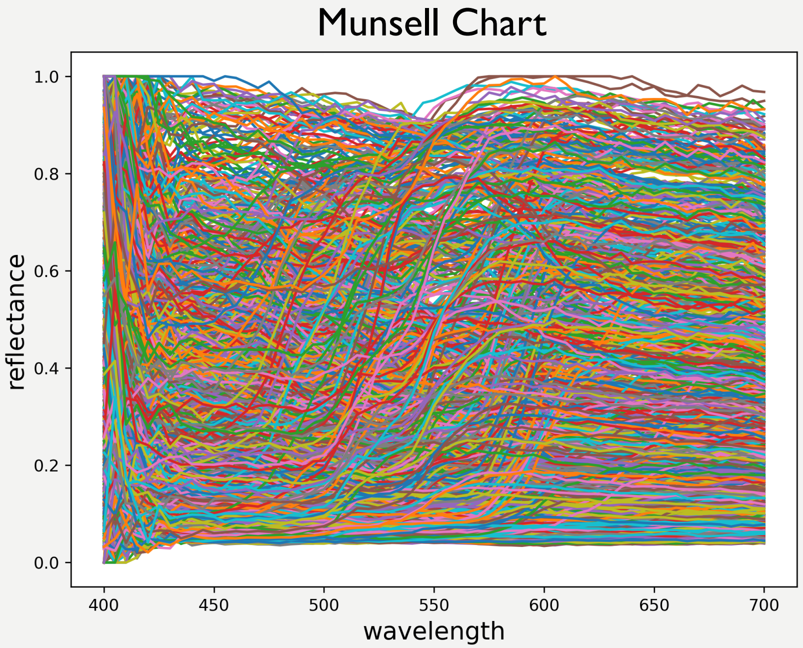
RGB TO SPECTRA USING PCA

ACTIVITY 04
PHYSICS 301

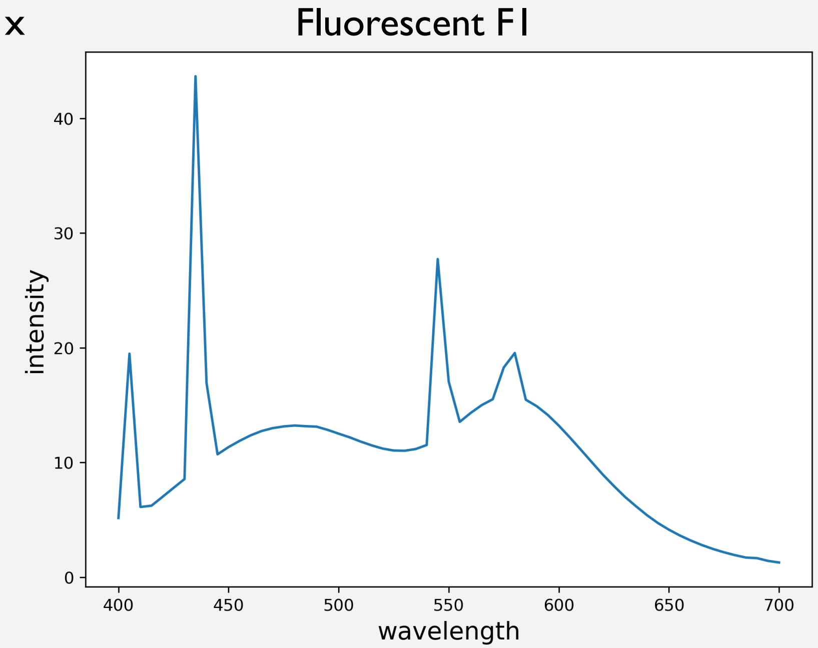
KENNETH M. LEO

THE MUNSELL CHART



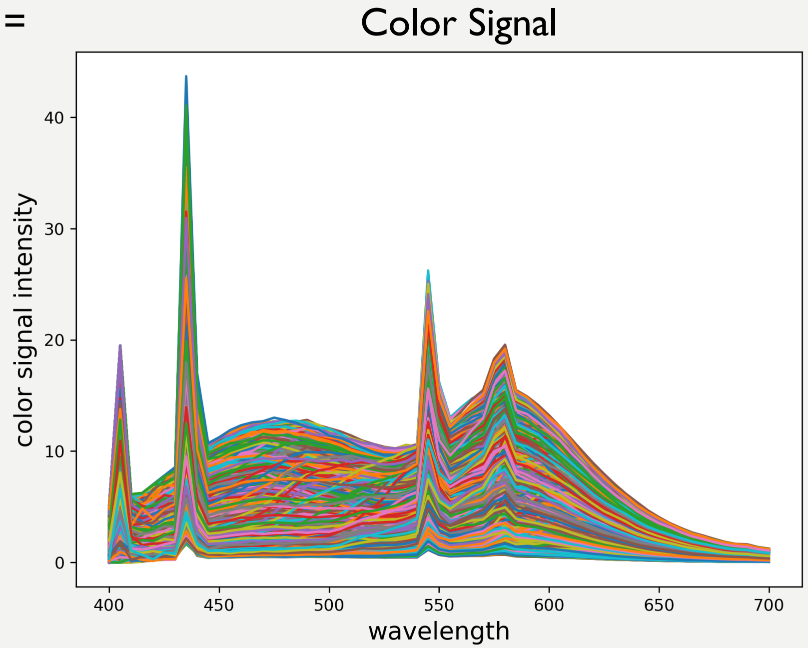
Shape = 61 x 1250

x



Shape = 61 x 1

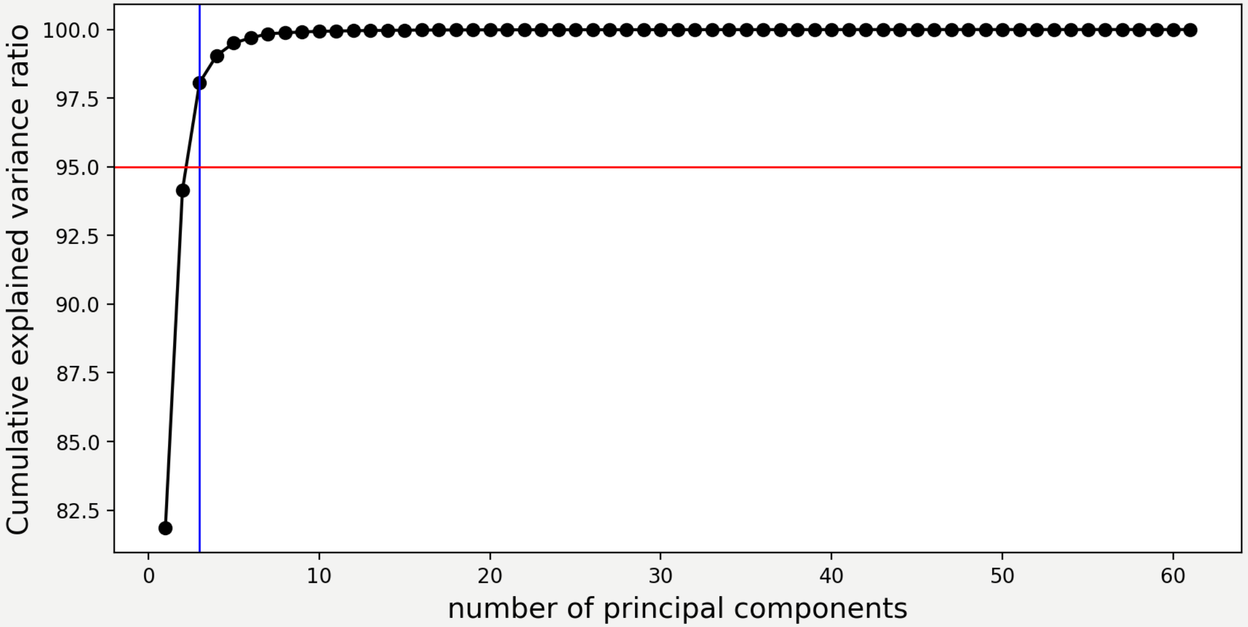
=

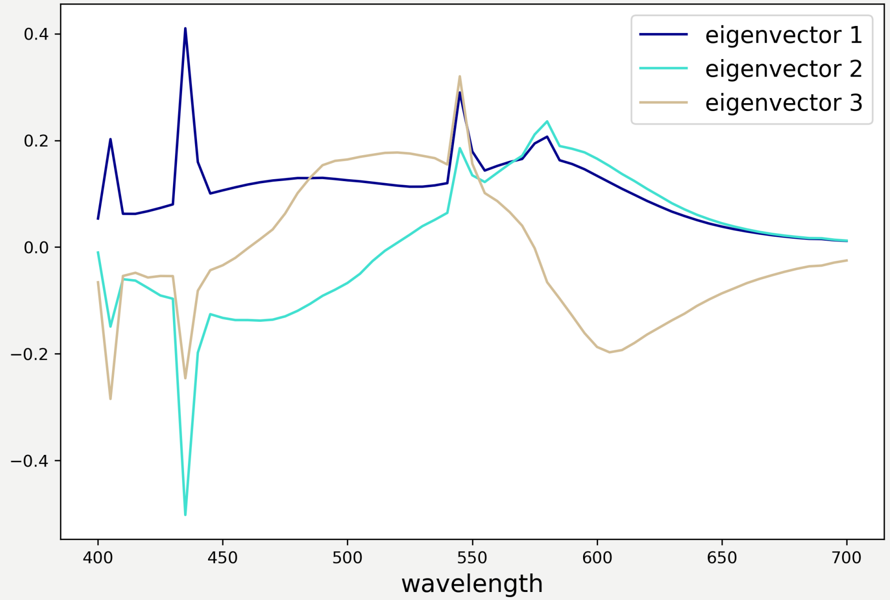


Shape = 61 x 1250

Similar to activity 3, we use sklearn's PCA function to apply Principal Component Analysis on our color signal dataset. In my case, my color signal is the product of the reflectance values from the Munsell dataset and the intensity spectrum of the fluorescent F1 illuminator.

