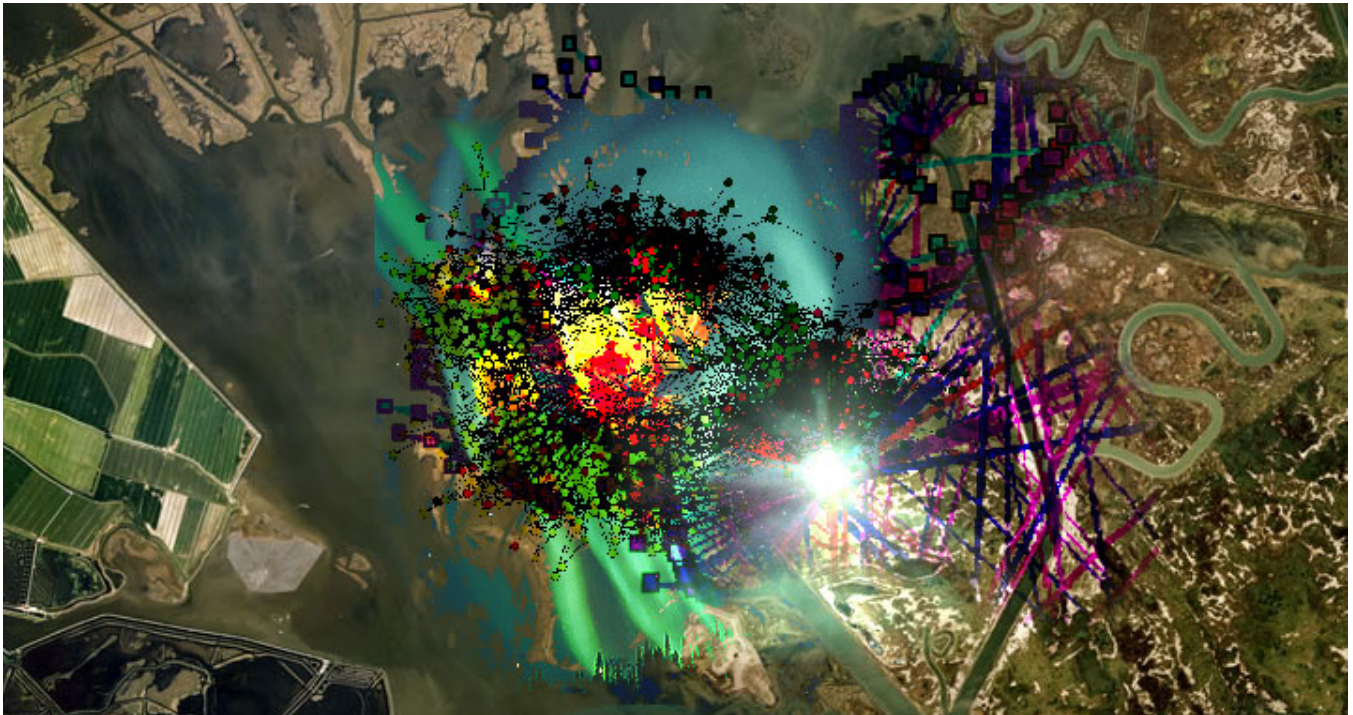
*The project's infocloud is assured by a library* of over 100,000 media-objects, whose utility is assured by its organization and distribution across a project database, a MySQL data management system hosted on the project's

servers. Component software based engines prepare each media object with necessary metadata for its organization in the database.

The cultural context of the project is represented using four general media types: images, video, sound and text. Culled from a public domain collection of nearly 100,000 images relating to art, architecture, technology and culture, they are prepared for distribution using the open-source content-based photo manager, *imgSeek*,<sup>[4]</sup> organizing them according to both descriptive and analytical metadata. Descriptive data (date, provenance, artist, title as well as social tagging) is either batch transferred from previously available information sources, or manually added to images as required, so as to consistently situate them historically, thematically and geographically.

