# Automatic Radiometric Calibration from Motion Images

Ricardo R. Figueroa
Assistant Professor, Motion Picture Science
GCCIS Part-time PhD Student
Jinwei Gu, Pengchen Shi
Advisors

# Topics

- Motivation
- Image Interchange Framework (IIF) Background
- State of the Art on Response Function Estimation Methods
- Methodology
- Initial Results
- Path Forward

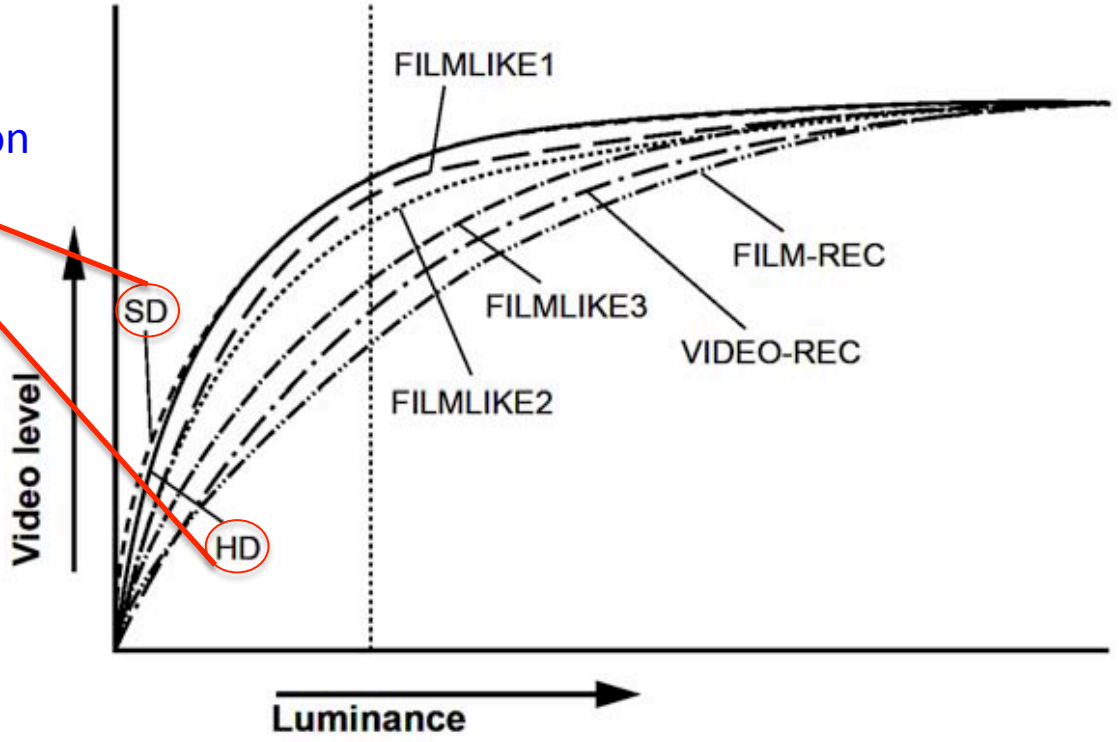
# Motivation

- Understanding of the camera response function provides:
  - Camera characterization
  - Irradiance/Radiance from measurements
  - Different source matching (IIF)
  - Surpass current electronic camera limitations
  - HDR imaging

