

IT TECHNOLOGIES IN ARCHITECTURE AND SPACE REPRESENTATION. BRUNO ZEVI METHODS REVISED

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Abstract

Space representation methods as described by Bruno Zevi in “Architecture as space” are still valid today. Projections, elevations, models, photos and films are commonly used and all of them define the space in a specific way, yet none defines it completely. The development of IT technologies caused emergence of new methods which shape the picture of today’s architecture. Originally, a conventional technical drawing was adapted to the computer environment, but it was the 3D technology that revolutionized spatial representation, by restoring priority to the three-dimensional aspect of reality. Models allow us to explore the virtual reality, which is a huge progress in spatial representation. Thanks to advanced software, buildings of complex structure are formed, bearing testimony of their times – times of IT technologies. A flawless spatial representation method that perhaps will be known in the future should satisfy multi-plane needs of the observer, who experiences the represented space with all senses and impacts it as well.

Keywords: IT technologies in architecture; Perception of space; Space representation methods; Three-dimensional technologies.

1. INTRODUCTION

In 1948, Bruno Zevi in “Architecture as space” [1] raised the issue of spatial representation in the chapter of the same title. He described therein the issues of presenting architecture and imperfect tools used at that time by architects and pedagogics. Today, seventy years later, these theses are still valid, but the work can be supplemented with new achievements, that seem to confirm Zevi assumptions that there is still a lot to achieve in the field of architecture representation. Architecture understood as the separation of space using various means requires presentation by methods showing these divisions in the fullest possible way. Spatial representation is also closely related to cognitive abilities of man and these depend on our senses and body. We sense the space with vision, hearing, smell, touch [2, 3] and taste. While being present physically in the space as observers we are dependent on the environment and we impact it. The observer and

the environment is a coupled system in which elements influence each other. The ideal spatial representation method would have to provide all the senses with necessary data, include the scale and mutual impact of the observer and the presented structure. The history of the development of the representation of space indicates the pursuit of a man to achieve the goal which is to imitate the real experience of space.

2. SPACE REPRESENTATION METHODS BY BRUNO ZEVI [1]

2.1. Drawing methods

Plans and elevations belong to the group of drawing methods originally executed by hand. They both have a flat figure in common, but they differ in content and form – while the former are a record of primarily the interior structure, the latter show an external shape. Technical drawing is still a basic tool to represent spa-

tial structures and acts as a basis of design documentation. A hand drawing is used by designers to record concepts and ideas, by which a final picture of the project is defined [4]. An objection made by Bruno Zevi against plans and elevations is their inability to capture the third dimension, which is the basic property of space. The technique of recording spatial structures to projections, sections or elevations bases on schematic record of information in the systematized language of design, deprived of plasticity present in space and architecture. This language is readable for few and understood depending on the individual sensitivity of the recipient. The 2D representation is a type of code describing the reality, whose interpretation largely differs from the real experience. The common method of recording data about space, the three-dimensional by nature, consists in conversion to the flat diagram, which result in a loss of essential data. On the other hand, as Maria Misiągiewicz notes, drawing by synthesis brings out what is most important [5]. The perspective discovered in the 15th century was the first technical attempt to depict three-dimensional space in a drawing, which was oriented on the target picture of represented spaces more than schematic projections or sections [6]. Three centuries later, Gaspard Monge invented a descriptive geometry allowing for precise mapping of spatial figures on a plane that has found its application in many technical fields, including architecture. Neither the perspective drawing nor the descriptive geometry was included in the work of Bruno Zevi, but their form and characteristics place them between flat projections and photography.

