National University of Sciences and Technology

School of Electrical Engineering and Computer Science

Department of Software Engineering

EE433: Digital Image Processing

Class: BESE-5

Assignment 2: Image Preprocessing and Spatial Filtering

Announcement Date: 31th October, 2017

Due Date: 7th Nov 2016 at 2:00 pm

Submission on LMS

Instructor: Dr. Muhammad Moazam Fraz

Course Learning Outcomes (CLOs)			
Upon completion of the course, students should demonstrate the ability to:		PLO Mapping	BT Level*
CLO 1	Understanding the fundamentals and basic concepts of image processing	PLO 1	C2
CLO 2	Analyze images using various image processing algorithms	PLO 2	C4
CLO 3	Develop solutions by using modern tools (Matlab) to solve practical problems.	PLO 5	C5
	* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		

Assignment No 2: Image Preprocessing and Spatial Filtering

Learning Outcome

CLO 2: Analyze images using various image processing algorithms

Background

In the class we have covered about image preprocessing algorithms for contrast enhancement and removing the effects of non uniform illumination. The purpose of this assignment is to apply / implement some preprocessing algorithms and evaluate / study their effect on human retinal images.

Retinal imaging has developed rapidly during the last 160 years and is a now a mainstay of the clinical care and management of patients with retinal as well as systemic diseases. Fundus photography is widely used for population-based, large scale detection of diabetic retinopathy, glaucoma, and age-related macular degeneration.

TASK-1

(25 points)

Pre-Processing Algorithm:

Preprocessing is applied to obtain an image with uniform illumination and better contrast between the retinal background and the anatomical structures present in the retinal image. A simple linear transformation for shade correction and variability normalization is used. We have obtained a shade corrected image by removing the background lighting variations. For this purpose, the estimate of background is obtained by applying a filtering operation with a large arithmetic mean kernel. The size of the filter kernel is not a critical parameter as long as it is large enough to ensure the blurred image contains no visible structures such as vessels. Then the difference between the morphologically opened image I_o and the estimated background I_{BE} is computed for each pixel to obtain a normalized image I_n.

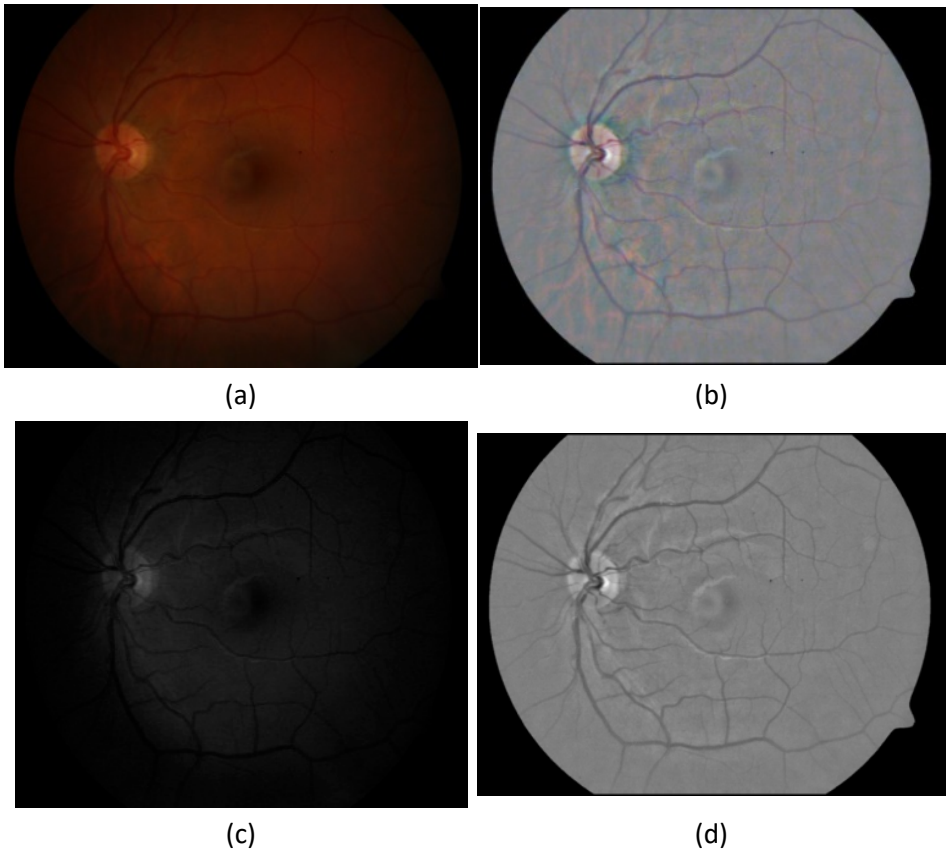
$$I_n(x,y) = I_O(x,y) - I_{BE}(x,y) \tag{1}$$

