Evolution of Computer Aided Design: three generations of CAD

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This paper describes the three generations of CAD systems. The first generation of (primarily analytical) computer programmes really aided designing. These programmes were the tools for finding a functional solution in different areas of designing, from flat plans to the space organisation of a hospital. One of the shortcomings of these programmes was the lack of graphic interface. With time, however, this kind of interface was developed. As a result of this second generation of CAD systems the computer was transformed into a drafting machine and CAD meant Computer Aided Drafting.

The main thesis of this consideration is that only now we have the chance to return to the idea of Computer Aided Design. One of the examples of these trends is the AVOCAAD programme in which Added Value of CAAD is analysed. The development of the third generation of CAD systems will be possible in the near future. Aiding the process of designing will demand the elaboration of new methods of using the computer at the early stages of this process. The computer should be used not for generating variants of functional solutions only but for also for the creation of 3D forms by 3D sketching. For this, the computer should be transformed from a tool into a medium; only then will designing become true Designing in Cyber Space.

Keywords*: Generations of CAAD, design process, creation, medium*

Introduction

Ever since the very beginning of the information era, we have been observing the ways in which new technologies have been influencing people. Our life is changing. We are working differently, we are becoming more and more open, and we know more. There are continuously more perspectives and opportunities. However, we also encounter problems which had not existed before. The information age has posed new challenges since its early beginnings, it has given better tools and, in consequence, has changed the working methods. I would like to start my deliberations over the topic of the new computer tool in designing by quoting J.Frazer who, at the AVOCAAD Conference in 1999 in Brussels said," Does anybody remember that before CAD, architectural design also required aid?" The search for new ways of the design process and its methodology cannot be analysed without the perspective of the historical background which the science of designing has gathered.

So what is designing?

We can characterise some suggestions thus:

> 1962 - Asimow – Making decisions in the face of uncertainty and severe punishment in case

of making a mistake.
1963 - Alexander – Finding the proper physical elements of physical structures.
1965 - Archer – Purposely aimed activity based on solving problems.
1966 - Jones – Realisation of a very complex act of faith...or Page – A jump of the imagination from the modern facts to future possibilities. (Jones 1977).

The above quotations undoubtedly give many bases for maintaining the opinion that designing is the same thing in many circumstances. The variety of the definition can be the foundation for overcoming weaknesses of both traditional designing as well as designing with the help of computer techniques.

Traditional designing

In traditional designing the task of the designer was to prepare the drawings approved by the client and for the purpose of instruction for the executors of the design. Owing to the drawings, the planning of things became possible, things which were "too big to be made by a single craftsman". Together with the use of drawings, designing became a separate profession. Due to the great collection of geometrical characteristics of the object (the form), the designer obtained a much wider range of perception in comparison to the one that the craftsman had. The designer is able to see the project as an entity, depending on introducing the ever new changes and modifications. These were made on a single drawing or on a series of layers placed on the initial sketch. The starting point was usually the single drawing, which the designer was able to precisely encompass by his thought. The designing process, by means of the drawing, could be therefore treated as an accelerated version of the evolution of the craftsmanship methods. The difference between the result of the craftsman's work ("the thing produced") and the result of the work of the architect ("the description of things") is included in the possibility of making the thinking process external. The architect, from the point of view of the thinking methods used in traditional designing, is at the same time a craftsman. It is worthwhile noting that in the traditional methods, the drawing can only be produced by one person. Moreover, the situations, which the architect must take into consideration, can be thought out by a single mind. Comparatively, the "thing" could be produced only by one craftsman.

New methods of designing

The main reason for developing the new designing methods, usually cited in the works devoted to the evolution of designing methodology, is the insufficiency of the traditional methods with regard to the ever increasing complexity of the world shaped by man. The basic problem leading to the fact that the designing process is difficult not only in description but also in realisation is that the designers are forced to use current information in order to foresee the future state. The conventional designing process is based on creating thought schemes, which in turn produce in the imagination visions, which are not yet existing, of the object, which is just to come to life. The collection and selection of information is one of the basic processes of thinking and all that is connected with it. There are interferences present in the process, which are caused either by the insufficiency or the overflow of information. The only accessible method allowing for the moderation of this phenomenon was the trial and mistake method. Also emotional elements had a great affect on the decision making process in traditional designing (Mazur, 1976) In the selection of associations (observations and ideas) in the traditional type of a designer's work, it was intuition and not logic that was the decisive factor. It caused an instability of the system. This instability makes designing an activity which is far more complex and fascinating than it could be thought by anyone who has never dealt with it. Seeking ways of overcoming this problem led to the creation of science called the science of designing. This new discipline was the expression of needs

resulting from identifying the aims and tasks posed before the designer.