# Motivation - Why?

- Example - Electronic camera limitations

Also known as Gamma correction curves

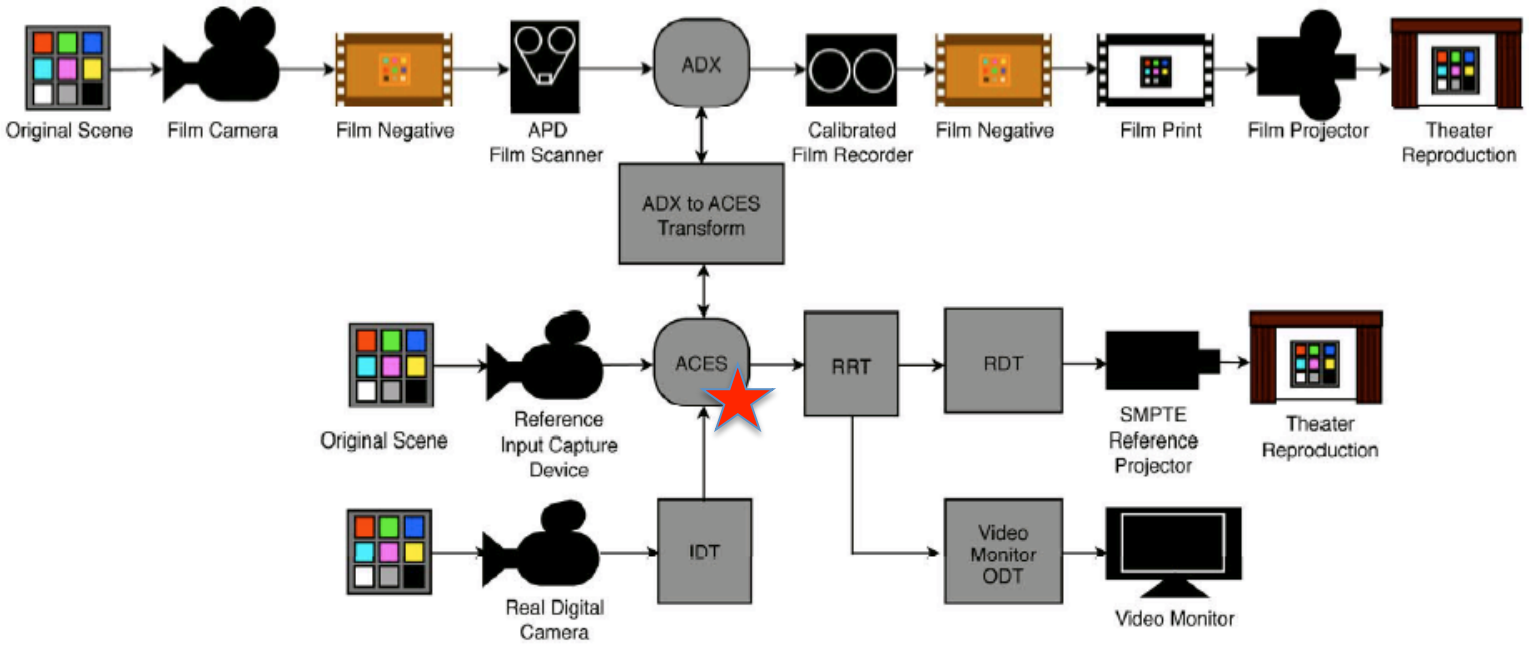



Graph borrowed from "Best Practices Guide to Digital Cinematography Using Panasonic Professional HD Cameras"

