

Color Correction for Optical See-Through Displays Using Display Color Profiles

Srikanth Kirshnamachari Sridharan

Dr. Juan David Hincapié-Ramos

Dr. David R. Flatla (University of Dundee)

Dr. Pourang Irani



INTRODUCTION

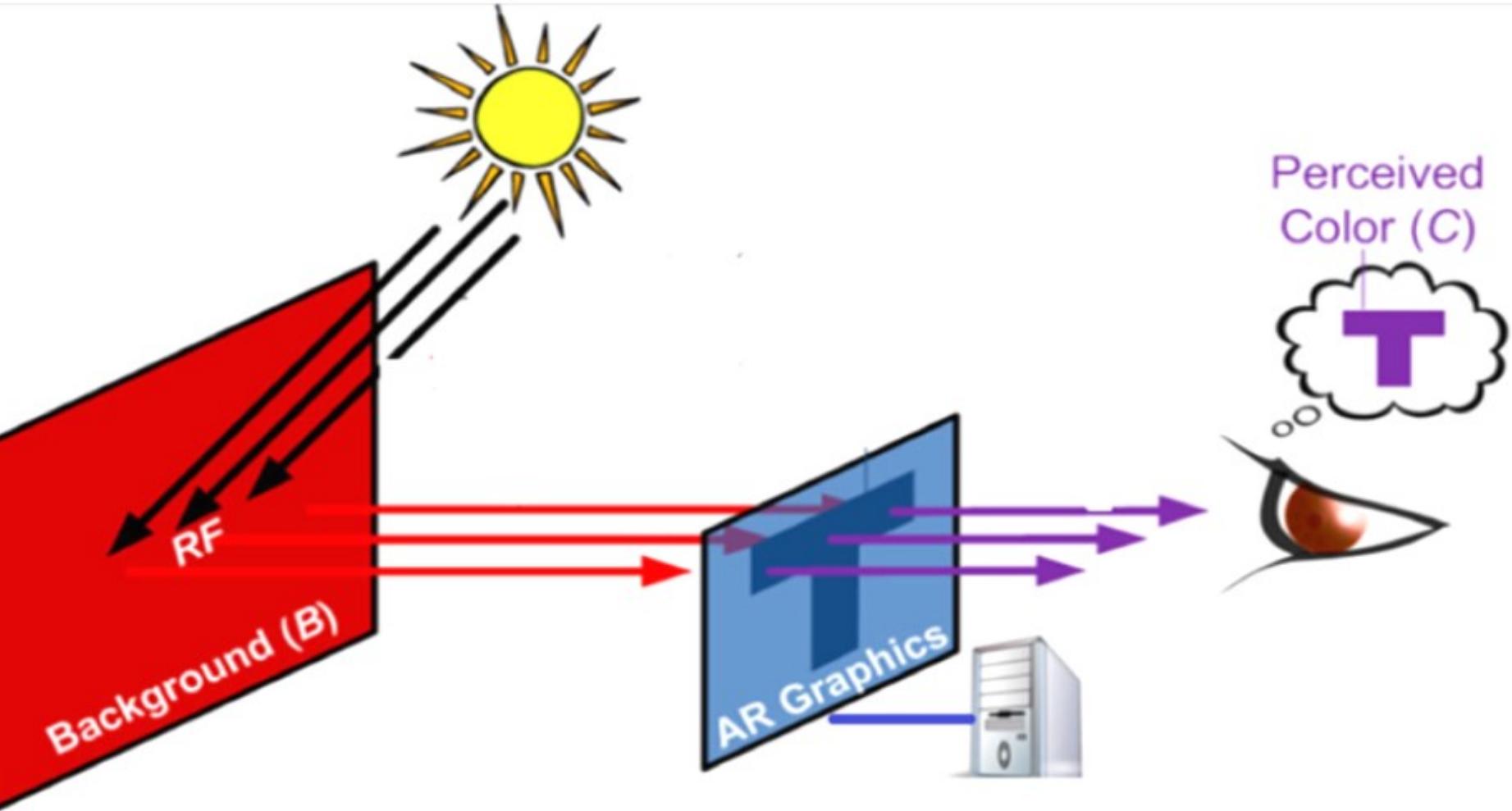
Optical see-through displays (OSTD) allow users to view digital content and physical objects simultaneously.



Additive OSTD: Has its own light source

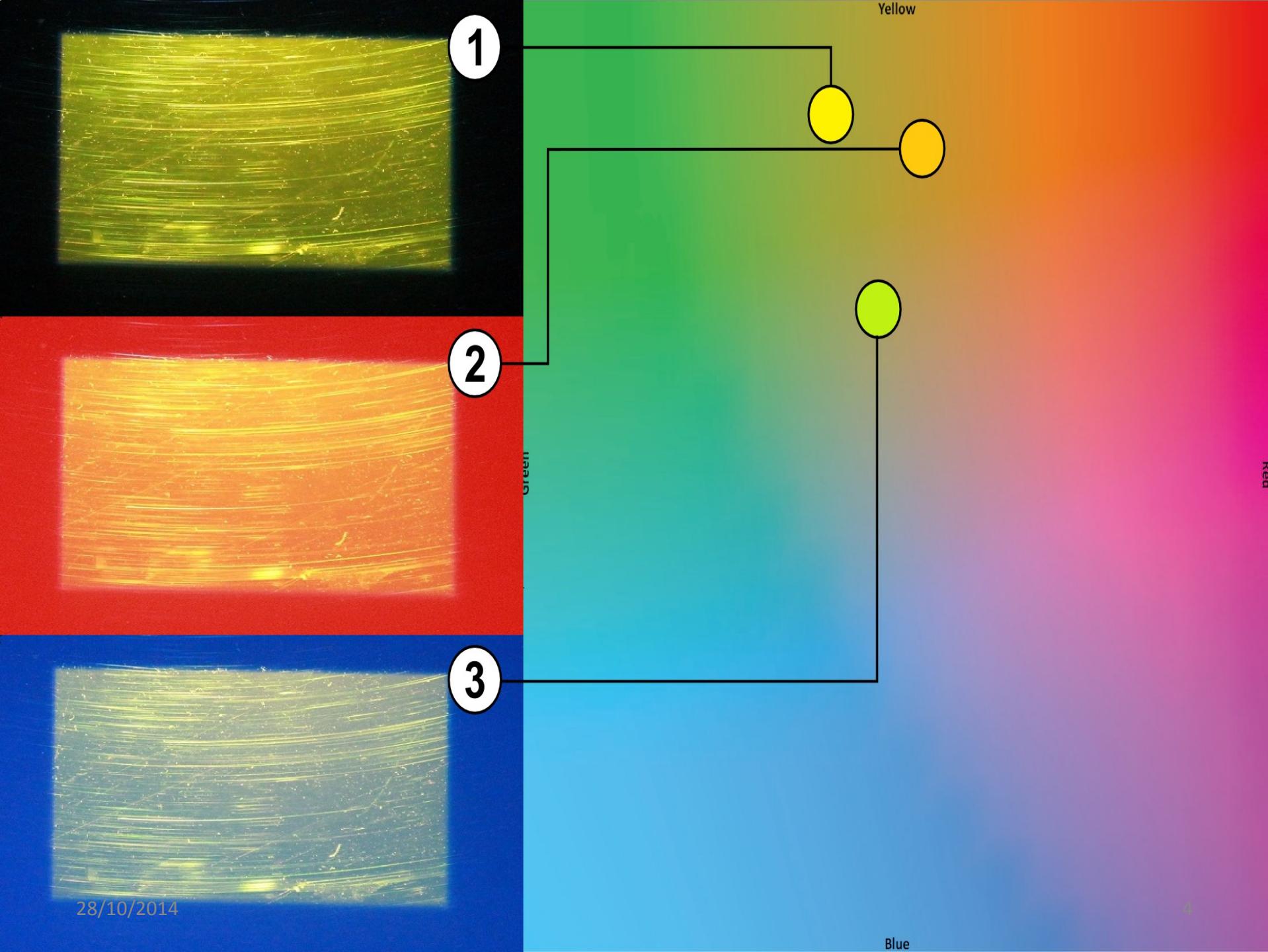
Subtractive OSTD: Filter external light source





Gabbard et al - More than meets the eye: An engineering study to empirically examine the blending of real and virtual color spaces , VR 2010

Real world background color affects the displayed contents on the digital display



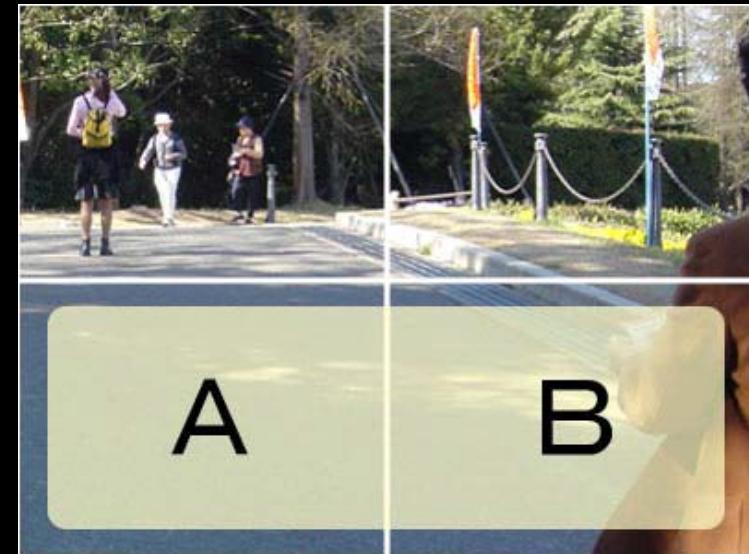
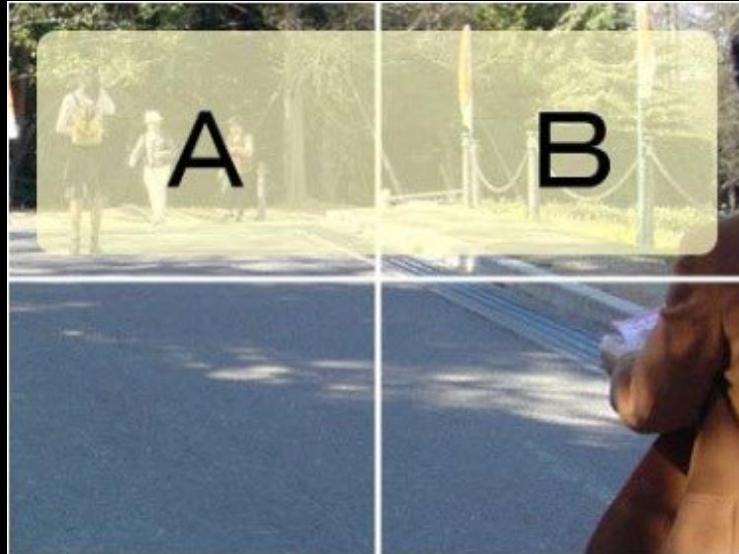
Usability Problem



