



DevCon 2016

Implementing Observer Metamerism Correction on Wide Color Gamut Display using iccMAX Framework

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Overview

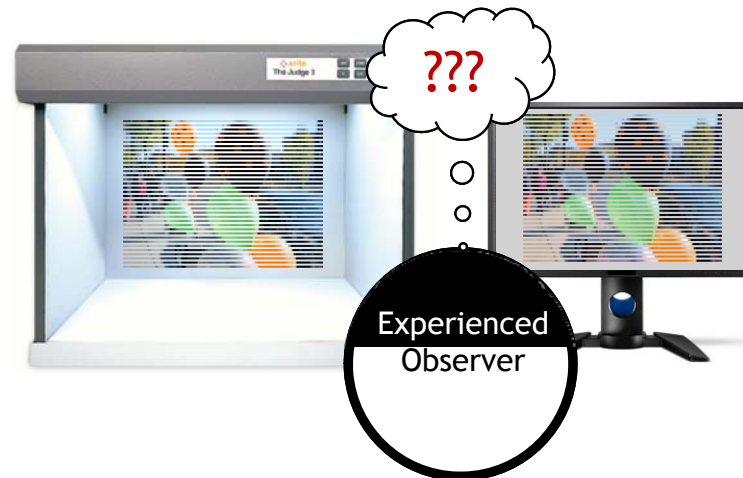
- What Happened?
- Some More Research...
- The Plan
- Result
- Conclusion
- More Work to Do...

Please Keep in MIND...

- This experiment is a PILOT STUDY
- Not meant to be a sophisticated academic research project.
 - But it will be done in the academic way, later...
- Goal:
 - To find a potential solution for LED backlight monitors (and other narrow bandwidth display devices)
 - To validate iccMAX framework in real world application

Back in 2013...

- When BenQ 1st LED backlight color management monitor was announced.
 - Very exciting news!
 - Experienced users found out LED backlight monitor did not performed well in soft proofing scenario.



Symptoms

- Variations in blue, green and pale yellow tones, for example.
- Difference in perceived saturation.

Overall
saturation is
different



Viewing Booth
(Simulated)



LED Backlight Monitor
(Simulated)

Slight hue
shift in blue

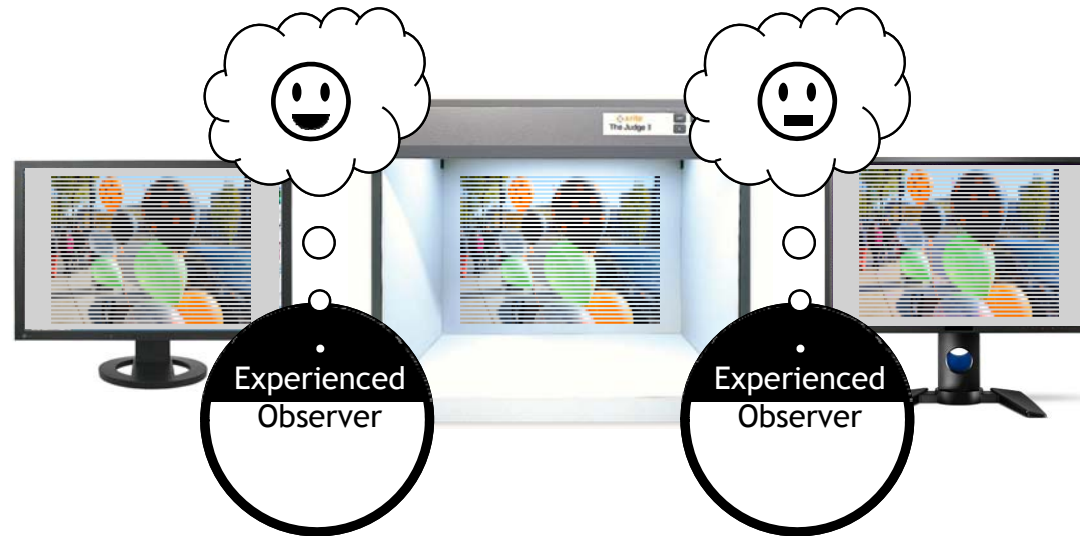
Slight hue
shift in green

Slight hue shift
in pale yellow

WHAT HAPPENED?

