PSYCH.221 Project Presentation

HDR Image Encoder for Brightside Display

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Outline

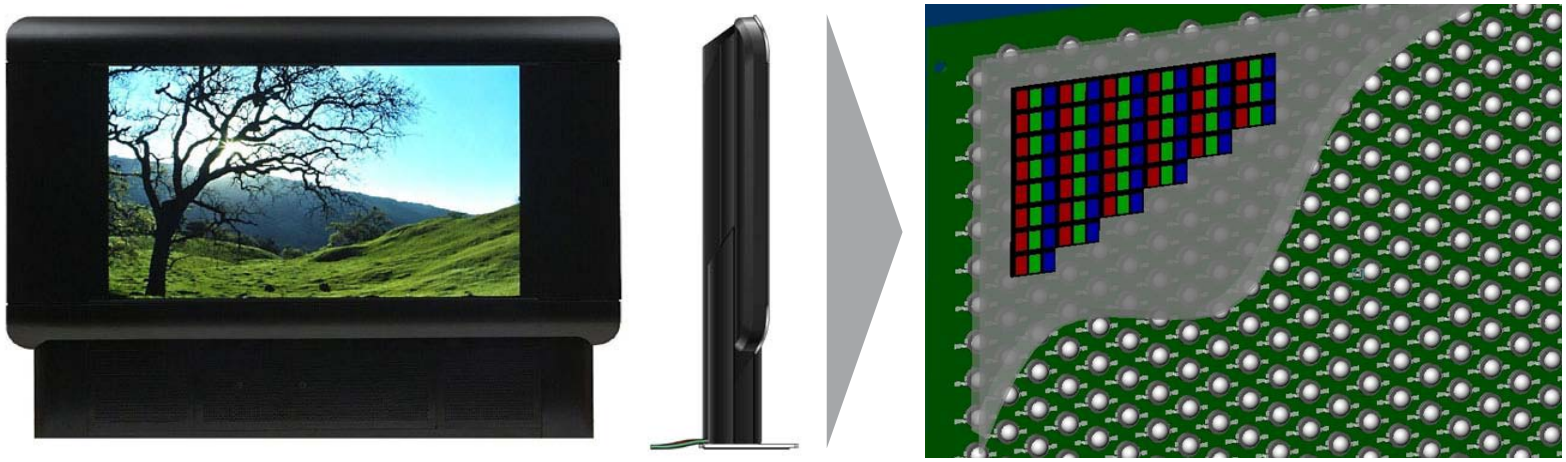
- **Object**
  HDR image encoding

- **Background**
  Image processing pipeline : HDR Image Capture $\Rightarrow$ Store $\Rightarrow$ Display

- **Implementation**
  HDR Image Encoder
  Improvements in solving optimization problem