PRINCIPAL COMPONENTS

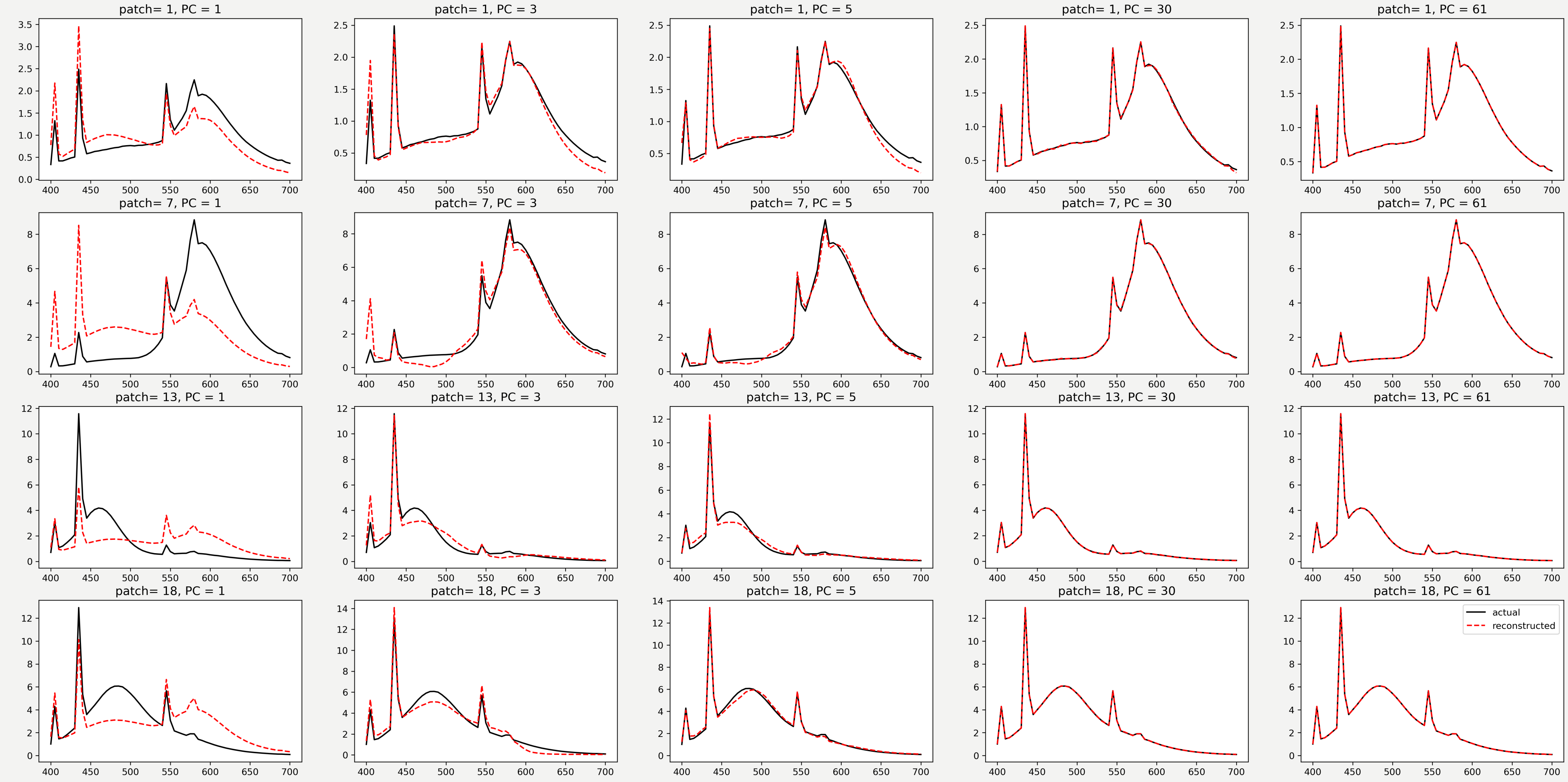




Number of components	Cumulative variance
1	81.8488409 %
2	94.16235588 %
3	98.06619298 %

Based on our dataset and cumulative variance, we only need the top 3 principal components to have 95% explained. These three eigenvectors are shown in the figure above.