Color and form analysis can also be performed by *imgSeek* algorithms, adding a layer of analytical information to the datacloud. Extracted directly from the object's content, patterns of color and form are revealed relative to other images in the library. This operation can either be performed in advance, according to predetermined query criteria, or in realtime, as an interactive process of the project.

Video and sound database management, necessary for impromptu access to video files, is based on descriptive information manually added using tags. Videos consist mostly of short clips of Venice and its lagoon filmed specifically for the project, or of public domain motion graphics. Text files are prepared using the information manager, *DEVONthink*.<sup>[5]</sup>, whose realtime search and



**Fig. 3** Plan of the South-West corner of Sant’Erasmus, showing real-time mutation of the *wave* as it transforms (and is transformed) in Venice’s Lagoon. From a screen shot taken from a simulation using Blender3D, based on data received from the project’s stream, synthesized using Pure Data.

retrieval of text using its artificial intelligence search and classification architecture, allow content based organization and navigation of text. The text used to animate and inform the database was either prepared during or for the projects conception, theoretical or descriptive texts, or reference material directly related to the project.

The natural environment is described using freely available statistical data[6] recorded in the lagoon since 1900. It traces the flux and patterns due to natural processes and man-made intervention through systematic measurement of atmospheric pressure, water and air temperature, humidity, water levels, wind speed, physical and chemical composition of the water and soil and tidal changes.[7] This location based information is used to graphically and statistically simulate the form, color and density of these environmental pressures, by using open source Geographic Information System[8] and 3D modeling and rendering[9] engine. Metadata information is transferred from component software to the database using any file type capable of storing tabular data (such as a .csv or .xml file), were it is made accessible to the server, thus forming the project’s datacloud.

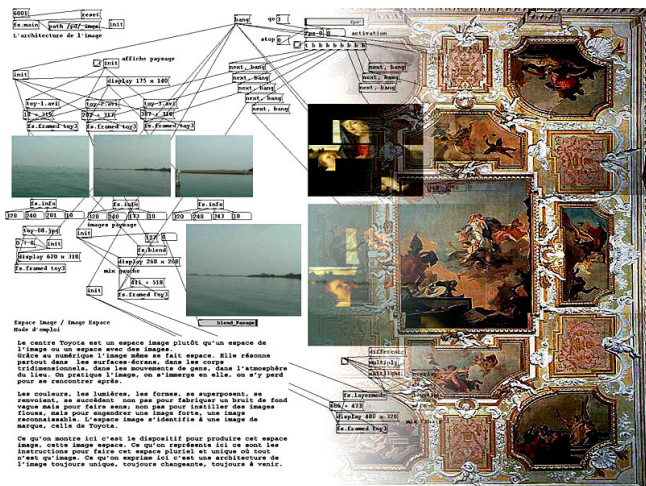
2/ *SYNTHESIZER*, machines for the production of the project’s data stream using the open-source sound and video synthesis platform, Pure Data[10]. Channels of image, text, video or sound are provided by the server upon request to a Pure Data *patch* which is designed to fabri-

cate a concentrated, coherent mix of these media-objects, thus producing the projects *stream* through synthesis. Requests for specific data from Pure Data, come from any combination of three decisional techniques –search, emergence or interaction.

Search input includes boolean qualified queries or direct requests[11] made either from within a Pure Data text entry object or from another application capable of exchanging network data with Pure Data (web service applications or Processing, for example). *Emergent* requests are made through the color and form recognition interface made possible using *imgSeek*. It is capable of spontaneously defining a data-set based on file contents, and can export this information to Pure Data.

Direct *interaction* with the chain of events leading to a database request using third-party hardware or software devices is a ludic means of engaging an audience and is especially propitious when the project is extended to a gallery or institutional exhibition context. It is also possible to solicit non-local interventions over networks using OpenSound Control (OSC)[12] to send or receive data between hardware, software or networked devices, communicating directly with the decisional nodes of a Pure Data machine.

