

Digital art, from the Bit to the Cloud

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ABSTRACT

Absolutely meaningless, the bit opens to the digital world, and art in particular, the way to universality of the “cloud”. Works grow in size and complexity, from sampling to coding through mounting and grammatical generation. Life, algorithmic or transformed, spreads into the networked art of transmedia.

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Laval Virtual VRIC '14, April 9-11, 2014, Laval, France.

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Categories and Subject Descriptors

J.5 [Arts and Humanities]: Architecture, Arts, fine and performing, Fine arts, Literature, Music, Performing arts.

General Terms

Algorithms, Design, Experimentation, Theory.

Keywords

Bit, Cloud, Art.

*I feel the Bit beating in my heart
No meaning but power.
I see the Cloud whirling high overhead
Calling us for an answer.
I share the Life, this growing spread.
The World we build together.*

1. I FEEL THE BIT

In another paper [], we present a “horizontal”, “database” state of the digital arts today. Let’s try here to propose a “vertical”, narrative theory of digital creation.

1.1. The bit's birth

The bit is today 67 years old. More precisely, the present current meaning of "bit" in the digital world. The date of birth is precisely known: 9 January 1947, his father John W. Tukey, his godfather Claude E. Shannon, who made his fame. The sky map was favorable. In these years, some of the best brains in logic, mathematics, communications, biology, psychoanalysis and nuclear physics were concentrated in the US. They used the best of various technologies from precision mechanics, chemistry, electricity and electronics (see for instance Dyson []). And, nearly at the same time, the binary nature of life was made explicit by the discovery of DNA by Watson and Crick.

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LEDs, icons of bits, spiraling in a cloud

The centrality of the bit was soon heralded by John Von Neumann and several authors [], who wrote " “We feel strongly in favor of the binary system”, for three reasons :

- hardware implementation (accuracy, costs),
- “the greater simplicity and speed with which the elementary operations can be performed” (arithmetic part),
- “logic, being a yes-no system, is fundamentally binary, therefore a binary arrangement... contributes very significantly towards producing a more homogeneous machine, which can be better integrated and is more efficient”.

Art itself had prepared the way. During the second half of the 19th century, pre-digital models had taken force, for instance:

- the view of language as a system of oppositions (then of bits, without saying it), with Saussure [],
- the "elementarization" (taking the word from Estelle Thibault []) of architecture, with the database/linguistic approaches or Viollet-le-Duc's *Dictionnaire de l'architecture* [] or Charles Blanc's *Grammaire des arts du dessin* []; no less graphic but slightly less artistic was the vogue in France of descriptive geometry, heir and crownprince of the traditional architectural

stone cutting (see Asanchev []),

- fragmentation in painting (impressionism, pointillism, cubism, collage, Bauhaus abstraction...),

- the formalization of music, with major steps as the *Well tempered harpsichord* of J.S.Bach, harmony and counter point, and in the late 19th century and early 20th, the new formalisms of dodecaphonism and serialism, and the publication of books like *The Mathematics of the Arts*, by Joseph Schillinger [],

So the bit was borne as the focal point in a convergent process of fragmentation, division, elementarization.

1.2. The good fairies around the cradle.

Would the new paradigm of science and technology bring it's proper name: binary? In fact, no. The term is no so pleasant by itself, and worse enough when coupled with mathematics, information, and still more in art. Then, the many good fairies circling the cradle and the nude newborn, choosed names as decent clothes matching their conceptual systems and meaning connotations.

The winners, in the common linguistic practice, were the mathematicians, which define the bit a the unit in numeration on base 2. The formal logicians use quite the same language, though insisting on the true/false pair (which can in practice be represented also by 0 and 1). The circuit makers tend to use the term "logic" as opposed to "analog". Some domains of art use rather "electronics". It's frequent in music (possibly reduced to "electro") and, more surprisingly, has been reborn in poetry by the American ELO (Electronic Literature Organization).

But, taken in itself, the bit is nothing of all that. It is only a being (or anything) than can take two different values. Why not male/female (as could be suggested by the rather explicit representation of both sexes by the typography of 1 and 0).

1.3. Unbreakable

You cannot cut a bit into smaller parts . As a material object, for instance, there is no meaning in cutting the thing in two. It is strictly atomic. Even more radical, if you use a bit as unit in numeration, the 1 is the smallest natural number (integer) greater than 0. If you want to represent smaller numbers, you have to add bits, or in the decimal way : 0,1, 00,1... or also using floating point coefficients.

1.4. Some part of matter

Art deals only with bits that have a material existence. You can imagine "spiritual bits" in a immaterial world, but cannot represent them without matter.

A bit is somewhere in space and time. Then it has an address. This address may be completely absolute (like in a GPS, but with a precision in nanometers or less.) But in general, this address wont be used directly, but through several layers of indirect addressing controlled by the software. Note also that this matter may be purely dynamic, if the bit is travelling on air or along a copper or fiberoptic line. To be accessed (read or written), it must spend some quantity of energy, and if "live", even when not active.

