This document quickly gives the main steps preformed by the retinal image software

1 Load the Judd51 $\overline{x}$, $\overline{y}$ and $\overline{z}$

Figure 1: Judd551 $\overline{x}$, $\overline{y}$, $\overline{z}$

2 Load the CRT's Spectral Power Distribution

Figure 2: CRT's Spectral Power Distribution

3 Compute (or load) the Smith-Pokorny fundamentals

Figure 3: Smith-Pokorny fundamentals

$$\begin{bmatrix} \text{L} \\ \text{M} \\ \text{S} \end{bmatrix} = \begin{bmatrix} 0.15514 & 0.54312 & -0.03286 \\ -0.15514 & 0.45684 & 0.03286 \\ 0.0 & 0.0 & 1.0204 \end{bmatrix} \times \begin{bmatrix} \overline{x} \\ \overline{y} \\ \overline{z} \end{bmatrix}$$

Table 1: Judd51 xyzbar2LMS conversion

$$\begin{bmatrix} \text{L} \\ \text{M} \\ \text{S} \end{bmatrix} = \begin{bmatrix} 0.15514 & 0.54312 & -0.03286 \\ -0.15514 & 0.45684 & 0.03286 \\ 0.0 & 0.0 & 0.01608 \end{bmatrix} \times \begin{bmatrix} \overline{x} \\ \overline{y} \\ \overline{z} \end{bmatrix}$$

Table 2: Judd-Vos78 xyzbar2LMS conversion

4 Compute the PSFs for each wavelength

$$PF(\lambda) = AT \times \exp\left(\frac{i2\pi W}{\lambda}\right) \tag{1}$$

$$ASF(\lambda) = ifft(PF(\lambda)) \tag{2}$$

$$OTF(\lambda) = fft(PSF(\lambda)) \tag{3}$$

$$RI(\lambda) = I(\lambda) \otimes PSF(\lambda) \tag{4}$$

$$PSF(\lambda) = Mod(ASF(\lambda)) = ASF(\lambda) \times conj(ASF(\lambda)) \tag{5}$$

$$PTF(\lambda) = Phase(OTF(\lambda)) \tag{6}$$

$$MTF(\lambda) = Modulus(OTF(\lambda)) \tag{7}$$

PF	Pupil function
AT	Amplitude Transmittance (Stiles Crawford effect)
W	Wave aberration = f(Pupil diameter)
ASF	Amplitude Spread Function
OTF	Optical Transfer Function
RI	Retinal Image
I	Displayed image (CRT)

Default Parameters :

Pupil Diameter	3 mm,
Focus Wavelength	570 nm,
Zernike order	15,
Pupil shift X, Pupil Shift Y	0mm,
Wavelengths	400:10:750,
Displayed image size	512 pixels,
Pupil function size	256.

Images given for wavelegths: 400, 450, 500, 550, 600, 650, 700, 750.

Full images, Zoom-in (110 × 110 pixels), Surface plot (110 × 110).

400nm

450nm

500nm

550nm

Table 3: PSFs

600nm

650nm

700nm

750nm

Table 4: PSFs

5 Read the input images (lsY2LMS2RGB)

R	G	B

Table 5: Input images

Background :
lsY = (0.72, 0.5, 10.0)
LMS =(7.2, 2.8, 5.0)
RGB = (17, 4, 2)
Grid :
lsY = (0.6, 3.0, 12.0)
LMS =(7.2, 4.8, 36.0)
RGB = (2, 7, 23)

6 Decompose the input image into wavelengths (for each (x,y) pixel)

$$\begin{aligned} Image[\lambda, x, y] = \; & Im_R[x, y] \times W_R \times SPD_R + \\ & Im_G[x, y] \times W_G \times SPD_G + \\ & Im_B[x, y] \times W_B \times SPD_B \end{aligned} \tag{8}$$

where Im_R, Im_G and Im_B represents the percentage of the R, G, B guns for each pixel, W_R, W_G, W_B are weighting parameters :

$$W_R = \frac{Y_R}{\sum_\lambda \left(V\left(\lambda\right) \times SPD_R\right)} \tag{9}$$

$$W_G = \frac{Y_G}{\sum_\lambda \left(V\left(\lambda\right) \times SPD_G\right)} \tag{10}$$

$$W_B = \frac{Y_B}{\sum_\lambda \left(V\left(\lambda\right) \times SPD_B\right)} \tag{11}$$

and SPD_R, SPD_G and SPD_B are the spectral power distribution of the Red, Green and Blue guns.

400 nm	450 nm	500 nm	550 nm
600 nm	650 nm	700 nm	750 nm

Table 6: Wavelengths images

7 Convolve each PSF with each wavelength image

This gives the retinal images for each wavelength.

Convolution theorem:

$$WI\left(\lambda\right) \otimes PSF\left(\lambda\right) = ifft\left\{fft\left[WI\left(\lambda\right)\right] \times fft\left[PSF\left(\lambda\right)\right]\right\} \tag{12}$$

where $WI\left(\lambda\right)$ is the wavelength representation of the displayed image

400 nm	450 nm	500 nm	550 nm
600 nm	650 nm	700 nm	750 nm

Table 7: Retinal images

8 Compute the LMS cones absorption

For each type of cones (L,M,S)
 For each (x,y) pixel position
 For each wavelength

$$conesabs\left(x,y\right)=\sum_{\lambda=400}^{850}\left(RI\left(\lambda,x,y\right)\times SPF\left(cones,\lambda\right)\right) \tag{13}$$

$RI\left(\lambda,x,y\right):$ Wavelength Retinal image,
$SPF\left(cones,\lambda\right):$ Smith-Pokorny fundamentals

L image	M image	S image

Table 8: LMS images

9 Compute l and s

$l = \frac{L}{L+M}, s = \frac{S}{L+M}, m = 1 - l$

Compute the average value on several windows sizes (2x2, 4x4, 6x6, 8x8, 10x10, 12x12 pixels) (The windows are centered in the middle of a square).

Different pupil size (2.5, 3.0, 3.5, 4.0 mm) and different Focus wavelengths (500, 525, 550, 575 nm) have been tested. 2 inducing chrfomaticities, 4 induced chromaticities.

Plots below shows results for a lsY=(0.6, 3.0, 12.0) inducing chromaticity and for a (0.7, 0.5, 10.0) induced chromaticity.

Pup diameter=25mm	Pup diameter=30mm
Pup diameter=35mm	Pup diameter=40mm

Table 9: Results

10 Apply a center-surround receptive field

Not tested yet, but the program allows to create and tune a +s/-s center surround Receptive field (Difference of Gaussian), and to convolve it with the LMS cones maps.