Chapter 13

AUTOSTEREOSCOPIC, PARTIAL PIXEL, SPATIALLY MULTIPLEXED, AND OTHER 3D DISPLAY TECHNOLOGIES

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Abstract: The technologies and advances in the field of three-dimensional (3D) displays within the past two decades are reviewed. Specifically, the developments in diffractive, refractive, reflective and occlusive 3D display strategies are discussed, highlighting the advantages and limitations of the associated systems. The partial pixel and the partial object pixel architectures associated with autostereoscopic displays are discussed in some detail, while other techniques are briefly introduced. It is shown that major breakthroughs occurred with the development of computer-generated holography (CGH), liquid crystal arrays (LCA) and other spatial light modulators (SLM), and also the discrete fabrication of diffractive and holographic optical elements (DOE and HOE), micromirror arrays, and microelectromechanical systems (MEMS). These techniques and components have enabled the implementation of spatially and angularly multiplexed 3D images and scenes with potentially dynamic (time-varying) features.

Key words: 3D displays; partial pixels; spatial multiplexing; holographic gratings; autostereoscopic displays; holographic stereograms.

1. INTRODUCTION

In recent years, the use of three-dimensional (3D) effects has experienced a resurgence. Many advertising labels use 3D stickers, and are increasingly seen in 3D audio and visual displays. In addition, a great number of medical and technological applications can be found in a variety of industries, including magnetic resonance imaging, computerized axial

imaging (CAT scan) imaging, architectural plan development and flight simulation. In theory, the 3D visual effect is generated by a slight spatial difference between the eyes of an observer. However, standard display technologies such as the cathode ray tube (CRT), liquid crystal display (LCD), and electric plasma display cannot offer a realistic 3D effect. The 3D pixels for a 3D display system, which diffract the incident light into an intensity distribution over the spatial domain, may be seen as a hologram consisting of a number of (superposed) gratings. Yet, techniques for the dynamic control or programming of the erasure and recording (OFF and ON switching) of these gratings are not readily available. This chapter will review the current state-of-the-art in 3D display technologies, providing an overall picture of the progress made in this field in the past decade or more. Brief introductions will be given to some of the well-known methodologies; in a few cases, such as with the *partial pixel*, or *spatial multiplexing architecture*, a more detailed description will be provided. Developed in 1995, the partial object pixel recording technique discussed in this chapter records a pixelated hologram which emulates a composite 3D pixel array for 3D display systems. The partial object pixel technique allows one to record a hologram that yields the predefined intensity distribution during the recording phase. Computer-generated object beam patterns for specific intensity distributions are recorded on a pixel area with a traditional two-beam recording setup. In section 2, modern 3D/stereoscopic display methodologies are reviewed. There are several approaches producing a 3D effect; these include the Virtual Reality (VR) technique, red-blue stereoscopic 3D display, polarized stereoscopic 3D displays, and LCD stereoscopic 3D displays with holographic/diffractive elements. In the VR technique, two LCDs are used to feed the left and right images (generated by a computer 3D image synthesizer program) to the eyes of an observer. The observer has to wear a special optical viewing device in order to correctly intercept the two images. Such devices are now widely used in the computer games industry because of their total capability in replacing the observer's surrounding scene with a virtual one. In contrast to the VR technique, the red-blue stereoscopic 3D display technique is not a recent innovation. Movies based on this technique have been made decades ago. New commercial products have been developed for scientific and medical visualization applications. For example, Silicon Graphics® Computer Inc. has recently announced a three-dimensional image-rendering system using stereoscopic 3D display techniques. However, a more prevailing 3D methodology is to use computer software in order to generate 3D scenes; this does not involve any specialized 3D output device. By interacting the user with vividly animated/synthesized 3D images, a low cost, *pseudo* 3D effect