CS276 Homework 1: Light Field Rendering

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1 Introduction

The purpose of this assignment is to perform refocusing based on light field data and to experiment with different aperture effects. The input for this assignment is a 16x16 image matrix, referencing classic projects such as Lytro camera data processing.

2 Implement

2.1 Light Field Loading

The 16x16 light field input used for the text is shown in Figure 1.

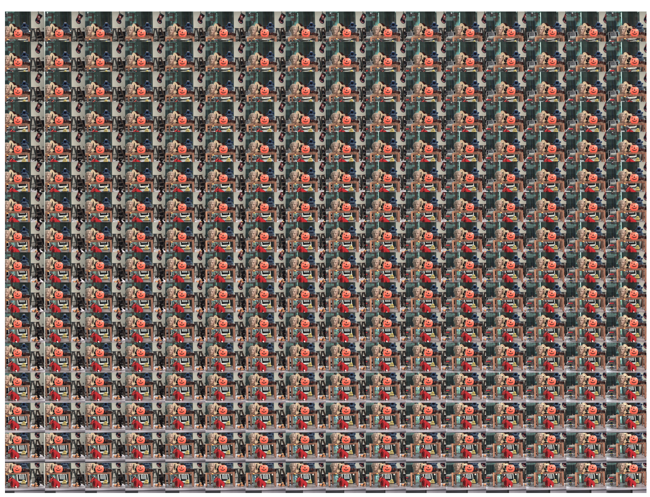


Figure 1: 16x16 Light Field Input

To create a light field, multiple images are captured from various viewpoints and organized into a 5D data structure, represented as:

$$\text{Light Field}(u, v, x, y, c)$$

where (u, v) represent the camera indices, (x, y) are the pixel coordinates, and c denotes the color channels. Each image is resized and stored in the array, ensuring uniform dimensions for accurate interpolation.

2.2 Interpolation Resampling

Interpolation is a crucial step in rendering the light field. Two primary interpolation methods are employed:

2.2.1 Bilinear Interpolation

For bilinear interpolation, the pixel value $I(x, y)$ at an arbitrary position is calculated using:

$$I(x, y) = w_a \cdot I_a + w_b \cdot I_b + w_c \cdot I_c + w_d \cdot I_d$$

where w_a, w_b, w_c, w_d are the weights based on the neighboring pixel values.

2.2.2 Trilinear Interpolation

In a 3D light field, trilinear interpolation is utilized, which extends the bilinear approach into the depth dimension. The formula is given by:

$$\begin{aligned} I(x, y, z) = & I_{000}(1 - x)(1 - y)(1 - z) + I_{100}(x)(1 - y)(1 - z) \\ & + I_{010}(1 - x)(y)(1 - z) + I_{110}(x)(y)(1 - z) \\ & + I_{001}(1 - x)(1 - y)(z) + I_{101}(x)(1 - y)(z) \\ & + I_{011}(1 - x)(y)(z) + I_{111}(x)(y)(z) \end{aligned}$$

2.3 Focal Plane Control

Let the camera position be $C = (x_c, y_c)$ and the focus distance be f. The distance from a pixel point $P = (x, y)$ to the camera position is calculated as:

$$d = \sqrt{(x - x_c)^2 + (y - y_c)^2}$$

The weight w for each camera view can be computed using the Gaussian function:

$$w = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{d^2}{2\sigma^2}}$$

where σ is related to the aperture size, influencing the weight distribution.

2.4 Aperture Control

Let A be the aperture size, which affects the weight calculation. A larger aperture allows more camera views to contribute to the final image. The relationship can be described as:

$$w \propto \frac{1}{A}$$

This means that as the aperture increases, the weight distribution becomes flatter, impacting the clarity and detail of the final image.

