Drawing Automata

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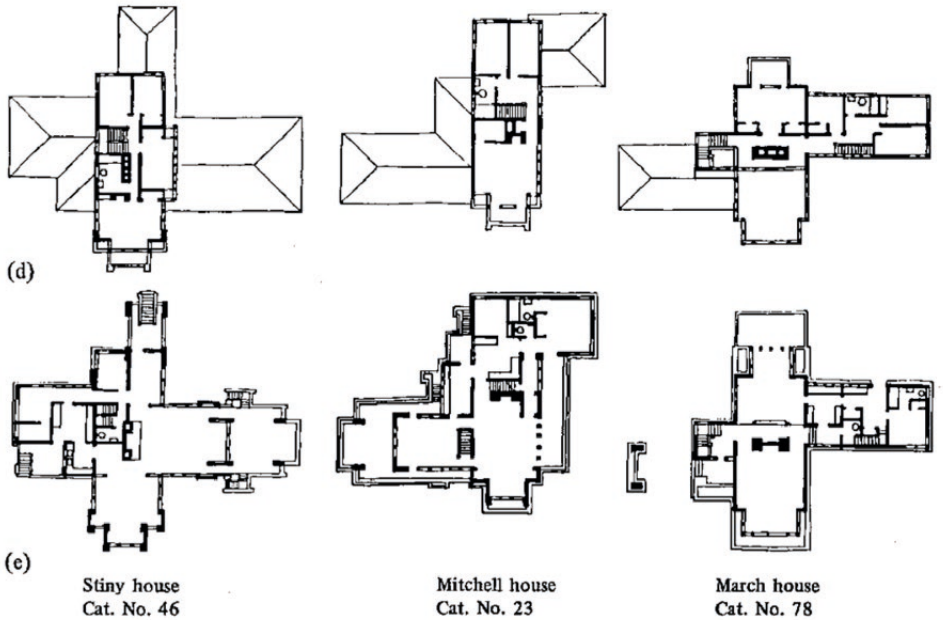
Abstract

The research analyses the evolution of automatic drawing technology, starting with some singular mechanical experiences, such as the puppets by Pierre and Henry–Louis Jaquet–Droz and Henri Maillardet up to developments in graphic technology for digital drawing, such as the ones by Ivan Sutherland, Timothy Johnson and Nicholas Negroponte.
Finally some potentials in the use of intelligent algorithms are described, showing how it is possible to use shape grammar for architecture, as the experiences by Hank Koning and Julie Eizenberg on Frank Lloyd Wright's Prairie houses demostrated.

Keywords
virtual reality, augmented reality, drawing machines, artificial intelligence, CAD systems.



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Introduction

'Drawing Automata' is an ambiguous title. It can mean at the same time 'to draw automata' and 'automata that draw'. But if in the first case the meaning is perfectly in line with the provisions of a certain discipline, the drawing one, in the second case we are in the presence of a phrase that exceeds this work, requiring additional skills, different from those of a good designer who, holding a pencil, draws lines on a sheet of paper.
Here we are interested in deepening in particular the second meaning we have indicated, namely that linked to the themes of Virtual Reality and Augmented Reality, which are among the topics addressed in this symposium. 'Drawing Automata' has something to do with Virtual Reality. In both cases, we can recognize an oxymoron, that is a rhetorical formula that undoubtedly captures attention by 'combining antithetical terms'. On the one hand, in fact, there is the term drawing, which each of us associates with one of the most traditional and creative human activities; on the other hand, the term automata brings to mind the world of the machine – more or less intelligent – which, autonomously from human will, exercises its role in total independence. There is a large variety of automata: from the robots operating in modern factories, to the human–like replicants in the film *Blade runner* by Ridley Scott, which in the future probably will be used also in our houses.
Nicholas Negroponte reminds us that phrases such as Virtual Reality and Artificial Intelligence, to which we could add our *Drawing Automata*, can be considered oxymorons – as we have indicated above – but at the same time also pleonasms, because they amplify the contents they describe, enhancing their semantic value [Negroponte 1995, p. 116]. We could integrate the list with the term Augmented Reality which, even more explicitly, exemplifies the idea of pleonastic enhancement that we described earlier.
We must not overlook the fact that Negroponte himself had underlined the epochal change that took place thanks to technology: from the world of atoms, in fact, starting from the mid–twentieth century to the world of bits, that is to say to the physical recording of information to the digital archives [Negroponte 1995, p. 11] . This current condition sees an exponential multiplication of the bits stored in digital memories, so much so that the neologism *Data–ism* was coined as a meaningful way to describe the period in which we live. The term was used for the first time in a text by David Brooks on *The New York Times* [Brooks 2013], but it has been taken up more extensively into a book by Yuval Noah Harari [Harari 2017, p. 449], in a chapter titled *The religion of data,* in which the author analyzes the epochal change in society, thanks to the invasion of data in our daily life.