The basic Pure Data patch design used for this project is a *four track looping mixer*. Files are loaded into each



**Fig. 4** A screen capture showing a project *machine*, the diagram and the code generating real-time images, sound and video from Pure Data synthesis. Responsible, as well, for signal modulation. To the right is an image of ceiling frescos of the Scuola dei Carmini in Venice, painted by Tiepolo. It serves as a template for the dataflow diagram.

channel based on the results of the invoked request and rendered according to a sequential interval. Standard plugin libraries offer image and sound filters to process transitions and blending between channels. Pure Data’s modular architecture treats subpatches “like bracketed blocks of code,” and *abstractions* “are like subroutines.” The physical organization of a Pure Data machine resembles a *dataflow*[13] language whose organizing diagram is directly tied to the formal output of the machine (or patch). Reorganization of that diagram will necessarily modify that output. An Artificial Neural Network (ANN), an extension to Pure Data, analyzes data input in relation to the stream’s output, revealing patterns of data abstraction.

3/ *MODULATOR*, for amplitude modulation, transforming the data stream into a waveform, a signal prepared for transmission using minimal broadcast hardware and the open-source, signal processing software, GNU Radio.[14] Permitting the “construction of radios where the actual waveforms transmitted and received are defined by software,” modulation becomes a “software problem” requiring only GNU Radio to encoded the stream. Now considered a *signal* due to its modulation with a carrier frequency, additional data, such as GPS coordinates, can be concatenated to it, thus augmenting its informational value.

4/ *RECEPTOR*, for capturing the project signal, “the *wave* in the lagoon,” and interpreting its content relative to the incipient stream data. The project signal is a complex and heterogeneous data container whose form and color, density and intensity, vary according to the its content and the location of its reception in relation

to the natural milieu. The waveform’s reception is made possible by flexible and decentralized demodulation software, using GNU Radio. Unlike traditional radio, whose fixed hardware device and quality based model of performance, strives to assure a fidelity of interpretation, this project depends on the *threshold of interpretation* between transmission and reception to engage the potential meaning, sense and scope of the project. This *synapse* represents not only the space and time between transmitted and received information, but also accounts for the signal’s transformation, from atmospheric refraction or interference, through its engagement with the meteorological, geographical and man-made conditions presented by the natural environment.

To this end, reception of the *wave* is designed to be a modular architecture permitting the development of many possible *plugins* capable of rendering the project’s final form as a continuity of potential material states. Protocols defining the signal, serve as the keys to its interpretation and create a project API.[15] Based on this architecture, the project permits an open demodulation of the signal relative to the stream, encouraging its interpretation by guest artists and inviting them to create devices capable of projecting and re-projecting its form according to their own code.

*SIRENS: A possible scenario* for the application of the project’s infrastructure is the performance entitled *Sirens*. Inspired by Homer’s epic poem, *The Odyssey*, and adapted from its description of the Odysseus’ journey to the Siren’s island: from his eerily calm approach, “hushed and still, because some divinity lulled the waters,” to the growing intensity of song and storm, image and ocean, danger and desire, “but the island was hardly left behind when I saw smoke above the heavy breakers and heard a great noise, the whirlpool of Kharybdis,” and culminating with the waning intensity of as the ship’s passing, “the Seirenes would die if a ship ever made it past them.” This description serves to illustrate the connexion between an immaterial territorial force, the Siren’s song, and the way in which it transforms that environment through varying levels of intensity projected by this invisible force, and only revealed to those possessing its code.

*Sirens* is a performance and an installation that begins with the broadcast of the project’s signal into Venice’s lagoon. A *vaporetto*, the performance and installation space of this scenario, is equipped with project hardware and software (antenna, computer, GPS, projector...) and boarded by the audience. It navigates through the dark lagoon, guided by the project infrastructure, towards the heterogeneous, dynamic *wave*. Though ostensibly still invisible, its signal is increasingly captured by the project receptors. Pure Data diagrams, programmed by the artist, will soon be able to interpret and project perceptible sensations decoded from the signal. The *vaporetto* ad-

vances towards the wave, which is progressively revealed by Pure Data's artificial neural net logical machine. As the signal's resolution becomes increasingly poignant, rendered by the ANN, its content becomes increasingly tangible. Interpretation of the signals images and sounds, and their projection onto the installation infrastructure constructed on the *vaporetto*, begins. The intensity of this experience is in direct proportion to the density, color and multiplicity of the captured signal, the interpretation of the streamed data.

