

## Session / Séance 09-B

### “Real” 3D Technologies for Relief Depiction

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#### Abstract

*When reading so-called user-oriented maps the major target is the generation of an adequate mental model of the three dimensional real world. In particular, the representation of our three-dimensional environment is one of the most challenging tasks of cartography. Hitherto, the “loss” of the third dimension during the depiction of the terrain has been parried by various methods. Despite continuous developments the majority of the observers have serious problems with so-called user-oriented cartographic depictions. The use of the new media developed in technology-based neighbouring disciplines enables us to go new ways in cartography, especially with regard to ISO 9000.*

#### Introduction

Cartography is a “moving”, ever evolving science. Its methods and developments take to a high degree their bearings at the advances in neighboring sciences, at the society and, to some degree, at its time spirit. The user requirements, last but not least strongly driven by today’s information and communication technology, change and increase, and, thus, demand also some flexibility and “motion” of the cartographer into new dimensions of cartographic communication.

New methods for communication are of a special interest, if the actual methods cannot fulfill the transmission of information required. As for the relief representation it has been proved more than half of the users have serious problems to read, understand and/or use the represented subject [cf. Toutin & Buchroithner, 1999]. The reasons for that are manifold. They can, however, not be explained at this place.

Principally the relief representation can be described as a special challenge of cartography. Starting from the classical relief representation the decisive issues are:

- a) dimensional reduction
- b) exaggeration in z direction
- c) considerable reduction of a multiform terrain, which cannot be overviewed in reality
- d) specific properties of the area depicted.

The relief information, which should be transmitted as the information subject within the cartographic communication process, is (within the scope of this article) limited to simple landforms, height relations, slope gradients and topology.

This meets the users’ basic requirements when using adequate maps (so-called user-oriented maps) for the purpose of orientation in the field.

In particular, the dimensional reduction and, due to it, the important extension in z direction can only be schematised by a hardcopy. So-called pseudo-3D representations on a screen are also just using the adequate gradients to simulate the third dimension. Other methods based on stereoscopy make use of the psychological and physiological cues to visualize the third dimension. Newly developed 3D LC displays make use of the latter technique. These autostereoscopic display offer the user an apparent spatial picture without any additional technical means like glasses.

In addition to this, the technique of holography has been applied for cartographic relief representation. In contrast to the hitherto existing representation methods holography displays the third dimension completely so that it does not depend on the different possibilities of simulation.

These new comings require from the cartographer the use of the developments of technology-oriented neighboring disciplines. One of his/her major tasks will then be the linking of these new techniques with the classical cartographic models and the further development of his/her scientific methods.

## Holography

The natural visual process works with the reception of light waves. Because of the physical properties of the retina the process of representation of a three-dimensional object leads to a loss of the spatial information in the wave field. This loss, again, leads to a reduced, two-dimensional display on the retina, which is only built up to a spatial 3D model by the physiological processes [Ostrowski,1988].

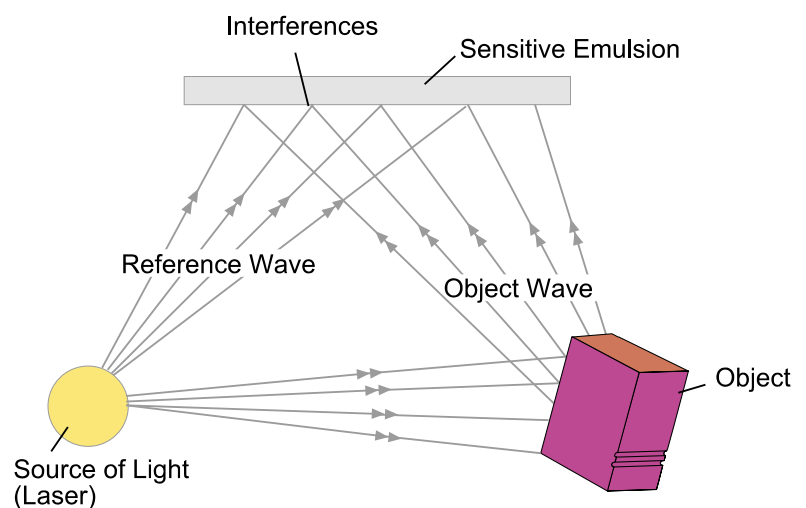
Holography is a process developed by the Hungaro-American physicist Denis Gabor in 1948. It uses and records the complete physical properties of light are used. That means that also the complete content of information of an electromagnetic wave – reflected by an object – is stored. Holography allows the recording and reconstruction of waves reflected by an object, which is illuminated with coherent light.