Kerr et al , Wearable mobile augmented reality: evaluating outdoor user experience. VRCAI '11

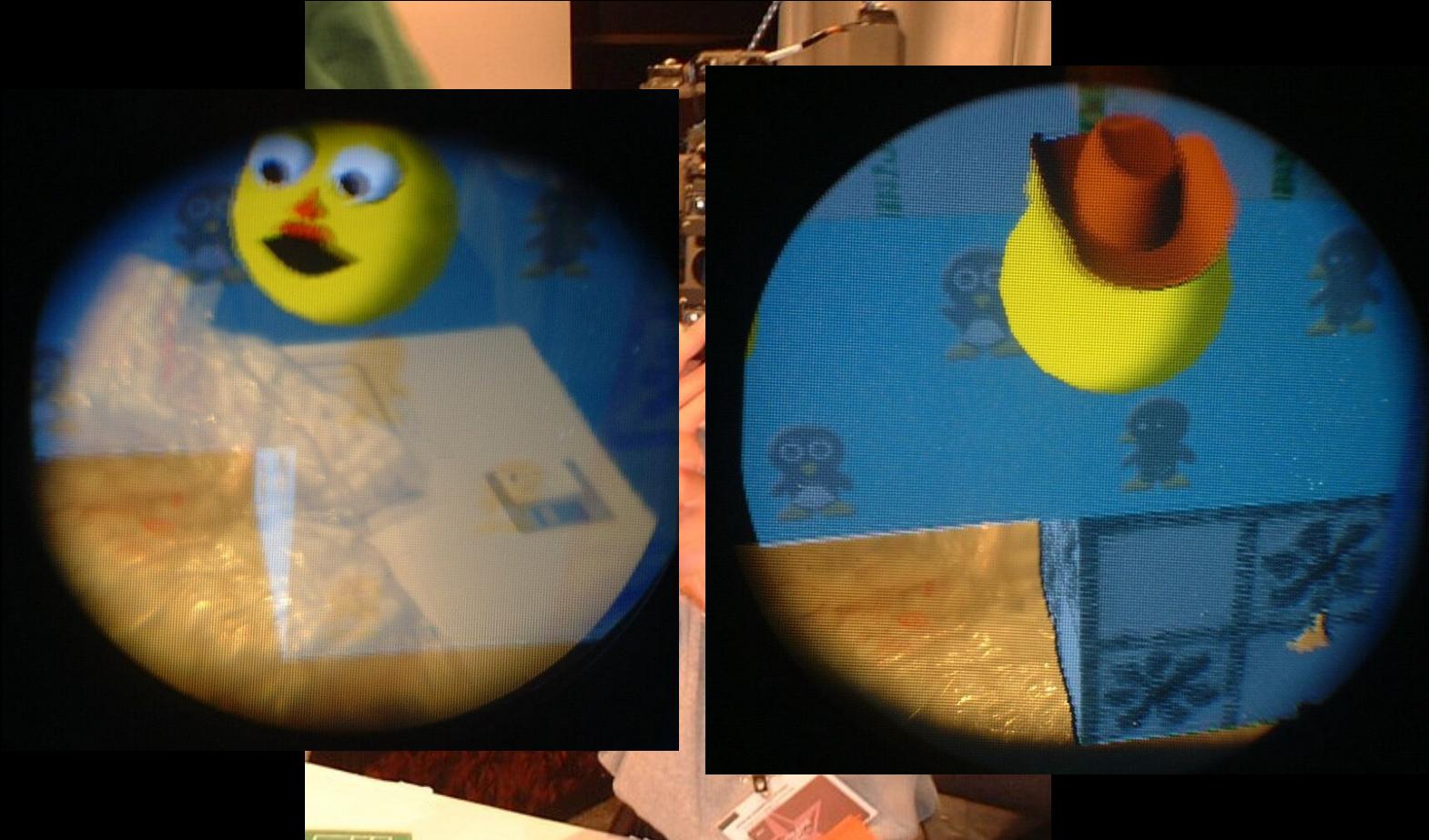
Content Based Solutions

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16



Tanaka et al, An information layout method for an optical see-through head mounted display focusing on the view ability. ISMAR 08

Hardware Based Solution



Kiyokawa et al, An Occlusion-Capable Optical See-through Head Mount Display for Supporting Co-located Collaboration. ISMAR 2003

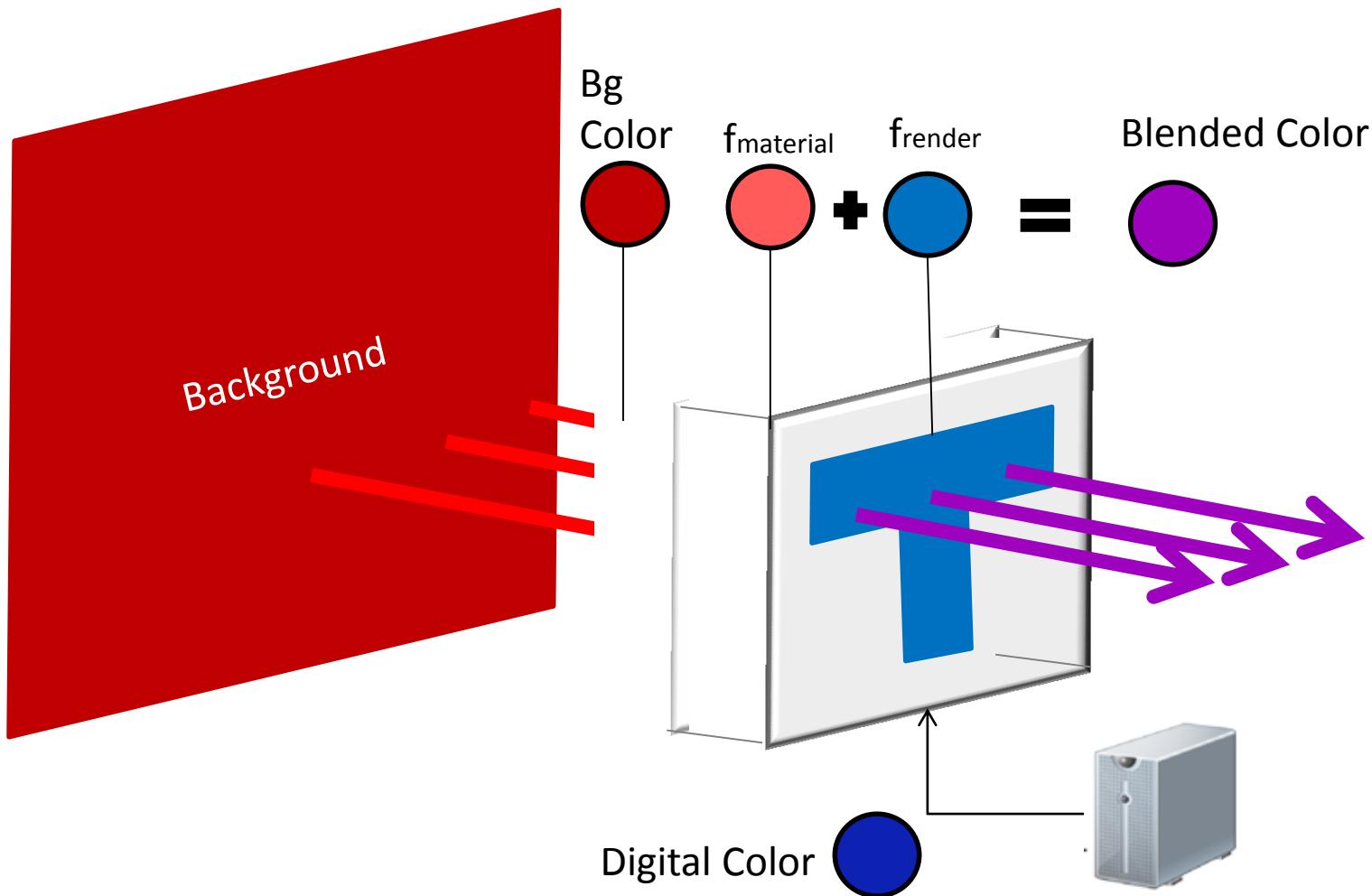
How We differ ?

Color Correction

Involves in the system finding an alternate digital color which, upon blending with the background comes closer to the desired digital color

Background

- To pick an alternate color we need ability to predict how colors blend on a given display.
- We propose a new color blending model that can predict how colors blend on a OSTD



$$\text{Blended Color} = f_{\text{render}}(\text{Digital Color}) + f_{\text{material}}(\text{Bg Color})$$

Contribution

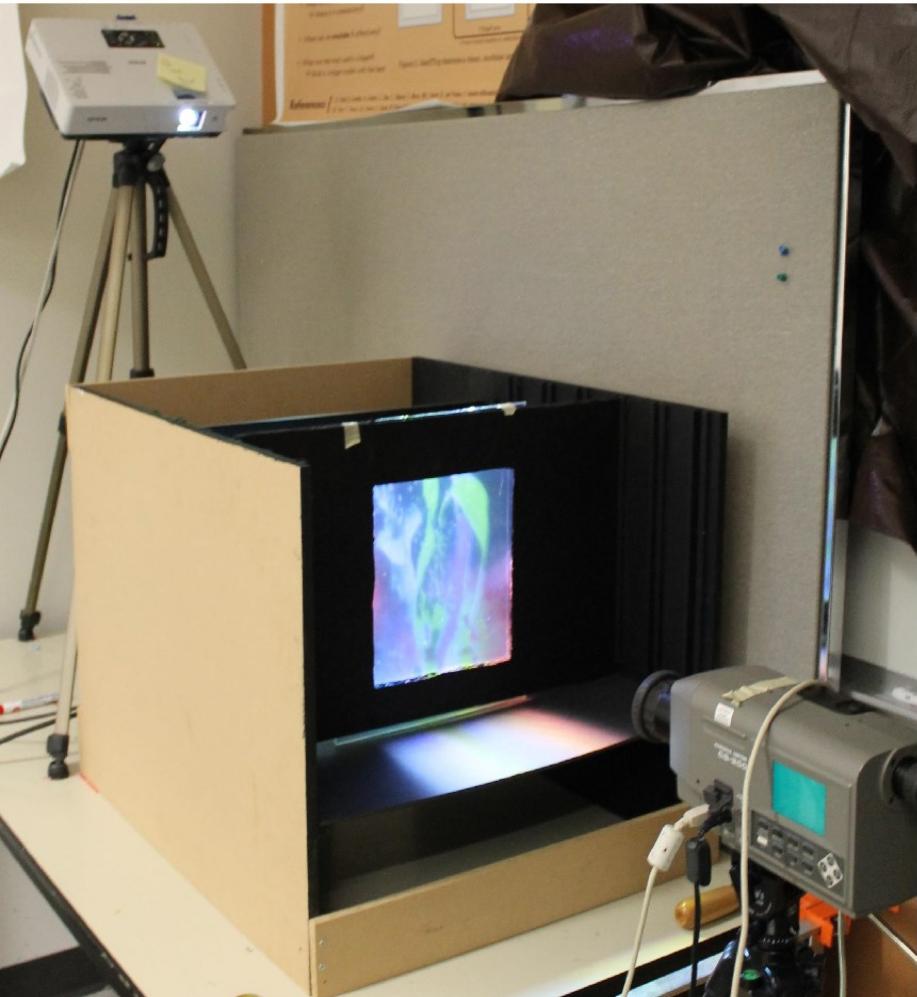
- A new Color blending Model for OSTD
- Binned Profile (BP) – To handle Render Distortion
- BP Based Color Correction
- Design guidelines for OSTD



