Light and Shadows in Holography: A possible dialogue between Art and Science by using Artistic Holography

Rosa Maria Oliveira rosaoliv@ua.pt
Department of Communication and Art, University of Aveiro, Portugal
ID+ Research Institute of Design, Media and Culture www.idmais.org

Abstract

The use of new technologies in visual arts brings a new way of understanding shape relationships, a new form of perceiving and appreciating the configurations that present them to our perceptive organization.

Light has been seen as a plastic material since Moholy-Nagy created and presented his work of art "Light-Space-Modulator". When Dennis Gabor discovered Holography new approaches of the use of Light as an Art medium became possible.

The basic holographic interactivity inherent to this technology can be amplified and diversified by the presentation in installations that use a pre-established system of controlling the light, or reacting to the observer's presence and movements.

The holographic installation adds or emphasises other factors like time to the holographic images. The global work of art can only be perceived by an interactive relationship between the observer and the work.

Nowadays several artists use Artistic Holography as their preferential medium. This paper is a presentation of the research of the author in this field and also a tribute to these two men, an artist and a scientist that contributed to the development of a better dialogue between Art and Science in ways that were impossible before their works.

A Hologram is light; but is there light without shadows?

Key words: light and shadows; light and space; art and science; artistic holography.

1. Lazlo Moholy-Nagy

Almost every artist has heard about Lazlo Moholy-Nagy (1895-1946), as a professor of the Bauhaus. With the rise of Nazism he fled to the USA as did other professors of Bauhaus. In 1937 he was called to be a director of the New Bauhaus, in Chicago, later called School of Design and now the Institute of Design. He was a multi-faceted artist (painter, sculptor, photographer, editor, film maker experimentalist, designer, etc.). He was influenced by the Russian Constructivism and defended that the industry and technology should be integrated in the design and in the arts. For him, it was important to understand every material to know how to use all of its potentialities. In a lot of works he explored the black and white as well as the possible game of greys.

He was always very enthusiastic about employing new media when exploring new ideas of creative expression. He began his work with visual media during military service in World War I, creating hundreds of drawings. Afterwards he used the film and photography as his

preferred media. Many of his artworks are abstract photograms, made without the use of a camera. He created these abstract photograms by placing objects on light-sensitive paper and exposing them to light without the use of a camera (Fig. 1, 2, 3, 4). "The organization of light and shadow effects produces a new enrichment of visions." (László Moholy-Nagy).

Eliminating details of the objects he was seeking to explore the relationships of light, color, or tone and nonobjective form. Moholy-Nagy "painted" these pictures with light using the photogram technique without a camera. He transformed unidentifiable objects into abstract representations of light and form. The sharp or some times softly blurred edges of ovals, circles, and lines reverberate with luminosity, in a deep contrast to the black shadow of the field.

