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Architectural Design Digital Change: Interactivity policy

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Abstract

Several researches have been focused on digital architecture historical perspectives of the design throughout the sixties. This paper purposes a different view based on the influence of art, science and computation in architecture that contributed to the use of interactivity in architectural design. The aim is to describe the evolution of interactive CAD from MIT's Project CAD and Ivan Sutherland's Sketchpad to the early digital architectural design pioneers: Steven Coons, Gyorgy Kepes and Nicholas Negroponte.

Keywords Digital Architecture, Sketchpad, CAD, MIT

INTRODUCTION

Throughout the history of architecture, processes have always been associated with the availability of tools and with the technological evolution. As Picon (2010) states, in the Renaissance, the adoption of new tools and procedures are inseparable fact of the broader phenomena that was the emergence of the modern architect. Several Ph.D. Thesis have traced historical perspectives on the importance of the origins of digital architecture and interactive CAD (Computer Aided-Design), considering both architectural design and graphic design (Gaboury, 2015; Llach, 2015a; Rocha, 2004; Steenson, 2017). These studies comprise an important basis for work on the evolution of digital architectural. However, they do not approach the change caused by transdisciplinarity and by science, namely by mathematics and computation in digital architectural. To understand the relationship between computer graphics and digital architectural it could be helpful to discuss also the association of architecture, science, and art. The main goal of this on-going study is to combine information regarding the start of digital interactive media used in the architectural design with a chronological approach to demonstrate a historical perspective of the evolution from the first interactive CAD.

This paper addresses specifically the evolution of interactive CAD from MIT's Project CAD (Coons & Mann, 1960) and Ivan Sutherland's Sketchpad (Sutherland, 1963) to architectural design through the sixties with special attention to the pioneering digital architectural design research of the architect Nicholas Negroponte and the influences of their advisors Steven Coons on the interactive digital design area and Gyorgy Kepes on the aspect of joining art and science. This paper addresses the influence of humanistic technological ideas of Kepes with the vision of human-computer interaction in design brought by Coons.

METHODOLOGY

According to the presented research objectives, a qualitative methodology was adopted. The bibliography mixed up primary and secondary sources, Ph.D. thesis, periodicals and other publications, scientific communications, bibliographical notes, in analog or digital format, audio, and video formats as well as web pages and other documents in electronic format only. Based on this research the analysis allowed gauging a group of relevant scholars to the evolution of digital architectural design. The methodology allowed a critical synthesis on the concepts and a historical revision of the beginning of interactive CAD systems, their antecedents and their extension to the digital architecture considering it as part of a historical perspective of transdisciplinary digital architecture.

THE EVOLUTION FROM FIRST INTERACTIVE DEVICES TO INTERACTIVITY AT THE FIRST CENTER FOR ARCHITECTURAL COMPUTER RESEARCH

Architectural design as evolved to be interactive but not only architects contributed to those developments (Table 1). A transdisciplinary view of design promoted by engineers foresaw the possibility of creative interact with computer. Different areas of knowledge used the human–computer interactivity in architecture as a technological humanistic approach.

Table 1: Researchers, Research and Relevance

Researcher	Research Lab	Research Period	Relevance to Architecture
Gyorgy Kepes	Visual arts in Science	1948-1974	Reviewer of Christopher Alexander's book *Notes on the Synthesis of Form* , Negroponte's Thesis Advisor
Steven Coons	Engineering Design and CAD	1948-1977	Project CAD, Negroponte's Thesis Advisor
Ivan Sutherland	Electronic Engineering, CAD, Zooming, Computer Graphics, VR	1959 –	Created SketchPad, VR, Zooming and Clipping
Nicholas Negroponte	Digital Architecture, Visual Arts and Computer Science	1965 -	Established the Architecture Machine Group, 1st computer-based architectural research center

MIT - FROM GRAPHICAL INTERFACES TO PROJECT CAD RESEARCH

Nowadays much of the objects that we use, on a daily basis, were impossible to produce without using scientific knowledge in their design (Table 2). The need to create innovative industrial solutions brought the integration of computing into the design process as a tool to solve design problems and as an aid to the technical and economic decision-making.

