COMP9517

Lab 1, S1 2018

This lab presents a revision of important concepts from week 1 and 2 lectures, and short questions around them. Most questions require you to use OpenCV, an open source software package that is widely used in the field. OpenCV v2.4.9.1 is installed on the lab machines and accessible through vlab environment. You are expected to use vlab during the lab sessions.

For information, the latest version of OpenCV is downloadable from https://opencv.org/

All questions should be attempted during the lab hour.

The last question (Question 6) is assessable IN THE LAB. Make sure to show your answer to your tutor before leaving the lab. It will not be assessed later on outside the lab.

DATA SAMPLES are can be downloaded from the class website.

1 LOADING, SAVING AND DISPLAYING IMAGES

To start off we will learn how to load, save and display images. The table below gives basic code snippets to perform the operations. For more information on the syntax kindly refer to the OpenCV documentation.

OpenCV
Loading/Reading an image
import cv2 image2=cv2.imread('threads.png',0)
Saving/Writing an image
cv2.imwrite('image3.png',image3)
Displaying an image
cv2.imshow('Title of the display window',image3)

QUESTION 1: Read two images, image1 and image2 and save a new image image3 by combining image1 and image2 as shown in the figure below. Make sure that the two images are of the same size, and if they are not, crop the bigger image.

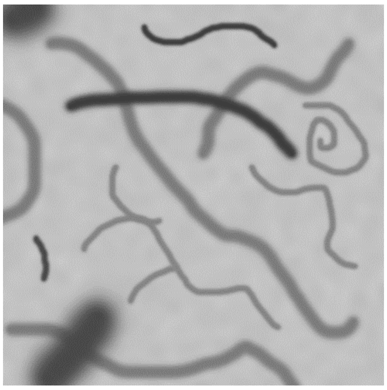


image1

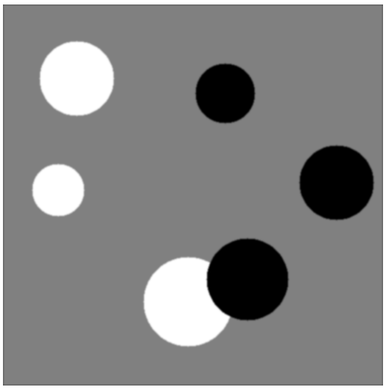


image2

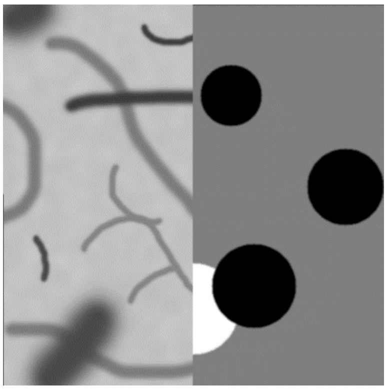


image3

2 IMAGE QUANTIZATION

A digital image is created by converting continuous sensed data into digital form. It requires two basic steps: sampling and quantization. Focus on digitizing the amplitude values, also called as quantization. If an image is quantized using 5 different levels of grey values, it means that the image will have 5 different colours, ranging from 0 (black) to 4(white). The quality of an image can be improved by increasing this level. If an image is quantized into 256 different grey levels, the grey level resolution goes up. In such an image, each pixel needs a storage space of 8 pixels ($2^8 = 256$).

256 Grey levels

32 Grey levels

8 Grey levels

2 Grey levels

QUESTION 2: Read a grey scale image and modify it to 32, 8, and 2 grey level images by using 5, 3 and 1 quantization levels respectively, as shown in the figure above. Note the deterioration in the image quality as the number of grey levels decrease.

HINT: To convert a 256-grey scale image to an 8-grey scale image, $= original\ pixel\ value * \frac{7}{255}$. While displaying the image make sure to set the correct colour map.

IMAGE PREPROCESSING (Image Enhancement)

Sometime captured images may have poor illumination or wrong setting of lens aperture which leads to images of low quality. The pre-processing of such images is an integral step for the success of any computer vision algorithm. The following figure from the book Computer Vision Metrics [1], gives an insight into the importance of pre-processing. The contrast adjustments made to the image has improved the performance of the Sobel edge detector.

