SPECTRAL IMAGING

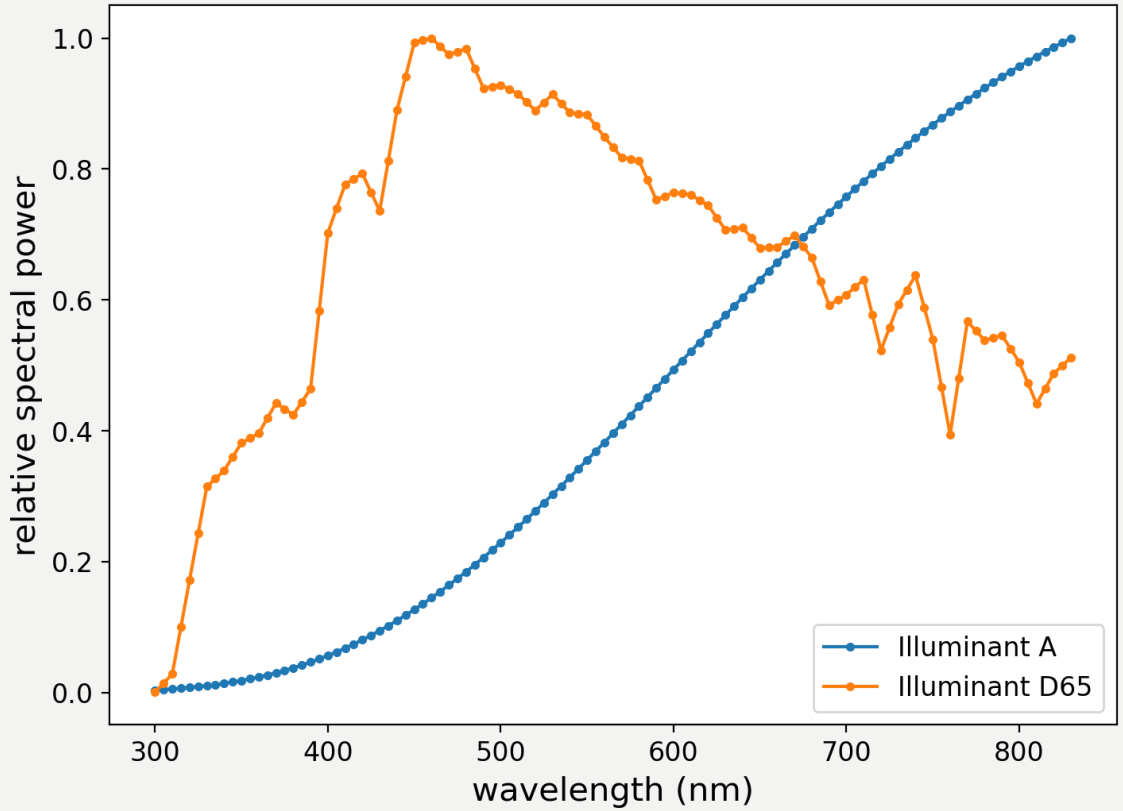
ACTIVITY 02

PHYSICS 301

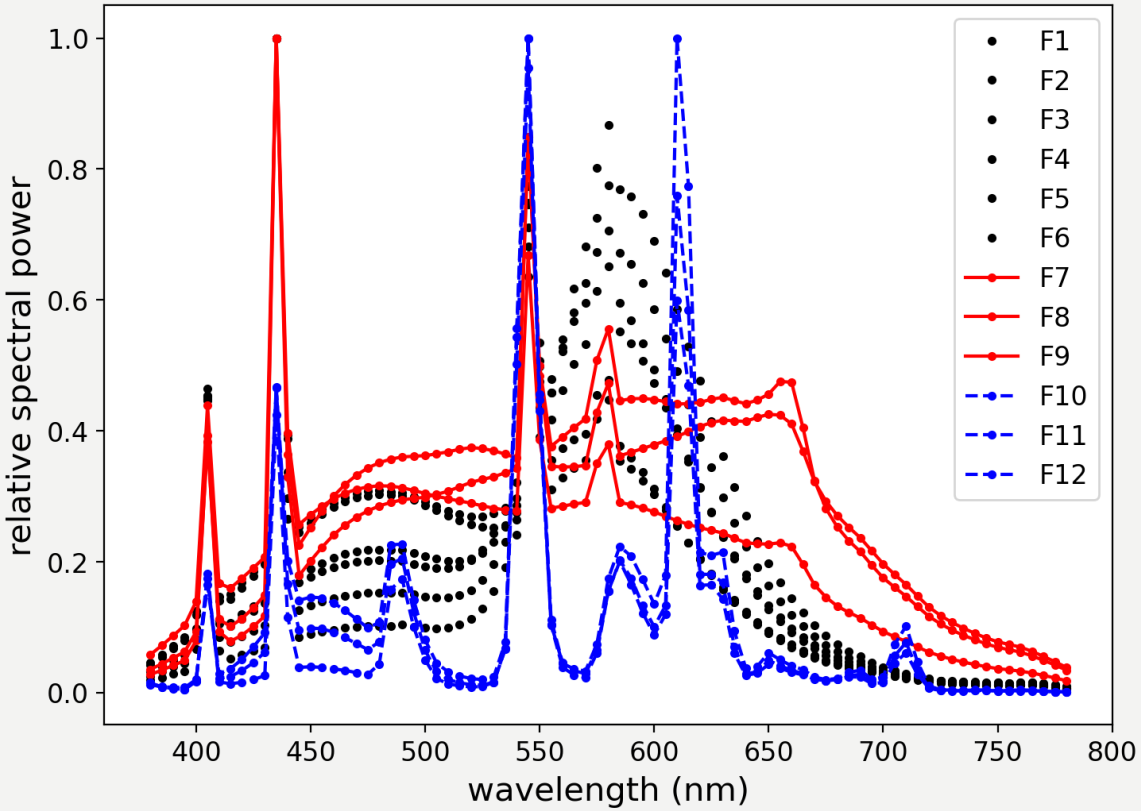
KENNETH M. LEO

LIGHT SOURCES

CIE Illuminants



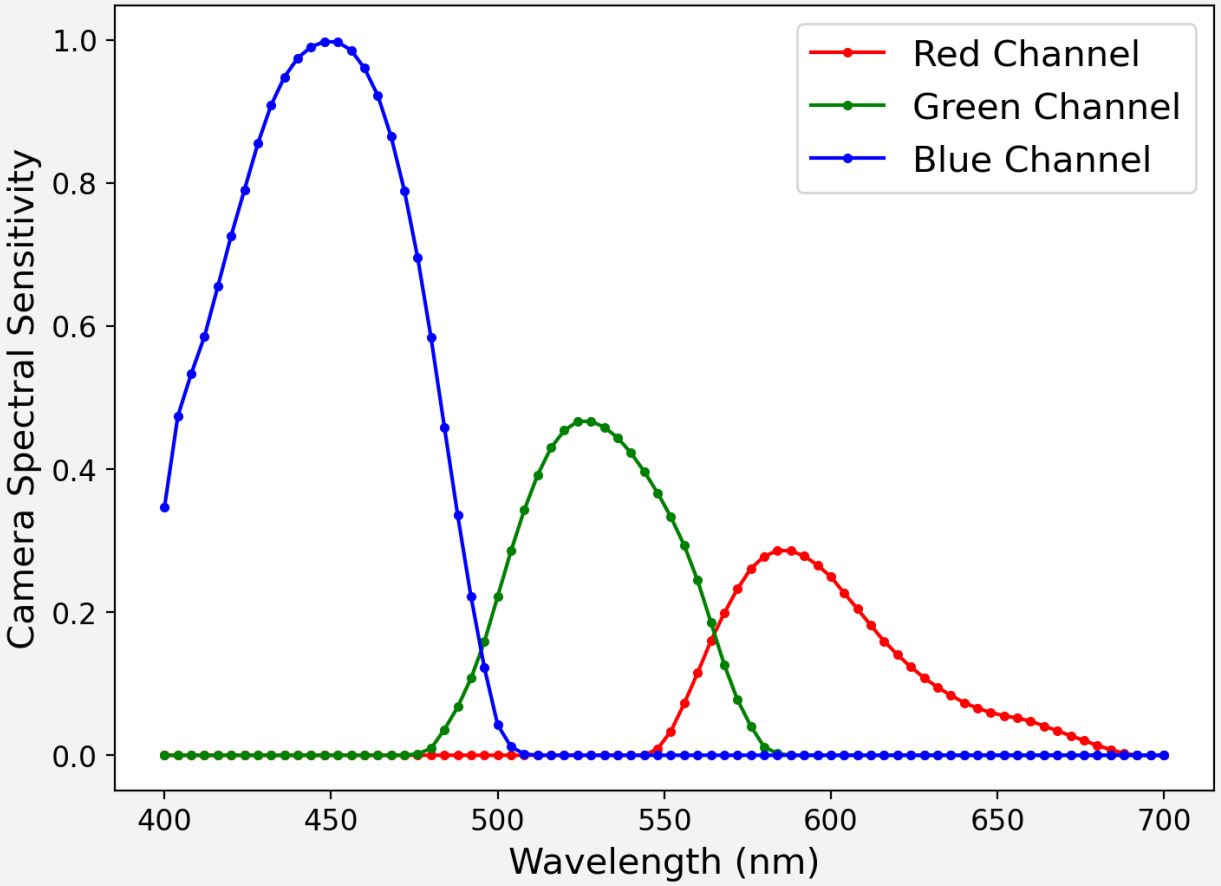
CIE Fluorescent lamps



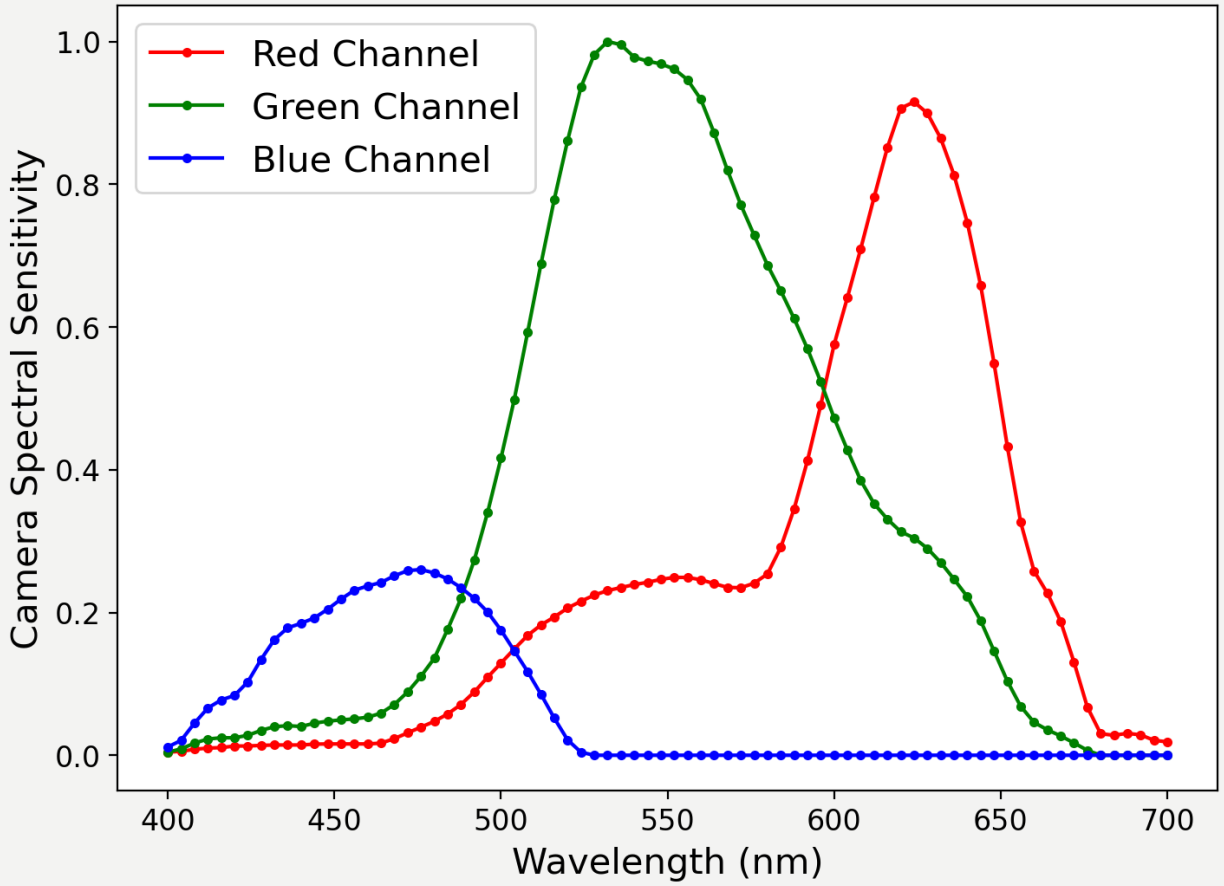
F1-F6: Common Illuminants