# Motivation - IIF

## Idealized System

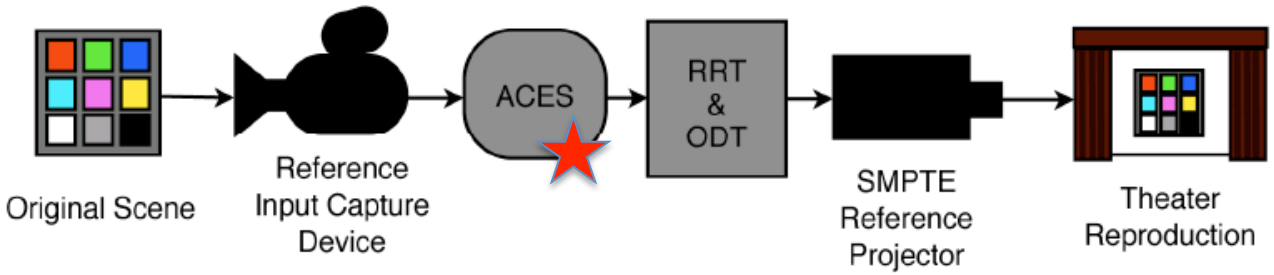
SCIENCE & TECHNOLOGY COUNCIL



# Motivation - IIF

## Brief Technical Overview

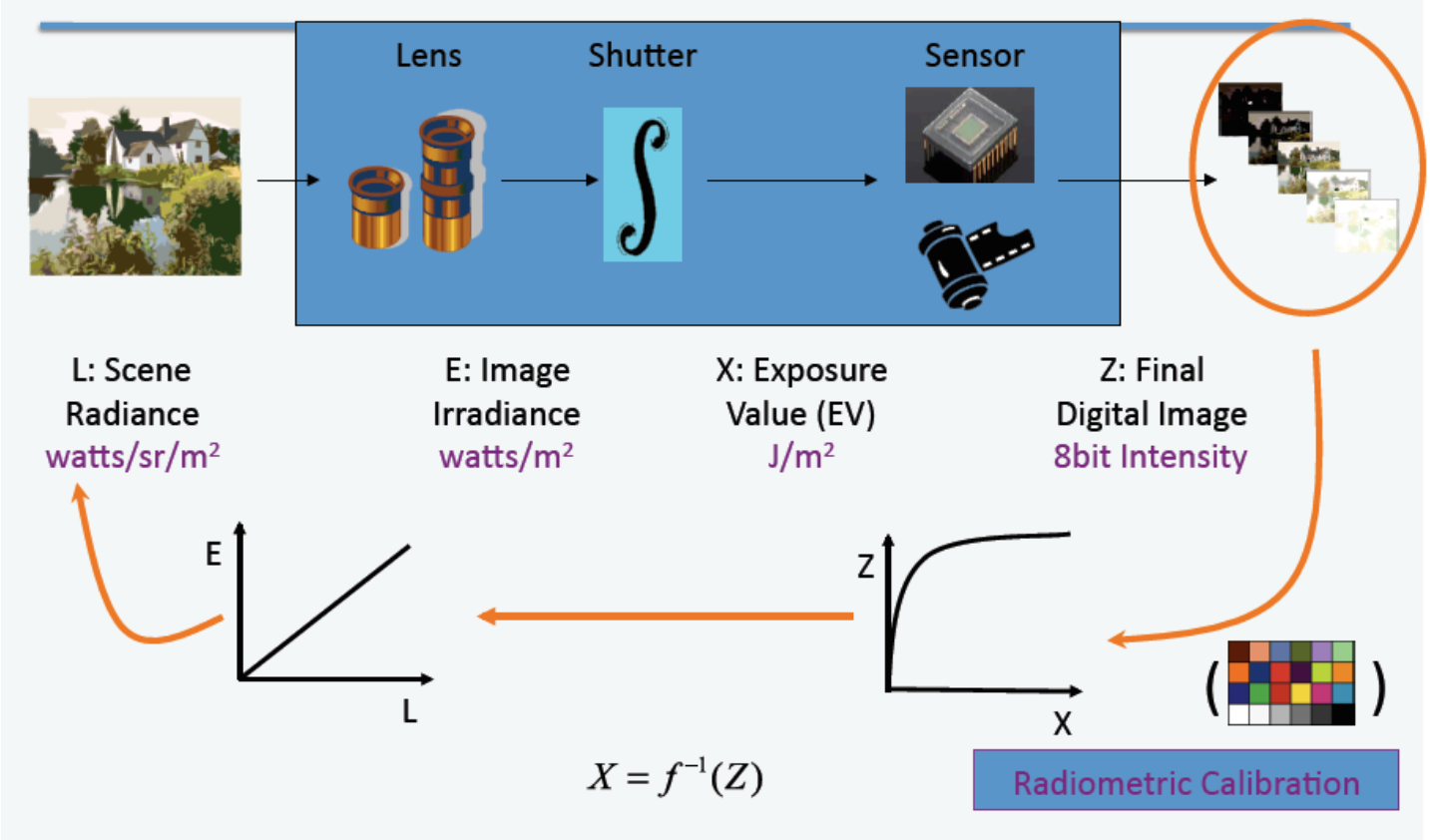
SCIENCE & TECHNOLOGY COUNCIL




- Academy Color Encoding Specification (ACES)
  - A Radiometrically Linear Light Encoding
  - We provide methodology to get from any source (Film, Digital, etc.) into ACES