Table 2: Important research milestones

Year	Research Milestone
1951	Whirlwind, 1st digital computer with graphical display
1958	Light Pen developed by Wesley A. Clark for SAGE
1959	Project CAD starts
1960	J.C.R. Licklider article "Man-computer symbiosis"
1963	SketchPad Ph.D. Dissertation, 1st interactive CAD
1964	Notes on the Synthesis of Form published
1964	"Architecture and the Computer" conference by the Boston Architectural College, 1st time SketchPad is shown at an architect's conference by Steven Coons
1968	Computer Mouse is developedby Douglas Engelbart and William English - article "A research center for augmenting human intellect" and patent granted to Engelbart in 1970 - US3541541A
1968	Sutherland creates the 1st Virtual reality display, article "Head Mounted Three Dimensional Display"
1968	Negroponte establishes the Architecture Machine Group, 1st computer-based architectural research center
1972	Edwin Catmull, Coons Ph.D. thesis advisee creates the first Digital 3D Animation movie, article "A System for Computer Generated Movies"
1972	Is granted to Sutherland a US patent to window zooming - US3639736A
1976	AMG develop first touch screens, article "Architecture-by-yourself: an experiment with computer graphics for house design" by Guy Weinzapfel and Nicholas Negroponte

Since the beginning of the cold war, Massachusetts Institute of Technology (MIT) became the largest beneficiary of public research funds from military agencies (Llach, 2015a; Perry, 2014; Weisberg, 2008). Computers were so expensive that the cost of three hours of computer usage was the same as a monthly wage of a trainee engineer (Weisberg, 2008).

In the 21st Century, the acronym CAD can be considered almost as a synonym of vector graphics on a computer, however in 1959 was the synonym of a research project at MIT. In fact, the acronym CAD was created by Robert W. Mann and Steven A. Coons (Llach, 2015; Weisberg, 2008; Llach, 2017). Coons and Mann were teachers and researchers from the Engineering Design and Graphics Division of the Department of Mechanical Engineering and MIT's project CAD. The project was financed by various contracts made by the Air Force's Air Materiel Command with the division and another MIT service called Electronics Systems Laboratory – ESL from the Department of Electrical Engineering. The main objective of the contracts was the improvement of the design in the manufacture of airplanes, missiles, and components through the production of a design machine (Llach, 2015a; Weisberg, 2008).

MIT's project CAD was a joint effort of two teams from two different departments of MIT School of Engineering. The ESL team headed by Douglas Ross and the technical design team, at the beginning leaded by Mann and after by Coons. At one side was what we would call nowadays, the IT scientists and at the other side, the designers. Coons and Ross were both co-directors of the project and two directors meant two different visions for drawing machine (Llach, 2015a). Ross envisioned an automatic and programmable design machine making non-interactive computer design while Coons foresaw the computer as interactive as it could be with a man using the screen to design. This evolved a man-machine system which would allow the human designer and the computer to work together on creative design problems (Coons and Mann, 1960) The idea of "creative design problems" (Coons and Mann, 1960, p. iii) is very important to demonstrate the fact that Coons envisioned an interactive design system for creative designers like artists and architects that do not have the idea of what they want to draw right from the start. The project's idea was achieved by artistic creation and interaction of man with a computer. Thanks to Coons ideas the MIT's project CAD can be considered the first systematic investigation of a man-computer interaction even before the research work of Engelbart at Stanford that led to the computer mouse, but almost certainly inspired by another member of MIT's faculty the JCR Licklider and his 1960 seminal paper on man computer interaction "Man-computer symbiosis". CAD Project engineers not only developed the pioneering technologies of CAD, but also theorized creativity and representation in computational terms, imagining humans and computers working in a collaborative assemblage around computational description, indexing all kinds of information (Llach, 2015a).

