Can the Analytic Engine Run the Art Machine? Computers in Art and Design

Cambridge (England, not Massachusetts), May, 1812: A group of students at Trinity College decided to establish The Analytical Society—one more society among tens and hundreds popping up in those days with almost the same fervor societies and associations pop up today and commence their public lives of conferences, congresses, and other meetings (and the less open intrigues and fights for power in those societies).

Background: The argument between Newton and Leibniz, apparently over who had first developed integral-differential calculus; in fact over two distinct systems of notation: Newton's dots and Leibniz's d's—what can be called two different semiotic approaches. The Analytical Society was initiated by Charles Babbage—today unanimously accepted as a pioneer of the computer; in those days, a rather non-conformist intellectual obsessed with machines that could calculate tables of numbers (the Difference Engine) and later with versatile, programmable automatic calculators (the successive models of the Analytic Engine).

Babbage was impressed by the accurate simplicity of mathematical language and correctly assessed that "An arbitrary symbol can neither convey, nor excite any idea foreign to its original definition." Despite the fact that Trinity College was a center of Newtonian scholarship, Babbage was able to acquire a good understanding of the conceptual framework in which Leibniz discovered calculus: the logic of signs that we use in our reasoning or, what Charles S. Peirce defined, shortly after the death of Babbage (with whose work he was familiar) as "...semiotics, a new name for logic." Leibniz's basic idea sounds very familiar in the context of our specialized society: thinking and reasoning in a new language is difficult. He emphasized the role of hypothesis, which would become the main operation in Peirce's system (under the name *abduction*).

The Analytic Engine, designed by Babbage to embody a complex logical system in a product of precision engineering, can be characterized as an *abstract* machine. Inspired by the romanticism of the Industrial Revolution, this Engine was not meant to manufacture/process raw materials. Its *mill*—supposed to carry numerical operations—and its *store* (a name inspired by the mill's storehouse)—a mechanical memory made up of a set of axes, on each of which a pile of toothed wheels carried what we today call constants and variables—anticipated the CPU and the memory of modern computers. The Engine "might develop," Babbage stated, "three sets of results: symbolic, numerical, algebraic (in literal notation)." Boole and DeMorgan were Babbage's contemporaries (let's not speculate about what would have happened if the three had met). This was the time of the Jacquard loom and of the punchcard it inspired, of the fascination with Adam Smith's idea of labor division. This was also the time when language and art were questioned as to whether their condition is personal or social, and—more importantly—what is the relation between the thinking process and the processed elements participating in thinking; between brain and mind; between what is expressed and the language expressing it.

So much for history! Actually, so much for *data* relating to Babbage and his time. I happen to mistrust history (i.e., the *interpretation* of data) for reasons that go beyond the scope of this lecture (but that also have more to do with it than one might surmise). And now to the rhetorical question: Can the Analytic Engine run the Art Machine? The Analytic Engine to be discussed here is not quite Babbage's never-built logic machine, but the *computer*. And not only the computer of today—from the cheap rip-off mini-micro to the super-duper fifth generation model—but also the computer of a tomorrow which, looking back at our VAXs and IBMs and Crays and all their copies and offspring, will give rise to smiles

and nostalgia—something like driving a Porsche Turbo and having a Ford Model T or a classic wing-door Mercedes in your backyard. Obviously. I am trying to say that computers are *still* at a primitive stage, even more so than the old Fords or Mercedes that are now collector's items. And I anticipate that the Analytic Engine will progress well beyond what Babbage and other pioneers expected. (I am not suggesting that you start collecting Ataris or Macintoshes in the hope that they will be worth a Ford or a Mercedes.) So, I shall not deal with the well-known and oft-discussed jaggies/aliasing problem; nor shall I scream for some hardcopy device that can match the quality of canvas, or for more user friendliness (which scares the hell out of me). Rather, I shall address a different matter: the relation between art and *logic*, and the consequences this relation has on human (the individual as well as groups) perception and interpretation of art, on its evaluation, on its cultural—and not only cultural—function.