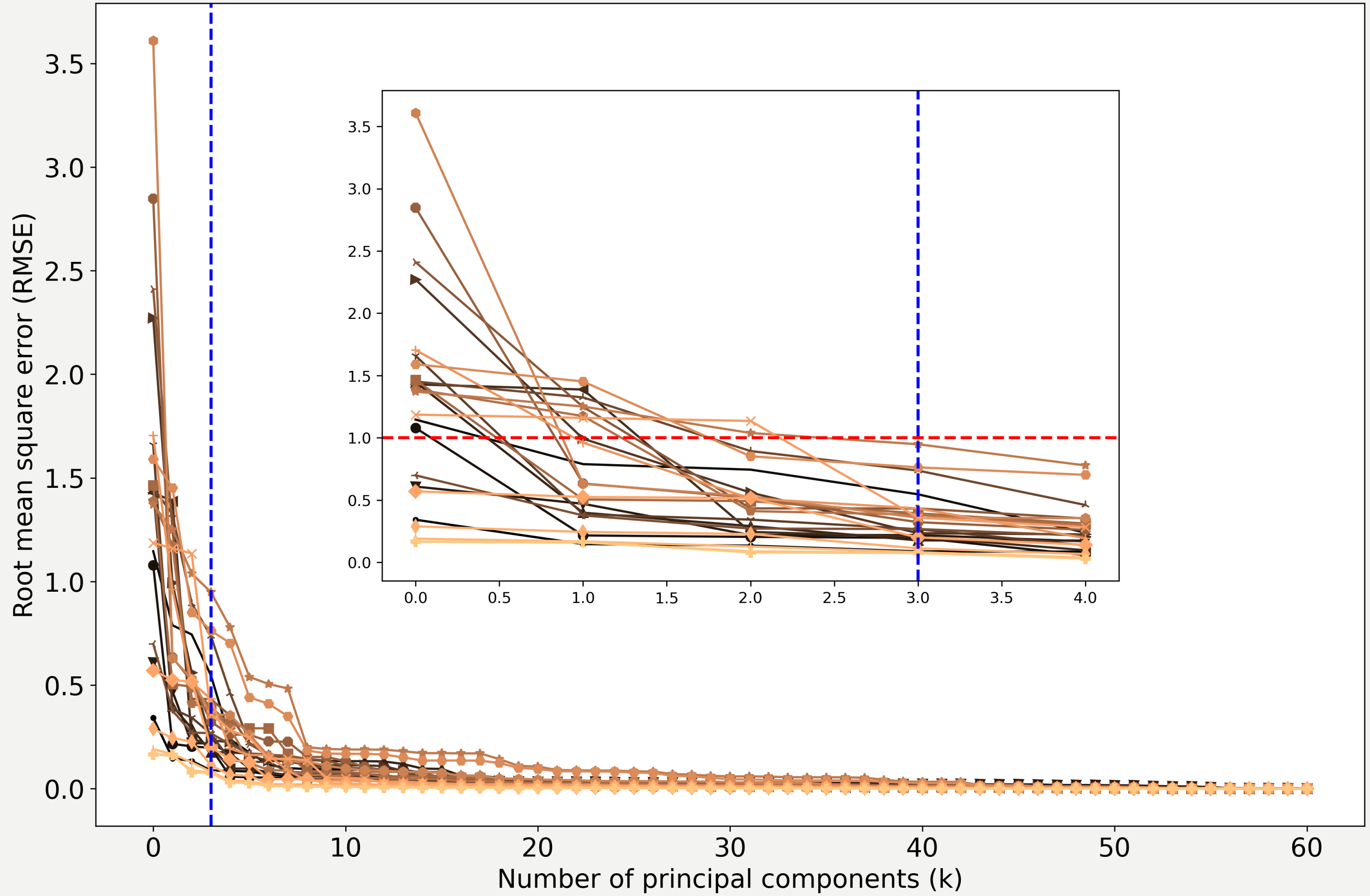
RANDOM PATCH RECONSTRUCTION



Here are 4 random color signals from the Macbeth chart, reconstructed using different numbers of principal components. We see that at PC =3, we start to see that the reconstructed color signal started to look like the actual color signal of that patch.