SKETCHPAD THE FIRST INTERACTIVE CAD SYSTEM

Coons's Project CAD ideas would be materialized by Ivan Sutherland, a 22-year-old Reserve Officers' Training Corps (ROTC) of the US Army that arrived at MIT in the

Summer of 1960 coming from a Masters at CalTech (Sutherland, 1963, 1994). Sutherland was an electrical engineer and the advisor Claude Shannon author of the important paper "A Mathematical Theory of Communication" (Sutherland, 1963, 1994; Llach, 2017). Coons was an advisor on Sutherland Ph.D. Dissertation committee with Marvin Minsk, the pioneer of artificial intelligence (Sutherland, 1963). Sutherland had become a computer programmer when he was a teenager and made acquaintance with Edmund Berkeley, the creator of one of the first personal proto-computers. It was also Berkeley introduced that Sutherland to his future Ph.D. Advisor Shannon, that worked at Bell Labs, an important computer research center of those times (Sutherland, 1989, 1994).

Coons interactive ideology of Project CAD was important to Sutherland´s original idea of creating Sketchpad. Also important was Sutherland's background, including the fact that his father was a civil engineer and, for this reason, he had learned to read engineering blueprints at a very young age and acquired a certain interest in the technical drawing (Sutherland, 1989, 1994). In 1962 he had the first version of Sketchpad and made a film about it for MIT promotion. In the film he described it as a tool for engineers (Sutherland, 1962).

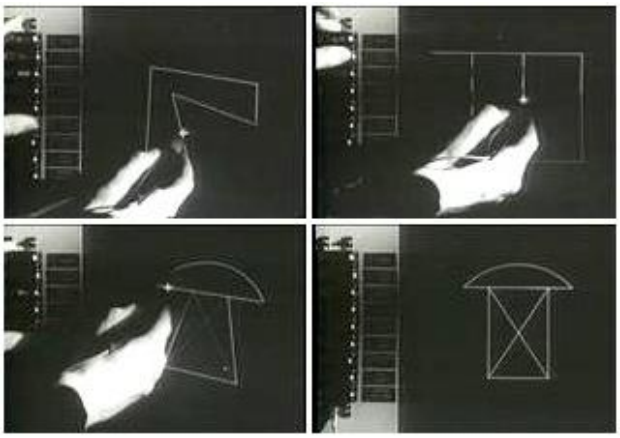

Figure 1: Ivan Sutherland demonstrating Sketchpad (Llach, 2015a).

Sketchpad (Figure 1) had to considered also a milestone by its graphical interactivity and one of the firsts Object-oriented programming language because unlike the other software available instead of a list of programming procedures it had "object" and "instance" (Negroponte,1995; Gaboury, 2015; Kay, 1996; Sutherland, 1963). Can be considered ahead of its time, since it was made in a very large computer with the size of a room in a Cathode Ray Tube (CRT) screen with the size of nowadays smartphone but that communicated with the user through a light pen that could draw (Perry, 2014). The computer was called TX-2 and had three core memories making a 64k-word index memory something that Sutherland at the end of the eighties a twentieth of the Apple Macintosh II (Sutherland, 1989, 1994; Weisberg, 2008). Sutherland work was also inspired by Licklider. Both researchers shared common ideas and it is a fact that in 1964, the year after Sketchpad's Ph.D. Thesis, Licklider have proposed Sutherland to be his successor as the head of the Information Processing Techniques Office (IPTO) of the military research bureau Advanced Research Projects Agency (ARPA) (Llach, 2015). ARPA was an organization that funded technological research under the American Department of Defense that was created to respond to Sputnik satellite launch and also can be considered one of the birthplaces of the internet, then named ARPANET (Sutherland, 1989). In the 1990s, Sutherland considered that the money spent by ARPA would have been paid for itself through the tax revenues of the companies and the jobs created. Through participation in ARPANET, Sutherland would also be considered a pioneer of the Internet (Sutherland, 1994).