F7-F9: High Color Rendering Illuminants
F10-F12: Three Band Illuminants

CAMERAS USED

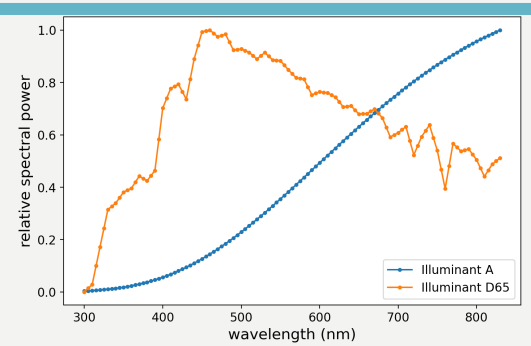
Sony DXC-930

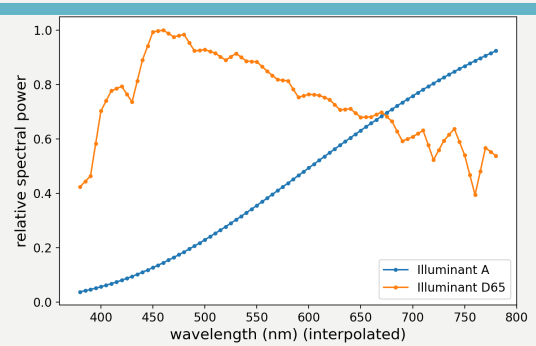


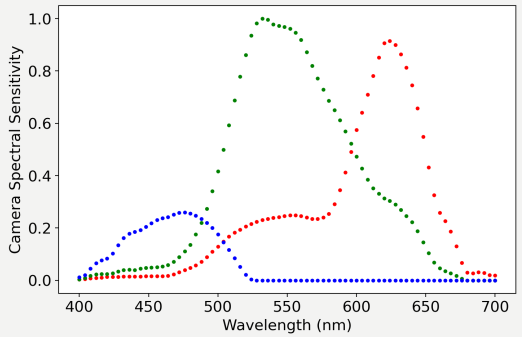
Kodak DCS-420

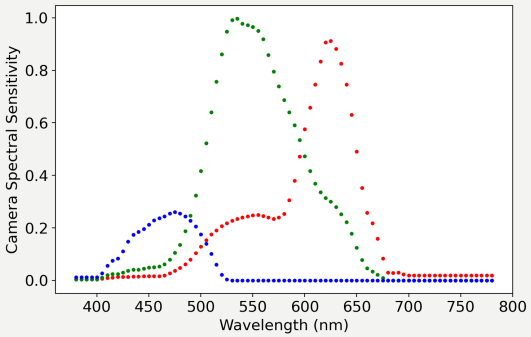


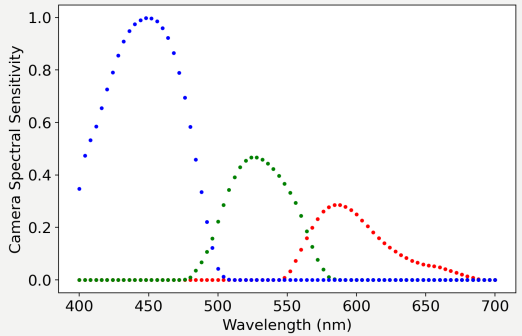
DATA - PREPROCESSING

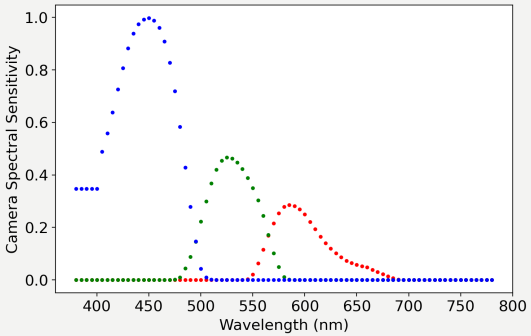












Before recreating the Macbeth chart, the data for the light source and camera sensitivity were interpolated (right) so that they have the same wavelength intervals as the Macbeth chart's reflectance value (below).