- **Results**
  Visual comparison Brightside Display and Sharp Aquos Display

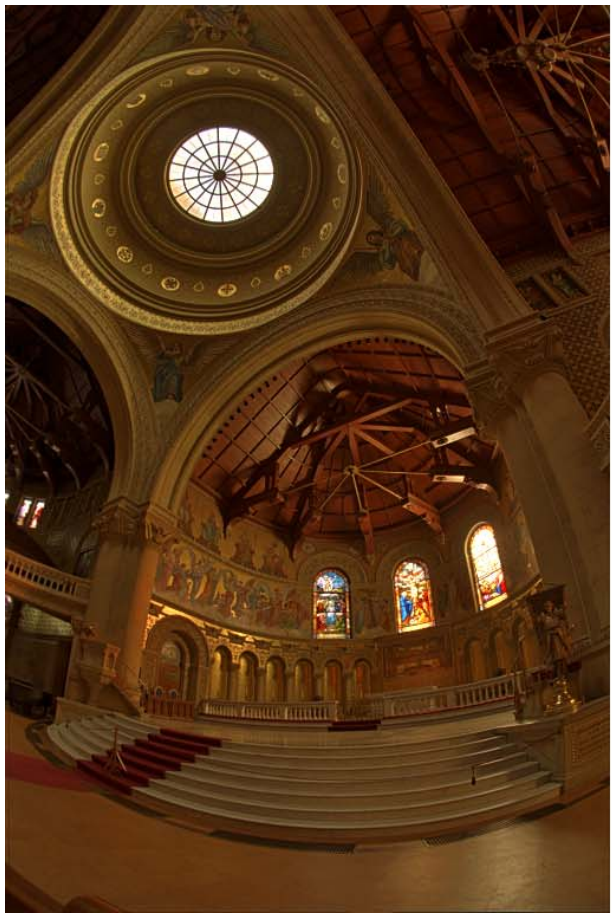
Object

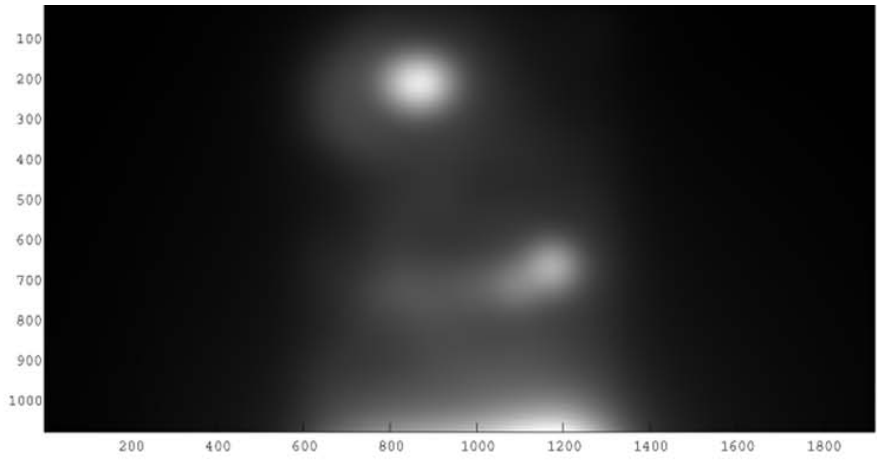


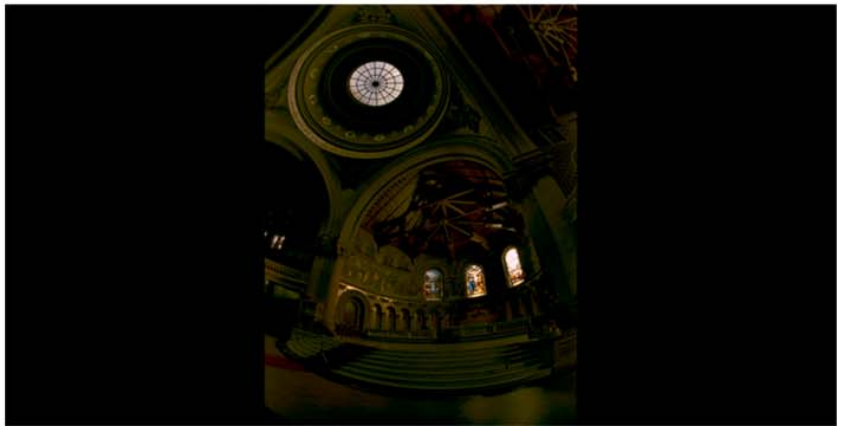
- Brightside has 2 modulation channels
  - Programmable LED array backlight $\Rightarrow$ High Dynamic Range
  - RGBcolor channel LCD front panel

	Dynamic Range(in cd/m^2)
Brightside Display	200,000:1
LC Display	1,000:1

Object







Goal : Separate input HDR image into two images(LED channel and LCD channel) s.t. when displayed on brightside, it represents the original image accuately

Background

HDR Image Capture ⇒ Store ⇒ Display

- Scene dynamic range exceeds 100,000:1

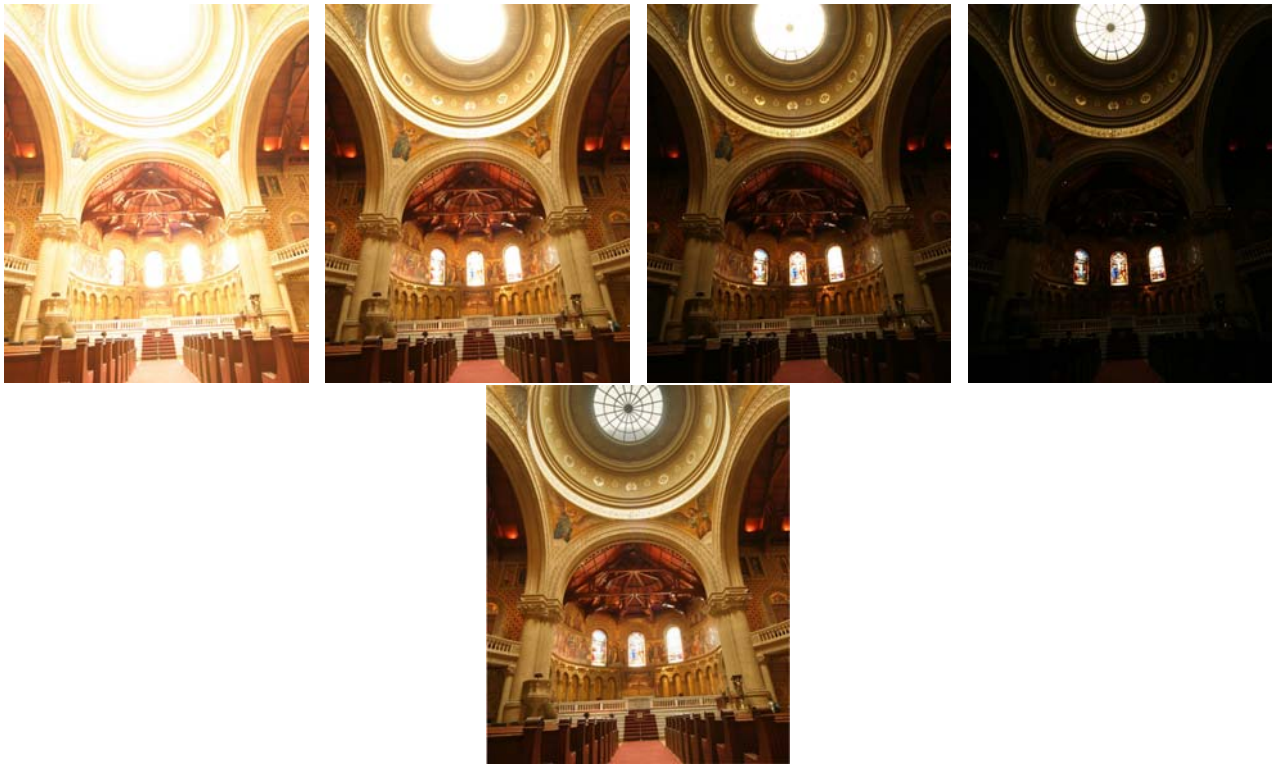


Figure 1: Memorial Church under various exposures (from PSY221 project 2006 by Tina Dong, Sufeng Li, and Michael Lin [10])

