Project 6 Report

Team 5: Shakira Garnett, Hridiza Roy

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Initialization

```
clear all; close all; clc;

% load the CIE observer and illuminant data
cie = loadCIEdata;
```

Step 3

```
load_ramps_data;
```

Step 4

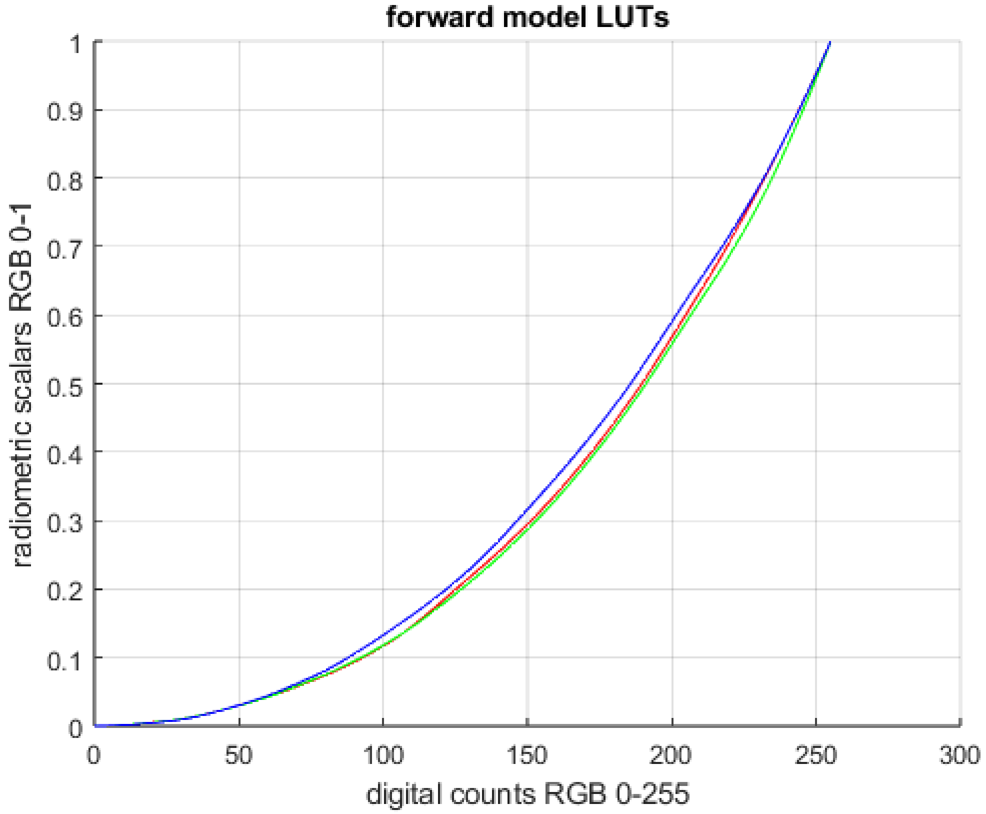
```
x_rmax = ramp_R_XYZs(1, 11);
x_gmax = ramp_G_XYZs(1, 11);
x_bmax = ramp_B_XYZs(1, 11);

y_rmax = ramp_R_XYZs(2, 11);
y_gmax = ramp_G_XYZs(2, 11);
y_bmax = ramp_B_XYZs(2, 11);

z_rmax = ramp_R_XYZs(3, 11);
z_gmax = ramp_G_XYZs(3, 11);
z_bmax = ramp_B_XYZs(3, 11);

x_k = XYZk(1);
y_k = XYZk(2);
z_k = XYZk(3);

y_w = XYZw(2);
```

```
M_fwd = [ x_rmax - x_k, x_gmax - x_k, x_bmax - x_k, x_k; ...
          y_rmax - y_k, y_gmax - y_k, y_bmax - y_k, y_k; ...
          z_rmax - z_k, z_gmax - z_k, z_bmax - z_k, z_k ] ./ y_w
```

```
M_fwd =

    0.4992    0.2803    0.1413    0.0011
    0.2371    0.7181    0.0502    0.0010
    0.0006    0.0412    0.7446    0.0027
```

