Real-time Content Adaptive Depth Retargeting for Light Field Displays

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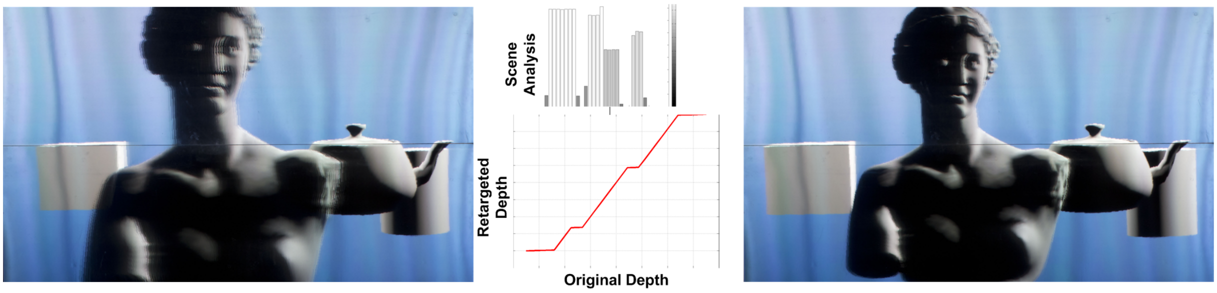

Figure 1: *Our method automatically analyses the scene and generates a non-linear function to constrain the scene depth to the depth range of a light field display.*

Abstract

Light field display systems present visual scenes using a set of directional light beams emitted from multiple light sources as if they are emitted from points in a physical scene. These displays offer better angular resolution and therefore provide more depth of field than other automultiscopic displays. However in some cases the size of a scene may still exceed the available depth range of a light field display. Thus, rendering on these displays requires suitable adaptation of 3D content for providing comfortable viewing experience. We propose a content adaptive depth retargeting method to automatically modify the scene depth to suit to the needs of a light field display. By analyzing the scene and using display specific parameters, we formulate and solve an optimization problem to non-linearly adapt the scene depth to display depth. Our method synthesizes the depth retargeted light field content in real-time for supporting interactive visualization and also preserves the 3D appearance of the displayed objects as much as possible.

Categories and Subject Descriptors (according to ACM CCS): I.3.2 [Computer Graphics]: Graphics Systems—Distributed/network graphics I.3.3 [Computer Graphics]: Picture/Image Generation—Display algorithms

1. Introduction

Recent developments in glasses free 3D display technologies show that the key factor that contributes to the effectiveness of 3D visualization is the display angular resolution. HoloVizio light field displays use a holographic diffuser that allows directional light transmission with minimum aliasing and can provide high angular frequency [BKM07]. However, due to the discrete nature of the system aliasing is inevitable, especially when displaying objects at depths outside the depth of field of the display. In the current work, we propose an approach to automatically modify the 3D scene to suit to the depth characteristics of a light field display.

2. Related Works

[LHW*10] proposed a method for remapping stereoscopic 3D disparities using a non linear operator that warps the stereo images independently. [MWA*13] explored the central view of light field to generate a mapping function to globally warp the light field. [APM*11] developed a display adaptive depth retargeting method that preserves depth planes closer to the screen plane.

3. Depth Retargeting

We assume a geometrical representation of the scene. By iterating through all the mesh nodes in a scene, we compute the depth space occupied by each mesh node in real world. To ensure smooth transition between successive depth steps in display space, we quantize the scene depth space into various depth zones. We then estimate a depth histogram to find out the salience inside each quantized depth zone. The number of quantization steps is carefully chosen to reduce perspective distortions at object boundaries. Using the saliency information, we formulate and solve a convex optimization problem to estimate the quantized depth values in display coordinates. Our aim is to minimize: $\sum_{i=0}^{qn-1} \frac{1}{2} K_i (S_i - X_i)^2$ where, qn is the number of quantized depth zones, K_i and X_i are the salience and length of i^{th} quantized depth zone. In our case, all the depth zones have equal lengths. The above optimization is subject to boundary conditions: $S_0 + S_1 + S_2 + S_3 + ... + S_{qn-1} = DisplayDepth$; $S_i < \rho$ & $S_i > \sigma, i = 0, 1, ..., qn-1$ where ρ and σ are the maximum and minimum size limits of the resulting depth zones. Generally, light field displays have higher spatial resolution on the screen plane and thus, important scene regions are usually rendered on the surface of the screen. To ensure that the objects on the screen plane remain on the screen after retargeting, we impose a third boundary condition: $S_0 + S_1 + S_2 + S_3 + ... + S_{(qn/2)-1} = (DisplayDepth)/2$. The resulting values $S_0, S_1, .., S_{qn-1}$ are the required lengths of constrained depth zone lengths within display depth of field. For a given vertex in world, the position in retargeted display space is computed using piecewise linear interpolation.

4. Results and Conclusions

Our main contribution from the current work is on-the-fly content aware depth retargeting in synthetic environment for light field displays. We analyze the scene depth characteristics and solve an optimization problem in real-time (60 FPS) to generate a non-linear mapping to display. The optimization is continuously fed with saliency information which makes the approach also usable for dynamic scenes. Results (see Figure 2) show that our method can be used to produce visually pleasing interactive light field content. In future work, we plan to extend this concept to retarget the light field rendered from image-based content given as multiview images.

5. Acknowledgements

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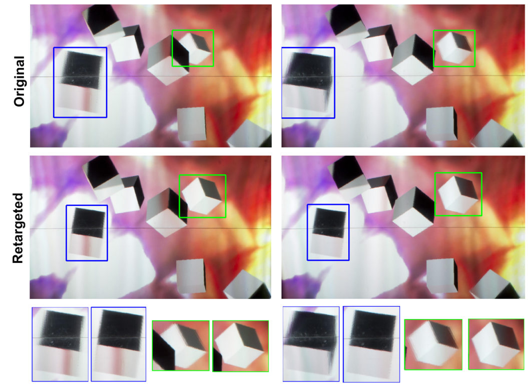

Figure 2: *Retargeting results recorded after displaying on a light field display. Top row: two views of original light field content. Middle row: corresponding depth retargeted views. Bottom row: close-ups of retargeting results.*

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