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Volumetric Imaging as Technology to Control Space

Jens Schröter
University of Siegen (Germany)
E-mail: schroeter@medienwissenschaft.uni-siegen.de

Abstract. Volumetric imaging is a relatively new technology for three-dimensional representation. In this article its political implications are sketched out. Especially important is that volumetric imaging can display spatial relations in an easily understandable way, thus it is a technology to control space. Its birth in the course of research on radar visualization points to this – and also its rare artistic usages, in which its implications are already critically discussed.

1.

Talking about 'defence' means talking about space. Any kind of defence – self-defence, military defence of a so-called nation or people – presupposes drawing a distinction, constructing a border which separates you from the subsequently defined, hostile Other.[1] One may try, perhaps, to make this barrier as impenetrable as possible to prevent every movement across the line. But in reality this strategy might fail. The moment the border is crossed by the Other the necessity of defence arises – for example, the necessity to destroy the invader with weapons or with pharmaceuticals.

This holds true even for the seemingly immaterial realm of cyber*space* – as it is revealingly named – in which you have to erect 'firewalls' that defend your digital *domain* against the hacking invader. Although this usage of the term 'space' is somewhat metaphorical, I think it is plausible to state a fundamental connection between defence and space.

[1] Other with a big 'O' in the sense of Lacan…

2.

Successful defence of one's proper realm is based on an efficient control of space. To control space means – of course – to *know* that space. You need information about where the Other is, how fast he can move through the territory, how fast you can move, whether there are for example natural phenomena such as storms which complicate the situation and so on. You need representations which give you information about the terrain. Traditionally – think of Lessing's *Laocoön* (Lessing 1962) – the type of media associated with space are *images*. There is – of course – *the map* as a kind of image/text-hybrid which had an enormous role in the history of space representation – indeed Farinelli spoke of the 'cartographical reason' of modernity (Farinelli 1996)[2].

It suffices to say that with the increasing scale and speed of wars in modernity the static map alone wasn't satisfactory any longer. Rapid information retrieval became vital. As already noted by Lev Manovich, radar was invented during the Second World War to retrieve *real time* information about the structure of spaces in which the enemy presumably moves: "Detected objects appear as bright spots on the display watched by [a] radar operator. […] All it sees and all it shows are the positions of objects, 3-D coordinates of points in space, points which correspond to submarines, aircrafts, birds, or missiles." (Manovich). The radar screen shows 3D-coordinates of points in space – but it often shows them using a two-dimensional screen. This became problematic under specific circumstances, insofar as the spatial structure of the observed territory would be much easier to understand and therefore to control by human operators if the spatial relations could be grasped intuitively. Some of the early developments in spatial imagery, therefore, took place in relation to radar. I will come back to this topic.

3.

Let me first outline the problem in more general terms. When dealing with two dimensions, images are obviously – as mentioned above – the preferred medium for representing spatial relations. But the representation of the third dimension on the picture plane can only be accomplished by techniques of *projection* of which the most important is of course *perspective*, invented in Renaissance painting. Since the 19th century, perspective can be automatically rendered by a lens or systems of lenses (as in photography, cinema, video, and even in

[2] I do not address this topic here.

photorealistic computer graphics, where one can find 'virtual cameras' with virtual lenses[3]). The perspectival system of representation reigned for centuries and continues until today. But in modernity – the decomposition of perspectival representation in modernist painting set aside – perspective clashes more and more with the needs of modern warfare, modern science and modern medicine. The problem is simply that perspective, although it may not be a conventional, but a mathematically based and to that extent objective system of projection, is not *isomorphic*. That means: you cannot reconstruct the spatial layout of a three-dimensional scene from a two-dimensional perspectival representation of that scene in every case. Many other configurations of objects would fit the same pattern on the image-plane. It is not difficult to imagine that perspective's non-isomorphism is a big problem for e.g. aerial reconnaissance, the analysis of bubble chamber volumes in particle physics, the visualization of weather phenomena, the correct mapping of the interior of the body in medicine and so forth (Manovich 1996).

