Project 7 Report

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Contents

Initialization

```
clear all; close all; clc;

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

Step 1

```
cam_RGBs_orig = load("Cam_RGBs.txt");
cam_RGBs = uint8((double(cam_RGBs_orig) / 255.0) * 100);

table4ti1 = [(1:30)', [cam_RGBs'; zeros(3, 3); 100 * ones(3, 3)] ];

uncal_XYZs = importdata("workflow_test_uncal.ti3",' ',20);

uncal_patches_XYZ = uncal_XYZs.data(1:24, 5:7);
uncal_disp_black_XYZ = uncal_XYZs.data(25:27, 5:7);
uncal_disp_white_XYZ = uncal_XYZs.data(28:30, 5:7);

uncal_XYZk = mean(uncal_disp_black_XYZ, 1);
uncal_XYZw = mean(uncal_disp_white_XYZ, 1);

uncal_display_Labs = XYZ2Lab(uncal_patches_XYZ', uncal_XYZw');

data = load('munki_CC_XYZs_Labs.txt');
% Columns 5-7 for Lab values, transpose to make it 3x24
munki_Labs = data(:, 5:7)';

deltaEs_uncal = deltaEab(uncal_display_Labs, munki_Labs);
min_deltaEs_uncal = min(deltaEs_uncal);
max_deltaEs_uncal = max(deltaEs_uncal);
mean_deltaEs_uncal = mean(deltaEs_uncal);

print_uncalibrated_workflow_error(munki_Labs, uncal_display_Labs, deltaEs_uncal);
```

```
Uncalibrated workflow color error
```

```
camera->RGB_cam->display

              Real vs. displayed ColorChecker Lab values
                    real                    displayed
patch #      L        a        b        L        a        b       dEab
      1   37.1865  14.9985  15.2592  23.9664  19.9315  21.5974  15.4686
      2   65.8188  16.8695  18.0267  64.7376  23.9002  22.7602   8.5444
      3   49.9949  -3.1841 -23.5159  45.7015  -0.5305 -31.1092   9.1177
      4   42.6411 -15.3251  20.0423  34.0086 -17.9552  30.0310  13.4615
      5   54.6852   9.6978 -26.7126  53.1739  11.6695 -30.4895   4.5207
      6   71.2441 -33.1391  -0.5010  70.1385 -39.0601   2.4161   6.6926
      7   62.2558  34.1094  57.7774  55.2246  45.4572  69.4492  17.7324
      8   39.5890   9.9980 -43.6388  25.9319  21.4780 -60.2753  24.3942
      9   51.8424  48.1403  16.0636  49.0796  64.0226  26.5741  19.2445
     10   29.4495  22.4255 -21.7661  10.8466  33.8047 -27.7551  22.6147
     11   71.6264 -24.3441  57.6850  74.4112 -31.0283  81.6949  25.0780
     12   72.2288  20.6039  69.0149  71.3163  22.6329  78.7694  10.0049
     13   28.6402  18.5907 -51.4092   8.4363  42.8543 -65.1793  34.4462
     14   54.6309 -39.5493  32.8341  45.8036 -45.2596  41.5981  13.6871
     15   42.5988  54.6049  25.7315  36.7070  68.3091  44.7099  24.1391
     16   82.4265   3.8689  78.8570  83.2902   4.2153  93.1871  14.3603
     17   51.5476  49.5154 -14.3758  47.8079  67.2402 -16.4313  18.2313
     18   49.3892 -26.5473 -28.6645  42.2902 -21.9136 -34.6778  10.3936
     19   95.4458  -0.4414   0.0244  86.1672   1.8938   1.3912   9.6650
     20   80.0339   0.1309  -0.9345  76.0798   0.2104   1.1822   4.4857
     21   66.0107  -0.0004  -1.1463  61.7053   2.1715   0.2022   5.0072
     22   50.5546  -0.6207  -0.9616  42.5691   0.1970  -0.1062   8.0728
     23   35.1532  -0.0632  -0.9708  18.7987  -2.0610  -1.0904  16.4765
     24   20.3224  -0.2858  -0.5603   1.4032   1.1918  -6.2063  19.7990

                                                    min      4.4857
                                                    max     34.4462
                                                    mean    14.8182
```

Step 2

```
cam_XYZs = camRGB2XYZ('cam_model.mat', cam_RGBs_orig);

XYZn_D50 = ref2XYZ(cie.PRD, cie.cmf2deg, cie.illD50);
disp_RGBs_orig = XYZ2dispRGB('display_model.mat', cam_XYZs, XYZn_D50);

disp_RGBs = uint8((double(disp_RGBs_orig) / 255.0) * 100);
table4ti1 = [(1:30)', [disp_RGBs'; zeros(3, 3); 100 * ones(3, 3)] ];

cal_XYZs = importdata('workflow_test_cal.ti3',' ',20);

cal_CC_patches_XYZ = cal_XYZs.data(1:24, 5:7);
cal_disp_black_XYZ = cal_XYZs.data(25:27, 5:7);
cal_disp_white_XYZ = cal_XYZs.data(28:30, 5:7);

cal_XYZk = mean(cal_disp_black_XYZ, 1);
cal_XYZw = mean(cal_disp_white_XYZ, 1);

cal_display_Labs = XYZ2Lab(cal_CC_patches_XYZ', cal_XYZw');

deltaEs_cal = deltaEab(cal_display_Labs, munki_Labs);
min_deltaEs_cal = min(deltaEs_cal);
```