To produce a hologram the waves coming from the object and a wave independent of the object (reference wave) are recorded on photographic film. The overlay of both waves causes an interference pattern. Subsequently this interference pattern is illuminated with the reference wave (Figure 1). This results in the bending of the light and furthermore enables the reconstruction of the object wave. At this point a virtual representation of the reality originates. [Ostrowski, 1988; Falk, Brill & Storck, 1986].

To introduce holography into cartography a transmissionhologram has been produced. This special method of holography is, among other things, employed to reproduce very large objects of reality as a miniature edition. This is not too usual for holography. Mainly this technique depicts objects 1:1.

Furthermore, what sets this method apart from other holographic techniques is a higher depth of field [Hieß, 1995].

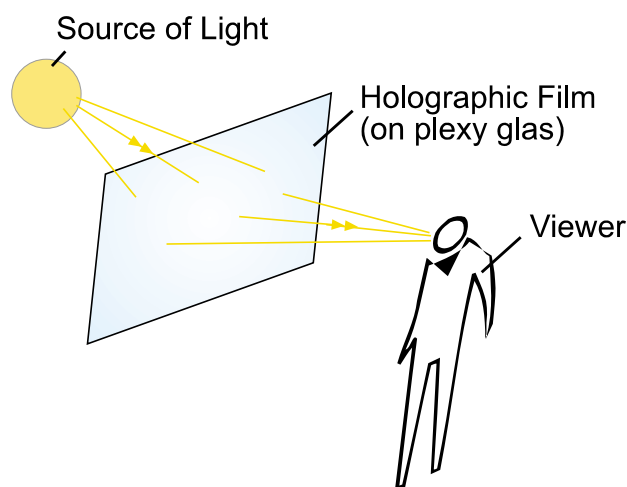
To reconstruct and look at a hologram a monochromatic source of light set up behind the hologram is needed. The viewer stands in front of the hologram. He/she acquires the information out of the picture points illuminated by the source of light (Figure 2).



**Figure 1.** Basic Principle of Holography.

Holography is known for its excellent properties of depiction. During the generation of a picture object the complete, incidental light on the hologram surface is used. Due to this characteristic feature the hologram is able to transfer the spreading of light intensity of the object which should be depicted without any significant distortion. In addition, holography enables a high-resolution and high-contrast transmission which can be manipulated by the optical components, their arrangements and by the photographic materials [Ostrowski, 1988].

The characteristic of a hologram can in summary be characterised by the realistic spatial impression of a holographic picture. Like in reality, changing positions permit the viewer to see the object in the correspondingly changing perspective. This, again, lets a holography appear in a nearly realistic manner.



**Figure 2.** Principle of a Transmissionhologram.

### 3D LC Display

The autostereoscopic (liquid crystal) display is based on the principle of stereoscopy. The generated (coloured) picture seems – in contrast to the hitherto existing pseudo-3D representations on screen – to be seen in a true 3D dimensionality. The displayed objects appear to come out of the screen or to be situated behind it. Stereo viewing can be achieved without any further aids like glasses.