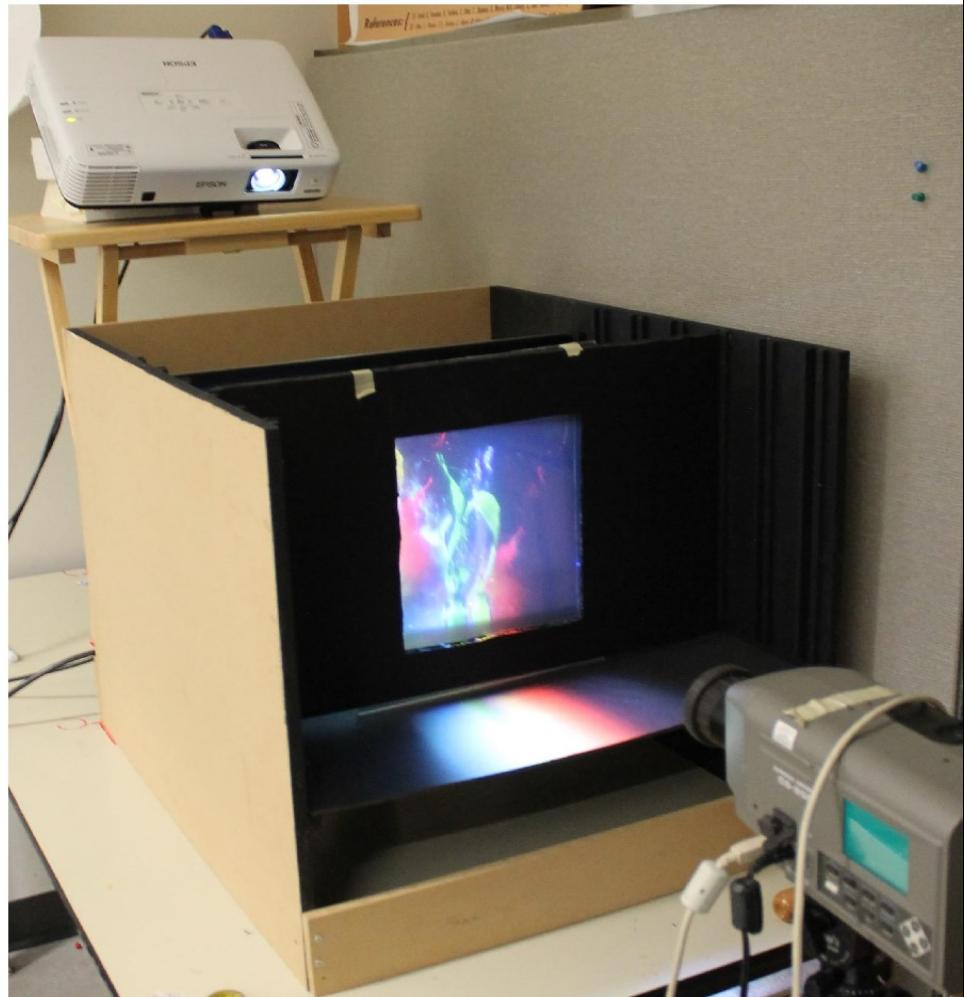
Experimental Test-Bed

Projection based

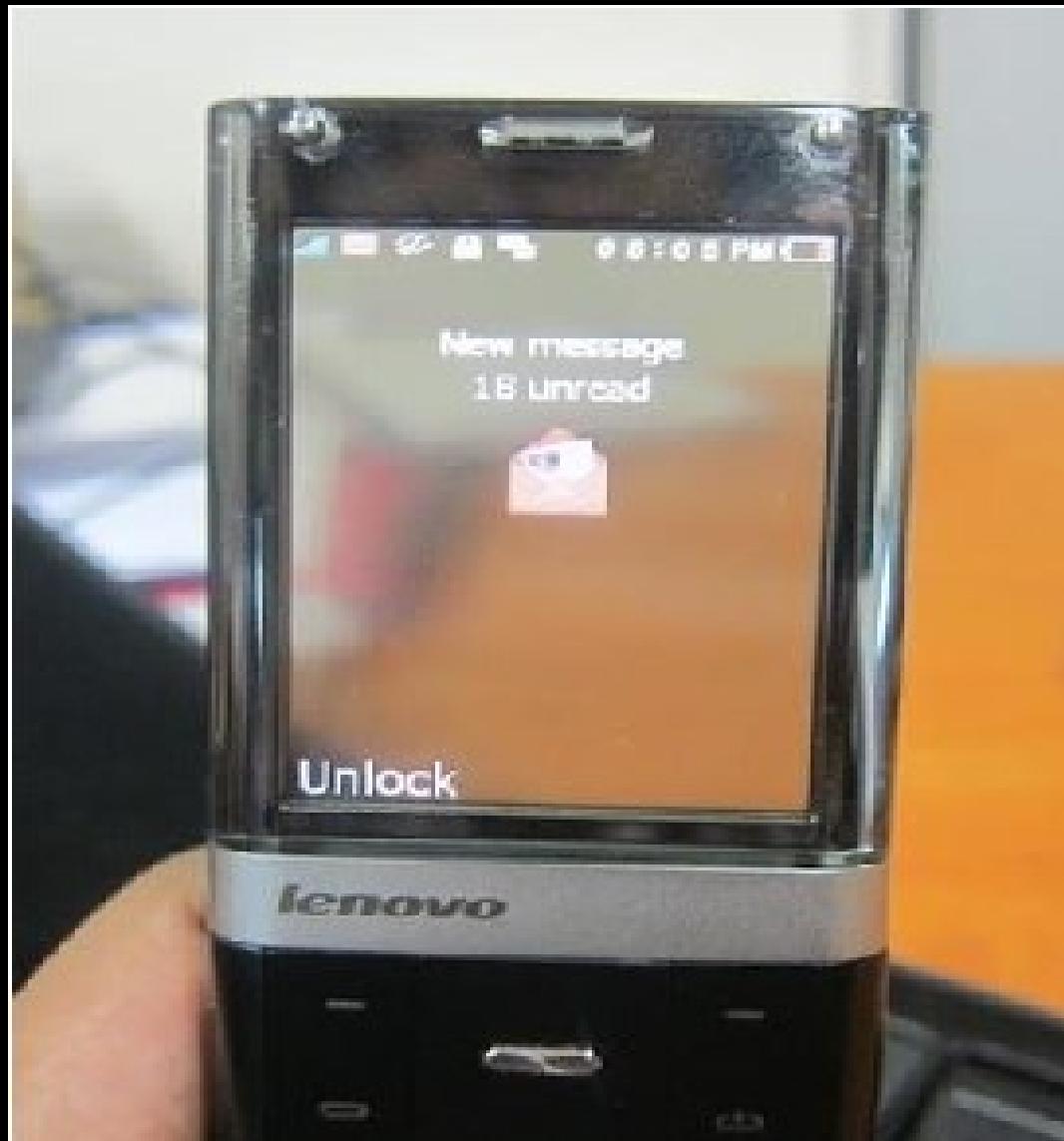
p2200 OSTD



p3700 OSTD



T-OLED



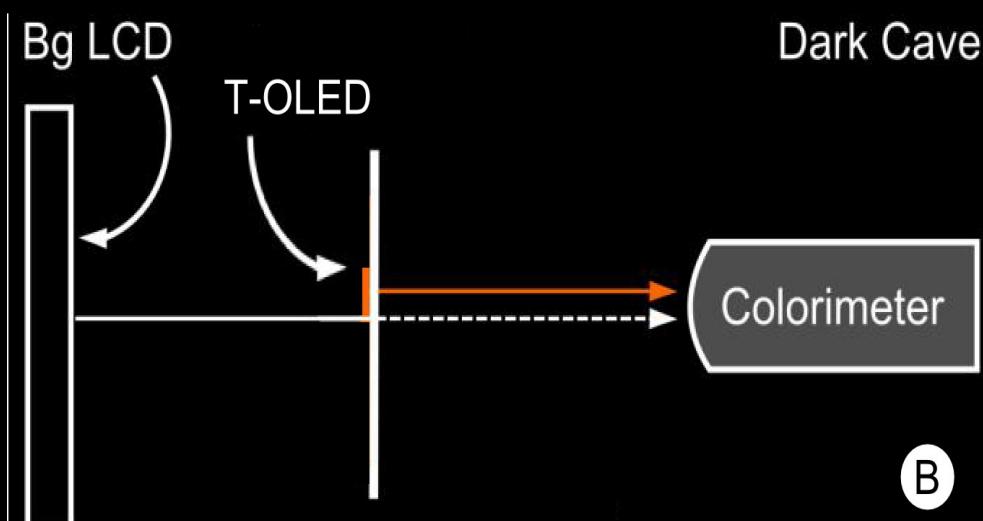
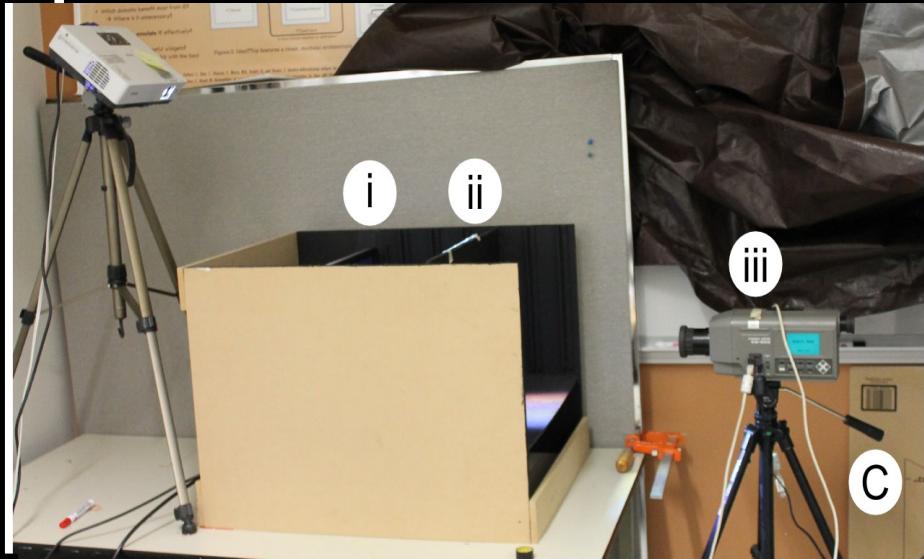
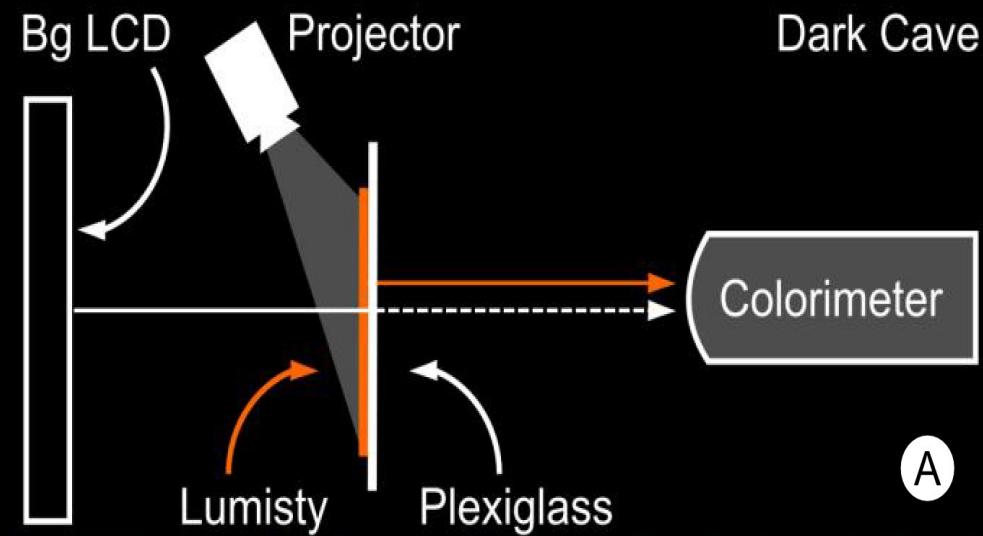
Background colors for experiment



Picture from Wikipedia

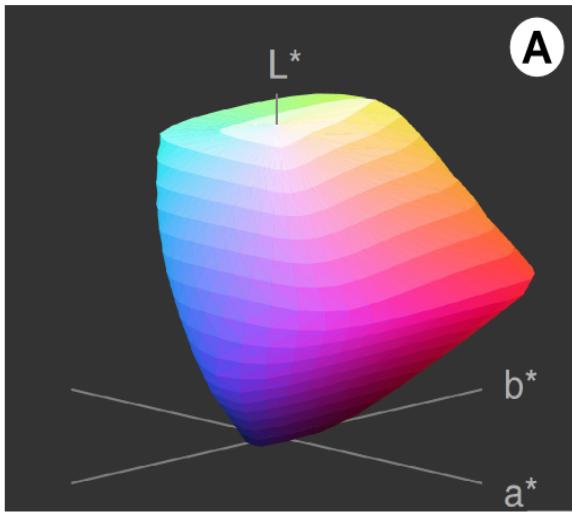
23 Macbeth chart colors used as background

