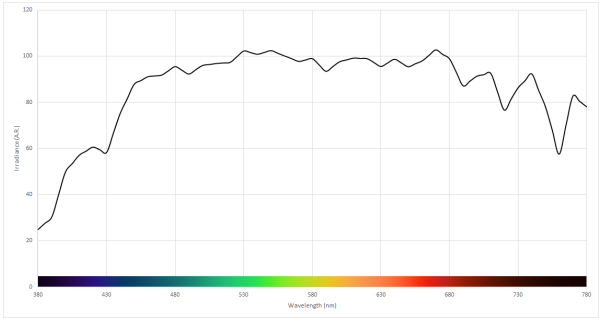
TAGA NextGen

Improving Perceptual Color Matching Performance between Different Backlight Displays and Color Managed Prints using Observer Correction Matrix in ICC Architecture

Dr. Chris Bai

Why?


xrite
The Judge II


120
100
80
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20
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380
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530
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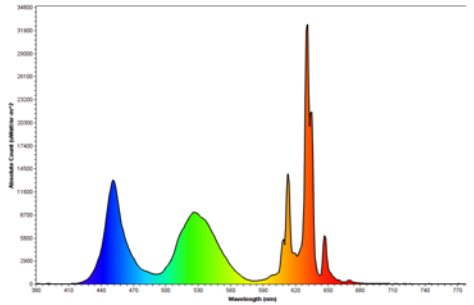
630
680
730
780
Wavelength (nm)



Experiment Overview

- To conduct “visual matching” between CCFL and LED displays and a hardcopy print.
- Adjusting the parameters on the display using designed software.

Experiment Overview

- Nine images (six chromatic and three grayscale) were utilized in formulating individual color matching functions.

Experiment Overview

- Two experiments were conducted:
  1. CMF (Colour Matching Function) Construction Experiment:
     - to use visual matching method to determine individual CMFs,
     - calculate average CMFs, and
     - utilize K-means method to obtain 3 groups of CMFs.
  2. Validation Experiment:
     - to validate the best matching set of CMFs.
- 45 observers participated the experiment:
  - 24 male and 21 female
  - Age ranges from 25 to 45 years old.
- Each observers were asked to conduct 3 trials.
  - There were 45x7x3 = 945 judgements conducted in the experiment.

Experiment Procedure

- CMF Construction Experiment:
  1. Calibrate the monitor to D50, and generate Display Profile.
  2. Use experiment software to adjust hue, saturation and lightness of the displayed image.
  3. Record the HSL values of each image.
  4. Repeat the adjustment for 3 times for each observer.
- Validation Experiment:
  1. Devise individual, average, and 3 K-means CMFs.
  2. Ask observer to evaluate 6 sets of CMFs (including 2°) for the best match.
  3. Calculate the ΔE values between the print and display.