# Motivation – Research Problem

- From Radiance to Code Values

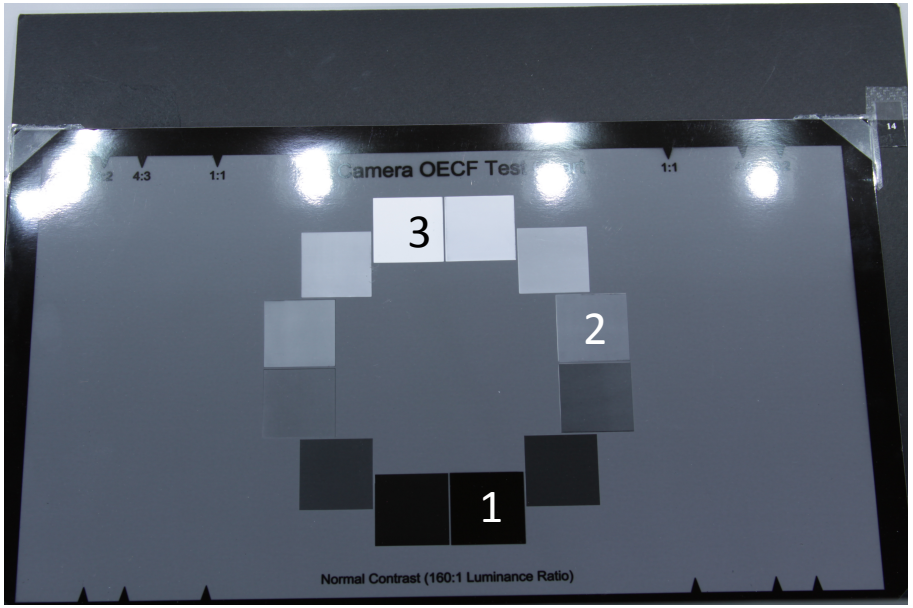


# Background - Previous Work

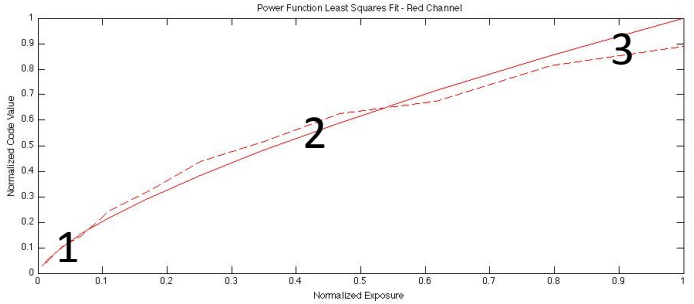
- Radiometric Calibration Methods
  - Direct chart measurement
  - Multiple exposures
  - Single image (physical image attribute)
  - Photo collections (aggregate statistic)

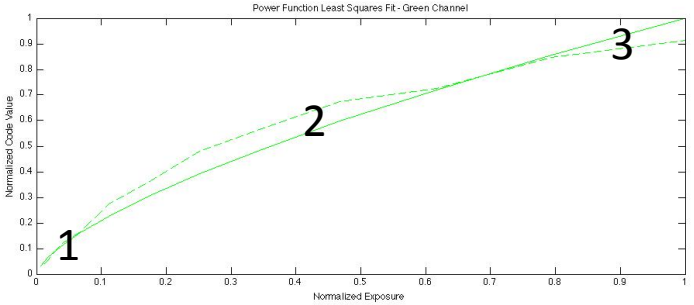
# Background - Response Function Estimation

