Design of three-dimensional displays with digital micromirror device

Joonku Hahn
School of Electronics Engineering, Kyungpook National University, Buk-Gu Sankyuk-Dong, Daegu 702-701, South Korea
Tel.:82-53-950-5514, E-mail: jhahn@knu.ac.kr

In general, three-dimensional(3D) displays require quite large amount of information for providing multiple views to observers. The product of spatial resolution and angular resolution can be one of the standard evaluating the quality of the three-dimensional display. In addition, the color depth needs to be considered to determine the size of the necessary bandwidth. Therefore, it is natural that digital micromirror devices(DMDs) have received lots of interest for constructing 3D displays[1] since they have outstanding properties in the bandwidth. The maximum data rate of commercial DMDs produced by Texas Instruments is reported as 48Gb/s and it means that the DMD has a potential to display about 300 times more pixels than full-HD display with 60Hz refresh rate. However, the comparison is not so simple because the DMD presents the image by using pulse-width-modulation(PWM) method. Sometimes, low color depth could be critical and the increase of the time for gray-level PWM brings the decrease of the refresh rate of the DMD.

3D displays with the DMD have another advantage in color consistency since the DMD is a device to reflect the incident light and it must have a strong point for multiplexing [2]. Some important points for designing the system are summarized in Table 1. In many cases, mechanical scanners are applied for increasing the range of the scanning angle, but there are alternative ways that the light source array can be useful if the only small deviation of the incident angle is necessary [3]. The information of the light field can be divided into several pieces for multiplexing. For space-multiplexing, the light field is usually divided at the image plane and for time-multiplexing, it is divided at the Fourier plane to provide different views according to the direction. But in some cases such as holographic display, the division at the image plane may be better for the quality of the reconstruction image [4].

Table 1. Decision points for designing the system with DMD

Decision points		**Features**
Multiplexing	Time	High suitability due to a large bandwidth Simple electrical connectivity
	Space	Moderate suitability due to a small form factor High scalability
Light source	Common	Good color consistency
	Individual	Easy for configuration
Scanning method	Light source array	Design flexibility without mechanical components
	Mechanical scanner	Large deviation in the angle of the reflected wave by filtering unwanted angular spectrum out.
Plane where the information is divided	Fourier plane	The method proper for multi-view displays
	Image plane	The method proper for holographic displays

References

1. G. E. Favalora, “Volumetric 3D Displays and Application Infrastructure,” IEEE Computer **38** 37–44 (2005).
2. K. Nagano, A. Jones, J. Liu, J. Busch, X. Yu, M. Bolas, and P. Debevec, “An Autostereoscopic Projector Array Optimized for 3D Facial Display,” ACM SIGGRAPH 3 (2013).
3. S.-K. Kim, D.-W. Kim, Y. M. Kwon, and J.-Y. Son, “Evaluation of the monocular depth cue in 3D displays,” Opt. Express **16**, 21415-21422 (2008).
4. Y. Im, H. Kim, and J. Hahn, “Iterative Fourier Transform Algorithm Based on the Segmentation of Target Image for a High-Speed Binary Spatial Light Modulator,” J. Opt. Soc. Korea **19**, 149-153 (2015).