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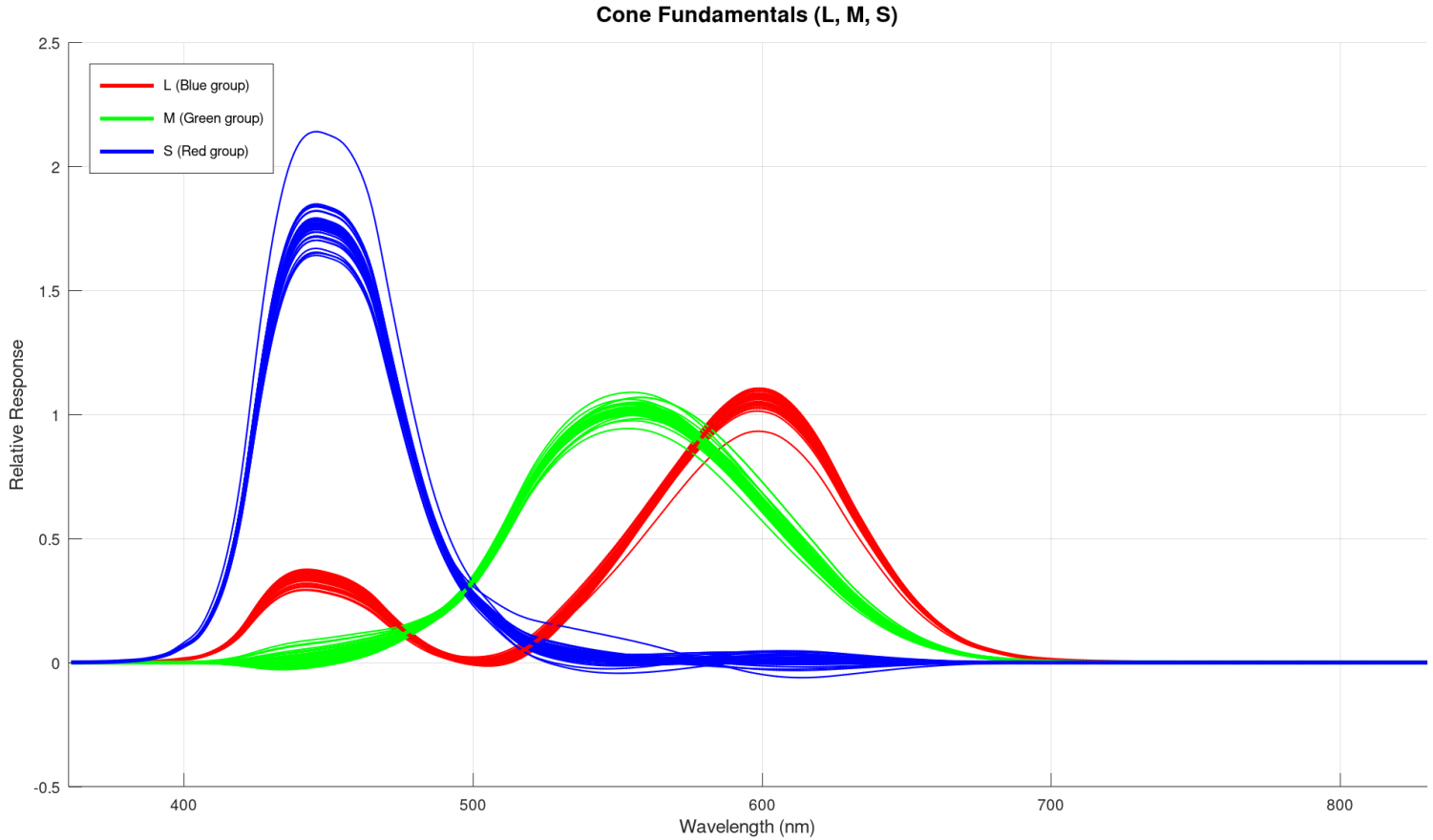
CMF Construction Experiment

CMF Construction Experiment

- Experiment Procedure:
  1. Calibrate the monitor to D50, and generate Display Profile.
  2. Use experiment software to adjust hue, saturation and lightness of the displayed image and colour patches.
  3. Record the HSL values of each image.
  4. Repeat the adjustment for 3 times for each observer.
  5. Measure the XYZ values of the colour patches for each observer.
  6. Construct individual CMFs using matrix transformation from 2° Standard Observer CMFs.
  7. Utilize 45 sets of individual CMFs to determine average CMF and 3 categories of CMFs using K-means method.

