Calculation of Lab Values for ColorChecker Charts

```
%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);
  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
xyzs = ref2XYZ(smallCheckerReadings, cie.cmf2deg, cie.illD65);
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

dbtype('ref2XYZ.m')
dbtype('XYZ2LAB.m')
```

```
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
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;
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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       sz = size(XYZ);
9       numCols = sz(2);
10
11      for col = 1:(numCols)
12
13          XYZind = XYZ(:,col);
14
15          % Calculate function result values that will be required
 to calculate Lab
16          funcXXn = calcLabFuncResult(XYZind(1) / XYZn(1));
17          funcYYn = calcLabFuncResult(XYZind(2) / XYZn(2));
18          funcZZn = calcLabFuncResult(XYZind(3) / XYZn(3));
19
20          % Calculate individual Lab values
21          L = 116 * funcYYn - 16;
22          a = 500 * (funcXXn - funcYYn);
23          b = 200 * (funcYYn - funcZZn);
24
25          labInd = [L, a, b];
26
27          % Append lab values to 3 x 1 array
28          Lab(:,col) = labInd;
29      end
30    end
31
32    % Calculates the inner value of f(x) in the CIELab algorithm
33    % The result of x will be calculated differently based on the
 value of X
34
35    %if x > .008856, calc x^(1/3)
36    %otherwise calc 7.787x + 16/116
37    function fResult = calcLabFuncResult(x)
38      if x > .008856
39        fResult = x ^ (1/3);
40      else
41        fResult = 7.787 * x + (16/116);
42      end
43    end
```

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