Assignment 13: Spectral Imaging

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Github Link: https://github.com/pratheepkumar1/Principles-of-Color-Science

Question 1

*In the m-file there is an "example" matrix to convert from 7-channel image to an approximation of XYZ. You should replace that matrix with a least-squares fit matrix (use the **** operator) that gives a better estimate of XYZ. Include your matrix in your PDF, and report the min, max, and mean ΔE00 between your estimate and the actual CCSG.*

For the best fit of XYZ of the estimated image, we are using least-square fit matrix using the image pixel data and the XYZ of the reference CCSG data.

```
% Least Square Fit matrix calculation
M = (patchC\SGXYZ)';
```

Channel 1	-0.5039378219	-0.4703246654	-0.3161626315
Channel 2	1.595858712	1.027126592	3.390678762
Channel 3	-2.070452355	-1.05903866	-2.901959291
Channel 4	1.795691372	2.083162193	1.882669594
Channel 5	0.4704275409	-0.01280549722	-0.7031008878
Channel 6	0.4633836608	0.3640982394	0.5534212
Channel 7	-0.1844813795	-0.1678184518	-0.219808447

```
% ΔE00 between estimate and the actual CCSG and min,mean and mean value
SGDE = deltaE00(SGEstLab',SGLab')';

min_SDGE = min(SGDE);
max_SDGE = max(SGDE);
mean_SDGE = mean(SGDE);
```

	Min	Mean	Max
*ΔE*00*	0.65033	1.2531	4.2787

Question 2

Generate an sRGB image from the XYZ pixel data and save it as a JPG.

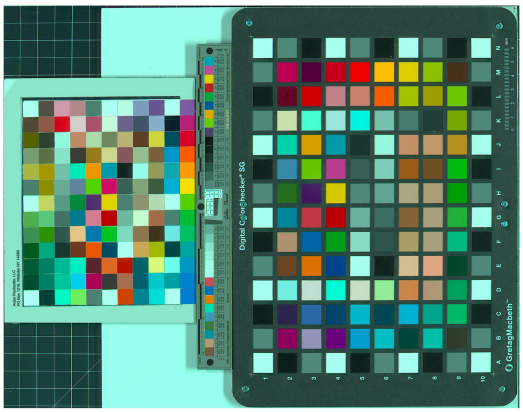
After applying the matrix calculated the from the previous question, we get a better color corrected sRGB image.

```
% go from Cam Signals to XYZ to sRGB
pixXYZ = (pixels)*M';
pixRGB = xyz2rgb(pixXYZ);
imgRGB = reshape(pixRGB,[nr nc 3]);

figure
imshow(imgRGB)

imwrite(imgRGB,'ImageOutput_sRGB.jpg');
```

After applying the Least Square Fit matrix



Before applying the Least Square Fit matrix

Question 3

Create a matrix to estimate spectra for each of the 140 CCSG patches. Make a plot of your matrix, like Fig. 6.42 in the book. And, make a plot of the actual and estimated spectra for the 6 patches near the middle of the CCSG: blue, green, red, yellow, magenta, cyan.

The following equation is used to calculate the transformation matrix using the spectral reflectance data of the reference and the pixel data of the Image.

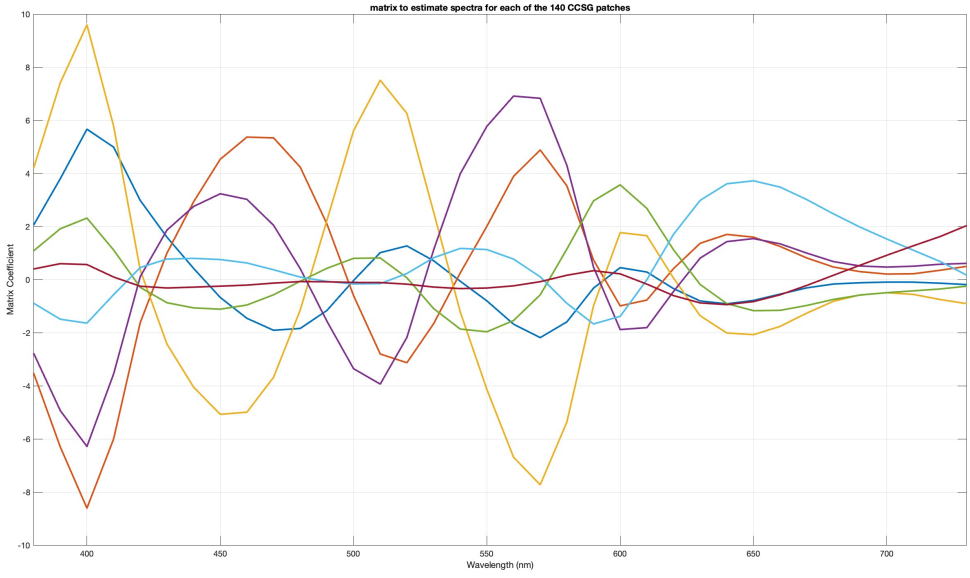
$$\mathbf{M} = \begin{pmatrix} R_{\lambda=380\text{ nm},1} & \cdots & R_{\lambda=380\text{ nm},24} \\ \vdots & \cdots & \vdots \\ R_{\lambda=730\text{ nm},1} & \cdots & R_{\lambda=730\text{ nm},24} \end{pmatrix} \begin{pmatrix} C_{370\text{ nm},1} & \cdots & C_{370\text{ nm},24} \\ C_{450\text{ nm},1} & \cdots & C_{450\text{ nm},24} \\ C_{520\text{ nm},1} & \cdots & C_{520\text{ nm},24} \\ C_{550\text{ nm},1} & \cdots & C_{550\text{ nm},24} \\ C_{580\text{ nm},1} & \cdots & C_{580\text{ nm},24} \\ C_{600\text{ nm},1} & \cdots & C_{600\text{ nm},24} \\ C_{710\text{ nm},1} & \cdots & C_{710\text{ nm},24} \end{pmatrix}^{+} \tag{6.27}$$

```
% Matrix to estimate spectra for each of the 140 CCSG patches
M_Trans = SGref*pinv(patchC');


% Plot of the Matrix
figure;
plot(SGwl,M_Trans,'LineWidth',2);
xlim([380,730]);
grid on;
xlabel('Wavelength (nm)'); ylabel('Matrix Coefficient');
title('matrix to estimate spectra for each of the 140 CCSG patches');
```