Step 5

```
M_inv = inv(M_fwd(1:3,1:3));

ramp_R_RSs = M_inv * ( (ramp_R_XYZs - XYZk) / y_w );
ramp_R_RSs = max(min(ramp_R_RSs, 1), 0); % clamp

% define the 0-255 display values (digital counts) that correspond to ramp values
ramp_DCs = round(linspace(0,255,11));

% interpolate the radiometric scalars across the full digital count range to form the forward LUTS
RLUT_fwd = interp1(ramp_DCs,ramp_R_RSs(1,:),[0:1:255],'pchip');

ramp_G_RSs = M_inv * ( (ramp_G_XYZs - XYZk) / y_w );
ramp_G_RSs = max(min(ramp_G_RSs, 1), 0);

% Repeat for green
GLUT_fwd = interp1(ramp_DCs,ramp_G_RSs(2,:), [0:1:255],'pchip');

ramp_B_RSs = M_inv * ( (ramp_B_XYZs - XYZk) / y_w );
ramp_B_RSs = max(min(ramp_B_RSs, 1), 0);

% Repeat for blue
BLUT_fwd = interp1(ramp_DCs,ramp_B_RSs(3,:),[0:1:255],'pchip');

figure;
hold on;

% Plot each channel (Red, Green, and Blue)
plot(0:255, RLUT_fwd, '-r'); % Red channel
plot(0:255, GLUT_fwd, '-g'); % Green channel
plot(0:255, BLUT_fwd, '-b'); % Blue channel

% Labeling the plot
xlabel('digital counts RGB 0-255');
ylabel('radiometric scalars RGB 0-1');
title('forward model LUTs');
grid on;
hold off;
```



Step 6

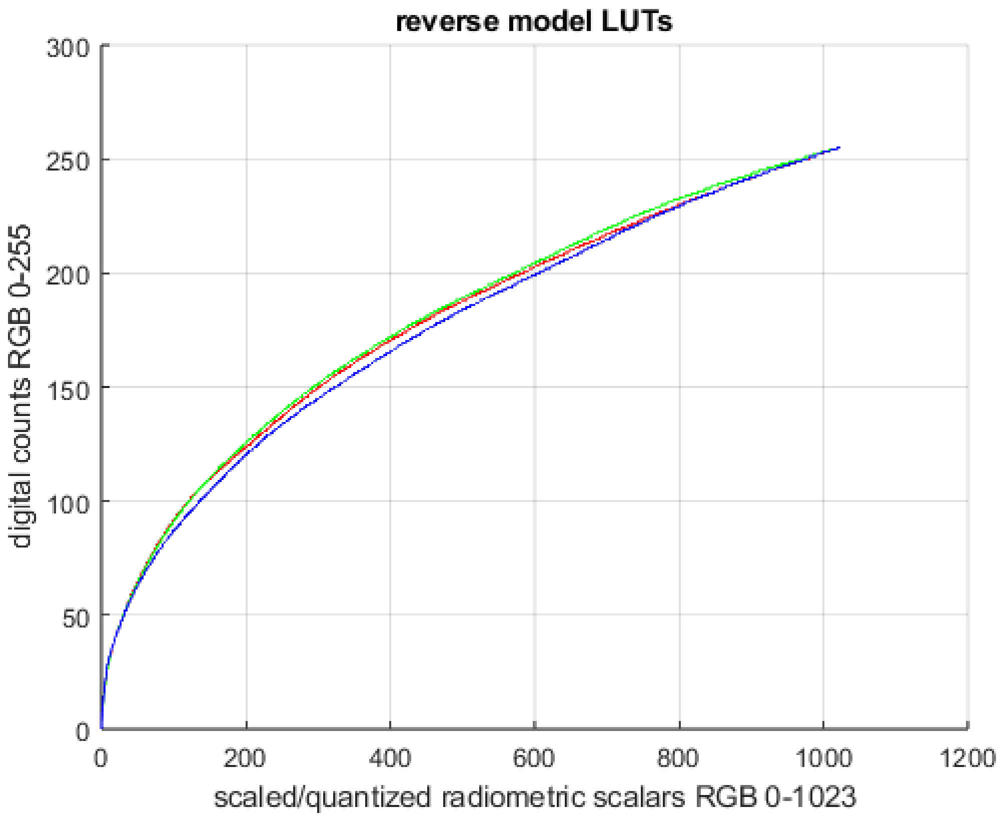
```
M_rev = inv(M_fwd(1:3,1:3))
```

```
M_rev =

    2.4460   -0.9318   -0.4014
   -0.8104    1.7067    0.0388
    0.0429   -0.0937    1.3412
```