For that reason, it is hardly surprising that different types of post- or trans-perspectival images were developed in modernity. These *trans-plane images* were [and are] giving increasingly precise spatial information. One example is – of course – stereoscopy. It was originally invented in 1838 by Charles Wheatstone to prove his arguments about the binocularity of vision and then became, roughly until the 1890s, a popular entertainment medium. As Jonathan Crary argues in his influential study *Techniques of the Observer*, stereoscopy disrupts the perspective paradigm by functionalizing the binocularity of the observer, even if the single images are still perspectival. His argument on why stereoscopy disappeared at the end of the 19th century rests exactly on that point. He argues that stereoscopy destabilizes the – so-called – 'paradigm of the *camera obscura*,' which he sometimes seems to identify with the perspectival order, whilst on other occasions he clearly differentiates both fields (Crary 1990).[4] This destabilization was – Crary argues – somewhat too obvious; therefore stereoscopy was superseded by photography which reconstituted the monocular, disembodied, perspectival gaze (Crary 1990, 132/133).

This argumentation is problematic in several respects.[5] My main point of critique is that stereoscopy simply *did not disappear* at the beginning of the 20th century. Even if it vanished as a popular entertainment medium and left that field

[3] On the historical roots of perspective see Damisch 1995. On the continuation of perspective in photographic media see Snyder 1980. On the continuation of photographic form in hegemonic computer graphics see Schröter 2003.

[4] See p. 118 for an identification of the '*camera obscura*'–paradigm with perspective and p. 34 for a differentiation of both fields.

[5] For a profound critique of Crary's account see Phillips 1993.

to cinema, the post card, Kodak-self-made-photography and so on, it continued to operate, and even gained importance, in aerial reconnaissance, especially in the First World War. It is downright impossible to discriminate between a valley and a mountain range or low and high buildings on a photo made from a very high altitude – unless you use stereoscopy (Judge 1926, Ch. XVIII).

It was and is also utilized, for example, in photogrammetry or in the analysis of bubble chamber volumes in particle physics (for the last example, see Bassi et al. 1957; Galison 1997, 378–379). Stereoscopy was (and sometimes is) used in these discursive practices to provide the necessary spatial information. Considering this, the all-too-popular conviction that modernity witnesses an 'annihilation of space,' as (among others) Virilio teaches us, has to be differentiated. Of course telecommunications shrank the world, or better: the richer countries, into the global village (McLuhan 1964).[6] But in other, especially pictorial contexts, space did not shrink – it literally expanded.

4.

Stereoscopy (here including so-called integral photography or lenticular imagery) is not the only type of trans-plane imagery. There are – I think – two further basic types[7]: the second type is *holography*, basically developed around 1948. The only lenseless form of image technology in the strict sense, holography is based on an ontology of light as wave (that is: on wave optics) and as such again underscores the break with the perspectival regime of light-as-rays in modernity.[8]

The third type, with which I am concerned here, is the *volumetric display* (into which I include so called varifocal mirror techniques). Volumetric displays were developed in the 20th century – intimately connected with the topic of defence. Only three years after the Second World War P.R. Wallis and E. Parker published a paper on *Three-Dimensional Cathode Ray Tube Displays* whose aim is to optimize the already mentioned display of radar signals: "The three-dimensional displays are used to display the positions of the reflected 'signals' with respect to the three coordinates of the volume, in order that the radar can be used as an

[6] For a critique of the rhetoric of a 'shrinking world' see Kirsch 1995.

[7] It is important to understand that these three basic types work by fundamentally different principles. Stereoscopy exploits the binocularity of vision, while volumetric display uses the so-called persistence of vision and is not at all stereoscopic. Holography is completely different from both. While stereoscopy and volumetric display could be said to adhere to the principles of physiological optics in the wider sense, holography belongs to the regime of wave optics – and in no way presupposes knowledge of the human body.

[8] On the rise of wave optics see Buchwald 1989. For a concise history of holography see Johnston 2006. For detailed discussions on several aspects of holography see Rieger and Schröter 2009.

object-detecting and -locating system in three dimensions. […] The physiological and psychological problems of the human operator peculiar to three-dimensional displays are discussed […].” (Parker and Wallis 1948, 371). They describe different 3D-displays which may be useful in optimizing the performance of the human operator and hence the control over space. Parker and Wallis analyze stereoscopic displays as well, but this “pseudo-3D” (as they call it), has some limitations. Therefore, they propose first steps towards what they name “truly three dimensional displays”: the first volumetric displays “in which the echoes appear as bright spots in an actual volume of light.” (Parker and Wallis 1948, 372.). This is the central point: *Volumetric displays represent the image not on a plane, but in a volume*.

