Aesthetics and Algorithms : Around the Uncanny peak

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ABSTRACT

The objective is to try to translate the traditional values of aesthetics into algorithmic terms. Central to this is the concept of complexity and its numerous declensions. Its application to aesthetics is not straightforward. The curves drawn by most authors show a surprising apex, an uncanny peak. To get a better understanding of it, and make a step towards practice, we begin by outlining criteria based on the work of art itself, and then move on to dealing with audience or spectators' values, be it by direct perception (interaction, transmedia) or through modeling. We conclude with an outline of the ways artists integrate algorithms into their creative processes, be they as a mere aid or a fully generative system. This review is more a call for further research and cooperation between theorists, computer geeks and artists.

Categories and Subject Descriptors
J.3.5 [**Fine Arts**]:

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1. A NEED, A SCANDAL, A REALITY

Is it sensible to look for aesthetic judgment algorithms? This seems particularly inappropriate at a time when art criticism itself is in crisis. But, at the same time, such tools are becoming necessary owing to :
- the development of "user content" in the transmedia world and the way tablets and smartphones encourage creativity, be it only the billions of photographs taken every day by all kinds of cameras,

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- the automatic production of works of art due to generative art (such as Capture, by Balpe and others), far outgrowing the absorption capacity of the market and even of family and friends' capacity to read, look and listen. Without ranking tools, the art world would be as impenetrable as the 'Big data' accessible on Internet.

This may shock or upset many art lovers. They invoke Kant and, more generally, the sacred transcendence of human nature. We shall then have to reconcile this necessity with the Kant dogma (we have translated from the French in Jean-Marie Schaeffer [1], which is easier than directly from Kant's native language. This has added some critical spice and shows notably that Kant's views evolved throughout his life): "There cannot be any objective rule of taste which would conceptually decide what is beautiful". And from concepts, of course, we move naturally to algorithms and computer programs.

Indeed, a lot of such algorithms are already currently operational, and we use them without even noticing :
- digital cameras apply the implicit principle that sharp is better than blurred (autofocus), and well lit better than too high or low key (auto aperture and speed);

- smile triggered cameras apply the principle than happy faces are more pleasant (in general) that sullen ones;

- automated functions in Photoshop like: AutoSmartFix, AutoLevels, AutoContrast, AutoColorCorrection, AutoSharpen, AutoRedEyeFix apply a lot of more or less sophisticated formulas.

Web developers are advised by Danny Sullivan (chief editor of SearchEngineLand.com) that "building a website accessible by robots which explore the Web is as important as designing the site with internauts in mind". Of course, Google ranking is based on relevance more than aesthetics, but somehow still manages to include it.

Several artists have already come up with concrete solutions:

- Perez y Perez, for Mexica [2],

- Pierre Berger [3] in his communication to Afig 2009 symposium, with several algorithms in Roxame software,

- Penousal Machado for Nevar,

- Leonel Moura, who goes very far with his Robotic Action Painter,

- Antoine Schmitt, who wrote an automated criticism program.

Several lectures in McCormack & d'Inverno [4] cover the different aspects of this topic. The following is a summary of some of their opinions.

- Harold Cohen takes a conservative approach "... the completion of each work provides an extension of the feedback-driven consideration operating in the in-line evaluation... I have some hope for the possibility of post-hoc evaluation by the generating program; no hope at all for evaluation by any other program".

- Frieder Nake reaches similar conclusions: "... you can use such dynamic evaluative measures during the generative process. That's all. Anything beyond this is human value judgment".

- David Brown is less negative, but limits himself to a list of questions.

- Jon McCormack is philosophically positive: "... while there may be many areas of human aesthetics, cognition and perception that are currently "off limits" to machines, it does not necessarily preclude machines that may be able to originate something that humans find aesthetically valuable. Indeed, a lot of "computer art" has given us very new aesthetics to contemplate".

- Paul Brown is more assertive: "I believe that the rational analysis and synthesis of aesthetics... is one of the key issues for humanity to address in the 21st century... If we do not, then we are in danger of handing our world to the priests, fascists and other bigots...».

- Philip Galanter reviews the methods, including his own previous synthesis (see [5]).

- Jürgen Schmidhuber proposes a new model : what is appreciated in a work is what the spectator learns. He refers to the classical ideal ratio between expected and unexpected (order vs. complexity), quoting several sources, including the Wundt Curve. And he pushes further: what counts is the change of subjective complexity through learning. Aesthetic reward is the first derivative of subjective beauty.

- Alan Dorin and Kevin Korb "define the creativity of a generative procedure by reference to its ability to create artifacts that are improbable with respect with those generated using previous methods".