Experiment Results

- 45 observers' Individual CMFs



CMF Sets

Displaying with Different CMFs - Red

2 Degree

Individual

Average

K-means 1

K-means 2

K-means 3

Displaying with Different CMFs - Green

2 Degree

Individual

Average

K-means 1

K-means 2

K-means 3

Displaying with Different CMFs - Blue

2 Degree

Individual

Average

K-means 1

K-means 2

K-means 3

Displaying with Different CMFs - Cyan

2 Degree

Individual

Average

K-means 1

K-means 2

K-means 3

Displaying with Different CMFs - Magenta

2 Degree

Individual

Average

K-means 1

K-means 2

K-means 3

Displaying with Different CMFs – Yellow

2 Degree

Individual

Average

K-means 1

K-means 2

K-means 3

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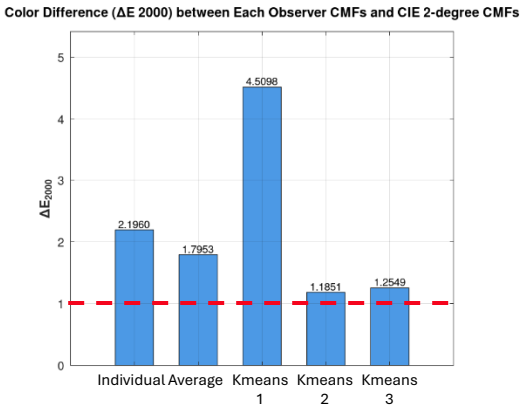
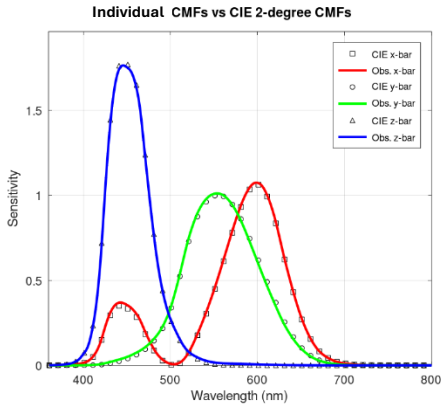
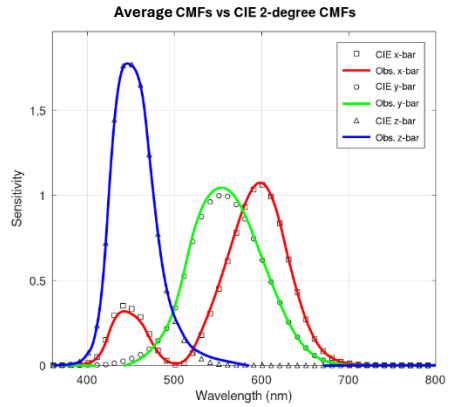
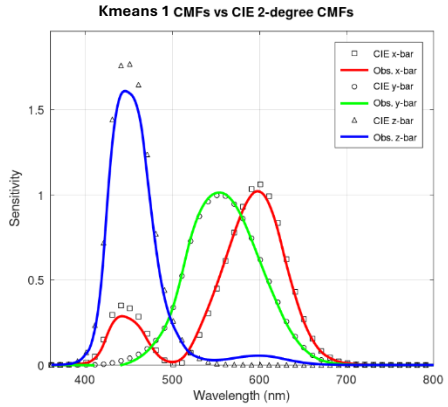
Validation Experiment

