Wavelength computation from RGB

Subtitle

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Pilsen City

(a) St.Bartolomew Church 1295

(b) FAV building

(c) The 2nd largest in Europe

Pilsen City

(a) Radbusa river & Museum

(b) even dogs drink a beer

Plzen is an old city [first records of Plzen castle 976] city of culture, industry, and brewery.
City, where today's beer fermentation process was invented that is why today's beers are called Pilsner - world wide

"Real science" in the XXI century

The mysterious castle in the Carpathians [1]

[1] Courtesy of the Czech Film, Barrandov

Introduction

There are many fields in which RGB images are used and processed, extracting important features in images, etc. Image processing techniques are based nearly exclusively on shadow processing and RGB image representation. It is well known that RGB does represent ONLY a fraction of natural colors contained in the rainbow spectrum.

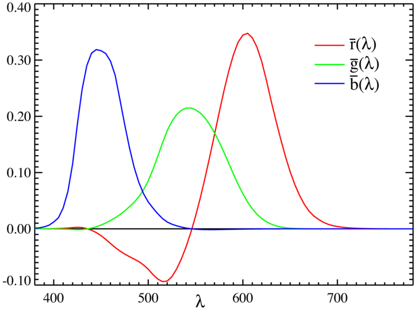
Surprisingly, computation of a wavelength λ of the color c given in RGB is not simple if the accurate value is required. Mostly, the RGB values are converted to the HLS, resp. HSV or similar color system, and the wavelength is estimated from the HUE value, which is quite inaccurate.

Introduction

This contribution presents a precise method for computing the wavelength λ based on re-sampling the spectral rainbow curve, i.e. the rainbow curve with 100% color saturation. The rainbow curve samples give the precision.
The preprocessing generates a look-up table for the whole interval of wave-lengths independent of images. The run-time is based on very simple computation and extraction of the wavelength using the look-up table.

RGB

The RGB values cover luminosity and chromaticity. It means that chromaticity is two-dimensional as it covers a wavelength and saturation of the given color. The wavelengths contained in white light are given using the reference wavelengths $\lambda_R = 780$[nm] for red, $\lambda_G = 546.1$[nm] for green and $\lambda_B = 435.8$[nm] for blue colors.

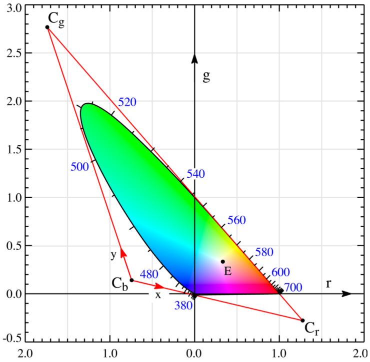


The rainbow spectral curves are partially negative, especially for the red color. Some colors of a rainbow are not represented within the RGB color model, as a color is represented by the RGB cube $[0,1]\times[0,1]\times[0,1]$.
To eliminate intensity, the RGB values are projected to the unitary plane $R+G+B=1$.
The chromaticity is given by values r and g in the $r-g$ plane representing color saturation and wavelength together.

$$r=\frac{R}{R+G+B} \quad , \quad g=\frac{R}{R+G+B} \quad , \quad b=1-R-G \tag{1}$$

RGB

Colors in the area $r < 0$ are not representable within the RGB system.



The rainbow curve is labeled by color wavelengths with 100% color saturation. Fig. represents colors available within the RGB system and E is the equal energy white light position, i.e. $(1/3, 1/3)$.