Let's now review the known criteria, adding critical notes from time to time. A general note is that many of these studies seem more theoretical and mathematical than really oriented towards the public and taking into account what must remain a fundamental aim of art: pleasure or, more generally, emotion.

We will be guided by the three classical features of beauty: clarity, integrity, harmony, as elucidated by Thomas Aquinas [6] based on Greek philosophers. We interpret clarity as substance and complexity. Harmony speaks for itself, and integrity plays a role in meaning. We will use also the modern definition of art as creation of "unpublished resonance".

2. SUBSTANCE OR VARIETY

The simplest criterion of all is the demand that the work has something to show, "substance" as one says, or "variety" in the cybernetic lingo. To put it briefly: there is more "substance" in Napoleon's Coronation by David than in the Black Square of Malevitch. Perhaps, the logics of negation, so powerful in the mid-20th century, has led to the blank canvas and the minutes of silence. But once is enough! After this, a minimum of substance is necessary to produce interesting works of art.

This criterion works well for basic evaluations : color is better than black and white, oil or acrylics better than watercolor, a large painting sells for more than a small one by the same artist; a film, with its thousands of frames, gives more than a simple image, an opera is more than a symphony or a simple song, a palace more than an simple house. It accounts also for sharpness: a correctly focused image is more pleasant and gives more information than a blurred one.

From a more formal angle, variety in digital artworks is the number of bits contained in a work. For sound or video, it is the sampling rate times multiplied by the bit depth. For images, the number of pixels times the bit depth (24, usually).

We go a little further if we take into account the probability of the different values for each element (energy, neguentropy). It is well known that a maximum of information is obtained when all values are equiprobable. On a sound flow, it can be evaluated easily, even on continuous, non-digital sound. Just fix an intensity threshold and count the number of times this threshold is crossed for a duration of several seconds. The Max "robot", uses this parameter to compare two radio stations and to choose the more "varying" one. [7].

On a digital image, it is equally as easy : count the number of pixels that differ from the ones on the left and above. If there are not?

3. COMPLEXITY

Complexity is indeed the "hard core" of generative art and its aesthetics. In the traditional computer environment, the term means rather simply the weight - in terms of computing time or memory capacity - required to apply an algorithm, do a task or make a given object. Seen such classical references as [8] or (easier, but in French) [9].

Others (Kolmogorov and followers) define complexity as a minimum: the complexity of an object is the length of the smallest program able to generate it. This definition is intuitively attractive. Unfortunately, it is generally considered as not measurable. In any case, for a given work (supposedly digital), it will vary considerably depending on the language chosen, which may fit more or less to which may fit more or less the document to be encoded, and depend on the previous "knowledge" of the system. If, for instance, you have stored a lot of images, the program to produce one of them is limited to the name of its file.

These levels can be enumerated, for example, in the Roxame image generating software [10] . At the lowest level, it runs in "machine language". At a higher one, it is in Java Code. But since it is written in Processing, the code is shortened, using the library of this open source tool. As well as this, Roxame includes many substantial number of functions, form generators, filters, compositing, evaluating), some of them not so simple (for instance, segmentation), all of them available through one item in a dictionary.

As the dictionary includes macro terms, defined by a sequence of dictionary terms, a single word may call up a program of any size, compatible with the host computer capacity.

When a new work is launched, a set of parameters has assigned

values. Then just type ***h***, and Roxame will draw a horizontal sienna line at a random high. Or type 'load', and it will load the last image used in this session or the preceding session. Last but not least, to make the fun complete, Roxame is built to work alone. So, once you have defined a type of work, just type ***$*** and it will create works according to this program for as long as you keep the programme running.

Here is an example of top-down deployment from this single symbol. The program launched by ***$*** builds images with approximately two thirds of differing pixels It starts with the loading at random of an image (possibly blank). If the number of differing pixels is too low, it applies a complexity increasing routine, selected at random in a list. Conversely, if the complexity is too high, it applies a complexity decreasing routine. It stops when it gets sufficiently near to the 2/3 proportion, of after 40 iterations (to avoid clodes loops). Concretely, ***$*** calls ***work***, a macro-instruction where ***nw*** and ***fnd*** prepare and finish the work done by ***action9.*** This latter one loads a file randomly selected in the ***test*** directory, and applies to it the ***target-num*** function with ***200*** as target value.

work macro_ nw action9 fnd work

action9 macro_ tests.rd 200 target_num

target num calls the ad-hoc Processing routine :

```
void targetNum(int int1){
M(1); int stepcount = 0;  int stepReached = 0;
while (stepcount < 40) {
M(1);
if (difg < int1*1000 - 30000) {
Ddo2("augment.rd");
stepReached ++ ;
}
 else {  if (difg > int1*1000 + 30000 )  {
Ddo2("reduce.rd");   stepReached ++ ; } }
stepcount++;
}}
```

Hence, complexity may be central to a lot of theoretical reasoning, and fits relatively well with post-modern philosophy (see for instance Edgar Morin [11]). But it's difficult for us to see how to use it directly in art generation or evaluation.