2.5 Z-Axis Control

The focal length factor F simulates depth along the z-axis. The displacement in the x and y directions for each camera view can be calculated as:

$$dx = (col - x_c) \cdot F \cdot \frac{width}{f}$$

$$dy = -(row - y_c) \cdot F \cdot \frac{height}{f}$$

Here, (col, row) represents the position of the camera view, and $(width, height)$ are the dimensions of the final image. The blur effect in the final image is controlled by the kernel size:

$$\text{blur\_kernel\_size} = \max(1, \text{int}(F \cdot 2))$$

3 Experiments

3.1 GUI interface

The user interface of this assignment consists of the components shown in the Figure 2, which includes 6 control sliders, 1 display page, and 1 confirm button.

3.2 Interpolation Resampling

The comparison of results between bilinear interpolation and trilinear interpolation is shown in Figure 3. In the relatively undersampled lower-left corner, the effect of multiple interpolations is superior.

3.3 Focal Plane Control

3.4 Aperture Control

3.5 Z-Axis Control

4 Conclusion

This work presented a comprehensive overview of light field rendering, detailing the underlying principles and implementation techniques. The experiments

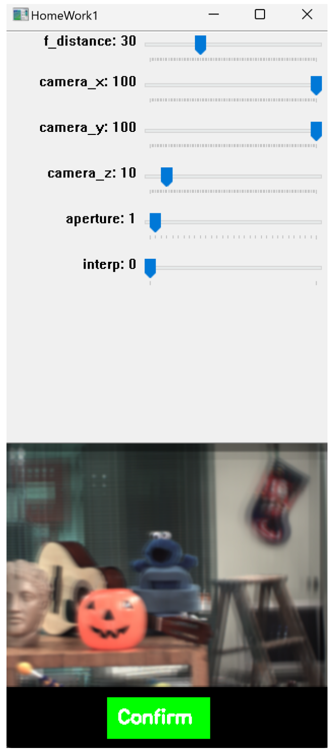
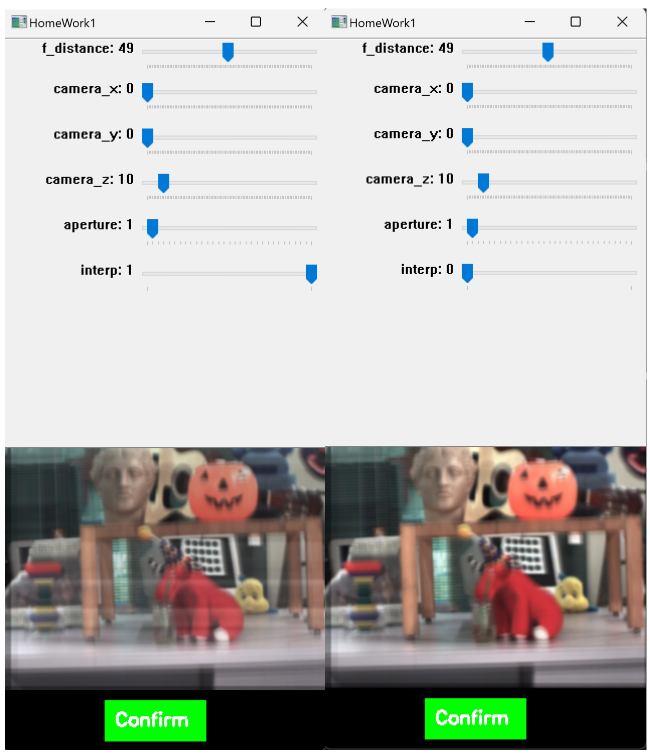


Figure 2: User interface overview

highlighted the benefits of using advanced interpolation methods and the impact of camera parameters on rendering quality. Future work will explore more complex scenes and real-time rendering capabilities, further enhancing the interactive experience in light field visualization.

References

[1] Author, A. (Year). *Title of the paper*. Journal Name, Volume(Issue), Page range.



(a) Bilinear interpolation (b) Trilinear interpolation

Figure 3: Comparison of interpolation resampling