

High-Quality Stereo Image Restoration from Double Refraction Supplemental Document

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1. Birefractive Image Synthesis

Double-refraction images are synthesized by Algorithm 1. The function `remap` is an interpolation function in 2D. \mathbb{I}_x and \mathbb{I}_y are 2D arrays representing x and y coordinates of all pixels. Therefore, the function `remap` warps o-ray images into e-ray images. It acts as spatial transformation that samples the value from the pixel location defined in the flow-field grid, where grid values are coordinates translated by the amount of birefractive disparity from the current pixel location. As declared in Line 5 of Algorithm 1, the maximum operator between the o-ray to e-ray disparity and the shifted disparity prevents empty hole formation by depth-based image rendering (DBIR). This approach allows for dense backward warping, instead of the typical forward warping, while the typical DIBR method naturally fills holes using the color of the background.

Algorithm 1 Double refraction image simulation

Input: \mathbf{I}_o, d_{oe}

$$d_{max} = \max(d_{oe})$$

$$d_{shift} = \text{remap}(d_{oe}, \mathbb{I}_x + d_{max}, \mathbb{I}_y)$$

$$d_{shift} = \text{remap}(d_{shift}, \mathbb{I}_x + d_{shift} - d_{max}, \mathbb{I}_y)$$

$$d_{shift} = \max(d_{shift}, d_{oe})$$

$$\mathbf{I}_e = \text{remap}(\mathbf{I}_o, \mathbb{I}_x + d_{shift} - d_{max}, \mathbb{I}_y).$$

$$\mathbf{I}_b = (\mathbf{I}_e * \tau + \mathbf{I}_o) / (1 + \tau)$$

return $\mathbf{I}_b, \mathbf{I}_e$

2. Depth Range

We assume the depth range for acceptable estimation is the range, where a change of one meter in depth is reflected by a change of one pixel or more in the disparity. As the disparity d_{oe} w.r.t. depth z and baseline c is expressed as $d_{oe} = \frac{c}{z}$, the disparity variation w.r.t. depth is $\frac{d}{dz}d_{oe} = -\frac{c}{z^2}$. Therefore, $|\frac{d}{dz}d_{oe}| \geq 1$ is reached if $z \leq \sqrt{c}$. With the calibrated baseline $c = 6.756$ px·m, we obtain $z \leq 2.599$ m. In addition, the baseline c increases linearly with the birefringent material thickness and focal length, as shown in [1], meaning that a larger depth range

can be achieved by changing those parameters. A smaller pixel pitch also naturally increases the disparity while the aperture size has no effect on the birefractive stereo baseline, as opposed to the depth-from-defocus methods.

References

- [1] Seung-Hwan Baek, Diego Gutierrez, and Min H Kim. Birefractive stereo imaging for single-shot depth acquisition. *ACM Transactions on Graphics (TOG)*, 35(6):1–11, 2016.