	wavelength	1	2	3	4	5	6	7	8	9	...	15	16	17	18	19	20	21	22	23	24
0	380	0.048	0.103	0.113	0.048	0.123	0.110	0.053	0.099	0.096	...	0.052	0.054	0.118	0.093	0.153	0.150	0.138	0.113	0.074	0.032
1	385	0.051	0.120	0.138	0.049	0.152	0.133	0.054	0.120	0.108	...	0.052	0.053	0.142	0.110	0.189	0.184	0.167	0.131	0.079	0.033
2	390	0.055	0.141	0.174	0.049	0.197	0.167	0.054	0.150	0.123	...	0.052	0.054	0.179	0.134	0.245	0.235	0.206	0.150	0.084	0.033
3	395	0.060	0.163	0.219	0.049	0.258	0.208	0.054	0.189	0.135	...	0.052	0.053	0.228	0.164	0.319	0.299	0.249	0.169	0.088	0.034
4	400	0.065	0.182	0.266	0.050	0.328	0.252	0.054	0.231	0.144	...	0.051	0.053	0.283	0.195	0.409	0.372	0.289	0.183	0.091	0.035

Then, I just used the equation below to compute for the color output (RGB value) that the camera will 'see':

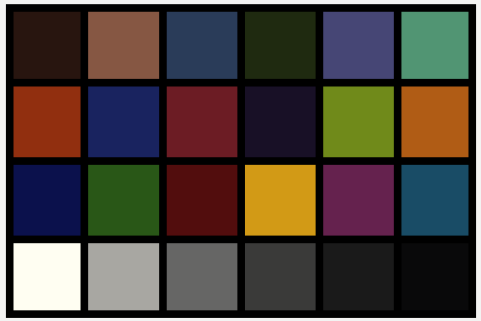
$$\bar{\bar{V}}_n = \frac{\sum_\lambda P(\lambda)R(\lambda)S_n(\lambda)}{\sum_\lambda P(\lambda)S_n(\lambda)}$$ ← White balanced color

$P(\lambda)$ – Spectral Power (light source)
$R(\lambda)$ – Object Reflectance (Macbeth chart)
$S_n(\lambda)$ - Spectral Sensitivity (camera)