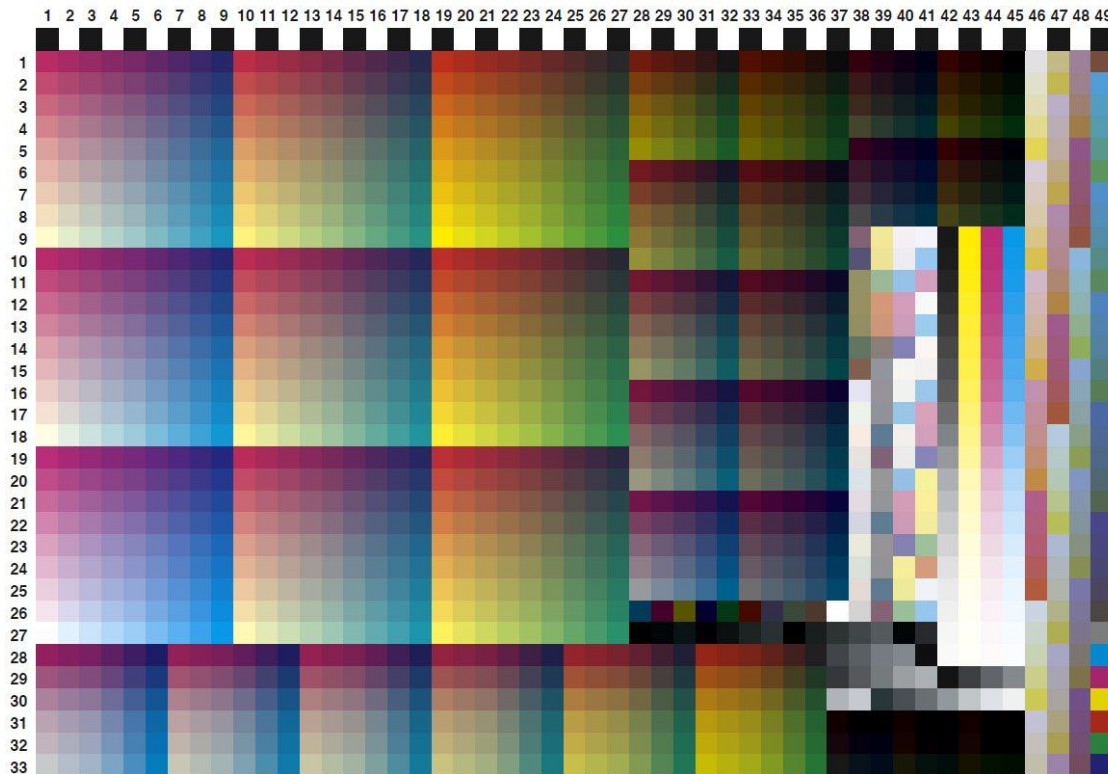
Compared to CCFL...

- To clarify the problem presented, a CCFL reference monitor was used.
- Sadly, experienced observers were happier about the match with CCFL monitor than LED monitor.



What was Wrong?

- ΔE_{00}^* is more or less the same...



Tested with IT8.7/4 1617 Patches:

- LED Monitor:
 - Avg. $\Delta E_{00}^* = 1.25$
 - Max. $\Delta E_{00}^* = 4.35$
- CCFL Monitor:
 - Avg. $\Delta E_{00}^* = 1.20$
 - Max. $\Delta E_{00}^* = 4.25$