Brief History of Automata

We find the term "automata" in one of the first treatises on machines written by Heron of Alexandria, who lived in the first century AD. Published for the first time in 1589 [Herone 1589], the treatise contained no reference to drawing machines, but was full of mechanical tools, some of them have become everyday used. These machines are reminiscent of those developed by Leonardo da Vinci, such as the beautiful gears in the manuscript of the *Codex Atlanticus* [Leonardo da Vinci 2006], drawn with great dexterity and skill already a century before the publication of the translation of Heron's treatise. It should not be forgotten that in Leonardo's library [Vecce 2019] there were some transcriptions of previous codices – such as Taccola's *De ingeneis* [Vecce 2019, p. 91] – from which Leonardo himself certainly took inspiration to draw up his extraordinary graphic drawings as well as some of those that are counted among his inventions. Think for example to the parachute, which the artist proposes in the manuscript mentioned (f. 1058v) in the form of a pyramid and which appears in a manuscript of an anonymous Sienese engineer in the form of a cone.
The first mechanical hand is found in the surgical treatise *Les Oevres d'Ambroise Paré* [Paré 1579], published in 1579. It is called "iron hand" (fig. 1a) by the author who describes it in a precise manner, with the aim of generating a prosthesis for the human limb. Represented in all its details, it recalls that of the "draftsman" (fig. 1b) created by two watchmakers, Pierre and Henry–Louis Jaquet–Droz, a little more than a century later, with the intention of gen-

Fig. 1. from left to wright: a) the "iron man" by Ambroise Paré [Paré 1579]; b) Pierre and Henry–Louis Jaquet–Droz, the draughtsman; c) Henri Maillardet, the draughtsman–writer; d) some drawings by the Maillardet's automaton.

erating curiosity on the part of bystanders [Perregaux 1906, Marchis 1994]. It is a puppet, that draws mechanically and infinitely the same drawing, because its moving mechanisms are regulated by time gears, reminiscent of those of a clock. It is no coincidence that at the same time the physician Julien Offroy de La Mettrie concluded his book entitled *L'Homme Machine* with the sentence: "the body is but a clock" [La Mettrie 1747]. Even today it is possible to see the mechanical doll intent on drawing if we go to the Musèe d'Art et d'Histoire in Neuchâtel, where the restoration of the mannequin made it possible to completely restore the object's operation. In reality, in those recursive drawings there is nothing creative: the mechanism is similar to that used by the first pen plotters of the 1970s which, through a pointed graphic tool, drew lines on the sheets, avoiding the method of inkjet used today. But it is interesting that the drawing is made by an automated instrument and not by a human hand.
Similar to the preceding one is the mechanical puppet realized by Henri Maillardet, who worked in the Jacquet–Droz laboratory [Ceserani 1969, pp. 116-118]. Maillardet's automaton (fig. 1c) was even more sophisticated because it could be programmed to generate different drawings (fig. 1d). So not just one, but several ones, as if it were controlled by an algorithm in which it was possible to modify certain parameters in order to return different results. About these automata, Thomas A. Heppenheimer wrote that "in these inventions we can discern many of the features of today's programmable industrial robots" [Heppenheimer 1985, p. 42], although we have to wait a few years before we see interesting results in the field of intelligent algorithms.

CAD and AI

To find experiences that deal with computer machines that produce graphic drawings we have to get to the 60s of the twentieth century, with the experiences of Ivan Sutherland [Sutherland 1963] and Timothy Johnson [Johnson 1963], authors of the first interactive tools for CAD drawing, in the first case two–dimensional, in the second already three–dimensional, a few months after the first. It is difficult to think that this synthesis could take place without the theoretical support of an authoritative figure such as Steven A. Coons, to whom we owe the first algorithm for the generation of complex surfaces, which take their name from him. Even today, many modeling software describe such forms as Coons Surfaces, an explicit reference to the author who described the algorithm in a well–known essay [Coons 1965]. Only a few years after that experience, Sutherland developed the first virtual reality system – which will be called *The Sword of Damocles*, borrowing the name from the well–known legend told by Cicero. The principle proposed in Sutherland's system – called by him also the *Ultimate Display* [Sutherland 1965] – is contained in every current virtual reality system, even if it presents a system similar to what is now called mixed reality, with the union of real vision with virtual vision. Stereoscopic glasses therefore offer the observer a virtuality that is perfectly superimposed on the actual vision.