As is well known, the quantity of matter and energy per bit has exponentially decreased since the 1960's, and will probably continue to do so in the years to come, with some limit at the quantum level. And the time to transmit or process one bit is decreasing in similar trends.

Remains open a difficult question: bit is an absolute limit in fragmentation. Sharp. There is no similar limit in matter. The atom is not a-tomic. Instead physics bump into the stochastic limits of quanta and relativity. For at least the 1970's, the question of how many bits can be stored on a gram of matter, or of how many atoms are necessary to represent a bit or operate a logic gate has evolved. Two tracks are nowadays actively explored, quantum computing and DNA computing. They are presently out of the art scope.

1.5. Absolutely meaningless

Shannon is famed for having formulated the separation of information and meaning []. It's complete at this elementary level: So the bit is totally meaningless, and from this absolute nakedness arises it absolute power to mean anything... provided bits are connecte in sufficient number.

We can even say that, in practice, a bit does not "exist" if it is not known, handled or controlled by another bit or bitset. It's the "subjectivist" facet of the bit and bitsets. By itself, you cannot know what it represents, how you can operate on it, and even know where in space and time it is materialized.

Fragmentation, indeed, has a meaning. It is a traumatism, and as soon as we have fragmented, we long for reunification. In the windstorm of information and emotions around us, we need to find back unity. The nostalgia of a lost Eden, where intuition and analogy (including analog computers in the 1950-1970's) gave life to instinct, in a ineffable expression of the soul. So we long for the Cloud...

2. I SEE THE CLOUD, CALLING

2.1. A sphere of synthesis

Let's use "The Cloud" in slightly more global sense than the NIST definition of cloud computing " a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction...". We shall take is as including the contents (big data, websites, transmedia) and not forget its powerful actors, be they public or corporate.

This historical trend to fragmentation has always gone along in duality with a quest for Universality. Aristotle was the teacher of Alexander the Great as well as the authors of "De partibus animalium", and if Shannon launched the bit term, it was to answer worldwide communication issues much more than computer development. Machines tend to unite. There is the famous sentence of Jean-Charles Sismondi. "In truth then, there is nothing more to wish for than that the king, remaining alone on the island, by constantly turning a crank, might produce, through automata, all the output of England." [] Jules Verne []

and AlberT Robida [] had foreseen the web in the 1880's. And at the time when the bit was born, Lewis Mumford stressed in his book entitled - note the singular - *The myth of the Machine* [].

It may be inspiring, but also misleading, to think the Cloud as a sphere including our world, with the bit as a point in the center, and various levels of bitsets, or beings, growing as successive layers.

Today, the Cloud is rapidly thickening. We assume here, perhaps without still sufficient evidence, that the global sphere embodies the convergence of series of generalizations/globalizations:

- the material sphere of Earth (and the outer space as far as we are present in it),
- the machinic convergence into a sphere of interconnected machines
- the economic and politic convergence of "globalization", with its markets, events and organizations
- the convergence of arts in transmedia, giving a renewed reality to the Wagnerian idea of "total art" (Gesamtkunstwerk)
- the convergence of values into universality... with global conflicts upon/for/against these values.

2.2. Matter

Materially, that means a total digitization of the material World. A progressive control of everything down to an ever high resolution applied to everything. An extrapolation of the "Internet of the things". That calls for a common language, for instance the URL (Uniform Resource Locator) URI (Universal Resource Identifier), GPS coordinates, UTC times and many standards.

2.3. Machinic convergence

The interconnectivity goes by itself. When bitset grow, they tend to become more and more interconnected, up to form a global system: transmedia, cloud, big Data, Internet of the things. And the meaning as a global issue. Everything becomes "massively multiplayer online". It has been seen early, as we have said.

2.4. The call to the universal

High level bitsets, can be both strongly autonomous, densely connected and deeply meaningful, thus, at the limit, thus forming a unified whole at the opposite of the single bit. The bitsets become meaningful for all the other ones. Perhaps not easy to understand. But it is here that art, and particularly digital art, has its part to play, and a major one. We are more and more immersed in this world.

In opposition to the bit, the Cloud calls us as a value. We look for universal concepts, universal truth. We wrote Summas (in the middle ages) then Encyclopedias (in the Age of Enlightenment). We have Wikipedia and all the web today.. It has also the moral attractiveness of the "common good".

Here finally comes the meaning and the sense. But it is a gradient, not a final point we can reach. And the unification dreams of the great conquerors (Alexander, the Roman Empire, Gengis Khan, Napoleon, The British Empire, the modern USA leaders) made sense... for some decades.

Religion if not mystique have connoted such views in Antiquity, with the hegemonic dreams of Abraham (semen tuum...), the

universalist message of Christ and Mahomet. And we can also compare the bit/cloud polarity to the self-negation of mystics leading to ecstatic access to universal immediateness. See the classical Seeds of contemplation by Merton [] or, more scientific The Psychology of the Mystics by Marechal [].