RGB - sectors

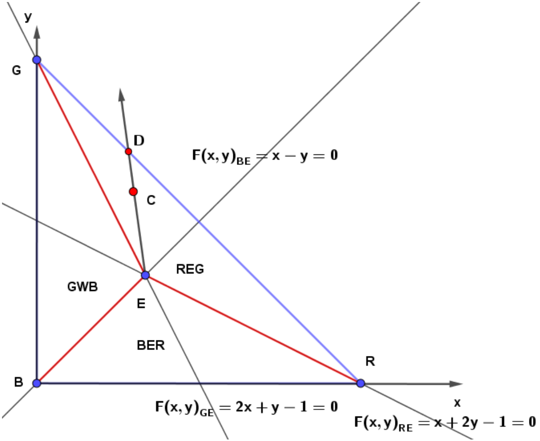


Figure: RGB - color sectors

RGB - sectors

The line G-E is given as:

$$\mathbf{p}_{GE} = \mathbf{x}_G \wedge \mathbf{x}_E = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 1 & 1 \\ \frac{1}{3} & \frac{1}{3} & 1 \end{vmatrix} = [\frac{2}{3}, \frac{1}{3} : -\frac{1}{3}]^T$$

$$p_{GE} : \quad \frac{2}{3}x + \frac{1}{3}y - \frac{1}{3} = 0 \triangleq 2x + y - 1 = 0 \tag{2}$$

where $\mathbf{x}_E = [1/3, 1/3 : 1]^T$ is the equal energy point position, $[0, 1 : 1]^T$ is the green color position and $\triangleq$ means projective equivalency.
It should be noted that positions are given in homogeneous coordinates of the white light, $\mathbf{x}_G = [0, 1 : 1]^T$ is a position of the pure green color.
The function $F(x, y)_{GE}$ forms a separation function, which is positive for colors in the Red(R)-White(E)-Green(G) sector of colors.

$$F(x, y)_{GE} = 2x + y - 1 \tag{3}$$

RGB - sectors

Now, edges of the sectors have to be labeled by the relevant wavelength λ.

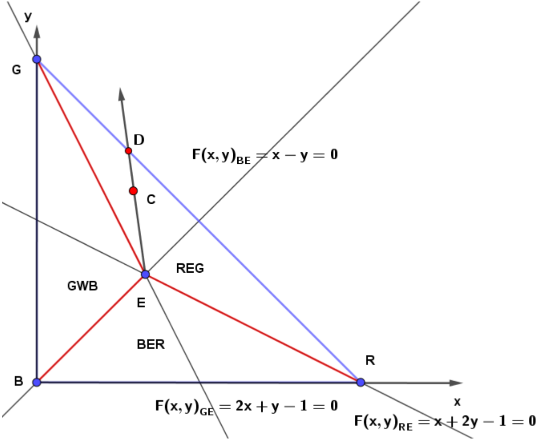


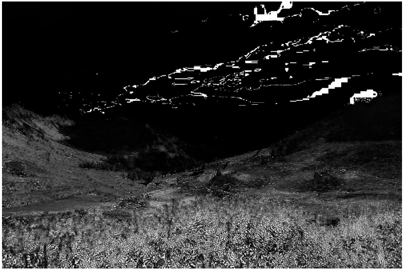
Figure: RGB - color sectors

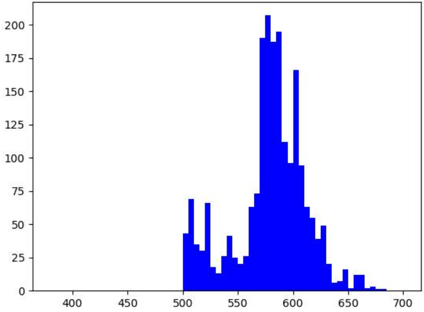
Experimental results

The experiments of the wavelength reconstruction from acquired RGB images proved, that wavelength can be determined as described above. Figs. present original image and wavelengths using a gray, i.e. it is pseudo-colored,

Experimental results

and saturation and histogram of wavelengths using 5[nm] wavelength sampling. 1[nm] sampling data available on a request.





Conclusions

A precise method for RGB conversion to the wavelength is presented. It consists of a look-up table generation, which is constant for all images and can be generated once forever. The run-time is simple as it needs only simple linear interpolation and actual wavelength extraction using the look-up table. The run-time is fast and convenient for processing of large images. The expected applications can be seen within image processing, computer vision. Standard techniques used in image processing, e.g. edge detection, feature detection etc., using the wavelength instead of grey, resp. RGB will be explored in future work.

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REFERENCES

Please, see the proceedings

Questions ?