Background

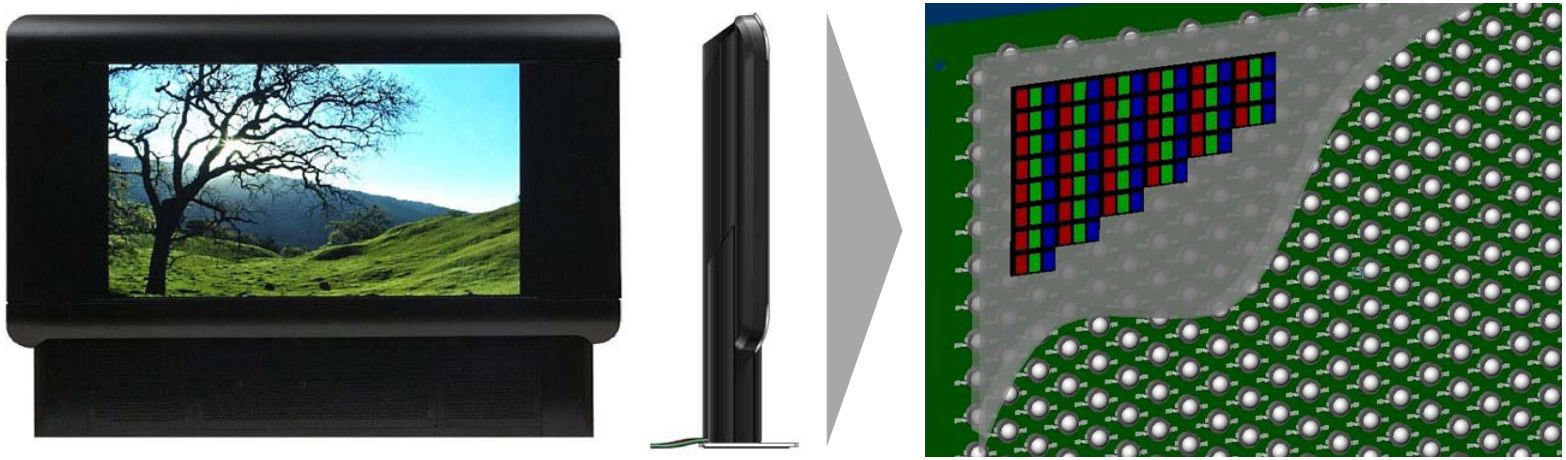
HDR Image Capture ⇒ **Store** ⇒ Display

Format	Encoding	bits/pixel	Dynamic Range	Relative Step
HDR	RGBE	32	76 orders	1.0%
	XYZE	32	76 orders	1.0%
TIFF	IEEE RGB	96	79 orders	0.000003%
	LogLuv24	24	4.8 orders	1.1%
	LogLuv32	32	38 orders	0.3%
EXR	Half RGB	48	10.7 orders	0.1%