Of course, the Cloud is not Heaven, nor infinite. It's dual to the bit, which is not "null". We never reach the infinity of autonomy, connection and meaning, no more than we can have a zero-matter bit, nor even a totally meaningless bit. But this rich unity is something we cannot avoid to dream of and to aim to. It's from there that come the meaning of all the rest, as well as the consistence and materiality come from the basic bit.



The web gives a real time expression of Earth's entirety, inspiring Maurice Benayoun's *Emotions mechanics*.

The cloud is no God, no more than the bit is immaterial. But it really bears meaning, as a promise as well as a threat of totalitarianism. Then the cloud must remain fragmented, in the line of the Montesquieu's division of powers, for instance.

Life, and art, spread in the middle spheres. It's time to look at that more in detail.

3. BITSETS GROW

Artists never see nor work directly on separated bits, but on groups of bits. To avoid any analogy with particular epistemology or human sensori-motor organisation, we shall use "bitset" to note sets of bits without any prejudice on what they will be used for. Other terms as "strings", "words" or "files" are from start loaded with textual or operating system connotations.

3.1. Bitsets as hardware

A simple way of having several bits connected is to have them on the same piece of matter. It's an important case, but non "material" constructions of bitsets are of the same importance. What count is that we have some "handle" on this set, which includes a way of finding its elements in the hardware. Among many examples, if your present computer lets you access to a "defrag" function, you can see a representation of the file distribution on your disks. At another limit, you can consider the Web as a (very large) bitset, where browsers give you access to millions of subsets which all are physically located somewhere, but you don't now and don't care where (unless you have the responsibility of their security and continuity of existence).

This distribution of locations all around the world and the circulation of information between them is a frequent source of

inspiration for artists, as a kind of "data visualization".

3.2. Getting "mass"

The number of bits in a bitset, its volume, or "mass" (the term opening the way to a sort of thermodynamics) grows along with different names, structures and functions. Let's sketch a scale:

- 1 bit. Nothing, but perhaps the digital clock,
- 8 - 64 bits. The "word" in the computer processor sense.
- 100 bits- several mega or gigabytes. The file. With its extension, header... And the material supports. Works of art stay within this interval:
 - . Text: a short poem has at least a hundred characters, or one thousand bits. A full fiction may reach one million characters.
 - . Still images : minimal ones, compressed, may be held in 100 K bytes HD ones grow to millions of pixels of 24 bits
 - . Video: gigabytes.
- Beyond the gigabyte, we have large databases, encyclopedias, libraries and collections of works of art.
- With peta and exabytes, we enter the "big data" and cloud.

Structures are necessary. Otherwise, complexity would rapidly send the bitsets beyond control. Indeed, without structures, complexity grows exponentially with mass, if we use the Kolmogorov [] definition (shortly) : "the smallest program able to generate the object". A fully random bitset has no shorter program than itself.

This relation of structure over mass is fundamental in aesthetics. We have developed this topic in ...

3.3. Asserting autonomy

Files are supposed to be passive. But they can change independently of their creator:

- at random, for unknown or unpredictable causes,
- by an input and to answer in interaction,
- by their own activity, if they have a clock (the basic motor of digital automata).

Bitsets integrate these changes into behaviors that range from unpredictable chaos to elaborate answers to inputs, engaging communication and self development (e.g. learning).

4. THE DIGITAL CREATION PROCESS

How to define digital art? The question is frequently asked. A first and coarse answer: it is digital if you use a computer. But then, anybody shooting a photo with their smartphone would be an digital creator, and any musician playing on a keyboard would make digital art.

So we have to refine our definition, and we propose levels of "digitization", according to the depth of fragmentation and composition. These processes are basic not only for the artist, but also for the cultural mediators (museums and show curators, critics...) and finally the collector for the presentation of their collections. Everyone selects or makes sets of compatible elements and assembles to meaningful or aesthetic criteria.

Fragmentation and assembly are them according complementary operations, and open general questions such as:

- How to make fragments ? Take them from nature, and if so how to cut into "life" more or less naturally. Or build fragments

from nil.

- How to structure fragments in such a way that they can be limited to one and only work, up to universal standards within a discipline (fonts combined; here, digital versatility itself may be very helpful; we find here the problems of standards and formats , from strictly local structures, possibly for text, Pantone for colors...) and also transdisciplinary (the file formats and the URL, for instance).

A key issue is: given the corpus of fragments, how to combine them in space (e.g; foreground/background) and time (texts, images, film cuts). It may be done at random or with strictly formal rules, with as always optima to be searched in a good balance between order and chaos.

4.1. From sampling to coding

Reasoning about digital poetry and literature, Bootz [] draws a line between two modes of assembly, which can be extended to the other forms of art:

- « combinatorial », using pre-built text fragments according to specific algorithms,
- « automatic » combining words (from a dictionary) and assembly rules (grammar, style).