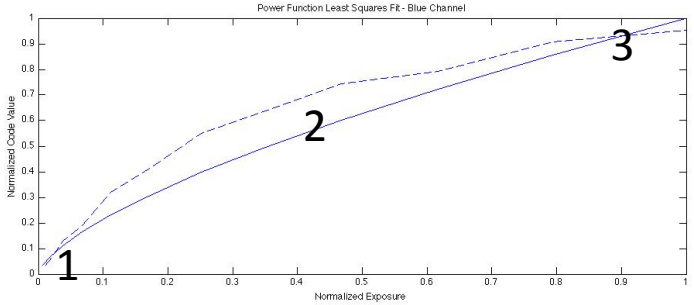
- Direct measurement




Opto-Electronic Camera Function CHART



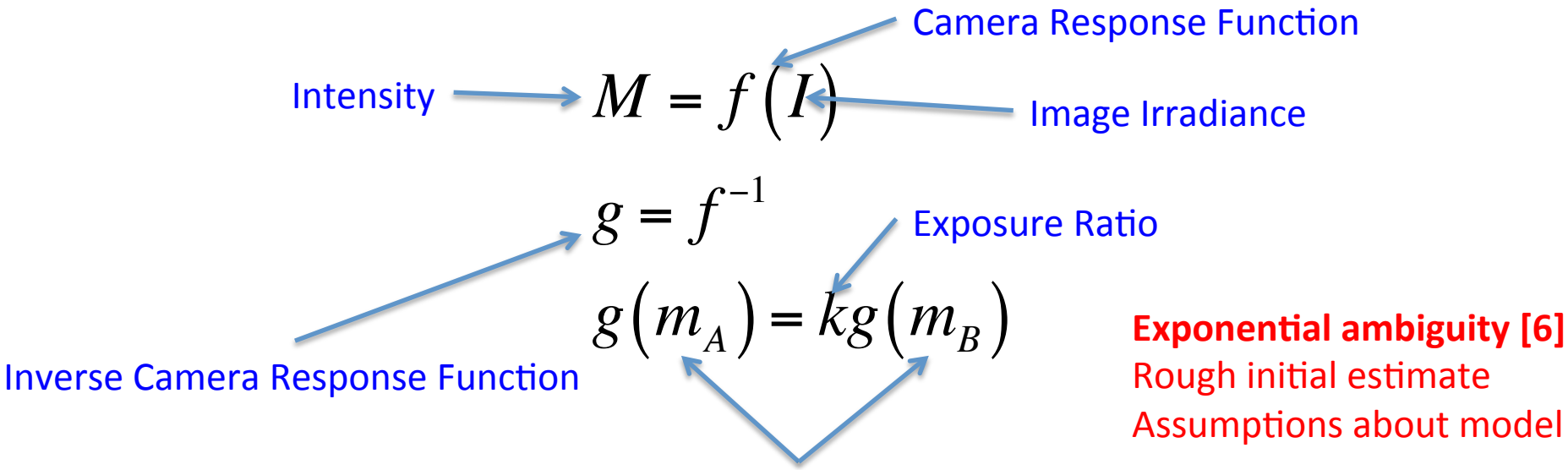



# Background - Response Function Estimation

- Multiple exposures

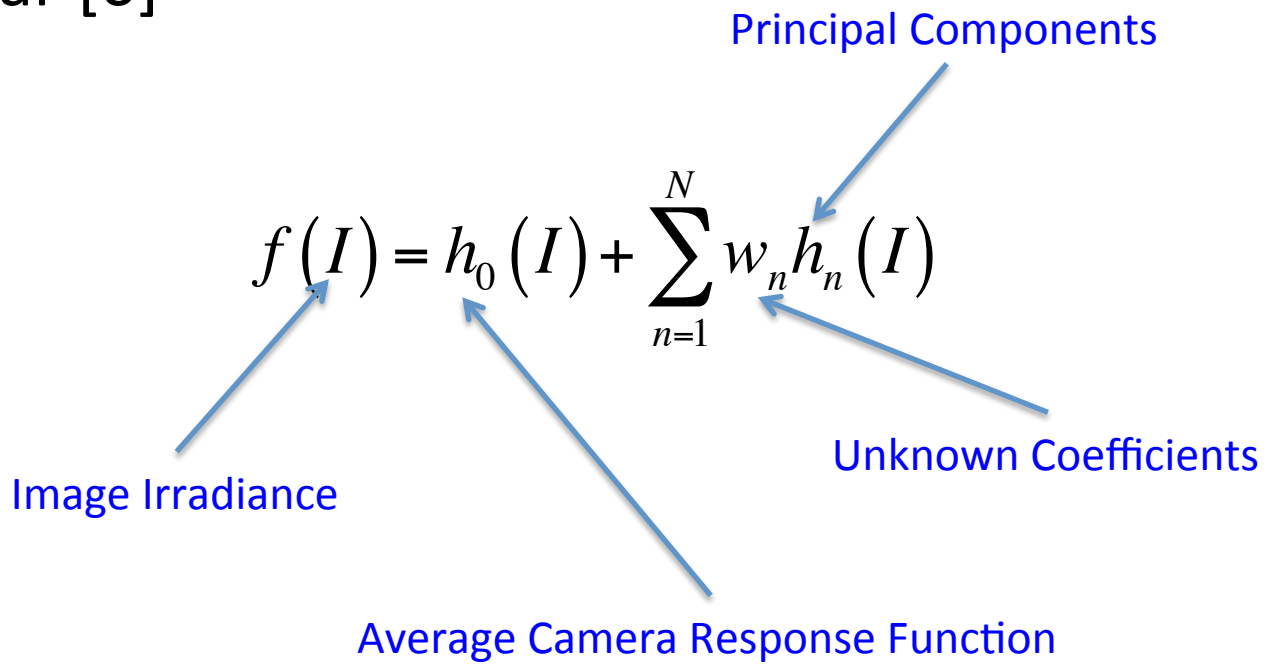
# Background - Response Function Estimation

- Automatic Camera Function Calibration
  - Debevec and Malik [2]
  - Mitsunaga and Nayar [3]