As expected, we see a perfect reconstruction of the color signal when all principal components are used.

METRIC ANALYSIS



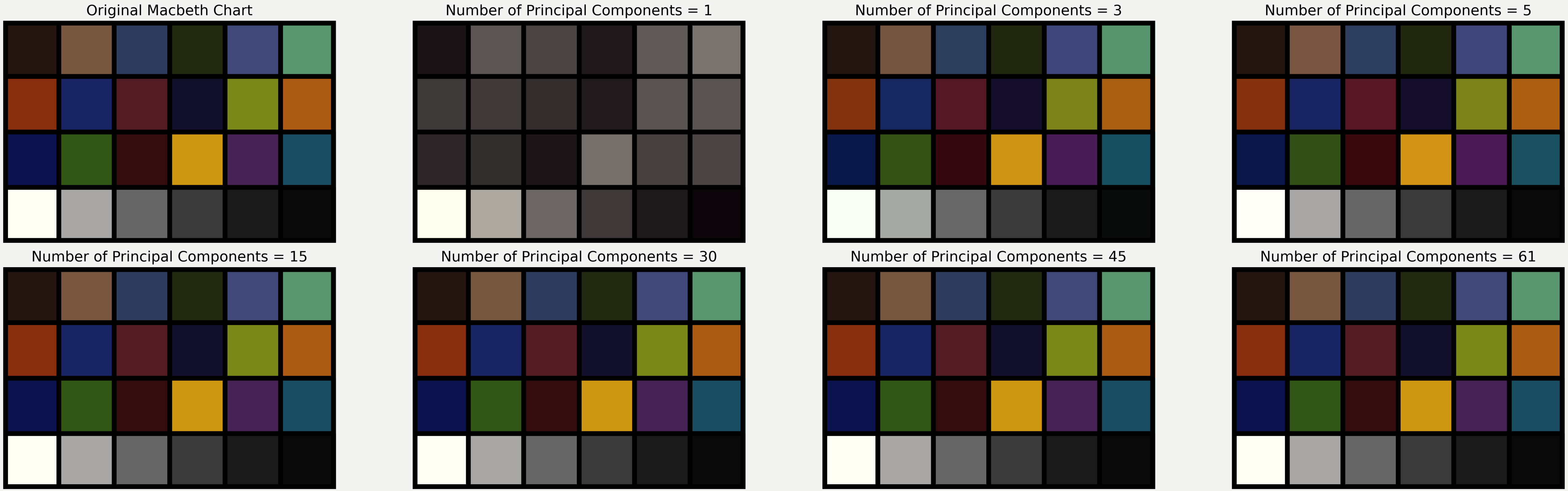
We see from the RMSE vs. number of principal components plot on the right that at k = 3, the RMSE of all color patches in the Macbeth chart is less than 1.0