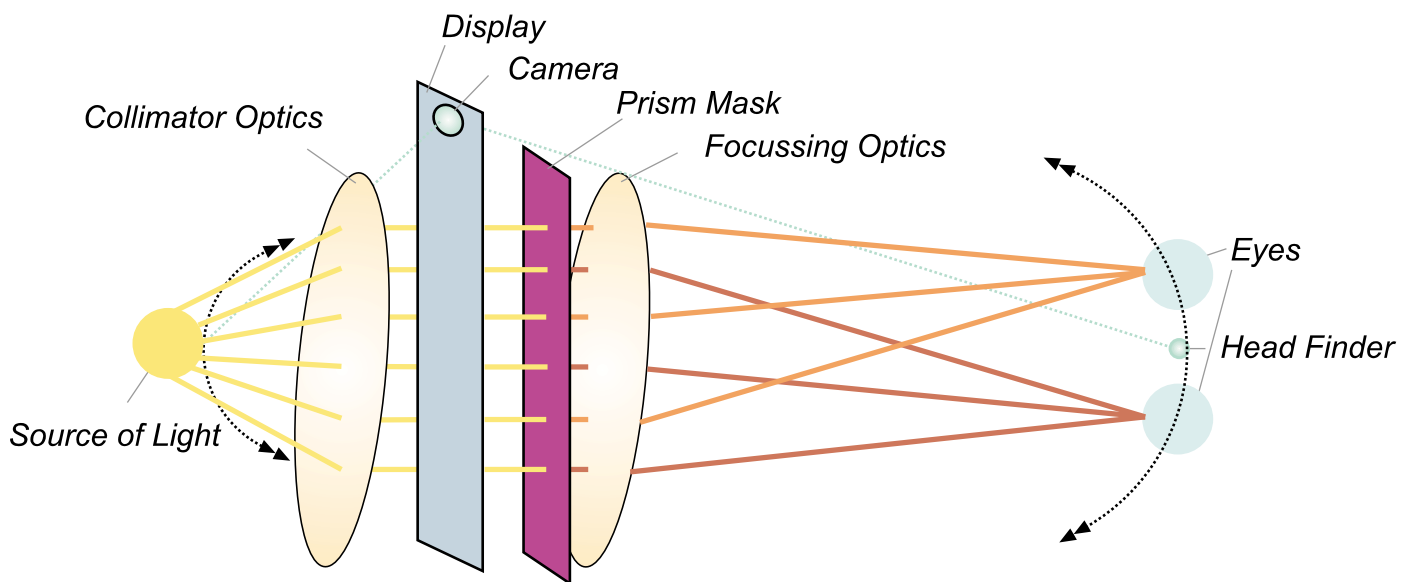
The two stereo mates of an object are, without any crosstalk, supplied to the viewers' eyes, under consideration of the eye distance, by a prism mask. The stereopartners are columnwise interlaced so that the right stereo picture is written into the even and the left one into the odd columns.

The prism mask technique makes use of a liquid crystal display (LCD) which is operated in penetrating light. The illumination is realised by collimated light. The prism mask brings about the steering of the light coming from a certain column of the LCD to the corresponding eye.

One advantage here is the practically free mobility due to a smart mechanism. An optoelectronic technique, also called as “tracking”, works with a head finder which determines the position of the viewer. The stereo mates are “driven” to the movement of the viewer by the appropriate shifting of the source of light in real-time (Figure 3).

The important properties for a cartographic relief representation realised by a 3D LC display can be summarised as follows:

- *full-colour display*
- high spatial effect
- possibility for the viewer to move around
- possibility for animation in real-time.



**Figure 3.** Basic Principle of the 3D LC Display.

## Effects of Representations on Information Transmission

“There is no objective picture of landscape” explained E. Imhof in his work “Terrain and Map” in 1950. This describes an essential and fundamental aspect of perceptive psychology. Perception cannot be put on one level with the objective imaging of the real world by means of a photographic camera (whose role in perception is played by the eyes). The centre of the information processing is the brain. Here the stimuli of the environment onto our eyes are interpreted. This is done with the inclusion of the pre-information and experiences gathered during our life. Perception is inseparably linked to knowledge. This implies that their quality (or kind) is influenced by experiences of our lives and living spaces.

This aspect effects two points in the cartographic communication process:

First, when the cartographer produces the map as a copy of the three-dimensional reality, and second, when the user derives information from the map. The latter process is furthermore biased by the user’s cartographic abilities and knowledge.

The “real” 3D visualization techniques allow us to expect a minimization or even elimination of the previous perception problems described above. Since the human user tends to organize each conception or imagination into a sort of “real-world scene”, the step from a “real” three-dimensional representation into that virtuality is relatively small compared to that from a rather schematic, two-dimensional representation.

This advantage of the 3D visualization technique must again be materialised with regard to the respective purposes. While these techniques offer the user an overall impression of the represented relief, the transmission of detailed information and precise height data as it is rendered by contourlines is not simplified very much, since at present for detailed landforms the techniques do not offer an adequate picture yet.

(It has, however, to be pointed out that the Dresden 3D LC display is going to be developed in that technical direction.)

When assessing the new techniques from the psychological viewpoint, the effect of getting habituated has also to be taken into consideration. The spatial depth together with the impression that he/she could touch the object on an actually flat medium differs from the three-dimensional impression of the hitherto existing media. This is especially true for the holography.