Setup



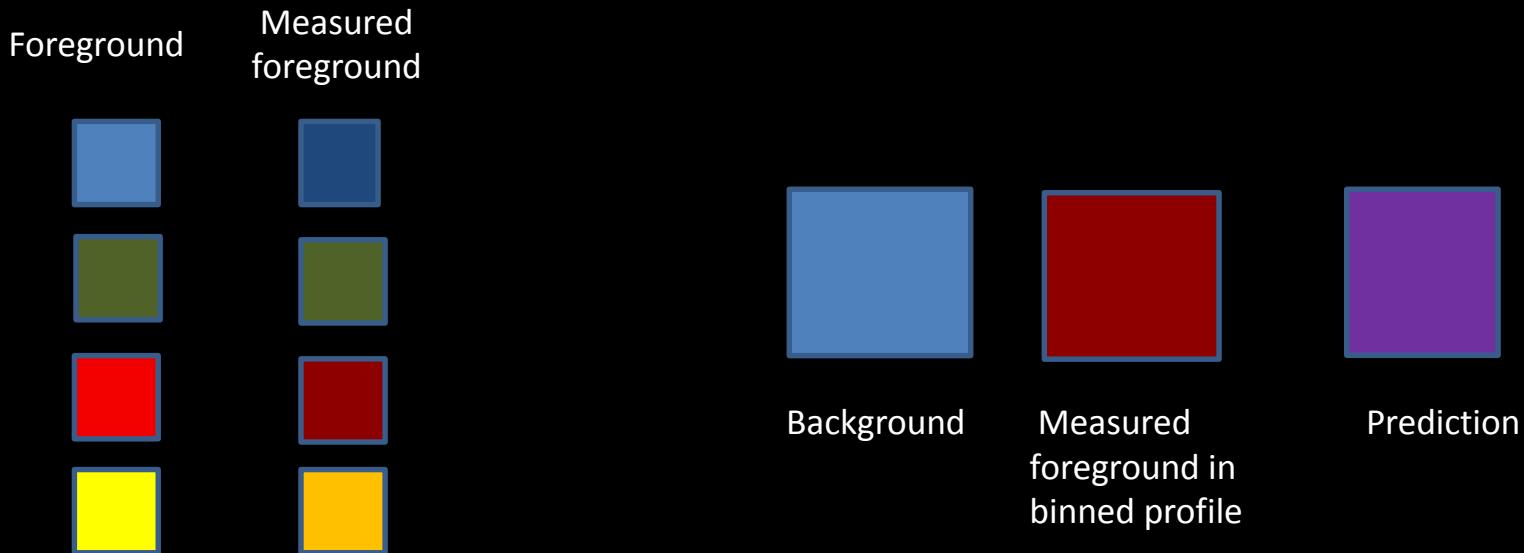
Binned Profile

RGB colorimetric AP spaces
CIE LAB



BP Method Color prediction

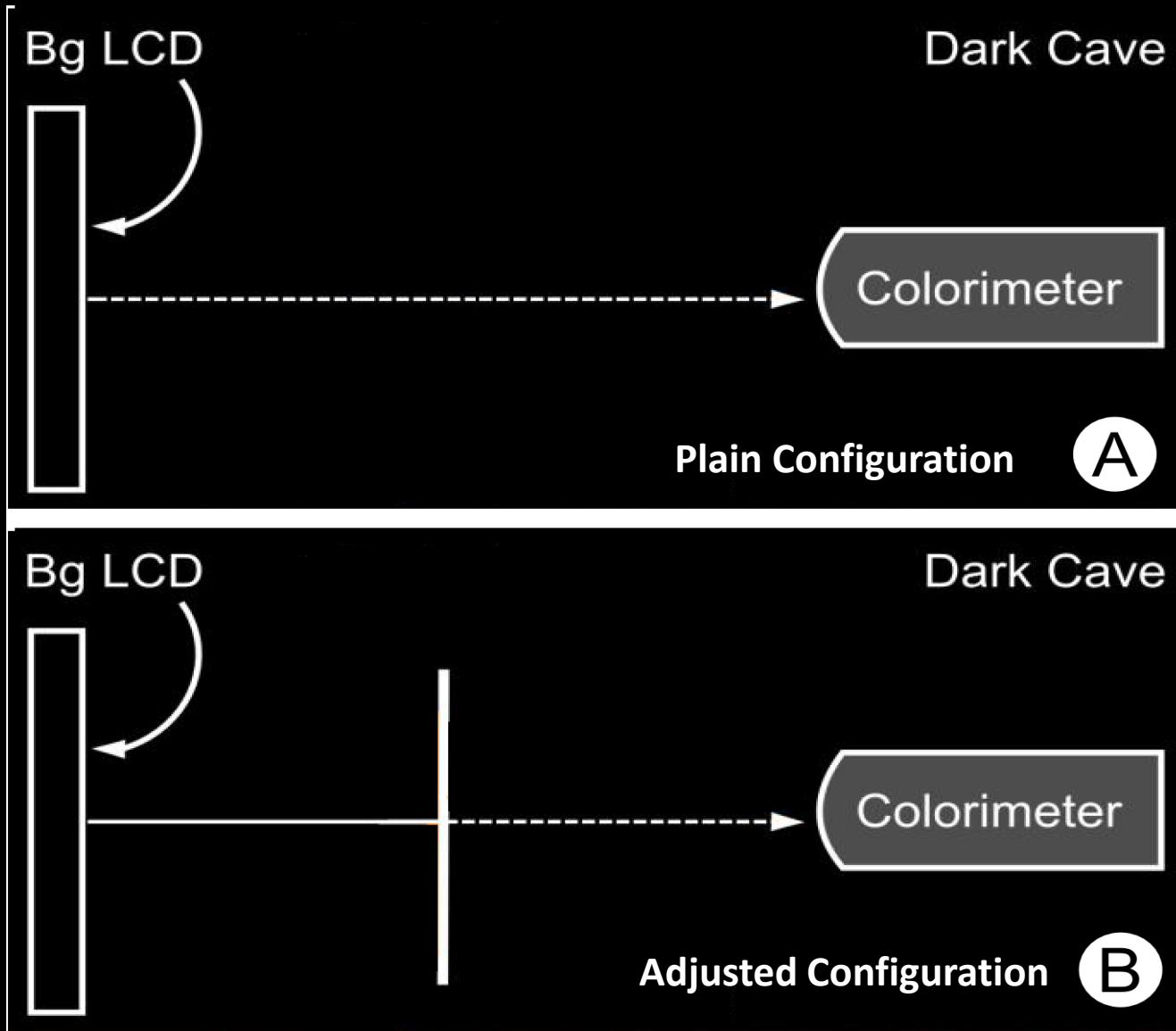
Binned Profile



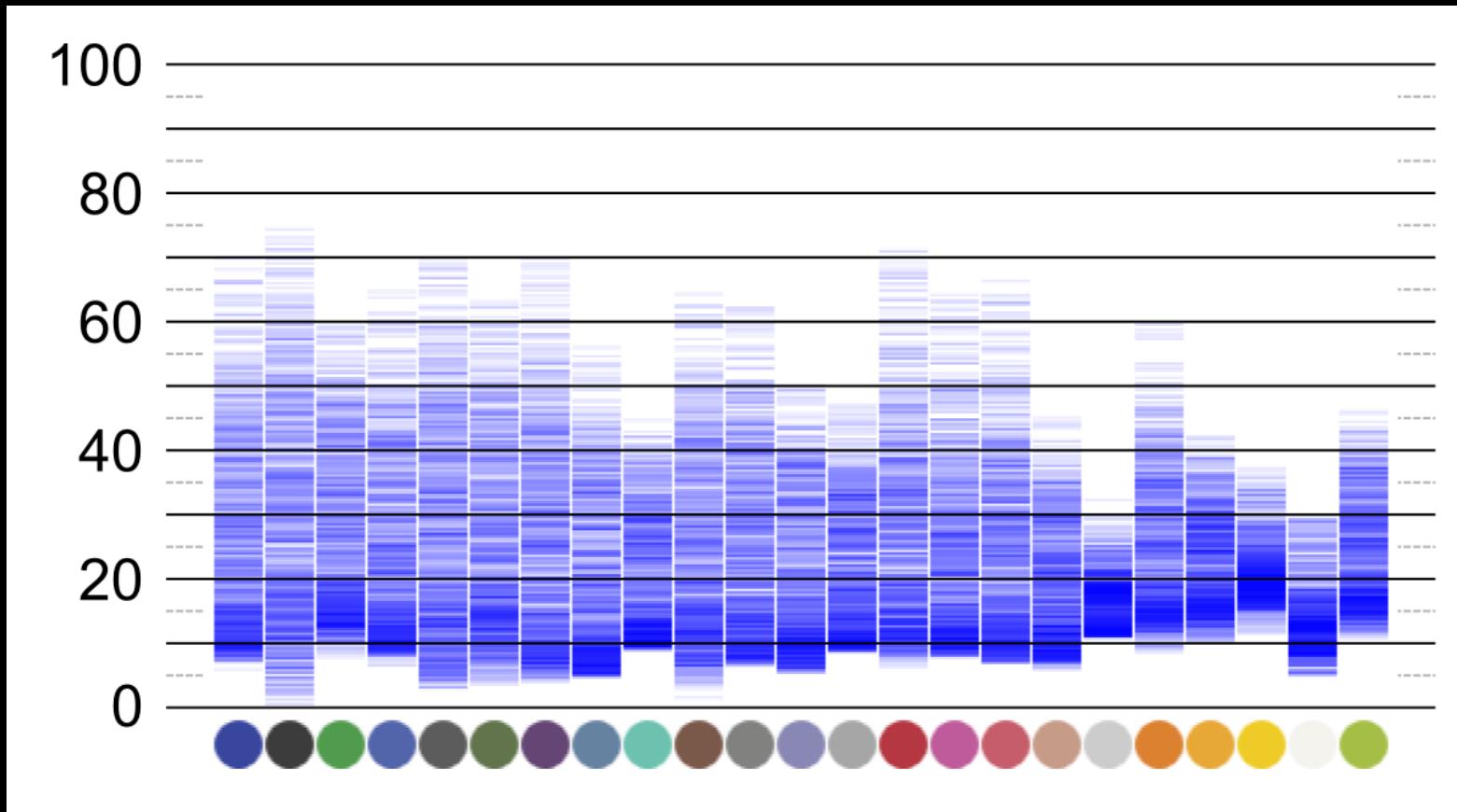
We tested the validity of this method against