We appreciate the distinction, but do not find the words appropriate, since "combinatorial" is also automatic, as it uses algorithms, and "automatic" is explicitly defined by combination. And, to cover all forms of art, we want to add a rawer level than combinatorial, and a top level freed from the structures of linguistics. Then we propose

- global sampling (just one fragment, typically a photograph or the video recording of a show),
- mounting (referring mainly cinema, working with necessarily large bitsets), corresponding to Bootz "combinatorial",
- grammar (referring to text but more or less naturally adaptable to other forms of art), using smaller bitsets (words, elementary forms) , but generally directly tied with at least some basic meanings; this corresponds to Bootz "automatic"
- coding, for the most "digital" creation processes, where fragments are bits or quite small bitsets, meaningless either totally meaningless (bits) or weakly (typographical characters, pixels, bricks).

With each step we walk up, the artistic creation is transferred from the fragments to the way they are assembled. The creator get more freedom and control, but at the price of a growing abstraction in the creation process. It becomes more "implicit, to take a word from Subsol [] about storytelling. And coding requires a minimum of computer education, be it programming in general of high level software tools mastering. If is not your cup of tea, you can cooperate with professionals... which requires an ability to cooperate and manage human resources. Some great creators excel particularly here, for instance Miguel Chevalier (for plastic arts) or Matt Pyle (for music and anything around), and of course all the company leaders in performance arts.

4.2. Just sampling

This lowest level of digital art amounts simply to pick out some fragment of nature (or a traditional work of art) and to digitize it with a scanner, a camera or a recorder. If there is art, it will be in the choice of the subject and the framing in space and time.

At this "zero" level, there is only one bitset. It could be digital, if obtained by sampling a signal (sound or image). Here, the meaning is totally borne by the whole document, digital or not. The digitization is meaningless by itself, but only a step to higher level operations. We could call that the "analog" level of digitization. Our retinas and ears do just that for the higher neurologic levels of hearing, seeing and understanding. The slicing of time use in cinema and video is, in the same manner, a digitization without introduction of meaning.

Remaining at this level, some artistic intervention can be done by color and contrast enhancing, music volume adjustment, etc. It can use sophisticated algorithms (convolution/deconvolution, histogram optimization...). Nowadays, these operations are for a large part delegated to automata integrated in the cameras and recorders. Even the framing and shoot triggering can be automated, by detection of human faces and their smiles.

The artists at this level are generally not considered as digital artists, and do not want to be so qualified.

4.3. Mounting: a few chunks

Here we enter a major domain of digital art, present in many forms of art. Creation is parted into two phases: the creation of the corpus and the assembly process.

To create a corpus is to collect assets (bitsets, fragments) in formats coherent enough to afford assembly, at least by hand but more digitally by automatic procedures.

The assembly rules can be pure random. Interesting result is expected from unexpected combinations. In this case, a vast majority of result will probably be discarded, the choice being done by the artist according to their tastes and intentions. More digitally, the assembly will follow algorithmic rules. They can use metadata about each asset (a sort of database) or automatic extraction or recognition of interesting feature (formats, coloring type, subject...).

Then the composition techniques will differ with the forms of art: collage, inlay or blending for still images, compositing in cinema, etc. Let's pan the field.

Literature. Cadavre Exquis and Oulipo were pre-digital models. One will find a review in Bootz []. Recently Desbazeille used it on the derisive mode about digital art critics. Some storytelling could be done at this level, but more conveniently at the grammar level.

Music. Remix and arrangement have always been practiced, and so more today with multitrack music processors and software. DJing does that naturally, and could be automated or at least procedurally controlled, at the borders of live coding (see below). Historically, at the end of the 19th century, many musicians spent a lot of time in recording "folklore" and using it for new creations, but with strong manual reconstruction. More procedurally, in the 1950's, Pierre Schaeffer [] and the concrete music movement, tried to create a new music from sounds from nature and the industrial world. With limited success. More globally, the choice of plays for a concert, as well as the making of a playlist on your personal computer are forms of mounting.

Still images. A typical and simple example: the images done by assembly of four horizontal stripes by Julien Levesque. Here we

have a small number of fragments, each one quite loaded with meaning, and the global message will be a sort of global universe. Long before him, the process began, at least, with the collages by Ingres [], the photographic compositing of Reijlander [] and is today a base of compositing and matte painting. Of course, by this time, assembly was done by hand. The collages of the Cubists and Dadaist and the Oupeinpo experiments added fantasy and random. Today, Du Zhenjun for instance, pushes the process at its limits.



Du Zhenjun's *Babel* series pushes mounting to its limits.

Textures, volumes and lights can be seen as fragments that are assembled in the rendering phase. Each fragment is potentially rich in meaning. Forms represent object structures, textures refer to matters and lights to the environment.

