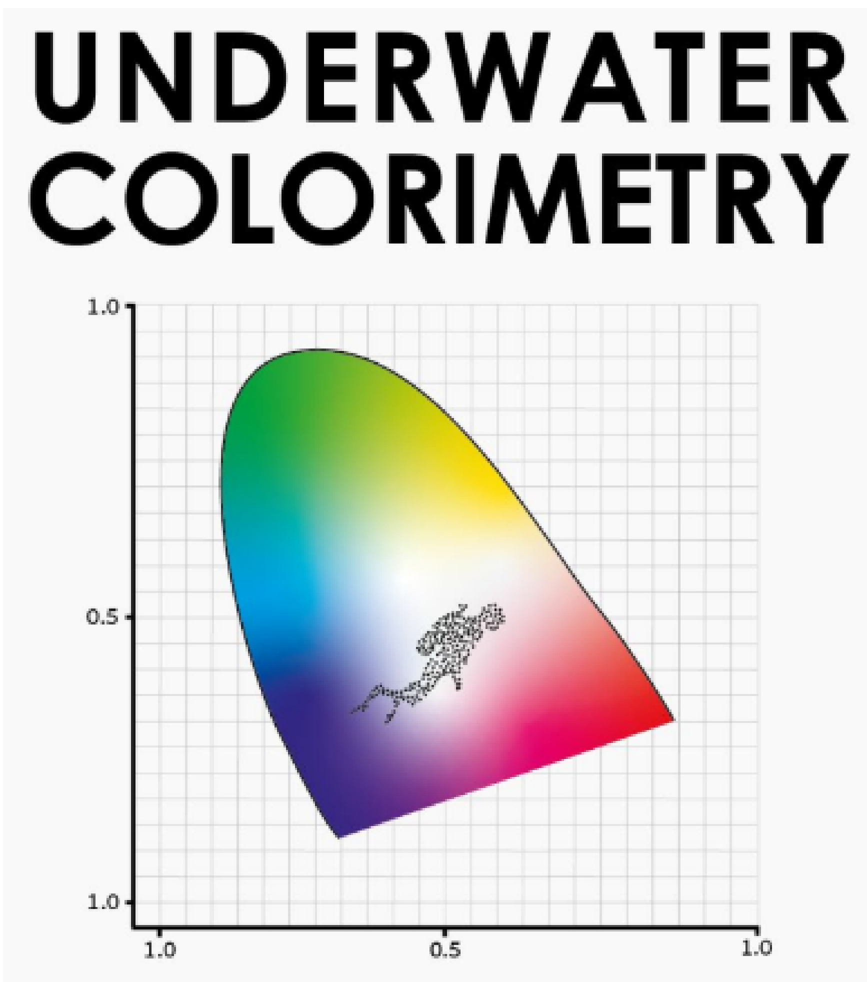
Underwater Colorimetry - fall 2024
Lab 2

IUI

January 2025



Basic Colorimetry

This lab focuses on basic colorimetry, aiming to compare RGB values captured by Nikon D90 and Canon $1Ds\ MkII$ cameras for a Macbeth ColorChecker under a specific illuminant. Exercises involve building RGB to XYZ transformations, plotting chromaticity diagrams, and converting XYZ values to the sRGB color space. The lab emphasizes the importance of standardizing color representation across cameras and understanding chromaticity variations under different illuminates.

Session objectives:

1. Carrying out basic colorimetry transformations.

2. Standardizing color variability between cameras.

Required equipment:

1. Laptop

2. MATLAB or Python

3. Camera able to capture RAW images

Provided data:

Underwater Colorimetry GitHub Repository

Download the repository as a .zip file. It is very important to place the repository in a folder whose path **does not** contain any spaces or special characters!

Provided file	Comment
`MacbethColorCheckerReflectances.csv`	Reflectances of all patches of a Macbeth ColorChecker: The 1-24 corresponds to the patches in the numbering order given here.
`illuminant-D65.csv,illuminant-A.csv`	Spectral power distributions of two CIE standard illuminants: daylight: D65, incandescent: A.
`CIEStandardObserver.csv`	CIE 1931 2-degree standard observer curves.
`NikonD90.csv`	Spectral responses of Nikon D90.
`Canon_1Ds_Mk_II.csv`	Spectral responses of Canon 1Ds II.
`RandomCamera.csv`	Spectral responses of random camera.

