Computer Vision
Assignment №7

Theoretical Questions
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1 Color Space Conversion

1. **RGB to CMYK**

$$\begin{bmatrix} C \\ M \\ Y \\ K \end{bmatrix} = \begin{bmatrix} 255 - R - K \\ 255 - G - K \\ 255 - B - K \\ 255 - Max(R, G, B) \end{bmatrix}$$

$$\Rightarrow K = 255 - Max(0, 255, 100) = 255 - 255 = 0$$

$$\Rightarrow \begin{bmatrix} C \\ M \\ Y \\ K \end{bmatrix} = \begin{bmatrix} 255 - 0 - 0 \\ 255 - 255 - 0 \\ 255 - 100 - 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 255 \\ 0 \\ 155 \\ 0 \end{bmatrix}$$

2. **CMY to RGB**

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 255 - C \\ 255 - M \\ 255 - Y \end{bmatrix} \Rightarrow \begin{bmatrix} C = 80 \\ M = 43 \\ Y = 100 \end{bmatrix} \Rightarrow \begin{bmatrix} R = 255 - 80 \\ G = 255 - 43 \\ B = 255 - 100 \end{bmatrix} = \begin{bmatrix} 175 \\ 212 \\ 155 \end{bmatrix}$$

3. **CMYK to RGB**

First we calculate color codes in CMYK terms (scale of 0 - 1):

$$\begin{bmatrix} C/255 \\ M/255 \\ Y/255 \\ K/255 \end{bmatrix} = \begin{bmatrix} 115/255 \\ 87/255 \\ 0/255 \\ 155/255 \end{bmatrix} = \begin{bmatrix} 0.45 \\ 0.34 \\ 0 \\ 0.6 \end{bmatrix}$$

Now we use the conversion formula on the values above

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 255 * (1 - C)(1 - K) \\ 255 * (1 - M)(1 - K) \\ 255 * (1 - Y)(1 - K) \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 255 * (1 - 0.45) * (1 - 0.6) \\ 255 * (1 - 0.34) * (1 - 0.6) \\ 255 * (1 - 0) * (1 - 0.6) \end{bmatrix} = \begin{bmatrix} 56 \\ 67 \\ 102 \end{bmatrix}$$

2 Normalized Cross-Correlation (NCC)

Normalized cross correlation is a commonly used metric to evaluate the degree of similarity (or dissimilarity) between two images.

Normalized Cross Correlation is confined in the range between –1 and 1. The setting of detection threshold value is much simpler than the cross correlation. Normalized Cross Correlation is less sensitive to linear changes in the amplitude of illumination.

In this approach, we calculate the degree of similarity of a specific region in the first image with all the possible regions in the second image. Wherever the degree of similarity is high, there is a strong chance that in that regions the first and second image are similar.[1]

3 Hessian Detector

Hessian Detector is almost identical to Harris Detector.

In a hessian detector, a Hessian matrix is used for score measurement:

$$H(x) = \begin{bmatrix} Ixx(x) & Ixy(x) \\ Iyx(x) & Iyy(x) \end{bmatrix}$$

The Hessian matrix uses second partial derivatives.

in contrast, in Harris Detector which uses a second-moment matrix (also called structure tensor):

$$M(x) = \begin{bmatrix} (Ix)^2 & IxIy \\ IxIy & (Iy)^2 \end{bmatrix}$$

Because of using second partial derivatives, Hessian detector performs better. For a single image, the Hessian Detector typically identifies more reliable regions than the Harris Detector.

Hessian Detector interest are usually more and smaller than other detectors.[2]

[1] International Journal of Research in Engineering and Technology
[2] Wikipedia

4 Eigenvalues

We calculate the eigenvalues for matrices provided and make our assumptions based on the eigenvalues.

- For M1:

  $$M1 = \begin{bmatrix} 84.33 & -16.97 \\ -16.97 & 59.48 \end{bmatrix} \Rightarrow np.linalg.eig(M1) \Rightarrow \begin{bmatrix} \lambda_1 & \lambda_2 \end{bmatrix} = \begin{bmatrix} 92.937 & 50.872 \end{bmatrix}$$

  Since both λ_1 and λ_2 are great values, so this matrix belongs to a place where there are significant changes in both horizontal and vertical directions, so M1 belongs to a corner i.e. **green area**.

- For M2:

  $$M2 = \begin{bmatrix} 163.54 & -0.217 \\ -0.217 & 0.1053 \end{bmatrix} \Rightarrow np.linalg.eig(M2) \Rightarrow \begin{bmatrix} \lambda_1 & \lambda_2 \end{bmatrix} = \begin{bmatrix} 163.540 & 0.105 \end{bmatrix}$$

  Since $\lambda_1 >> \lambda_2$, so there is significant change in horizontal direction, so this matrix belongs to a vertical edge i.e. **blue area**.

- For M3:

  $$M3 = \begin{bmatrix} 0.1714 & -0.496 \\ -0.496 & 164.4 \end{bmatrix} \Rightarrow np.linalg.eig(M3) \Rightarrow \begin{bmatrix} \lambda_1 & \lambda_2 \end{bmatrix} = \begin{bmatrix} 0.169 & 164.401 \end{bmatrix}$$

  Since $\lambda_2 >> \lambda_1$, so there is significant change in vertical direction, so this matrix belongs to a horizontal edge i.e. **red area**.

- For M4:

  $$M4 = \begin{bmatrix} 0.1439 & -0.009 \\ -0.009 & 0.323 \end{bmatrix} \Rightarrow np.linalg.eig(M4) \Rightarrow \begin{bmatrix} \lambda_1 & \lambda_2 \end{bmatrix} = \begin{bmatrix} 0.143 & 0.323 \end{bmatrix}$$

  Since λ_2 and λ_1 are both very small, so there is no significant change in any direction, so this matrix belongs to a flat region i.e. **yellow area**.