Cinema. Mounting of the cuts is considered the central part of cinematographic art. Unfortunately, the mounting rules (one could tell the grammar) are seldom published. Then, in spite of the years, Eisenstein (see for instance []) remains a useful reference.

Metacrane, by Thomas Israel is an extreme example of generative algorithmic mounting. He took all his corpus of videos, fragmented them in a base of cuts, and presents them in succession according to an algorithm mainly stochastic but using some parameters to get some coherence and so model the natural succession of scenes in our brain.

Animation is much more digital than traditional cinema, since compositing and mounting can much more make use of different kinds of assets. Not only textures and volumes as with images, but also movements and facial expressions acquired through motion capture.

Sculpture and architecture. Mounting of diverse elements is a classical inspiration of kinetic art (Tinguely, Keene). Classic architecture used the basic motives of the three "orders" (doric, ionic, Corinthian). Contemporary architects are more oriented to deeply integrated forms, with organic connotations (typically Zaha Hadid). They also fragment the whole into structural/functional parts on the one hand and a "skin" around.

Bio-art has a traditional bias to assembly of strongly meaningful fragments, like trees and plants in gardening. More recent forms tend to create chimeras, or cyborgs. Stelarc and Orlan transform their bodies with implants.

4.4. Grammatical generation

The linguistic model is strongly pregnant in art analysis and

critic. Saussure [] is the main reference. He had been preceded in plastic arts by at least Charles Blanc and Viollet-le-Duc but his models of language as a system oppositions has inspired structuralism and art analysis.

Grammatical generation, from a codified and standard set of meaningless (or weakling meaning) bitsets is a major avenue of generative art, though coding takes it farther.

Literature. Linguistic structures are here at home, with their generative grammars. Jean-Pierre Balpe [] has been a major reference for this form of art for decades, and has still recently taken part in generative projects like Capture. An extensive review of the domain is given by Bootz [].

Here, the rules of assembly are clearly given by the dictionary and grammar... but only the structural laws and some schematic schemes (subject, predicate, complement...). Another set of rules can be derived from a formalization of an author's style (typically, Balpe for Flaubert, musical pastiches of Mozart, or generators of images à la Mondrian). The rest is let to random or to "manual" operations by the author.

Oriental languages make a complex and synesthetic use of grammar, since ideograms can have meaning both directly (for instance 中 for middle) and by definitions. Calligraphy and Haiku poems draw on this duality, and some attempts have been done to use it in digital works.

On a large scale, the rules of construction of a narration can be considered as a grammar.

Music. Nearly all music applies "grammatical" rules, be they in synchrony (harmony) or diachrony (counterpoint). That made of music one of the first art domains to be explored by computers, See for instance *Composer au XXIe siècle. Pratiques, philosophies, langages et analyses* by S. Stevance [], and the regular flow of publication by Ircam (Paris), though a large part of computer music works at the coding level more than at the grammatical one.

Still images. The impressionist touch and the pointillism are actually reduction to small and individually meaningless fragment. But they relate more to the human visual system operation than to a proper research of meaning by construction, though remaining more visible than the cinema frames. The arrangement of touches and points is made by analog correspondance with the subject represented.

Structural/grammatical construction of images are at the core of the Bauhaus movement, with the texts of Kandinsky [] and Klee [] for the form, and Itten [] for colors.

More explicitly, George Stiny and James Gips [] proposed a grammar of forms, inspired by the generative grammars of Chomsky.

This approach is never quoted in image processing or literature about algorithms in art. But it was never forlorn, as shows a review presented in 1999 by Gips *Computer implementations of shape grammars*, by Gips in a MIT symposium [] It contains a list of 26 grammars of forms, several of which are available as software tools.

Sculpture. The brick is a basic element for a possible grammar, and cement as a tool for 3D programming... Thus also a form of superiority of the Plakat game over Lego: your construction creativity is limited only globally by the total number of

elements, not by the number of a specific piece. Here each system looks for a balance between the superior meaning content and high definition similarity of each component and the generality of more universal components, which will create "aliases" as do large pixels in painting or voxels in sculpture.

A grammar to build coffee machines, has been devised by Agarwal and Cagan [], but as far as we know, never been used in practice. It remains nearly a form of conceptual art.

Performance

Theater is based on language and gesture, then integrate the grammar of language and the much less (if at all) formalized structure of gesture and expression.

Shakespeare raised the mounting structure of the Italian comedy to modern theater grammar by a typical transfer of meaning

- from the mounting large fragments (the characters of Italian Commedia), with their own meaning and freedom within the loose structure of a global scenario,

- to the grammar of a text completely worded by the author, which has to be respected by each actor, with of course the important coloration of their personalities.

Choreography has for long developed some sort of language and grammar. Laban's language is typical (See Lon [] and Laban [] (in French). The dancer Myriam Gourfink [] uses it through scores generated by a computer, that she reads in real time, from screens around her, during her performance on stage.