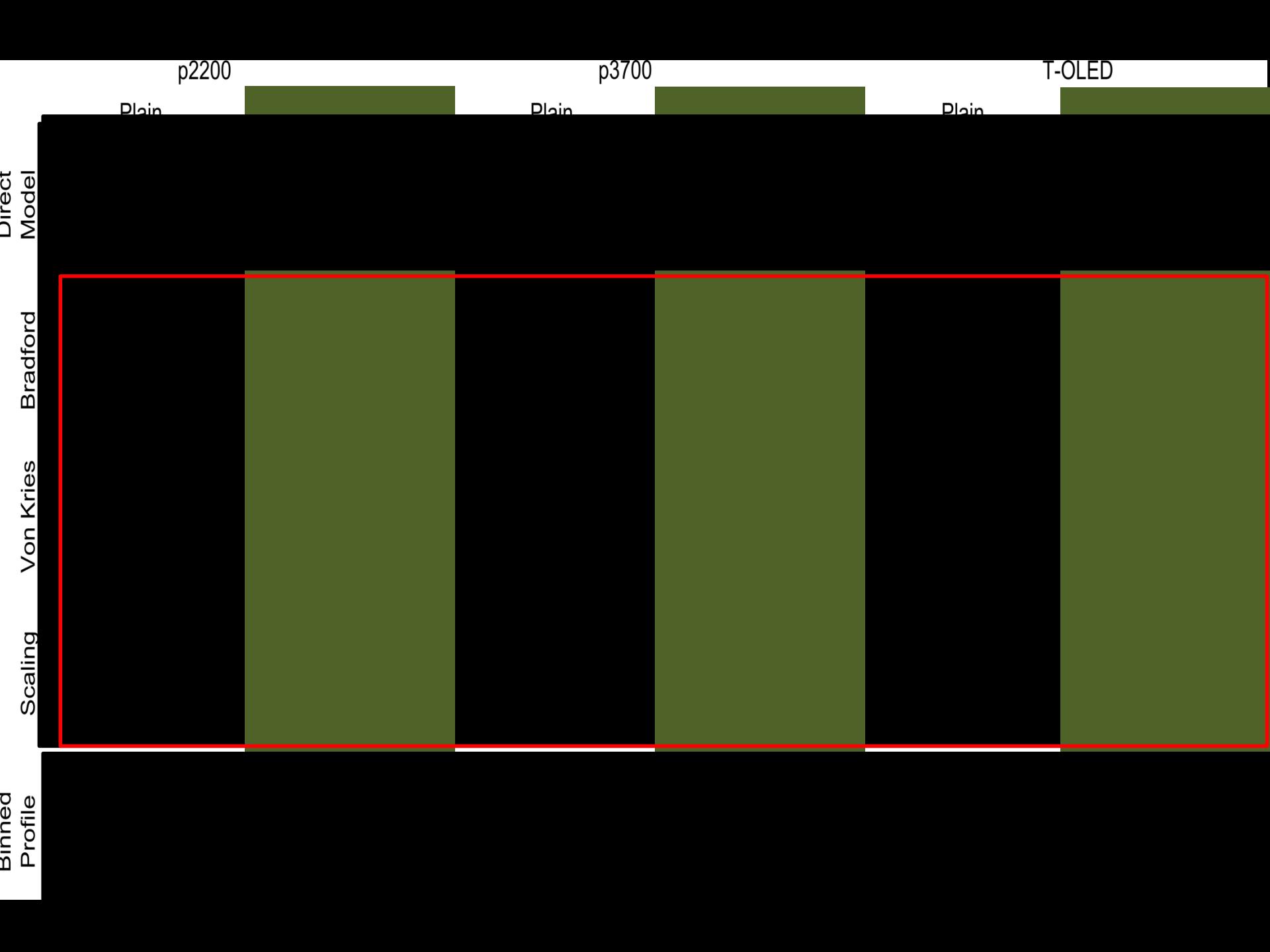
- Direct Method
- CAT Method

Background Configuration

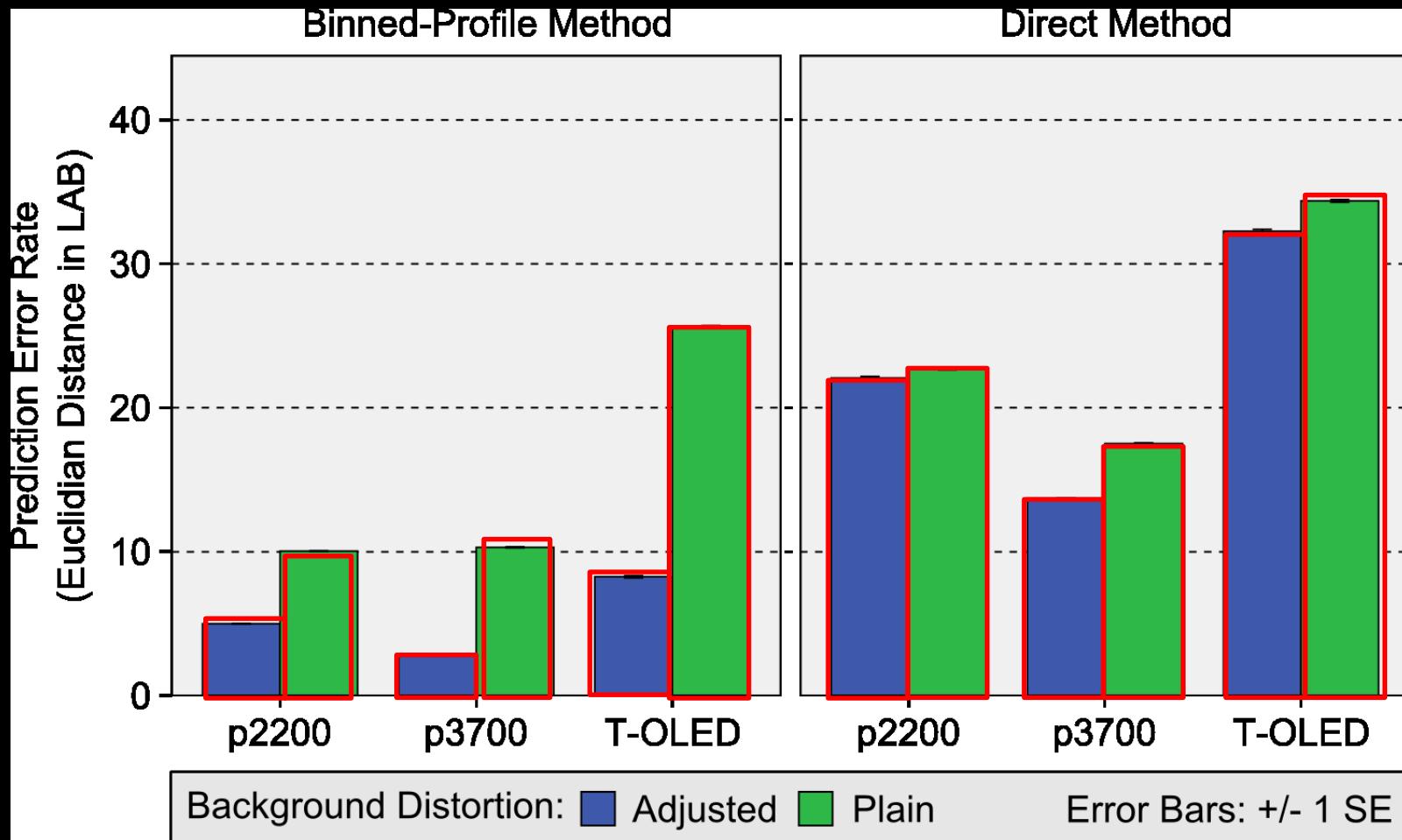


Result Visualization





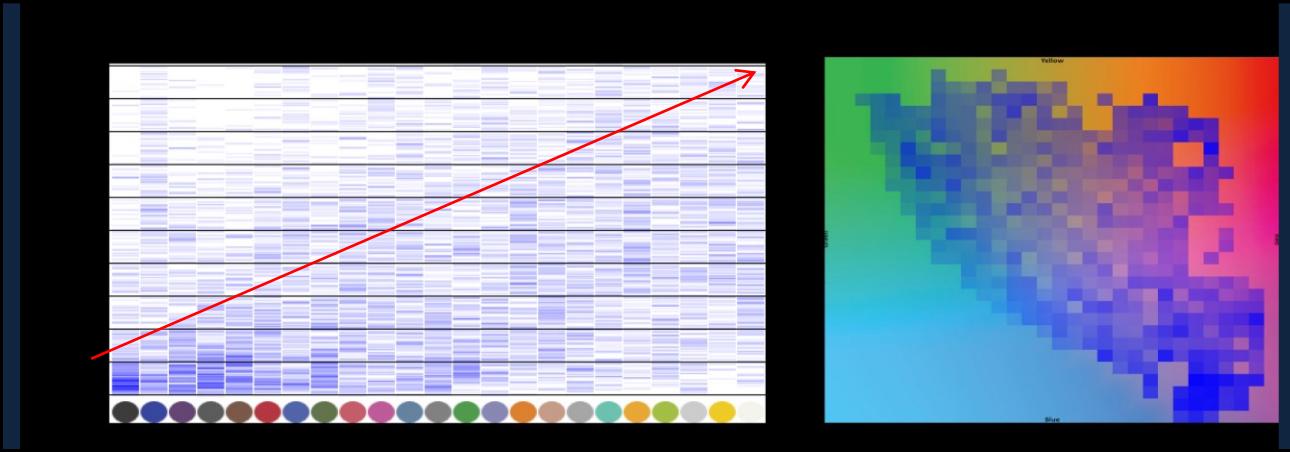
Quantitative analysis



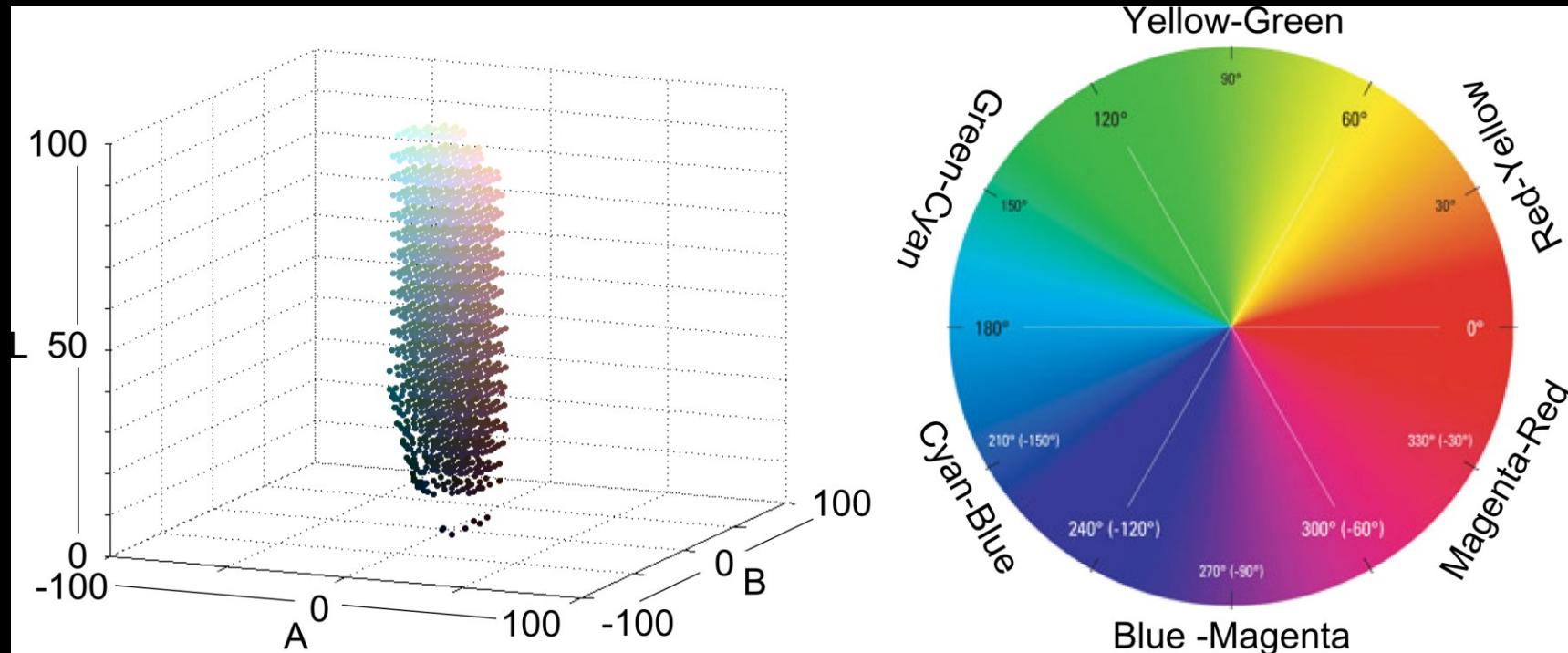
Kruskal-Wallis test was done, Sig <0.001

Color Correction

- We developed a color correction algorithm based on BP method
- Input to this algorithm is BP of that OSTD, Desired foreground color, Background Color



