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The Meta-Mechanics of Holography and How It Affects Architecture

Kourniatis Nicolaos[1, 2], Christidi Nikoletta[2], Fakiri Ioanna[2], Tsoumpri Dimitra[2], Tsoukalas Nikolaos[3], Karas Vaggelis[3]

[1]Department of Informatics and Telecommunications, National Kapodistrian University of Athens, Athens, Greece

[2]School of Architecture, National Technical University of Athens, Athens, Greece

[3]Department of Computer Systems Engineering, Piraeus University of Applied Sciences, Athens, Greece

Email address:

perspect.geo@gmail.com (K. Nicolaos)

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Abstract: In recent years there has been a gradually increasing interest in the terms on which the design and representation of the architectural object is based. This interest, as a product of the occurrence of digital technologies and the convergence of different scientific fields, is based on the specialization of design tools in such a way as to support and enhance the discussion around digital holography as an open process for action. Up until now, the dialogue on the form and representation of the architectural object has paid much greater attention to the creation of tangible models, which function as vehicles for the shaping and projection of visual messages that express and convey the designed object to the social whole. However, the true challenge lies in the development of a methodology or mechanism which, having as its starting point the traditional object representation practices, will allow for a combination of new technologies towards creating new visual messages. In this text, the process of putting together a new architectural object, the digital hologram, will be seen as one such mechanism. The new views and strategies on space are open to treating spatial constructions, as a restructuring of the structures that could bring about changes for more favorable conditions for the representation of the architectural form. Thus, the strategies of architectural pioneering are judged by their ability to develop new procedures that are capable of reversing. This is clearly a pragmatic approach to pioneering, which in the best cases manages to assign new meanings to traditional concepts with which architecture is associated, and to take different design and representation parameters into account in the process of creating an object.

Keywords: Digital Holography, Syntax, Architectural Object, Hologram, Quantum Geometry

1. Introduction

Holography -> Όλον (olon: Greek for "whole") + γραφή (graph: Greek for "writing")-> Recording of all the information on the object.

Holography is the process of recording optical information deriving from an object, when it is suitably illuminated by a monochromatic source of light (laser light). It is based on the phenomenon of the intersection of waves. A section of the laser beam illuminates the object (object beam), while another is directed towards the photosensitive film (reference beam). The light reflected by the object intersects on the surface of the film with the light of the reference beam, thus creating the interference fringes that contain the optical information. The hologram is the recording of this interference. The entire process is carried out in laboratories based on strict requirements concerning the stability of the system.

Conventional (analogue) holography produces a singular copy of a material object of our choice: on the one hand, this copy is a physical object as it consists of light, however it is not tangible, giving the impression of a hybrid balancing between material and digital reality. The next step is the production of a hologram starting from a digital object. The

object, having been designed on a computer, is projected on a screen which, in the layout of the holographic experiment, takes the place of the material object. The produced object is a hybrid of information and material whose starting point is not the material world, but the digital world. The object of holography (physical and immaterial), defined in this bidirectional way, throws doubt on the boundaries of reality as we know it, transforming the linear – up until now – relationship between the material and digital in a system of constant supply and recycling of matter and information.

Thus, the architectural object (digital hologram) ceases to constitute only information or only matter; it is both at the same time through a chreodic process that will be described in the framework of this research. The construction of the holographic medium, the chreod, is a high point in the journey towards researching a new architectural object. As opposed to the traditional methods of design of the architectural object, the mechanism in question aims at the production of an architectural object through a renewed view of the notional aspect between digital and physical space in the architectural scene.

2. The Research Framework

Before formulating the basic issue, it is necessary to present the broader framework within which the research is being conducted, as this is the base that feeds research interests, produces the general questions and guides the research methods.

