Light Measurment

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Objectives

The main objectives of this lab session are:

- To **understand the interaction between illuminants, surface reflectance and sensor**.
- To **perform a radiometric measure** of a surface under different illuminants.
- To **compute reflectance based on the radiometric measurement of the surface**.

Key Definitions

- **Chromaticity**: A specification of the quality of a color regardless of its luminance. It describes the hue and colorfulness of a color as represented on a chromaticity diagram (e.g., CIE 1931). Chromaticity is often described by two coordinates (x, y) that specify a color's position in the chromaticity space.
- **Color Temperature**: Expressed in Kelvin (K), it refers to the hue of a theoretical black-body radiator at a particular temperature. Illuminants with high color temperatures (>5000 K) appear bluish, while those with low color temperatures (<3000 K) appear reddish. It provides a single value representation of the color tone of a light source but not its full spectral composition.
- **Reflectance Cube**: A 3D data structure obtained from hyperspectral imaging, where two spatial dimensions (x, y) represent the surface and the third dimension (λ) represents the reflectance spectrum at each pixel. It allows for analysis of material properties independently of the illumination.
- **Metamerism**: A phenomenon where two colors appear the same under one lighting condition but differ under another due to differences in their spectral reflectance. This highlights how color perception is not only a property of the object but also of the illuminant and observer.

1 - Visual Perception Under Controlled Lighting

Setup

A surface is placed in front of a led matrix able to generate a controlled light source generated using the application showcased in figure 1 :

- The two illuminants will have the **same chromaticity** or **correlated color temperature (CCT)**.
- However, their **spectral power distributions (SPDs)** will differ significantly.