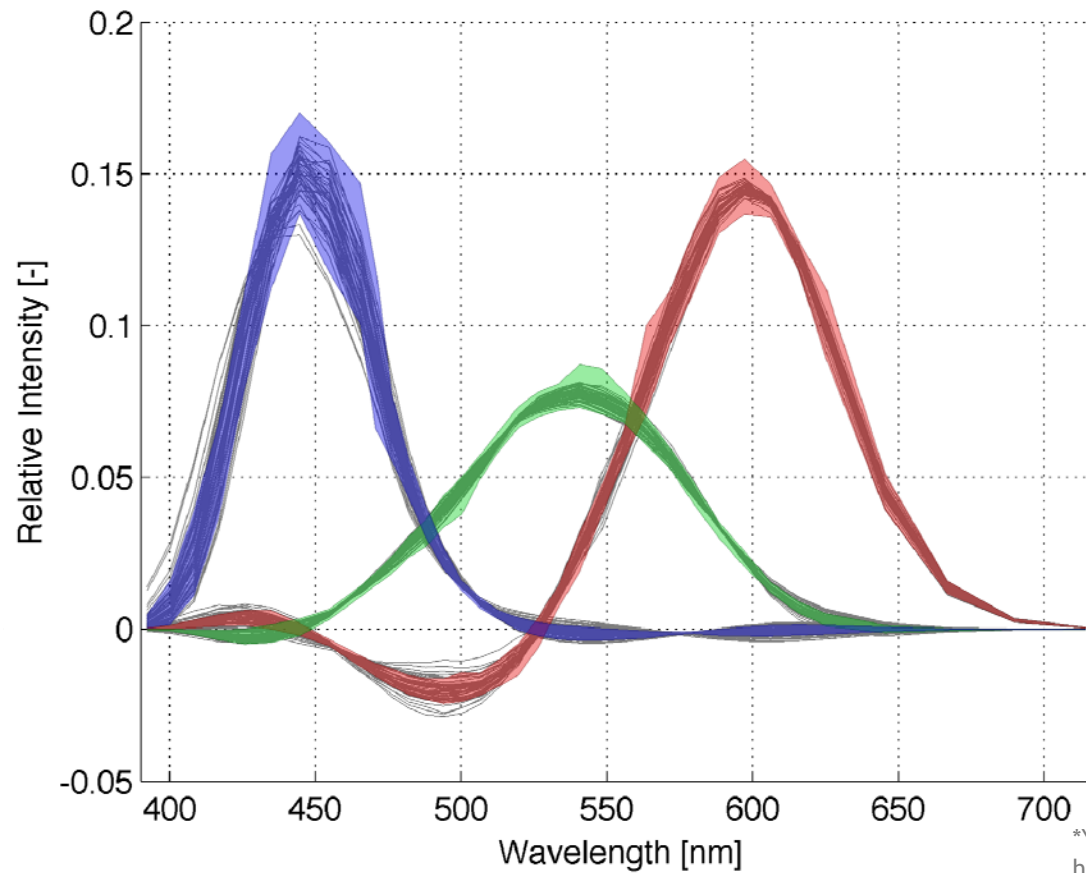
Not much difference from the values alone.

Observer Variations

- CIE Report* suggested:
“A potential practical solution is to implement an observer-dependent color imaging workflow at the device level. ... Conceptually this is similar to the device-dependent color imaging, a well-established color management concept. ”
- But no spectral color management workflow was established at that time.
- Only Standard Observer could be applied.