```
max_deltaEs_cal = max(deltaEs_cal);
mean_deltaEs_cal = mean(deltaEs_cal);

print_calibrated_workflow_error(munki_Labs, cal_display_Labs, deltaEs_cal);
```

```
Calibrated workflow color error
camera->RGB_cam->camera_model->XYZ_est->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  40.8345   8.1187  18.9977   8.6381
      2   65.8188  16.8695  18.0267  68.7555  18.4823  19.2251   3.5584
      3   49.9949  -3.1841 -23.5159  53.6878  -1.3400 -23.0314   4.1560
      4   42.6411 -15.3251  20.0423  46.5355 -12.8293  20.8206   4.6905
      5   54.6852   9.6978 -26.7126  57.1489  11.4127 -26.2307   3.0403
      6   71.2441 -33.1391  -0.5010  73.0365 -34.1675  -0.6145   2.0695
      7   62.2558  34.1094  57.7774  60.1030  36.8991  65.9315   8.8829
      8   39.5890   9.9980 -43.6388  40.8059   7.1166 -42.7157   3.2612
      9   51.8424  48.1403  16.0636  54.4854  49.8429  14.4949   3.5136
     10   29.4495  22.4255 -21.7661  31.0703  25.9209 -24.5825   4.7725
     11   71.6264 -24.3441  57.6850  73.4609 -28.0075  60.3378   4.8809
     12   72.2288  20.6039  69.0149  73.7237  18.2062  71.2252   3.5873
     13   28.6402  18.5907 -51.4092  23.0242  27.1876 -57.8539  12.1236
     14   54.6309 -39.5493  32.8341  53.1782 -37.1196  29.9513   4.0404
     15   42.5988  54.6049  25.7315  44.1032  58.5936  24.4364   4.4554
     16   82.4265   3.8689  78.8570  83.5569   4.2016  76.5299   2.6084
     17   51.5476  49.5154 -14.3758  51.0050  53.1904 -16.8672   4.4730
     18   49.3892 -26.5473 -28.6645  50.8871 -26.3166 -27.2838   2.0502
     19   95.4458  -0.4414   0.0244  95.3075   1.5883  -2.6431   3.3548
     20   80.0339   0.1309  -0.9345  80.1038   0.8825  -0.8071   0.7655
     21   66.0107  -0.0004  -1.1463  66.3393  -1.6564  -0.7183   1.7416
     22   50.5546  -0.6207  -0.9616  51.5354  -2.8939  -2.5852   2.9607
     23   35.1532  -0.0632  -0.9708  39.1181  -2.1010  -1.2614   4.4674
     24   20.3224  -0.2858  -0.5603  19.6650  -3.7294   6.8374   8.1864

                                                      min      0.7655
                                                      max     12.1236
                                                      mean     4.4283
```

Step 3

```
% Get XYZ values
munki_XYZs = data(:, 2:4);

% Create the color transformation structure for XYZ to sRGB
cform = makecform('xyz2srgb', "AdaptedWhitePoint", XYZn_D50');

% Apply the color transformation
munki_RGBs = applycform(double(munki_XYZs), cform);

% Rescale RGB values from 0-100 to 0-255
munki_RGBs_uint8 = uint8(munki_RGBs * 255);
```

```
% Repeat rows of ground truth to create 48 x 3 matrix
top_row = reshape([munki_RGBs_uint8'; munki_RGBs_uint8'], [3, 48])';

% combine calibrated and uncalibrated data in an alternating fashion
bottom_row = reshape([cam_RGBs_orig; disp_RGBs_orig], [3, 48])';

% combine the top and bottom rows and reshape them
workflow_diffs = pagetranspose(reshape([reshape(top_row, [12, 4, 3]); ...
                    reshape(bottom_row, [12, 4, 3])], [12, 8, 3]));

% Resize the final image to 768 x 1024
workflow_diffs_resized = imresize(workflow_diffs, [768, 1024],'nearest');

% Visualize the result
figure;
imshow(workflow_diffs_resized);
title('Ground-Truth, Uncalibrated, and Calibrated RGB Values');
axis off;