Sketchpad was a design system that could draw lines or points in real time, due to the fact of not using a punched tape. The real-time factor gave Sketchpad an interactive attribute. It is also important to highlight the impact and innovation capacity of Sketchpad regarding how the computer could synthesize the representation and the level of the introduction of new concepts in various areas of computing such as dynamic graphics, visual simulation, resolution restrictions and an almost virtually infinite coordinate system (Negroponte, 1995). For some authors Sketchpad in the first half of the sixties constituted a fundamental element for the development of the media in the subsequent decades, being considered either as a central element in the history of computational design (Manovich, 2013; Wardrip-Fruin & Montfort, 2003).

STEVEN COONS - RELATING THE DEVELOPMENT OF THE FIRST INTERACTIVE CAD WITH THE PIONEERS OF DIGITAL ARCHITECTURAL DESIGN

In this research Coons is considered the main mentor of the project CAD. For him, the computer could keep the repetitive work while the man could rest only on the creative component of the design. Coons foresaw the computer as a universal representation machine, a "perfect slave" (Coons, 1966) for the man who designs that could be creative or not (Coons, 1966; Llach, 2015). Coons is possibly one of the most important figures to understand the change in architectural design made with the use of technology. He is undoubtedly the most influential person in the development of its digital component, with important contributions to the introduction of a technology culture in drawing. Gaboury, (2015), Llach (2015) and Perry (2014) consider Coons both fundamental to the development of CAD and computer graphics as it is being developed in the 21st Century. Those authors regard Coons as the first figure in the design and Computer graphics as the key theorist of the 20th century or even as the grandfather of computer graphics (Gaboury, 2015; Gaboury, 2015; Llach, 2015; Perry, 2014)

Coons after Sutherland left MIT went back to the American Army became the main advertiser of Sketchpad to audiences bigger than engineering academia and that included artists and architects. When a new Sketchpad movie of Sketchpad was done for National Educational Television, in 1964, Coons was the main protagonist and he synthesized the degree of interactivity reached by the software, peculiarly, arguing that Sketchpad allowed a man to speak to a computer, not with his voice, but to speak graphically (Morash, 1964). With a few words, Coons described the arriving of interactivity to design but also the importance of interactivity to the human-machine dialogue (Figure 2).

Figure 2: Computer Sketchpad (1964) MIT Interview (VintageCG, 1964).

At the end of the year of the referred movie, in early December, occurred the first presentation of the Sketchpad system at a congress of architects called “Architecture and the Computer” organized by night college Boston Architectural Center. Coons, the Sketchpad presenter, was a speaker on the same day of the Congress as two important teachers of architecture, the then young sensation of the sixties architecture, Christopher Alexander and the 81-year-old veteran Walter Gropius that had founded Bauhaus more than forty years before the and was retired from Harvard Graduate School of Design (GSD) since the early fifties. Coons made a presentation called “Computer Aided Design”, in which he emphasized the importance of the interaction between architect and computer through the interactivity of design. It is important to refer that while Coons spoke about architects working directly on a computer, the veteran Gropius still made the presumption that the computer design needed a programmer to work with the architect, a presumption valid for almost all the other non-interactive design programs available at that time (Rocha, 2004; Vrachliotis, 2010; Steenson, 2017).

NEGROPONTE – PIONEERING INTERACTIVITY AND TECHNOLOGICAL HUMANISM AT THE FIRST CENTER FOR ARCHITECTURAL COMPUTER RESEARCH

Three years after Sketchpad, Coons would be the master thesis advisor of Nicholas Negroponte called ‘The computer simulation of perception during motion in the urban environment’. The young architect was already envisioning the need for scientific research in architectural design. He considered that the research in architecture had a huge delay to the industry and the advanced engineering research of the sixties at the National Aeronautics and Space Administration (NASA) (Negroponte, 2010). This vision was also very close to the one argued by the Design Methods Movement and in particular Horst Rittel. He wanted to make a design with the scientific developments of NASA and the military design, namely by using problem-solving methods in the civil areas of design (Bayazit, 2004).

