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Mixed light modulation mode application for 3D visualization system

Krišs Osmanis, Pēteris Misāns

3D visualization system consists of a multilayer optical shutter screen and a projection system. High-frame rate projector projects images on shutter screen. Projector is based on spatial light modulator (for example, Texas Instruments Digital Micromirror Device), that consists of a number of micromirrors, displaying a binary image. To achieve image with desired color depth, several light modulation methods can be used – binary pulse width modulation, light source intensity modulation and mixed modulation. Color depth is defined in a number of bits per pixel (or color), for example, for three colors, 8 bits per color there are 16.7 million color variances.

Binary pulse width modulation, light source is set to maximum brightness and color depth bits are time-modulated using spatial light modulator (with binary-weighted time periods – least significant bit is output for one time step, next bit for double the previous time steps, etc.)

Light source modulation implies, that required color depth is modulated by showing binary patterns a fixed time period while adjusting light source intensity for each binary pattern (least significant bit is output with X intensity, next significant bit with 2X intensity, next with 4X, etc.

Mixed modulation implies that color depth bits are output with combined binary pulse width modulation and light source intensity modulation. Mixed modulation is defined as bit combinations of (x,y), where x digit defines bits modulated with pulse width modulation and y digit defines bits modulated with light source intensity modulation.

Better projection system parameter trade off (refresh rate versus luminance versus color depth) can be achieved by using mixed modulation. For example, output of 8 bits per color with system's refresh rate of at least 50Hz, mixed modulation shows higher overall luminance.

Mixed mode application for spatial light modulator based projection system is shown in figure. Figure depicts that application of mixed modulation (2,6), (1,7) results in higher luminance than for pulse width modulation or light source intensity modulation alone.

System analysis shows that overall luminance increase is from 49 to 68% based on bits per color for 50Hz minimum refresh rate. Higher increase, over 100% is achieved for 25Hz minimum refresh rate.