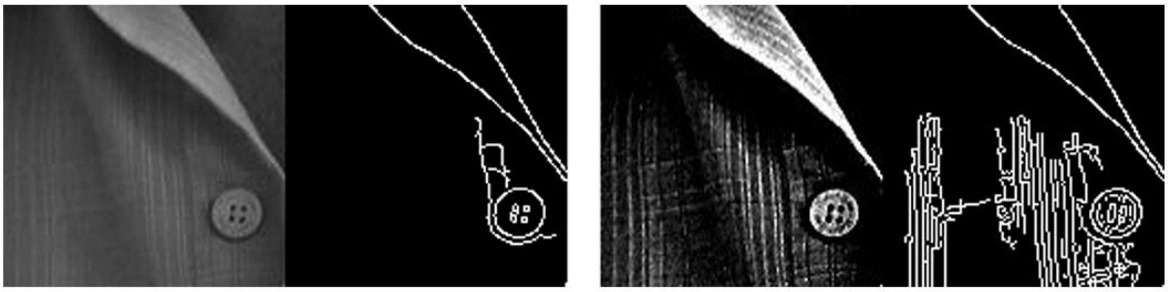


Figure 2-2. *The effects of local contrast on gradients and edge detection: (Left) Original image and Sobel edges. (Right) Contrasted adjusted image to amplify local region details and resulting Sobel edges*

These processes can be broadly divided into two categories: spatial domain methods and frequency domain methods. In this lab session we will be dealing with spatial domain methods. Grey Level Transformation is the simplest and basic image enhancement technique. Assume that ***Or*** is the original image and ***Tr*** is the transformed image.

3 IMAGE NEGATIVE

Negative of an image is given by, $Tr = L - 1 - Or$, for an image with grey level in the range 0 to L-1. This enhancement makes the visual analysis of the image easier although the content of the two images are the same.

QUESTION 3: Read a grey scale image and find its negative, a sample is shown in the figure below (Picture from [7]):

Original Image Image Negative

4 CONTRAST STRETCHING

Contrast in an image is a measure of the range of intensity values within an image and is the difference between the maximum and minimum pixel values. The full contrast of an 8-bit image is 255(max)-0(min)=255, and anything less than that results in a lower contrast image. Contrast stretching attempts to improve the contrast of an image by stretching (linear scaling) the range of intensity values**.**
If ***a*** and ***b*** are the min and max pixel values allowed in an image (8-bit image, ***a***=0 and ***b***=255), and let ***c*** and ***d*** be the min and max pixel values in a given image, then the contrast stretched image is given by the function:

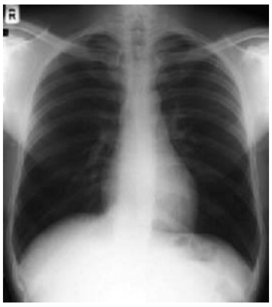
$$\boldsymbol{Tr = (Or - c)\left(\frac{b-a}{d-c}\right) + a}$$

Note:

- If there are spurious pixels with very high or very low values it seriously affects the value of ***c*** and ***d***, so it is advisable to choose ***c*** and ***d*** in such a way that 5% of the pixels will have a value less than ***c*** and 5% of pixels will have a value more than ***d*** respectively.
- Values of ***a*** and ***b*** can be chosen depending on the amount of contrast that has to be obtained for full contrast on an 8-bit image 0 and 255; for a lesser contrast modify ***a*** and ***b*** appropriately.

QUESTION 4: Read a grey scale image and perform contrast stretching to improve the quality of the image. Shown below is a poor contrast X ray image (Picture from [2]) and its contrast stretched version.

Original Image



Contrast Stretched image

5 HISTOGRAM

Histogram of an image shows the frequency of pixel intensity values. It only gives statistical information and nothing about the location of the pixels. For a digital image with grey levels from 0 to L-1, the histogram is a discrete function $\boldsymbol{h(Or_k) = n_k}$, where $\boldsymbol{Or_k}$ is the kth grey level and $\boldsymbol{n_k}$ is the number of pixels with a grey level $\boldsymbol{Or_k}$.