Table 1: Provided files and their descriptions.

Exercise 1

Quantitative color comparison between different cameras

In Exercise 3 of Lab 1, you simulated a "photograph" of a Macbeth ColorChecker by two different cameras under the same illuminant. Now we want to quantitatively check if the two cameras captured colors the same way or not.

Steps

1. Make a simple plot comparing the RGB values of each patch, as captured by each camera. The x-axis will be patch number 1-24 and the Y-axis will be the captured intensity in a given color channel.
2. Since there are 3 color channels, please make 3 subplots and mark each camera with a different marker.
3. Repeat this exercise but this time choose another random camera from :

   Spectral sensitivities

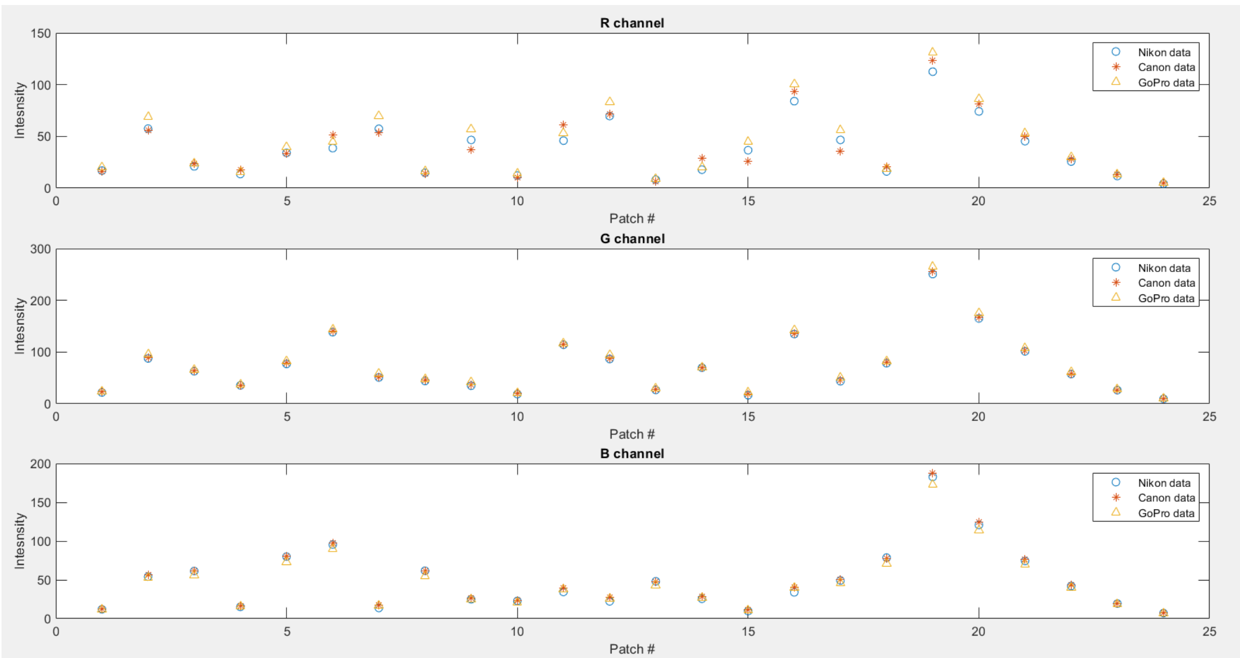
4. Plot RGB values of each patch with either the Nikon or Canon data you already have.