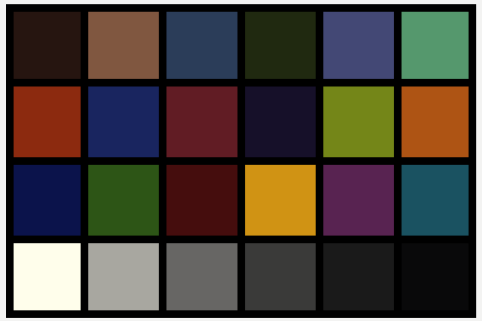
MACBETH COLOR CHART RENDERING

Using 5 Different Light Sources and 2 Different Camera

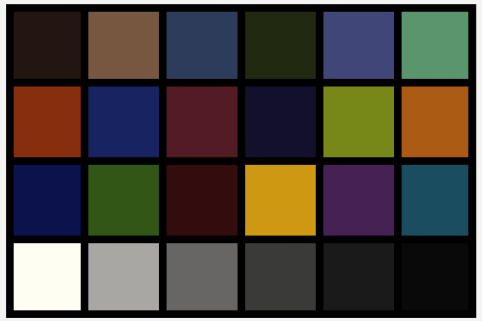
Camera: SonyDXC-930, light: A



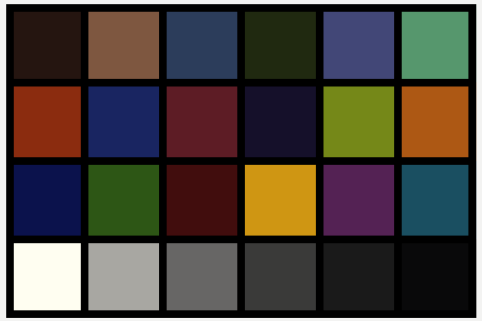
Camera: SonyDXC-930, light: D65



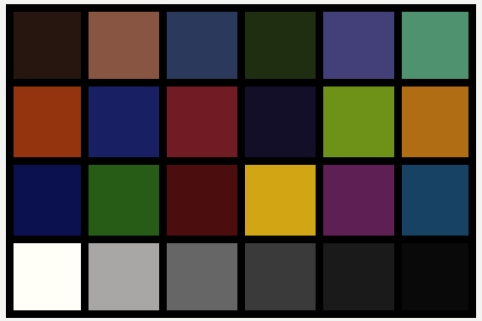
Camera: SonyDXC-930, light: F1



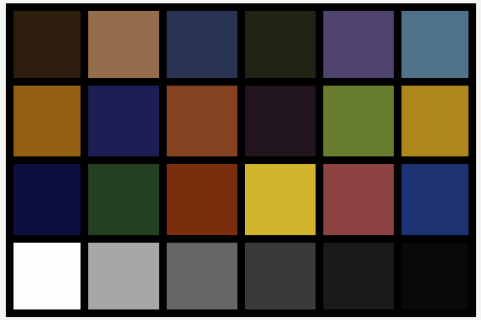
Camera: SonyDXC-930, light: F7



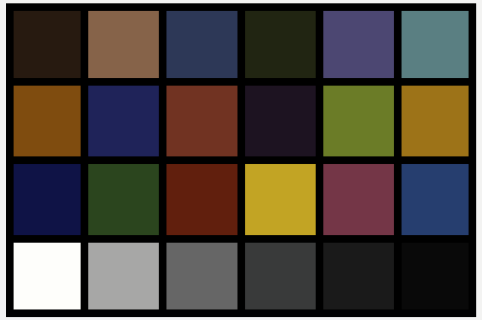
Camera: SonyDXC-930, light: F10



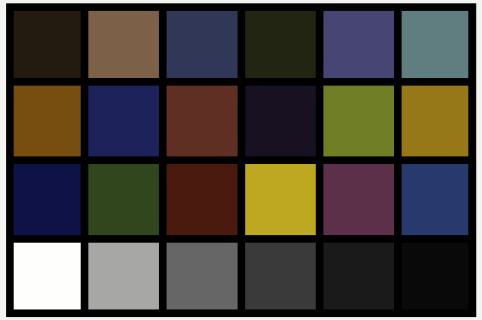
Camera: KodakDCS-420, light: A



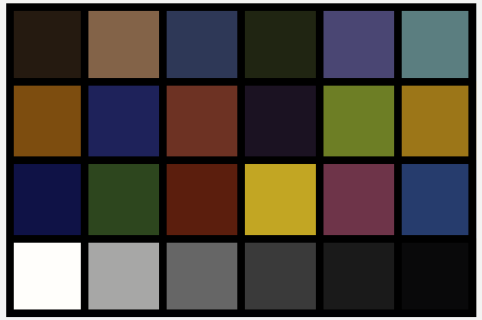
Camera: KodakDCS-420, light: D65



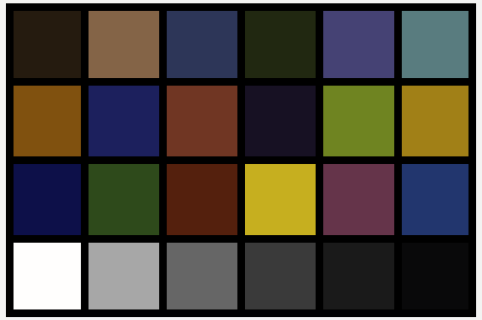
Camera: KodakDCS-420, light: F1



Camera: KodakDCS-420, light: F7



Camera: KodakDCS-420, light: F10

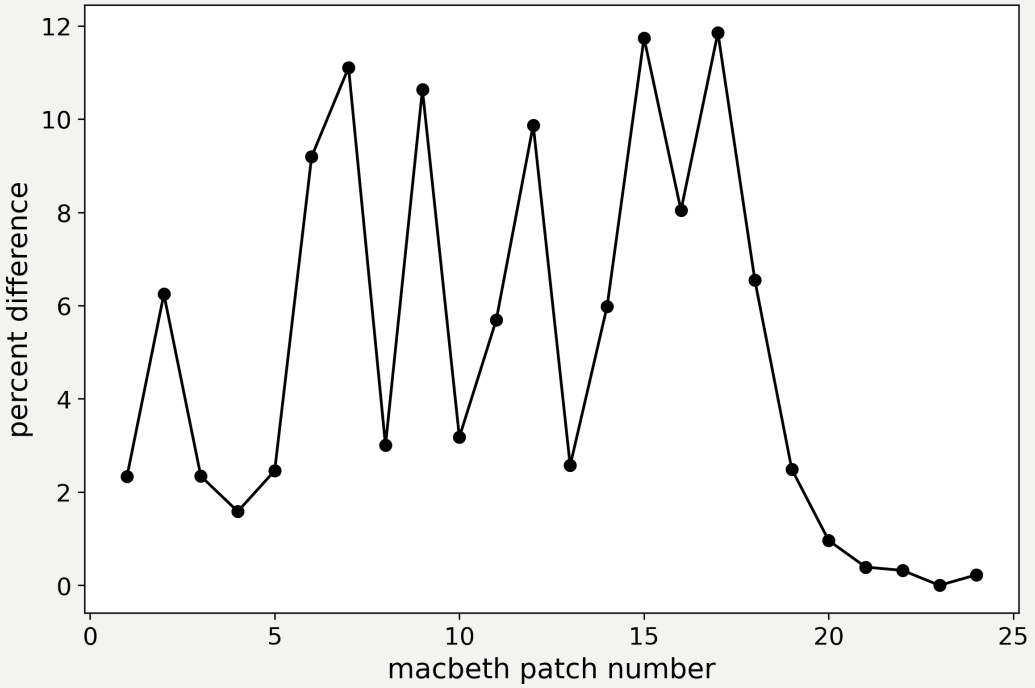


Notice that there are few differences when we use different light source (though not that obvious). We see a big difference in the colors of the Macbeth charts when we compare two different cameras. It seems like Sony cameras (above) produce cooler colors while Kodak cameras (below) have a warmer tone.

