DEVICES OF ROBOTIC ART

University of Avignone, Congress of the International Association of Empirical Aesthetics, Jul. 2006 / LOMBARDO, Sergio - LOMBARDO, Giuliano

Abstract
Can artistic creation be automatized? Robotic Art is based on the idea that the artist in the future will abandon the method of inspiration and embrace the method of the scientist. The scientist describes a procedure (program) and anyone who will use such a procedure will make (execute) a work of art, whose author is the scientist. If anyone is able to better the program, he will be the author of a new series of art works. Such attempt was imagined by early '900 avant-gardes (like Futurism, Surrealism, Suprematisme, Agit Prop), but never strictly actuated. In the Sixties, international avant-garde, of which one of us is a member, and especially American artists tried to bring on the idea. From Allan Kaprow to Sol LeWitt, from Monochrome Malerei to Conceptual Art, the attempt was very serious. Roy Lichtenstein describes as "industrial Art" the same Pop Art, of which one of us is a member. The creation of a procedure is the patent to make industrial art.

There are many difficulties; one is the slowness and the expensiveness of scientific research against the easiness of free creativity. Another is that the task is not easy, because the results must be more creative, more interesting and deeper than arbitrary inspiration. The procedure must generate figures that human brain cannot imagine and that humanity has never seen before.
Since 1980 we are trying to solve the problem. Here some automatic procedures one of us employed in artistic work are described. Artworks produced in such a way are known as "Stochastic Paintings" or "Stochastic Tailings". Some minimal and Heawood maps are described as well.
The aim of automatic art according to the Eventualist theory is not to find a method to do what painters already do, or can do, using traditional methods. It is not the creation of software that will enable a computer to do what used to be done using a paintbrush, but the invention of a procedure that will create images that are impossible to create using intuition.
These shapes must be more interesting, surprising, original and deeper then those created by traditional artists. These shapes must excite the publics' imagination, so each spectator will project in these shapes his own deepest and personal issues. These projections will be different for each spectator. The automatic method must substitute the artists' creative genius, improving that and not his manual ability. This is based on the fact that an automatic method, as opposed to the artists' genius, may be applied repeatedly and improved.
Five automatic procedures one of us have used in artistic production will be discussed. The first, discovered by F. Attneave and M. D. Arnoult in 1956, with the intent of creating "Nonsense Shapes". The second, a modified extension of the first, was used starting from 1980 in some works that are the basis of my "Pittura Stocastica" (Lombardo, 1983; 1986, 1994) and, in particular, in "Pavimenti Stocastici" (Lombardo, 1994a). This procedure is called "Pioggia di Punti", or Ran method. The third procedure, called Lab, creates labyrinth-like shapes. The fourth and fifth, known as TAN and SAT methods, have already been described elsewhere. As far as the maps and the Heawood maps are concerned, they are not precisely automatic procedures but solutions to complex formal problems.
We will then describe in detail two closing methods of one of the SAT method (Lombardo 1986). This method Sergio Lombardo used, starting from 1984, creates very complex shapes that are able to stimulate projective interpretations among the public. No intuitive painter could create such surprising and attractive shapes, but nonetheless, we think the automation may be improved. For this reason, in this article, we will compare to different closing techniques.

“Nonsense Shapes” by Attneave-Arnoult

In 1956, Attneave and Arnoult invented a famous method for constructing “Nonsense Shapes” in order to find an intelligent way to choose the stimuli for experiments investigating the learning and memorization of unfamiliar shapes.

Dots Rain

This method is an extension of the previous, but it is applied to a bi-dimensional torus (T2). The torus is flattened out in order to become a rectangular sheet. This way we can trace a virtually endless line remaining in the same rectangle. Infact, when the line meets the border of the rectangle, it will continue in the same direction from the opposite border. Juxtaposing copies of the toroidal rectangle as if they were tiles the picture continues undisturbed beyond the borders of the tiles.
A pioggia di punti P(1...n) creates a random n side polygon inscribed in a torus. The first step is to create a stochastic triangle by extracting 3 random points and tracing the smallest possible triangle connecting the three extracted points. Now we can apply the “pioggia di punti” procedure to transform the triangle in a polygon. Each time a new point will be extracted, 2 new sides will replace an older side of the polygon. To choose which side must be replaced one can follow different procedures:
1. The side is randomly chosen among those where a straight line could connect the vertexes without crossing other lines (visible).
2. Choose the closest among the “visible” ones.
4. Choose the farthest among the “visible” ones.