The present paper is being written at a time when the centre of gravity of architectural activity is shifting from its perception as a form or (and) functional organization, which corresponds to a given architectural program, to its perception as a combination of elements, the main concern being to define their properties and relationships. In this framework, in 2005 Philippe Morel [1], in the introduction to a digital technologies workshop, confirmed this shift and argued that setting aside 'stylistic and decorative' eclecticisms, in today's age architectural composition is being shifted from a 'first-level realism' which involves 'the direct perception of data with the naked eye', to a 'second-level realism' which 'has no eyes in order to see the whole'.

Further on in the same text, Morel accuses the advocates of 'first- level realism' of extreme subjectivism given that, based on their stance on reality, they select the number of data that is to be collected, as well as the method for their collection and transmission, by constructing a reality and confirming – through this reality – its pre-existing interpretations. In this case, every architectural object is considered as a completely organized whole, which fulfills both a specific and strict function. The relationships between its parts are fixed and unvarying, measurable and compliant with a certain moral- aesthetic rule. The existence of a unique monitoring point acknowledges the existence of an interiority, which may control the different versions of reality through the functions of similarity and restriction. Any change, transformation, transmutation or destruction which does not emerge as a critical function is corrosive, as it differentiates the object from its initial, absolute state, which can be attributed to an architect-creator. Architecture is the image of the architect.

A "self-referential architecture" is placed in juxtaposition, which cannot be observed externally or be looked down on, and consciously accepts its inclusion among the sciences of the artificial, thus focusing on the study of its tools and practices. The second perception, according to John Wiley [2], corresponds to design requests in changing environments for the housing of constantly changing uses. In this direction, architecture loses its rationalistic approach, where design is assumed to be a closed, deterministic system and the decisions on form are taken a priori, eventually converting it into a field of forces, an opening body of relationships within which design processes are born. Making use of technology, these processes organize the constantly changing information within the dynamic fields, which contain the concepts of movement and time. The architectural work emerges as a catalyst for the consent of the forces that are in a potentially changing balance. Based on this particular view, the architect plays the role of the coordinator who, on the one hand observes the relationships between the forces and on the other hand evaluates the process of emergence step-by-step.

To John Wiley, this entire endeavor is something more than a search for a "style"; it is a deep change of paradigm, where the creative endeavor no longer lies in the personal gesture of the architect, but in the design methods that waver between accident and intention. The breakthrough for Wiley is the relationship of the architect himself with the dynamic field, where his every movement does not produce a designed object but contains a multiplicity of different results.

So at the dawn of our late-capitalist era, we bear witness to a change of paradigm that encourages a new relationship between design and object, which according to Michael Hays is none other than the passing from a "critical history" to a "theory" of architecture. Many researchers believe that this change in paradigm opens up the door for Architecture to completely redefine its theoretical and tool-related position. In the field of design, new concepts and tools are established, placing emphasis on change, modification and the ultimate logic. The exploration of this new relationship between design and object and the introduction of new design concepts and tools in an era in which 'the death of the monologic world of International Modernism has been pronounced', are the main elements that have given occasion to pursue this research proposal.

However, if one takes away the indisputable phantasmagoria of the objects emerging as results of the new design processes, and focuses on the manner in which the processes in question are articulated so as to yield a methodological tool for the formation and depiction of the architectural object, what shapes/conclusions can result from this negotiation of the object on new terms? Within this logic, through the acknowledgment of the "architectural object" as an internal element of the cross-functional synergy of concepts such as those of information, matter, structure and

the "explicit" shift of design from the creation of a "physical scene" to a practice for managing variable elements, the research focuses on ways in which these central concepts yield an architectural tool that focuses on the tool-related and performance logic of forming and depicting the architectural form. Our aim is, through such an exploration, to shift the management and depiction of the object from a juxtapositional, typological version of the structuring of elements and forms to a diagrammatic and relational typological approach.

