The layer-based holographic rendering algorithm working in conjunction with the dynamic CIH display enables us to calculate the holograms with all appropriate depth cues, including full-parallax, accommodation cue, occlusion and perspective. The algorithm's rapid speed reduces the computation time for a full holographic frame with all the relevant 3D cues, from theoretically hours or even days down to seconds, even when rendered from a single graphic card. While still not real-time, further optimization, the use of multiple graphics cards, the improvement of GPU computation, and increased data transmission speeds will also lead to the real time holographic video.

9. Conclusion

A new holographic display structure – dynamic Coarse Integral Holography, is used to create a video frame rate, full colour, full parallax holographic video display. This structure uses opto-mechanical scanning and coarse integral optics for efficiently reorganizing information from a low SBP high-bandwidth SLM to create dynamic holograms with a large SBP at video rates. An overall hologram frame consisting of 141.6 Megapixels for each of three colours is presented at a frame rate of 23.33 fps, equal to a rate of 10 billion bps from a single display device.

A multi-view multi-layer holographic rendering algorithm (Appendix) works in conjunction with the optical system to further optimise the use of the display's available bandwidth by removing visual and object redundancies, while providing important view dependent cues such as occlusion/disocclusion and being conducive to parallel computation on GPUs.

Appendix

n1. For solid angle with a rectangular field of view.

$$\Omega = (\phi_2 - \phi_1) \times (\cos\theta_2 - \cos\theta_1)$$

$= \Delta\phi \times (\cos \pi/2 - \cos(\pi/2 - (\theta_2 - \theta_1))$, with $\theta_1 = \pi/2 - (\theta_2 - \theta_1)$, $\theta_2 = \pi/2$:

$= \Delta\phi \times \sin \pi/2 \times \sin(\theta_2 - \theta_1)$

$\approx \Delta\phi \times \Delta\theta$, for small vertical/polar fields of view:

where $\Delta\phi$ is the horizontal/azimuthal diffraction range bound by $[\phi_1, \phi_2]$ and $\Delta\theta$ is the vertical/polar diffraction range bound by $[\theta_1, \theta_2]$ for the rectangular solid angle Ω in spherical coordinates.

n2. $1{,}024 \times 768 = 0.78 \times 10^6$

n3. 10.24 mm $\times$ 7.68 mm $\times$ $1.81°$ $\times$ $1.81° = 257.64$ mm^{2}deg^2

n4. $1{,}920 \times 1{,}080 \times 1$ bit $\times$ $23{,}148$ Hz $= 47.99$ Gbits/sec

n5. $1{,}920 \times 1{,}080 \times 8$ bit $\times$ $100 = 1.66$ Gbits/sec

n6. $\sin^{-1}(4 \cdot 0.633/13.68 + \sin(-12°)) - \sin^{-1}(3 \cdot 0.633/13.68 + \sin(-12°)) = 2.654°$ which is close to the same diffraction range when on-axis illumination is used $\sin^{-1}(1 \cdot 0.633/13.68) = 2.652°$ with only a $(2.654 - 2.652)/2.654 = 0.07\%$ difference.

n7. $(30 \times 6) \times (1{,}024 \times 768) = 141.6$ Mega pixels

n8. 23.33 fps × 30 views × 6 views × 3 colours = 12,600 frames per second

n9. $[23{,}430 \times 23.33] / [43.4 \times 22{,}727] = 55.4\%$

n10. 1,024 × 768 × 1,000 × 50 (horizontal views) × 30 (vertical views) × 3 (colours) × 25 (video rate) × 8 (256 grey levels) ~2.35×10^{14} bits per second (bps)

n11. (1,024 × 768) pixels × 50 horizontal view × 30 vertical views × 3 colours channels × 25 fps × 8 bits per pixel = 2.35×10^{11} bps

n12. 1,024 × 768 × 30 horizontal views × 6 vertical views × 3 colours = 4×10^8

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