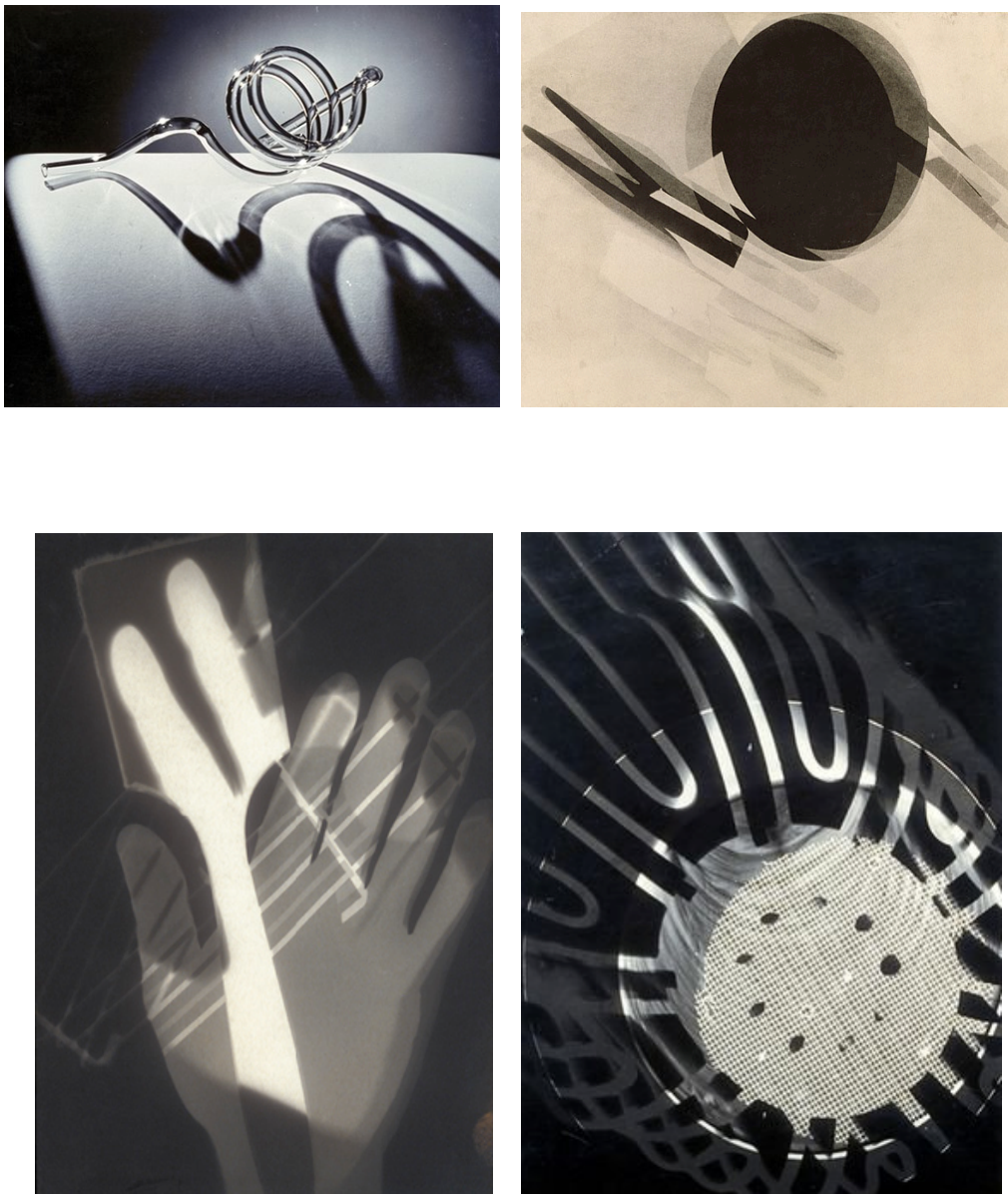

Fig.1, 2, 3, 4 - Photograms, by Lazlo Moholy-Nagy.

This experimental work leads to a more structured proposal: the light and shadow as an immaterial artistic medium. This proposal is conceived as a machine: the Light-Space-Modulator.

"The reality of our century is technology: the invention, construction and maintenance of machines. To be a user of machines is to be of the spirit of this century. Machines have replaced the transcendental spiritualism of past eras", Moholy-Nagy said.

In this context, his work Light-Space-Modulator (Licht-Raum-Modulator) (fig.5) is an important example. “This piece of lighting equipment is a device used for demonstrating both plays of light and manifestations of movement” (Moholy-Nagy: 1931). The piece was driven by electric motors, but for aesthetic purposes only, being one of the early forms of media art works. It is more than the bulbs and the rods that built it, because the shapes designed by the light and shadow and the movement are the real work of art. The experimental concept of the light as a material is really revolutionary for the time and a true inspiration for other artists, even nowadays.

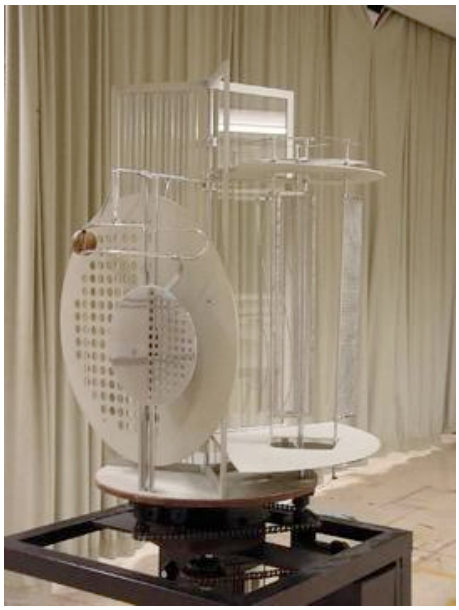

Fig. 5- Light-Space-Modulator, by Lazlo Moholy-Nagy, 1930.