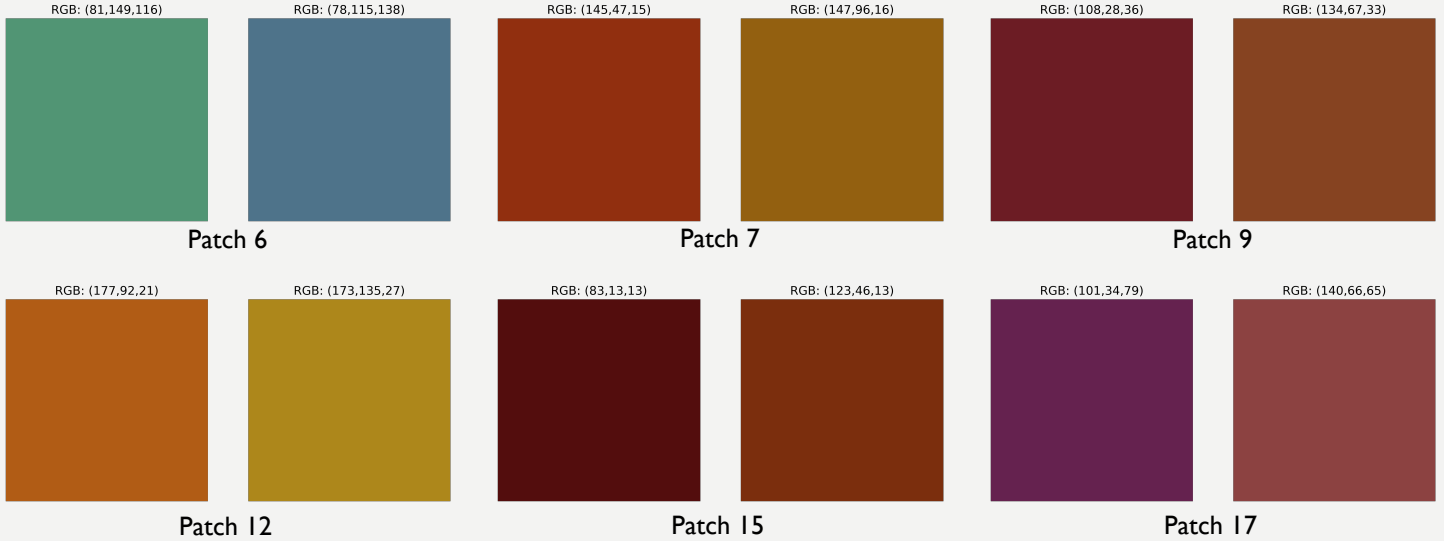
COMPARING RENDERED COLORS

Color Difference using different Cameras

We compare how different the colors produced by different cameras under same light source. For this, we can just actually use a simple metric called the Euclidian distance between the two colors and we can already see the differences.



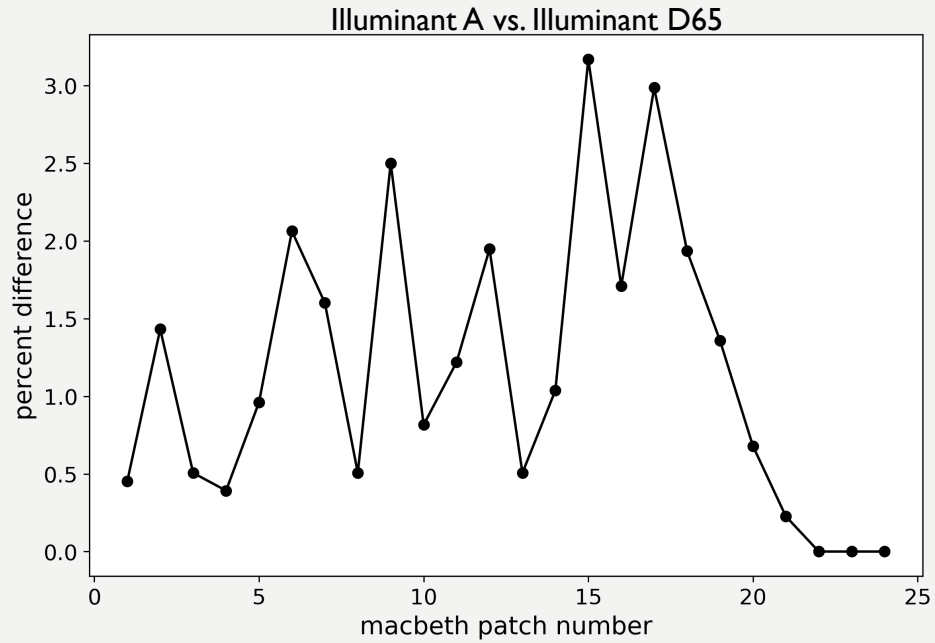
We see that there are patches with very high percent difference from each other, specifically patches 6, 7, 9, 12, 15, and 17. Visualizing them, we can perceive the difference between the colors.

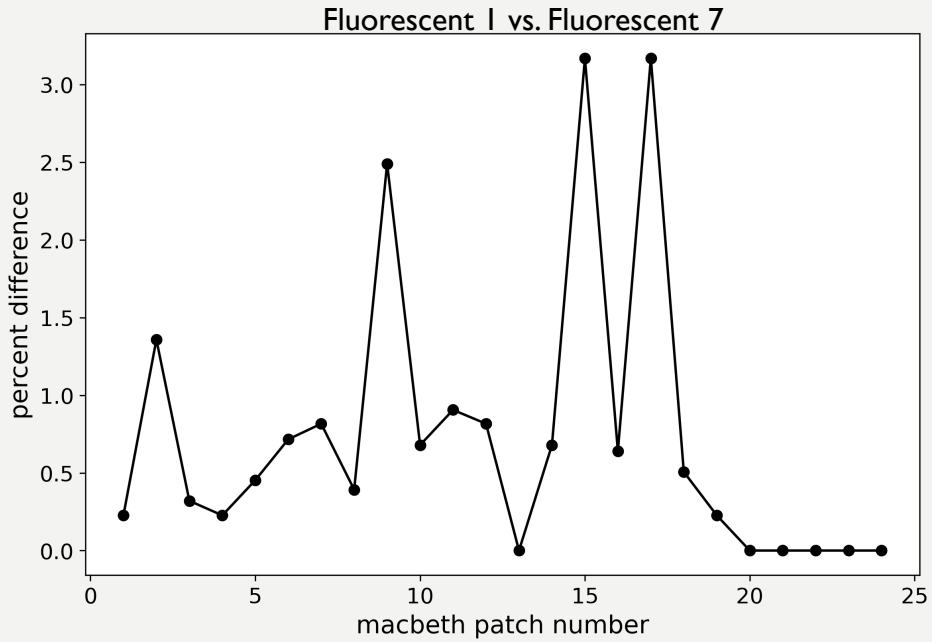


COMPARING RENDERED COLORS

Color Difference using different Light sources

Next, we compare the effect of using different light sources





Notice that the effect of using different light source is not that noticeable as compared to using different cameras. The patches where the color difference are apparent are patches 15 and 17, the brownish and purplish patches.