But, seen together as signs of richness, variety and complexity are a natural aim for artists. We see this in all the arts, especially today - for example, in digital animation's on-going race towards higher and higher definitions,

Variety and complexity can even be increased using random generators, whether it be with algorithms (always "pseudo-random, but possibly very powerful) or nature (even turning to nuclear devices to get quantic randomness, made available by the Cern, Geneva, Switzerland).

So good. But creating complexity simply for the sake of complexity can lead to chaos. This explains why rules and canons have been developed to 'keep the peace'.

4. HARMONY AND ORDER

Harmonious proportions have been explicitly used since the Greeks and, in a less direct way, by the Egyptians [12]. The work must conform to rules of harmonious proportions, based on experience as well as observation of nature. This is exemplified by the 'golden section' in architecture where proportions are fequently based on simple ratios (1/2, 1/3…) for example.

The case of music is also emblematic, with the harmonic proportions of the Pythagoreans extended to the whole universe ("harmony of the spheres").

Other forms of harmony and order are traditional in different art forms:

- in drawing, for example, symmetry [13], the basic rules of landscape construction (horizontal, pyramidal, diagonal), and even the laws of perspective,

- in music - counterpoint, tones and scales, and musical forms (sonata, fugue, etc),

- in theatre, the Aristotelian rules [14],

- in poetry, versification rules, see [15] for English Verse, [16] for French,

- in architecture - from Vitruvius [17] to the 18th century, canons have stressed a particular set of forms, based notably on the three "orders" (Doric, Ionian, Corinthian). Other canons came later, see Viollet-le-Duc [18] and Charles Blanc [19], and more recently, Le Corbusier's Modulor [20].

These kind of rules, although not easily programmable are generally of practical use in the creation process.

But too much order leads to dryness and boredom.

5. ORDER, CHAOS, THE UNCANNY PEAK

Somewhere between too much and too less, a lot of authors have stressed the need for balance between order and disorder.

Concerning poetry, for example, Dorchain writes (our translation): "The function of verse is to give to the spoken language as much musical power as possible. This exceptional power is reached by adding (as the measure in music) an element of security for the ear and the mind, to the surprise element of ordinary language". The role of transgression and its expressive effects is studied by Leech.

As for painting, a notion of « right measure » between order and disorder is a classical motto; for instance, the use of symmetry in painting as observed by Funck-Hellet: « Symmetry brings a voluntary order… but if, at first sight, the symmetry is visible, it destroys the unity of aspect and downgrades the superior attractiveness of the composition » (our translation from French).

Graphics and the plastic arts also look for a balance between abstract construction and "the arabesque" – Viollet-le-Duc referred to this in his comments about the schemes of Villard de Honnecourt, a medieval architect [21].

Concerning cinema, Eisenstein, has written extensively on this art form and specifically . about the role of conflict (our translation from French, in [22]) : "In the domain of Art, the aesthetic

principle of dynamics embodies itself in the conflict as the most essential principle of existence of any work of art and artistic genre."? The hypertrophy of an initiative conscious of its aim – of the rational logic principle – freezes art into a mathematical technicism (The landscape becomes a plane, "Saint Sebastian" an anatomical drawing). The hypertrophy of the organic natural – of the organic logic – dissolves art into shapelessness (Malevich becomes Kauflblach, Archipenko a waxworks museum).

Since the end of the 19h century these words of wisdom have been challenged by photography. This has pushed painters (and more generally plastic artists) into a progresssion of transgressions, which include notably the Impressionists, Surrealists, and, of course, Marcel Duchamp. At the end of the 20th century, we reached a point where nothing remained but pure conceptual transgression.

Formal, and, as far as possible, scientific (mathematical formulas and experimentation) expressions of this balance have been developed by many writers since the late 19 th century.

Gustav Theodor Fechner and his Zur experimentellen Ästhetik is the founder of experimental aesthetiks. 30 years later, a review of the topic by Larguier des Bancels [23] that we are still waiting for meaningful results.

The idea becomes sharper with Gips and Stiny [24], explicitly entitled "Algorithmic Aesthetics. Computer models for criticism and design in the arts". They connect their concepts with generative grammars.

Rather magically, aesthetic research converges with research on life by Murray Gell-Man [25], with artificial life (Conway) and cellular automata (Li, [26]), presented in' The machinic way of life' by John Johnston [27] (a compelling title!) and biosemantics by Abel and Trevors [28].

