5 3D video display technologies

Your goals for this "3D video display technologies" chapter are to learn about:

- 3D display categories.
- 3D viewing aids.
- Auto-stereoscopic displays.

3D displays are the last node in the 3D video chain and expect to produce pleasing pictures to end-users. The 3D displays generate a number of physiological cues such as binocular disparity, motion parallax, ocular convergence and accommodation in order to produce depth sensations in the Human Visual System (HVS). However, conflicting clues may cause discomfort and fatigue. Unlike standard video displays (e.g. PC monitor), 3D video requires special display techniques or additional viewing aids such as polarization glasses and shutter glasses. Furthermore, only the cost effective and adaptive displays will enable 3D video in every household. For, example rather than having a specific 3D display at home, a single display that can work as 2D or 3D display get more attention from the users. A survey of 3D display techniques is presented in [88]. The major types of 3D video display techniques and the display type used in this research are discussed in the following.

The 3D display techniques can be categorized into three main types namely;

- Volumetric displays

Figure 5.1: Volumetric display

- Holographic displays

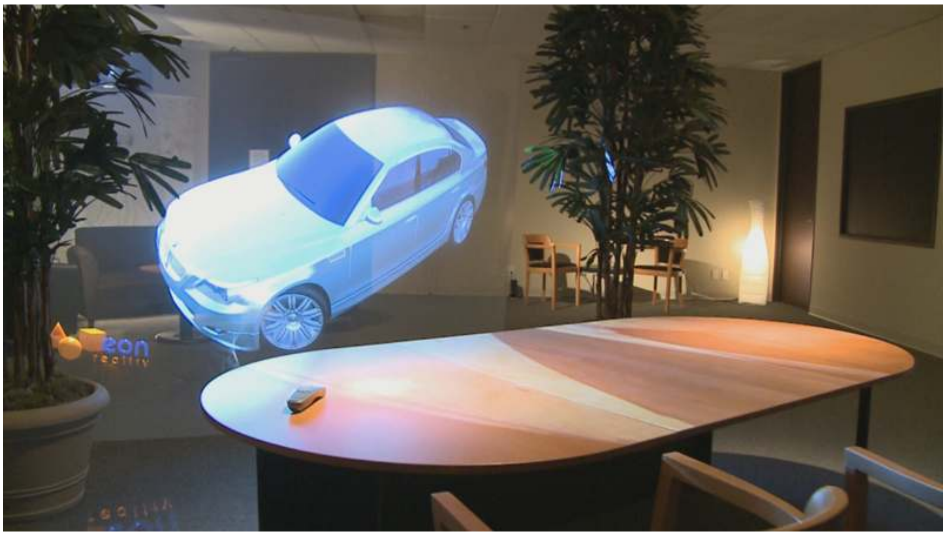

Figure 5.2: Holographic display

- Autostereoscopic displays

Figure 5.3: Auto-stereoscopic display

Volumetric displays form the image by projection onto a volume space. This allows the users to look at the scene from wide range of angles and viewpoints. However, these displays tend to have limited resolution. The descriptions of commercially available and prototype volumetric displays can be found in [89–91]. Due to the unavailability of natural scene capture for these displays, volumetric displays are more suitable for computer graphics than 3D video applications. In holographic display techniques, the image is formed by wave-front reconstruction, and includes both real and virtual image reconstruction. The quality of 3D video produced by colour holography is more rich in depth cues than the 3D video reproduced by other techniques [88] [92]. Some of the proposed display techniques using holography are detailed in [93-95]. The advantage of this technique is that it captures the true 3D wavefront of a scene and the retention of motion parallax. However, due to the demand for high resolution recording medium and replay medium, this display technique is difficult to implement for natural scenes with acceptable image resolutions with the existing technologies. For instance, a large display of say 100 mm diagonal will need dramatic improvements in Very Large Scale Integration (VLSI) techniques to enable a Spatial Light Modulator (SLM) to be manufactured with sufficient pixel resolution [88]. Nonetheless, holographic display technique can be deployed in reduced parallax systems (e.g. stereo-holography or lenticular), which reduce the demand for high-end technologies.

Autostereoscopic displays provide depth sensation to the viewers with no requirement for special glasses or user-mounted devices. Prior to the introduction of these displays viewers have to wear special viewing aids to facilitate stereoscopic viewing. The viewing methods can be classified into several categories depending on how they are going to render left and right image sequences to the user. According to [96], some of the widely used stereoscopic viewing methods are