Step 7

```
RLUT_rev = uint8(round(interp1(RLUT_fwd, 0:255, linspace(0,max(RLUT_fwd),1024), 'pchip', 0)));
GLUT_rev = uint8(round(interp1(GLUT_fwd, 0:255, linspace(0,max(GLUT_fwd),1024), 'pchip', 0)));
BLUT_rev = uint8(round(interp1(BLUT_fwd, 0:255, linspace(0,max(BLUT_fwd),1024), 'pchip', 0)));

figure;
hold on;

% Plot each channel (Red, Green, and Blue)
plot(0:1023, RLUT_rev, '-r'); % Red channel
plot(0:1023, GLUT_rev, '-g'); % Green channel
plot(0:1023, BLUT_rev, '-b'); % Blue channel

% Labeling the plot
xlabel('scaled/quantized radiometric scalars RGB 0-1023');
ylabel('digital counts RGB 0-255');
title('reverse model LUTs');
```

```
grid on;
hold off;
```

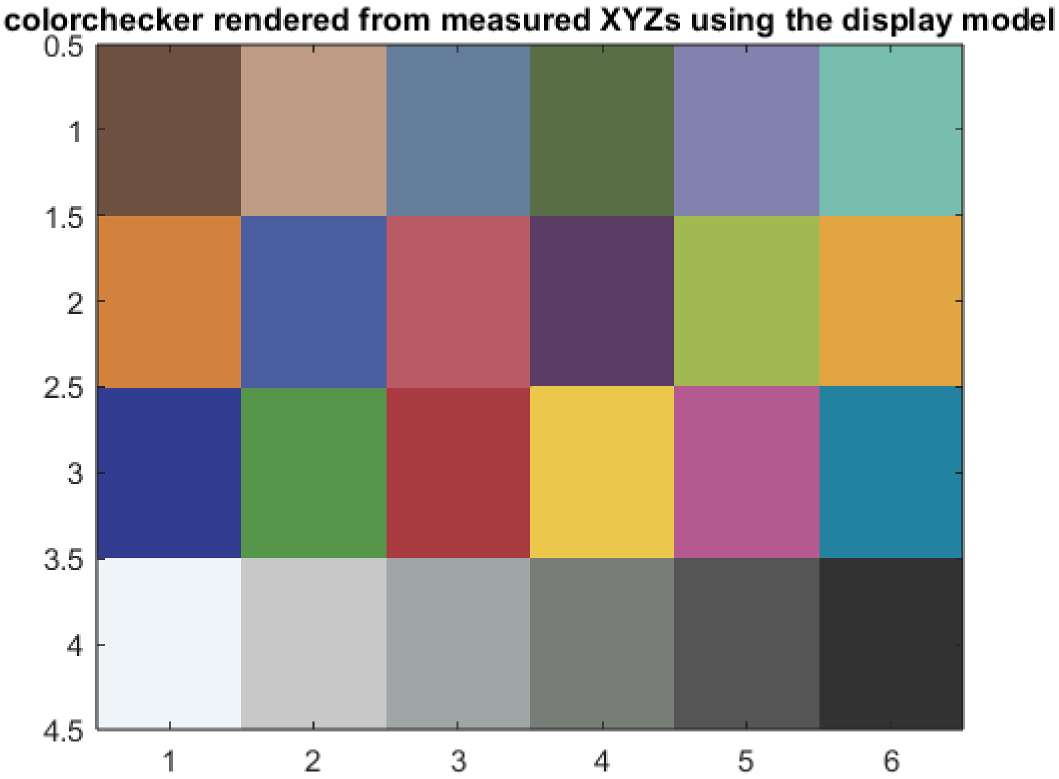


Step 8

```
XYZw_disp = XYZw;
XYZk_disp = XYZk;
M_disp = M_rev;
RLUT_disp = RLUT_rev;
GLUT_disp = GLUT_rev;
BLUT_disp = BLUT_rev;
save('display_model.mat','XYZw_disp', 'XYZk_disp','M_disp','RLUT_disp','GLUT_disp','BLUT_disp');
```

Step 9

```
% Load the data
data = load('munki_CC_XYZs_Labs.txt');

XYZn_D50 = ref2XYZ(cie.PRD, cie.cmf2deg, cie.illD50);

munki_XYZs = data(:, 2:4)';   % Columns 2-4 for XYZ values, transpose to make it 3x24
munki_Labs = data(:, 5:7)';   % Columns 5-7 for Lab values, transpose to make it 3x24

munki_XYZs_disp = catBradford(munki_XYZs, XYZn_D50, XYZw_disp);

adjusted_XYZs_disp = munki_XYZs_disp - XYZk_disp;

munki_CC_RSs = (M_disp * adjusted_XYZs_disp) ./ 100;
munki_CC_RSs = max(min(munki_CC_RSs, 1), 0);

munki_CC_RSs_scaled = round(munki_CC_RSs * 1023 + 1);

munki_CC_DCs(1,:) = RLUT_rev(munki_CC_RSs_scaled(1,:));
munki_CC_DCs(2,:) = GLUT_rev(munki_CC_RSs_scaled(2,:));
munki_CC_DCs(3,:) = BLUT_rev(munki_CC_RSs_scaled(3,:));

% visualize the CC XYZs using the display model
pix = uint8(reshape(munki_CC_DCs', [6 4 3]));
pix = fliplr(imrotate(pix, -90));
figure;
image(pix);
set(gca, 'FontSize', 11)
title('colorchecker rendered from measured XYZs using the display model');
```