He experimented mainly the light and shadow and its effects. He also painted in oil on polished and transparent surfaces in order to produce mobile lightning effects that are indicative of the interest on movement and the kinetic art that will appear later. A movie was made in order to record the resulting effects: all the possible aesthetic compositions.

2- Dennis Gabor

Dennis Gabór (1900-1979) (fig. 6) was born in Budapest and became a physicist and researcher. He entered the Budapest Technical University when he was 18 years old and later moved to Berlin, where he attended the Technical University of Berlin. There he studied with important scientists such as Max Planck or Albert Einstein. Gabor stayed in Germany until the rise of Hitler, and then fled to England where he developed the main part of his work.

In his research he tried to solve the problem of resolution of pictures in electron microscope,

theorized that it would be possible to take a picture containing the complete information of the light. He called it Hologram (total picture) from the Greek *holos* (all). He was the first to realize the awesome capabilities of the phenomenon of interference of light. In 1948 he published a paper entitled “Image Formation by Reconstructed Wavefronts” (Unterseher; 1982: 15-19). For this discovery he was awarded with several prizes, including the Nobel Prize in Physics in 1971. Gabor’s major problem was the inability to find the proper source of light until the discovery of laser in 1960 by Theodore Harold Maiman. The laser provides a coherent source of light that means light with just one wavelength. After this, several other scientists such as Emmet Leith, Juris Uptanieks and Steven Benton among others gave a great impulse to the development of holography. Also the artists were seduced by this technique and since the late ‘60s up to now holography has been a medium for the arts.

Fig. 6- Portrait of Dennis Gabor. Reflection Hologram.

3. What is a Hologram?

Many times the kinds of images referred to as holograms “are the result of matt-screening techniques often used in filmmaking. One technique often used is a double parabolic mirror, which makes a real object appear to be located elsewhere” (Unterseher; 1982: 14) for example floating in space.

In fact, a hologram does not speak or make any other interaction with the observer besides those inherent to the conditions of the technique at the moment of recording. But what is really a Hologram after all?

There are several types of holograms (Caufield; 2004). However, the type that is interesting for this work is the hologram of Image. It is a recording of an object, assemblage, scene or person, using a set-up of optical devices organized in a defined geometry on an optical table. The source used in holography is coherent light (laser light with just a wavelength). One part will light up the object and is called the object beam; the other will be the reference beam. Together, they will combine (interfere) making a wave front of light that is a microscopic interference pattern containing all the information of light at the moment of the recording. It lies on a plate or a sheet of film coated with a photographic emulsion of high resolution that is chemically developed. After that the information remains stored until the hologram is reconstructed by illuminating it with a source of light in the same angle of the reference beam

of the recording geometry.

Yuri Denisyuk, a Russian scientist, discovered another kind of hologram that keeps his name. Apparently it uses just one light beam for the hologram recording. However, in fact the optical principle is the same. This is the easiest hologram to make and it was the most used technique for recording valuable objects kept in some museums, mainly in the so called Soviet Union.

A hologram is light. In holography the shadows are the absence of light, but they can be used for making new shapes, different images of the world, different approaches to art, to poetics, to imagination. It can be the most mimetic recording technology and an immaterial support for artistic images. Like in most things in life and nature, light is just understood in comparison to shadow. The equilibrium between light and shadow resides in the presence of both.

Artists have accepted, even exploited, the peculiarities of the medium, using it as a material developing holography as a technique applied to art. Each artist has learned to make holograms in different ways. The practice is fundamental for each artist to find out his/her own expression through the medium.

In daylight a typical hologram looks like a simple piece of glass. To see what is in the hologram it must be illuminated in a correct angle. So it is possible to see the subject of the hologram behind the plate of glass or in some cases, floating in front of it. You see the subject when you look through the hologram's surface, as the hologram was like a window or a box containing an object. The object can be tin 2D or 3D and can be both multicolour or in just one colour.