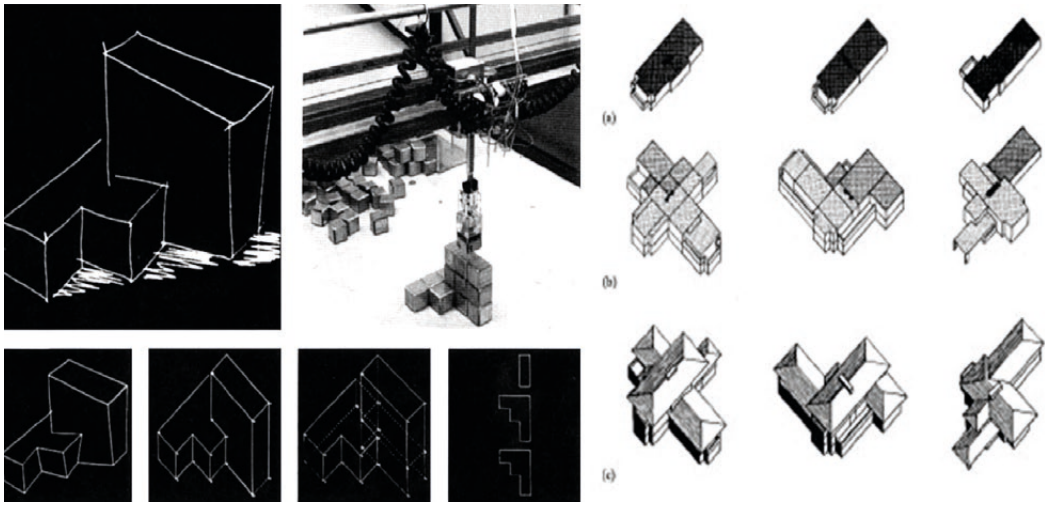

Fig. 2. from left to right: a) N. Negroponte, system that recognizes shapes and constructs 3D model [Negroponte 1975]; b) H. Koning, J. Eizenberg, Shape grammar applied to Prairie Houses by F.L. Wright: Stiny house, Mitchell house, March house [Koning, Eizenberg 1981].

To find the use of artificial intelligence, it is necessary to wait few years, in which shape recognition tools are developed. This is the case of some experiences described by Negroponte in two books, *The Architecture Machine* [Negroponte 1970] and *Soft Architecture Machines* [Negroponte 1975], where graphic recognition algorithms are proposed, which can include graphic signs and return consequent three–dimensional shapes (fig. 2a). But the most interesting experiments will be the ones carried out in the field of shape grammars, and in particular those in which the role of architecture is involved. We thing, for example, at the experiences conducted by Hank Koning and Julie Eizenberg to develop methods of analysis on the works of Frank Lloyd Wright, thanks to which to re–propose architectures in imitation of those of the American architect. So three new Wrightian houses were developed (fig. 2b) to which the two researchers gave the name of three important figures in the filed of computer science, whose studies were decisive in the development of the investigation of architecture using new technologies: George Stiny, William Mitchell and Lionel March, helping to define the process of digital semantic analysis of architecture that is now implemented in many studies. We can remember the ones conducted at Massachussets Institute of Technology by José Pinto Duarte (Pinto Duarte 2001) on the work of Alvaro Siza Vieira, in which the shape grammar of the Malagueira's houses was studied to understand the way in which the architect used the composition rules to design his work, proposing new possible variations of them.

Conclusions

The archives of stereometric forms, investigated in a timely manner with syntactic and semantic analysis tools, can constitute a morphological database from which useful information for the project can be drawn, both by human designers and by intelligent algorithms that can select and propose solutions suitable for different purposes. Precisely this new methodology of intervention gave rise to an acute debate to understand the thin border between human creativity and computational intelligence.
The breakthrough on the table of the designer of the automated drawing is ultimately modifying the architect's work – i.e. we think to the Building Information Modeling process, in which clash detection algorithms can help architect to find problems during the creation phase – so much so as to arouse enthusiasm and anxiety at the same time. A recent essay by Mario Carpo – one of the most authoritative figures in the field of criticism of new technologies for the architect – clearly expressed this status, underlining how developments in algorithmic design can find unthinkable ways out. This reflection is well expressed in one of sentences by him – which closes the cited essay – which summarized the concept with a highly communicative hyperbole: "Architects cannot do without technology, but technology can do without them" [Carpo 2018].

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