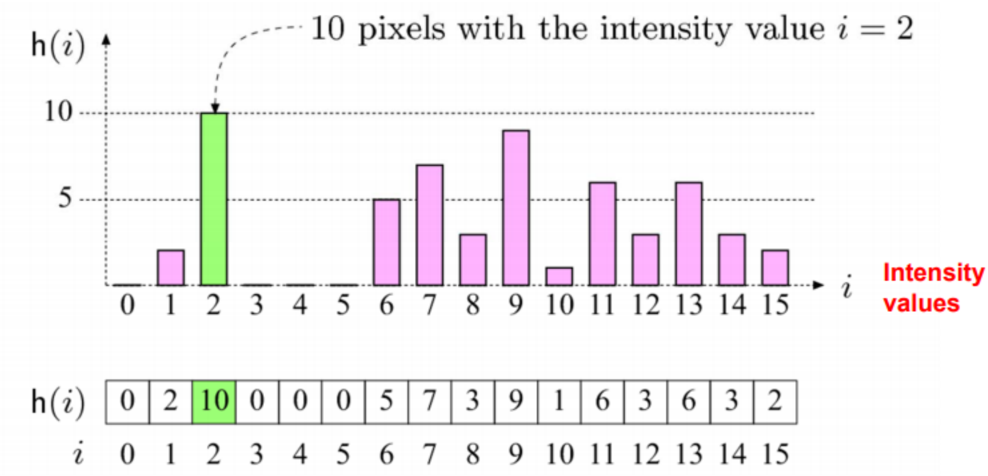
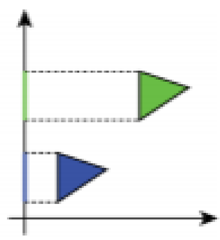


Figure 1: Histogram (Picture from [3]).

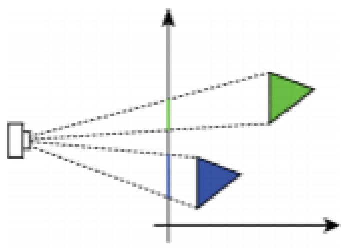
QUESTION 5: Write a function that computes the histogram of a given grey scale image and displays a plot. Do not use in built MATLAB or OpenCV functions.

6 PERSPECTIVE AND ORTHOGRAPHIC PROJECTION

Orthographic Projection maps 3D points to 2D by moving them along a projection direction until they hit an image plane [4], and the image plane is perpendicular to the viewing direction. In perspective projection the projection is done along lines that pass through a single point until they hit an image plane.



Orthographic Projection



Perspective Projection

For more information on this topic visit the links provided in the following references [4], [5] and [6].

QUESTION 6 (for evaluation by lab tutor): Suppose there are two 3D cubes on the ground facing the viewer, one near, one far.

a. What would they look like in perspective?
b. What would they look like in weak perspective?

7 REFERENCES

[1]. Krig S. (2014) Image Pre-Processing. In: Computer Vision Metrics. Apress, Berkeley, CA, https://link.springer.com/chapter/10.1007/978-1-4302-5930-5_2#citeas

[2]. http://cursa.ihmc.us/rid=1GJRS5FYJ-HBJGJG-1FF0/Cindy%20and%20Melonie's%20CMAP%20Digital%20Imaging%20Processing.cmap.cmap

[3]. http://web.cs.wpi.edu/~emmanuel/courses/cs545/S14/slides/lecture02.pdf

[4]. http://www.cs.uu.nl/docs/vakken/gr/2011/Slides/07-projection.pdf

[5]. https://cg.informatik.uni-freiburg.de/course_notes/graphics_03_projections.pdf

[6]. https://www.scratchapixel.com/lessons/3d-basic-rendering/perspective-and-orthographic-projection-matrix/projection-matrix-introduction

[7]. http://decsai.ugr.es/cvg/CG/base.htm