2.2. Recording methods

In the 19th century came mechanized photography, which allowed to capture real figure of photographed objects. A disadvantage of both methods, perspective drawings and photography, was the limitation to a single frame – “no number of photographs can ever constitute a complete pictorial rendition of a building” as claimed by Bruno Zevi [1]. The discovery of perspective and photography contributed in architecture to a more perfect presentation of spatial structures. The continuation of photography's achievements was the discovery of video, allowing to record sound and dynamics where changes in the camera location in the space imitate an observer's movement. The whole process of changes between the plastic arts, photography and video was depicted by André Bazin in a short citation: “Objectivism of photography gives the picture a force of credibility that does

not exist in other plastic works (...) the video becomes something that annexes time for photographic objectivism” [7]. Photography and cinematography as new technologies and recording methods contributed to the development of visual arts and thus the spatial representation by eliminating similarity in visual forms of transmission and replacing them with realism. Important seems to be the fact that the mechanism of photography and film in technical terms is based on recording lights and shadows. One of the operating definitions of architecture is the statement by Le Corbusier, that it is the “game (...) of forms assembled in the light” [6], which points directly to the dependence of methodic on the essence of spatial structures. The movie industry contributed to the development of spatial representation also by using models that give impression of space of natural size. The pioneer work using this method was the picture “A Trip to the Moon” by George Méliès from 1902, but the actual display of potential was presented 25 years later in the futurist “Metropolis” by Fritz Lang. It is an example of synthesis two spatial representation methods to achieve better effects. The invention of cinematography as a phenomenon itself had many interpretations, which today may serve as theoretical basis for meditations on the nature of spatial representation. The realism and creativity of cinematography underlie the cinema analyzing theories, which relate to: recording the reality – reproduction and abstract creation – arts [7].

2.3. Cubature methods

Models are a method which can be called cubature, that is the one that maintains three-dimensional properties of the space it represents but impairs one of the main characteristics of space – the scale. Producing fragments or the whole structure in the target scale to verify an intended effect is rarely done in architecture due to the high costs. This practice is applied for example in the aircraft industry. In Toulouse, at the main office of Airbus, the so-called mock-up center, models of interior of aircrafts A321, A-340-600, A380 and Airbus Corporate Jet were constructed. The last but one, A380, is currently the biggest passenger aircraft in the world and its model covers 550 m² of interiors located on two boards. Jan Gehl points to the fact that the perspective of a standing or moving man changes completely the perception of space, giving the example of the capital of Brazil: „Brasilia as viewed from the height is a beautiful composition (...). But the city is a disaster from the human perspective” [8]. A drawback of models is

their inability to satisfy the needs of human senses and demands of human scale. The dependence of human perception is an element directly determining the quality of space representation, therefore despite many similarities to the represented original, it is not a fully satisfying method.

3. IT TECHNOLOGIES IN SPACE REPRESENTATIONS

3.1. Two- and three-dimensional representations of space in a computer environment

In the 20th century, IT technologies revolutionized all branches of industry, including the architectural. CAD (Computer Aided Design) software enabled digital record of data replacing the hand drawing as a basic method of developing technical documentation [9]. The individual sensitivity was replaced by a neutral precision and since that time, designs are created with a computer technology allowing for change of scale, multiple print and unlimited adjustments. At first, IT technologies only transferred already known mechanisms from a drawing board onto monitor screen, but the discovery of three-dimensional graphics has completely transformed the spatial representation by restoring priority of the three-dimensional aspect of reality [10]. 3D modelling is creating data on the space in the virtual environment with a specialist software, allowing to represent data of any spatial structures. What differentiates this method from the others, is that in fact it is not the spatial representation, but creation of equivalent space. Model in digital environment is not a representation, but an alternative space, which can then be represented by conventional plans, sections, elevations, perspectives, visualizations and animations. The three-dimensional technology also affected the process of developing documentation, which resembles the mechanism of erecting a building, whereas preparing two-dimensional drawings was an attempt to transpose abstract data onto paper. Three-dimensional model is “both a design and communications medium” as described by Chris Abel presenting the main assumptions of the Bio-Tech architecture, which is not characterized by the form of buildings, their style or technology, but a design process based on a model in a digital environment. According to his interpretation, the virtual prototype allows “simulating visual, functional, structural, environmental and even economic properties (...), modifying them until such point as the required result is achieved” [11]. Elizabeth Grosz calls virtual reality a parallel world and notes that it always exist-

ed, it is a place for potential possibilities and it is no different from creation through writing, reading, drawing or thinking – it is an alternative reality for things that do not exist yet [12]. From this point of view, the computer environment is just another area for the acts of creation, but it undoubtedly reveals new paths of presentation of complex spatial ideas. What's more, this leads to the conclusion that the methods do not affect the creator's ability to invent new concepts, but they affect his ability to present them and as a consequence, they influence the implementation.