### 3 GENETICALLY MODIFIED SPACES

*The project's scope* ranges from the natural environment, on one hand, to the man-made context, artifice and edifice (art and architecture), on the other. The project began by determining a common representational code to assure the engagement and interaction between these two disparate domains. A representational media and not a technology –their common spatial context (topological, geographical, geometrical...) is the connective, distributive tissue. A space's actualization, its projection *through* a specific media, determines its formal qualities.

Space is the project's most substantial material, and taking control of this dynamic space, one defined by diverse immaterial media to determine its qualities, is the means by which transform is exercised on the project's milieu. The infrastructure developed to exercise this control is its most innovative development. Its attachment as an *architectural project* is through its capacity to meaningfully transform a territory.

The digital representation of space begins with the invention of machines (software and hardware) capable of formally and *information-ally* manipulating it. To this end, the project aims for the conceptualization and the realization of a **Genetically Modified Spaces (GMS)**, a project infrastructure that acts directly on the informational structure of a space, modifying it *genetically* so as to effectuate a *graft* onto the landscape, so that it must react to the organic elements (ground, water, air, fire) that compose it.

*INSTALLATION, THE FABRICATION OF A RADICAL MATERIALITY:* Genetically Modified Spaces are constructions or installations, full-scale experimentations aimed at radicalizing the notion of space, engaging it as the project's primary material. To this end, emphasis is placed on the conceptualization and fabrication of the spaces' surfaces and envelopes.

Grafted onto nature, marking a territory and transforming the landscape, a GMS attempts to capture the natural environment, absorbing it as the project's material substance, thus interacting with numerical space and the

space of the installation. Images project space, space becomes image, resonating on its surface, through its envelope and beyond its physical reach, to project atmosphere. Bodies merge in image, emerge through image, losing themselves in an image, only to reemerge through it. The colors, lights and forms, the tensions and compressions of the space's force, superpose to project an *Image-Space* (rather than a space for images or a space with images) as its primary atmosphere and not as background noise.

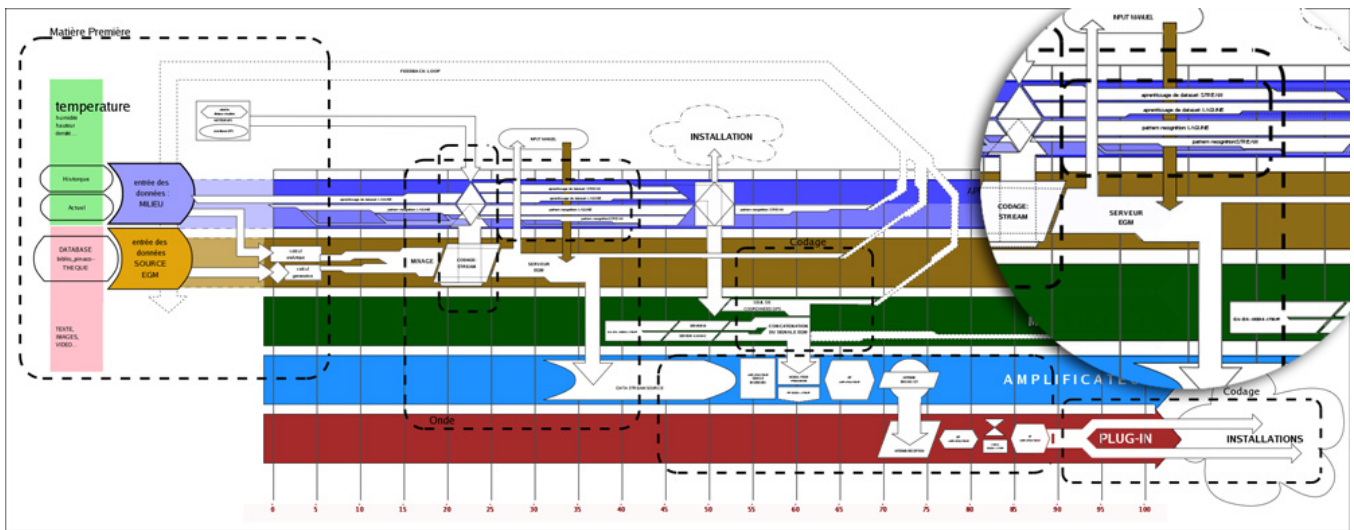
To this end, the project seeks to extend the scope of materials traditionally used to define architectural space, from *concrete* materials that partition, cover and limit spatial continuity, to those seeking to fabricate a palpable, qualitative atmosphere, one that projects the invisible or inaudible to the threshold of perception, and augmenting the virtual or informational to the realm of sensation.