A particularly interesting synthetic view of generative art is put forward by Galanter and his lecture on McCormack . It is even extended to social systems by Anantahanarayanan [29] , with a EUM (Existential Universe Mapper) scheme. And we have found a forerunner in Teilhard de Chardin [30].

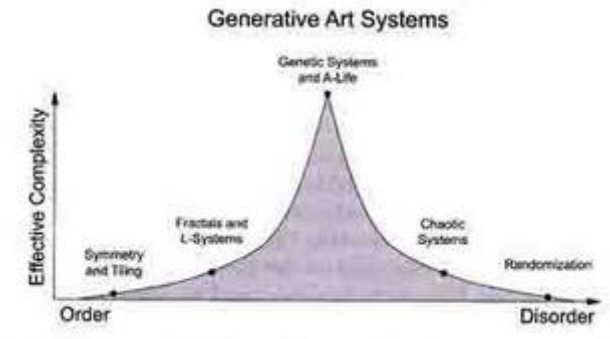

Fig1. The peak scheme, by Galanter.

All (or nearly all) of these efforts show curves culminating on a point where "beauty" and "life", whatever that may be.

This apex has different patterns. Sometimes it is rounded, like a statistical bell curve (one version of Gell-Mann, Ananthanayanan, Abel-Trevors, Teilhard). Sometimes it is just sketched as angular (one version of Gell-Mann). It may be seen as a fork in Langton, and is showed as such by Teilhard. But, the most fascinating of all is the cusp shown by Langton and Galanter.

Unfortunately, the apex's coordinates, and even their meaning is nearly always rather fuzzy.

On the x axis, we start generally at 0 and reach a rather indefinite maximum (sometimes equal to 1). 0 is considered to be total order, with no variation. 1 is considered to be total chaos. The values on this axis represent:

- algorithmic complexity, or algorithmic information content (Gell-Mann, Ananthanarayanan),

- a rate of modification at each step (Langton), named λ (a precise definition may be found in [26],

- time, for Teilhard,

On the y axis, no scale and no limit are given, apart from a starting point at zero. The values represent:

- complexity (Langton),

- effective complexity (Gell-Mann, Galanter),

- quality of social systems (Ananthanarayanan and Malhotra),

- energy and reflection (Teilhard).

Abel and Trevors present 3 dimensional graphics, with x for complexity, y for algorithmic compressibility and z for algorithmic function.

The continuous curve is completed by a set of categories of classes:

- the four classes inherited from Conway: static/stable, periodic, complex, chaotic,

- classic, low gnarl, high gnarl and surreal, a renaming of Conway classes by Rudy Rucker [31] for science fiction novels (Rucker makes explicit reference to Conway),

- clan, clockwork, ecological, integral, network, arena (social systems according to EUM (Malhotra [32]),

- Three qualitative kinds of sequence complexity exist: random (RSC), ordered (OSC), and functional (FSC) for sequence complexity (Abel & Trevors).

Samuel Monnier wrote that he does not think it is possible to define a appropriate set of algorithms (what Galanter calls "Generative Art Systems") and a sufficiently precise definition of effective complexity.

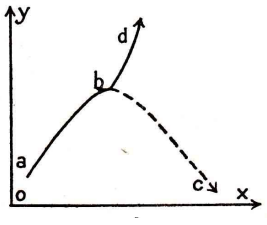

Fig2. The peak and rebound scheme, by Teilhard de Chardin

He writes (our translation): « It seems that this kind of effort is doomed to failure, if we consider all the algorithms. Indeed, a theorem - Chaitin's incompleteness theorem - states that there

exists a constant C such that if the Kolmogorov complexity of an algorithm is higher than C, it cannot be computed. In other

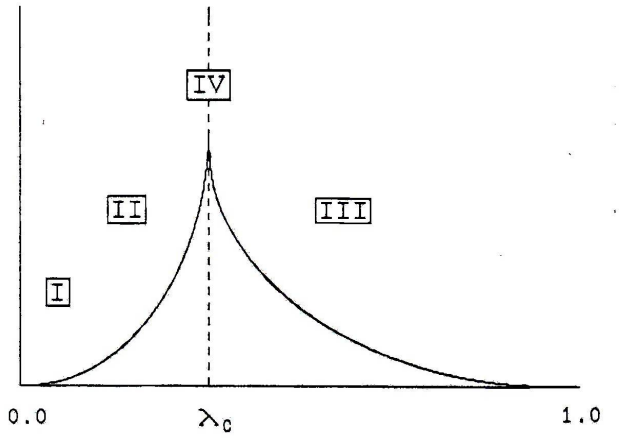

Fig 3. The peak scheme, by Langton.

words, the Kolmogorov complexity of most algorithms is not computable, and they cannot even be located on the x axis. The explanation is given in Wikipedia [33]. But this obstacle could perhaps be avoided if the search is limited to a finite set of algorithms.