Include in your report - Exercise 1

1. The plots you made showing differences of the captured RGB values for the two different cameras
   (a) Nikon and Canon
   (b) Nikon/Canon and random Camera

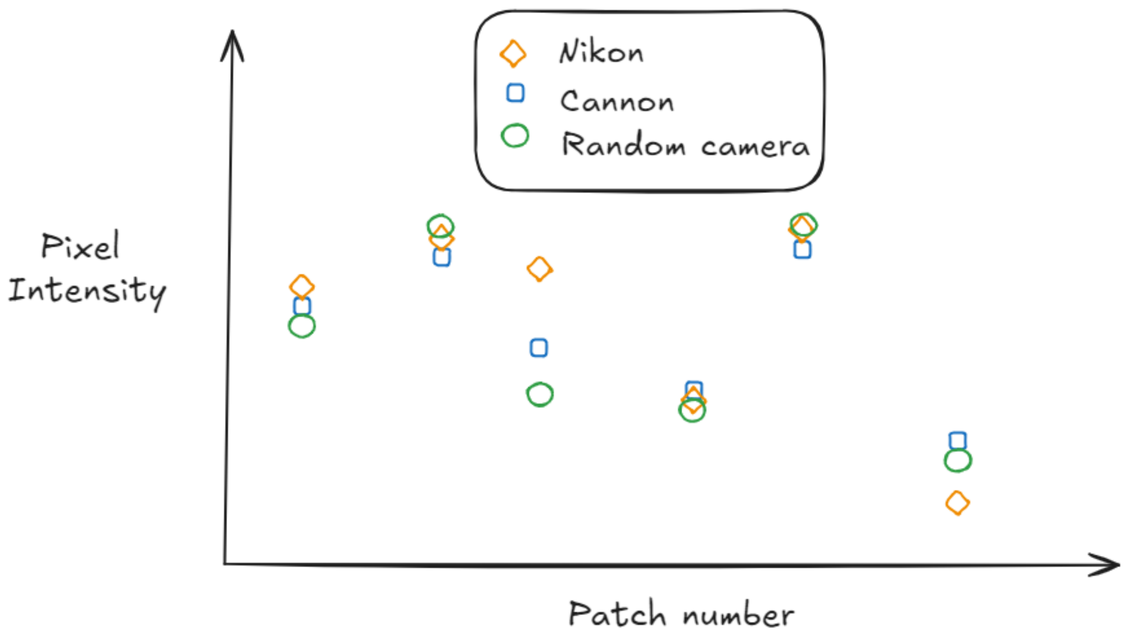
Are the large differences?
small differences?
Uniform across colors?

Discuss. Don't forget to note which illuminant and camera you used.



Guidance for writing the code

1. Use the *importdata* function to import:
   (a) Spectral sensitivities (Nikon, Cannon and random camera)
   (b) Reflectances of Macbeth ColorChecker
   (c) Illuminant (D65/A)
2. Create wavelength range of $400:700nm$ and use the $interp1$ function to interpolate the imported data to the same range.
3. Use the *getradiance* function from lab 1 to extract, or simulate, the RGB values of each patch given a specific camera under the chosen illuminant.
4. Plot the results.



Exercise 2

Camera RGB to XYZ transformation

Steps:

