

## **An approach to relational artworks as complex dynamical systems.**

### **Subtle Technologies.**

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#### **Intro:**

My initial artistic production was developed through painting. Later on I started creating installations, videos and video-installations.

During the last few years I have mainly focused on developing interactive installations that work through the use of digital technology.

This last artistic process is closely linked to my previous experience in the field of physics, more specifically in plasma physics.

The concept, research and implementation of my works are strongly influenced by the scientific process in terms of the formal aspect as well as the technology involved.

I like to explore those fields where the boundaries between science, art and technology become blurred.

This work is an approach to the process of designing interactive works, which results from the aesthetic experiences developed during the last years.



The inclusion of digital technology, which enables the setting up of bridges that encourage material interactivity by virtue of mathematical abstraction, is significantly leading to the progressive virtualization of the artistic process.

The use of digital technology, communications, interfaces and other technological devices involves concepts and paradigms belonging to the field of techno-science that offer the possibility to explore other artistic experiences and, at the same time, consider the artwork as a system.

If we analyze the formal elements involved in such a creative process, we will find that the aesthetic exploration is strongly displaced from the artwork as an object to the creation of relational bridges or connections through the use of technology in many different materials and in various contexts.

Every element can be included as part of an inter-related work that exists as a system.

In two articles published in Artforum in 1968 and 1969, Jack Burnham describes the impact of the theory of systems applied to art and considers that such approach is an emerging witness of the techno-scientific culture extending throughout very different environments that range from science, society, the relationship between men and machines, education and production. Burnham supports the idea of considering a work of art as a "cybernetic organism" using concepts of self-organizing systems applied to sculpture, and he also encourages the notion of art that includes the process of information in "real time".

During the last years, many of the artworks created dealt with concepts deriving from life sciences, cybernetics, artificial intelligence and other techno-scientific paradigms.

Notions such as complexity, diversity, self-organization and emergency, among others, are frequently recalled, although in some cases they are not extensively developed as formal elements to be modeled and experimented on.

## Artwork as System

An artwork made up of parts which, by interacting between each other show an emerging dynamic form, encourages the exploration of new aesthetic aspects that somehow exceed the way we traditionally approach an artwork, that is, by focusing mainly on an object and how it is made.

Therefore, I suggest approaching the artistic process of modeling interactive artworks by applying a strategy inspired in science and scientific methods in order to engage in an alternative aesthetic exploration.

The idea is to suggest a method to promote the shaping of the interactive relationships arising between the different parts of the work and, at the same time, the development of the different insights resulting from the emergent dynamics.

My intention is to approach an interactive system where such concepts as complexity, diversity, self-organization and emergency, can be modeled as a formal substance in order to open the artistic process to the esthetical exploration and the formal expression.

The artist combines parameters as formal elements and dynamics by conforming a structure in an interactive system that is to be modeled.

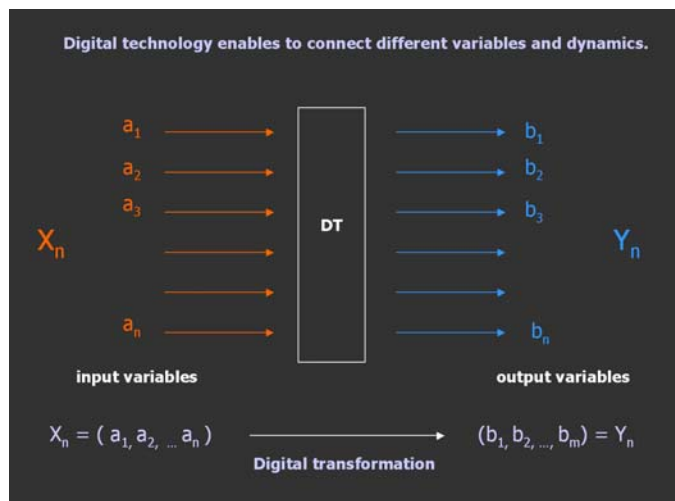
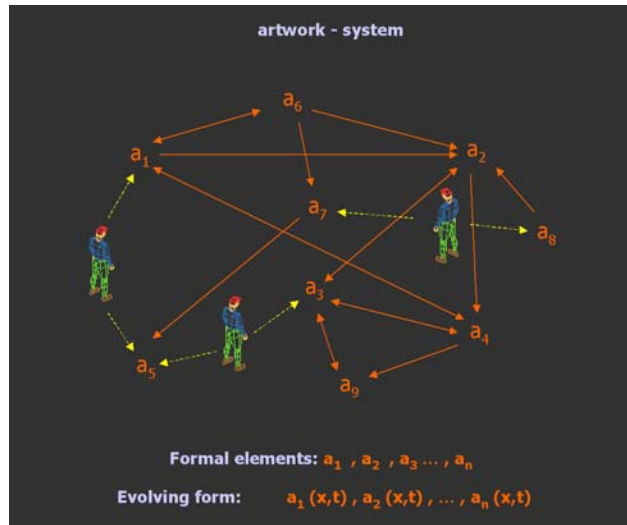
The artistic process lies in the course of experimenting on the evolving forms spread out in space and time.

