Computer Vision

Exercise 1

This is the first exercise for your computer vision course. After finishing this exercise, you are expected to know:

- How to work with images in OpenCV.
- How to perform image zooming.
- How to enhance the contrast of images through various methods.
- How to apply different operations on pixel values in order to modify images.

Instructions

- Please provide a proper answer for each part of the questions.
- Use the cells beneath each question for your answer.
- Feel free to add more cells whenever needed.

Good luck!

Question 1 (15 points)

In computer vision, image zooming is a process that enlarges or reduces an image while preserving or altering its details.

You are provided with an image, *einstein.jpg*, and your task is to apply zooming with a factor of 2 using the following two methods: **Pixel replication** and **Zero-order hold**.

A) Describe each of the two methods (Pixel replication, Zero-order hold) for image zooming.

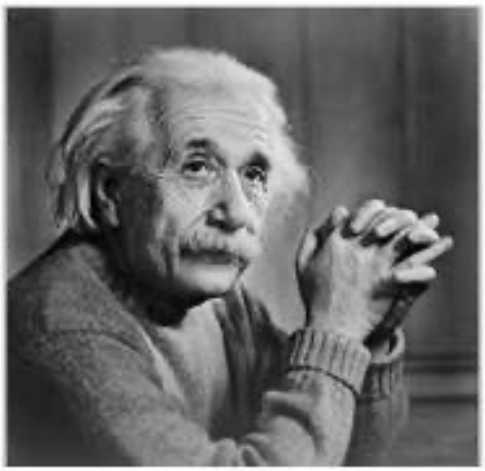
B) Implement Python code to perform zooming in on the image 'einstein.jpg' using a zoom factor of 2 for each of the two methods. Provide step-by-step explanations of your code for each method.

C) For each of the two methods, discuss their advantages and disadvantages. Consider aspects such as image quality, computational complexity, and suitability for different types of images.

D) Display the zoomed images for the two methods and report the results. Examine the effects of increasing the zoom factor (e.g., from 2 to 4) on image quality and detail preservation.

E) Suggest an improved zooming method and compare its results with the two experimented methods.

You can see the original form of the image below



einsein.jpg

Question 2 (15 points)

You are given a low-contrast grayscale image, 'low_contrast.jpg', which has lost significant details due to insufficient contrast. Your task is to enhance the image using logarithmic and gamma correction techniques. Additionally, you need to plot the histograms of the original and enhanced images for comparison.

low_contrast.jpg

A) Normalize the image to ensure its pixel values are within range (0 to 1).

B) Describe each of the two methods (Logarithmic correction and Gamma correction) for contrast stretching.

C) Apply logarithmic contrast stretching to 'low_contrast.jpg' using the formula:

enhanced_pixel_value = c * log(1 + original_pixel_value)

Choose an appropriate constant 'c' to scale the enhanced pixel values to the range (0 to 1).

D) Apply gamma correction to 'low_contrast.jpg'. Choose a suitable 'gamma' value for enhancing the image's contrast.

E) After applying both contrast enhancement techniques, plot histograms for the original and enhanced images on a single figure.

X-axis: Pixel intensity values (0 to 1)
Y-axis: Frequency of each intensity value in the image

Question 3 (15 points)

Histogram equalization is a technique widely used in image processing to enhance the contrast of an image by redistributing the intensity values. In this question, you will explore the concept of histogram equalization step by step.

lena_gray.gif

Use the image below for this question.

A) Normalize the image to ensure its pixel values are within range (0 to 1).

B) Calculate and plot the histogram of the original image. Analyze the histogram to understand the distribution of pixel intensities.

C) Implement the histogram equalization algorithm on the original image then calculate and plot the histogram of the equalized image.

D) Display the original image, the histogram-equalized image, and their respective histograms side by side for comparison.

E) Analyze and compare the visual differences between the original and equalized image. Discuss how histogram equalization has affected the distribution of pixel intensities.

Question 4 (15 points)

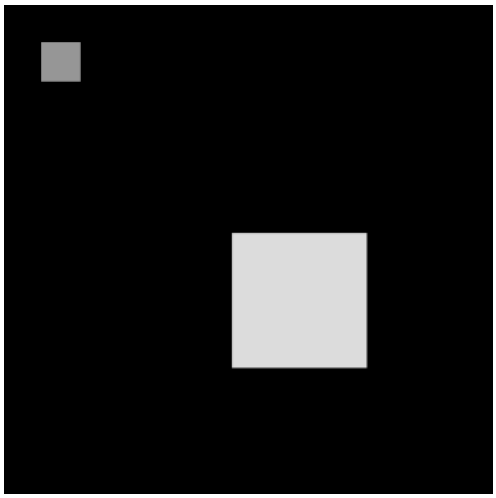
The image square.gif contains two square objects. Pixels in the first square have the intensity of 150, while those in the second square have the intensity of 220. Read the image and do the following:

A) The small square is to be translated by 40 pixels in both directions.

B) The large square is to be rotated by 60 degrees counter clockwise.

Write the code to perform these transformations. Show the image before and after transformation on the same figure.

you can see the original form of the image below:



square.gif

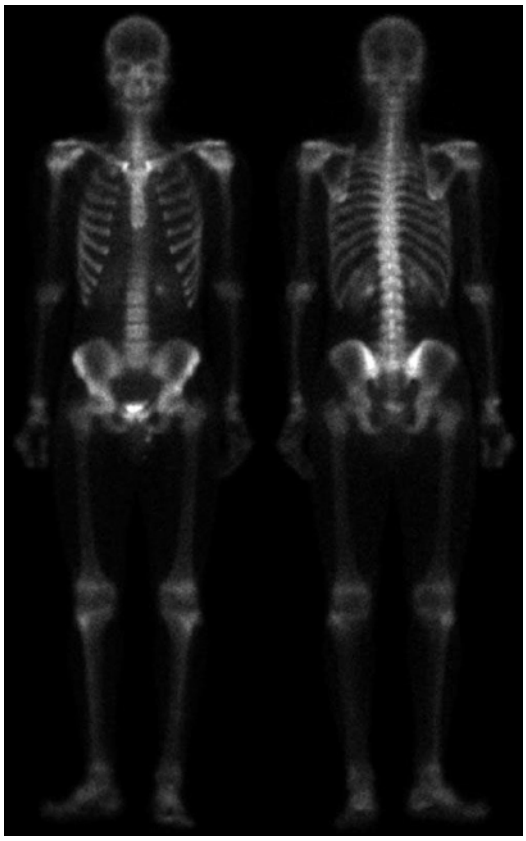
Question 5 (10 points)

For the image skeleton.gif, try to modify the normalized image using the following functions:

1) $g(x,y) = e^{cf(x,y)}$
2) $g(x,y) = c\log_{10}[(f(x,y)+1]$
3) $g(x,y) = \begin{cases} f(x,y) = f(x,y) & f(x,y) < 0.1 \\ f(x,y) = 2 * f(x,y) & otherwise \end{cases}$

Show the results in each case. Which function produces the best result in your opinion? Discuss your results.

you can see the original form of the image below:



skeleton.gif