Simulation beyond perspective. The discourse of holography as a tool for imagery, art, media studies and science

Pier Luigi Capucci

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A historical foreword

In 2010 the 50th anniversary of the L.A.S.E.R. invention was celebrated, while in 2011 is the 40th anniversary of the Nobel Prize awarded to Dennis Gabor, [1] the Hungarian scientist who invented holography. In 1947 Gabor was working in the microscopy realm, in order to make a light-made three-dimensional replica of a specimen that could substitute the original one, allowing the scientists to exchange it without any problems of degradation. Since the XIX Century the theories about the physics of light, and in particular on the interference of light waves, were achieved. However, unfortunately no light source able to generate a monochromatic and coherent light existed at that time, and Gabor, after repeatedly filtering the light of a mercury-vapour lamp, could only obtain a one millimetre square hologram. [2] Therefore, the holography-related studies and applications went into sleep for about 14 years, until the invention of the L.A.S.E.R. (Light Amplification by Stimulated Emission of Radiation).

The first functioning L.A.S.E.R. was operated in 1960 by Theodore H. Mainman in the USA. The L.A.S.E.R. can generate the highly monochromatic and coherent light for creating holograms, and in 1962 Emmett Leith and Juris Upatnieks at the Michigan University in the USA made a transmission laser-viewable hologram, while Yuri Nikolarcvitch Denisyuk in the USSR created a reflection hologram viewable in white light. From this moment onward, visual holography exits the labs, and with the improvement of the related techniques and of the photosensitive supports, it can be used in many fields: from displays to publicity, from publishing to theatre, from art to security, from portraits to museums...

Some early limitations in the original holographic process – for instance in the chromatic field, since the laser light has one colour and consequently generates monochromatic images – have been addressed. And since the early '80, scientists and researchers have been experimenting on the holographic cinema and TV, [3] which in a few years will likely lead the holographic images to enter into our mass visual panorama. However, maybe this diffusion process will not be so plain because the holograms' peculiarities hardly fit into the ground where the everyday pervasive flat imagery is based on, and they challenge the way we make, use and enjoy the images.

The peculiarities of visual holography

Holography should not be confused with the so-called 3D techniques which are commonly used in the movies, that are based on the stereoscopic recording and viewing processes: these techniques simulate the binocular vision and, unlike in the holographic process, they do not record and show the tridimensionality of the "real" space – which is a very complex issue – but only its depth. Moreover, holography should neither be confused with the pseudo-holographic applications that are called "holographic" because they involve 3D images, but indeed they are made with techniques

1 Dennis Gabor, "Holography, 1948-1971" (Paper presented at the Nobel Lecture, 1971), also in http://nobelprize.org/nobel_prizes/physics/laureates/1971/gabor-lecture.html?print=1 (accessed June 27, 2011).
2 Dennis Gabor, "Comment j'ai invénté l'olographie," *Science et vie* 671 (1973).
3 Victor Komar, "Holographic Movie System in the USSR," *Holosphere* vol. 15, n. 2 (1987): 9–11.

that are not holography-based. The holographic images are light-based but with relevant differences from the other light-based images.

A light wave is defined by two values: the amplitude (the information about the intensity) and the phase (the information about the periodicity). The images generated by the light's recording (photography, cinema, video) are commonly produced, reproduced and transmitted by the media using only the wave's amplitude (more precisely: the distribution of its square). In fact, since no material is able to record the phase in an absolute way, this information is lost, although it pertains the spatial dimension of an object.

By means of holography, according to the physical principle of the interference of two coherent waves, it is possible to record the phase relatively to a reference wave with known phase distribution, in a process which freezes in the space the wave reflected by an object, that encoded in a static interference pattern can be recorded on a photosensitive plate. The holographic process records the encounter between the object beam (which is reflected from the object and therefore contains the information about the object's surface and volume) and the reference beam (which only contains the information about itself). It is indeed a very delicate process, with a lightwave-size space tolerance. When activated, this encoding (the interference pattern) can restore a replica of the original wavefront reflected from the object, so moving our viewpoint in the wavefield, we can see again the object from different angles, with the sensation of its three-dimensional and concrete nature. [4] Holography activates a sensorial synergy between the sight and the touch, so that the real 3D holographic images, with total parallax, suggest the materiality of that space, of that object. The sense of touch, which is deceived, becomes the sense able to discern materiality from immateriality, physical reality from visual simulation (and this explains why holography is so interesting for the military realm).