3.2. Parametric design

The development of digital design tools has also resulted in the emergence of a new type of design – parametric design. Computer software based on mathematical calculations and algorithms, enabled the growth of a new mechanism for creating information about spatial objects [13]. It consists in controlling the designed form by defining principles (parameters) that are subject to automated transformations when changing selected data about related elements. Space design has always consisted in intentional adjustment of its individual parts – parametricism in turn, often referred to as a new style in architecture, transfers part of this procedure to specialized software. Krystyna Januszkiewicz summarized this phenomenon with the following words: “Parametric modeling has changed the representation of the project from a readable geometric record into instrumental geometrical relations” [13], which points to a new property of digital design tools – their ability to generate possible scenarios for the development of the original idea, with vestigial involvement of the designer. Human participation is still necessary, but it is limited to determining parameters, bypassing the tedious process of calculation and redrawing, which seems to bring the architect closer to the profession of a programmer.

3.3. Exploration of 3D model space

3D model also enables space exploration, which has never been achieved before. By using a monitor screen and a controller, an observer may explore the virtual space by moving position and direction of camera – but still, the experience is far different from actual exploration of space in reality, which depends on human perception and locomotion. A response to this issue is the currently available VR (Virtual Reality) technology, enabling exploration of 3D mod-

els not only in the appropriate scale, but also from the realistic human perspective, including the natural observer's movement. The commercial goggles can detect natural head movements in real time and emit sounds introduced to the model by earphones. This method consists in the immersive separation of an observer from the real surrounding, who now becomes subject to visual and auditory stimuli, representing the space carved inside virtual reality. The perception of space depends on properties of the human body and the time parameter due to the observer's movement in the environment. The perception of space evolves with the change of perspective, which Francis Ching described as "circulation" – a movement in space, as a natural element shaping architecture along with other properties like form, proportion, scale or organization [14]. An example use-case for technology with three-dimensional models dependent on time are video games, where players explore the space created by authors within the imposed narrative structure [15]. FPP (First Person Perspective) video games are characterized by observation of space by the player from the perspective of main character/avatar, which gives an impression of taking part in a simulated activity. It is important to note, that some of the solutions used in video games are already known from cinematography, whereas the new ones are based mainly on player's interaction with the virtual surroundings, which indicates improvement of new spatial representation methods. A spectacular achievement seems to be the overcoming of so far unattainable barrier of perceiving the computer created reality in atavistic and primary way, including observer's movement and time parameter in this process.

4. SPATIAL REPRESENTATION METHODS AND ARCHITECTURAL PROJECTS

4.1. The Guggenheim Museum in Bilbao – a design phenomenon

Advancement in spatial representation methodology allowed, or at least facilitated the architectural concepts previously considered as unattainable or unjustified economically. An example of that kind of structure can be the Guggenheim Museum in Bilbao by Frank Gehry, spectacular building erected in 1997. This building became an architectural and economic phenomenon, reviving the local economy immersed in crisis, basically through its sophisticated form [16]. This unusual event was later referred to as "the Bilbao effect", which was attempted to be reproduced by

many cities but with no such brilliant results. The project of the New York's museum branch refers subtly to the original of Frank Lloyd Wright being literally its variation. The harmonious and stable spiral from 1959 was transformed into the unpredictable series of shells and splinters forming a whole and giving an impression of constant change and movement. On that example we can notice a breakthrough between the architecture created with traditional representation methods and the architecture created with IT technologies. The branch in Bilbao was designed and implemented using digital three-dimensional technology, which allowed the use of complex non-Euclidean geometry in building practice.