"Similar things could be done with images. For a given definition and bit depth, we have a finite number of possible images. Then the Kolmogorov complexity of an image can be defined as the size of the smallest program able to paint it. That would be the x axis of the Gell-Mann figure. Then you would have to define a natural notion of effective complexity on the y axis. If you have that, then you can hope to compare effective complexity with attractiveness for a spectator. However it seems clear to me that the attractiveness of an image cannot be related exclusively to any notion of effective complexity".

Some others try different tracks:

- The « narrative interest » is defined by Jean-Louis Dessalles [34] as the difference of two complexities: complexity of generation and complexity of description. This calls for developments of the real nature of this difference between generating and describing.

- A survey of several AJS (aesthetic jugdgment systems) has been carried out by Juan Romero, Penousal Machado, Adrian Carballal and João Correia (in McCormack & d'Inverno).

As for us, we have tested, with partial success (to be confirmed), a very rough criterion on 640x480 pixels images: how many pixels differ from their immediate left and upper neighbors. We define here "complexity" as the proportion of pixels that are different between the ones of the left and the upper ones. The best images have a complexity at almost 2/3. Images of lower complexity are of poor quality? (with the limited case of monochromes, of course). Images of higher complexity (up to 100%) are "natural" images, like photographs, without "artistic" effect.

These latter results are crude and basic , (not to say worse) but they convince us that we must not give up this search for complexity. We shall look at other reasons for hope below.

6. RESONANCE: ANOTHER PEAK

Resonance brings other hopes to reach a convincing and effectiv model, for two reasons:

- resonance takes us beyond a purely internal analysis of a work and its complexity, up to an appreciation of its relationship with something else, which could be the spectator ; here, the work becomes the energy-loaded frequency which renders the resonator active;
- we have a full quantitative and mathematical expression of the curve and of the peak; and the peak is more or less flattened, which corresponds better to our intuitive idea a an interval of good values and not just a point with supposedly exact x value.

Basically (see Wikipedia [35]) , resonance is driven according to a formula of the form: ***a/ ((d ** 2) + c)***, where ***a*** is a scaling parameter, ***d*** is the difference between two frequencies : the external energy source and the resonator's specific frequency. And ***c*** a damping factor. When ***c*** is large, the peak is flattened (the resonator is lazy, but responds to a wide range of moving energies). When ***c*** is small, the peak is pointed (the resonator is sensitive only to frequencies similar to its own, but then can accumulate energy. In the limited case where ***c*** is null, the peak would reach infinity.

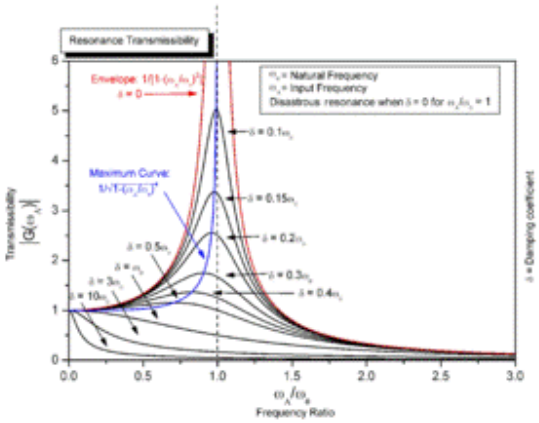

Fig 3. Resonance (Wikipedia)

We can also observe that the formula is the opposite of a parabola. When d is null, we are at the base of the parabola with an interesting feature: at that point, there is no preferred direction; somehow the system is "free to choose". If we transform our flat parabola into a parabolic cup, then, at the bottom of the cup, the system is free to go in any direction on a whole 360° gamut.

Indeed, ***d*** can be interpreted as a distance. This is a promising term. Just looking into Bres [36], we find ten types of distances for image processing!

So we could extend the model to any metric space:
- modeling audience tastes according to several parameters
- combining it with recognition (see below, meaning) using the classical method of recognition by minimal distance in a feature space.

There is also a correlation with the psychological concept of cognitive dissonance.

The damping factor also gives hope. It can be any meaningful number, and may related to noise, and hence to the medieval critewria of clarity and integrity.

It would be interesting to explore further in this direction, hoping to find a common model for complexity and resonance… assuming that the similarity of curves is not deceptive.

7. "UNPUBLISHED" ORIGINALITY

As far as we know, this aspect of art has not been, up to now, studied in this environment. It is not purely mathematical, since it relates to a "state of the art", with a collection of existing works before which a new work must be tested : if there is no similar work in the collection, the new one is considered original (and, implicitly, added to the collection).