Negroponte’s thesis had two more advisors, one from the specific area of the master, Kevin Lynch, urban planner and author of the book ‘The Image of the City’ (Negroponte, 2010; Steenson, 2017). The third advisor was Gyorgy Kepes that sponsors science in architecture with a touch of in technological humanism. Kepes was a Hungarian visual artist, but he was not really a German Bauhaus teacher or student, still, though he was a teacher at the American version of the School, the New Bauhaus (Finch, 2005; Kim, 2006; Wisnioski, 2013; Halpern, 2015; Wiesenberger, 2018). Kepes embodies Bauhaus heritage in his architectural research fusing architecture, art, science, and technology. This school was linked to machine use based learning. Mainly after the Hungarian visual artist Lazlo Moholy–Nagy arrival, in 1923, the school’s curriculum reflects not only technology but also science (Findeli, 1991). Design teaching methods were more than simply modernists were also scientific (Kim, 2006). Bauhaus’s architecture marks a change of attitude towards science, to the point that architects from Bauhaus were treated by his contemporaries as scientific architects. Another important idea concerns the fact that Bauhaus designers observe science as a vehicle for the development of the design (Anker, 2010).

However, Bauhaus's contributions to science in architectural design do not stick only to Moholy-Nagy or to the school’s director Walter Gropius that went to became main responsible for the Department of Architecture of the Harvard GSD. Other teachers also made important contributions like the Swiss painter Paul Klee with ‘The Thinking Eye’, a book focused on the theory of form that revealed the important influence of science on drawing (Findeli, 1991). Moholy-Nagy predecessor as preliminary course teacher Johannes Itten or Russian painter Wassily Kandinsky with the book called ‘Point and Line to Plane’ also contributed to a language of the form (Kim, 2006). Nevertheless, the school was also the guardian of a humanist tradition focused in functionalism and regarding human rational, emotional but also environmental needs that linked the school to ecological sciences (Anker, 2010).

In the late thirties, part of the Bauhaus faculty fled from the eminent World War II in Europe to become teachers in the USA and in the case of Lazlo Moholy-Nagy to establish new design schools in Chicago. The New Bauhaus, the School of Design and the Institute of Design where schools where Moholy-Nagy developed a pedagogical method in which students designed, in collaboration with art, science and technology and in which science meant social sciences also (Findeli, 1991, 1995). From his early work with Moholy-Nagy and the Chicago Bauhaus, Kepes gained his Bauhaus lineage, being on the first group of teachers that established the school in 1937 although he had missed the first weeks due to still being in London (Finch, 2005; Negroponte, 2008).

For all the presented reasons, Negroponte considered that Kepes was “the last of the Bauhaus” (Negroponte, 2008, 2010), but Negroponte himself can be considered, during the late sixties and early seventies, a successor of the lineage and tradition of both science in design and technological humanism of the Bauhaus, embodying himself the offspring of the Bauhaus and New Bauhaus schools. These ideas, together with the ideology of the man-machine interaction of the MIT CAD project, were present into the Architecture Machine Group (AMG) research center (Vrachliotis, 2010; Steenson, 2017), and

also in the journal article 'Towards a humanism through machines' (Negroponte, 1969) or in his first book 'The Architecture Machine' (Negroponte, 1970).

In 1967, Kepes established at MIT the Center for Advanced Visual Studies – CAVS based on his interdisciplinary aspirations of stopping with divisions between scientific knowledge and poetic or artistic ideas. Those interdisciplinary ideas also considered that science and art were complementary and a possible joint solution to the problems of environment affecting large cities. CAVS had the goal of offering artists a place where they could develop creative aspirations with support from scientific and technological disciplines. Throughout the sixties, Kepes defended the humanist idea of developing new urban intervention tools with artists contributing to better living conditions in cities (Finch, 2005; Cueva, 2017). Evocating CAVS, Negroponte considered that Kepes was the last of the Bauhaus originals (Negroponte, 2008). He was recommended by the renowned art critic and academic Rudolf Arnheim to the editors of Harvard University Press to be the reviewer of Christopher Alexander's book *Notes on the Synthesis of Form* (Martin, 1998). Book based on a dissertation that can be is considered the first Ph.D. in Design Methods (Bayazit, 2004; Steenson, 2017).

