Depth from Spectral Defocus Blur
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**Goal**

**Our Goal:** Simultaneous acquisition of clear multispectral image and scene depth from a blurred single multispectral image

- Spectral Images (450-700nm)

500nm Image 650nm Image

- Different wavelength images have different focal positions

**Depth Clues:** Conventional depth-dependent blur and wavelength-dependent blur (known as chromatic aberration)

**Imaging Model**

Captured Image \( \rightarrow \) Gaussian Blur \( \rightarrow \) Texture (Pinhole)

\[ I(x, y, \lambda) = k(x, y, \sigma(\lambda)) \ast P(x, y, \lambda) \]

- Both \( k \) and \( P \) are dependent on the wavelength \( \lambda \)

\[ \text{Depth} = \frac{\alpha(\lambda) \Delta I}{\beta(\lambda) \Delta I - \partial_\lambda I} \]

- \( x, y \): spatial coordinates
- \( \alpha, \beta \): lens parameters
- Depth \( Z \) can be derived by two types of derivative of captured image [1]; one is spatial (\( \Delta I \)) and the other is spectral (\( \partial_\lambda I \))

**Method**

**Theory:** Depth \( Z \) is actually derived as a closed form by the lens rule and the two types of derivatives of Gaussian blur

- Lens rule
  \[ \sigma(\lambda) = \left( \frac{1}{Z} - \frac{1}{f(\lambda)} \right) \mu_s + 1 \]

- \( \gamma \): RMS width of Gaussian
- \( f \): focal length of the lens
- \( \mu_s \): distance from the lens to the sensor

**Computation:** \( \Delta I \) is obtained as laplacian filter. \( \partial_\lambda I \) is approximated as the change of blurriness \( B = I(\lambda) - I_{\text{focused}}(\lambda) \).

\[ \partial_\lambda I = \partial_\lambda k \ast P = \left( k(\lambda_i) - k(\lambda_j) \right) \ast P \approx B(\lambda_i) - B(\lambda_j) \]

- Focal connected image are also utilized to generate clear multispectral image

**Results**

Scene Input Depth Original-Sharpen Comparison

- 450nm
- 650nm

Website of our laboratory

[1]: Q.Guo, et al. ICCV’17, pp.966-974
[2]: H.Hariharan, et al. CVPR’07, pp.1-6