SCENE RENDERING

Illuminant A	Illuminant D65	Fluorescent 1	Fluorescent 7	Fluorescent 10	
					Sony DXC-930
					Kodak DCS-420

* Intensity is increased to make the colors more visible

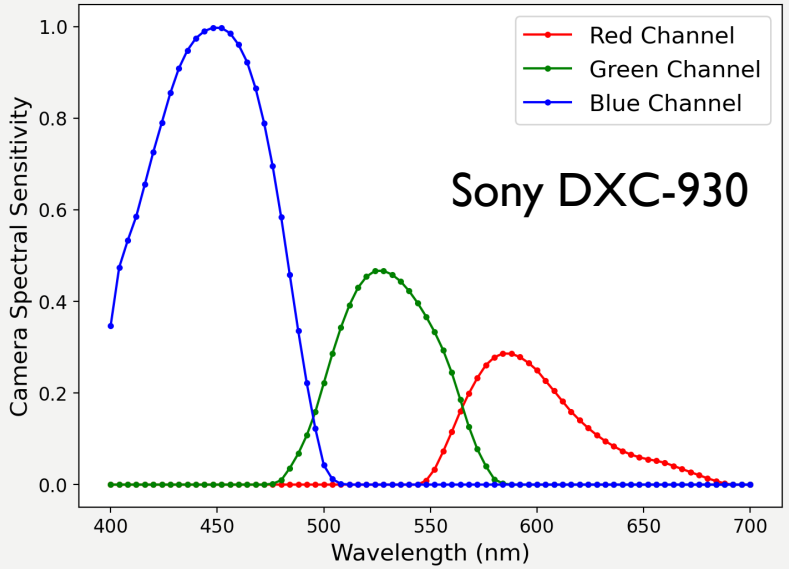
Data taken from: Nascimento, S.M.C., Ferreira, F.P., & Foster, D.H. (2002). Statistics of spatial cone-excitation ratios in natural scenes. Journal of the Optical Society of America A, 19, 1484-1490.

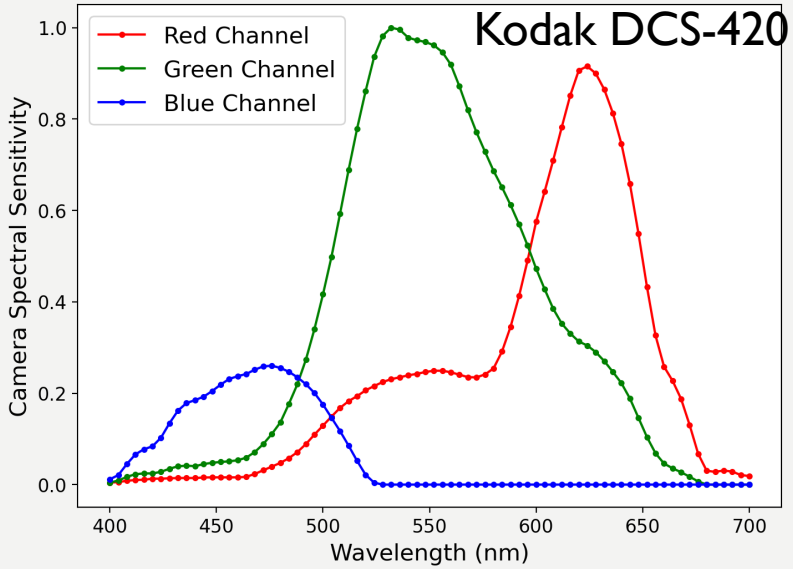
SCENE RENDERING (DIFF CAMERAS)

Sony DXC-930

Kodak DCS-420

From this scene rendering using two different cameras under the same light source (illuminant A), we can now see more clearly that the Kodak camera has an overall warmer/washed out colors compared to the Sony camera. If we look at the camera spectral sensitivities, the Sony camera has high sensitivity in the blue channel while the kodak camera has high sensitivity in both green and red channels which is the reason why the rendered scene looks yellow-ish (R + G = Y).