When a work is a digital file, or may be correctly represented by digital file (or set or files), its originality will become easier to evaluate, for two reasons:

- any work other than private will be somehow present or presented on the Internetn,

- comparison methods and algorithms will improve since intellectual property protection, more powerful marketing techniques, and security and defense issues will need them ; their results could be applied to originality in the art field.

The problem is then to make comparisons and to define a level of similarity (or dissimilarity). This already exists for music, for example the Sacem in France (Société des auteurs, compositeurs et editeurs de musique). It has been functioning now for many years.

This will go hand in hand, of course, with ranking and market value.

It should be noted that:

- originality is not a yes or no feature; nothing can be totally new, and even a copy can exhibit interesting differences with the original, with one exception: duplicates of the same digital file;

- what matters will be the definition of originality thresholds, with practical consequences on law and trade;

- originality relates not only to a definite individual work, but to series and categories: originality of a style, of an artist, of a "school", of a region or religion;

- appreciation of originality differs according to the audience; for a child, everything is new; for a mature art historian, meaningful originality is rare ; and there are middle grounds, according to the specific culture of the spectator, according to his/her profession or social environment. These features, too, can be more or less modeled (see part 9).

The terms "original" oand"originality" are absent from the index of (McCormack & d'Inverno). But novelty is (rather shortly) dealt with in the book, mainly concerning improvisation (lecture by Tim Blackwell, Oliver Brown and Michael Young).

An automated evaluation of originality cannot rely only on algorithms. It must be supported by a base of the complete existing works of art. Or at least a base of specific kinds of works. Up to the 2000's, this seemed totally unrealistic: the storage capacities available as well as the labour to acquire the works (scanning, for instance) were just not possible. Today with the Internet, the billions of contributors and the power of browsers, it is no longer a dream. There is,of course, the risk of omitting works, but no more than human art critics.

For a long time, this kind issue has been a fundamental impediment to the development of Artificial Intelligence. Today, the defining victory of the Watson machine in Jeopardy, as well as other exploits, has proven that this barrier, too, has been broken through. See the CACM paper by Kroeker [37] or, for the story of the contest, Baker [38]. And note that Watson had (contractually) no access to the Internet during the contest.

Let's conclude noting that originality can be seen as another kind of distance, this time between a work and the set of all other works. If the distance too short, the work is no original. If it is too long, the work will not be understand by the audience (think of the first presentations of Beethoven innovative works). In between lies a sort of comfortable zone, where works please and raise interest without asking too much for their audience. In this kind of model, if we can define some damping parameter, we will again find our peak shaped curves.

8. FEEDBACK FROM THE AUDIENCE

Art is possible without any feedback from the environment, or with only a very limited environment, such as Theo Van Gogh for his brother Vincent. And artists work for "eternity". But shorter and stronger feedback loops are highly desirable.

Real time feedback is important for the performance arts. All performing artists stress the importance of performing in front of an audience. The other arts (plastic arts, musical composition, and cinema) must use a longer feedback loop: public reaction to the preview, and sales figures. These data are fed back to the creator weeks later, and often months and years later... even many years after death in the case of '*artistes maudits*' – those unsung artists, neglected and shunned by society.

With the digital arts, the works can become interactive. They can perceive their environment. A mere photovoltaic cell is enough to detect a presence. A basic camera will give even more information (for instance using the free Open CV library). Some artists make effective use of this ability. For example, in his work 'The Year's Midnight', Rafael Lozano-Hemmer gets powerful effects from machine vision: the person mirrored in the work, sees its eyes burning and turning to smoke.

The most interesting, says Florent Aziosmanoff [39] is to perceive the psychological attitudes of the spectators. These functions reach a high level of complexity, and Aziosmanoff groups them in a "perception motor" : « … in a relational system, the attitudes and reactions of the audience capture is the means given to the work so that it can adapt the process of its enunciation to the evolution of its distribution ». That means that the capture must be

able to reach a symbolic level of information. Rather than indicating that the spectator has moved several millimeters in this direction, it will say, for instance, that the audience is loose or compelled, distant or engaged".

Aziosmanoff quotes an easy but effective measure : the average time spent by a spectator in front of the work. In a museum the visitor is said to devote an average of three seconds on each work. Only works of exceptional interest retain the spectator more than 20 seconds. (This kind of measure is easy to verify by anyway with a cell phone, which has a stopwatch function and can be used unobtrusively).

To engage the spectator for a longer time, the work must allow the public to enter into a relationship with it, to play with it and get control of it? Then the interaction may last several minutes. We have tested this with the audience of'Frequency and Volume' by Rafael Lozano-Hemmer presented in La Gaîté Lyrique in Paris in the fall of 2011. The work the work does not capture anything the audience does; it just provides shadows, of variable size according to position. And the spectators rapidly understand how they can use it, for individual or group action. And even create their own work out of it, recorded on their smartphone camera.