% Save the resized image as a PNG
imwrite(workflow_diffs_resized, 'workflow_diffs.png');
```

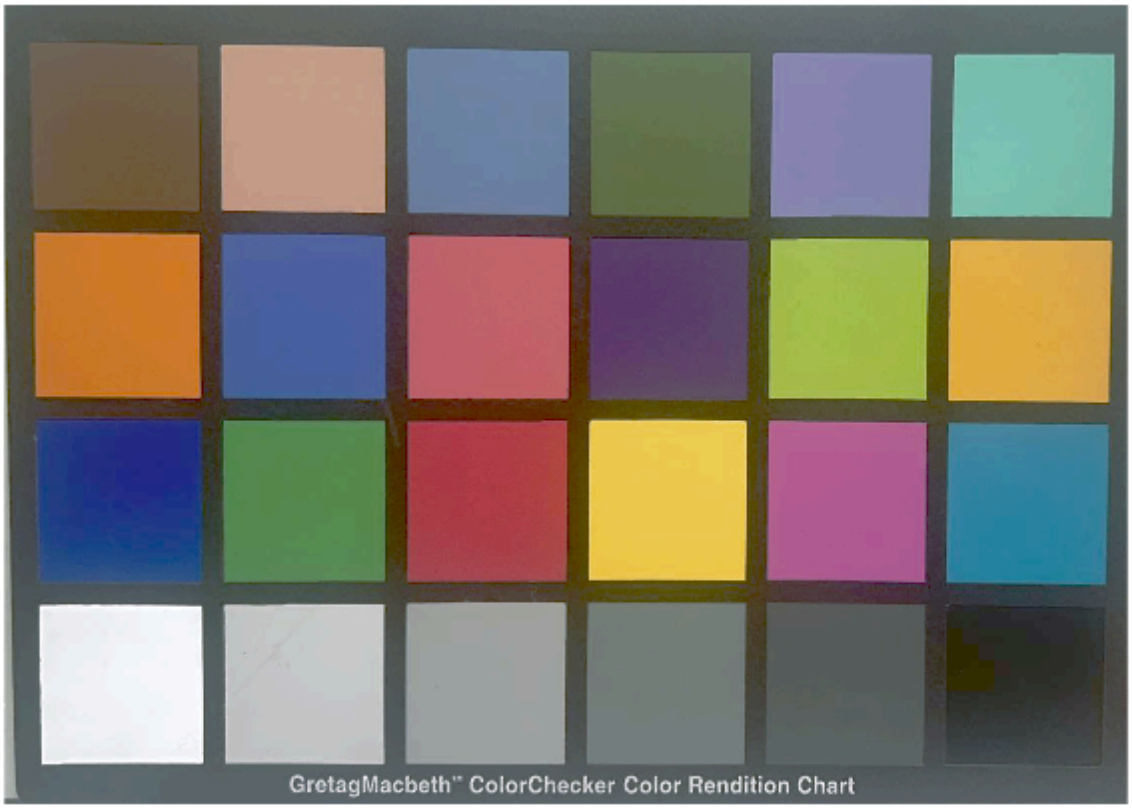
Step 4

```
% Load the original ColorChecker image
img_orig = imread("chart.jpg");

% Reshape the image into a pixel vector
```

```
[r, c, p] = size(img_orig);  % Get the dimensions of the image
pix_orig = reshape(img_orig, [r*c, p])';  % Reshape to 3x(rows*cols)

% Convert RGB to XYZ, pix_orig' is 3xN
pix_XYZ = camRGB2XYZ('cam_model.mat', pix_orig);

% XYZ2dispRGB will take the XYZ values and convert to calibrated RGB
pix_DCs_calib = XYZ2dispRGB('display_model.mat', pix_XYZ, XYZn_D50);

% Reshape the processed pixels back into an image
img_calib = reshape(pix_DCs_calib', [r, c, p]);

% Save the color-calibrated image as a .png file
imwrite(img_calib, 'color_calibrated_image.png');

% Show original image
figure;
imshow(img_orig);
title('original image');

% Visualize the result
figure;
% Display the color-calibrated image
imshow(img_calib);
title('color-calibrated image');
```

original image

color-calibrated image



Feedback

i. Who did which parts

Shakira - 3, 4

Hridiza - 1, 2, 3 (minor)

ii. Problems

- Creating the matrix for part 3 was very tricky

- Figuring out that we needed to use "AdaptedWhitePoint" in "makecform"

iii. Valuable parts

- Part 3d was a fun challenge, and helped us learn about how "reshape" really works in MATLAB

- Practically seeing the differences between calibrated and uncalibrated workflows

iv. Improvements

- Minor fixes in the writeup:

- Part 3d: Visualizing the 8 x 12 x 3 array (using image cmd) produces an extremely small image. It helps if we visualize the 768 x 1024 x 3 array instead

- Part 3c: The resulting RGBs from xyz2srgb are not scaled 0-100, but 0-1.

- Parts 1h and 2j: Seem unnecessary since we're not printing them, and they're already being printed by the supplied print functions

- Part 2g: Typo - It should say "workflow_test_cal.ti3" instead of "workflow_test_uncal.ti3"

Published with MATLAB® R2024a