*CIE Final Report for R1-54: Variability In Color-Matching Functions

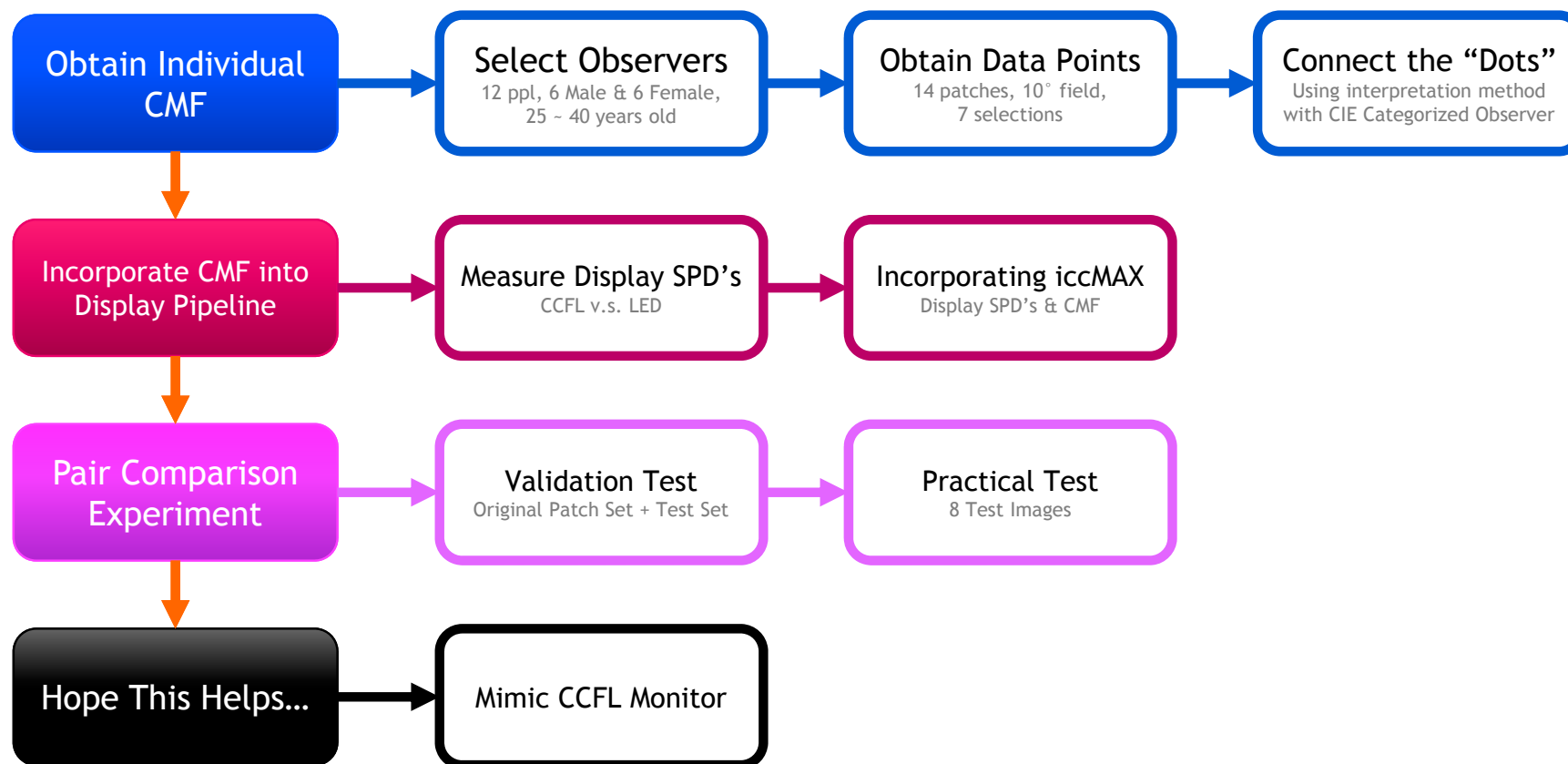
Observer Variations



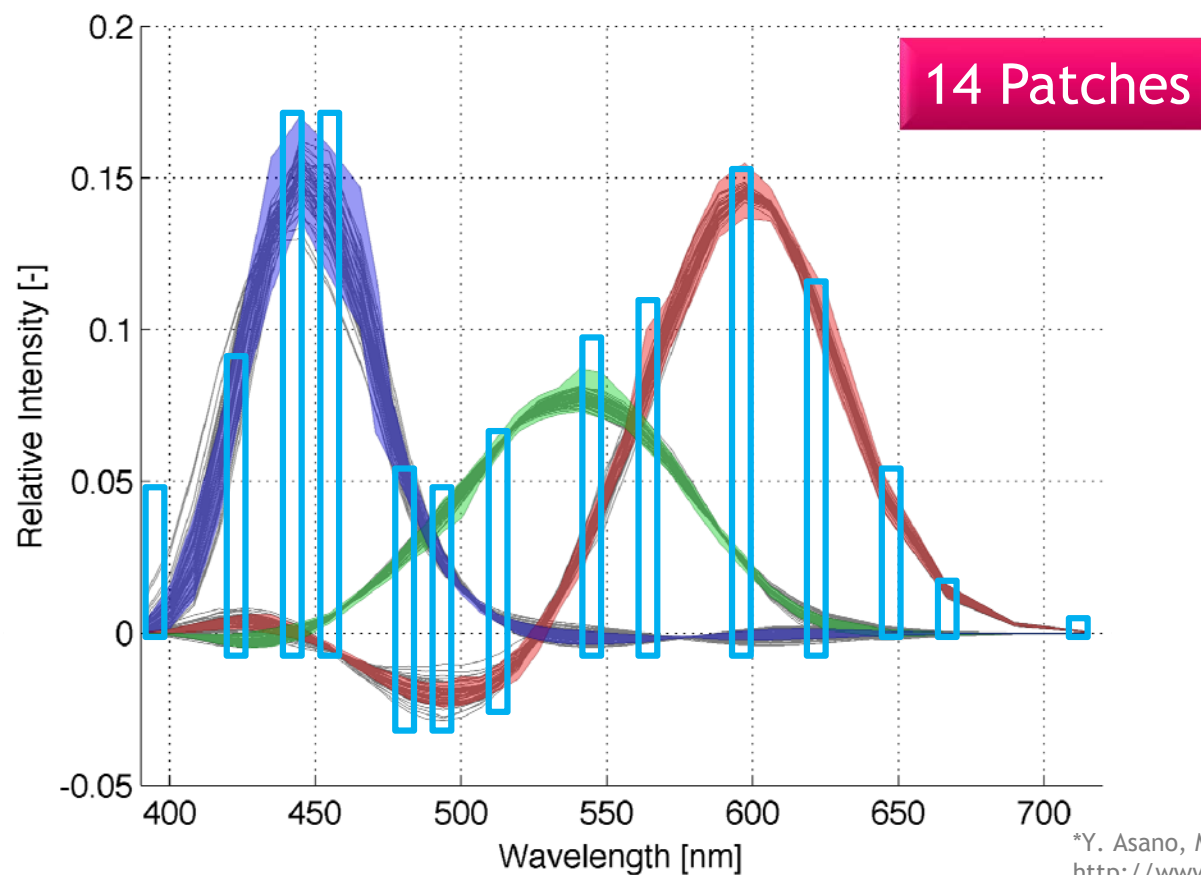
*Y. Asano, MSCL, RIT, USA