Aesthetics, conceived by Baumgarten (in 1750) as the logic of the senses, was supposed to answer the questions of whether there is any logic in art; whether logic can be applied to art; whether any knowledge can be derived from a logical explanation of art. The only chapter Baumgarten never wrote is the final one, the one dealing with semiotics, i.e., the language of art. And this is the subject (or at least part of it) we discuss today. In his youth, Babbage derived a hedonistic principle of rationality from his own observations: "Occupation of the mind is such a source of pleasure that it can relieve even the pain of a headache." What is the role of thinking in art? Certainly, thinking *about* art can be a source of pleasure. (It can also be a pain.) But can thinking be the source of art? Goya warned us about the dangers of reason that sleeps: "The sleep of reason gives birth to monsters." I mean that rationality is *part* of art, but not necessarily that art can be *reduced* to rationality. Leonardo da Vinci, while paying attention to the laws of physics, anticipated some of our current algorithms, but never reduced art to measurement. The rational component in his art was of a propaedeutic nature. In a book (*Esthétique*, Paris, 1953) that deserves more attention, Pius Servien described interesting laws of harmony (regarding music, architecture, etc.). So did the Bauhaus artists.

As you have noticed, my attitude is rather cautious. If we believe that art can be reduced to a simple or complex logical or rational formula, we agree that logic is universal (and implicitly that the so-called universality of art is of a logical nature). This sounds good, but the concept of universality is far from being logically defendable. No matter how much I mistrust history, I trust (and even fear) less something that claims universality. At the other extreme, if we refuse to accept the logical component, we say that no definition of art is possible; each work claims a condition of its own. Each work is its own definition. This leads me to confess that there is something I mistrust even more than history and universality; and this is dualism. No computer professional will start an argument for history or universals. Writing a program that manipulates a database is like producing not just one history, but as many as one can imagine. The combinatorial nature of history can be used to create some of the most intriguing computer games. The same holds true for the game of universals. But in the end, each computer professional has to fight for his zeros and ones, for his Boolean flag, for TRUE and FALSE, for IF-THEN and WHILE..., for YES and NO, because at this moment in the evolution (I was about to say "history") of the *digital* computer, all there is to it is the fast and ever-faster joggling of huge amounts of zeros and ones, storing and retrieving, the closing and opening of files, the switching on or off of hundreds of thousands, or millions of pixels, the mapping from world coordinates to windows and from windows to viewports. (The analog machine is a different story altogether! Watch for endowed chairs at the level of a football player's or a movie star's income!)

Thesis 1. Art is irreducible to binary numbers.

Thesis 2. Binary modeling of aesthetic processes is a source of better knowledge of art.

Thesis 3. The logic of art interpretation in the logic of vagueness.

Conclusion: The Analytic Engine can run the Art Machine insofar as the binary system and its applications in computer programs can model the logic of vagueness—since there is no art that starts without being interpreted (by the artist, by the public, by experts, even by computer scientists).

Is this the end of the lecture? Definitely—for those looking for a yes-or-no answer to the question posed in the title. This is a partisan scene: one group trying to convince the other about their truth. However, the cognitive scene has no clear-cut position. In a certain respect, the model of fuzzy sets (Zadeh and others) describes it acceptably in the principle of incompatibility (precision vs. significance), to be discussed shortly.

There are computer professionals who will swear on programs to the extent of emulating some expressive features usually associated with art:

- Looks like art
- Has such formal qualities as symmetry, harmony, rhythm, etc.
- If it were on canvas and signed by some big shot, it would be in a museum (change the medium and the same holds true for sculpture, music, etc.)
- It's unique
- It is an artifact with an end in itself
- It's beautiful
- Etc.