4.2. The impact of IT technologies on design possibilities

Concepts with such a complex body as the Guggenheim Bilbao Museum could probably arise in the intention of architects also in times before the IT technology revolution – but developing design documentation and implementation of the investment in the form known today was a challenge that could only be coped with thanks to IT technologies. Without them, the investment would be one of many unfulfilled bold concepts, abandoned due to the economic situation. The project of Bilbao Museum was created with CATIA (Computer Aided Three-dimensional Interactive Application) used mainly in the aircraft and automobile industries. The technology enabled the fulfilment of the project through the data of 3D model, that allowed for fine design of a complex body and cost estimation. The architects from Frank O. Gehry and Associates (currently Gehry Partners, LLP) used the software which was not created for buildings purposely, but virtual models proved to be an answer to architectural design requirements. This technology made it possible to control the multi-threaded, complex building structure and to share information about it with other participants of the implementation process.

4.3. Space representation methods on the example of the Guggenheim Museum in Bilbao

The original concept was shown as hand-made author's drafts and surprisingly, they are relatively convergent with the final form of the object (Figure 1). In the movie "Sketches Of Frank Gehry" [17] Sidney Pollack illustrated the workshop of architect from a hand-made drawing, through forming and transforming models, to the processing of pre-deter-

mined bodies in the virtual reality of computer environment. The three-dimensional model was created on the basis of a physical model, through a laser tool storing information about points in space, then the data was processed by the computer to obtain information about individual surfaces in a virtual environment, where the model was refined and supplemented with further data. At the last stage, it enabled the building elements to be made by machines and robots using data from the complete model [18]. Each representation method used in designing process carries a baggage of experiences and conclusions, which shapes the creator's vision, while specifics of each method defines the represented space in a different way. Guggenheim Museum in Bilbao with a deconstructivism, quasi-accidental external body can be considered as a specific final of architectural achievements of the twentieth century which is represented with all available methods: hand-made drafts, technical drawings, models, 3D models, photographs and films (Figure 1, 2, 3, 4, 5).

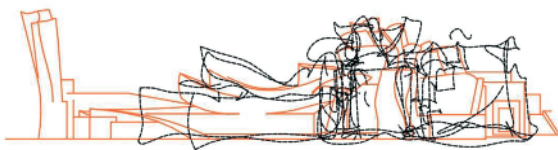


Figure 1. Diagram showing the comparison of a freehand drawing (dashed line) and the outline of a façade (solid line). Author's elaboration based on Drawing of the Guggenheim Museum in Bilbao by Frank Gehry (1991) and contour of the northern facade of the building



Figure 2. Model of Guggenheim Museum in Bilbao – photography from Public Collections of Arstor Digital Library within the Images for Academic Publishing (IAP)



Figure 3. View of 3D model of Guggenheim Museum in Bilbao shared based on the Licence of CC0 Creative Commons within the platform Pixabay.com



Figure 4. Photography of Guggenheim Museum in Bilbao shared based on the Licence of CC0 Creative Commons within the platform Pixabay.com



Figure 5. Frame from movie Guggenheim Museum Bilbao – “catch the light” by Carlos Silveira [19], shared under the License of Creative Commons

5. CONCLUSION

Bruno Zevi undertook the subject of space representation, which is extremely important for architecture, referring to both practice and theory. The methodology results from the nature of space itself and how we experience it, thus the nature of human cognition. Each of the available methods describes the space in a specific way, emphasizing its selected features. Through centuries, methods were sought for the most complete representation of space. This process has evolved along with technical and cultural development, manifesting itself in architecture and also many other fields, such as painting, mathematics, machine construction, photography, film or computer games. During this progress, distinct periods of rapid development can be observed, accompanying

important scientific and technological discoveries. From the moment Bruno Zevi described the then state of knowledge on this subject, the IT technology revolution took place, which significantly influenced the architectural industry by providing completely new, digital design tools. In a computer environment, it is possible to create virtual, three-dimensional spaces, which are not only simulations of reality but also constitute new, alternative spaces with their own development possibilities. Specialized software made it possible to build 3D models with complex geometry, where a part of operations, especially computational, was transferred from the designer to the machine. With the help of appropriate tools, virtual space can be explored on the basis of natural, human cognitive mechanisms, which has never been achieved before. New methods of space representation did not change the designers' ability to come up with architectural concepts, but they significantly expanded the possibilities of their presentation, to the extent software and hardware functionality allows. In this indirect way, digital tools influence architectural realizations, making it possible to design and build facilities such as the Guggenheim Museum in Bilbao.

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