LAB Method

Between 1980 and the middle of the nineties, during long phase called "Pittura Stocastica", Sergio Lombardo invented some automatic procedures for creating nonsense shapes. These shapes were constructed to induce endless interpretation in the public. These automatic procedures are based on randomly picked of points, and on rules for the connection of these points, in order to construct planar or toroidal colored maps.
The LAB method consists in randomly extracting a point and connecting it to a previously extracted (older) one in order to create a tree. Each extracted point is numbered progressively. The connections between points, called sides, are straight-line segments. The sides must not cross over, nor come close, to previously drawn (older) sides or vertexes. The newly extracted vertex must be connected to an older vertex following this preference order:
- connect to the closest vertex already connected by 2 sides
- if that is impossible, connect to the closest vertex already connected by 1 side,
- if this is impossible also, delete and extract the last vertex again.
The tree must then be transformed into a map by connecting the vertexes of the hanging sides, called leafs, by using the same rules that have been used for the creation of the tree, preferring the 2 sided vertexes, then the 1 sided ones, the 4 or more sided ones, and finally the 3 sided ones because, in this case, it is not possible to extract the hanging side again.
The map is then colored using the following algorithm:
- arrange the countries in order of complexity (the most complex country is the one that has a common border with the most countries that have common borders with at least 4 countries).
- color a country at a time from the most complex to the less complex.
- attribute color A, if there are countries of color A that share a border attribute color B, if there are countries of color B that share a border attribute color C, and so on.
- continue until the map is completely colored.

Minimal and Heawood maps

Minimal maps follow exact topological rules. These graphs are made of colored flat surfaces called regions or countries. The color used for each country may be the same as that used to color other countries, as long as the same color is not used for countries that share the same borders. If the maps are constructed on a plane they are called planar, while if they are constructed on a torus they are called toroidal. These maps are called minimal when they cannot be constructed or colored differently without them becoming more complicated, and there isn't a way to simplify them. In this case, three borders must begin from each vertex. The economy of these maps is given by the fact that they reach maximum complexity with less possible components, this is why they are

almost always more beautiful then those that are not minimal. But, not all minimal maps are equally beautiful once colored. Infact, minimal maps may be constructed and colored in endless ways. We can ask ourselves, from an aesthetic point of view, which is the best way, if such a way exists, to design and color minimal maps.
Minimal maps may be sorted from two different points of view: color and structural simplicity, maintaining the same topological properties. The problem of the coloring is formulated in the following way: which is the best possible way of coloring a certain map? The problem of the map structure is formulated in the following way: which is the simplest way to design a map with certain topological properties? These problems may not be treated separately because some maps that are considered aesthetically the best if colored following certain rules, if designed the simplest way may require different coloring rules.
Maps where all countries are independent can be colored with a minimum number of colors; this number is called the chromatic number of the map. All planar maps can be colored using 4 colors or less. All toroidal maps can be colored using 7 colors or less. Heawood maps are instead more complex, because their countries are not independent, each country is made by an m number of disconnected regions, to be colored using the same color in order to show that they belong to the same country. All Heawood maps where m=2 can be colored using 12 colors or less, the ones where m=3 can be colored using 24 colors or less. Planar Heawood maps may be colored using a maximum of 6m colors; if these maps are constructed on a torus their chromatic number is 6m+1.