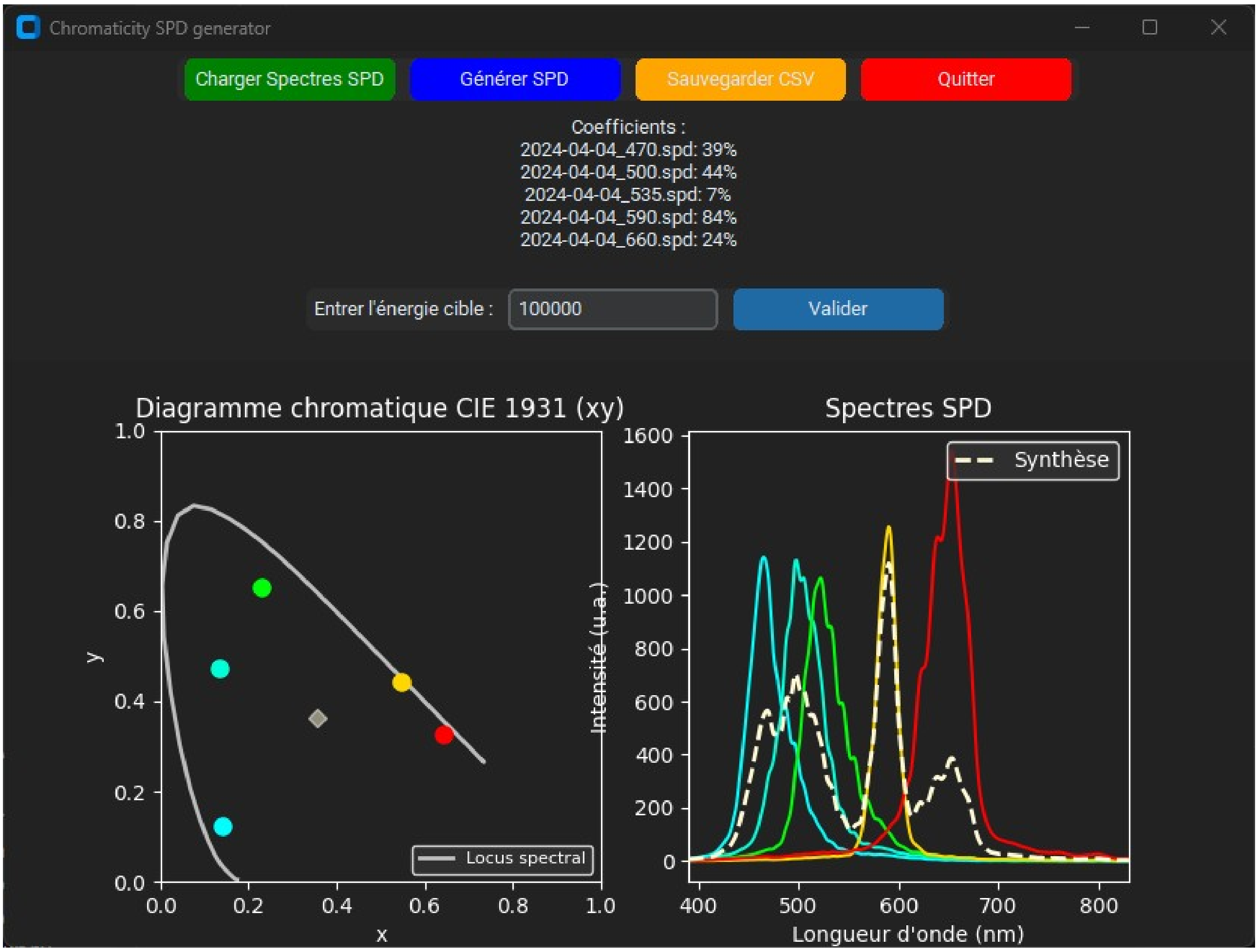

Fig 1 : Illuminants generation application. On the left side the chromaticity coordinates of our LEDs alongside the chromaticity coordinates of the generated illuminant. On the right side the spectral power distributions of our LEDs and the generated illuminant spectra.

Procedure

1. Participants are asked to look at the illuminated surface under different illuminant with similar color temperatures.

Led center / Temperatures	K = 7200	K = 7200	K = 3600	K = 3600
470nm	20	19	30	15
500nm	10	50	5	25
535nm	25	0	10	6
590nm	30	2	100	30
660nm	20	100	40	60

Tab : Coefficient used to replicate spectrums on led matrix

2. Observe and describe the color appearance of the surface under each illuminant.
3. Discuss:
    - Does the surface appear to have the same aspect ?
    - How does this relate to metamerism and the human visual system's response to spectral differences ?
    - How does illuminant variations impact the perception of non-uniform aspect of surfaces ?

This task emphasizes how identical color appearance (in terms of chromaticity) can result from different spectral compositions, and how this can still lead to noticeable perceptual differences under certain conditions.

2 – Radiometric measurement

Equipment

- JETI
- White reference
- Lighting source

Procedure

1. **Spectral Acquisition:**
    - Measure the white reference under fixed illuminant.
    - Choose 3 color patches on the macbeth.
    - Measure the color patch with the same illuminant.

2. **Reflectance Computation:**
    - Compute the reflectance spectrum of the surface for each illuminant used.
    - Compare the results:
        - Are the reflectance spectra the same?
        - Does the illumination spectrum affect the measured reflectance if proper calibration is performed ?

Discussion Points

- Differences between appearance and physical measurements.
- **Real-world implications**: color reproduction, material identification, and metamerism in digital imaging and computer vision.
- **Variations in Human Vision**: Human color perception varies across individuals due to differences in cone sensitivity, aging of the lens, or even color vision deficiencies. These individual differences are not accounted for in standard models like the CIE 1931 color matching functions.
- **Critique of CIE 1931 Standard**: The CIE 1931 color space is derived from color matching experiments involving a small group of observers with typical trichromatic vision. It does not consider variations across a broader population, such as those with color vision deficiencies or age-related changes. While the model is practical and widely used, it simplifies the complexity of human vision and can be insufficient for applications requiring high perceptual fidelity or personalized visual experiences.