A radiometric response function relates sensor irradiance and brightness values. Radiometric calibration aims at recovering the inverse response function. Our method avoids over-regularization and can achieve close-to-ideal calibration for multiple exposure based method.

### Transform Invariance Low-Rank Structure

- Radiometric calibration problem as Low-rank recovery problem
- An irradiance matrix has a low-rank structure

### Calibration Algorithm

- Rank minimization $\rightarrow$ Nuclear norm (sum of the singular values) minimization
- Response function changes not only the rank, but also the spectral norm (the largest singular value) of a matrix. The spectral norm changes after response function

We minimize the condition numbers (a ratio of singular values)

- Main factors causing rank variations:
  - Nonlinearity of response function
    - Low-frequency nature: monotonic and smooth curve
    - Only 2nd condition number has large value
  - Image noise
    - High-frequency nature: zero mean Gaussian random noise
    - All the condition numbers have very affected

Cost function

$$\hat{g} = \arg \min_G \| G \|_F + \lambda \sum_i H(\frac{\partial g_i(t)}{\partial D}) \quad \text{s.t. } A = g \circ D$$

$g$: response function

$D$: observation matrix

$H(x) = 1$ if $x \geq 0$, otherwise $H(x) = 0$

### Experiments

- Simulation of multiple exposure based method
- 201 response functions in DoRF
- 4 radiance distributions
- Gaussian noise with $\sigma=0.005, 0.010, 0.020, 0.030$

### Conclusions

- We introduce radiometric calibration algorithm that use low-rank structure of irradiance matrix.
- Radiometric calibration is formulated as rank minimization and solved by the condition number minimization.
- Our method can avoid over-fitting.
- Our method can be applied to various kind of radiometric calibration problems.

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Quantitative results using the synthetic dataset in comparison with Misunaga and Mayer’s method (M4).

- Effects of condition numbers (D1, D2)
- Results of synthetic experiments (D1, D3)