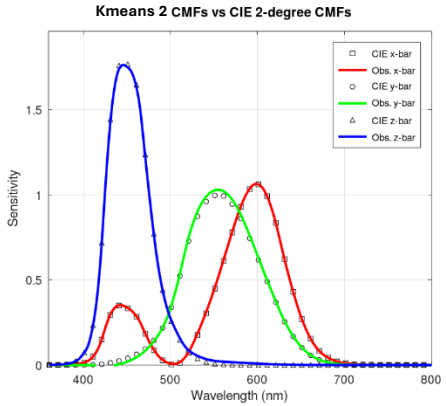
Validation Experiment

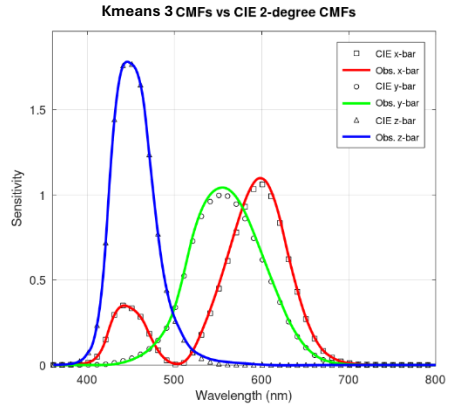






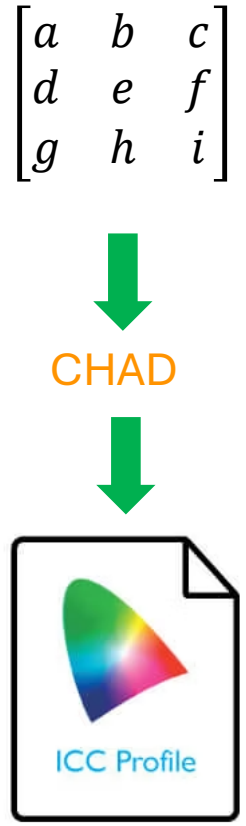






Validation Experiment

- Experiment Procedure:
  1. Calculate the corresponding matrices related to 2° Standard Observer CMFs from:
     - Individual CMFs
     - Average CMFs
     - 3 Categories of K-means CMFs
  2. Generate corresponding ICC profiles using CHAD tag.
  3. Ask observer to evaluate 6 sets of CMFs (including 2°) for the best match.
  4. Calculate the ΔE values between the print and display.