At this point it has to be noted, that an outdoor use of the respective techniques is not yet possible at this stage of development. Thus, concerning the derivation of the above mentioned relief information, the use is restricted to indoor applications. Nevertheless, basing the decision on the characteristics of a cartographic relief representation, as described above, the techniques come up to aspect a) and b) in particular (cf. section 1).

The dimensional reduction is not relevant to holography. The techniques described above meet the extension in z direction, because their specific strength is just the visualization of the z dimension.

Through an efficient use of the “real” 3D visualization techniques a new dimension of quality in the cartographic relief representation can be initiated. This means that a new scale of quality has to be created which is oriented at these improved techniques and their effects.

## 5 Quality Aspects in the Context of ISO 9000

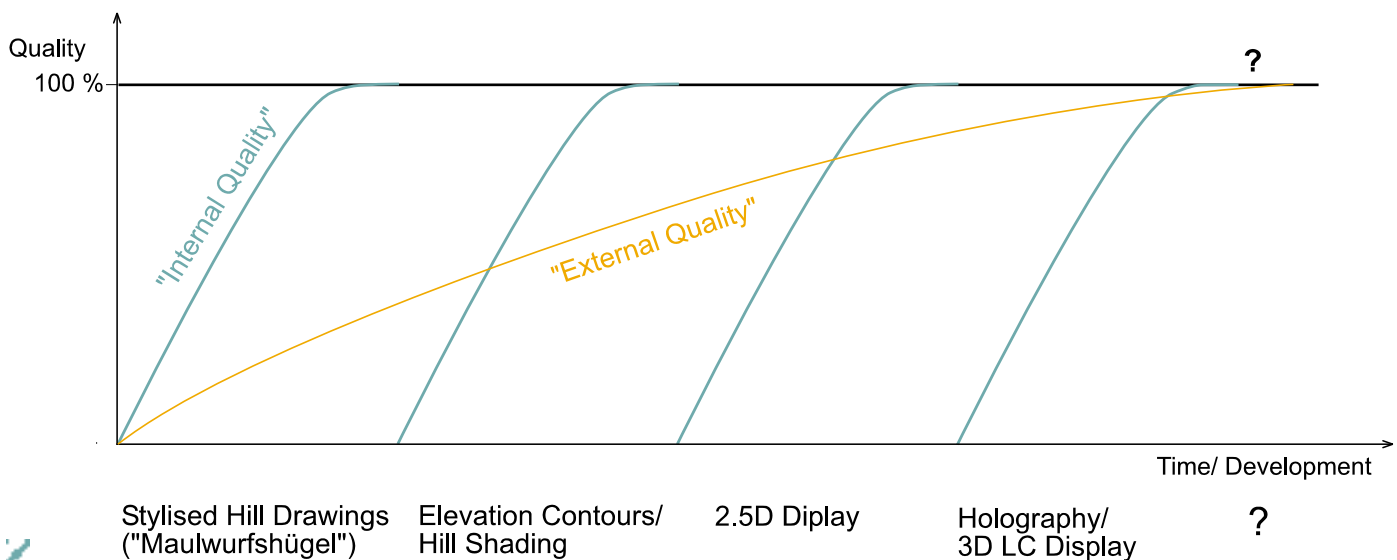
Scientific and technological developments have always caused the emergence of a variety of new cartographic relief depictions. They comprehend both quantitative and qualitative changes. Besides a general alteration of our society, changing needs of the map users can be observed as an effect of these developments. As for the cartographic relief representation, e.g. changes in the field of tourism, leisure and sport activities significantly influence the needs and requirements of the map users. Increasing educational levels and a growing individual development also increase the mental and cultural needs respectively. This implies that the map user becomes a critically assessing consumer, who deliberately selects from a varied supply of cartographic relief depictions.

Cartography acts and reacts. Thus, it also shapes the definition parameters of quality and value. In dependence of the individual disciplines and the application quality can be defined in very different ways. The term “value” is determined by the respective application. Some practical examples may illustrate these relationships: A three-dimensional relief model can have a quite high quality, for the direct orientation in the field, however, it is unsuited and therefore does not have any value for its user concerning this very purpose. A large-scale cartographic relief representation for touristic purposes cannot be evaluated concerning its geometric accuracy, since its preciseness might have been purposely degraded for the sake of other esthetic aspects.