3. Hybridity

When considering digital space, one cannot ignore the aspect where virtual space coexists or is associated with physical space. The digital always exists in relation to physical space; it is defined within it and therefore its relationship with it somehow affects its syntax. A typical example is that of augmented reality, which uses a combination of VR (Virtual Reality) and characteristics of physical space, superimposing graphic information on real space. Augmented reality helps the user to work on physical space, enriching it with additional information. Lev Manovich [3] talks of "augmented space", which is defined by successive levels of information on physical space. This category refers to many applications, all of which are related to the dissemination of digital information in physical space and to its management in the most direct manner by the typical feedback systems.

He claims that architects have the ability to see material

architecture in combination with the new immaterial architecture of the flow of information, as a unified whole. He concludes that the design of electronically augmented spaces can be approached as an architectural problem. "In other words, architects […] can take the next logical step to consider the 'invisible' space of electronic data flows as substance rather than just as void – something that needs a structure, a politics, and a poetics". In recent years, references to the coupling of the digital and physical are increasing as technological advances mark the transition from the immaterial to the material. "We observe that the digital dimension is involved directly with the 'physical' in a series of hybrid conditions". A few years ago, virtual reality was tantamount to an artificial reality. Today, when we talk about "virtual reality", emphasis is placed on "reality".

Within this logic, in digital holography the designed object ceases to be defined by three dimensions, but is activated and travels through light to infinity, constantly changing based on its parameters. It is a hybrid of the physical and digital world, having inherited the properties of its matter, of light, and those of particle and wave nature. The object does not constitute only information or only matter; it is both at the same time through a chreodic process. The placement of the holographic medium is a high point on this journey; a specific high point at a given time with given parameters. As the procedure is recycled, the object is activated, yielding a different result each time.

4. The Experiment

The transition from analogue to digital holography requires, in theory, a simple change of the holographic subject. The physical object is replaced in the experiment's holographic bank by the digital object, which can only have a physical presence in our reality as an output datum through a computer screen.

The experiment was conducted in the Holography Laboratory of the School of Architecture of the National Technical University of Athens. The process is the following: a single laser light beam is released through the movement of a shutter made of an aluminum sheet. Thereafter, it goes through the beam splitter where it is split into two separate beams, that which interacts with the holographic subject (object beam) and that which is directed towards the film (reference beam). The two beams meet again after successive reflections on the surface of the holographic film, where the waves converge.

In the case of analogue holography, this interaction occurs when the beam of light falls on the physical object and is reflected in such a way that it carries information on it. The reflected light contributes with the light of the beam that shines directly on the film, thus producing the hologram. In digital holography, the light beam goes through an LCD screen and contributes with the second beam, which carries information on the two-dimensional representation of the object on the screen, viewed from a specific angle [4]. In order to go from the two-dimensional representation of the object to the three- dimensional holographic object, it is necessary to record on successive thin strips (1 mm in width in our experiment) on the film, successive snapshots of the object from neighboring angles of observation, each one with its next angle. For this purpose, we have constructed – with the help of students Vangelis Karras and Nikos Tsoukalas from the Department of Computer Systems Engineering of the Piraeus University of Applied Sciences – a metal mask that covers the film, leaving uncovered only a single strip with a width of one millimeter in each position. The recording of snapshots is carried out using a photorealistic rendering program [5].

5. The Tools-Media

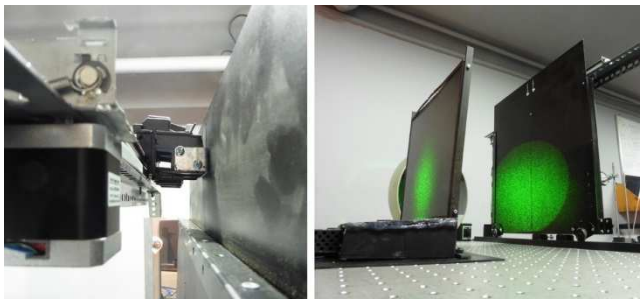

Figure 1. *Metal Mask and Moving Mechanism, Holography Lab, School of Architecture, N.T.U.A.*