The humanistic influence of Kepes is particularly noted in a Negroponte's article called 'Towards a humanism through machines' (1969) published first in the Technology Review in April and in September of that year in the Architectural Design. Also, MIT Project CAD/ Coons ideas are present with the proposition of a natural dialogue between computers and human designer through really computer-aided systems instead of simply computerized systems that only mimic the designer (Negroponte, 1969). In an article written in the first years after establishing the Architecture Machine Group, a computer-based architectural research center (Vrachliotis, 2010), Negroponte expresses clearly two important influences of two of their advisors, the environmental humanism of Kepes but also Coons's interactivity of design.

Another important point of Coons influence in Nicholas Negroponte is the start of his teaching activity at MIT. This is related to the fact that Coons requested an unpaid absence for a year to work at Harvard with Sutherland, mainly on the pioneering research on Virtual Reality that would be better known by Democles Sword but was published as 'A head-mounted three-dimensional display'. Coons invited Negroponte to teach CAD seminar at the mechanical engineering department (Negroponte, 2010; Steenson, 2017). Negroponte took this opportunity for mixing architecture and science on the following year when he started teaching future architects. During the late sixties, at the AMG, Negroponte associated science and art to architectural research and namely interactive CAD to architecture, developing several research projects like: URBAN 2, URBAN 5, SEEK or HUNCH. All of them included military funding to study interactivity like Project CAD, but in this case, interactivity applied to architecture. That research would originate two important books to digital architectural design in the seventies (Steenson, 2017). At AMG the initial research corresponded to CAD systems running on an interactive computer with local memory and local processing ability, called the Architecture Machine that worked also linked to a mainframe computer IBM 360/67 (Scott, 2016; Steenson, 2017). URBAN2 and URBAN5, the initial projects, used Block Worlds that were cubes with characteristics that facilitate the application of robotic arms in the movement of the object, a specific type of artificial intelligence research domains called Microworlds (Steenson, 2017). URBAN2 and URBAN5 combined a simple graphical CAD system with computer-vision running on the Architecture Machine computer with three-meter Block Worlds cubes manipulation by a robotic arm. The interactive dialog between man and machine was done through question and answer on the computer keyboard and buttons (Negroponte, 1970; Steenson, 2017). The second version URBAN5 was designed to explore natural language as a vehicle for machine-man collaboration in design and to analyze the interaction of data between human users and computer (Llach, 2015; Steenson, 2017).

The next Negroponte / AMG project was the strangest of all but at the same time innovative at the interactivity level that achieved, and it was called SEEK. In the Kepes tradition, SEEK was a scientific research project that was also an art installation and was the Architecture Machine Group's contribution to the 1970 exhibition Software: Information Technology: Its New Meaning that took place at the Jewish Museum of New York, curated by Jack Burnham. The project would also be on the exhibition catalog cover (Llach, 2015; Scott, 2016; Wiesenberger, 2018). SEEK (Figure 3) consisted of another Blocks World domain that simulated a "city" planned to interact with its inhabitants and to be taught by them (Steenson, 2017).

Figure 3: SEEK project / installation comprising a colony of gerbils in a 1.5 m x 2.4 m large glass "city", 5 cm blocks and a sensor-enabled robotic arm to change the habitat (Llach, 2015).

A configured automatic device connected to the Architecture Machine computer, conceived to deal unpredicted incidents. The blocks that in URBAN 2 and 5 had 3 meters were shortened to 5 centimeters cubes to match the size of the "city" inhabitants, a colony of gerbils. The city was a 1.5 m x 2.4 m large glass, based on the idea of the mega-grid in the Ville Spatiale of the French Architect Yona Friedman with whom Negroponte has worked as a technical translator. Negroponte had explored the idea of mega-grid using it before in his Bachelor of Architecture Thesis advised by the other AMG founder, the professor of structural engineering Leon

Groisser (Scott, 2016; Steenson, 2017; Werner, 2018). SEEK can be summarized as a machine designed to interpret what the gerbils craved with the ability to create new environments out of 480 cubes through a robotic arm (Werner, 2018), some responsive architectures that the system evaluated as more suited to the population (Scott, 2016; Werner, 2018).