First generation of AAD Methods

People began to analyse designing from the point of view of system methods, which divide reality into a small number of subsystems with specific and clear influences. In accordance with the theory of general systems, each system acts in relation to another on the basis of direct (linear) coupling, with a defined deterministic way of associating. The set of information included in the design system analysis contains all what is contained in the memory of the designer according to the conventional method of architectural planning. An "open" thinking method is created, where each image and observation associated in the memory is recorded, taking into consideration the deterministic model of associations.

The assumptions of the General System Theory have become the methodological basis for the developed methods of aiding design. Systematic designing methods can be divided into two groups. The first one is strategic methods. The second – tactical methods. The typical examples of strategies are sequences:

- analysis, synthesis, evaluation
- divergence - analysis, transformation, synthesis, convergence - evaluation
- synthesis, analysis, evaluation.

The two first strategies come from scientific research methodology, however the third one represents the idealistic creative approach.

Among the tactical methods, the most universal group are the methods of spatial distribution of the programme, both in the urban scale as well as in the architectural one. Depending on the degree of abstractness of the received results, the methods are further divided into types of spatial distribution methods:

relational – for example HIDECS 2, HIDECS 3,
geometrical – CRAFT, CORELAP, FLATWRITER,
relational – geometrical - RUGAR, GRAMPA (Dorosinski, 1981)

However, it is not by any means obvious that the new methods are better than the old ones. On the contrary, they could hardly have been successful – even when used by their own creators. With regard to the ever increasing difficulties, they often went back to the more traditional course of actions. Such situation was caused by the fact that by digging deeper and deeper into the systematising procedures, a difficulty arose which was based on the loss of control over a particular designing situation. The procedures, to a contiguously smaller extent, referred to designing activities.

The efforts to present the designing process as logically formal and internally cohesive from the mathematical point of view were meant to fail form the beginning. Man is naturally contradictory and often times can be for - and even against – simultaneously. It is a characteristic trait of multi-value logic. The quotes of many creators are proof of that fact.

Krzysztof Penderecki

In his interview for the "Polityka" magazine Pendereki said, " In my house in Lutosnawice I created a maze. I wanted to have the possibility of hiding and losing my way. Each artist wanders and loses his way from time to time as without that nothing can be found. (Ö) I start writing each bigger piece from the middle. I started the "Passion" from Sabat Mater and around it I kept trying out the sound material and the choir technique. Only later did I start sketching the whole work. In the maze I hide, I move back wards and forward. I do not necessarily find the way but I am interested in the process of wandering more than in the process of finding." (Janowska K., 1998)

Tadao Ando

Who wrote, "Architectural thought is supported by abstract logic. By abstract I mean to signify a mediative

exploration that arrives at a crystallisation of the complexity and richness of the world, rather than a reduction of its reality through diminishing its concretness." (...) The real world is a complex and contradictory. At the core of architectural creation is the transformation of the concretness of the real through transparent logic into spatial order." (Ando, 1991)

Summing up, it should be said that the first generation methods had many flaws. Among these were:

- deterministically treated designing process,
- thesis concerning the linearity of the process,
- limitation of the scope of use only to solving functional problems,
- the use of computers made difficult due to the lack of graphical ways of communication between the user and the computer.

On the other hand, however, these methods influenced the process of design problem solving. These programmes were the tools for finding a functional solution in different areas of designing, from flat plans to the spatial organisation of a hospital.

Second generation of AAD Methods - CAAD

The difficulties associated with the use of computers in designing, resulting from the lack of interface and so characteristic of the architect's work, have caused the lack of agreement with regard to their use in architectural practice. In result, works were undertaken on facilitating the method of the designer's communication with the computer. First programmes began to appear which enabled one to draw on the screen – without having to know the programming languages.