2.0527	-3.5204	4.2005	-2.7725	1.0807	-0.8910	0.3985
3.7974	-6.3022	7.4089	-4.9336	1.9132	-1.4936	0.5984
5.6622	-8.6090	9.5931	-6.2856	2.3145	-1.6413	0.5650
4.9874	-6.0035	5.7814	-3.5560	1.1136	-0.5685	0.0953
2.9805	-1.6176	0.3553	0.1105	-0.2946	0.4533	-0.2516
1.5973	0.9940	-2.4257	1.8619	-0.8717	0.7711	-0.3174
0.4210	2.9280	-4.0520	2.7522	-1.0672	0.7979	-0.2856
-0.6740	4.5313	-5.0743	3.2312	-1.1157	0.7543	-0.2486
-1.4598	5.3648	-4.9951	3.0212	-0.9583	0.6249	-0.2085

-1.9102	5.3359	-3.6786	2.0440	-0.5736	0.3677	-0.1330
-1.8405	4.2338	-1.1472	0.4090	-0.0631	0.0946	-0.0746
-1.1648	2.0962	2.2267	-1.5671	0.4219	-0.0691	-0.0836
-0.0348	-0.6043	5.6066	-3.3572	0.7987	-0.1659	-0.1089
1.0132	-2.8032	7.5084	-3.9364	0.8141	-0.1523	-0.1135
1.2666	-3.1317	6.2579	-2.1796	0.0679	0.2278	-0.1734
0.7110	-1.6673	2.5531	1.1080	-1.0900	0.8206	-0.2824
-0.0614	0.2467	-1.2150	3.9810	-1.8640	1.1729	-0.3401
-0.8026	2.0072	-4.1368	5.7718	-1.9661	1.1298	-0.3187
-1.6791	3.8842	-6.6889	6.9095	-1.5431	0.7700	-0.2367
-2.1877	4.8814	-7.7301	6.8258	-0.5764	0.1038	-0.0801
-1.5935	3.5284	-5.3671	4.3029	1.1478	-0.8950	0.1627
-0.3218	0.7366	-0.9848	0.4681	2.9645	-1.6728	0.3340
0.4490	-0.9910	1.7693	-1.8834	3.5678	-1.3852	0.2147
0.2831	-0.7722	1.6508	-1.8100	2.6803	-0.0081	-0.1719
-0.3402	0.4117	0.0540	-0.4493	1.1221	1.7024	-0.6042
-0.8059	1.3670	-1.3637	0.8097	-0.1857	2.9830	-0.8800
-0.9138	1.6996	-2.0118	1.4290	-0.9057	3.6070	-0.9438
-0.7856	1.5971	-2.0743	1.5421	-1.1722	3.7190	-0.8304
-0.5478	1.2461	-1.7630	1.3455	-1.1588	3.4817	-0.5735
-0.3128	0.8121	-1.2630	0.9959	-0.9753	3.0114	-0.2207
-0.1678	0.4721	-0.8178	0.6767	-0.7479	2.4731	0.1622
-0.1197	0.2980	-0.5785	0.5106	-0.5834	1.9744	0.5408
-0.0955	0.2066	-0.4962	0.4701	-0.4932	1.5267	0.9143
-0.0977	0.2184	-0.5599	0.5033	-0.4251	1.1028	1.2734
-0.1376	0.3498	-0.7517	0.5772	-0.3544	0.6799	1.6201
-0.1890	0.4978	-0.9079	0.6097	-0.2485	0.1632	2.0338



```
% A plot of the actual and estimated spectra for the 6 patches
% near the middle of the CCSG: blue, green, red, yellow, magenta, cyan.

figure;
SGEst = (M_Trans*patchC');
plot(SGwl,SGEst(:,47:52),'LineWidth',2);
hold on
plot(SGwl,SGref(:,47:52),'LineWidth',0.5);
xlim([380,730]);
xlabel('Wavelength (nm)'); ylabel('Reflectance Factor')
title('Estimated (thick lines) and Reference (thin lines) spectral reflectance')
subtitle('6 patches near the middle of the CCSG')
```