

Chapter 18

Introduction to Autostereoscopic Displays

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ABSTRACT

This chapter is an introduction to the principles of operation in autostereoscopic displays. It explains the most important autostereoscopic technologies and their principles, the image representation, and the resulting strengths and weaknesses. Beside the general principles, all necessary steps for a successful 3D display design are illustrated. This includes the fundamental dimensions, the generation of the screen images, as well as the creation of the 3D optics. To characterize and classify a certain 3D display, a display metric for autostereoscopic displays is proposed. Even though all parameters are explained for a static 3D system, the basic principles are also applicable for dynamic systems (i.e. 3D displays with head or eye tracking). In such cases, the described geometrics are only correct for a singular point in time.

INTRODUCTION

Since the early days of television and with the progress in television technology, there were consistent technical adaptations of various features to improve the presentation of realistic 3D. Even as the glasses based 3D technologies are quite popular nowadays, it was and is an everlasting dream of viewers, engineers and researchers to achieve the same impressive 3D image quality without glasses too. The formulas, equations and

matrices used in this chapter deal with 3D technology without glasses and they are illustrated by examples. The matrix generation is explained by using the universal formula (Grasnick, 2010). In such cases the notation is according to Mathematica (Wolfram Mathematica). All samples are created with Mathematica 7.

DEFINITION

An autostereoscopic display is a device for representing a 3D scene without the need of viewing

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aids. There are two main principles of spatial impression (Grasnick, 2010): Spatial Existence (used in volumetric displays) and Binocular Disparity (used in stereoscopic and autostereoscopic displays).

“Spatial Existence” means the real presence of spatial information within an observed volume. This kind of representation can be achieved by projecting a sequence of flat images or light points on rotating flat screens (i.e. the “100 million voxel display” (Favalora et al., 2002)), rotating curved screens (i.e. the “Felix 3D display” (Langhans et.al., 1998)), fog screens (DiVerdi et. al., 2006) or varifocal mirrors (Fuchs and Pizer, 1986). Other volumetric technologies are multi-layer displays (Sullivan, 2002), light excitation in a solid medium (Downing, 1997), multi-lens projection (Grasnick, 2001) and of course holographic displays (Spatial Imaging Group @ MIT, 2010). These and similar devices are also referred as “volumetric displays”. Because of their complex and sophisticated technologies, volumetric displays have only a little commercial impact today.

The 3D effect in stereoscopic displays is principally caused by the difference in between the left-eye and right-eye images (Binocular Disparity). Usually, an observer has to wear 3D glasses to separate the stereoscopic image pair to the “destined” eyes. If this separation doesn’t needs any additional 3D glasses, the device is typically called “autostereoscopic”. Autostereoscopic displays are 3D devices at which the spatial impression is mainly based on the reproduction of a disparity in between the represented perspective images without the requirement of viewing aids.

GENERAL PRINCIPLE

As per definition, an autostereoscopic 3D impression is based on binocular disparity. The stereopsis is the determining principle, but all

other monocular or binocular depth cues can be used to improve the 3D quality.

An autostereoscopic display has to contain at least two elements: A display device to represent the specific image data (screen image) and an optical modulator to separate parts of the screen image(s) into different parts of the viewing area.

A common display device will show the images as raster image, in which each pixel position can be described with two coordinates. The raster image is a combination of certain number of raster images, representing different perspective views. The combination rule for the screen image can be completely specified in a two dimensional matrix (Figure 1).

where

- i, j position indices
- i_0 first horizontal index
- i_n last horizontal index
- j_0 first vertical index
- j_m last vertical index
- V perspective view number at position i, j

The optical modulator (Figure 2) is an array of optical elements. For the most popular technologies, the optical elements are arranged in one layer. Similar to the screen image, the arrangement of the optical elements can be described also with a matrix. This matrix could be a transformation of the screen image matrix (and vice versa), at which the perspective view number has been replaced with the number of the optical element, the balance or the anchor point of the element. As this number represents now a certain characteristic and value of optical modulation, these values could be described as the “optical mode” for a specific pixel position.

where

- k, l position indices
- k_0 first horizontal index

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