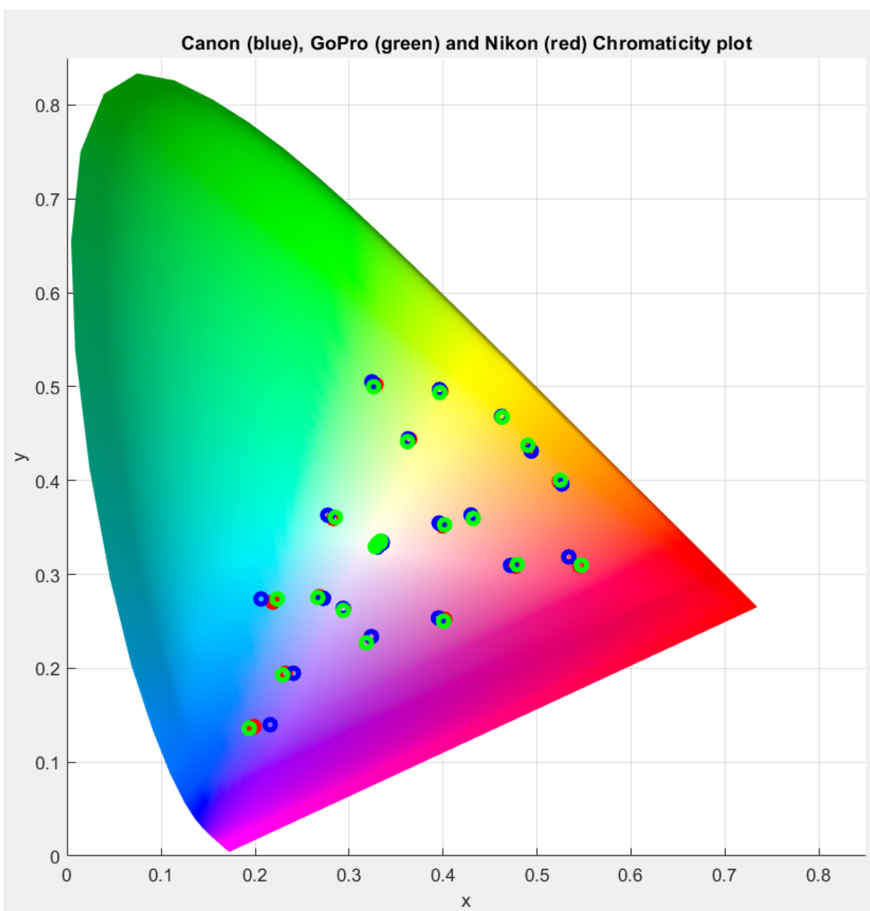
1. For each camera, under the illuminant you chose, build a 3×3 transformation from the (white balanced) camera RGB to (white balanced) XYZ values. Re-calculate the xy-values for both cameras.

2. Plot them on the CIE chromaticity diagram. Use different colors (or markers) to denote patches that came from each camera.

Include in your report - Exercise 2

1. The CIE chromaticity diagram that clearly shows the location of the 24 patches of the color chart for each camera (use a different color or different marker to distinguish cameras).

Don't forget to mention which illuminant you used. Are the xy values captured by each camera similar? Identical? Discuss.



Guidance for writing the code

1. Import the standard observer curves and interpolate to the defined wavelength range.
2. Use the *getradiance* function to get the XYZ values.
3. From the XYZ values derive the xy values.
4. White balance the XYZ values.
5. White balance the RGB values of each one of the 3 cameras.
6. For white balancing - pick the 23rd gray, with 9% reflectance but experiment with different patches!
7. Camera RGB to XYZ using camera specific transformation matrix T_{camera}

   $$[XYZ] = T_{camera} \cdot [RGB]'$$

   Where:

   $$[XYZ] \in 24 \times 3$$

   $$T_{camera} \in 3 \times 3$$

   $$[RGB]' \in 3 \times 24$$

8. Calculate the XYZ values from each camera using the transformation matrix T_{camera}

   $$[XYZ]_{camera} \approx T_{camera} \cdot [RGB]$$

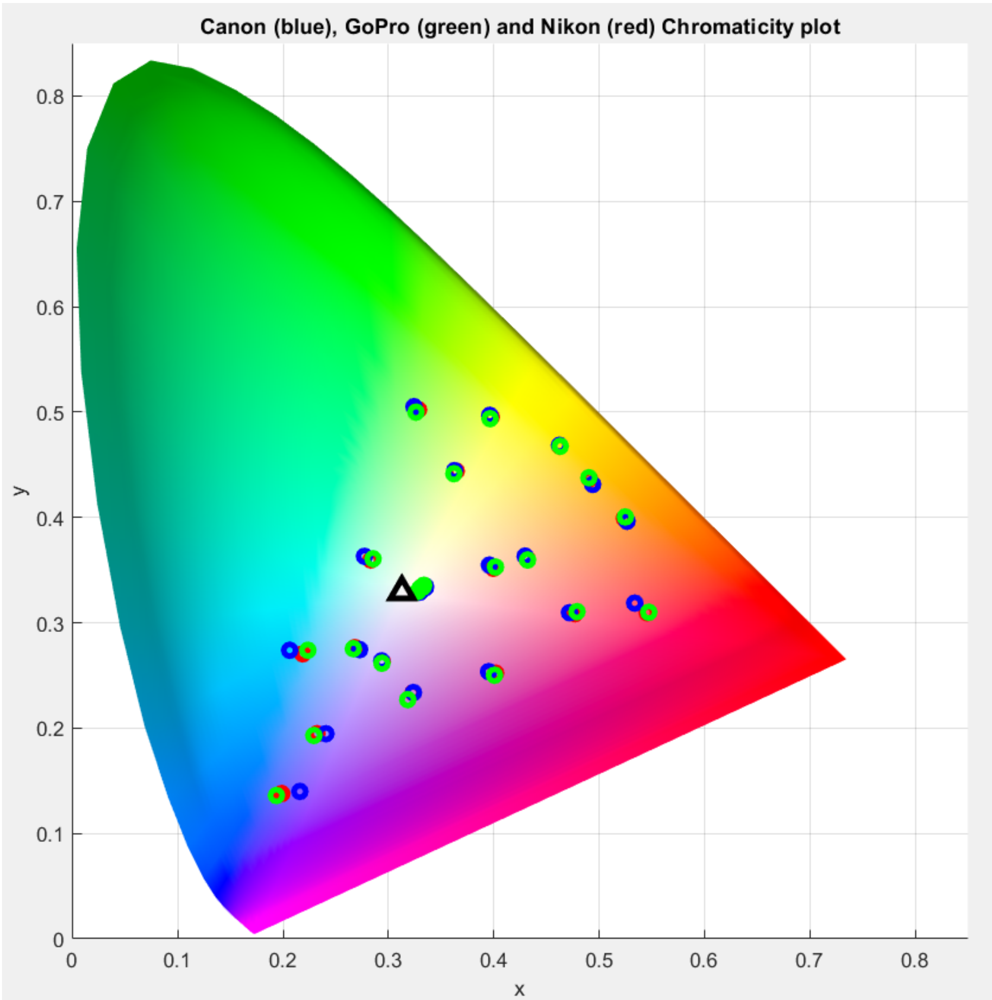
9. Obtain the xy coordinates for the 2D chromaticity diagram plots.

Exercise 3

Calculate the xy white point coordinates of the illuminant you used

Plot the white point on top of the previous chromaticity diagram from exercise 2.