The low values for RMSE means that our model is 'good' predicting color signals of different objects. Note that the RMSE equation has a similar look as the Euclidian distance equation which we will use to compare two colors.

$$RMSE = \sqrt{\sum_{i=1}^{N} \frac{(x_I' - x_i)^2}{N}}$$

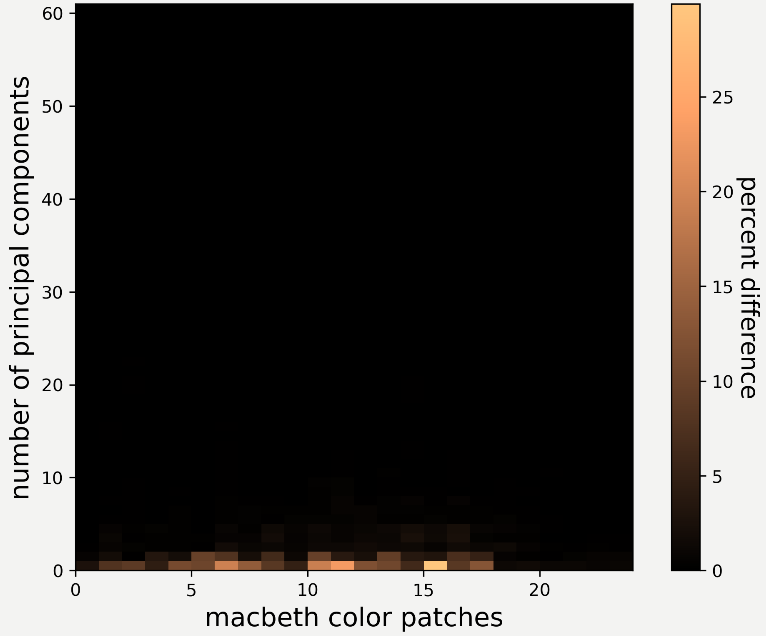
x_i' - predicted values
x_i - observed values
N - predicted values