Game designers are very keen on these issues. But artists of traditional culture and education do not give the audience much latitude or control, even when they seem to call for interaction. This results perhaps from their professional education which tends to despise audience scores and mainstream box-office figures, and to look mainly for an elitist recognition in the art market.

Today, any creator of art on Internet can have daily reports through observation sites like Google Analytics.

Transmedia is forcefully changing the landscape. (The term has been defined in its present acceptation by Jenkins and presented in depth in his 2006 book [40] and we have attempted a comparatively short and systematic review in [41]). The reactions of multiple audiences and the metadata on them are taking up more and more space in the creative process itself.

9. MODELING THE TASTE(S)

De gustibus and coloribus non est disputandum (Of tastes and colours there is nothing to be disputed). This Latin maxim anticipates Kant's anathema. Taste would be irreducibly subjective, and above any attempt at formulation.

Nevertheles, a scientific modeling of "taste" and the possibility of drawing up creative rules for artists has long been sought after. The results of experimental aesthetics (19th century) were a long way from achieving their aims. But one century later, some results have begun to emerge. There are, for instance, algorithms to predict the success of a piece of pop music. And there are several references to this issue in the lecture of Galanter in McCormack& d'Inverno, pointing to psychological models of human aesthetics, empirical studies, and neurosciences.

Some tastes are universal among humans, Alain Gheerbrandt [42] for instance, tells of the moment when an expedition in the Amazonian rainforest played Mozart music to local tribes, and how it was immediately appreciated. Some general tastes are sometimes even shared with animals (many are positively sensitive to some kinds of our music).

Of course, common sense as well as art history tell us that tastes differ according to individuals. This does not take away the validity of general laws: if tastes were totally different from one individual to another, art would be impossible. So a certain amount of modeling is possible, and is actually used, as we have seen with autofocus, auto-exposure time and aperture, with smile triggering, etc.

The scolastic traits of beauty refer implicitly to taste, in the line of the motto « pulchrum est quod placet visum » (is beautifaul what pleases to be seen) : integrity (we do not like an object which lacks one of its constitutive parts), clarity (we like optical sharpness, regular scales of sound pitches, and non-ambiguous language), and harmony.

And the progress in marketing methods, with their increasingly elaborate profiling, is moving that way. From the modeling of human beings in general, the tendency is now towards one-to-one marketing, which goes hand-in-hand with individual taste descriptions. Why shouldn't art build on that?

Here, too, transmedia appeals to feedback from individual spectators kindles new hope. Moreover, the capacity to generate collective attitudes and opinions can lead to more sophisticated taste "education". The feedback to authors and producers is channeled and communicated in two ways :

- direct messages to the emitting sites,

- metadata collected by specialized firms.

How far can this kind of feedback lead to scientific modelling of tastes ? We can imagine that the think-tanks of large media corporations have come up with quite a few results. In this case, they are considered to be trade secrets, and buying/selling algorithms in financial markets.

However, there are some seemingly effective tools which are available off-the-shelf. In pop music, for example, algorithms are doing well in predicting the success of potential hit (Burkeman [43]). And anybody can get a song rated on line by musicxray.com.

10. MEASURE THE MEANING

How to evaluate the semantic value of a work? Some authors, in the Shannonian line of information theory, tend to reduce this criterion to the substance such as defined above. This is the case, for instance, for Osgood's "The Measurement of Meaning" [44] or Moles' "Théorie de l'Information et Perception Esthétique" [45]. We have seen the value but also the limitations of this approach.

We think that an alternative way could be explored (but is not currently being done so as far as we know). With a detection and pattern recognition system, we should be able evaluate the "quantity of patterns" that a work is able to provide to the system, and consider this quantity as a measurement of meaning. This « generative power » would be something like an inverse of Kolmogorov complexity : the longest story that the system may read out of the work.

The scolasttic criterion of integrity relates directly to recognition. We know that small defects can create strong displeasure, as has been shown with the "uncanny valley" in android robots.

We could also measure the consequences of this perception on an observer's behavior and thus extend the cognitive side of meaning with something like emotions (this subject is being increasingly studied and experimented on in robotics, for example).

Different evaluation systems will give different appreciations results. A powerful recognition system, with a large library of pattern and a large stock of features, will extract more meaning than a basic one. But this is precisely a confirmation to this approach validity: two different persons have different tastes, and an expert like Panofsky [46] can write 25 pages on "Arcadia Ego" by Nicolas Poussin, in which a non-specialist visiting the museum will only see some undefined characters talking in front of a rather dull stone monument?

Since Google is investing in these evaluation tools – and many others, too, including military and medical professionals - we can expect great things in the years to come. And this kind of Watson-type cognitive machine will give them the technological resources they need (if they don't have them yet).