In result of this, the second generation of CAD systems was created. Designers started to use the computer as a technical pen. They began to use the CAD software permitting to produce technical flat drawings as well as 3D computer models. CAD software used as an intelligent technical pen allows to change cross sections or facades while still elaborating on the technical documentation. Typical use of CAAD software at subsequent stages of designing could be described as follows:

- **Concept** - It is possible to get a project off to an efficient start by taking a sketching package, or techniques such as scanning or digitising to bring the paper drawing into an electronic format.
- **Design studies** - Once the parameters of a project are determined, it is possible to begin creating drawings in both 2D and 3D, allowing architects to explore a border range of design solutions at an early stage of the process.
- **Design co-ordination** - Once the initial design sketches and studies have been done, the design professional begins to generate hard information about the nature of the project. At this point, it is often necessary to work with other disciplines.
- **Presentation** - At this point in the project, the design is precise enough so that the architect can create rendered 3D models that give the client a sense of what the finishing building will look like. [A]

As we can see there is no difference between the old and new way of designing. Suggestion made by the software companies is limited only to the replacement of a pencil, drawing pen and a brush with a computer mouse and programmes imitating the pencil, drawing pen and the brush. The computer was transformed into a drafting machine and CAD means Computer Aided Drafting.

The explanation that owing to the freedom that the architect gained from not having to laboriously

manually draw his design he will be able to spend more time on the creative stages of the process, are not convincing. The only advantage of such type of programming was the undoubted acceleration of the development of technical documentation as well as the possibility to design architectural forms which broke away from the canon of the right angle and straight line. However the Ronchamp Chapel by Le Corbusier or the TWA airport terminal in New York by Saarinen, which are examples of the greatest architectural achievement, were created without the use of computer.

Third generation of CAAD

The real support of the designing process requires one to learn the new methods of using computers, particularly in the early stages of the process. The main problems here - is transforming the computer into a medium.

At the "CyberReal Design" Conference in Bialystok in 1998, during the discussion over the role of Information Technology (IT) in the process of creation, two theses were formulated. The first, by Sabina and Mikhail Porada. They said that the computer was treated like a "prosthesis" (artificial limb) in the creation of architectural forms. The second thesis, of which I am the author, claimed that the computer is an "extension" of the designer's abilities. The contradiction between the two opinions is superficial as, in fact, these theories are complementary. IT is a "prosthesis" if we make the computer responsible for the activities usually carried out by the designer. The computer can be used to create an over-measure variety (Lem, 1968), i.e. it is responsible for generating the variants of the designed object. It can take place in the memory of the computer on the basis of the random function or genetic algorithm. From the point of view of the obtained effect, there is no difference which method is used. Just as a "prosthesis" substitutes a lacking organ, a computer substitutes the brain. On the other hand, the computer is an "extension" when it stimulates the designer to a more efficient work on generating the idea of the designed object. IT supports creative design if it allows the designer to define novel prototypes to cover his ideas. It is creative if it discovers new prototypes by itself. The creative nature of the architectural design, suggest that the assistant role for the computer system is much more practical than that of a complete autonomous system.

Expression in architectural design is often ambiguous and unable to provide complete information for direct input into the computer. But such expression is not meaningless at all. Rather, it has meaning through association and imagination. The computer is used as a "metaphorisation machine" (Asanowicz, 1999) or a means of mediation techniques (Van Berkel, 1999).

Metaphorisation machine

The analysis of the design process shows that the graphic art has always been one of the basic designing media because it ensured the operational and flexible fixation of design ideas. Each sketch, being the expression of a defined view of the form, allows for an evaluation and formulation of the new aspects of the idea of composition. At the same time, a deeper interpretation of the architectural image requires the development of a sufficiently long sequence of visual models. The graphic computer transformation, together with the creation of the history of the undertaken activities, allows for a fuller exploration of design metaphors, for the metaphorisation of the process of form creation. Designing at the early stages is becoming more and more metaphorical. Whereas the manual sketch made it possible, with a bit of skill, to graphically represent the idea of the creator, it did not, being a tool, create an additional value in the very design process (excluding its aesthetic value that it possessed). Computer can be useful as a "metaphorisation machine" and can serve the role of the "Superior" in the process of creation, taking upon itself the role of the generator of chances. And as Lem once said: "The accident is an early, especially decisive factor in every evolution process where the

arrangement during the creation produces its own patterns which cannot be found at the very beginning of it." (Lem, 1968)

Mediation

In order to explain the term, the van Berkel (1999) should be quoted:

> "The three most important architectural potentials of the **new mediation techniques** are: the expansion of the spatial imagination, the radical break with a hierarchical design approach, and the introduction of different disciplines into the design process, relating the design immediately to its final execution. To begin with the first: the tantalising new spatial modes suggested on every computer screen result in a general familiarity with the potential of a multi-dimensional spatial experience. Computer-generated special effects express a delight in explorative spatial situations, leading to a rapid increase in the capacity for spatial conceptualisation. The artificial world of the computer rendering, with its flat light shaving as sharp as a razor over planes so smooth that not a single molecule is out of line, is appalling and exciting at the same time. Gradually, we are beginning to see that this new computer-generated fantasy is being transformed into reality. The rendering becomes real; the artificiality of the image is actively reproduced in the constructed realm."