There's no use trying to contradict them. Emulating, imitating art is possible. And sometimes quite successful. And even useful in many instances (manufacturing. communication, enjoyment). Moreover, the history (again history) of art can be interpreted—here is where the speculation starts—as the history of imitation: art after art. But what about the moment—an art fiction hypothesis—when all art was imitated? (A logical extreme mentioned here only for the sake of argument.)

Certainly, to make a point about the possibility of emulating, which is a knowledge/cognitive/gnoseological process, is the same as saying that the Analytic Engine can run the Art Machine to accomplish what Rembrandt. Beethoven, Dostoyevski. etc. did. But should we expect such accomplishments from it, together with the implicit romantic notion of art and genius? Or should we understand that the Analytic Engine determines some changes that make such expectations seem if not ridiculous, at least outdated? There are some voices, many voices, swearing that:

- Looking like real is not what makes something art.
- Formal qualities (harmony, symmetry, rhythm, etc.) are not necessary and not sufficient conditions of art. (Are they necessary?)
- Not everything in a museum (on canvas, on a screen, signed or not) is art.
- Uniqueness (hmm? associated with computers?) is not what defines something as art.
- Artifacts, with or without an end in themselves, can be anesthetic.
- There is an art of the ugly.
- Etc.

There is no use trying to contradict these voices either. They argue on a logical level, despite the emotional appearance, showing that no definition—strict or even fuzzy—of art holds; that art is not the rule but the accident; that the Analytic Engine taught then to argue a cause that for a long time seemed undebatable: WHAT IS ART?

The discipline of semiotics has been mentioned several times up to this point—in respect to notation (Newton's and Leibniz's systems), to language, to thinking, in respect to logic, to conventions. And so was the name of Charles S. Peirce, the founder of this discipline (in its *panlogical* development; *panlinguistic* development is associated with the name of Ferdinand de Saussure). Peirce, who happens to be one of the founders of the modern *logic of relations* and, among other things, a pioneer of the computer. (Reference can be made to Martin Gardner's *Logic Machines and Diagrams*, 1958, and to Kenneth L. Ketner's recent research, "The Early History of Computer Design: Charles Sanders Peirce and Marquand's Logical Machines," in *The Princeton University Library Chronicle*, XLV:3, Spring, 1984). Peirce defined semiotic as the "loqic of vagueness," a logic that refers to sign systems at all levels of their existence: syntax semantics, pragmatics. It would be fastidious for me to start here an introduction to semiotics. But I would not be able to continue the analysis of the interdisciplinarity involved in considering the relation of computer and art/design without making clear that to ask the question whether computers can generate art means to ask whether we can anticipate sign processes of *interpretation*. My idiosyncrasy towards the interpretation of the past (history) becomes even deeper when the need arises to interpret the future. How can we anticipate whether a certain artifact produced by the processing of data will be interpreted as art or as something else? And what would be the relevance of such an interpretation?

The pragmatics of our sign systems—language, art, ceremonial, education—is not always predictable. The way people use sign systems is very hard to describe, precisely because we cannot control their future context in which signs will be used. Obviously, the burning of books and of art works under Hitler's dictatorship, as well as under other dictatorships running the continuum between extreme left and extreme right, was not a function intrinsic to those books and works of art. The context, i.e., the very precise conditions under which a certain interpretation became possible and even justifiable, explains a pragmatics alien to the book or work of art. Placing computer-generated artifacts—images, sounds, texts, objects, etc.—in the context of what is culturally acknowledged as art is not the appropriate way to validate them as art. Interpretation is so forced to be referential that an epistemological vicious cycle—an infinite loop caused by the absence of a "stepping out" clause—is created. In order to avoid such a situation, I should point out that the conditions of the Analytic Engine's functioning is described in a language without precedent in human culture. The issue is the *processing of signs*; in other words, sign processes within limited sign systems, i.e., the reduction from infinite to finite languages, from complex configurations to sequentiality.