In their very early paper Parker and Wallis suggest different types of display for different “aerial scanning patterns” – that is, different ways for the radar system to scan the territory in which the enemy is suspected. The aim is to represent the radar-scanning of space in the most direct way. In Fig. 1 one can see a so called ‘spiral’ scan pattern. That means, it shows how the radar beam moves through the volume of space, the third dimension is – so to say – into the page. Fig. 2 (both figures are from Parker and Wallis 1948; Reprinted with permission from the IEE) shows the rather primitive apparatus, which is used to produce a seemingly three-dimensional image representing the scan movements. At that time, only analogue computation was available to Parker and Wallis (although digital computers already existed) and so their goal was to map the radar scan directly into the image volume. The Cathode Ray Tubes paint the elevation and the bearing scans on the rotating mirror, where they fuse and represent the radar volume.

Before turning to more advanced volumetric displays, I would like to draw attention to a weird coincidence. See Fig. 3 (from: Krauss 1993, 102 and slightly rotated), which is one of Marcel Duchamp’s *Rotoreliefs* from 1935 (this one is called *Corolle*, © Succession Marcel Duchamp / ADAGP Paris 2010). Compare it to Fig. 1, the spiral scan pattern from the early paper from Parker and Wallis. In *The Optical Unconscious,* Rosalind Krauss writes on these discs by dada- and proto-conceptualist-artist Duchamp: “Mounted on a record player’s turntable, the disks revolved soundlessly, the product of their turning a series of optical illusions, the most gripping of which was that rotation transformed their two-dimensionality into an illusory volumetric fullness […].“ (Krauss 1993, 99). Perhaps this is only a superficial coincidence – yet Duchamp was interested in mathematics, and the spiral radar scan and his rotorelief are quite obviously so-called Lissajous figures … (Dalrymple Henderson 1983, 117–163). But more importantly: the similarity may be a symptom for a kind of – via Krauss – *optical unconscious* generated by or connected with the need to control space in modernity. I think that there is a similar knowledge implied in both the volumetric radar display and the volumetric art of Duchamp, namely knowledge about the perceptual production of an image-volume by rotation. It is – this time in accordance with Jonathan Crary – knowledge about specific attributes of human vision. And indeed Duchamp was very interested in the psycho-physiological foundations of vision and in trans-planar images, as his experiments with stereoscopy show (see Krauss 1993, 131). And of course military research in the effectiveness of radar operators presupposes that knowledge, too. This is obvious in the development of volumetric display technology.

In the years after 1948, many different volumetric display technologies were conceived. Some of them are still difficult to realize even now, but some of them became really important. It is not necessary here to discuss their various archaeologies and effects, especially the basic distinction between solid state- and moving parts-types of display (Blundell and Schwarz 2000). I will concentrate on the currently established forms which belong to the moving parts category. In this type of volumetric display the image, or to be precise, the image-volume is based on the rotational movement of a planar or helical mirror screen. In a sense the old *paragone* of painting and sculpture is resolved in an image-volume, which is produced on a flat screen itself moving in space. An optical or laser beam system synchronized with the movement of the screen writes the image in points or lines or parts (dependent on the design) onto the spinning screen. Quite obviously, the knowledge on persistence of vision discovered in the 19^{th} century does not only lead to the movement- or time-images of cinema (as Deleuze named them), but also to the volumetric type of trans-planar space images.[9]

The two most important advantages of volumetric displays are *first*, that the representation of the spatial object is itself spatial and insofar intuitively understandable, and *second*, that the representation is better suited to collective reception and consequently to teamwork. Until now, one central disadvantage is the transparency of the images, which eliminates one important clue for the reception of space – *occlusion* (although there is at the moment a lot of research in 'opacity descriptors', which admittedly can only be realized in static volumetric displays). But the advantages seem to prevail – it is therefore not surprising that the military is already working with such display technologies.

[9] On the role of the research into the so called 'persistence of vision' for the emergence of optical techniques and lastly cinema, see Crary 1990, 104-112.

Interesting in this context is a paper on a volumetric imaging in the context of a book on health care (Soltan et al. 1995). In this paper, a relatively advanced helical volumetric display-technology (Fig. 4, from Soltan et al. 1995, 352. Reprinted with permission from IOS Press) is discussed. Especially interesting is that part of the paper in which potential usages of the display – to be precise: of a future volumetric display – are sketched out. One example: a representation of the potentials of volumetric display technology includes a woman (Fig. 5, from Soltan et al. 1995, 357. Reprinted with permission from IOS Press), but there you have – not surprisingly – the idea of bodily control, of the transparency of the body. Here defence does not lie so much in the localization of the outer enemy, but in the control of the female body which is rendered transparent to be functional – to allow an optimized birth.