4. Stereoscopic View – 3D View

Techniques have been developed that allow a 3D sensation from 2D recordings or representations, which were based upon the binocular parallax principles. In stereoscopy two photographic images are used, which correspond to the images of one scene that each eye would capture, i.e. with both viewing angular perspectives. The observer will have the 3D sensation of the original scene corresponding to an observer's steady position, when only the respective eye observes each photo. Points of view are fixed, the observer cannot move the head or look around, or the image will be lost (Unterseher; 1987: 319).

Photographs are spatially separated, as in stereoscopies, or spatially overlapped. In the last case, each eye will also have to differentiate them separately. At this point, each photograph should be assigned with a distinct colour, usually blue and red, or a sharp polarization. The eyes will require "glasses" with the respective coloured filters or analysers, to be able to spot the difference. In parallax stereography both photos are overlapped in narrow strips interwoven alternately, over which a network of strips successively bright and dark is laid, at a proper distance, so that one strip will be seen by one eye and the other eye will see the nearby strip.

Of all the known 3D representation systems, only holography provides a parallax identical to the original object, with no need to use any other auxiliary interpretation instrument, as in stereoscopy.

In a hologram, all the object information existing in amplitude and light phase is recorded. As a consequence, when we see the image reconstructed, it displays nearly all the object visual information, although the notion of solidity, value and colour intensity are to a certain extent ethereal or even unreal.

It might be said that the holographic image looks like a "light sculpture", free from tangibility, i.e. "blind" to the touch. However, the hologram (glass or film on which the holographic image is recorded) appeals to the tangible and motor sensations. This happens because only when we

hold it in our hands and move it forwards and backwards like a mirror, or look at it from various angles, do we see the holographic image and "discover something similar to a painting" (Popper; 1993: 37-38).

One of the most frequent confusions about holography is the idea that the primary visual property of the medium is producing "illusion" of 3D images – a sort of spatial photo, with an added dimension. Holography is not defined by 3D objects, but by "wave fronts" that may be generated by objects or non-objects (Kac; 1995: 1-7). Therefore, we see that new research perspectives are open to the holographers interested in exploring the optical, kinetic and immaterial particularities of this means of expression (Oliveira; 2001: 6).

Holographic installation is an artistic production mainly composed with the shining integration of holographic images in a given space, in such a way that they are not the only formal vehicles of the work sense and the observer can wander among them.

White light transmission holography is particularly convenient to use in installations practice, because the light points of the image shining transmission require the inclusion of the holograms in the middle of the exhibition space, or far away from the wall.

Holographic installation adds the time factor to this sort of shining and kinetic images, since the globality of their sensitive presence can only be perceived in an interactive relationship between the observer and the work. This basic holographic interactivity can be diversified and amplified by the ways of presentation that utilize a pre-established illumination control system, or reacting to the presence and movements of the observer (Poissant; 1995: 177).

Holograms need to be correctly illuminated, which is very difficult sometimes. However, although those requirements can be considered as restrictions, some artists have succeeded in transforming them into creative tools. In fact restricted view angle and disappearance of the holographic image according to the spectator position are used to create art installations in which the viewer active involvement is an essential part.

5. Light, pseudo-colour and immateriality: resources in artistic holography practices

Holography can provide new ways of comprehending the world. There are different types of lasers that can be used for artistic holography. Usually artists work with low-power continuing wave lasers (He-Ne or Ar). That implies a restriction to the use mainly rigid objects and inanimate sceneries because the exposure times necessary for their recording is relatively long and the hologram are not obtained if the subject moves even slightly. But it is also possible to use lasers that emit short and bright pulses of light, like the ruby laser, which allow to record living or moving subjects, like human portraits, falling water, etc. Such lasers make it easier to use spontaneous imagery and natural subject matter. However, this type of holograms are more difficult to obtain for two main reasons: first, because pulse lasers are very expensive and are available only in few labs; second, because it is necessary to record first a "master" hologram by a pulse laser, which freezes moving subjects during exposure. Then it is possible to record a second hologram a "transfer" hologram from the "master" that contains all the information recorded in the previous hologram. This is a two-step process that is very much time consumer.