#### VENICE MILIEU

The perpetual mirage of water and its reflections, the crystalline particles, suspended in the moisture of the air, all of this gave birth to certain dreams, certain tastes, which translate with magnificence through the imagination of the poets, the intensity of the painters. There is no better place for the realization of a project whose milieu is capable of reaching through, into the genealogy of the work. [16]

The project context is Venice, Italy and its surrounding lagoon. The historical, cultural and aesthetic motivations for engaging Venice are matched by, and reversible with, the radical confrontation between architecture, engineering and art and this fragile but forceful natural milieu. It bears witness to a culture that has been under constant pressure to innovate, for over 1000 years, techniques of adaptation and appropriation of its immediate environment. That response has been able to transcend mere engineering and incorporate a synthesis of art, architecture and design, and whose depth can be said to emanate from the radical nature of its condition. This technical and cultural innovation is the mark of its territory.

*A WAVE IN THE LAGOON:* Genetically Modified Spaces are activated by the broadcast of a data stream throughout the lagoon of Venice, the diffusion of an *electromagnetic wave* containing project data. Captured (sensors or cameras recording the flow and ebb of the natural environment); clouds (user i/o, community tagging, ordering, ranking); and, silos (data-base scrubbing and mining to infer trends in the natural environment). By superposing the heterogeneous layer, this *wave*, over the natural environment, we invent a singular material, an active and reactive, to weather conditions, tides, lunar cycles, human activity, the movement of boats in the lagoon... modifying the signal, and in turn, the space determined by it.



**Fig. 5** A detail a diagram, a *timeline* showing the sequence of data flowing through the project network. The horizontal bands represent the project's machines: the Server, Synthesizer, Modulator and Receptor, as well as a fifth band showing plugins. Superposed is the flux of system processes moving through and transformed by the network's nodes using Pure Data: infocloud, stream, signal, input and output, decisional nodes.

*SYNTHESIS:* A stream is produced from this datacloud by code, open source *machines*, made from audio and video synthesizers. It is a platform where sound, images, video, three dimensional objects, text and databases can be seamlessly mixed to form a *dense and intense* flow of meaningful data. A signal whose color and quality is dynamically, algorithmically or interactively produced by a matrix of hardware and software, logical machines whose structure is reversible with the content they emit.

*BROADCAST and MODULATION:* As in all wireless transmission models, information is encoded into a packet, a discrete block of data, containing instructions, but also GPS information for the localization of data-packets. Reception hardware and software is responsible for decoding the signal, information capable of the projection of Genetically Modified Space infrastructure.

The encoding and decoding devices, software designed to interpret a signal. Unlike the traditional broadcast model, where the received signal attempts to replicate as close as possible the signal that was emitted, fidelity is a question of interpretation, timing and effect. Thus, independence between the points of diffusion, transmission and reception is a system feature, permitting the intervention at any point in the network by artists, machines, communities, artificial intelligences or a community of users.