5.

There surely is an – if you like – *Defence-Unconscious* in volumetric display technology. See for example the actual advertisements for the *Perspecta 3D-Display*, which is currently one of the best volumetric displays commercially available. It renders the image volume in 768 x 768 x 198 Voxels, which is the spatial equivalent of the pixel, in 8 colors at a refresh rate of 24 kHz onto a disc rotating with 730 rpm (Fig. 6, found some time ago on the Internet, shows some older representations of the display, chosen for their symptomatic character; the recent types and their developer is to be found here: http://actuality-medical.com/Home.html).

The advertisement is highly symptomatic. In one case the volumetric display is used to present the flight of an airplane over a landscape; and in the other it presents a three-dimensional representation of – *HIV*. In the first case it might be the defence of the territory against an airplane; in the second the topic is the defence of bodily integrity against the deadly virus. Again we find the territory and the body as the central sites of defence, which have to be mapped and analyzed.

This is another reason why I argue that space became an important problem in modernity (whilst disappearing in other fields). Moreover, in modern warfare space is not any longer an always already fixed territory on which troops meet and fight – space itself has to be controlled preventively. Modern medicine – as part of what Foucault called the regime of biopolitics – has not only to observe the symptoms showing up on the surface, but has to map the body in more and more detailed depth to control, optimize and mobilize the worldly flesh (cf. the work of Michel

Foucault). These two types of defence – against the internal and external enemies – result, among other things, in the development of three-dimensional trans-planar images; or at least in certain applications of those image-types.

It is not surprising that one can also find traces of that *space control* in twentieth-century art. I already mentioned the weird visual analogies between one of Duchamp's *Rotoreliefs* and one specific radar scan pattern. Duchamp situates the disturbing Other in the corporeality of the observer, until then always excluded in art-historical narratives, and so points to the relation between art and the discursive practices which strive to control the body outside of the art-historical domain.

A seemingly similar strategy can be found in a different aesthetic field much later – in Jenny Holzer's installation *Sex Murder* (1994). In one specific realization of her installation, she uses volumetric display technology in a highly revealing context. She also suggests the uncanny connection between the two central topics of defence – control over the territory and control of bodily integrity – and space. First, the work is itself an installation taking up space. It maps out a territory which symbolizes in very different ways and in very different materials (bones, tables, photography and Holzer's famous neon writings) the Bosnian war zone – and thematizes very decidedly the violating assault on female bodies.

The volumetric display used here resembles a kind of shrine in which texts circulate: Holzer presupposes the work of Duchamp – but for her it is no longer a problem that the 'observer' can be tricked by rotation. She simply admits that there is a military-industrial-entertainment-complex which can produce – to cite Deleuze – 'any-space-whatever.' The point is that those techniques are nowadays – years after Duchamp – no longer disruptive in an enclosed realm of art, but within the standards of culture industry. She tries, as her work with neon writings show, to appropriate commercial media technologies for a political agenda. And this is the point of her installation: even before volumetric display will enter the household she already shows that it can (or should?) be used otherwise – or at least that volumetric display was not at all a development for entertainment purposes. She shows the *3D/efence-unconscious* in volumetric display technology – by using texts, which describe in a poetic and condensed way the horrors of a breakdown of defence and of the moment when the Other – in rape literally – intrudes into the private realm. We read: "She asks me to sleep in the house but I will not with her body and it's noises and wetness/She is narrow and flat in the blue sack and I stand when they lift her" (Holzer 1996, 49). That is: she is first in the *house* and then she is *flat* – this spatial metaphor might be a further hint. The act of becoming-flat is marked as decidedly violent – that might also be a commentary on the violence of perspectival projection, which renders all three-dimensionalities on a plane and so reduces their spatiality. Perspective produces a *dominated world*, as Merleau-Ponty once said... Jenny Holzer shows in one move the violence of projection and the even increasing violence when the territory can be mapped by post-projective image technologies. We are left with the question: what should we do with new imaging technologies – and their potentials to control space?

6.

I was only able to adumbrate that there seems to be an intricate network connecting military and biopolitical defence, strategies for controlling space and the development and application of trans-planar imagery. This network implies special – and spatial – forms of knowledge which circulate through different fields and can also be found in art. There is a lot of research left to be done until this discursive network can be itself mapped out in more detail (see Schröter 2009).

