Calculation of Lab Values for ColorChecker Charts

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```
%Script to calculate XYZ and LAB values for color checker chart under
 2deg
%standard observer and D65 light source. Format into a text table fr
 pretty
%printing with color chart names

%Fetch color values for each patch (omitting name field)
CC_spectra = importdata('ColorChecker_380_780_5nm.txt');
CC_delimited_spectra = CC_spectra(:,2:25);

%Load CIE struct
cie = loadCIEData();

% Calculate XYZ values for D65 light
XYZn_D65 = ref2XYZ(cie.illE,cie.cmf2deg,cie.illD65);

% Calculate all xyz values for colorchecker chart w/ 2 deg observer
 and D65
% light source
xyzs = ref2XYZ(CC_delimited_spectra, cie.cmf2deg, cie.illD65);
result = XYZ2Lab(xyzs, XYZn_D65);

% Read names of patches to pump into table
names = textread('ColorChecker_names.txt','%s','delimiter','|');

%Pretty print table of XYZ and Lab values for color patches
fprintf('ColorChecker XYZ and Lab values (D65 Illuminant and 2deg.
 observer)');
fprintf('\nPatch #\tX\tY\tZ\tL\ta\tb\t Patch Name\n');

sz = size(xyzs);
numCols = sz(2);

for col = 1:(numCols)
  xyz = xyzs(:,col);

  x = xyz(1);
  y = xyz(2);
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```
  z = xyz(3);

  lab = result(:,col);
  l = lab(1);
  a = lab(2);
  b = lab(3);

  strn = names{col};

  fprintf('%i\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%s
 \n',col,x,y,z,l,a,b, strn);

end

%Print table with reduced values to trigger alternate Lab calculation
smallCheckerReadings = CC_delimited_spectra.*(.02);

% Calculate all xyz values for colorchecker chart w/ 2 deg observer
 and D65
% light source
```

```
ColorChecker XYZ and Lab values (D65 Illuminant and 2deg. observer)
Patch # X Y Z L a b  Patch Name
1 11.515 10.382 7.150 38.519 12.410 13.309 Dark Skin
2 39.135 36.598 27.056 66.974 14.329 17.320 Light Skin
3 18.349 19.633 35.647 51.420 -1.624 -21.603 Blue Sky
4 11.149 13.855 7.427 44.024 -13.963 21.774 Foliage
5 25.844 24.387 45.614 56.473 11.544 -24.698 Blue Flower
6 31.711 43.860 44.878 72.135 -33.101 3.115 Bluish Green
7 37.146 29.559 6.501 61.272 32.497 55.059 Orange
8 13.863 12.318 39.309 41.717 14.416 -42.900 Purplish Blue
9 29.133 19.847 14.994 51.664 45.468 13.382 Moderate Red
10 8.589 6.457 15.474 30.537 23.785 -24.136 Purple
11 33.917 44.153 11.430 72.331 -26.083 57.948 Yellow Green
12 46.186 42.496 8.677 71.211 17.187 64.297 Orange Yellow
13 8.918 6.418 32.274 30.443 27.024 -53.277 Blue
14 15.035 24.108 9.638 56.196 -40.771 35.342 Green
15 19.345 11.358 5.553 40.176 51.976 22.689 Red
16 55.846 58.973 9.641 81.277 -0.508 78.575 Yellow
17 29.677 19.352 32.263 51.096 50.004 -17.653 Magenta
18 14.414 19.975 39.001 51.809 -25.642 -25.126 Cyan
19 87.840 92.378 95.613 96.975 0.076 3.262 White
20 57.962 61.043 65.491 82.402 -0.133 0.831 Neutral 8
21 35.229 37.041 40.226 67.308 0.079 0.125 Neutral  6.5
22 19.349 20.471 22.154 52.365 -0.541 0.237 Neutral 5
23 8.765 9.291 10.319 36.540 -0.568 -0.600 Neutral 3.5
24 3.211 3.376 3.931 21.492 0.035 -1.462 Black
```

CC_Delimeted spectra XYZs

```
xyzs = ref2XYZ(smallCheckerReadings, cie.cmf2deg, cie.illD65);
fprintf('CC_XYZs = \n');
disp(xyzs);
```

```
result = XYZ2Lab(xyzs, XYZn_D65);

fprintf('ColorChecker(Dark) XYZ and Lab values (D65 Illuminant and
 2deg. observer)');
fprintf('\nPatch #\tX\tY\tZ\tL\ta\tb\t Patch Name\n');

sz = size(xyzs);
numCols = sz(2);

for col = 1:(numCols)
  xyz = xyzs(:,col);

  x = xyz(1);
  y = xyz(2);
  z = xyz(3);

  lab = result(:,col);
  l = lab(1);
  a = lab(2);
  b = lab(3);

  strn = names{col};

  fprintf('%i\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%s
 \n',col,x,y,z,l,a,b, strn);

end

%display functions used for reporting
dbtype('ref2XYZ.m')
dbtype('XYZ2LAB.m')
dbtype('deltaEab.m');

CC_XYZs =
  Columns 1 through 7

    0.2303    0.7827    0.3670    0.2230    0.5169    0.6342    0.7429
    0.2076    0.7320    0.3927    0.2771    0.4877    0.8772    0.5912
    0.1430    0.5411    0.7129    0.1485    0.9123    0.8976    0.1300