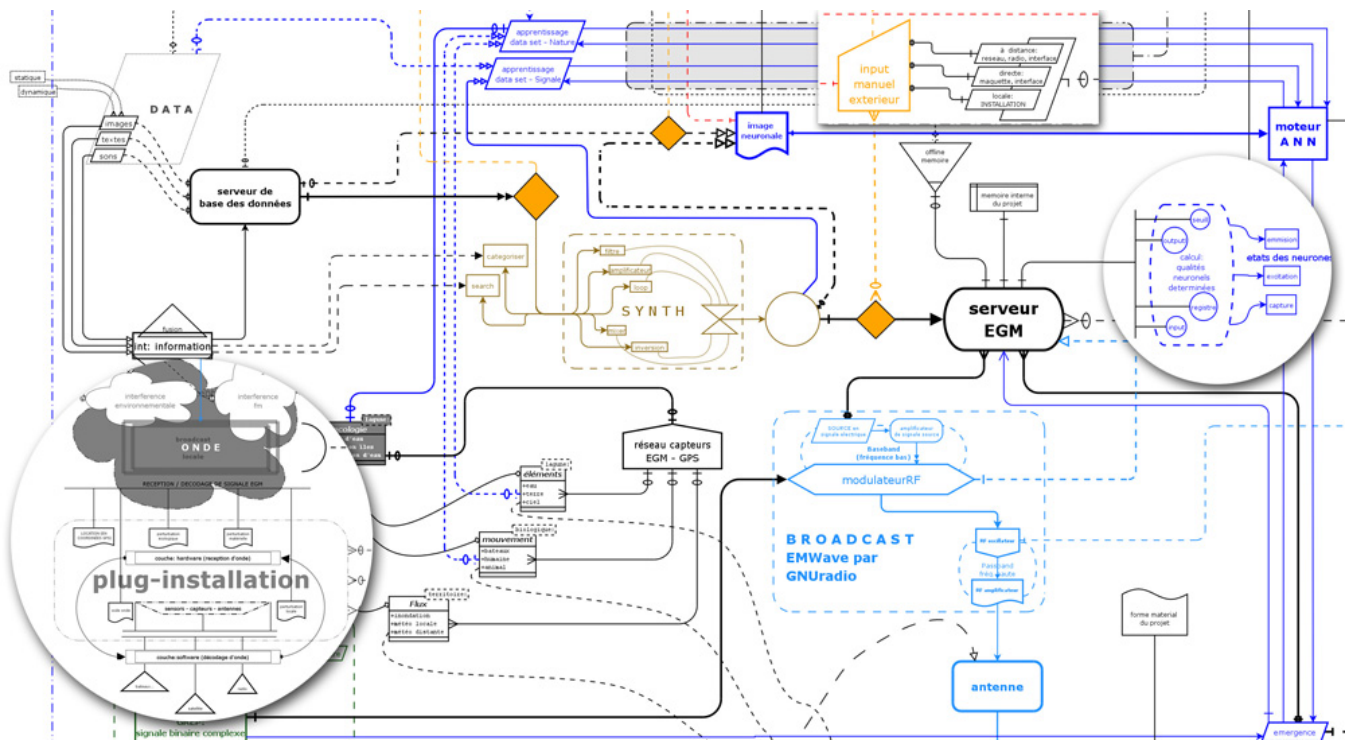
*INTELLIGENCE:* The confrontation between technology and nature as simulated by grafting a *wave* in Venice's lagoon, is actively observed and recorded by project artificial neural nets[17] designed to analyze this interaction, the natural environment transforms (and is transformed)

by the signal. These patterns and mutations over space and time are revealed by this intelligent network, a feedback loop, machines developing the independence of intelligence and self-decision: Genetically Modified Space, *an autopoietic machine*.