4.5. Coding: creating the language

Coding is the extreme border of fragmentation assembly. The creation is totally digital... nearly. The limit is never totally reached, since any language we use to control or program retains always the minimum of analogy with the structures of our brain and sensorimotor system.

It can really be creation of meaning directly from meaningless bits if your work at a very low level, let's say by assembly of logic gates at a hardware level. An AND gate can mean everything (including, of course, the properly logic function AND). But if you assemble several gates, you get an adder, which is definitely associated with arithmetic meaning.

You remain very near to this level if you use microcontrollers (as does for instance Alain Le Boucher for his LED's sculptures). But, as soon as you use a full-fledged processor, you work with bitsets of some length) and, even using "machine language", you work within the frame of a Von Neumann machine, with its ALU (Arithmetic and logical unit), RAM (Random Access Memory) and his basic set of instructions. All the more so if you use "high level" programming languages (C++ and variants, Java), and still more with specialized tools (word processing, musical sequencers and home studios, graphic software, and surface controls for performane). But, nevertheless, you code. And coding opens really the road to generativity and interactivity.

So, the different levels of language pile up. In our Roxame software, for instance, we use Processing, which is based upon Java and below it upon machine language, the operating system and the linguistic part of the processor itself. But,

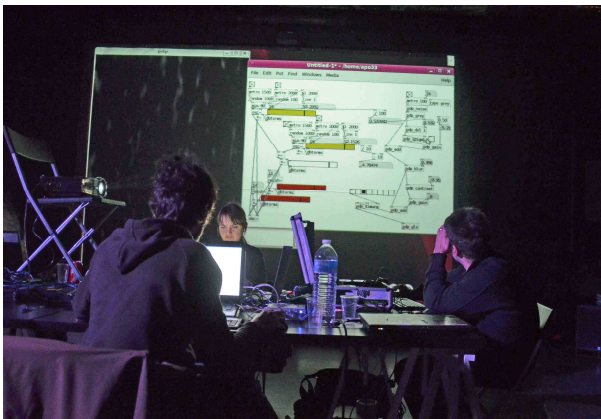
Roxame lets you build macro-instructions that can call other macroinstructions, up to the point where one character only can trigger a rather heavy set of procedures and apply it indefinitely.

Nobody has expressed so clearly the power of coding than Anne-Sarah Le Meur, a plastic artist specializing in images and interaction. Starting with a "lyrical abstraction" sensitiveness, she has felt the excitement and power of digital systems and programming. Exhilarated by the richness of the creation spaces so opened, she dared to launch concepts as "negative light" and transgressing the traditional classifications: "The images are abstract, but organic metaphors of a world both cellular and cosmic, very fleshly, minimal to the point where they become archaic, a sort of anti-semantic (pre-linguistic) vision".

Literature. It seems difficult to go deeper than the grammatical assembly. But you can code grammar, and possibly generate irregularities, which are essential in poetry, as comments Leech []. Programming by itself may be considered an art, since a program is a text, which can be aesthetically appreciated independently of its functions. That's certainly true in principle. But this kind of beauty can be appreciated only by other experienced programmers.

Music. Music software and instrument design dig deep in direction of the bit level. You actually reach it if you work on hardware and can solder elementary circuits. At first sight, a musical note is very simple: a pitch and a duration. But a note has timber, which is a more or less complex combination of frequencies. And the note is not uniform along its duration, following notably the ADSR structure (attack, decay, sustain, release).

At a higher level, the way Wagner composed comes very near to object oriented programming, with a major class: the characters, and their specific variables and methods.



Live coding at La Fabrique (Nantes, France), by the Apo33 group, using the Pure Data language.

Live coding reaches interesting limit issues. Programming is a demanding intellectual task, and even when you have got the idea, it takes some time to code it properly. That induces several constraints on live coding:

- . the music cannot evolve rapidly, since from one change to another one, you have to write your code
- . it takes to write the music as "loops", which afford to be called rapidly by their names, but limit the universality of your live interventions.

Still images. In images, it seems that we could go deeper than the pixel if not the bit itself, working on the points, using meshes, vectorial graphics and formal calculus. But, in practice, images have to be displayed on screen or printed on paper... then we are back to pixel matrices.

Cinema. Procedural techniques (modeling, textures) are taking it upon sampling, for quality as well as to reduce costs, using more and more automated functions instead of artists.

4.6. Philosophy: narrative Vs. database

At a global level, two main types of composition are opposed in *The Language of New Media* by Lev Manovich []:

- narratives, or argumentations, are linear, with an opening and an end; in the between progress is made according to various schemes; the basic rules were set by Aristotle in his *Poetics* [] and *Rhetorics* [], depending on the finality (artistic, political...); they were born for human performance and remain so today.

- databases are basically bi-dimensional, with a series of objects and, for each of them, a series of features; even if such structures were prepared by the articulations of thought in the middle ages (Summae) and then the dictionaries and encyclopedias, they are typically a product of the computer, and well adapted to automated processing.