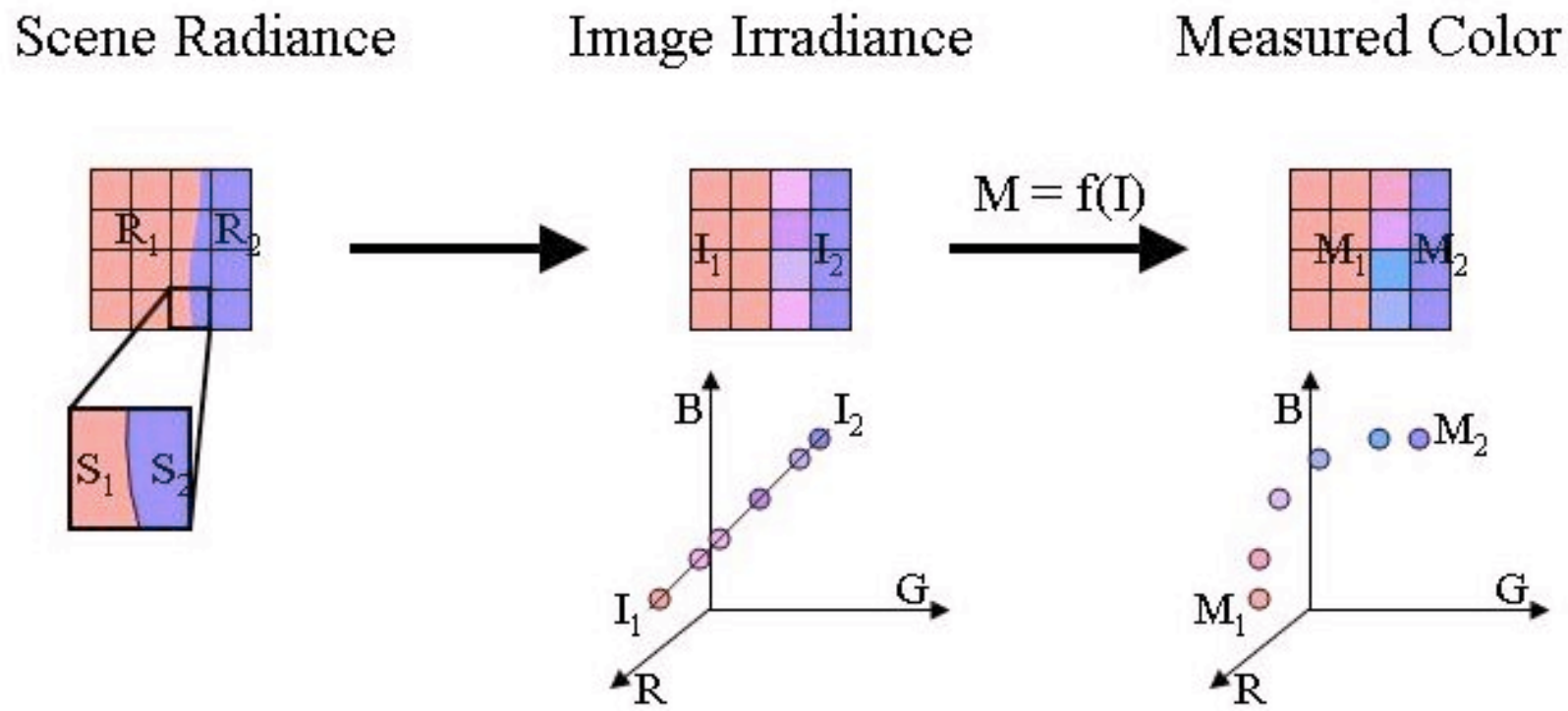
# Background - Response Function Estimation

- From Radiance to Code Values and Back
  - Popular camera response model by Grossberg and Nayar [6]



# Background - Response Function Estimation

- Single Image Analysis [4]
  - Measured edge color distributions
  - Minimization of distance from $f^{-1}(M)$ to I



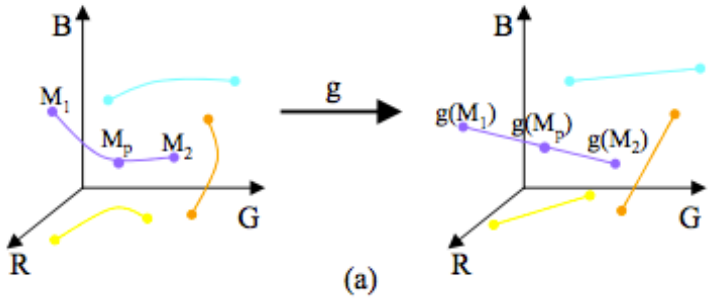
# Methodology

- Expanded Lin et al. [4] work to include multiple frames
  - How?
    - Look at color edges across multiple frames
    - Color edge detection
    - Add correlation constraint to response estimation
    - Do we need a prior in the estimation
  - Why?
    - Increase amount of color edge data available
    - Avoid binary response
    - Additional data might be sufficient for estimation