SAT method and two different closure procedures

It involves drawing by lot the points of a Cartesian plane inscribed in a bi-dimensional torus and connecting them using straight line segments, in order to create a map. The map will be colored by means of another algorithm. The N number of extracted points, called vertexes, represents the complexity of the drawing.
The procedure is divided in 3 different phases:
- creation of one or more N complexity SAT stochastic trees over a bi-dimensional torus (if the trees are more then one the graph is said to be a forest).
- the closure of the tree or forest in order to transform the graph into a map.
- coloring the countries of the map.

Here we will describe in detail the automatic procedure that creates a forest of 10 SAT trees of complexity N = 150. In the second phase we will apply two different closures, one called close and the other called far, obtaining two maps that we will then color using the same coloring procedure and the same colors.
This way, two stimuli will be created and evaluated, using aesthetic and Eventualist evaluation methods, in order to determine which one of the two methods is better.
The plane of the picture is x = 0…60, y = 0…40. Obviously, being a bi-dimensional torus 40 = 60 = 0.
- Extract the coordinates of 10 different points in the torus area. Name these points using progressive numbers according to the order of extraction. These 10 points are 0 degrees vertexes called roots. Infact, each one of them may generate a stochastic tree when the other vertexes will be extracted. The degree of the vertex may grow when the connected sides are drawn.
- Extract another 140 vertexes, the overlapping ones, the ones that are too close to each other (distance<1) or to a side must be deleted and extracted again. Give each vertex a progressive number from 11 to 150.

Before extracting another vertex, starting from vertex 11, connect with a line, called side, the last accepted vertex and connect it with the closest vertex, among those visible in a straight line without crossing or coming close (distance<1) to vertexes or sides that have already been drawn (older). If there is more then one vertex at the same distance, the most recently extracted one (youngest) is preferred.
In order to transform this forest into a map, one must draw other sides from the vertexes that are connected to only one side, 1 degree vertexes, also called leafs. For this purpose, all the vertexes must be considered, in their order of extraction. If the vertex is a 0 degree one (a root from which no tree has grown) one must draw 2 sides that begin from this vertex. If the vertex is a 1 degree one (a leaf), one draws a new side beginning from this vertex. If the vertex is a >1 degree one, one must move on to the next. To

choose the vertex that will be connected to the considered one, two different closure criteria may be used.
Close closure: the new closure sides must be connected to the closest visible 2 degree vertex, if that is impossible, they must be connected to the closest visible 1 degree vertex, if this is impossible they must be connected to the closest visible >3 degree vertex, if this is also impossible they must be connected to the closest visible 3 degree vertex. If there is more then one possible vertex the youngest one is preferred.
Far closure: the new closing sides must be connected to the farthest visible 2 degree vertex, if that is impossible, they must be connected to the farthest visible 1 degree vertex, if this is impossible they must be connected to the farthest visible >3 degree vertex, if this is also impossible they must be connected to the farthest visible 3 degree vertex. If there is more then one possible vertex the youngest is preferred.
The coloring algorithm is the following:
- arrange the countries in decreasing order of complexity (Lombardo 1999, page 16, tab. 2).
- attribute color A. If there are countries of color A that share a border, attribute color B. If there are countries of color B that share a border, attribute color C and so on.

Lombardo S. (1983, 1985, 1987) Pittura Stocastica. Galleria Jartrakor, Roma

Lombardo S. (1986) Pittura stocastica. Introduzione al metodo TAN e al metodoSAT. Rivista di Psicologia dell'Arte n.12/13. Jartrakor, Roma

Lombardo S. (1991) Event and Decay of the Aesthetic Experience. Empirical Studies of the Arts, vol. 9(2) 123-141

Lombardo S. (1994) Pittura stocastica. Tassellature modulari che creano disegni aperti. Rivista di Psicologia dell'Arte, a.15, n.3/4/5,

Lombardo S. (1986) Pittura stocastica. Introduzione al metodo TAN e al metodo SAT. RPA n.12-13.

Lombardo S. (1999) 5-cromatic minimal toroidal map. Galleria Marchetti, Roma

Lombardo S. (1999) Estetica della colorazione di mappe. Rivista di Psicologia dell'Arte, a.20, n.10

Lombardo S. (1999) estetica della colorazione di mappe. RPA n.10.