  Columns 8 through 14

    0.2773    0.5827    0.1718    0.6783    0.9237    0.1784    0.3007
    0.2464    0.3969    0.1291    0.8831    0.8499    0.1284    0.4822
    0.7862    0.2999    0.3095    0.2286    0.1735    0.6455    0.1928

  Columns 15 through 21

    0.3869    1.1169    0.5935    0.2883    1.7568    1.1592    0.7046
    0.2272    1.1795    0.3870    0.3995    1.8476    1.2209    0.7408
    0.1111    0.1928    0.6453    0.7800    1.9123    1.3098    0.8045

  Columns 22 through 24
```

```
    0.3870    0.1753    0.0642
    0.4094    0.1858    0.0675
    0.4431    0.2064    0.0786

ColorChecker(Dark) XYZ and Lab values (D65 Illuminant and 2deg.
 observer)
Patch # X Y Z L a b  Patch Name
1 0.230 0.208 0.143 1.876 1.350 1.188 Dark Skin
2 0.783 0.732 0.541 6.612 3.565 3.659 Light Skin
3 0.367 0.393 0.713 3.547 -0.255 -4.082 Blue Sky
4 0.223 0.277 0.149 2.503 -1.654 2.191 Foliage
5 0.517 0.488 0.912 4.406 2.184 -5.453 Blue Flower
6 0.634 0.877 0.898 7.924 -8.173 0.823 Bluish Green
7 0.743 0.591 0.130 5.340 7.416 7.347 Orange
8 0.277 0.246 0.786 2.225 1.766 -7.409 Purplish Blue
9 0.583 0.397 0.300 3.586 8.414 1.893 Moderate Red
10 0.172 0.129 0.309 1.166 2.009 -2.416 Purple
11 0.678 0.883 0.229 7.977 -6.593 10.483 Yellow Green
12 0.924 0.850 0.174 7.677 4.646 10.754 Orange Yellow
13 0.178 0.128 0.645 1.159 2.309 -7.234 Blue
14 0.301 0.482 0.193 4.355 -6.454 4.752 Green
15 0.387 0.227 0.111 2.052 7.005 1.949 Red
16 1.117 1.179 0.193 10.405 -0.138 15.181 Yellow
17 0.594 0.387 0.645 3.496 9.246 -3.202 Magenta
18 0.288 0.399 0.780 3.609 -3.745 -4.935 Cyan
19 1.757 1.848 1.912 14.666 0.021 0.885 White
20 1.159 1.221 1.310 10.710 -0.036 0.226 Neutral 8
21 0.705 0.741 0.805 6.692 0.019 0.030 Neutral  6.5
22 0.387 0.409 0.443 3.698 -0.088 0.038 Neutral 5
23 0.175 0.186 0.206 1.679 -0.054 -0.058 Neutral 3.5
24 0.064 0.068 0.079 0.610 0.002 -0.073 Black

1     %% ref2XYZ Function
2     function XYZ = ref2XYZ(ref,cmfs,ill)
3         % compute XYZ from surface reflectance factor(s), color
 matching functions,
4         % and illuminant spectral power distribution
5         % can handle multiple ref(s) simultaneously
6         % 3/9/16 jaf
7         %compute normalizing constant for each illuminant
8         k = 100./(cmfs(:,2)'*ill);
9         %compute XYZ
10        XYZ = k.*cmfs'*diag(ill)*ref;
11        % % alternate calculation method that doesn't use diag
12        % ill_array = repmat(ill,[1,size(ref,2)]);
13        % XYZ = k.*cmfs'*(ref.*ill_array);

1     %% XYZ2Lab Function
2     % Takes a 3 X n array of tristimulus values as well as the 3 X
 1
3     % tristimulus values of a reference illuminant
4     % and returns a 3 X n array of
5     % CIElab values based on these tristimulus values.
6     function Lab = XYZ2Lab(XYZ, XYZn)
```

```
7
8           % Calculate function result values that will be required
 to calculate Lab
9           funcXXn = calcLabFuncResult(XYZ(1, :) / XYZn(1));
10          funcYYn = calcLabFuncResult(XYZ(2, :) / XYZn(2));
11          funcZZn = calcLabFuncResult(XYZ(3, :) / XYZn(3));
12
13          % Calculate individual Lab values
14          L = 116 * funcYYn - 16;
15          a = 500 * (funcXXn - funcYYn);
16          b = 200 * (funcYYn - funcZZn);
17
18          Lab = [L;a;b];
19
20
21      end
22
23      % Calculates the inner value of f(x) in the CIELab algorithm
24      % The result of x will be calculated differently based on the
 value of X
25
26      %if x > .008856, calc x^(1/3)
27      %otherwise calc 7.787x + 16/116
28      function fResult = calcLabFuncResult(x)
29        x(x > .008856) = x(x > .008856).^(1/3);
30        x(x <= .008856) = x(x <= .008856) * 7.787 + (16/116);
31
32        fResult = x;
33      end
```

```
1       %Calculate delta values between two sets of Lab values
2       %This function operates on a 3 x n column matrix
3       function DEab = deltaEab (Lab1, Lab2)
4           DEab = sqrt((Lab2(1,:) - Lab1(1,:)).^2 + (Lab2(2,:) -
 Lab1(2,:)).^2 ...
5           + (Lab2(3,:) - Lab1(3,:)).^2);
6       end
```

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