> "For the observer this meant a new architecture, which changed from day to day according to how the little animals inhabited it "(Negroponte, 1979, p. 25)

> "The intent was simply to show an interactive system observably dealing with unpredictable events, from an unsettled heap of blocks to its own malfunctions" (Negroponte, 1979, p. 25)

Another important project of the AMG directed by Negroponte was more related to Sketchpad and also to architectural digital design was HUNCH (Negroponte, 1975). It translated to the screen, a user's hand sketch while still in its provisional version and was also a project that joined several disciplines like cybernetics, architecture, behavioral cognition, construction and machine learning (Werner, 2018). In the HUNCH research, human hand sketch was considered a vehicle for training following the concept that much of the thought of architectural drawing took place in the form of sketches on napkins and pieces of paper. It was more than a drafting system through sketching and it could also interpret the user pressure and density of lines and could also preform the rationalization of drawing through B-spline techniques, a research area much developed in those times through Coons and his advisees. HUNCH was one more medium that permitted the interaction man – computer, in this case through sketching. It enabled the computer to act as an extension of the architect or other creative designer an empowerment that also lead us to Coons ideas and MIT Project CAD (Werner, 2018).

Besides the importance of Negroponte's early AMG pioneering work to CAD and to the crossing of art and technology, the aspect of the interaction man – computer is also worth of mention. JCR Licklider the author of 'Man-Computer Symbiosis' would refer in the late sixties that the "graphical explorations in architecture of Negroponte" (Licklider, 1969, p. 619) were together with important names of interactivity, like Engelbart, some of the few exceptions in the sixties research of interaction man – computer since Sketchpad more than five years before. Another five years and would be Negroponte's turn of recognizing the same idea of little progress related, in this case, to interaction in computer graphics that was more focused on technical developments made on the realism of pictures or in the efficiency of data structures (Negroponte, 1975). The example for this overview was the book Principles Of Interactive Computer Graphics co-authored by Sutherland's best student and long-time research partner, Robert F. Sproull (Sutherland, 1994).

By that time Negroponte's research was stepping out of digital architecture interactivity and stepping out of architecture in his second book Soft Architecture Machines (1975). Negroponte's first book 'The Architecture Machine' (1970), was focused on architecture and architectural research projects like URBAN 2 and URBAN 5 or SEEK, the second, in 1975, had four chapters the last more distant from architectural research than the first, that included the HUNCH research. The second chapter was called 'Computer Graphics' and had an introduction by Coons.

Negroponte took the idea of a science of design together with the CAD interactivity ideology of Coons applied computation architectural research to AMG with and then to its successor, the MIT's Media Lab (Negroponte, 2010).

He would take also the transdisciplinary ideas of art and science of Kepes also to the AMG and to the Master of Science in Visual Studies, a program that he established in 1979, by Negroponte and Kepes successor at CAVS, Otto Piene, for artists more unconventional than a traditional Master in Fine Arts (Finch, 2005). But Kepes ideas of science and art was also presented at the Media Lab, that Negroponte considered as a "Digital Bauhaus" (Negroponte, 2010).

DISCUSSION

This paper is about digital architectural design that started with military-funded research and a conception of a design machine for engineers. Coons envisioned a man interacting with a computer on creative design problems. The engineer's Computer-Aided Design was adapted for future architects use. Coons found on Negroponte an opportunity to put his interactive design ideas in practice in architectural research. Nevertheless, Negroponte also benefits from the ideas of mixing architecture with art and science that came from his other advisor Kepes. Using interactivity in architectural design was an important step that came from Coons but not less important was the technological humanistic approach of Kepes.

This represents a change of policy on architectural research that provided the interaction between a man and a computer but also tried to use that computer to make a better environment in which the man lived in. Therefore, the on-going research is suggesting that the "technological humanism" of the Bauhaus lineage mixed with Coons's interactivity, that can be related to Licklider's ideas, which made way to a digital change in architectural design, created by Negroponte's research, with impact in nowadays architecture.

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