# Methodology

- Distance calculation

$$D(g;\Omega)=\sum_{\Omega}\frac{\left|\left[g(M_1)-g(M_2)\right]\times\left[g(M_1)-g(M_p)\right]\right|}{\left|g(M_1)-g(M_2)\right|}$$




- Bayesian Estimation

$$g=\arg\min\ \lambda D(g;\Omega)-\log\ p(g)$$

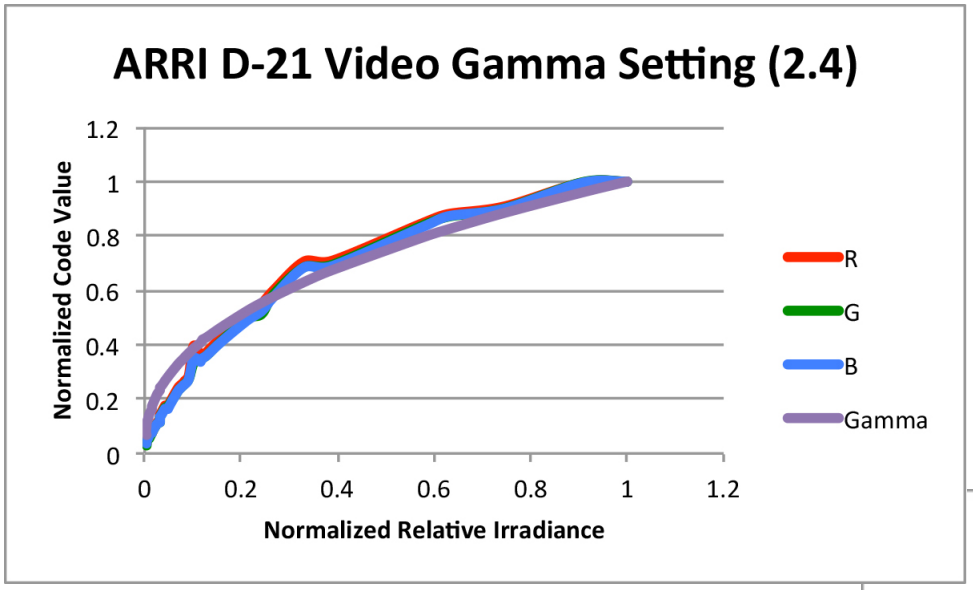
Prior – GMM of DoRF [6]

# Initial Steps - Camera/Sensor Data Collected

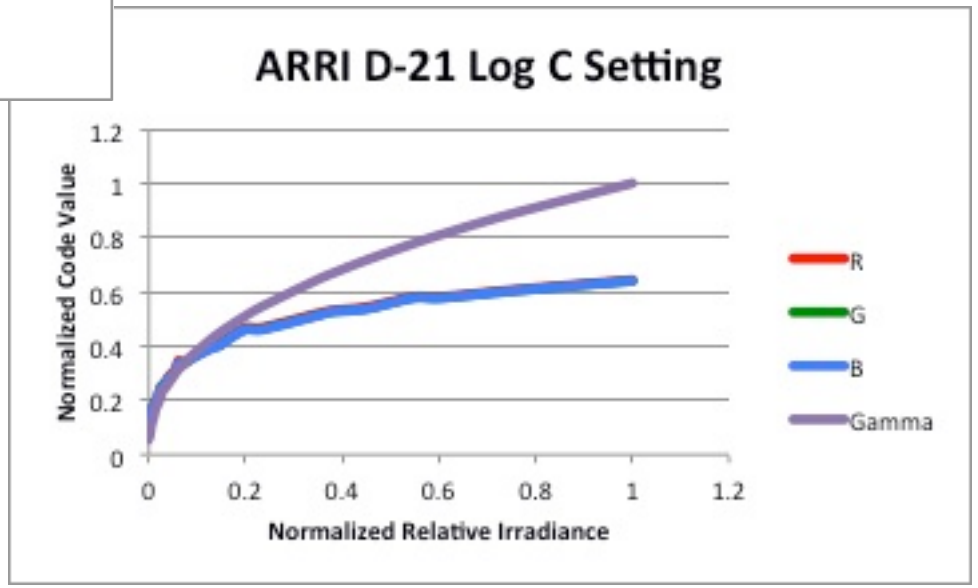
- Panasonic GH2
- Canon 5D MarkII
- Arri D-21 (2 modes)
- Eastman Kodak 7213 (200T)