Color Analysis

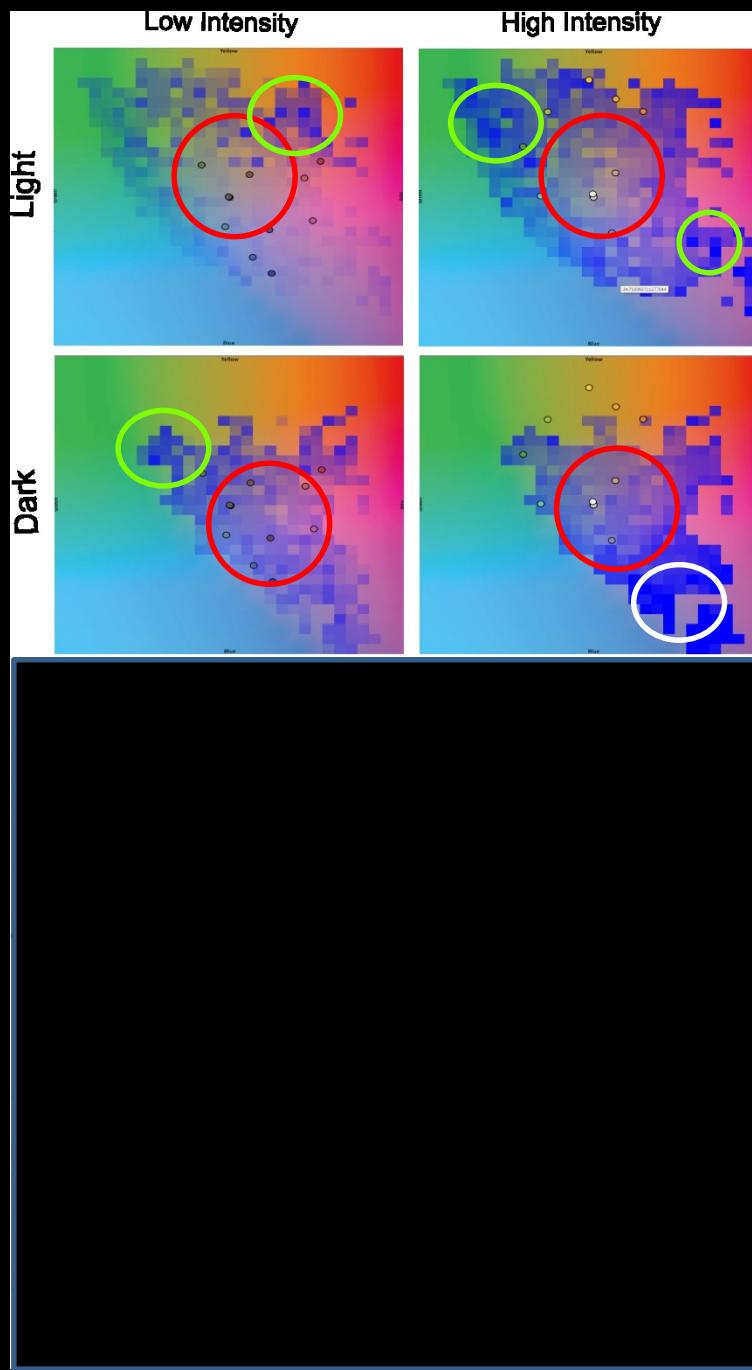


Low Intensity

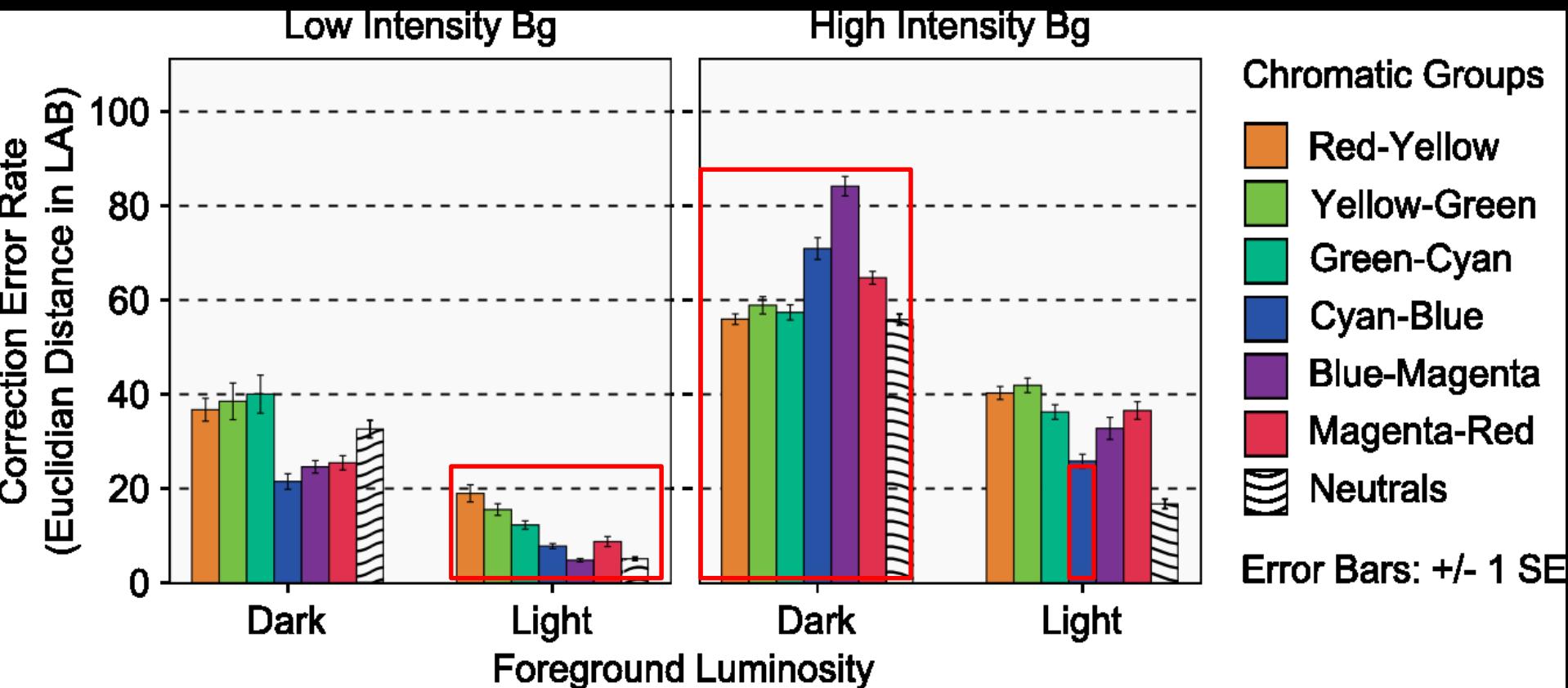
Black	Neutral 3.5	Purplish Blue	Magenta
Blue	Dark Skin	Foliage	Blue Sky
Purple	Red	Moderate Red	

High Intensity

Neutral 5	Orange	Bluish Green	Neutral 8
Green	Light Skin	Orange Yellow	Yellow
Blue Flower	Neutral 6.5	Yellow Green	White



Quantitative Analysis



Kruskal-Wallis test was done, Sig <0.001

Research Implication

Design Implications

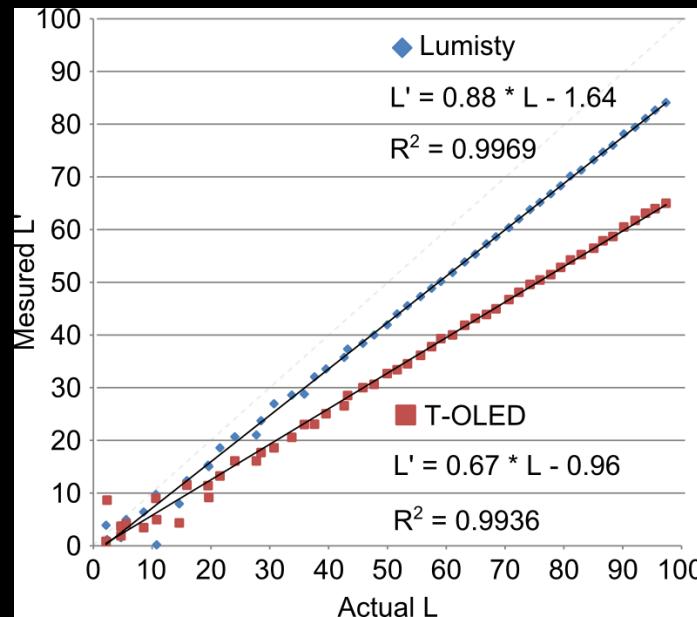
- Light neutral colors for information that needs to be preserved best
- If more hue is needed, designers can use light colors in the Cyan-Blue region
- Dark colors should be avoided for text and color-encoded information
- Usage of color themes based on the background will be wise

Hardware Implication

- Is smaller display profile better?