#### 4 THE PRODUCTION OF AN ATMOSPHERE

*This project has been influenced* by the theoretical and technical developments in ubiquitous computing, which inspire and inform its conception, fabrication and representation. The diffusion of this information through research, but also through popular tech-culture has structured its development as a cross-disciplined synthesis of sometimes opposing postulates: art and science, material and immaterial, concrete and virtual, nature and technology. The project's vision of a radical spatial and architectural order, engages innovations introduced by transitive materials, whose research and techniques have given it credibility as a legitimate alternative for the realization of a sustainable and interactive contemporary built environment.

*THE MATERIAL INSTANTIATION OF AN IMMATERIAL SYSTEM:* New types of objects are emerging from the influence of pervasive computing. They begin and end their existence as data, their utility focused by their material instantiation. From simulation to model, material specification to manufacturing, back to data, a database entry, a search, a memory, objects flicker between material and immaterial representations as a function of their utility at a given instant and for a certain duration. Their material (or immaterial) instantiation



**Fig. 6** A detail of the project’s functional diagram showing the schematics of dataflow through the project network. It is organized so that location (geometric, cartographic) instantiates data, determining the state of information at any given point in time.

supersedes their presence, their objective quality is neither permanent nor necessarily stable, their state and location encoded as an essential attribute.

*DATAFLOW and LOCATION AWARENESS:* The research and project described here are profoundly structured by the dataflow model of computation, where a graphical environment models the flow of the control of information in the system. The design of the diagram and its operation are reversible (“the code is the diagram,”). Data is transformed according to its location in the project network, its functional nodes are positioned according to its geometry. The diagram is spread across the territory, superposed upon its cartographic representation, that determines its scale and extents, its resolution and limits, and poses a direct correspondence between location and operation.

*THE REVERSIBILITY BETWEEN CONCEPTION, FABRICATION, and USAGE:* The projects succession of events within a geo-temporal framework, where the flux of information, objects and materials is the rule rather than the exception, calculation proceeds according to the code’s dataflow. Objects or instantiations are reversible; this is not necessarily an indication of a loss of control, but rather a creative process of transformation and mutation. The inception of an object or space,

the process of its fabrication and the induction of its usages, are in fact reversible. This is a feature of the new objectivity and not a system bug.

*MATERIAL AND MEANING:* By accepting a form, or by being deformed, a material collaborates in its ultimate configuration. A material is predisposed to accept or refuse certain configurations. On one hand, the material must adapt or accommodate to the form being imposed upon it. Or, the form must adapt and conform according to the capacity of the material to accommodate it. On the other hand, the material reveals that which is hidden or not yet revealed about that form, until the real form, the material-form being revealed by this material, actively participates in its own definition. A material is that which resists.

## References

1. *Radical Materiality*, video showing early experiments and installations made by and for the project, Genetically Modified Spaces, 2005, <http://tinyurl.com/32tflk> [Link to video]
2. *Mysimulacrum.com*, a web site with biographical and contact information for team members, as well as a presentation of current and past projects. <http://mysimulacrum.com>
3. *Art, architecture et paysages*, *Ministre de la Culture et de la Communication, Direction de l’architecture*