VR - Direct Design

The third way of using the computer is working in virtual space.

> "As you move your head, you can look around the office (…). You can see a representation of your hand as you search for a book on the shelf; your virtual hand may either grab the book or slide through it like the hand of a ghost. Then maybe you'll stumble upon a gesture that points on (or suggests it to you) and - whoa! - you fly above the office, higher and higher, until it's just a little construct far below, and you are surrounded by darkness of cyberspace." (Laurel, 1993)

When saying that the electronic image is the one determining the image (icon) character of the post-modern epoch, we are discussing the image on the monitor screen as the result of the reaction of a cathode beam. The appearance, the development, and the scale of the reaction of the emitted iconic reality define the new epoch - saturated with images to an extent never before found in the history of human development. In the times filled with images emitted by television, being the inevitable part of games and computer animations as well as simulations of virtual worlds, socio-cultural conditions are created, which broaden the human practice leading to the still unknown areas of cultural experience. In the world which breaks away from the photographic, reflective "dialectic logic of images", a "paradoxical logic of images" is created, together with the "simulation ideology". Art and architecture with it, starts to exists in different dimensions.

Owing to the appearance of VR, the work of the architect is closer to that of an artist. Painters or sculptors are not interested in the future – they are fully engaged in the present time. For the mere satisfaction of the activity, they manipulate the means existing in the same time as their actions. They act in the real time, making full use of the fast reaction of their nervous system to the intuitive image of the real world. The architect in the virtual world also has the possibility of a direct relation with the forms, which he creates. Direct Design is the third possibility of the creative use of computer techniques in designing. [B]

Conclusion

The development of the third generation CAD systems will be possible in the near future. The aid of the

process of designing will demand the elaboration of new methods of using the computer at the early stages of this process. The computer should not be used for generating variants of functional solutions only, but also for the creation of 3D forms by means of 3D sketching. For this the computer should be transformed from a tool into a medium - only then designing will become the CyberReal Design or Designing in the Real Cyber Space. “C-R” is not virtual reality, understood as an unreal world. Whereas virtual reality (VR) could really be treated as a sort of an illusion, “C-R” is a fully realistic being, defining the area in which our creative activities are taking place. The fact that the forms created by us, completing the virtual reality, are not absolute beings but rather abstract ones is not, in the light of the assumptions of Husserl’s Phenomenology, of greater significance in our deliberations. (Asanowicz, 1988) We may conclude that Computer Architecture has been revolutionary in both sensorial and the intellectual spheres, by using the computer not only as a tool or medium but as a purveyor of abstract information and as a generator of virtual realties in cybernetic space.

References

Ando T., Toward New Horizons in Architecture, in Theorizing a New Agenda for Architecture, ed. by Nesbit K., Princeton Architectural Press, N.Y., 1996

Asanowicz A., From Real to Cyber Reality, 5th International Conference ≤Cyber-Real Design≤ Bialystok, 1998

Asanowicz A., Computer in Creation of Architectural Form, 2nd AVOCAAD Conference, Brusseles, 1999

Dorosinski W.C., Gasparski W., Wrona S., Zarys metodyki projektowania, Arkady, Warszawa, 1981

Janowska K., Labirynt czyli bodnik, Polityka Nr 42, 17.10.1998

Jones Ch. J., Metody projektowania, WNT, Warszawa, 1977

Laurel B. - Computer as Theatre, Addison-Wesley Publishing Company, 1993

Lem S., Filozofia przypadku, Wyd. Literackie, Kraków,1968

Mazur M., Cybernetyka i charakter, PIW, Warszawa, 1976

Van Berkel B., Mediation, 2nd AVOCAAD Conference, Brussels, 1999

Notes

[A] See Autodesk for Architecture, in: Progressive Architecture No. 6, p. 3, 1993

[B] The paper was developed within the framework of the research project W/WA/1/99.

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