<http://www.cis.rit.edu/~yxa8513/Research.html>

SOME MORE RESEARCH...

Experiment Flow



Color Patch Selection



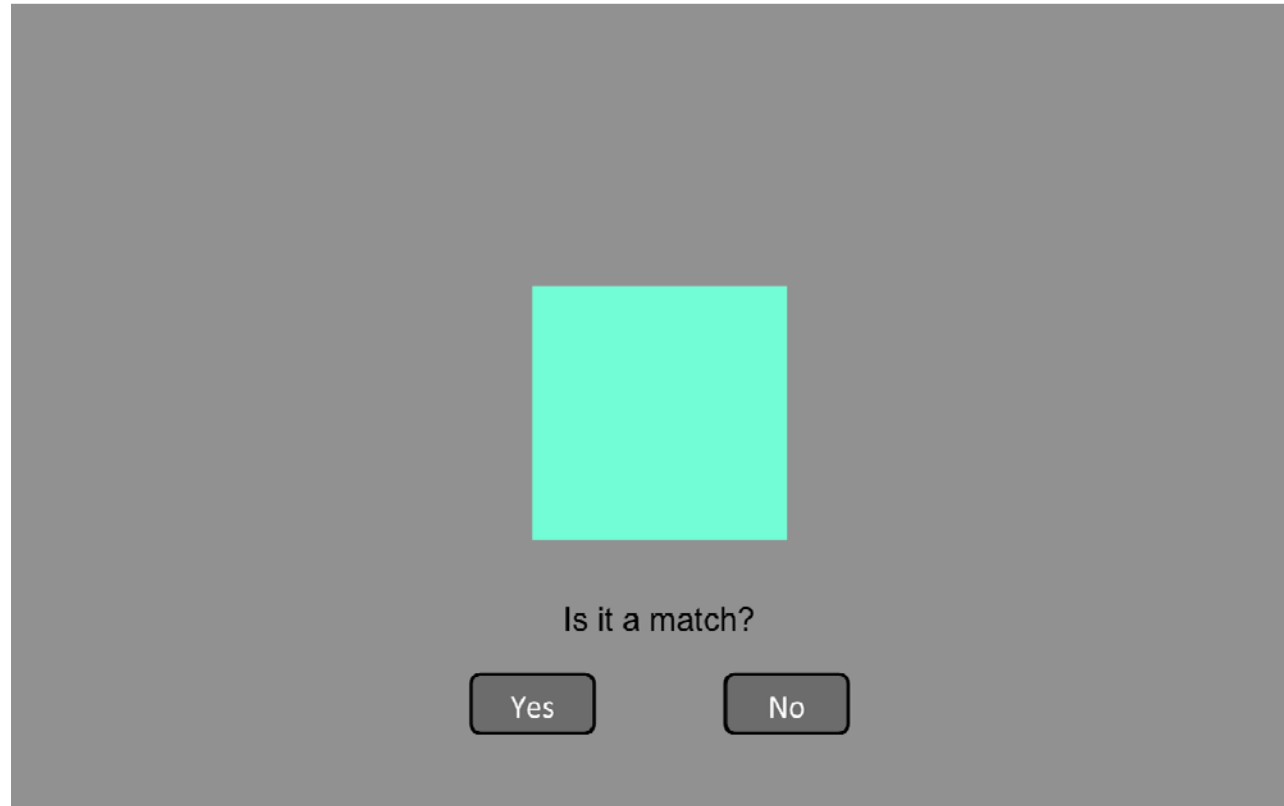
*Y. Asano, MSCL, RIT, USA
<http://www.cis.rit.edu/~yxa8513/Research.html>