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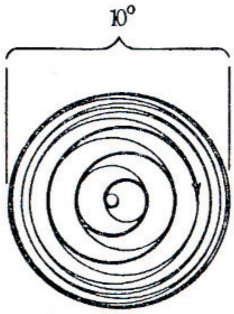


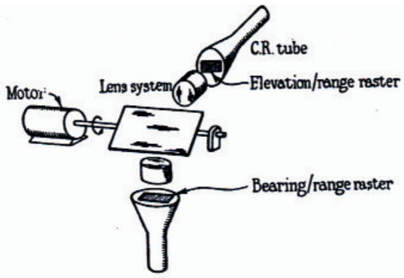
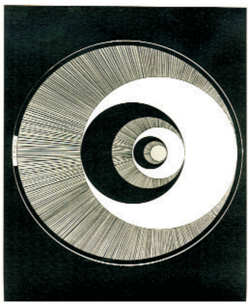


Fig. 3.—Truly three-dimensional displays. The "moving screen" display.

Figures 3–4.



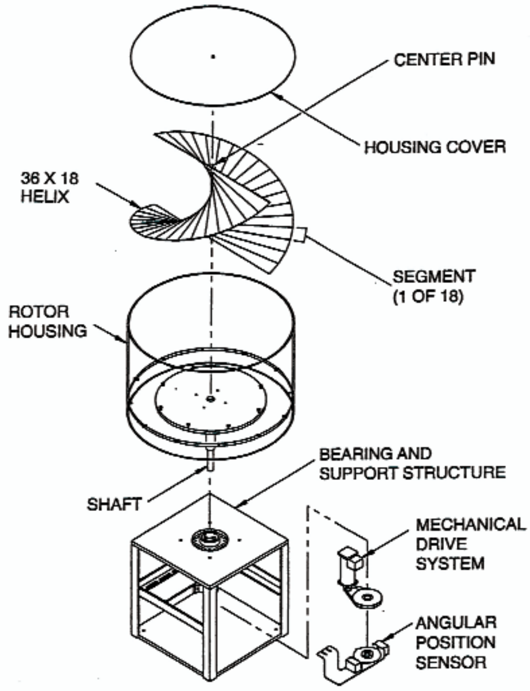
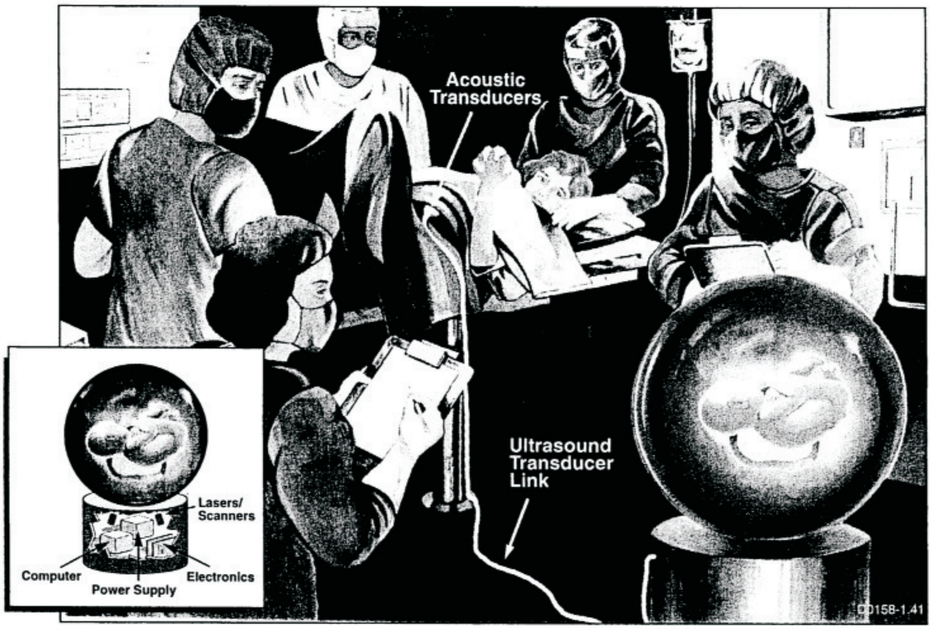


Figure 2. Major components of Helical Display.

Figure 5.



Concept by NRaD
January 1994
P. Soltan

Figure 12. Laser-based 3-D Volumetric Medical display.

Figure 6.

This simulation of a plane flying over hills shows how 3-D problems involving a changing environment can be modeled.

This representation of HIV allows researchers to study its structure from all angles and to "test-fit" protein molecules.