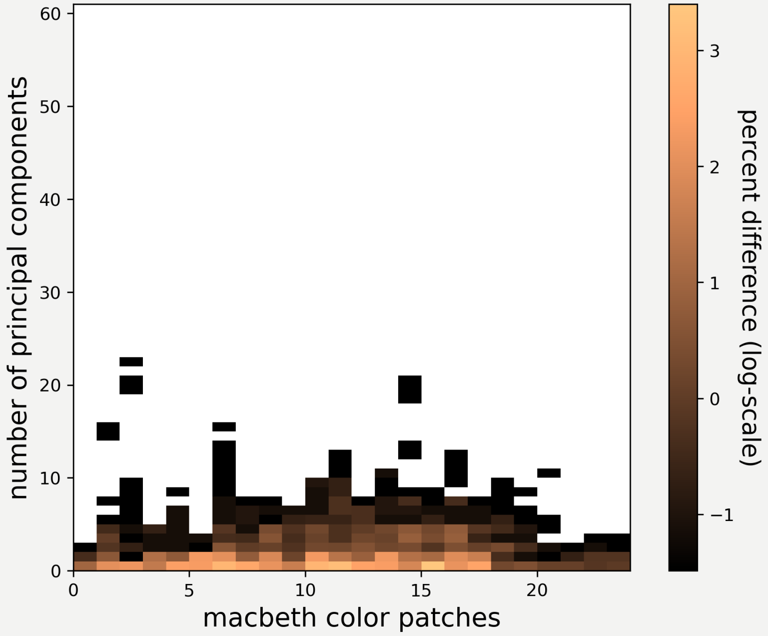
MACBETH CHART RECONSTRUCTION



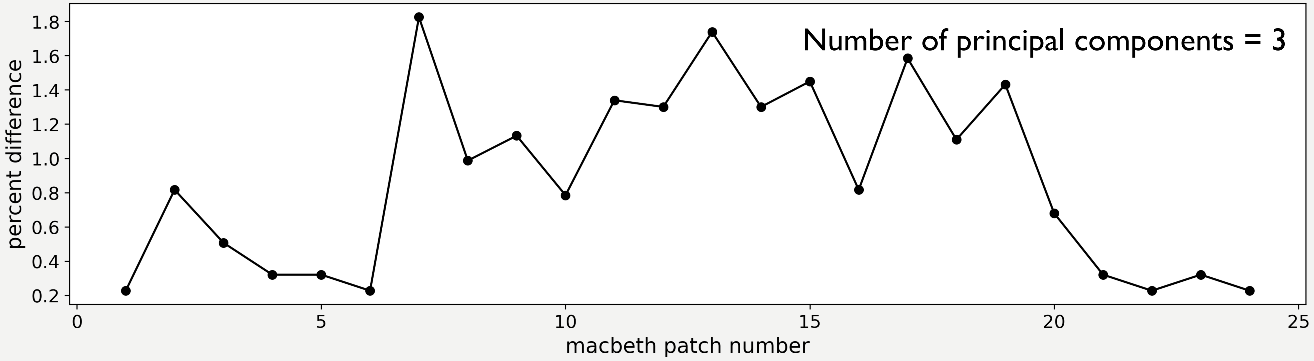
Using the principal components, as well as the spectral sensitivity of our chosen camera, we were able to obtain the transformation matrix which we then use to reconstruct the Macbeth charts. The top left figure is the rendered Macbeth chart using the untouched color signal while the other figures are rendered Macbeth charts using different values of k (number of principal components). As expected, we already see that using k =3 will give us a Macbeth chart reconstruction that is similar to the top left figure. We can quantitatively explain this using the color difference metric.

COLOR DIFFERENCE ANALYSIS





The white regions here means that the RGB colors of the two images are the same.



Now, looking at the color difference (measured by taking the Euclidian distance of the RGB values of the 'original' Macbeth chart and the reconstructed one), see that the colors becomes indistinguishable if we use more than 5 components (percent difference < 1).

SUMMARY PLUS REFERENCES

Summary

This experiment is basically a combination of activity 02 and 03. The new thing that I learned in this experiment is the Munsell chart and about the different HSV values. I learned that there are better ways to represent color and not just in the RGB domain. Also, like in activity 03, I was amazed by the fact that just using very few eigenvectors, I am able to reconstruct whatever color signal I tested.

References

[1] Niku Ekhtiari, P. D. (n.d.). *Comparing ground truth with predictions using image similarity measures*. UP42 Official Website. Retrieved June 7, 2022, from https://up42.com/blog/tech/image-similarity-measures

[2] Macbeth color checker : http://www.rit-mcsl.org/UsefulData/MacbethColorChecker.xls

[3] CIE Fluorescent lamps : http://www.rit-mcsl.org/UsefulData/Fluorescents.xls

[4] https://nae-lab.org/~rei/research/cs/zhao/database.html

Score:

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

Total – 100/100