Categorization

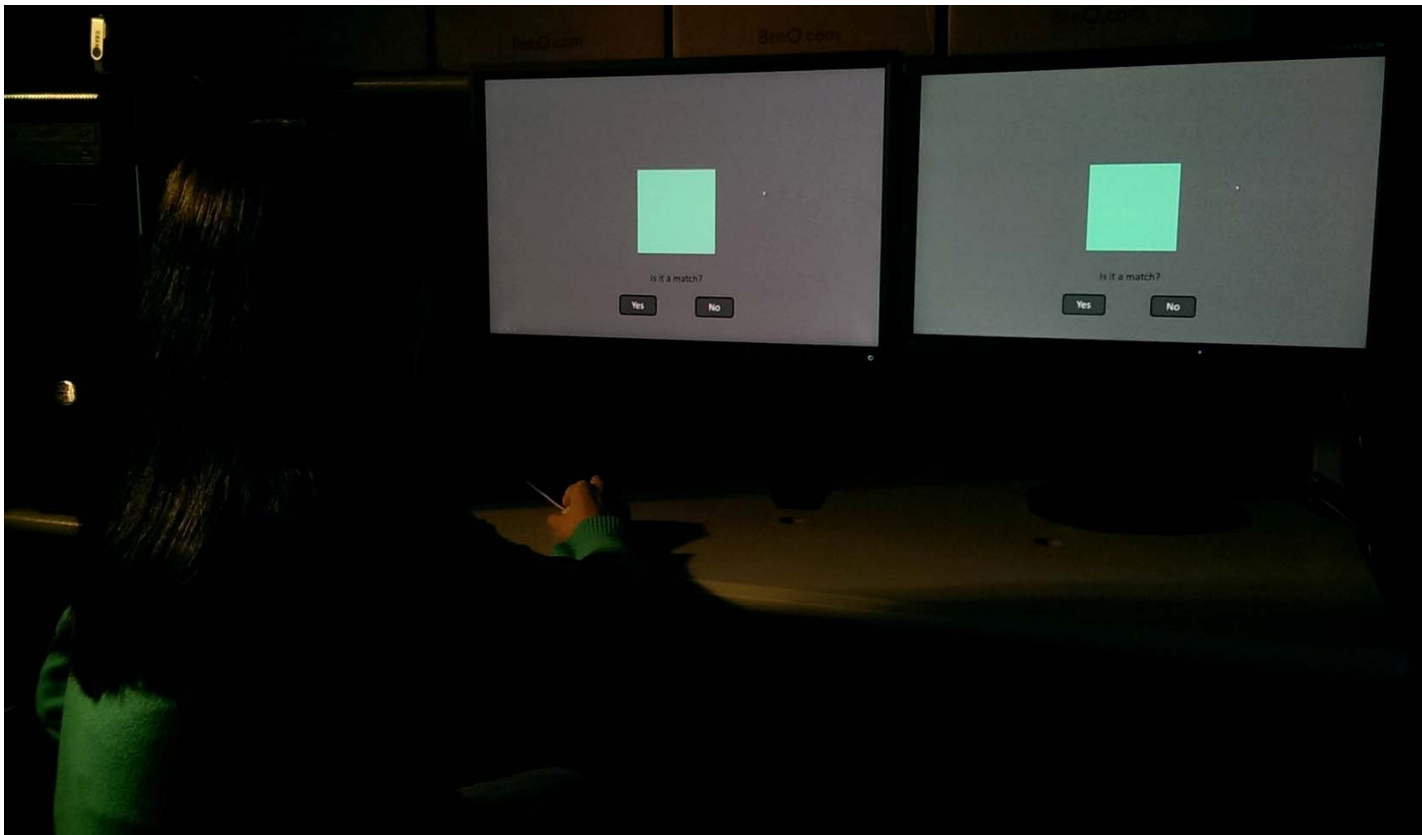
- It's very difficult and time consuming to obtain individual's CMF.
 - Apparatus is also another difficulty...
- Used categorized method to determine CMF:
 - As suggested in CIE Final Report*
 - 14 color patches were used to determine fixed data points
 - Interpretation was used to obtain the intermediate data points

