Anaglyph Representation as Medium for Spatial Design

Marco Hemmerling¹, David Lemberski²
¹,² Detmold School of Architecture and Interior Design, Hochschule Ostwestfalen-Lippe, University of Applied Sciences, http://www.hs-owl.de/fb1
¹ marco.hemmerling@hs-owl.de, ² david.lemberski@hs-owl.de

Abstract. The paper discusses the use and possible applications of stereoscopic projection and anaglyph representation for the design-process and visualization of architectural spaces and three-dimensional objects. As the topic of stereoscopic vision is quite broad and has a long tradition in various fields (photography, art, virtual reality) the paper focuses on the implementation of anaglyph representation in 3D-Modeling-Software as a tool to support spatial perception within the design process. Against this background and based on a test-series with 113 students the benefits and conditions of spatial perception, vision and sense using anaglyph representation are examined.

Keywords: stereoscopic vision; spatial perception; anaglyph representation.

Introduction

Spatial vision and spatial sense are important conditions for the development and evaluation of architectural spaces and three-dimensional objects. Architects and designers usually work with two-dimensional illustrations of the spatial objects, that they design. Todays CAD-Software allows a comprehensive modeling of the digital 3D-geometry. However, the representation on the screen remains a two-dimensional image of the three-dimensional shape.

Stereoscopic projections and anaglyph representation are methods, that support a three-dimensional perception and simulates the three-dimensional vision of human-beings. These methods originate from the 19th century and were refined with the development of photography. They are used nowadays in various software-applications – ranging from image processing to virtual reality. The application of stereoscopic projections in an immersive virtual environment, that allows a navigation in real-time requires complex hardware and software components. In that respect it is quiet an exclusive technology.

Against this background the possibilities of stereoscopic projection – especially the anaglyph representation – will be examined in the following regarding possible applications for the education of an architect and designer as well as its relevance for the design process in general.

Stereoscopic vision

All visual experiences are gained in the dimensions of our physical world. The abilities, that are acquired in that context form - beside the genetically
determined visual experience - the conditions for the phenomenon of spatial perception. Spatial perception as one of the basic achievements for orientation can be differentiated into two principles of perception:

1. The perception of the position of objects in space (height, width, depth, distance of the object to the point of view) and
2. The perception of movement (change of the position of an object or the point of view in time).

Spatial vision is based on the binocular system. The fact that the vision conus of both eyes penetrates itself partially and secondly the eye-muscles are fixing the objects accordingly enable the stereoscopic perception of space. Both two-dimensional retinal image (parallax) - slightly varying by the distance of the eyes - are combined neurally to an overall image of the three-dimensional world. The process of spatial perception is based on three aspects:

1. The real environment - including its objects - is three-dimensionally perceived;
2. A two-dimensional image emerges on the retina ('retinal image'); from this two-dimensional image a three-dimensional impression is generated.
3. A three-dimensional impression can also be evoked by an artificial spatial representation of an object or space, e.g. a perspective drawing.

Designs and other two-dimensional images are interpreted spatially if they fulfill a sufficient degree of depth criteria. A drawing or an illustration, which in its functions adapted to stereoscopic vision, is called stereogram or -copy. It is composed from two stereoscopic half-images, whose deviations correspond with the parallax of monocular retinal images.

**Anaglyph representation**

An anaglyph representation is a stereoscopy, in which the deviations are displayed in complementary colors (e.g. red and green/blue). The procedure as such was developed by Wilhelm Rollmannn in the 19th century. The half-images are combined on top of each other and not next to each other. As a consequence the outlines of the half-images are not congruent (deviations appear as double outlines). By using so called ‘3D-glasses’ with according red and/or green/blue colored foils, the colored deviations are no longer visible and an unusually strong spatial impression of the represented scene appears in the eyes of the beholder.

In historical methods using camera filters, on film, two images from the perspective of the left and right eyes are projected or printed together as a single image, one side through a red filter and the other side through a contrasting color such as blue.
or green or mixed cyan. The anaglyph method of stereoscopic vision unfolds its best effect with photorealistic representations and illustrations, that are generated by an appropriate software and are displayed via a screen projection.

**Stereoscopic 3D-modeling**

The 3D-Modeling Software Rhinoceros offers from V4 on two options to display a geometry using a stereoscopic representation. Next to the the anaglyph generation via red/blue glasses the Software offers a display related to 3D-Shutter glasses. The use of 3D-Shutter glasses requires special hard and software features like a video card and drivers that support Open GL Stereo modes and a monitor that can support a fresh rate of 100hz or higher. The anaglyph generation in contrary requires only a pair of inexpensive red/blue glasses. The stereo display allows a direct verification of the spatial appearance during the modeling process, by switching the display-mode in Rhinoceros.

**Case Study – spatial perception through anaglyph representation**

The question whether and in what respect the anaglyph representation can be a relevant assisting tool in the designing process of three-dimensional objects and spaces was the major subject within the empirical experiment at the chair of Computer Aided Design (CAD).

In a case study 113 students of the department of Architecture and Interior Design completed a test series, where the principles of anaglyph representation were examined in relation to the cognition of three-dimensional objects on a two-dimensional flat screen. In order to minimize the influence of common visual habits it was important to use figures and illustrations which are not part of the usual perception of the real world. As a consequence the objects used in the test series where based on abstract, digitally generated geometrical forms, represented by line-drawings, surfaces and volumetric figures. Another important aspect concerned the protanomaly (or deuteranomaly) - a color vision defect in which a deficiency of red (or green/blue) retinal receptors results in poor red-green hue discrimination. With the help of the Ishihara-test students, with such a defect, could be identified within the test series.

By using an interactive user-interface, that is based on a digital PDF-format on the one hand and inexpensive anaglyph glasses (red-green/blue) on the other hand the developed test series could be performed on low operating expenses. The test took approximately twenty minutes. Some students mentioned, that the use of the anaglyph eyeglasses became stressful for the eyes toward the end of the test-series.

The test contained 24 pages, that displayed 3D objects (line-, surface- and volume- models) both as standard two-dimensional and anaglyph representations. Two different methods of investigation were used to identify the quality of spatial perception in
relation to the projection mode. The first range of images (16) was related to the perception of a three-dimensional shape by identifying foreground and background of the 3D-object. The second set of images (8) was based on a comparison of two figures in different positions, whether they are identical or not. As a result the anaglyph representation supported the spatial perception of three-dimensional line-drawings and the recognition of different or similar shapes projected in various positions best. Especially the spatial perception of complex and ambiguous geometries improved significantly by displaying the objects in the stereo mode. The quality of spatial perception of surface- and volume-models, that were displayed in a shaded mode, didn’t differ relevantly in relation to the stereoscopic projection mode.

Conclusion and Outlook

The case study showed, that the use of stereoscopic projection can support the spatial perception and sense of three-dimensional objects significantly. Especially the perception of complex and ambiguous geometries can be improved by using an anaglyph representation.

In that way the stereoscopic projection could be used as an educative tool to train the spatial sense. The comparison of a two-dimensional and
A stereoscopic projection of the same model could lead to an extended contemplative sense of the spatial appearance of a design. In that respect the 3D-effect of anaglyph representation could deliver important spatial information and cognition in an early stage of the design-process without the need to build expensive and time-consuming physical models or establish a complex virtual environment – like CAVE or Powerwall. It allows a direct and fast examination of the spatial qualities of the 3D-model and it can be implemented easily in every work-station.

In a future research project further aspects of perception will be placed into the focus (e.g. the anaglyph representation of movement-animation, real-time - and a refined stereoscopic projection, that displays also aspects of material properties and light-ambiance).

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