Artists using holography as an art medium can record all the information contained in the light at the moment of recording the object or scene on a light sensitive emulsion which is coating a glass plate or film sheet (the hologram). That information is stored and remains invisible until the moment it is revealed by illuminating the hologram in the right angle by a source of light (white or with the same wavelength of the recording, depending on the type of hologram). In

the case of holography the materiality is reduced to the support (plate or film). And no other energy is as immaterial as light itself, which is the essence of the holographic image.

Artists explore concepts like real and virtual space, hyperspace, parallel realities and time reversal. The subtle levels of emotions' perception and sharing of those explorations are possible through holography. Some ideas, like the ambiguity of concave and convex, orthoscopic and pseudoscopic, are just possible to express in this technique. The relationship between the real and virtual spaces is also ambiguous.

Holographic immateriality is an inherent quality of this technique that allows artists to express some types of subjects impossible to obtain in the other media used in artworks. The real world and the fantastic imagery are possible to mix in ways that are very difficult to achieve in other media and to mix recorded images with real objects in the same conceptual artwork. As the recorded image is noting more than spaces and objects built by light, yet they seem to be substantial. Our perception is convinced by the illusion of the physical material.

The holographic space is also a quality that changes the traditional physicality and volume of the object. It is possible to overlap different holographic images in the same space (Garcia-Robles; 2006: 134-140) (fig. 7 and fig. 8). The orthoscopic space is no more the unique option in holography because the object can be recorded as if it were seen from outside as well as from inside. However, either in 3D or 2D holograms (Oliveira; 2009) (fig. 9 and fig. 10) colour is another resource for this technique. As it is pure light, the colour is the purest (Oliveira; 2000: 113-121). The mixture is made by additive colour model. The most common in holography is the use of pseudo-colour, although the true colour is also possible. Even when light is the material, the shadows are necessary to understand the shapes. Mostly in the series "Faces" it was necessary to use the drawing, a shadow, to help the perception of the faces. Without it, as the holograms are two dimensional, it was very difficult to perceive the portraits recorded.

Fig. 7 "Cocoon", Ana Maria Nicholson

Fig. 8 "Tigirl", Margaret Benyon

It is also possible to make non-figurative holograms where the object is light (fig.11 and fig. 12). The holograms may invoke the appearance of evanescent space, suggested through lines that recede or visual elements that proceed. The observer is invited to explore them dynamically, by discovering subtle chromatisms and space changes, as he moves before them. Sometimes

these holograms reveal new elements not seen at the beginning, which can be simultaneously experienced by various observers. These works confirm the idea that what is unique in holography is the fact that the image is at the same time present and absent (Oliveira; 2010), depending on the position of the observer. Being able to see the work, illuminated to the front or from behind, (in the case of transmission holograms) allows the observer to examine and consider all the angles of the image and finally make subtle levels of perception react.

The movement is an important quality inherent to holography. The parallax that exists like in reality helps to create the aesthetic concept of movement associated to the hologram and demands the interaction of the observer to see the entire subject recorded. Holography is dynamic, and requires an interaction to the image, moving around. In this process the dialogue between artist and the observers through the artwork is reinforced. It makes a kind of fusion between all the elements that are involved in the appreciation of an artwork.

Transmission holograms are a very interesting type of holograms though a bit difficult to exhibit. They are often used in artistic holograms not only by the possibility of achieving beautiful colours but also by the possibility of having transparent holograms illuminated from the back, allowing a different point of view of the hologram which can be part of an artistic installation.

Unless a true colour holography is wanted, the real colour of the recorded object does not matter. The important is its qualities of reflectance of the light. It is also usual to use transparent objects or materials to create abstract compositions in rainbow holograms whose artistic production syntax is mostly based on those effects.