*CIE Final Report for R1-54: Variability In Color-Matching Functions

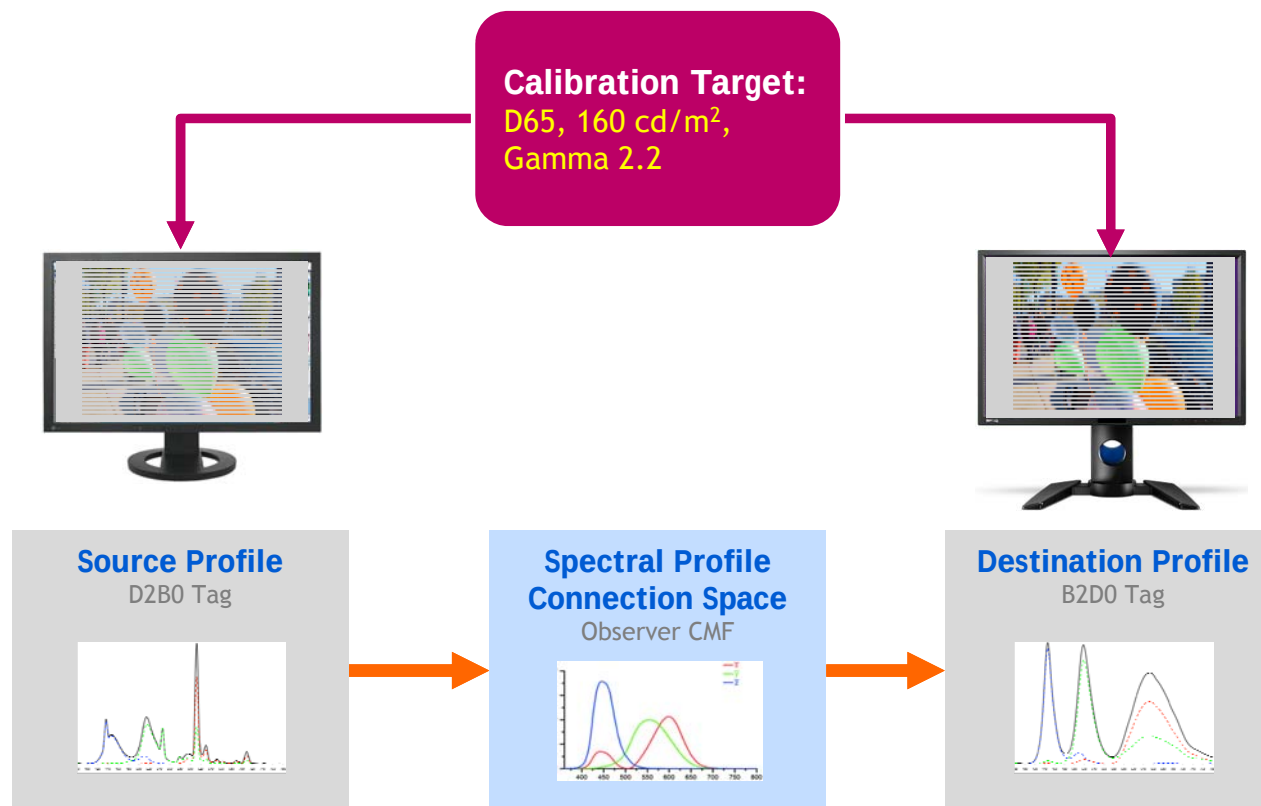
Interface



Experiment Setup



iccMAX Workflow



Test Images



Test Image 1



Test Image 2



Test Image 3



Test Image 4



Test Image 5



Test Image 6

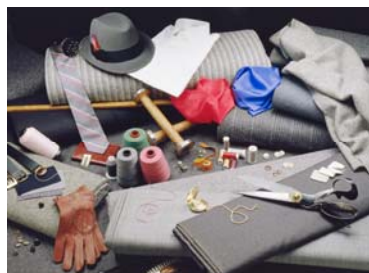


Test Image 7



Test Image 8

Result



Test Image 1



Test Image 2



Test Image 3



Test Image 4

BEFORE	No. of Acceptable	7	9	3	4
	No. of Unacceptable	5	3	9	8
	Rate of Acceptable	58.3%	75.0%	25.0%	33.3%
AFTER	No. of Acceptable	9	10	8	6
	No. of Unacceptable	3	2	4	6
	Rate of Acceptable	75.0%	83.3%	66.7%	50.0%
Improvement		+16.7%	+8.3%	+41.7%	+16.7%

Result



Test Image 5



Test Image 6



Test Image 7



Test Image 8

BEFORE	No. of Acceptable	4	8	6	5
	No. of Unacceptable	8	4	6	7
	Rate of Acceptable	33.3%	66.7%	50.0%	41.7%
AFTER	No. of Acceptable	3	10	9	6
	No. of Unacceptable	9	2	3	6
	Rate of Acceptable	25.0%	83.3%	75.0%	50.0%
Improvement		-8.3%	+16.6%	+25.0%	+8.3%

What Do Images Look Like for One Observer?



Before



Before

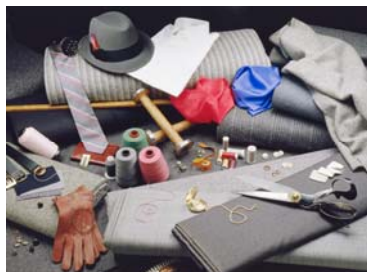


Before



Before

Test Image 1



Original

Test Image 2



Original

Test Image 3



Original

Test Image 4



Original



After



After



After



After

What Do Images Look Like for One Observer?



Before



Original



After

Test Image 5



Before



Original



After