The content of the variable “quality” is determined by its respective parameters. The resulting “index number” is only valid for this very concrete application-driven evaluation system. The different discipline-independent descriptions of terms concerning the variable “quality” lead to a global definition “fitness for use”. Morrison (1995) explains the term “quality” in connection with data quality: “..., quality means fitness for use and ... users are not willing to spend much on it anyway”. This behaviour of the users can also be assumed for the task of the derivation of relief information from maps. This fact, however, leads to the idea that the definition of quality, which is only based on purely theoretical scientific aspects, cannot come up to a comprehensive, application-oriented quality control. Hence, it is inevitable that the concerns and ways of views of the whole variety of cartographic products have to be considered equally for the determination of quality parameters.

Already C. W. Morris pointed at this phenomenon in his “Theory of Values”: He defines the value in a philosophical sense in the context of the respective conditions within a certain system and describes the nature of objects in relation to interests. For our issue this thesis can be applied in that the value is neither resident in the objects which are isolated from the interests, nor only in the interests which have been isolated from the objects which enable the satisfaction of interests. Quality is not exclusively an objective feature but an aspect which is strongly dependent on human perception.

The question what quality means for cartography and in particular for cartographic relief representation shall be answered with the following more global definition attempt: *A cartographic product/a cartographic relief representation has a high quality, if the user and the cartographer of this very cartographic depiction can, through application and examination of various criteria which have to be defined within the scope of the*



**Figure 4.** Quality-Development.

*envisaged application purpose of the map product, assign positive meanings to the objective features and the features based on the human perception. Furthermore, based on these positive evaluation criteria this product can be used by the map user to the optimal satisfaction of his/her needs.*

The mutual interaction between cartography (cartographic relief representation), society, and technological-methodological development will always result in a new coining of the term “quality”. The general pursuit of quality improvement contains new quality standards which are adapted to the respective innovations. The level of quality increases with improved technology. This type of quality, independent of the individual technological states of the art, maybe called “external quality”. It is put opposite the “internal quality” and describes the maximum reachable quality assessment within a certain technological state of development. Figure 4 illustrates the quality types in the context of the cartographic relief representation.

The guiding principle of ISO 9000 more or less provokes the above mentioned syntactic structure and, on the other hand, can be taken as a confirmation of the quality definition “fitness for use”: “Give the customer no more, and no less, quality that what he needs.” According to that the highest possible accuracy and the exact graphic elaboration would not be the “relief drawer’s” highest goal. Thus, he/she has to find an optimum composition out of geometric accuracy, geographic realism, graphic logic, and esthetics for maps with the “predetermined message” and the “implicit message” according to A. MacEachren (“Predetermined message” standing for maps with an explicit information, “implicit message” standing for maps without any well-defined information.). Individual quality parameters have to be systematically degraded for a certain purpose - last not least, however, with the objective to obtain a product which is optimally tuned to the application and tailored to the user.

This guiding principle would loose its significance, if a product could be created, which meets all the overlapping requirements.

## Prospects

Within the above context the new cartographic representation methods lead to the assumption, that their physical and Gestalt properties have, in a first instance, a strong influence on the early phases of viewing, since the stimuli “radiated” by this type of cartographic depiction have to be estimated very high. Concerning the



further visual/cognitive process also for this representation method the positive influence will strongly depend on the capabilities of the individual user. However, for the high-level process a comparatively high utilisation effect for the inexperienced user can also be expected. The theses formulated above have to be seen in the light of the respective utilisation and the respective task, because here additionally the intellectual attributes of a symbol become effective. They are frequently overseen, because in cartography the adequate elaboration of the physical and Gestalt properties belong to its major tasks.

The outcome based on an opinion poll made during the Annual German Cartographic Conference 1998 corroborates these theses. The experienced cartographic experts rather see advantages for the average map user of so-called user-oriented maps and improvement through holography than for themselves. The findings, however, also assume that an improved cartographic communication cannot be accomplished through an improved representation only, but rather the cognitive aspects, in particular the component “experience”, have to be considered.

To what extent such technologies are extendable for cartographic relief depiction, will on one side depend on the response of the users, on the other hand also on the creativity and openness of the cartographers. New media can stimulate cartography, they can be an impulse to go new ways, even if they are not yet fully developed.

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