Softproofing with Different CMFs - Red

Softproofing with Different CMFs - Green

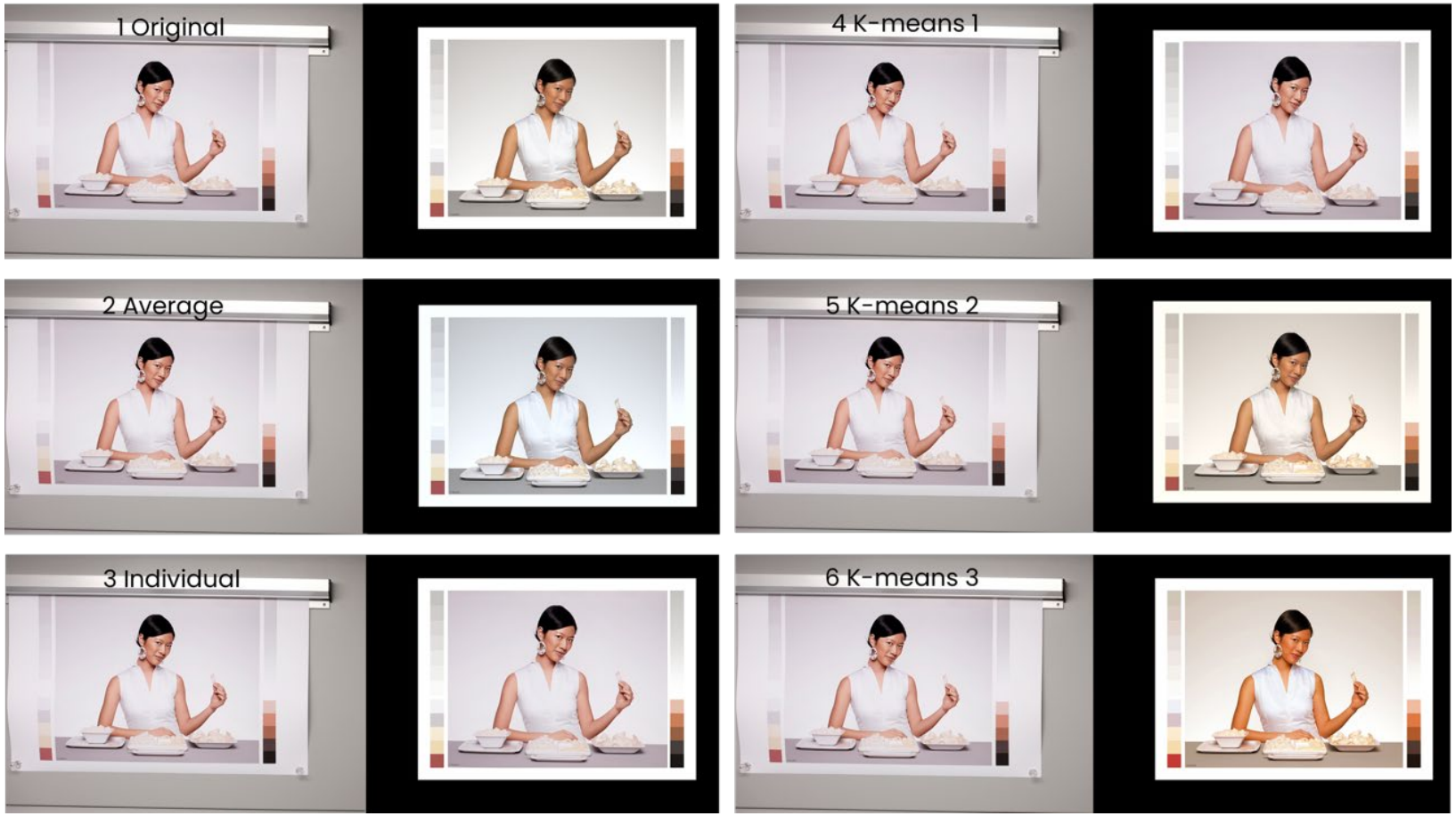
Softproofing with Different CMFs - Blue

Softproofing with Different CMFs - Cyan

Softproofing with Different CMFs - Magenta

Softproofing with Different CMFs - Yellow

Softproofing with Different CMFs - White



Preliminary Validation Result

Observer	W	R	G	B	C	M	Y
A	3	3	3	3	3	4	1
B	4	3	4	3	3	1	1
C	4	3	4	3	3	4	1
D	3	3	4	3	4	1	1
E	3	3	4	5	4	4	1

1. Original Image	2. Average CMFs	3. Individual CMFs	4. K-means Cluster 1	5. K-means Cluster 2	6. K-means Cluster 3

Average	0.99735	0.01117	-0.0047
	-0.00895	1.02252	-0.00596
	0.00429	0.00324	0.98685

Individual	1.0064	0.0059	0.00937
	-0.03893	1.0297	0.01305
	-0.0068	0.00901	0.98823

K-means 1	0.92439	0.05876	-0.02164
	-0.03143	1.02909	-0.00851
	0.05247	-0.002	0.89287

K-means 2	0.97016	-0.01438	0.01763
	-0.00959	0.9896	0.00812
	-0.01495	0.0088	0.99652

K-means 3	0.94288	-0.00617	0.00851
	0.0068	0.96276	-0.0116
	-0.13801	0.11356	0.95021

Preliminary Validation Result

- Using ISO 14861 patches to validate the differences between CCFL monitor, LED monitor, LED monitor with CMF correction and hardcopy proof.

All Patches	CCFL	LED	LED with CMF	Threshold
Mean ΔE_{00}	2.72	3.79	3.16	4.0
Max. ΔE_{00}	5.81	6.81	6.46	6.5

Gray Patches	CCFL	LED	LED with CMF	Threshold
Mean ΔE_{00}	1.03	3.22	1.38	3.0
Max. ΔE_{00}	1.98	5.19	2.98	-

Conclusions

1. Modern wide colour gamut display can cause colour matching failure.
2. The degree of colour matching failure is observer specific.
3. Experiment results had shown using CMFs other than 2° Standard Observer CMFs can improve softproofing performance.
   - Both in terms of visual and colorimetric measurement.
4. Observer specific CMFs can be implemented in current ICC profile architecture.