- et du patrimoine*, from October 2004 to June 2006. <http://tinyurl.com/2fc58g>
4. *Genetically Modified Space (in French)*, The team's work is documented on this web site, a wiki that served as a platform for exchange, collaboration and communication of the research, 2004-06. <http://egm-projet.fr/>
  5. *ImgSeek*, imgSeek is a photo collection manager and viewer with content-based search and many other features. The query is expressed either as a rough sketch painted by the user or as another image you supply (or an image in your collection). The searching algorithm makes use of multiresolution wavelet decomposition of the query and database images. <http://www.imgseek.net/>
  6. *DEVONthink*, information manager with a integrated artificial intelligence search and retrieval engine, <http://tinyurl.com/o5jaq>
  7. *Istituto Veneto*, whose freely available statistical data was the basis for the project's database describing Venice's Lagoon. <http://tinyurl.com/yoewc7>
  8. *Espace Génétiquement Modifié, Database Ecologie*. The team's work is documented by this web site, a wiki that served as its collaborative platform. These pages show an example of the data used in determining the statistical projections for describing the flux of the natural environment. <http://tinyurl.com/2glzej>
  9. *Grass GIS*, a Geographic Information System (GIS) used for geospatial data management and analysis, image processing, graphics/maps production, spatial modeling, and visualization. GRASS is currently used in academic and commercial settings, as well as by many governmental agencies and environmental consulting companies. <http://grass.itc.it/>
  10. *Blender 3D*, an open source 3D content creation suite, available for all major operating systems under the GNU General Public License. Blender 3D and Grass GIS were chosen for the access to source code and their compatibility for sharing data using Python scripts. Both have large and active development communities who were invaluable to this project. <http://www.blender.org/>
  11. *Pure Data*, is a graphical programming language developed by Miller Puckette in the 1990s for the creation of interactive computer music and multimedia works. Though Puckette is the primary author of the software, Pd is an open source project and has a large developer base working on new extensions to the program. It is released under a license similar to the BSD license. Pd is very similar in scope and design to Puckette's original Max program (developed while he was at IRCAM), and is to some degree interoperable with Max/MSP, the commercial successor to the Max language. Both Pd and Max are arguably examples of dataflow programming languages. In such languages, functions or "objects" are linked or "patched" together in a graphical environment which models the flow of the control and audio. <http://puredata.info>
  12. *Search query* boolean based request "((painting NEAR fresco) AND (Venice OR Padua) AND 142?)" or a request for a specific media object "(Carpaccio Schiavoni St George)"
  13. *OpenSound Control*, is a communication protocol which allows musical instruments (especially electronic musical instruments such as synthesizers), computers, and other multimedia devices to share music performance data in realtime over a network. OSC is meant to supersede the MIDI standard, which was implemented after 1983 and which many consider inadequate for modern multimedia purposes. Because it is a networking protocol, OSC allows musical instruments, controllers, and multimedia devices to communicate via a standard home or studio network (TCP/IP, Ethernet) or via the internet. OSC operates at broadband network speeds, allowing new types of realtime interactions which were not possible because of MIDI lag. OSC also gives musicians and developers more flexibility in the kinds of data they can send over the wire, enabling new applications which communicate with each other at a higher level. [<http://tinyurl.com/ynq36v>]
  14. *Dataflow*, "term used in computing... closely related to message passing... software architecture based on the idea that changing the value of a variable should automatically force recalculation of the values of other variables. Dataflow programming languages embody these principles, with Spreadsheets perhaps the most widespread embodiment of dataflow (though) not restricted to recalculating numeric values, as done in spreadsheets. For example, dataflow can be used to redraw a picture in response to mouse movements, or to make robot turn in response to a change in light level. The term dataflow may also be used to refer to the flow of data within a system, and is the name normally given to the arrows in a data flow diagram that represent the flow of data between external entities, processes, and data stores." <http://tinyurl.com/39dubo>
  15. *GNU Radio*, A software radio is a radio whose channel modulation waveforms are defined in software. That is, waveforms are generated as sampled digital signals, converted from digital to analog via a wideband DAC and then possibly upconverted from IF to RF. The receiver, similarly, employs a wideband Analog to Digital Converter (ADC) that captures all of the channels of the software radio node. The receiver then extracts, downconverts and demodulates the channel waveform using software on a general purpose processor. <http://tinyurl.com/rpg7y>
  16. *API*, An application programming interface (API) is a source code interface that a computer system or program library provides to support requests for services to be made of it by a computer program. An API differs from an application binary interface in that it is specified in terms of a programming language that can be compiled when an application is built, rather than an explicit low level description of how data is laid out in memory. <http://en.wikipedia.org/wiki/Api>
  17. Henri Focillon, *The Life of Forms in Art*
  18. *Artificial Neural Net*, (ANN) is an interconnected group of artificial neurons that uses a mathematical model or computational model for information processing based on a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network. They can be used to model complex relationships between inputs and outputs or to find patterns in data. The ANN for Pure Data can be found at <http://tinyurl.com/2z63o5>