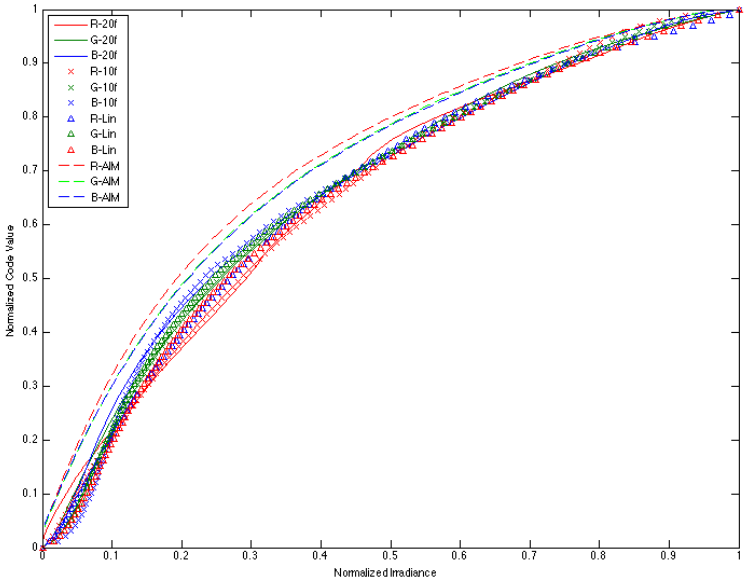

# Initial Steps - Camera/Sensor Data Collected





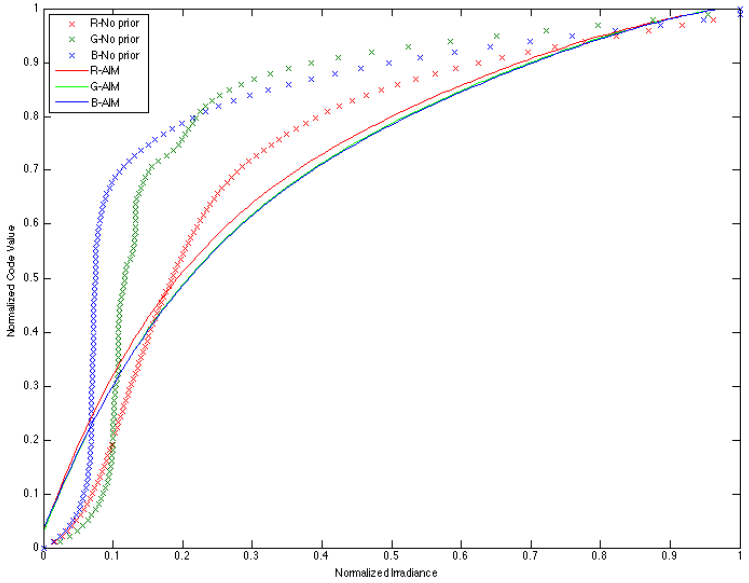


# Initial Results




Camera Response Estimates

Camera Response Estimates w/o Prior



# Path Forward

- Use video footage of additional camera models
  - 24 or 30 fps provided
- Study demosaicing algorithms on sets selected
- Understand image sequence statistics obtained from this footage
  - Obtain different priors for optimization
- Automatically obtain accurate camera response function from motion images

# References


- [1] http://www.oscars.org/science-technology/council/projects/iif.html
- [2] Paul E. Debevec and Jitendra Malik. Recovering high dynamic range radiance maps from photographs. In Proceedings of the 24th annual conference on Computer graphics and interactive techniques, SIGGRAPH '97, pages 369–378, New York, NY, USA, 1997.
- [3] Mitsunaga, T.; Nayar, S.K.; "Radiometric self calibration," Computer Vision and Pattern Recognition, 1999. IEEE Computer Society Conference on. , vol.1, no., pp.2 vol. (xxiii +637+663), 1999
- [4] Lin, S.; Jinwei Gu; Yamazaki, S.; Heung-Yeung Shum; , "Radiometric calibration from a single image," Computer Vision and Pattern Recognition, 2004. CVPR 2004. Proceedings of the 2004 IEEE Computer Society Conference on , vol.2, no., pp. II-938- II-945 Vol.2, 27 June-2 July 2004
- [5] Sujit Kuthirummal, Aseem Agarwala, Dan B Goldman, and Shree K. Nayar. "Priors for large photo collections and what they reveal about Cameras", 2008.
- [6] Grossberg, M.D.; Nayar, S.K.; "Determining the camera response from images: what is knowable?" Pattern Analysis and Machine Intelligence, IEEE Transactions on , vol.25, no.11, pp. 1455- 1467, Nov. 2003