It takes little to show that some human activities are more finite than others: work on an assembly line (Charlie Chaplin will remain the best example of grasping the pressure of the finite on the human being); typing (advanced to computer word processing); generating tables according to a formula (Babbage almost built his Differential Engine to tabulate logarithms and products of π [pi], etc.). Within a finite language, consistency is possible and usually achieved. Moreover, a finite language represents a section that for practical purposes isolates systems that are both complete (relatively speaking) and consistent. This sectioning has epistemological consequences. Any description of the system, i.e., any knowledge thus gained, is of a *local* nature, which is perfectly acceptable for such activities as design, communication, and animation, which are successfully supported by computer programs. Valid

inferences from one system to others, however, are not possible. The legitimate hope that once all the elements of a work of art are identified—the implicit assumption is that these elements represent a finite set—and duplicated in some programs makes those who share it somehow blind to the effect that all the knowledge thus gained is still local, pertaining to a work, or representative of a set of works, but not to art as a whole. While art indeed shows an impressive amount of repeated patterns, it is, by its very nature, non-repetitive.

Would all this, and similar arguments, add up to a disguised way of saying that the Analytical Engine can move data but not run the Art Machine? If it did, I would not be here now, and I would not at all be in the profession I am in if an answer were so straightforward. Actually, local aesthetic knowledge proved to be of extreme importance for understanding our relation to art. It also proved a very efficient means of production of para-aesthetic artifacts: design for communication and entertainment, product design, architecture, animation, and so on. Due to the Analytic Engine, we can endow design objects with formal artistic qualities and thus influence culture in the most efficient way. Products we use are indeed better educators than books and lectures. Sometimes the local knowledge sought is identified in programs seeking emulation of real life (fire, storm, landscape, flight, body movement, etc.); other times, emulation of some physical phenomena (reflection, refraction, relative position in space, etc.); emulation of psychological issues (3-D representation and perception, color, interactivity, etc.). But while Gödel's proof that a formal system is incomplete if it is consistent and non-self-referential only makes us aware of the distinction between emulating and generating art. Zadeh's abovementioned principle of incompatibility suggests the need for a different approach. He states the principle informally:

> As the complexity of a system increases, our ability to make precise and yet significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive.

He goes on to suggest a corollary principle:

> The closer one looks at a real-world problem, the fuzzier becomes its solution. (*Outline of a New Approach to the Analysis of Complex Systems and Decision Processes*, 1973)

Computer graphics is essentially the activity through which data is visualized. It answers practical needs as developed in the process of deeper and ever more encompassing labor division. Precise data and significant/relevant presentation for specified purposes (the pragmatics of engineering design, of marketing, of education or of propaganda) go together. Relations not dealt with in previous times, due to the difficulties involved in the pre-computer ways of processing data, become available and prove to be socially necessary for matters of urban planning, ergonomic studies, visual communication. The computer participates in the process through which our culture switches from a dominant form of communication—embodied in literacy—to alternate modes, better adapted to the reality of the human being and to reflecting needs derived from the adopted principle of labor division. The Analytic Engine brought a more efficient use of quantitative models—manipulation of signs quantitatively representing objects—for the more comprehensive knowledge of systems such as economy, community life, etc. But modeling such systems quite often means only adapting knowledge previously gained from humankind's physical experience: mechanics and the law describing mechanical phenomena, thermodynamics, electromagnetism, and, partially, chemistry and biology.

Deterministic thinking, dualistic in nature, was brought to some of its most refined expression and, more often than not, confirmed in human praxis: extraterrestrial space navigation, expert systems, genetic engineering, landing on the moon, and collecting samples are not a matter of interpretation. The functioning of an expert system in an industrial environment is describable in terms of productivity, safety, reliability, and not subject to opinion but expressible in precise numbers. Genetic engineering partially submits to the same description. This is not the case with the sound of a peculiar musical note, the use of colors, the invention of forms, the relation between individuals, the light in a picture. The so-called "Lawless World of Programming" has almost no laws, hence it displays a reduced predictive power. The almost "touchable" reality of "automatic programming" is not the result of a change in this condition, but a necessary escape from a chaos in which the difference between good and bad programming is rather a matter of taste.