Step 10

```
munki_CC_DCs = uint8(double(munki_CC_DCs) * 100/255);
table4ti1 = [(1:30)', [munki_CC_DCs'; zeros(3, 3); 100 * ones(3, 3)] ];

disp_XYZs = importdata('disp_model_test.ti3',' ', 20);

CC_patches_XYZ = disp_XYZs.data(1:24, 5:7);
disp_black_XYZ = disp_XYZs.data(25:27, 5:7);
disp_whiteXYZ = disp_XYZs.data(28:30, 5:7);

XYZk = mean(disp_black_XYZ, 1);
XYZw = mean(disp_whiteXYZ, 1);

display_Labs = XYZ2Lab(CC_patches_XYZ', XYZw');
```

```
DEab = deltaEab(display_Labs, munki_Labs);

% print table
print_display_model_error(munki_Labs, display_Labs, DEab);
```

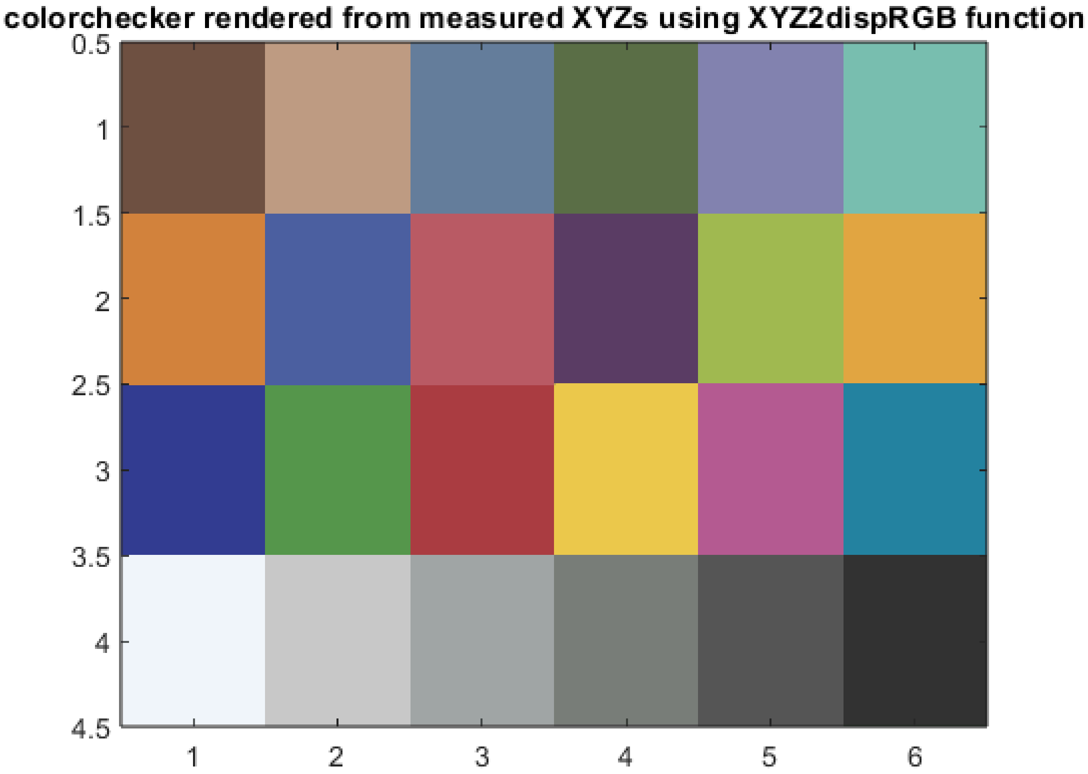
```
Display model color error
XYZ_real->display_model->RGB_disp->display

               Real vs. displayed ColorChecker Lab values
                     real                        displayed
patch #       L         a         b         L         a         b       dEab
      1   37.1865   14.9985   15.2592   37.2614   16.3788   11.6634   3.8524
      2   65.8188   16.8695   18.0267   65.8875   17.9862   14.7529   3.4597
      3   49.9949   -3.1841 -23.5159   48.6173   -5.4339 -26.8756   4.2716
      4   42.6411 -15.3251   20.0423   41.8292 -13.1993   14.3545   6.1261
      5   54.6852    9.6978 -26.7126   53.7770    6.0890 -28.9516   4.3429
      6   71.2441 -33.1391   -0.5010   71.3770 -36.4762   -2.9641   4.1498
      7   62.2558   34.1094   57.7774   61.8813   40.0053   51.2524   8.8021
      8   39.5890    9.9980 -43.6388   38.0863    7.0100 -46.5533   4.4363
      9   51.8424   48.1403   16.0636   51.0173   53.0937   12.8294   5.9730
     10   29.4495   22.4255 -21.7661   29.8534   19.1610 -22.1735   3.3145
     11   71.6264 -24.3441   57.6850   71.6131 -22.5815   51.2149   6.7059
     12   72.2288   20.6039   69.0149   72.1863   27.5791   61.9033   9.9614
     13   28.6402   18.5907 -51.4092   28.6998   11.1237 -51.7457   7.4748
     14   54.6309 -39.5493   32.8341   54.5875 -38.4995   28.8870   4.0846
     15   42.5988   54.6049   25.7315   42.4766   57.0637   21.5756   4.8304
     16   82.4265    3.8689   78.8570   82.8065   11.4959   72.8810   9.6969
     17   51.5476   49.5154 -14.3758   50.3447   52.4773 -16.8838   4.0633
     18   49.3892 -26.5473 -28.6645   48.8198 -32.1163 -29.2721   5.6309
     19   95.4458   -0.4414    0.0244   96.0919    0.0487   -3.4232   3.5418
     20   80.0339    0.1309   -0.9345   79.4828    1.2266   -4.0189   3.3193
     21   66.0107   -0.0004   -1.1463   65.5689   -0.3418   -3.5707   2.4878
     22   50.5546   -0.6207   -0.9616   49.7249   -0.2129   -3.7596   2.9468
     23   35.1532   -0.0632   -0.9708   34.7888    1.6090   -4.2625   3.7100
     24   20.3224   -0.2858   -0.5603   22.0001   -0.3545   -1.2454   1.8135

                                                             min      1.8135
                                                             max      9.9614
                                                             mean     4.9582
```