Many relational systems include the spectator as an active part of the artwork, where he or she plays a direct action upon the formal elements. The participant activates the initial relations and rules existing between the parts in the work, which the artist has previously defined, by providing a sort of "internal energy" necessary for the development of the system.

The subsequent transformations the artwork undergoes represent a sequence of states where there is a constant dynamic redefinition that is tightly related to the immersed user.

I have stated that the use of digital technology enables the setting up of bridges for material interactivity across different variables.

These variables are those formal inputs and outputs that the artists intends to link on a material environment.



A digital transformation maps from the input set to the output set.

A new state emerge by means a transformation of a former state:

$$Y_0 = T(X_0)$$

And transformations are successively applied  $m -$  times according the work evolves.

A state of the work can be described as an  $m$ -dimensional vector with relevant parameters for the artist.

$$s\text{-state}(n) = (a_1(n), a_2(n), a_3(n), \dots, a_n(n))$$

and a later state will be described as following:

$$s\text{-state}(n+1) = (a_1(n+1), a_2(n+1), \dots, a_m(n+1))$$

Then we'll have a sequence of states:

We'll have a set of "time points" or "instants".

At any given time, the installation or system can be in any one of a large number of possible states. This set of states is called the "state space" of the dynamical system.

We refer to the different ways in which the state, input, and output can evolve over time as "histories", "time lines" or "trajectories".

The output states are related to the input states as follow:

$$Y_0 = T(X_0)$$

⋮

$$Y_n = T(T(\dots T(X_0)\dots)) \quad n\text{-times}$$

**s-state**  $(n) = (a_1(n), a_2(n), a_3(n), \dots, a_m(n))$

**In a later time:** **s-state**  $(n+1) = (a_1(n+1), a_2(n+1), \dots, a_m(n+1))$

**Trajectory:**  $s(n), s(n+1), s(n+2), \dots, s(n+j)$

## Books of Sand

For example, let's consider *Libros de Arena* (Books of Sand):

This installation was mounted in the Museum of Modern Arts of Buenos Aires in 2004 and Daum Museum of Contemporary Art in Missouri during 2005-2006. The work refers to a story written by Argentine author Jorge Luis Borges.