Figure 2: Bit breakdown for the 32-bit/pixel RGBE encoding

Background

HDR Image Capture ⇒ Store ⇒ **Display**



- LED : 31×(44,45)
- LCD : 1080×1920

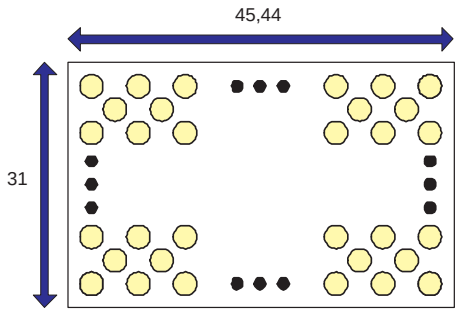
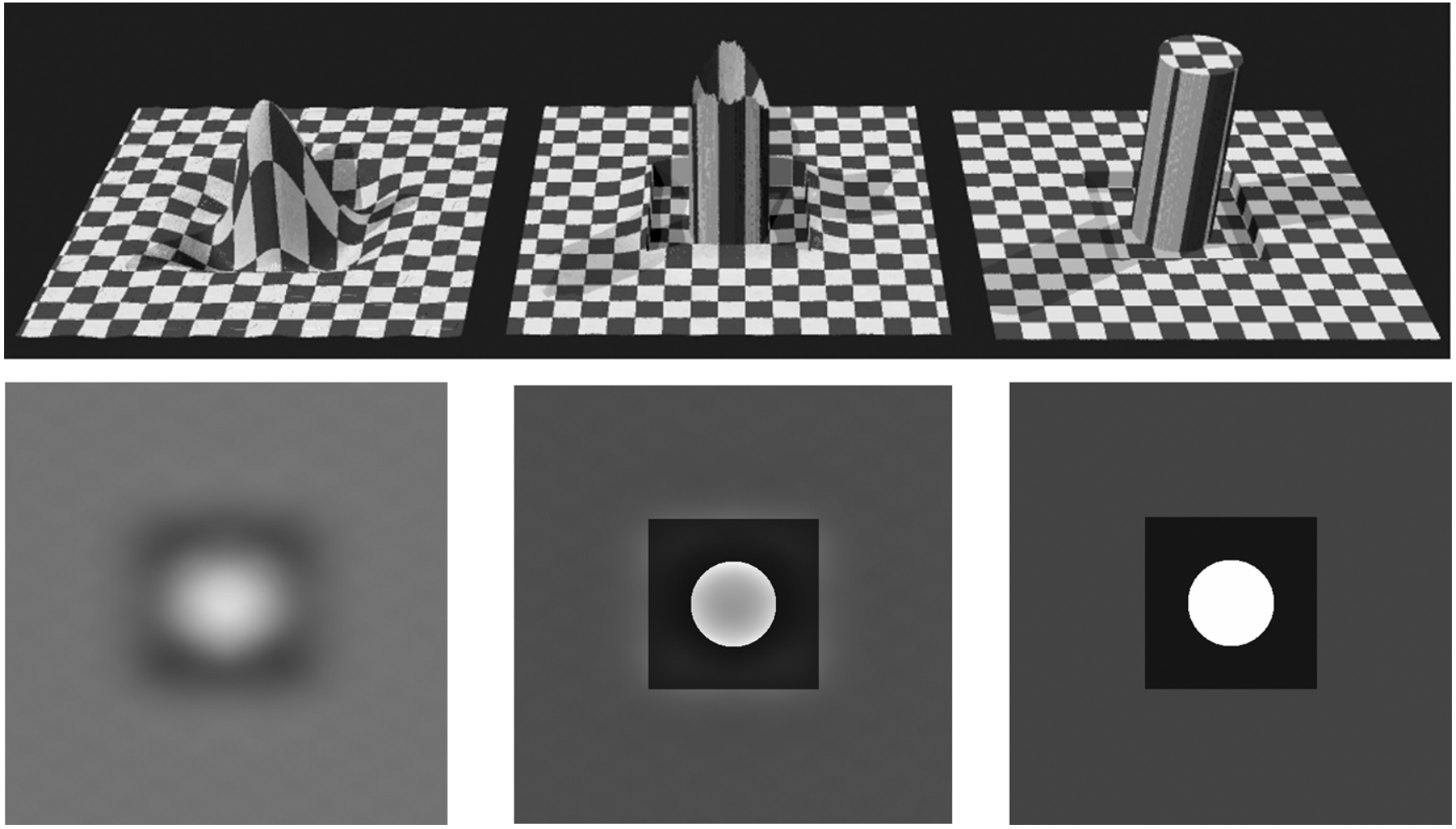
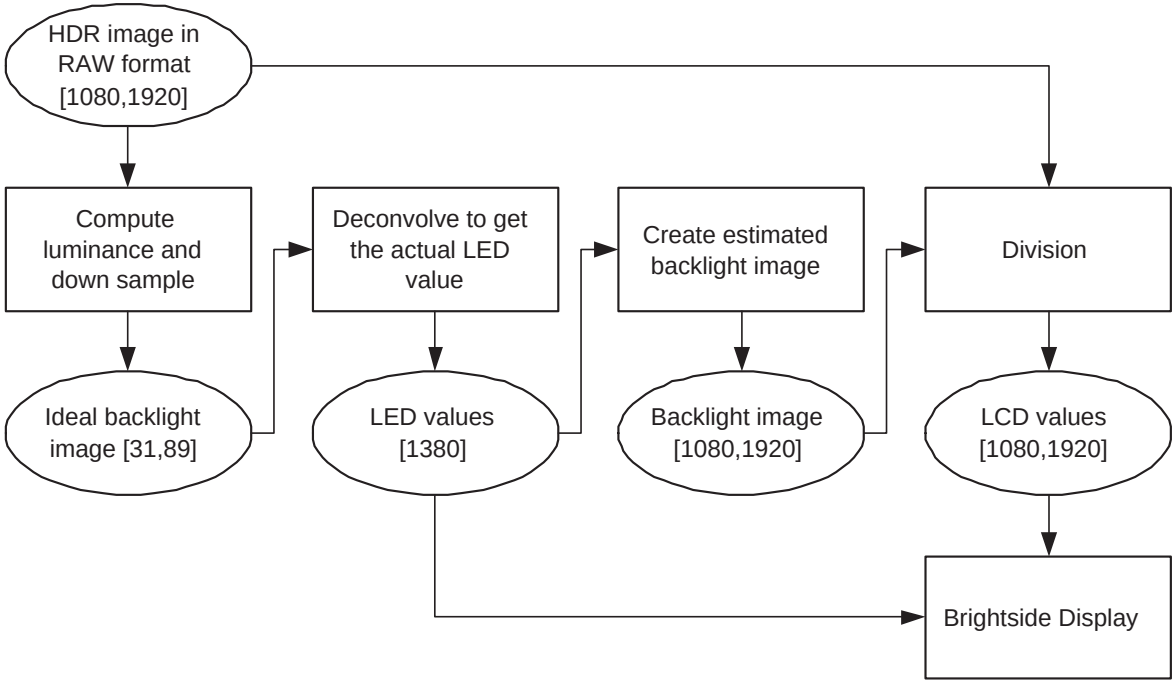
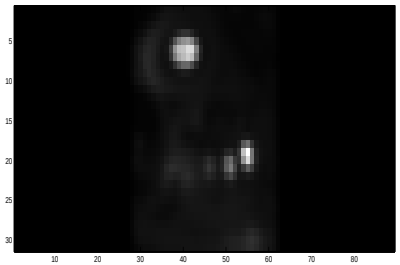