Test Image 6



Before



Original



After

Test Image 7



Before



Original



After

Test Image 8

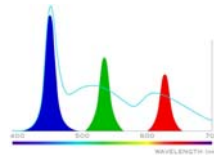
Conclusion

- Improvement was shown after utilizing iccMAX workflow.
 - Blue and green tones
 - Saturated colors
- Some area still needs further investigation:
 - Pale and low brightness colors
 - Skin tone
 - Red tones
- Overall, with proper adjustment, iccMAX is the key to solve observer metamerism on narrow band emission devices.

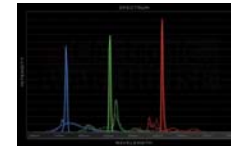
For the Future...

1. More observers with different age, ethnic groups, experience level...
2. Incorporate more wide gamut displays with different spectral characteristics: (In progress...)

- ❑ Quantum Dot Technology



- ❑ Laser Diode + LED Technology (Red Laser Diode + Cyan LED)



- ❑ OLED

3. Improvement on CMF estimation:

- ❑ Validate current CMF estimation.
- ❑ A better fitting algorithm for “connecting the dots”.
- ❑ Construct a robust and simplified method to estimate individual’s CMF.

For the Future...

4. Fine tune for different applications:

- ❑ Matching to projectors
 - Halogen lamp
 - Laser
- ❑ Matching to hardcopies under different light source types
 - Fluorescent light
 - LED light

5. A “metric” to reflect the perceived color difference.

6. How to integrate all pieces into a simple workflow.

Thank You for Your Attention