The experiment is conducted with the help of the Arduino

micro controller, using Arduino and Processing open software. With the exception of the optical instruments and reflectors available in the holography laboratory, the remaining mechanical and electronic tools used in the experiment have been designed, constructed or modified by us. More specifically, the filters, lamps and diffuser have been removed from the LCD screen in order to achieve translucency [6]. The mask of the film, which is made of a metal sheet, is placed to close proximity to the metal film case. The mask remains still, while the film case moves with the help of a printer mechanism. This mechanism has been suitably modified in order to be connected to a motor that receives orders from the Arduino. The construction is supported by metal elements which, in order to offer the experiments greater flexibility, are screwed onto magnetic bases which can be transferred on the metal table in the laboratory. The shutter is made of aluminum and moves with the help of a motor connected to the Arduino, and it is programmed to automatically open and shut with the movement of the mask.

6. Experiment Process

The metal mask stays in place, in perfect alignment with the LCD screen and close to the film, in order to achieve stable lighting conditions of the slot throughout the process. At the beginning of the experiment, the film's case is in the X0 position, that is the left end of the film, leaving a one-millimetre-wide strip uncovered. At the t0 time point, the first snapshot of the holographic object is projected onto the screen through Processing. After a pause of a few seconds (t2), the computer gives an order (via Arduino) to the shutter to perform a 90-degree rotation, thus releasing the laser light beam. After a specific time period, which is determined by elements such as the intensity of the light on the surface of the film, the quality of the film, its age, etc. the shutter moves in the opposite direction, thus closing the opening of the laser (t3) and preventing the light beam from moving to the system. The system settles down for a few seconds, and at the t4 time point, the film case shifts to the right by 1 millimeter, to position X1, thus leaving the strip neighboring that in position X0 uncovered. This process is repeated in position X1 after a necessary pause. At time point t5, the second snapshot of the holographic object is projected onto the screen, having been imprinted from an angle of observation following that of the first snapshot. The process continues until all snapshots of the object are recorded on the holographic film. At the end of the process and after the necessary pause in order for the system to settle down and not affect the hologram, the case returns to position X0, ready for the next experiment.

