1 Camera Profiling

1.1 Obtaining the conversion parameters

- Values y in RAW files aren't directly poisson distributed with variance y. Assume that observation y is generated from Poisson distributed signal c according to

$$y = \alpha c + \beta, \tag{1}$$

  with scale factor α and offset β.

- Counts c of real value x are noisy according to Poisson statistics $\mathcal{P}$:

$$c = \mathcal{P}(x) \tag{2}$$

- x is expectation value

- Standard deviation σ of Poisson is square-root of expectation value:

$$\sigma = \sqrt{x} \tag{3}$$

- Thus:

$$y = \alpha\mathcal{P}(x) + b \tag{4}$$

$$\Leftrightarrow \frac{y - \beta}{\alpha} = \mathcal{P}(x) \tag{5}$$

- Expectation value m of mean for measurement y over a flat patch with identical expectation values x:

$$m = \alpha x + \beta \tag{6}$$

$$x = \frac{m - \beta}{\alpha} \tag{7}$$

- Measured standard deviation σ' :

$$\sigma' = \alpha\sigma = \alpha\sqrt{x} \tag{8}$$

- It follows:

$$\Rightarrow \sigma' = \alpha\sqrt{\frac{m - \beta}{\alpha}} = \sqrt{\alpha(m - \beta)} \tag{9}$$

- Thus, the conversion parameters α, β can be estimated by fitting the measured standard deviation σ' as a function of the measured mean m according to:

$$\sigma' = \sqrt{\alpha(m - \beta)} \tag{10}$$

1.2 Transforming measurement to poisson-distributed counts

- The measured values y can then be converted to counts with poisson-noise according to

$$c = \frac{(y - \beta)}{a} \tag{11}$$

- Back-Transform is according to above:

$$y = \alpha c + \beta, \tag{12}$$

1.3 Ascombe transformation

- Variance stabilization for transformed data c using Anscombe tranform:

$$\tilde{c} = 2\sqrt{c + \frac{3}{8}} \tag{13}$$

- After denoising, the denoised signal $\tilde{c}_d$ can be transformed back using

$$c_d = \frac{\tilde{c}_d}{4} - \frac{1}{8} + \sqrt{\frac{3}{2}}\frac{\tilde{c}_d^{-1}}{4} - \frac{11}{8}\tilde{c}_d^{-2} + \frac{5}{8}\sqrt{\frac{3}{2}}\tilde{c}_d^{-3} \tag{14}$$

1.4 Transformation from values

- Ascombe transformation, directly from measurement:

$$\tilde{c} = 2\sqrt{\frac{(y - b)}{a} + \frac{3}{8}} \tag{15}$$

- Inverse Ascombe transformation directly to image values y_d:

$$y_d = \alpha\left(\frac{\tilde{c}_d}{4} - \frac{1}{8} + \sqrt{\frac{3}{2}}\frac{\tilde{c}_d^{-1}}{4} - \frac{11}{8}\tilde{c}_d^{-2} + \frac{5}{8}\sqrt{\frac{3}{2}}\tilde{c}_d^{-3}\right) + \beta \tag{16}$$

2 NL Means

- Filter image $\vec{y}$, obtaining denoised Pixel u_i:

$$u_i = \frac{\sum_{j \in \Omega_i} w_{ij} y_j}{\sum_{j \in \Omega} w_{ij}} \tag{17}$$

- Ω_i: Group of pixels whose neighborhood is evaluated for non-local Mean of pixel y_i.
- Weights w_{ij} from patches $\vec{p}_i, \vec{p}_j$ around pixels y_i, y_j according to

$$e^{-\frac{||\vec{p}_i - \vec{p}_j||^2}{Nh^2}}, \tag{18}$$

with number of pixels N in a patch.

3 Application to RAW data

- For profiling, profile each color filter individually by concatenating the pixels in the RAW image with each filter to a respective sub-image that is profiled indicidually
- Transform all pixels according to Equation 15 with α, β for their respective color filter.
- For filtering a pixel y_i according to equation 17, construct Ω_i only of pixels that have the same position in the repeating Bayer pattern.