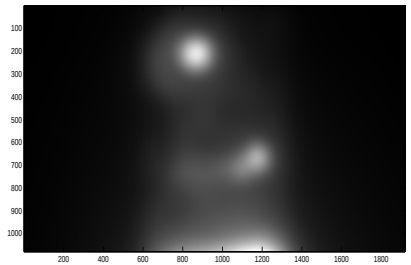
Image Processing



Implementation

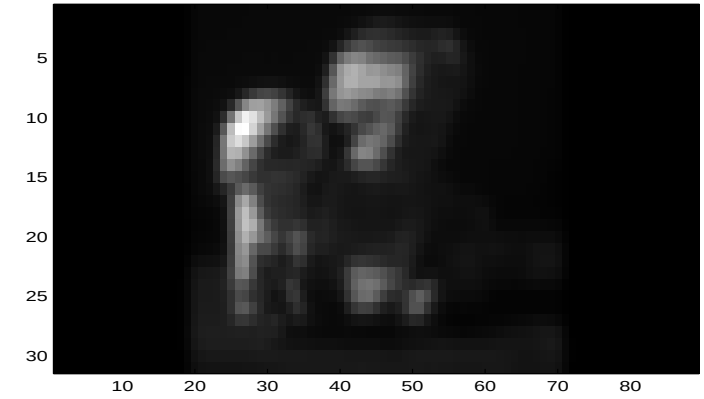


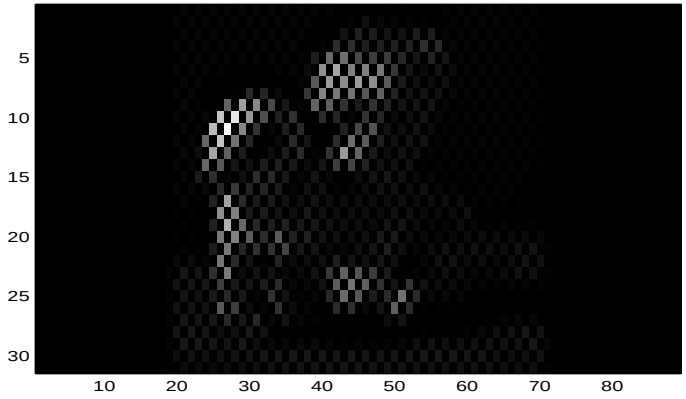


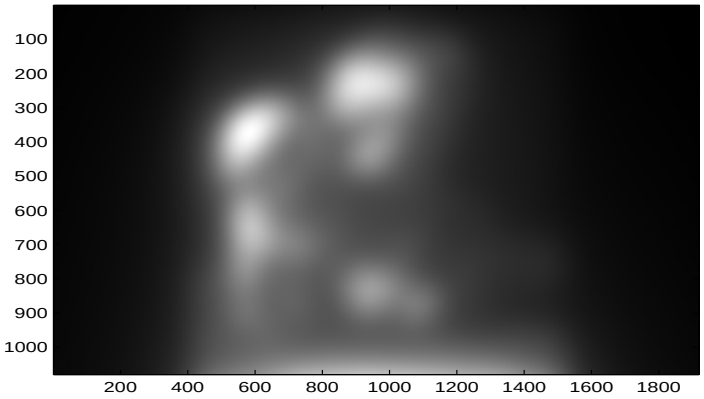


Implementation

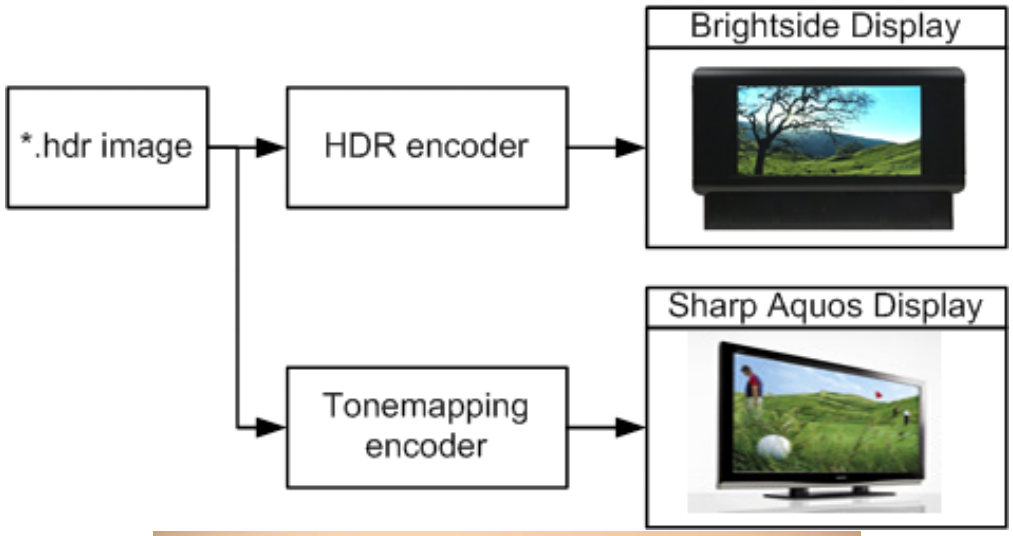
Implementation







Results


*.hdr image
HDR encoder
Brightside Display
Tonemapping encoder
Sharp Aquos Display

Results

Results

Conclusion

• Conclusion : LDR tone mapped image "looks better". But, HDR image repruduces the original scene more accurately.

• **Brightness**

Tone mapped image is brighter, especially in the dark regions. In the real scene those dark regions may not be visible to human eye, so in that sense, HDR image reproduces the real scene more accurately(left figure). However, when we recollect the image we know, we remember all the details, including those dark regions. Hence, we're more attracted to the tone mapped image, which represents the image in our memory(right figure).

• **Color**

Colors seem to be more clear in the tone mapped image, and colors seem to be saturated in HDR image. We are not sure which one represents the original color more accurately. For the same reason as before, our memory remembers colors to be somewhat stronger, and people like what they remember. However, we need more experiments on scene HDR images to confirm which algorithm or display is more accurate in reproducing the original color.

Suggestions

- Optimization problem for finding ideal backlight LED level.
- Color saturation.
- Tone mapping.

Ideas for finding ideal LED levels

Problem

$$minimize \quad |\underline{\mathsf{d}} - \underline{\mathsf{A}} * \underline{\mathsf{x}}|^2$$
$$subject \quad to \quad 0 \leq \underline{\mathsf{x}} \leq 1$$

- Method 1. Using CVX tools to directly solve the constrained least squares problem.[9]
- Method 2. Solving relaxed least squares with no constraints
- Method 3. Solving relaxed least squares with no constraints, and truncating all the solutions outside of the feasible set.
- Method 4. Using the original method of anti-crosstalk filtering.