- Optical (e.g. the stereoscope),

Figure 5.4: Stereoscope

- Colour based (e.g. anaglyphs),

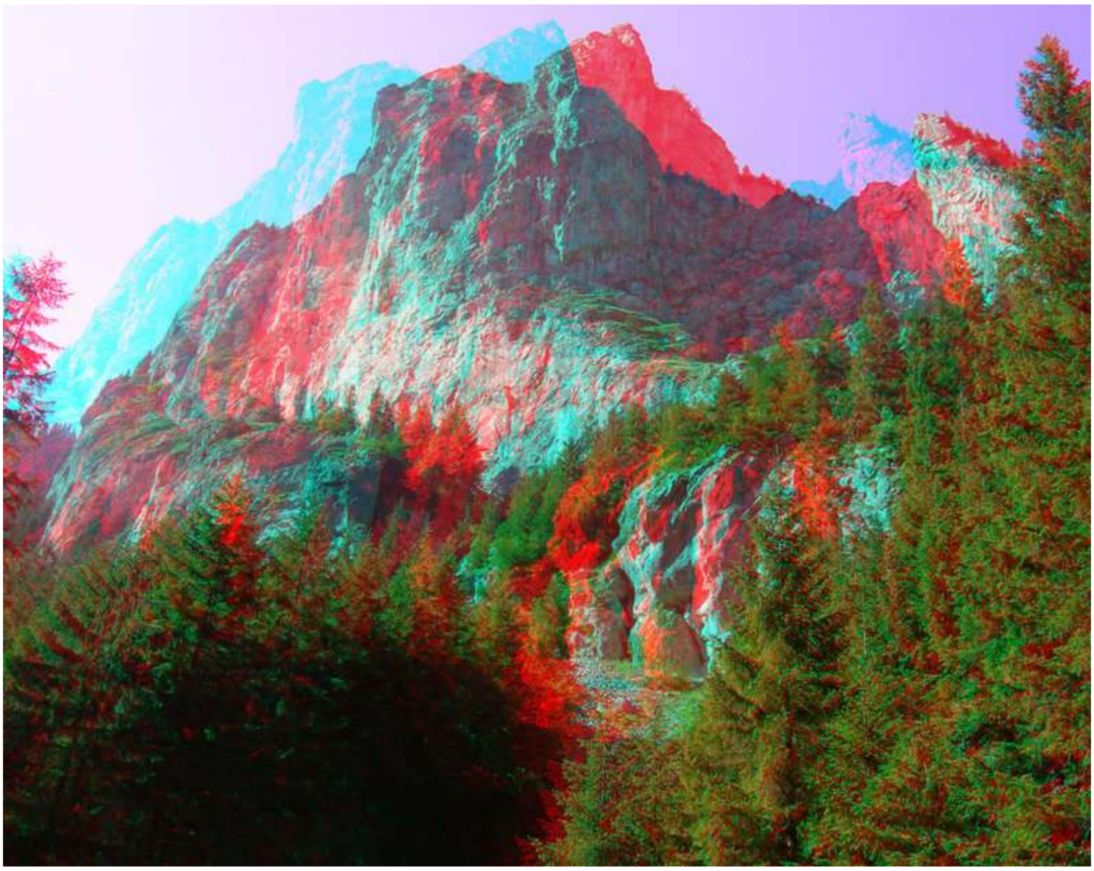

Figure 5.5: anaglyphs image (colour based)

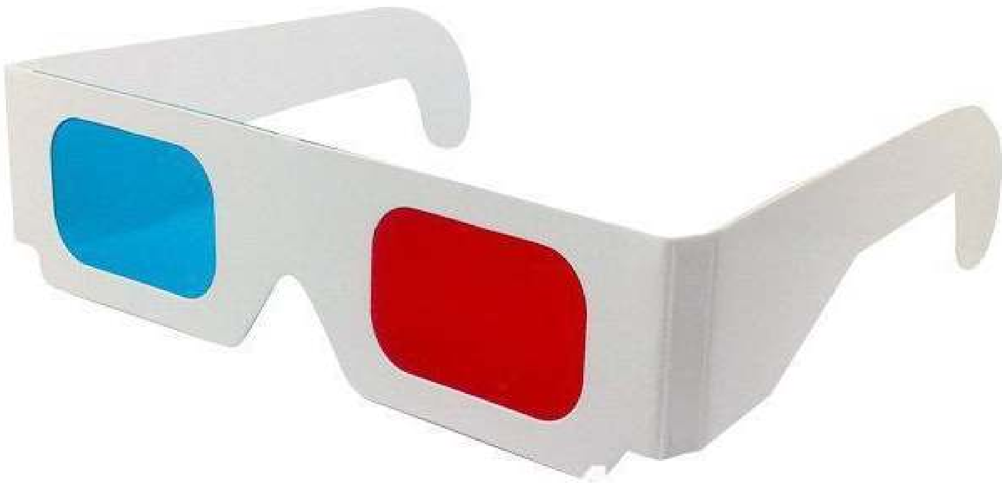

Figure 5.6: anaglyphs glasses (Red-blue glasses)

- Polarization based (e.g. polarization glasses),

Figure 5.7: Polarized glasses (Red-blue glasses)

- Temporal separation based (e.g. liquid crystal shutter glasses), and

Figure 5.8: Shutter glasses

- Head Mounted Displays (HMD)

Figure 5.9: Head Mounted Display

HMD in particular renders the left and right views to the user based on their head position. These are mostly used in interactive 3D video applications. Even though the viewing 3D with eye-wears is cost effective solution, the users at home may not like to wear them due to the general discomfort. Moreover, these eye-wears introduce specific artefacts to the stereoscopic image sequences. For example, with polarization glasses each eye sees a faint version of the other eye's image [96]. Therefore, autostereoscopic displays provide convenient solution for 3D viewers and due to the wide popularity of this technique the cost for a display unit going to be lowered in the future.