Although it is possible to digitally generate holograms by means of computers, [5] holograms are basically analog referential images. In this picture I classified the images' realm in two families, based on how the images are made and not on what they represent. They are 'referential images' and 'non-referential images'. In the first category, the images can only be obtained in presence of the referent (from the Latin *res ferens*, which means "that carries the thing"), namely of what is represented. In this category the presence of the subject, object or phenomenon during the image making process is mandatory: without this 'being there', in front of the camera objective or the photosensitive plate, there is no image. Recalling Roland Barthes, in front of a photo we can never deny that the represented subject, object or phenomenon 'has been there', for some occurrence, in some time of its existence, in front of the photosensitive plate. [6] The image is generated by that presence (that 'being there') during the image making process, it is some sort of emanating made by the light action and the chemicals and/or the physics. On the other hand, in the 'non-referential' images that co-presence is simply neither mandatory nor relevant in the image process making.

Holography can create an accurate visual simulation, with total parallax: a replica of the real object, made of light which has the real object's visual properties but is immaterial, intangible. Holographic images are volumetric and can exist in a real and measurable space. While all the other imaging techniques that simulate reality are based on the Renaissance perspective, holography is not. The Renaissance perspective can represent the three-dimensional physical space onto a bi-dimensional one.

Starting at least from the Renaissance, the thrust for reproducing the way we perceive space has played a key role in western culture. Although the perspective was invented in the third decade of

4 Michael Wenyon, *Understanding Holography* (Vermont: David & Charles, 1978).

5 Slinger Chris, et al., "Computer-Generated Holography as a Generic Display Technology," *Computer* n.38, Issue 8 (2005): 46–53, also in http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1492266 (accessed 22 June 2011); David Pizzanelli, "Digital Holography," *The Royal Photographic Society Holography Group*), http://www.pizzanelli.co.uk/DIGITAL/digital.htmlml (accessed June 27, 2011).

6 Roland Barthes, *La chambre claire: note sur la photographie* (Paris: Cahiers du cinéma/Gallimard/Seuil, 1980).

the XV century – the work of Filippo Brunelleschi and the treatise *De pictura* by Leon Battista Alberti [7] – we are still immersed in (and influenced by) this way of representing and seeing the world. In fact, the perspective was inherited by photography, cinema, video, computer photorealistic images, virtual reality, 3D videogames, the metaverses: we live in a perspective-based culture.

However, although the perspective is presented as an "objective" visualization technique, its objectivity is theoretically and technically based on the "point of view", that is on the most subjective and personal element. Moreover, moving away from that viewpoint decided by the image-maker means loosing information. Hence, we could affirm that the images performed by most of modern and contemporary visual communication media are suited to a static and spatially privileged viewing position and to a substantially passive attitude of the viewer.

Holography gives more freedom to the observer: in front of a hologram we can choose the viewpoint and our spatial position, we can successfully change our own visual perspective, like in front of a real, material, object and scene. Unlike the perspective-based images, moving in front of a hologram we acquire, instead of loosing, information, and this activity on the viewer's side can never be eliminated.

Holography and the mediascape

Holography stands apart from the media realm, it represents an exception, that in part explains the difficulties of this technique to emerge and integrate into the mediascape, where all the other visual media simulate through the perspective using the same, although simplified, rules of the Renaissance perspective.

The media can produce, reproduce and transmit bi-dimensional images on flat supports. While in the holograms the shape of the image and the shape of the support are different (in most holograms bi-dimensional supports display three-dimensional images), the usual images are morphostructurally dependent on the support: they have the same shape of the support. This allows an easy convertibility and circulation of the images among different media platforms. For instance, an analog photographic image can be digitized and transferred to a computer screen, to a movie and a TV program, it can be printed on paper on posters and journals, without any fundamental loss. Conversely, taking a photo of a hologram means flattening it, and so eliminating its peculiarity.

Presently holograms cannot be translated into the language of the other media unless erasing their uniqueness, they can only be displayed through their direct exposition, they cannot be remediated. [8] The current media system has a high coherence and the images that it performs share similar morphostructural rules, so they can be easily transferred from one medium to another without any fundamental loss of information: bi-dimensionality and image-support coincidence appear to be at the basis of this high level of compatibility, coherence and convertibility.

The mismatches between the holograms and the current mediascape are also evident in the fields of cinema and television. Since the early '80s there have been experiments in projecting holographic dynamic images and transmitting them in remote. Common cinema and television images are based on the perspective and the spectator should be watching them from a precise viewpoint or area, which is ideally situated on the perpendicular axe of the image at a distance from the screen which is a function of the image area (indeed we spontaneously choose this position in a cinema hall). The filmmaker chooses the perspective of the scene: we see the scene through his/her eyes, from the viewpoint he/she wants us to watch it from. He/she decides the frame from his/her personal point of view, which he/she proposes and then the cinema and TV language imposes it on the viewer.