Fig. 9- “Linda”, Series Faces,

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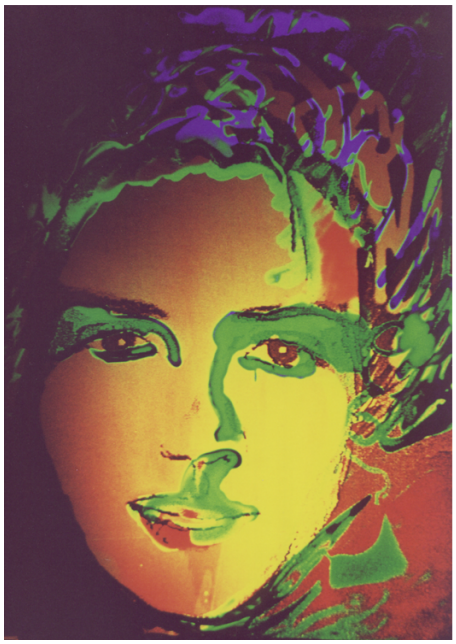

Fig.10- “Irina”, Series *Faces*,

Rosa Maria Oliveira

There is a specific type of hologram called “Holographic Optical Element” (HOE) which literally are only wave fronts created by lenses without any visible image being registered in the hologram. Some artists, mainly to achieve two aesthetic effects, have largely used HOEs: as a

texture to produce an enlarged variety of spectral colors and as element for visual and spatial composition of abstract holographic images (Garcia-Robles: 2006; 136-140).

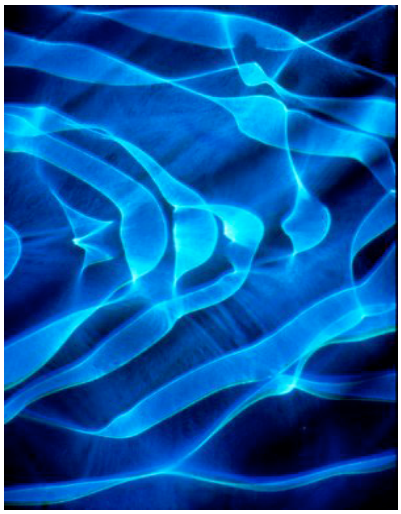

Fig 11- “Study in Light No. 6”, Rudie Berkhout

Fig. 12- “Trails”, Rudie Berkout

5. Artistic Holography in classes

Holography is a technology that needs a cooperation between the artist and the scientist.

Being such an interesting technology, holography needs some laboratory conditions that are not usually easy to have. These conditions are different for beginners or for advanced holography. In the first case, it is possible to make holograms with few resources; it is necessary to have a darkroom with two different parts: a dry place with a small kit composed by an optical table, some mirrors and lenses, two spatial filters, a beam splitter and a laser (it is not necessary to be a very powerful laser) where the recording is made; and a wet place with running water for the chemical development (Pombo; 2000: 231-1238) (Pombo; 2002: 109-114). For advanced artistic holography it is necessary to have a more complex laboratory and another type of equipment. The light sensitive material is bought from different sellers, for instance, Geola.

In the context of a class, there are some dangers to consider in a lab tat require all the teacher’s attention. The chemicals used in this technology and the equipment itself need to be handled with care by the students, who must be old and careful enough, not to get hurt.

Fig. 13, 14, 15- Aspects of the Lab for basic holography (recording and developing).

6. Conclusions

In conclusion, artistic holography is an example of the cooperation between art and science to produce artworks.

I would like to pay tribute to these two men, Moholy-Nagy and Gabor – the first an artist, who contributed to the advance of new artworks through the experimental concept of the light, time and space as artistic media is really revolutionary for the time and a true inspiration for other artists; the other, a scientist, who discovered Holography as a Physics phenomenon of interference of light.

But I also wish to pay tribute to all male and female artists and scientists who followed their leads to experiment and divulge the new art forms, bridging the gap between art and science, some working in cooperation, some working alone, but all of them applying concepts or technologies that help to build new paths for the knowledge.

The qualities of Holography are key features of the holographic image that were used by artists in a wide variety of forms. But there is still experimental work to be done, for example by using other holographic techniques that have not been explored by artists yet.

With this technique it is possible to work on the RGB system of colour. That is a common outcome when artists use sophisticated media such as holography. They contribute to discover new approaches and perspectives on the field. However the cooperation between the artist and the scientist is often required.

Restricted view angle and lighting special requirements have conducted artists who use holography to carry out their art production with an installation-oriented approach. These have not been the only motivations to resolve obstacles, but it is also important to realize that artists have many times turned difficulties into creativity.

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