Beyond their technical opposition, narrations/argumentations and data bases match different philosophies and, more recently, different ways of creating and receiving art.

Narration and argumentation follow the natural human behavior: an individual talking and acting on a "line". There is a past, a present and a future, highs and lows, and why not left and right. It takes to dramatization, engagement. Data bases are more digital, with their multidimensional fragmentation and openness, engaging the readers to freely assemble their own narrations.

Religions, nationalisms and ideologies in general are built upon grand narrations or, more exactly, build them during their foundation years. Modernism drew databases out of them, but for a large part replaced them with new grand narrations, like Condorcet's *Esquisse d'un tableau historique des progrès de l'esprit humain* [] for the French revolution, the great texts of American Independence, the global epics of Soviet Union (with the films of Eisenstein) or People's republic of China.

Nowadays, the database model and postmodernism seem on the way to definitely win over narrations. Letting us free but disoriented in a fiercely changing world. Whitelaw [] writes : "New media also fractures that technocultural material into millions of heterogeneous interests and agendas, specific investigations, aesthetics, approaches, and projects".

Forty years have passed since the days of *Mille Plateaus* [] (by Deleuze and Guattari) and the "French school" with its vocabulary that raises skepticism in non-nonsense minds. But they are still an inspiration for present thinkers like Katherine Hayles, in *How we think* [] as well as, at the cultural and geographical antipodes, Hiroki Azuma *Otaku* [].

Perhaps are we walking up a new step with Anna Munster in her *An Aesthetics of Networks, Conjunctive Experience in Art and Technology*. []. Here also, the blossoming vocabulary may disconcert, with sentences like "Here the diagram becomes a

machine for expressing the relational thingness of networks; here an aesthesia of networks edges into perception". She builds daring bridges between the Web and the brain structures...

Is the "Cloud" able to bring the sense and meaning we so strongly need, to propose a new grand narration? We have seen above the limits of this approach, and think that the important narration develops in the middle, with the high level bitsets inspired by life and humanity. Is'nt "life" a more concrete way, for the best and the worst, to build a new world.. Indeed, digital art is more and more active on this axis.

5. I SHARE THE LIFE

Somewhere between bit and cloud, higher and ever higher levels of bitsets are developing. Some of them we consider as living, others with only some life features, others as more or less humans, humanoids. Reaching here is to enter the "uncanny valley" where our creations become similar to us, but with small imperfections which reveal their deep difference in nature, and then are disturbing, if not threatening.

It has been a literary topic since Antiquity, but it's more and more important for art today:

- as an inspiring theme: robots are more and more present in our lives; the transhumanist singularity [] is no longer a pure dream but the theme of a university funded by important corporations;
- as a sort of medium, since artists can themselves become creators of biologic or bio-inspired works of art.

The creation follows several different paths, more or less engaged in actual living processes: representation of life, generative art, robotics, cyborgs.

5.1. Representations of life

A review of literature, comic books, paintings and artistic performance arts about life and robots would list thousands of titles and artists. Just some notes. In the West, these representations are sometimes softly humorous, like the videos of Catherine Nyeki, but more generally negative, from Fritz Lang's *Metropolis* to the Wachowskys' *Matrix*, with the remarkable exception of Disney's *Wall-E*. It's very different in the Japanese culture, where robot can be perverse, but are more frequently friendly and saviors of the human race, as show for instance the series of lectures edited by Lunning [].

5.2. Generative art

Generative art focuses on the capacity of computer programs to behave like living beings and somehow to become artists by themselves. ... a book to this subject [].

This form of art models different facets of life, borrowing from (and contributing to) artificial intelligence and artificial life development. It stresses three patterns: autonomy, interactivity, reproduction.

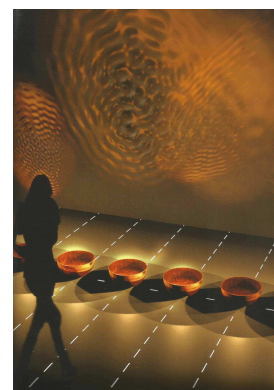
Autonomy. A bitset becomes autonomous as far as it behaves in an unpredictable manner. Then random functions are here a basic tool. But random alone would not give interesting results without composition with rules governing the behaviors. This point is basic for artists like Antoine Schmitt, François Zajega... and ... with our Roxame software. Neural networks bring

another kind of modeling... less "centralized", and have been applied to art by Michel Bret. A major aspect of autonomy is self-reference (an English equivalent of the Greek autonomous).

Recursive functions bring the mathematical ground to "self", and are also widely used here. They are rarely shown explicitly in art, but there are some examples, like the bugging program of Samuel Bianchini's *In Realities I am a bugged program* or the iterative video shooting *N+1* by Stéphane Trois Carrés.