Results

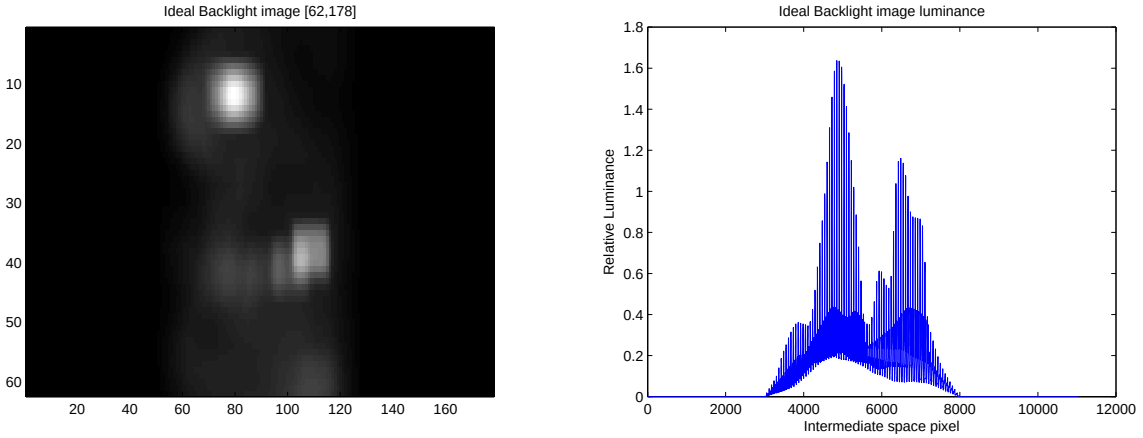


Figure 3: Ideal Backlight image

Results

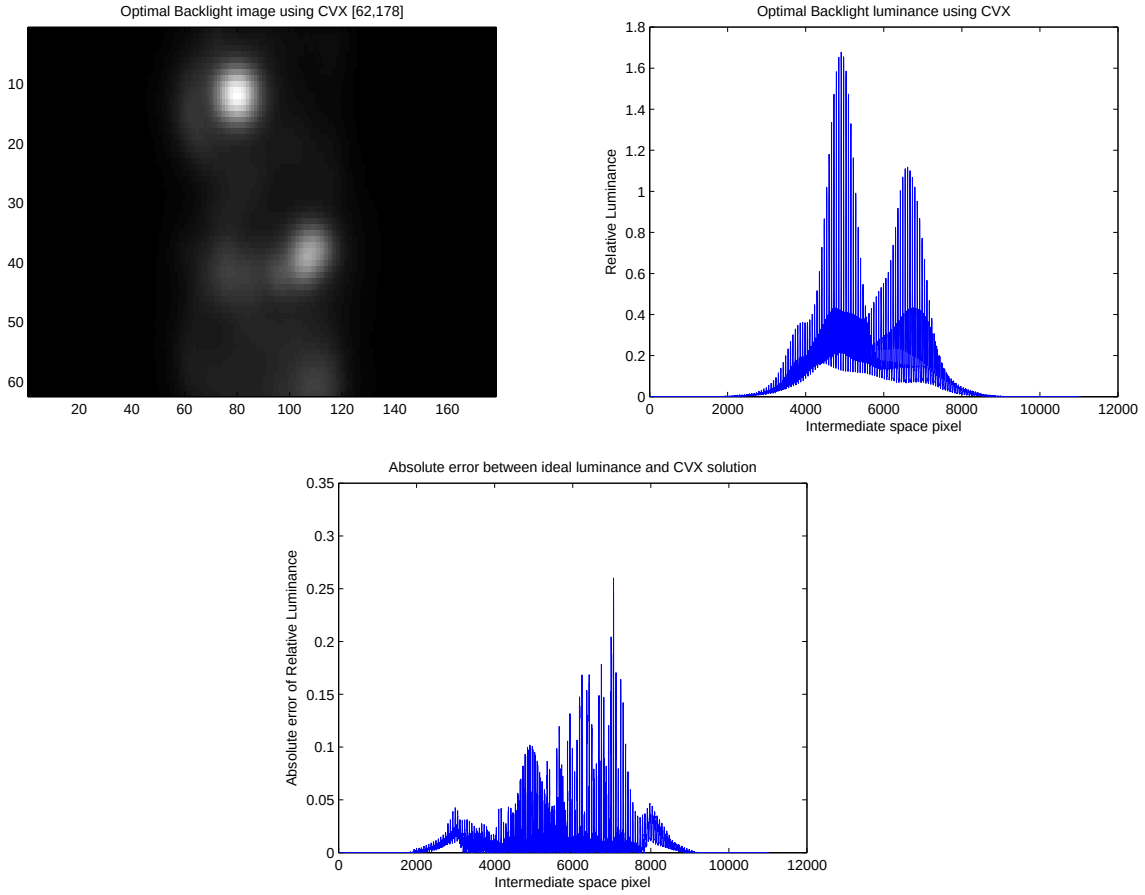


Figure 4: Optimal solution using CVX[9]