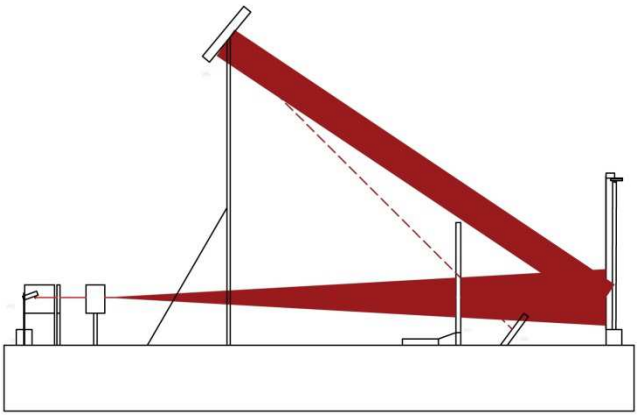

Figure 2. *System Set-Up upon the Metal Table, Front View.*

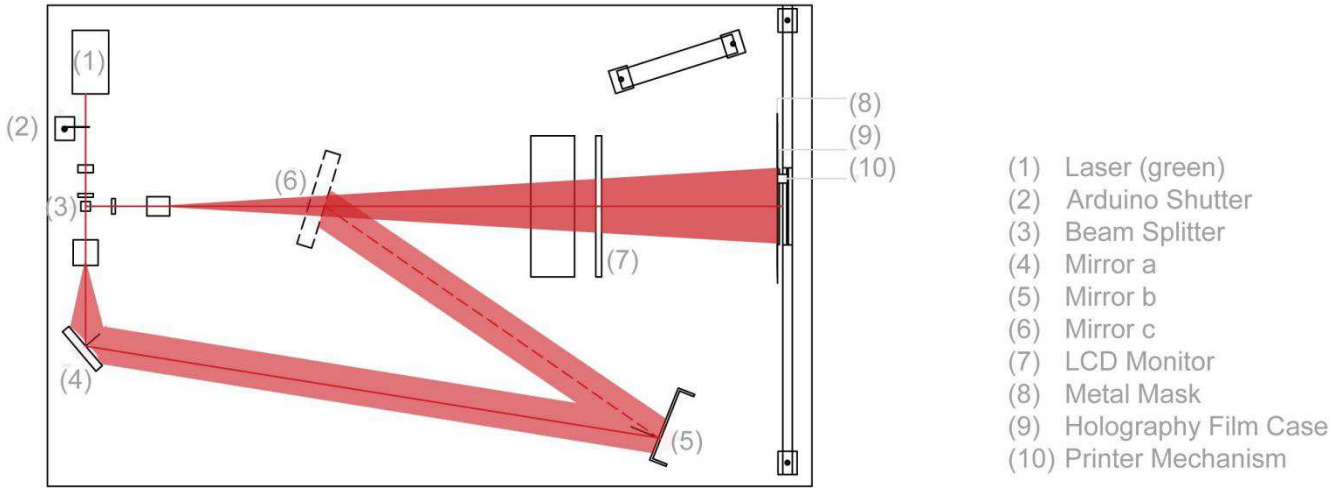

Figure 3. *System Set-Up upon the Metal Table, Ground View.*

7. Afterword

In The Structure of Scientific Revolutions, Thomas Kuhn placed science in a cultural framework, bringing about a paradigm shift, which provided a specific way of viewing the reality through which we examine both the role of science and of the scientific community, and the issue of scientific change. According to Kuhn, the successful theories that have gained general acceptance are established as the "paradigm" of scientific activity in a field. However, the appearance of "riddles" and the inability to solve them, combined with the logical consequence of the construction, inevitably lead the

members of society to the foundations of science and the paradigm itself begins to be questioned. This unpleasant yet unavoidable development, according to Kuhn, takes on uncontrollable dimensions within society if combined with the occurrence of a new society or a new competitive paradigm which promises a more solid and dynamic scientific base. In this case, the period of regular science is considered to have irreversibly come to an end, giving its place to an unusual science, which can be restored only through the prevalence of a new paradigm.

Similarly, the need for a change of paradigm, that is, the need for the formulation and establishment of a new theory that includes and explains all contemporary questions posed by science, is evident in the field of digital holography. The way we treat holography today and the applications we are in a position to juxtapose, indicate the (visible) boundaries we impose on its potential and on the advancement of the research field supporting it.

In summary, if today the cultural view changes in search of a new architectural object, then the design strategies will have to move from point interventions to construction techniques that manage change through evolving and developing platforms. The architectural object is now in a constant state of transformation, and therefore we must offer our knowledge, as well as our conceptual and technological tools, so that it may incorporate this change. In the shaping of a new architectural object, the production process should not constitute a scene on which the object is to be placed, but should constitute a dynamic field for studying the management of the object in question.

It is on this basis that we have in this text attempted the first conceptual and, primarily, practical approach to a mechanism that may monitor change and be supplied with data resulting from its analysis, aiming at their composition and the redefinition of the architectural object. This is a chreodic process and it could be argued that it functions as a filter that does not only receive information but also checks whether this information can be modified, while also producing connections and forms, which eventually give shape to the architectural form. The basic element of this mechanism is the production of an information substructure, which may gather information through distributed systems and networks, while always taking into account the temporariness, change, gradual evolution and adaptation of this information through time. As opposed to the traditional design methods of the architectural object, the mechanism in question aims at the production of a smarter architectural object, in the form of a digital hologram, through a renewed perception of the notional aspect between digital and physical space in the architectural scene.

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