*In this story, the author is offered to trade a confusing and endless book.*

*He tries to analyze it but cannot completely understand its writing.*

*He is unable to find the first and the last page of the book.*

*The pages are not consecutively numbered: after page 999 comes page 16824.*

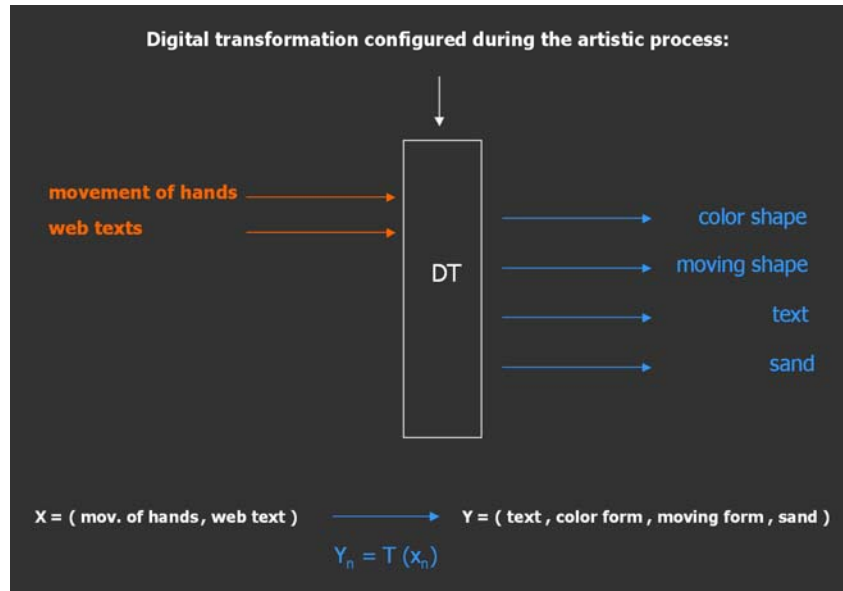
*He seeks in vain to return to the picture of an anchor on a page in the book, even though he has memorized exactly where it is supposed to be.*



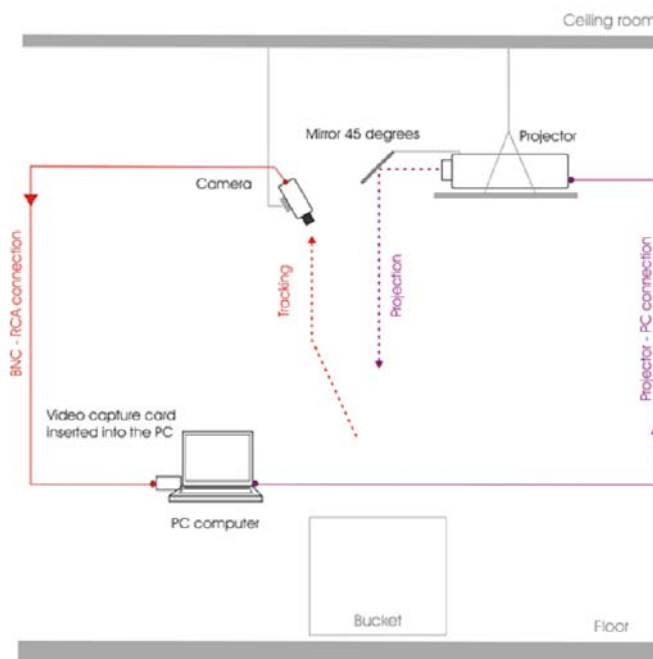
This work is an interactive installation where people can discover Web-found texts written by Jorge Luis Borges by moving their hands over the sand placed in big glass cubes.

*Note that the texts retrieved from Web could be considered as an environment variable that seeds the installation. Changes according to some HTML code characteristic could be used as agent for changing the text dynamics of the installation.*

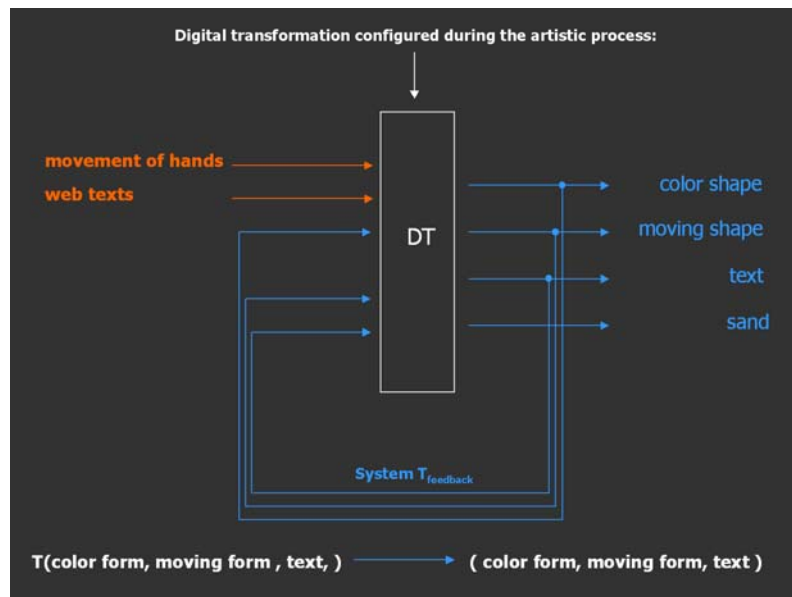
The input and output variables I'd like to consider in this case are the following:



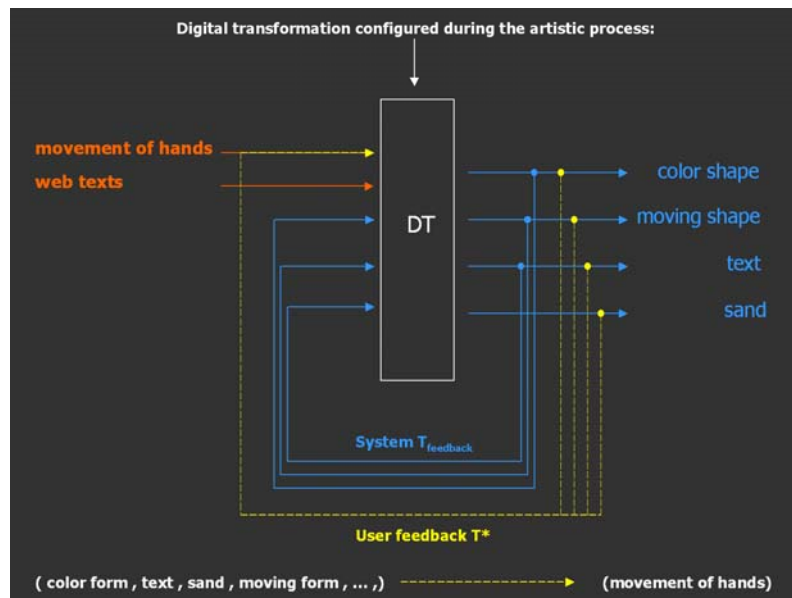
A digital transformation is configured during the artistic process as follow:



A video camera is used to capture the movement of hands, the image is processed in real time and the movements are translated into the texts that are cast over the sand.  
 The texts are downloaded from the Web in real time by means of a program that searches and analyzes HTML codes that include texts written by Jorge Luis Borges.

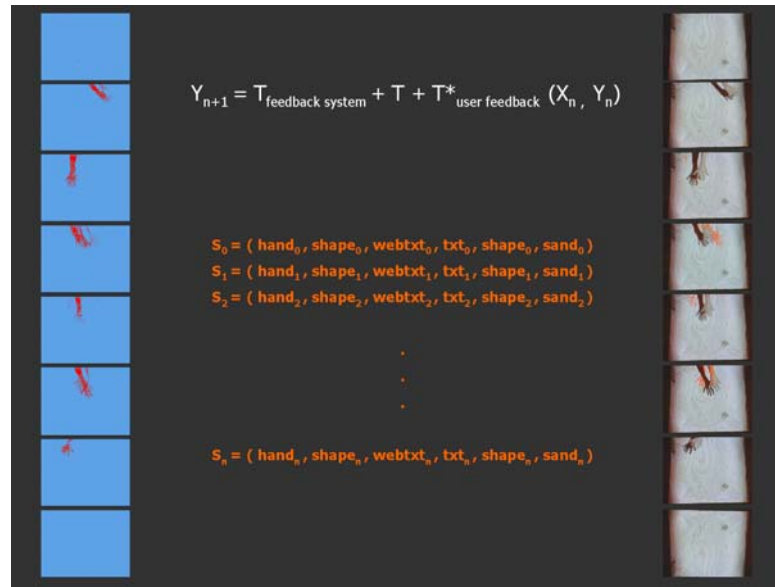


By modeling the interaction between the hands and the text, several parameters associated to the hands are transformed into a text image.  
 The system can be disrupted by its own process. In this case, the text image projected on the sand is repeatedly analyzed by the system, triggering a feedback that is adjusted to converge to a stable state.



The participant closes the interaction cycle by becoming a symbolic link with the material nature and dynamics of the artwork in a phenomenological relationship.  
 I will consider this relationship as unknown and it appears in the graph as a dotted line.

Thus, this is a system where a set of input parameters are transformed into a set of output parameters. Some transformations partly take place during the artistic process, e.g., there is the transformation experienced by the participant's link with the system plus another transformation of the system feedback in itself.