Results

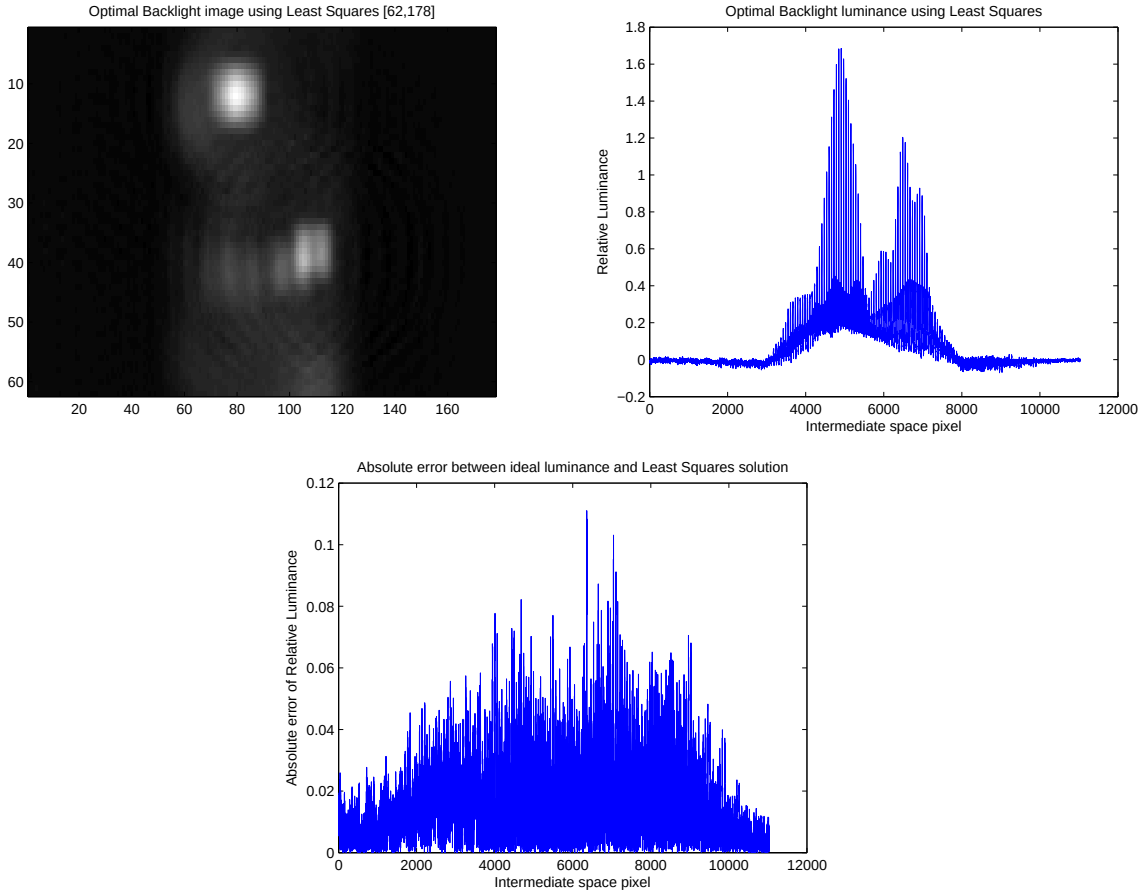


Figure 5: Optimal solution using Least Squares without the nonnegative constraints