- Lower transparency, For OSTD?
- Usage of SLM?

Practical Implication

- Usage of camera to capture the background?
- How to capture account for the Material Distortion?



Future Work

Take Away

- Use color themes for displaying Contents on OSTD
- Render distortion must be handled for color related study
- Research is needed in the area of BG color capture

Acknowledgements



- Dr. Juan David Hincapié-Ramos
- Dr. Pourang Irani
- Dr. David R. Flatla



- Special thanks to Jango Guo
- NSERC for funding and people at HCI lab In university of Manitoba



THANK YOU, QUESTIONS?

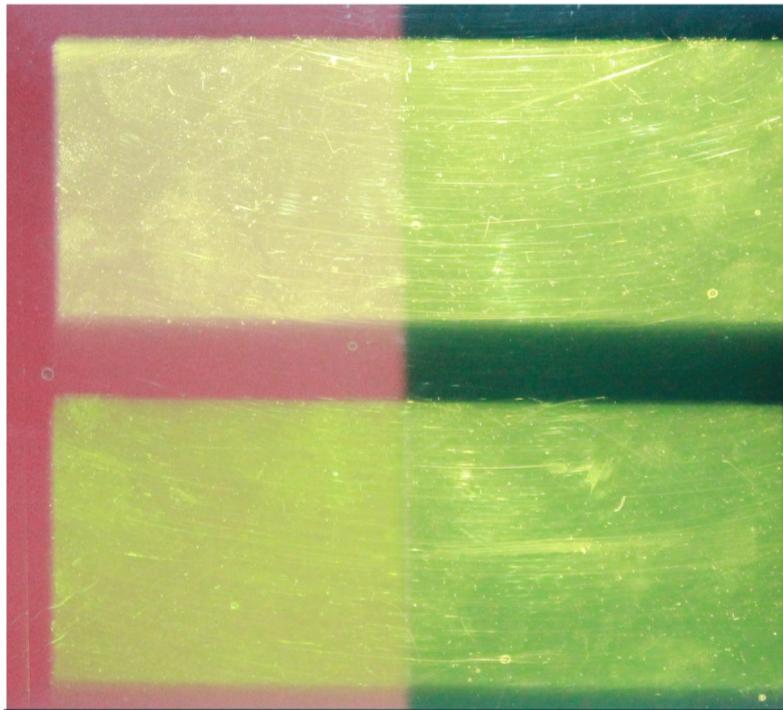
Presented by,

Srikanth Kirshnamachari Sridharan

Annexure

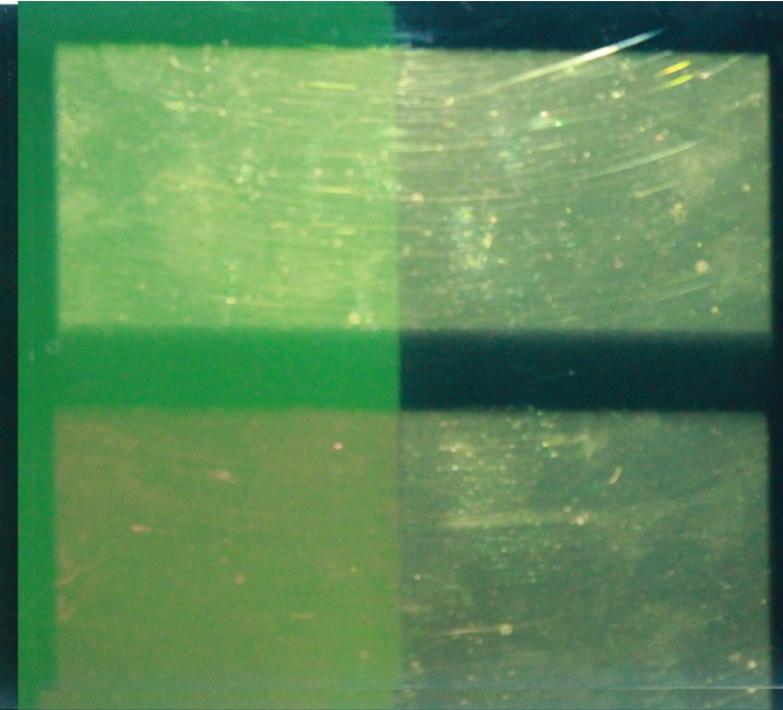
Compensated
Uncompensated

Blended color



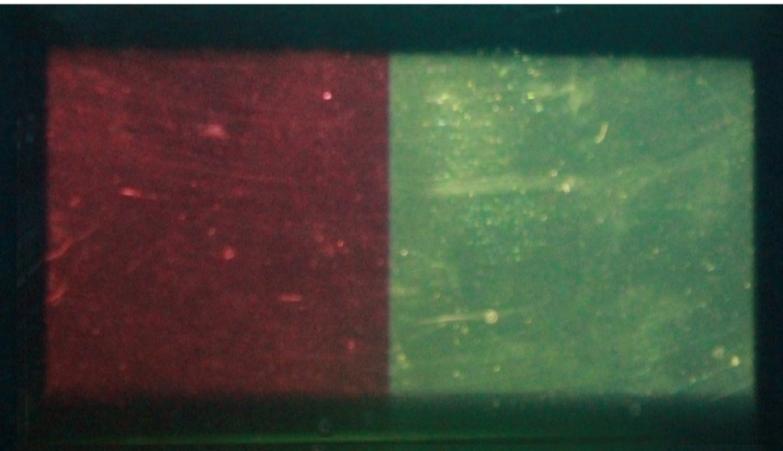
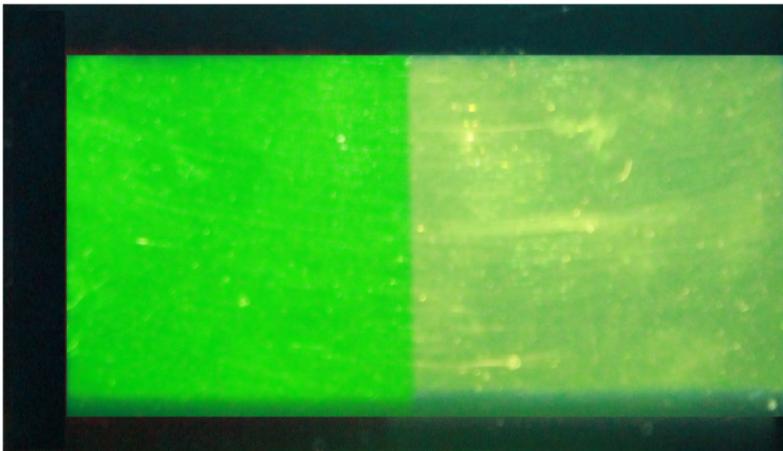
Reference