These displays can be employed to produce binocular (single user), multi-view (multiple discrete stereoscopic views) and holoform views. Unlike other 3D displays (e.g. volumetric display) this display supports limited number of viewers. Two design approaches for autostereoscopic displays are shown in Figure 5.10. Figure 5.10 (a) shows a lenticular array of cylindrical lens-lets placed in front of the pixel raster, directing the light from adjacent pixel columns to different viewing slots at the ideal viewing distance. Therefore, with this approach, each eye of the viewer sees light from only every second pixel column and thus provides stereoscopy. Figure 5.10 (b) shows a Parallax barrier in which a mask is placed in front of the pixel raster so that each eye sees light from only every second pixel column. These autostereoscopic displays divide the horizontal resolution of the underlying, typically liquid-crystal display device into two sets. One of the two visible images (e.g. left view) consists of every second column of pixels; the second image (e.g. right view) consists of the other columns. The two image sequences (i.e. stereoscopic video) are captured or generated with the DIBR method so that one is appropriate for each of the eye pair [97]. As this technology is still at the early age of development, there are certain issues to be addressed such as flipping between views and vertical binding on the image [88].

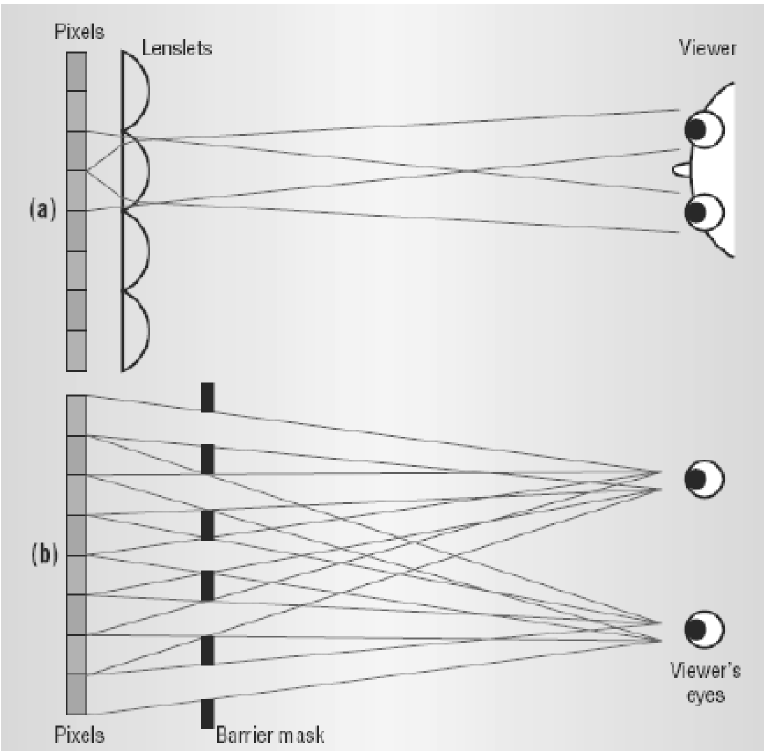

Figure 5.10: Auto-stereoscope arrangements

Autostereoscopic displays are commercially available as Mobile/tablets/PC/laptop monitors [98], and TV monitors [99]. Philips and Sharp Corporations have also developed Autostereoscopic displays which can work with both 2D and 3D content [98][99]. The 42" Philips multi-view Autostereoscopic display is used in the experiment to display the stereoscopic material. This exploits lenticular lens technology to separate left and right views [99]. The maximum resolution of the 3D display available is 1920×1080 pixels and the optics are optimized for a viewing distance of 3 meters. Nine users are allowed to view 3D video content at the same time. Moreover, this display supports screen parallax enabling users to look around the scene objects (see Figure 5.11). The input video format of this display is colour and depth map video sequences, which are arranged side-by-side. Therefore, the processed/original colour plus depth image sequences are combined to form side-by-side image sequences before fed them to the display. Before displaying 3D content on the display, the supplied colour and depth image sequences are converted into left and right image sequences using the DIBR technique.

Figure 5.11: Viewing of stereoscopic content using multi-view display