Results

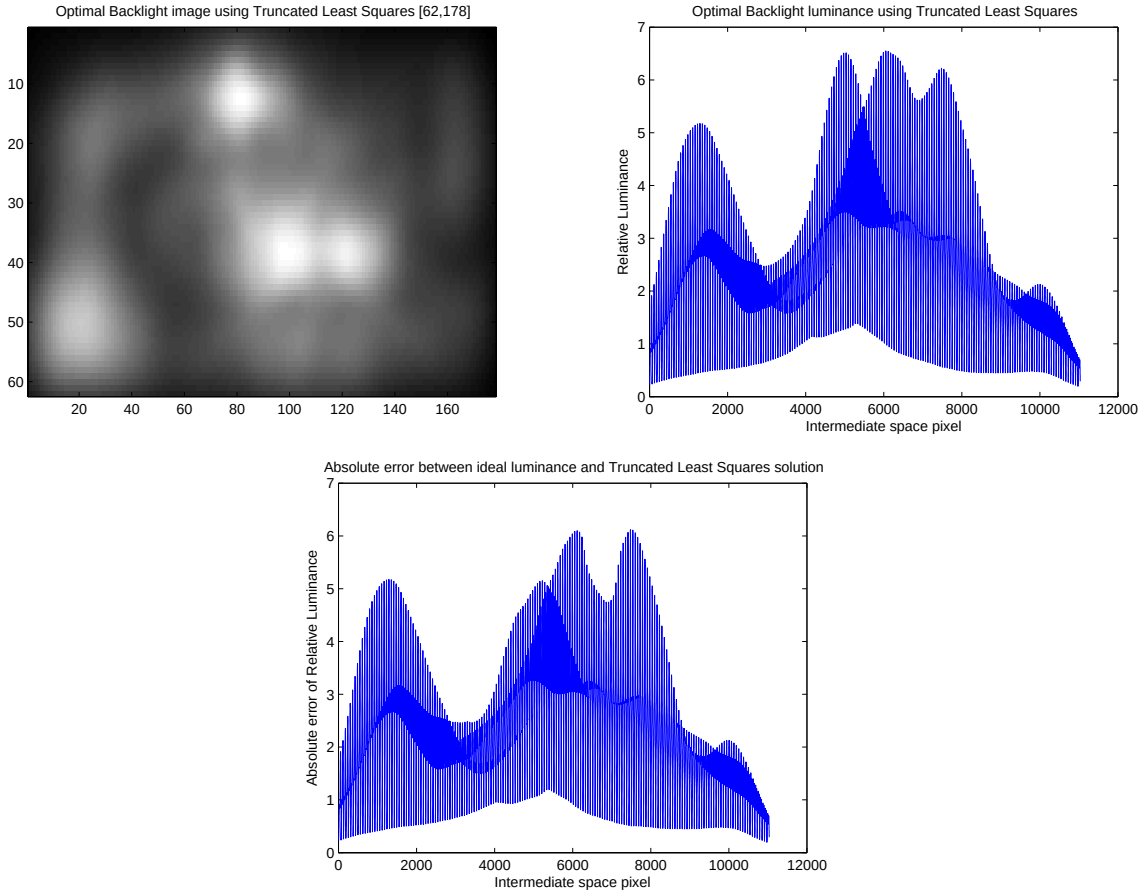


Figure 6: Optimal solution using Least Squares and truncation

Results

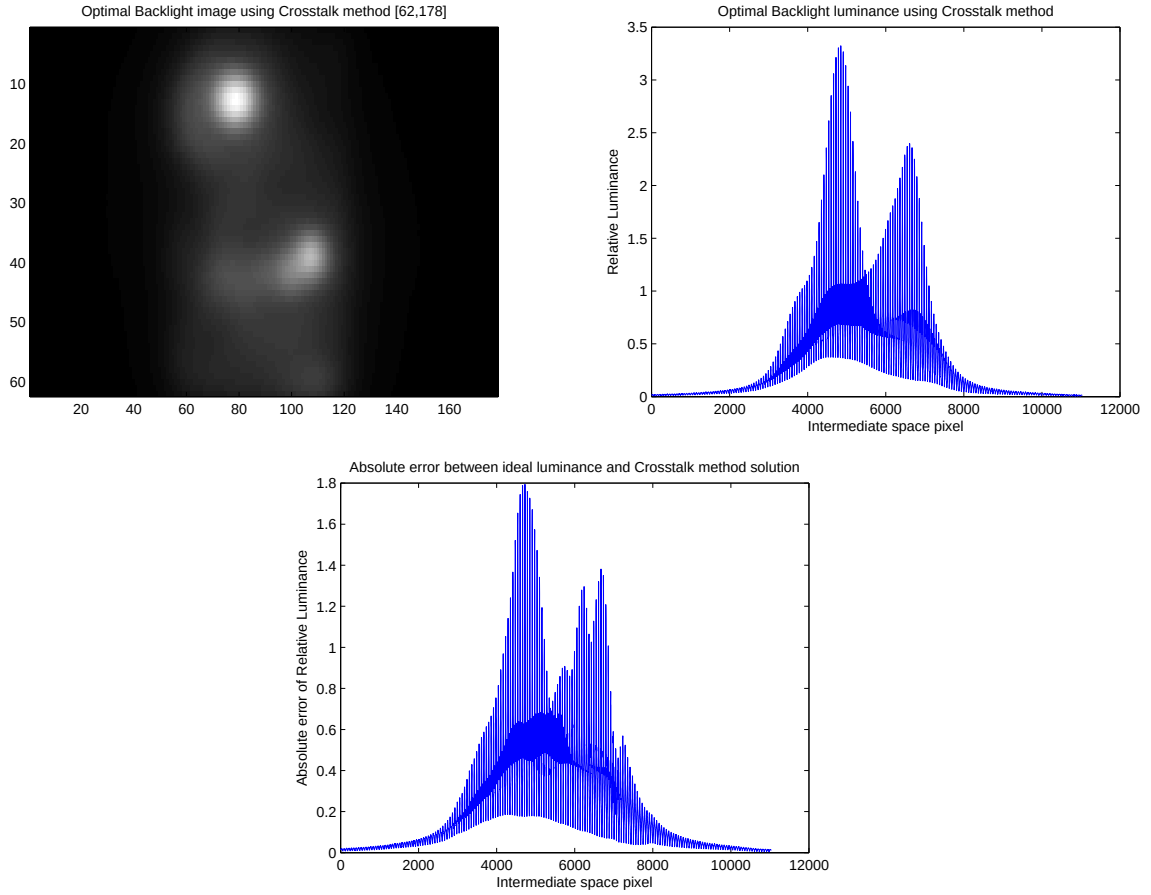
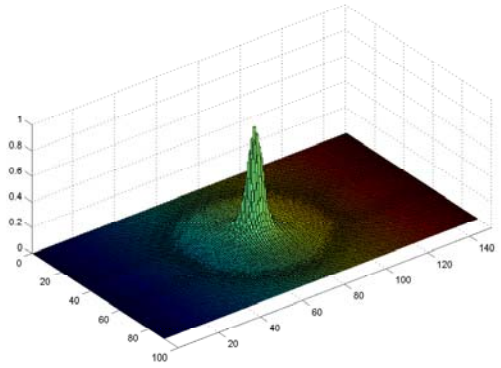
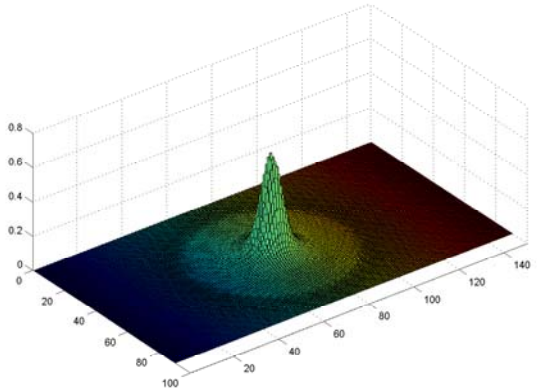


Figure 7: Optimal solution using naive anti-crosstalk method

Results





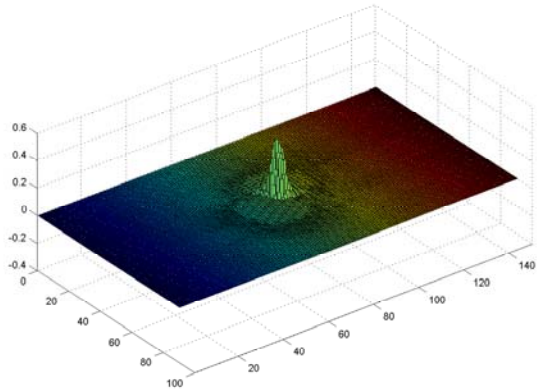


Figure 8: Measurement PSF data, Gaussian approximation of the data, and the error

References

[1] Wandell, B. (1995) Foundations of vision science: Behavior, neuroscience, and computation. Sinauer, Sunderland.

[2] REINHARD, E., WARD, G., PATTANAIK, S., AND DEBEVEC, P. 2005. High Dynamic Range Imaging: Acquisition, Display and Image-Based Lighting. Morgan Kaufmann Publishers, San Francisco.

[3] Brightside Technologies Overview. http://www.brightsidetech.com/

[4] F. Xiao, J. DiCarlo, P. Catrysse and B. Wandell, High dynamic range imaging for natural scenes, In Tenth Color Imaging Conference: Color Science, Systems, and Applications, 2002. Scottsdale, AZ.

[5] HDR shop from Paul Debevec's website http://www.debevec.org/HDRShop/

[6] HDR range compression software from Yuanzhen Li's website http://web.mit.edu/yzli/

[7] Doll HDR image from Yuanzhen Li's website. http://web.mit.edu/yzli/

[8] Memorial Church HDR image, from Paul Debevec's website. http://www.debevec.org/Research/HDR/

[9] CVX convex optimization tool from GRant et al. http://www.stanford.edu/ boyd/cvx/

[10] Tina Dong, Sufeng Li, and Michael Lin. "High Dynamic Range Imaging for Display on Low Dynamic Range Devices", 2006 PSY221 class project

[11] Eino-Ville Talvala. "Encoding HDR Images for the Brightside HDR Display", 2006 PSY221 class project

[12] Kanako Hayashi, "HDR Display calibration", 2006 PSY221 class project

acknowledgements

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