When this artwork is "alive", the properties of the elements involved will vary and the system will show an emerging dynamic shape whose underlying foundation is the modeling of the interaction between its constituent parts. It is worth considering that the material aspect and shape of the interface, in this case, the sand placed into the cubes, plays a key role in the process of modeling the interaction and acts as a material and sensory link to the participant.

Therefore, all along the evolution of the artwork there will be a sequence of non-predictable states characterized by a set of elements or variables that are measured or classified:

$$S_0 = \{ T, C, S, mov, sand\ shape, text\ shape, \}$$

$$S_1, S_2, \dots, S_n$$

The search for ambiguity in the interaction is intentional, and it aims to leave aside the direct cause-and-effect relationship between participant and system. In this case, it is impossible to control certain variables, such as the text to be seen and the image it will have. This is controlled by a program and the system feedback.

In many works, ambiguity is caused by algorithms that show less reactive and more adaptive behavior and which are included in the software that controls the installation.

If the programming criteria are changed, the evolution of the artwork will naturally also change, originating a new sequence of states and shapes.

Thus, the system can exhibit various behaviors in the course of its evolution or shape, such as diverging, showing chaos or converging into certain states or in a particular one.

Modeling the interaction between the constituent parts of a system locally is a well-developed practice in many areas of contemporary science.

In an artistic process motivated by such practices, we can approach artworks as systems composed of multiple parts that





interact between each other locally and experiment on their emerging complexity in a macroscopic level.

Now, how can we engage in an aesthetic exploration of a dynamic artwork considering the notions of order, emergency, adaptiveness, dynamics, among other system variables, in a formal and material level?

We can record different variables or characteristics that develop as the artwork evolves.

We can visualize the consecutive states or trajectories the artwork adopts every different moment in an phase-space.

As it has been said, the sequence of states can be altered by changing the codes that govern the internal interactions but, at the same time, a change in the formal or material elements of the interface will impact on the link created with the participant.

All changes made to the configuration, in terms of both the formal aspect and the internal structure of the system, will influence the emerging dynamics shown.

The number of states that can be registered and the diversity of the variables considered represent a challenge for data processing.

The states that an artwork adopt can be characterized by vectors of many dimensions. Actually, as many dimensions as the artist considers.

We are presently using the Self Organizing Map by Tehuvo Kohonen in order to analyze the distribution of the states existing in an installation.

SOM is neural networks that can be used as a tool for the visualization of high dimensional data. In its basic form it produces a similarity graph of input data.

It converts the non-linear statistical relationships between high dimensional data into simple geometric relationships of their image points on a low dimensional display, usually a regular two-dimensional grid of nodes.

The SOM thereby compresses information while preserving the most important topological and / or metric relationships of the primary data elements on the display; it may also be thought to produce some kind of abstractions. Both aspects, visualization and abstraction, can be utilized in process analysis.

An interactive installation may be a very complicated system in terms of state variables; the number of which may be enormous and may also be related in a highly non-linear way.

Together with proper visualization methods the SOM could be a good tool for discovering and visualizing general structures of space states and the system behavior too.

## Conclusion

The idea is to develop an approach to work upon and explore the aesthetics of different interaction models that take place in an artistic process.



This is a hybrid practice that encompasses art and science, where the characteristics of participant interaction with the interfaces are modeled and the emerging shapes arising from that interaction can be experimented in a more extensive way.

The ambiguity, predictability, order and diversity exhibited by the artwork can be considered as formal elements to be modeled that are reflected on the record maps of the system dynamics.



This process can give insights towards the emerging behavior in the time and space an artwork stands and, at the same time, provide formal elements for reflecting on the changing, unpredictable and unfinished nature of this kind of artworks.

We are presently using this approach for the development of interactive works in the courses taught at the university.

It is useful to reflect on the artistic practice interacting with science and technology in a natural way, introducing techno-scientific paradigms such as life sciences, dynamic systems, artificial intelligence, neural networks, and so on.

It is also useful to introduce the students some sensations and concepts related to the material form of interactive interfaces, the different ways of designing interaction, the programming codes and how they are related to the resulting form as an aesthetic event.

All these aspects are not thoroughly explored when the traditional artistic approaches are used and even in many of the practices that include techno-scientific paradigms.

For more information: <http://marianosardon.com.ar>