Step 11

Include a listing of the XYZ2dispRGB function

```
function disp_RGBs = XYZ2dispRGB(display_model, XYZs, XYZn)
    load(display_model, 'XYZw_disp', 'XYZk_disp','M_disp','RLUT_disp','GLUT_disp','BLUT_disp');

    XYZs_disp = catBradford(XYZs, XYZn, XYZw_disp);

    adjusted_XYZs_disp = XYZs_disp - XYZk_disp;

    CC_RSs = (M_disp * adjusted_XYZs_disp) ./ 100;

    CC_RSs = max(0, min(1, CC_RSs));
    CC_RSs_scaled = round(CC_RSs * 1023 + 1);

    CC_DCs(1,:) = RLUT_disp(CC_RSs_scaled(1,:));
    CC_DCs(2,:) = GLUT_disp(CC_RSs_scaled(2,:));
    CC_DCs(3,:) = BLUT_disp(CC_RSs_scaled(3,:));

    % visualize the CC XYZs using the display model
    pix = uint8(reshape(CC_DCs', [6 4 3]));
    pix = fliplr(imrotate(pix, -90));
    figure;
    image(pix);
    set(gca, 'FontSize', 10.5);
    title('colorchecker rendered from measured XYZs using XYZ2dispRGB function  ');

    disp_RGBs = uint8(CC_DCs);
end
```

```
disp_RGBs = XYZ2dispRGB('display_model.mat', munki_XYZs, XYZn_D50);
```



Feedback

i. Who did which parts

Shakira - 3, 4, 5, 6, 7, 8, 9

Hridiza - 1, 2, 5 (minor), 9 (minor), 10, 11, 12

ii. Problems

- Keeping the matrix dimensions in mind, and figuring out when to transpose

- Images were getting clipped when trying to publish

iii. Valuable parts

- The "Info only" sections that gave more context about what we were doing

- Learning how to practically derive LUTs and create reverse models

iv. Improvements

- Minor: Perhaps we should test that the output from XYZ2dispRGB (disp_RGBs) is as expected (Currently we are just testing the plot)

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