Blended color

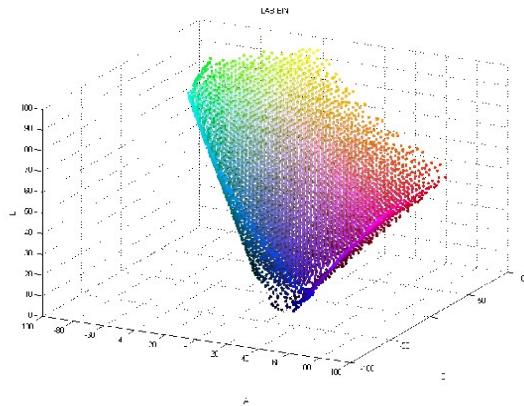


Reference

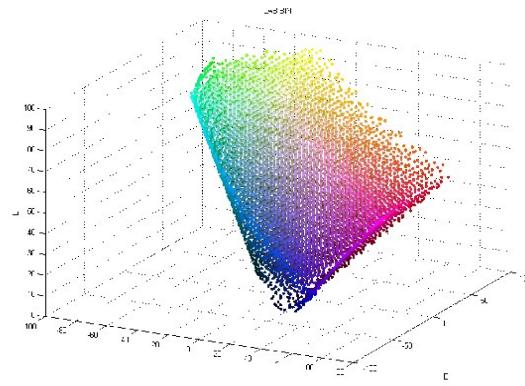
Compensated without background



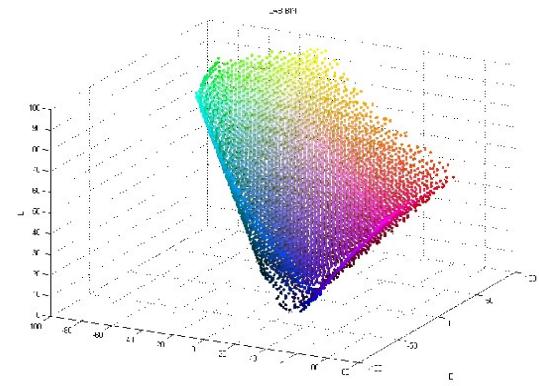
BradFord



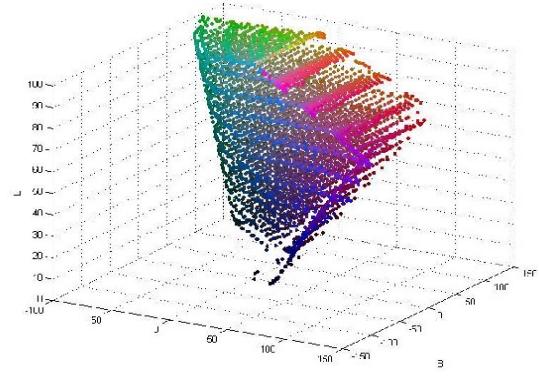
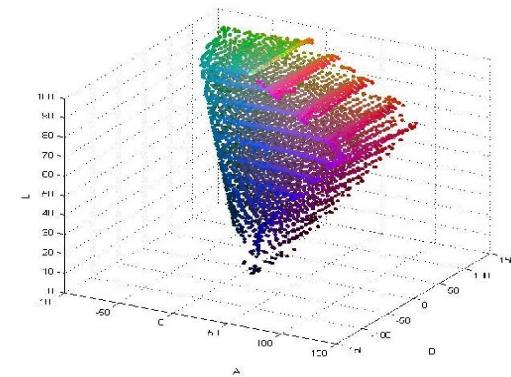
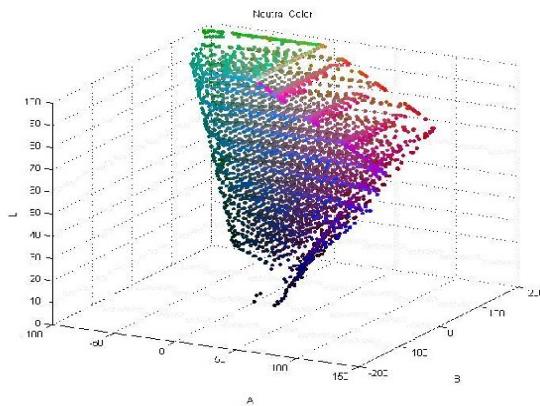
Von Kies



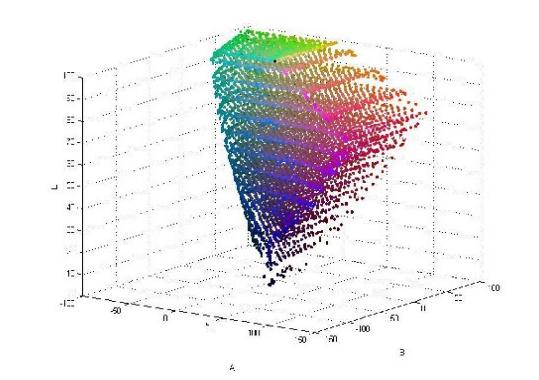
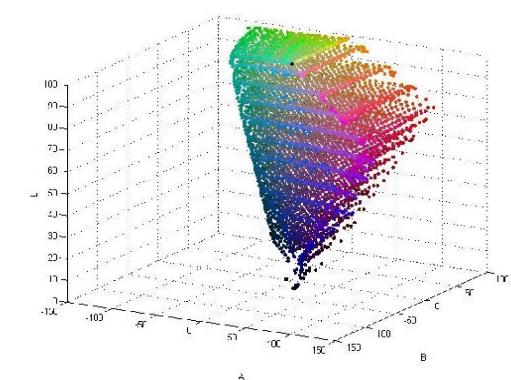
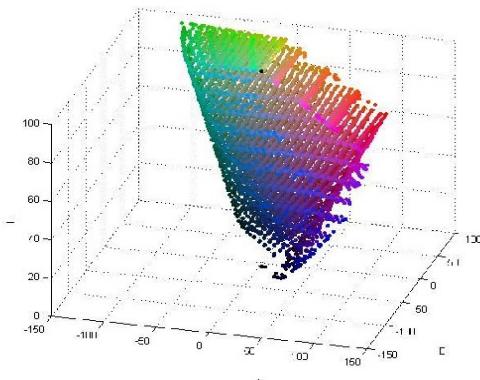
Scaling



p3700

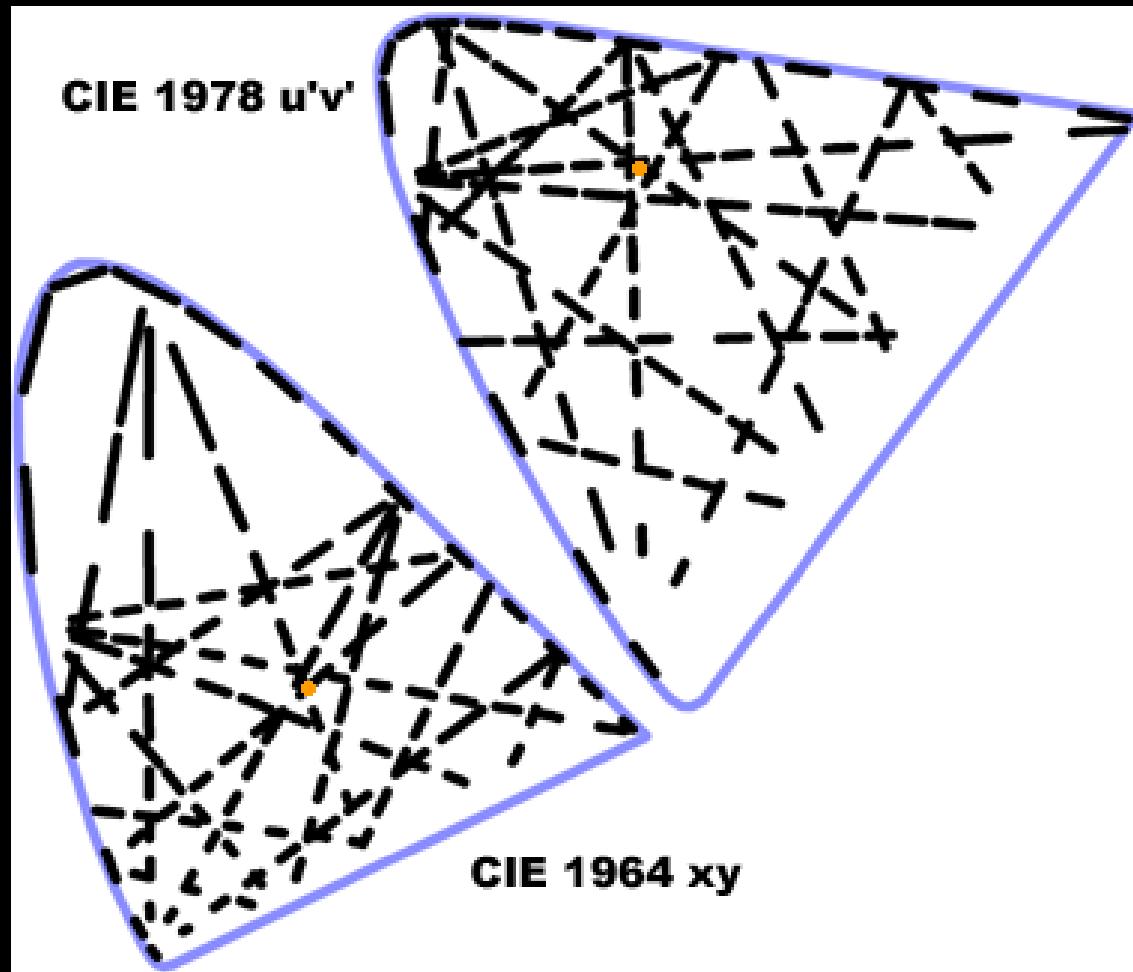


p2200



T-OLED

Just Noticeable Difference



Result