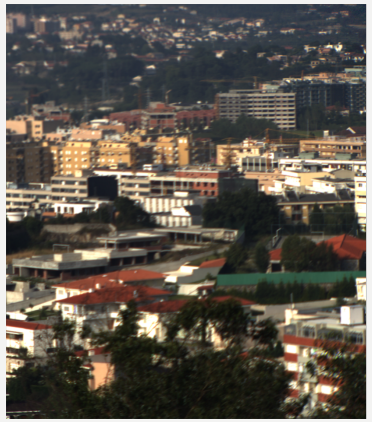
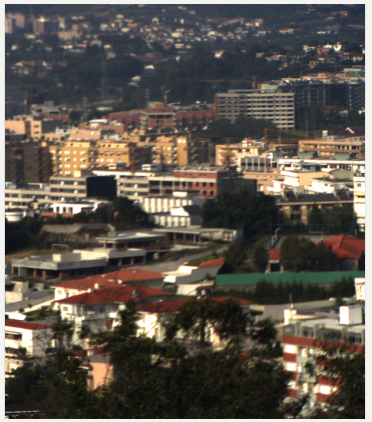
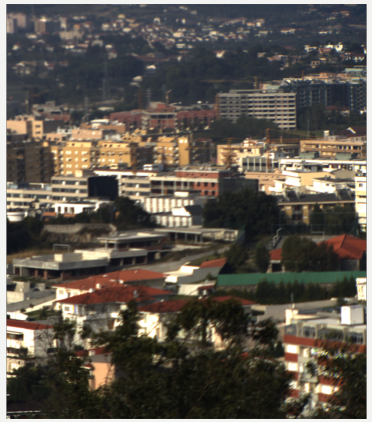
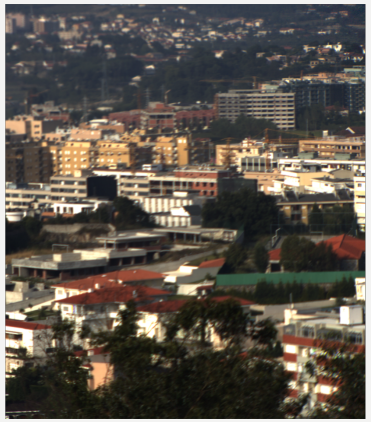
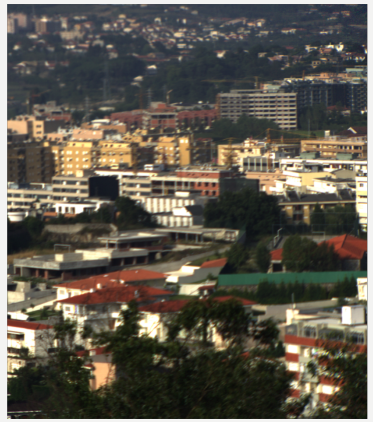
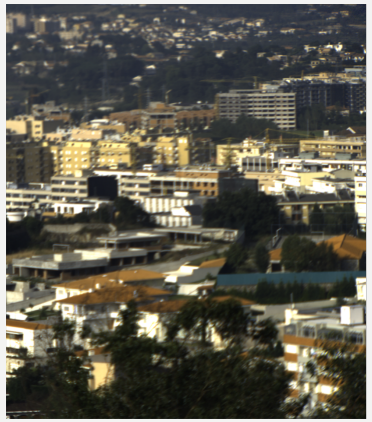
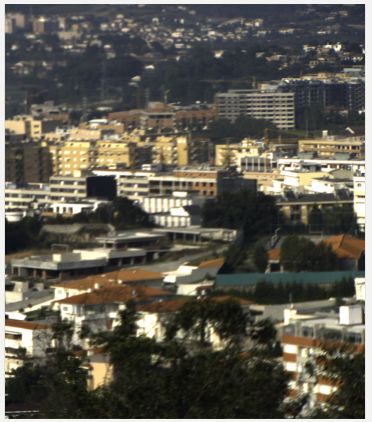
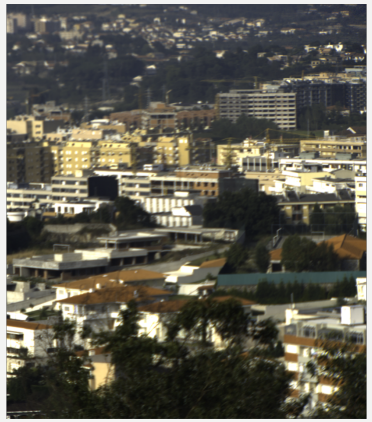
Data taken from: Nascimento, S.M.C., Ferreira, F.P., & Foster, D.H. (2002). Statistics of spatial cone-excitation ratios in natural scenes. Journal of the Optical Society of America A, 19, 1484-1490.

SCENE RENDERING (DIFF LIGHT SOURCES)

Illuminant A | Illuminant D65 | Fluorescent 1 | Fluorescent 7 | Fluorescent 10

Now looking more closely to the effect of different light sources, we see (specially on the highlighted objects) that there is indeed an effect in using different light sources. Illuminant A have a broad spectrum which makes the color distribution somewhat even. On the other hand, D65 has high spectral power at high wavelengths which is why you can somewhat see that the reds are *bolder* in terms of color. The different fluorescent light sources also produce different colors since their spectral power distributions are not the same.

ADDITIONAL RENDERED SCENE

Illuminant A	Illuminant D65	Fluorescent 1	Fluorescent 7	Fluorescent 10	
					Sony DXC-930
					Kodak DCS-420

* Intensity is increased to make the colors more visible

Data taken from: Nascimento, S.M.C., Ferreira, F.P., & Foster, D.H. (2002). Statistics of spatial cone-excitation ratios in natural scenes. Journal of the Optical Society of America A, 19, 1484-1490.

SUMMARY AND REFERENCES

Summary

This experiment was like the group experiment that we did during my undergrad. The additional thing that I did here was the analysis of the rendered patches. It was nice to see and know that there are apparent difference with the color recreation of different cameras. This interests me because as a fan of casual photography, it is nice to have a knowledge of this when buying cameras. Another thing I was able to learn in this experiment was how to handle hyperspectral data.

References

[1] Nascimento, S.M.C., Ferreira, F.P., & Foster, D.H. (2002). Statistics of spatial cone-excitation ratios in natural scenes. Journal of the Optical Society of America A, 19, 1484-1490.
[2] CIE Illuminats A and D65 : http://www.rit-mcsl.org/UsefulData/D65_and_A.xls
[3] CIE Fluorescent lamps : http://www.rit-mcsl.org/UsefulData/Fluorescents.xls
[4] Macbeth color checker : http://www.rit-mcsl.org/UsefulData/MacbethColorChecker.xls
[5] https://nae-lab.org/~rei/research/cs/zhao/database.html
[6] https://stackoverflow.com/questions/9018016/how-to-compare-two-colors-for-similarity-difference

Score:

Technical Correctness – 30
Quality of Presentation – 30
Reflection – 30
Ownership – 10

Total – 100/100