Include in your report - Exercise 3



White point marked in black triangle

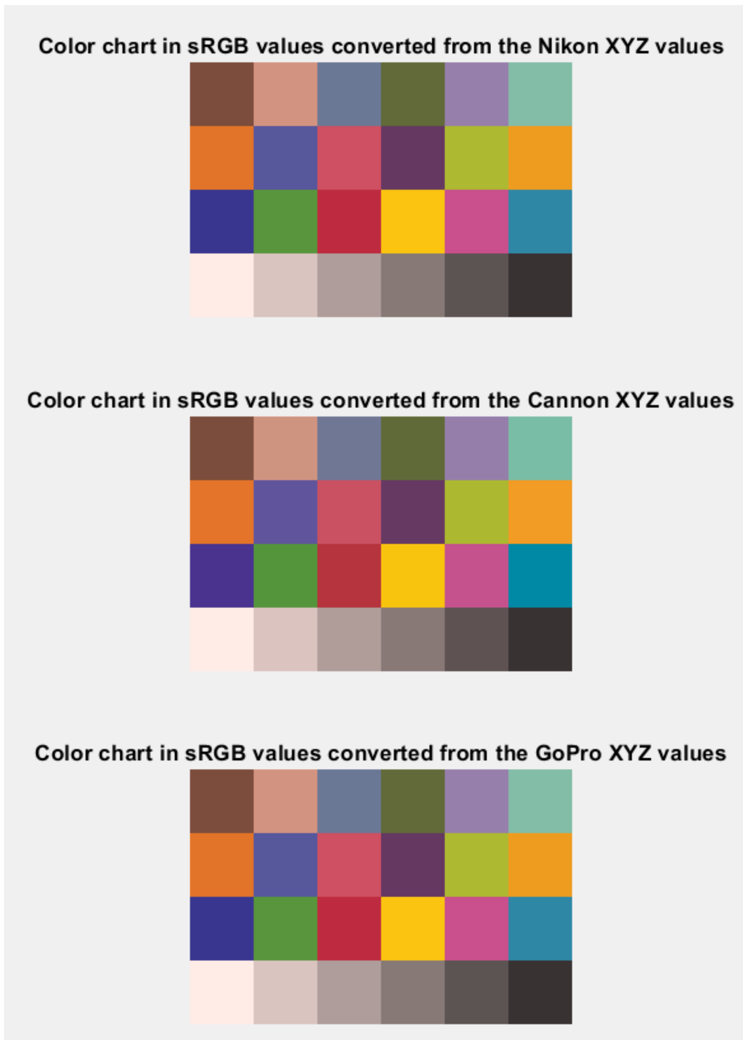
Exercise 4

XYZ to Standard RGB transformation

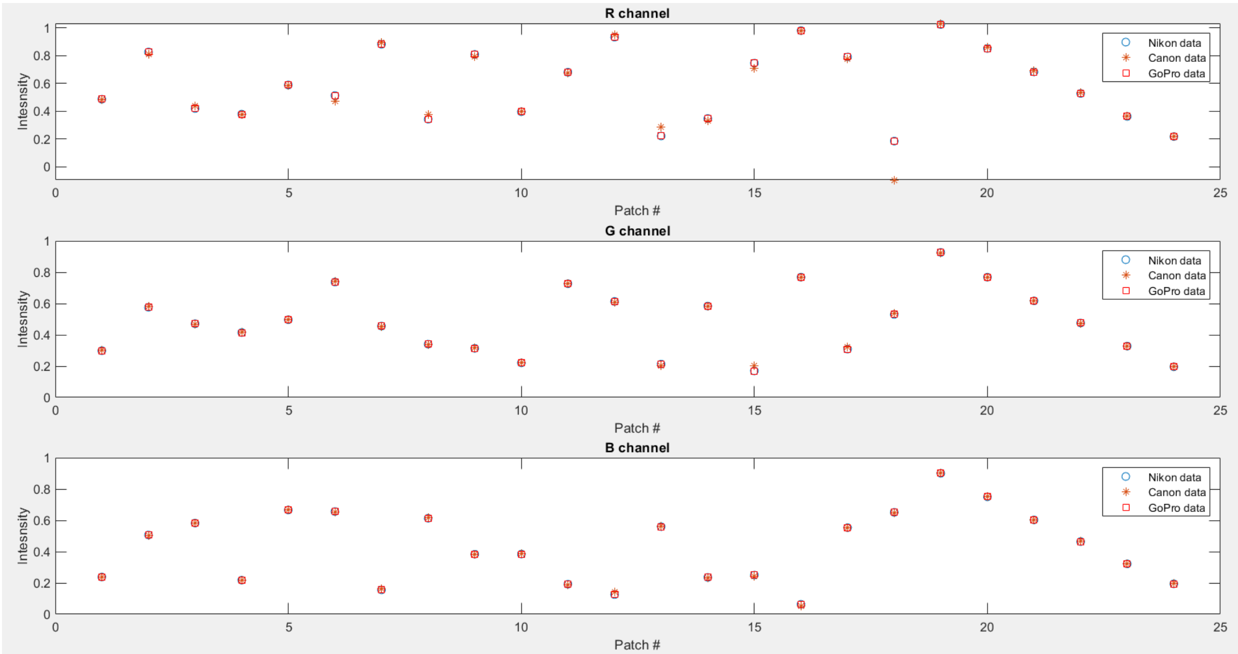
Convert XYZ values from the 3 cameras to sRGB color space. Don't forget to check if chromatic adaptation is needed (if the XYZ is already white balanced, it is not needed).

Include in your report - Exercise 4

1. The sRGB appearance of your color chart as "photographed" by each camera.



2. Similar plot to the one in Exercise 1, but now using the sRGB values for all 3 cameras.



3. Discuss what differences you see.

Guidance for writing the code

1. Use the $xyz2rgb()$ function to obtain sRGB values XYZ values for each image.
2. Visualize the simulated sRGB color-chart for each camera in **similar way you did in lab 1 - exercise 3**
3. Plot the three simulated color-charts in sRGB using the *subplot* function, one simulated color-chart per camera.
4. In new figure, plot the sRGB values for each patch in all cameras.

Lab report: Maximum 2 Pages!