10. CRITERIA IN CREATION

We come to our last question: how to integrate these criteria into the generative process (assuming we are doing generative art, of course). Some examples of integration of an AJS (aesthetic judgment system) into a generative program are briefly presented by Juan Romero, Penousal Machado, Adrian Carballal and João Correia (in McCormack & d'Inverno).

In fact, there are many different kinds and levels of integration of criteria into the creation process.

a). Human creation aided by the computer

There are a fast-growing number of useful aids for artists to use. More and more artists are turning to them, even those who refused to consider the computer as any more than a simple technical device.

Writers, too, have used external aids for a long time such as dictionaries, grammars and versification treatises. Since the 1980's, spell checkers have been in use and these are improving year by year. In the early versions, they could only detect misprints at the word level. Today, even standard word processors make observations and suggestions about punctuation and word agreement. Tomorrow (and maybe even some today) they may well be able to improve style : point out inappropriate language and register (useful for foreign writers !), detect excessive repetition of a word or expression, or the excessive length of a sentence, or highlight an anachronistic element in a historical text

They will also be able to take into account the target reader's supposed tastes or the preferences indicated by the ranking automata.

They could also search on the web for similar names (brands !) and for plots, too, thus saving themselves from accusations of plagiarism!

Current word processors have already begun to make suggestions for better ways of expression. For poetry – and even more easily in music - they could suggest breaching the conventional style rules to add interest. This could be extended to more in-depth proposals concerning the features of the fictional characters, and the time and period context. Or suggest creative alterations of existing works, or subtle remixes.

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b). Generative art

If artists accept the computer not as a mere tool but as a partner, or even as an artist in itself, we enter the realm of generative art [47].

Here, several approaches are possible, more or less generative/

- The artists exclude any programming of criteria, except, of course, those which are implicit in the generative algorithms, like the range of patterns and colors available ; then, to keep the production within marketable quantities, they can arbitrarily limit the number of works per day (or month or year), or leave the market itself to do it, through a web site for instance.

-The artists select the works they intends to keep and show, according to their taste,

- The artists integrate a sufficient number of criteria into the generative process to reach an adequate quantity of production; these criteria can be applied in an evolutionary or genetic (Darwinian, if you like) framework. The most advanced example of this is the RAP of Leonel Moura. In this case, the automated system works by trial and error, the old cybernetic feed-back way. Roxame software also implements a rough application of this method, using our 2/3 different bits criteria (see the code in part 3). Art inspired by life uses the classical two-fold criterium: random crossover of genes, and selection according to fitness criteria.

An interesting question is asked by Cristian S. Calude and J.P. Lewis [48] Is there a universal image generator? Or, more precisely, is there a generator able to produce all the images to satisfy a given criterion. Perhaps this issue could profit of benefit from our peak models, if we interpret the criterion as a resonance performance.

We could also design algorithms to generate original systems by negation of the existing corpuses.

Even with fully automated systems, evaluation included, some artists have a "purist" philosophy : they will not accept to change anything in the finished work, but only continue to develop the program to fix its defects or enhance its results (in music, this was the case of Barbaud and Hiller). Other have a more pragmatic and "humanist" view: they will adapt the final result to their taste and own creative genius.

c) Transmedia and art/science cooperation

Transmedia enables us to break new ground in integration. By itself, even in its simplest forms, it requires the cooperation of automata and human authors *écrivains?* Artists? Artistic creators?

Take, for example, a writer who produces books, but has also a rich website, a blog and is active on social networks. The blog, by itself, is generally hosted by a site operating a content management system. This CMS combines the author's production (HTML, like documents, mainly) with graphic charts embedded into "themes". And the finalised setting on the user's screen is adjusted by the browser, according to the author's machine and his/her preferences? Similar composition processes operate on the social networks. So, the author's criteria, the programmed aesthetic criteria and the spectator's tastes are integrated into the final version presented to the spectator.

To continue forward in this field will require the collaboration of artists. This could provide several alternatives using the kind of algorithms reviewed here, and the results of tests to see how well

they correspond to audience perception. In the traditional domains of fine arts (in particular plastic arts), cooperation between artists and scientists is very difficult to develop today. Because of the transcendental nature of art , artists work in an individualistic way. The market requires them to produce a variety of different works, and does not pay them to use experimental protocols. For their part, the research laboratories have little incentive to allocate their precious human resources to activities of low industrial impact.

Transmedia will, hopefully, encourage substantial investment in these transdisciplinary developments. Here, the producers aim to long lasting and worldwide franchises. Then they can bet on the long term with substantial funding, and pay for fundamental research.

Then we can hope that the uncanny peak of complexity, resonance and beauty will be explored by committed and well supported interdisciplinary teams.

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