Note that the fragmentation/assembly process is generative by itself. If you have a two series of objects, of respectively m and n numbers, the direct addition of the two will give you $m + n$ objects. If, on the other hand you have a series of $m + n$ features for a same category of objects, the combination of the two opens a space of $m.n$ objects, which is many more as soon as m and n are greater than 2. By itself, this operation opens the way to exploration of the new spaces and creation of new objects.

Communication and interactivity This is an important feature of living beings, a base or their ability to survive against entropy. In art, interaction has been heralded at least since the 1970's, with a frequent use of the term "spectator". Digital artists make use of the natural ability of computers to use sensors and effectors.



Interaction with *Corps en resonance*, by Naziha Mestaoui. At left, what the casual visitor sees. At right, the full richness awakened by a performer.

Many "interactive" works, videos and sculptures, require some training, if not professionalism, to offer their full expression, which then becomes a sort of performance. We have a proof of it with the Naziha Mestaoui' chanting bowls, *Corps en résonance*. The casual visitor or the critic in a hurry will see a quite poor installation with minimal moves. Only an informed performer will really raise the full power of the work.

Florian Aziosmanoff [] has made reflections on the way we could do better, with a richer perception of the public behavior, and works answering also with more elaborate behavior, in what he calls "living art". This point could evolve favorably in the years to come.

Reproduction. Population breeding is another way of combining random and fitness. The topic is dealt with notably by Whitelaw [] and Johnston[]. Sommerer & Mignonneau did create a lot in this domain, and nowadays show it mainly with their funny Lifewriter.

Viruses are a fascinating case of "living beings". In nature as in

computing, they exist at the limit between life and non-life: they reproduce themselves, but cannot live independently of another autonomous being (computer or living organism). Ludwig [] concludes cautiously a long discussion: "As far as evolution goes, viruses may be imagined to be alive, unless evolution itself...". But they are rarely studied outside of the hackers and security professionals circles. A form of viral art has been developed by Nechvatal, but only on the disintegrating function of viruses and not in their positive aptitude to multiply and develop (and, today, to change their appearance in order to escape the antivirus software).

Less prejudiced, but perhaps no less dangerous, are the artificial life models in their advanced forms. Are living processes of Conway's game of life or the genetic processes really art, as told in Metacreation, art and artificial life, by Mitchell Whitelaw []? Until now, the works of Karl Sims, Driessens & Vestappen, Steven Rooke... remain quite out of the art world. Perhaps, as Whitelaw lets us think, is this vein exhausted, at least temporarily. Perhaps, as for artificial intelligence in general, should we wait for a larger availability of powerful machines like the IBM Watson..

5.3. Robotic art and bio-art

Here also we are on the borders of research and art. Artists properly speaking give frequently derisive presentations of robots. Or at least ambiguous, like Robot mon amour, by France Cadet.

Robots begin to play on stage, to begin with music, where they are more and more able accompanists. Or as a full rock group, like *Capture*, a collective work by Olivier Alary, Jacopo Baboni Schillingi, Jean-Pierre Balpe, Crystelle Bédard, Gréogry Chatonsky and Dominique Sirois.

This art form is limited by the cost of robots, the difficulty of programming them... and their possible obsolescence. A subtle work like *The little Red Riding hood* by Florent Aziozmanoff, staged three Aibo dogs (See a description in []), but is now impossible to run again due to the end of production and support by Sony.

Life did not wait for men to use digital techniques, with the DNA and its pairs of bits implemented as base pairs. And some vegetal forms or animal behaviors may be perceived by us as artistic. For long, humans have oriented and more or less controlled the living processes for artistic aims, by gardening and breeding.

This form of art remains active. It operates on organic soups (Honf), vegetables (Howard Boland and Laura Cinti's Nanomagnetic plants), tissues (Oron Cattes and Iona Zurr) and even on complete animals, like the luminescent rabbits of Eduardo Kac.

Convergence of robotics and biotechnologies converge towards humanized machines and "augmented humans". But this view of superior beings cannot go without the universal cooperation called by the cloud and, for art, implemented through transmedia.

5.4. Transmedia, a name of the cloud

Art tends naturally to the universal, from the antique Seven

marvels of the World to some oxymoronic brands as Art Basel Miami. "New media art self-consciously reworks technology into culture... it does so... with a nonindustrial attitude that admits misapplication and adaptation, rewiring and hacking, pseudo-functionality and accident", says Whitelaw [] about artificial life. Transmedia goes the same way., as says Jenkins [].

These global forms can be seen as the media facet of the Cloud or, better, as the present best way to combine the universality of the cloud with the creativity and pleasure of all, from artists to spectators and from individuals to large communities.

We build together a new world. "We"... including the robots? For the best or the worst ? For the dictatorships of Orwell's *1984*? For a general (and rather happy) control by Asimov's robots ? For indefinite fights between the super-humans of Bennett []? The peaceful Ecotopia of Callenbach [] of the network aesthesia of Anna Munster ?

Cultural assets will play a major part in the future. Digital artist, as far as their to dive down to the bits, can play their part in the foretelling and the development of our future.

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