7 Leon Battista Alberti, *De pictura* (1435-36). Here the text in Vulgar and Latin: http://www.liberliber.it/biblioteca/a/alberti/de_pictura/html/index.htm (accessed June 27, 2011).

8 Jay David Bolter, and Richard Grusin, *Remediation: Understanding New Media* (Cambridge: MIT Press, 1999).

As far as we know of the future holographic cinema and television, the classical figures of filmmaker and spectator could undergo a great transformation. The spectator could look at the image moving around it as if it were a sculpture, or he/she could be able to move his/her head to observe a background partially hidden by a close-up face, or an actor's profile: a totally different spectator from the passive one of the usual bi-dimensional narration. And the filmmaker, whose narrative art's centrality would break up, could employ new exciting expressive opportunities to offer the spectator more topics, viewpoints and information to enjoy. The few spectators of the first 47-second monochromatic holographic movie, made in 1976 by the Russian scientist Victor Komar, tell that they could see a young woman holding a bouquet of flowers. At a certain point, she went out of the cylindrical screen and moved around in their space, and they could move around her and see her from different viewpoints. [9] Like in the Elizabethan Theatre, the holographic cinema halls will not require the chairs for a frontal passive view, because the people will be able to choose the perspective they are interested in.

With the holographic cinema and television there are no more three dimensions (two spatial and one temporal) but four (three spatial and one temporal). Time is the physics quantity that is responsible for the image motion and metamorphosis. In the common visual media, this transformation takes place on a bi-dimensional space, the support of the image. This means that the human visual system is allowed an easy focalization which remains roughly steady in time, only needing simple and small adjustments (in my opinion one of the reasons in the failure of the 3D cinema in the second half of the Fifties depends on having disregarded these requirements, and in fact today's 3D movies are not so invasive on the space of the viewer). Therefore, for the visual system it is very comfortable following quick camera movements, flashing running shots, and rapid cuttings. Moreover, because of their inner structure, the camera optics can resolve only some parts of the image, hence acting as information limiters, and furthermore the filmmakers can use them as a system for focusing the viewer's attention. In fact, resolving only some parts of the image implicitly means suggesting to the visual system to discharge the unresolved information, limiting the amount of the information to be taken into account. For these and other reasons, commercial spots, music video clips and action films can reach the human physiological limit in the perception of rapid image changes. The universe of the moving flat images that we are usually staring at onto our flat screens is a metamorphic calembour in constant, discontinuous and rapid change.

Conversely, a look at the real world through a window involves a process which is much more complex. Like in a hologram, there are no unresolved parts of that panorama, and since it does not lie on a flat screen, our visual system must focus many parts of it at different distances in order to comprehend the image. Although the fast visual system adaptability, this adjustment activity requires time, and it should be noted that this example does not involve any dynamic situations, which would have greatly complicated the process. If we only consider these arguments, we can say that the fast rhythm of the bi-dimensional movies if applied to the holographic cinema and television would simply be too aggressive for the human visual system. The future holographic dynamic images will certainly be performed, but not according to the languages of the current communication forms.

Therefore, both in the static and in the dynamic fields there are many basic incompatibilities between holography and the current media platforms. These mismatches are not only technical and technological, but pertain the way we produce, use and enjoy the mediated communication: they involve the global mediascape consistency. It follows that holograms require new displays, new visual media, and new genres of communication, even if they hybridize with the existing media.

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9 Victor Komar, "Progress on the Holographic Movie Process in the USSR," *SPIE* Vol. 120 (1977): 127–44; Victor Komar, "Works on the Holographic Cinematography in the USSR," *SPIE* Vol. 1183 (1990): 170–82; Komar's first holographic colour film (5 minutes) was produced in 1984; P.-A. Blanche, et al., "Holographic Three-Dimensional Telepresence Using Large-Area Photorefractive Polymer," *Nature* 468 (2010): 80–83, also at http://www.nature.com/nature/journal/v468/n7320/pdf/nature09521.pdf (accessed June 27, 2011).

Holography suggests a new visual universe within a culture where the visual simulation is the most effective communication system; and it let us reflect about the need for a more comprehensive definition of “image”. We can believe that future images will also be holographic and that we shall communicate more and more through them, in a delicate balance between presence and absence, immediacy and remoteness, present and past, materiality and immateriality, matter and energy. However, the volumetric images require designing the right applications. Holograms have only been around for fifty years and they are so promising. Art, science and imagination are welcome!