The Analytic Engine is the product of a dualistic system of thinking; and as such it is well suited to the solving of deterministic and even pseudo-deterministic problems. One step forward was made by the *Geometric Engine*. (Dr. James H. Clark was celebrated at SIGGRAPH '84 for work on the Geometric Engine. I would have celebrated some other scholars, for instance, Benoit Mandelbrot and Alvy Ray Smith.) Without dwelling on this here, I would like to suggest that geometry, especially in its topological applications, is of a different nature. It involves abstract concepts and abstract thinking that relies on data but goes well beyond data processing into the realm of the quality of space. The Geometric Engine allowed for the rapid switch from raw data (coordinates in particular) entered by hand to the *sketchpad* (Ivan Sutherland), to digitizing, and to some impressive algorithms used in 2D and 3D and in animated computer graphics. Fractal geometry (Benoit Mandelbrot), providing a trade-off between precision and relevance in capturing irregularity and fragmentation in nature, and more recently the use of *graftals* (Alvy Ray Smith) determined a re-evaluation of some previously applied programs and of some of our current research concerning the relation between computers and art. The assignment of an intermediate value, reflecting some irregularity, to a curve as complex as a segment of a coastline goes pretty much along the line of assigning intensities or degrees of membership to a fuzzy set. In the case of graftals, based on formal grammars (L- languages), randomness becomes unnecessary; the database "grows," pretty much according to the model of biological growth (of plants, in this case!). Processing is still based on "machine intelligence," but a move away from the use of quantified variable toward fuzzy descriptions is actually made.

The *Semiotic Engine*, i.e., a system based on the logic of vagueness and operating at a level at which human beings actually operate, would not be the Promised Land, but rather a necessary future step. This is not to say that the Semiotic Engine will produce art while the Analytic Engine only emulates it. Rather, it will allow for a different framework for our entire system of thinking, feeling, reacting, evaluating, etc. In short, for our entire existence. Freed from the constraints of dualistic thinking, but applying dualistic models where appropriate and effective, we might even reconsider our relation to art, or discover that it was only a passing instance in the evolution from dualism to a multi-valued logic system. The Semiotic Engine corresponds to the obvious *semiotization* of our entire existence, a process that reflects the ever deepening mediated nature of our thinking, working, and behaving. Activities such as design—providing the most appropriate signs for an intended activity—entertainment, communication, and education are possible only if we better understand how people generate and interpret signs.

Nevertheless, this is not only an issue of programming, but of the underlying principle of the Analytic Engine: in other words, of hardware and software and firmware understood in their necessary unity. Overcoming exclusive sequentiality, the limitations involved in the manipulation of binary values,

von Neumann's one-at-a-time processing, etc. cannot and will not be only a result of better engineering, but of more appropriate conceptual models that will recuperate continuity and will make multi-valued logic a structural component. The Semiotic Engine, dealing with signs operating in the universe of the logic of vagueness, might prove only an intermediate step. It is partially implemented in new ways of conceiving and designing user interface. It continues being adopted in artificial intelligence applications (where the Inference Engine, a smart retrieval procedure, applies semiotic principles). The human mind has the ability to use inexact representations in order to attain various forms of exactness. Art is such a form, and its paradoxical nature stems form this condition.

Peirce, in his article on "Logical Machines" (1887), mentions that "Every reasoning machine...has two inherent impotencies." In relation to my subject, I shall mention only the first: "It is destitute of all originality, of all initiative. It cannot find its own problems." He goes on to say: "We no more want an original machine than a house builder would want an original journeyman, or an American board of college trustees would hire an original professor."

Wanting it or not, art, according to our understanding of it, is bound to be original. About professors, I'm not so sure. But for that matter, I have avoided the issue of whether the Analytic Engine can run the Education Machine.

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