Likewise, when the fluctuation in background intensity of retinal images is examined, there can be significant variation in intensities between images due to different illumination conditions in the acquisition process. Therefore, a shade corrected image is obtained by applying a global transformation with the purpose of reducing the intensity variation and contrast enhancement. For this purpose the pixel intensities are modified according to the following global linear transformation function,

$$I_H(x,y) = \begin{cases} 0, & if\ I_n(x,y) < 0 \\ 1, & if\ I_n(x,y) > 1 \\ p(x,y), & otherwise \end{cases} \tag{2}$$

$$p(x,y) = I_n(x,y) + 0.5 - val_{MAX\_PIXEL}$$

where, $I_H(x,y)$ is the homogenized image, $I_n(x,y)$ is the normalized image shown in (1), val_{MAX_PIXEL} is the intensity value presenting the highest number of pixels in the normalized image $I_n(x,y)$.



(a) (b)

(c) (d)

Fig. 1: Retinal image preprocessing; (a) Original image, (b) Normalized image (c) Green channel of original image, (b) Green channel of normalized image

The pixels with intensity value equal to val_{MAX_PIXEL} belong to the background of the retinal image. This global transformation will set them to 0.5 and will standardize the intensity around this value of those background pixels with different illumination conditions. Fig 1 shows that illumination variation is normalized and preprocessed image has uniform contrast

Read the set of retinal images one by one and apply following algorithms. Matlab file is included contains code for iterating through the images.

1. **Implement the Pre-Processing algorithm described above, and apply on the retinal images. (20 pt)**

Bonus Points (5 pt)

1: Create a Field of View (Mask) for each retinal image using (adaptive) thresholding [2 pt]

2: Perform Task 1 on non-null pixels only. Explain how it can be done. You can write the algorithm in Matlab / Python file as comments. [3 pt]

Task – 2

(50 points)

You have to implement an algorithm to extract the centerlines of retinal blood vessels. The algorithm is presented in the following research paper.

A. M. Mendonca and A. Campilho, "*Segmentation of retinal blood vessels by combining the detection of centerlines and morphological reconstruction*," *Medical Imaging, IEEE Transactions on,* vol. 25, pp. 1200-1213, September 2006.

The research paper can be downloaded from the following link when you are within NUST Campus.

http://ieeexplore.ieee.org/xpls/icp.jsp?arnumber=1677726

The method herein presented can be schematically described by the functional block diagram in Figure 2, where we identify three main processing phases:

1) **Preprocessing**, for background normalization and thin vessel enhancement;
2) **Vessel centerline detection**, for defining a set of connected segments in the central part of the vessels; and
3) **Vessel segmentation**, for finally labeling the pixels belonging to the vessels. These phases are further subdivided in several steps, as follows:

The processing pipeline of the algorithm is explain in Figure 2. You need to implement the Steps 1 and Step 2 only i.e. ***Preprocessing*** and ***Vessel Centerline Detection***, which are highlighted in light red color in the figure below. For understanding, please read **section 3** and **section 4** of the research paper.

You need to implement the **Section 4A and Section 4 B only**

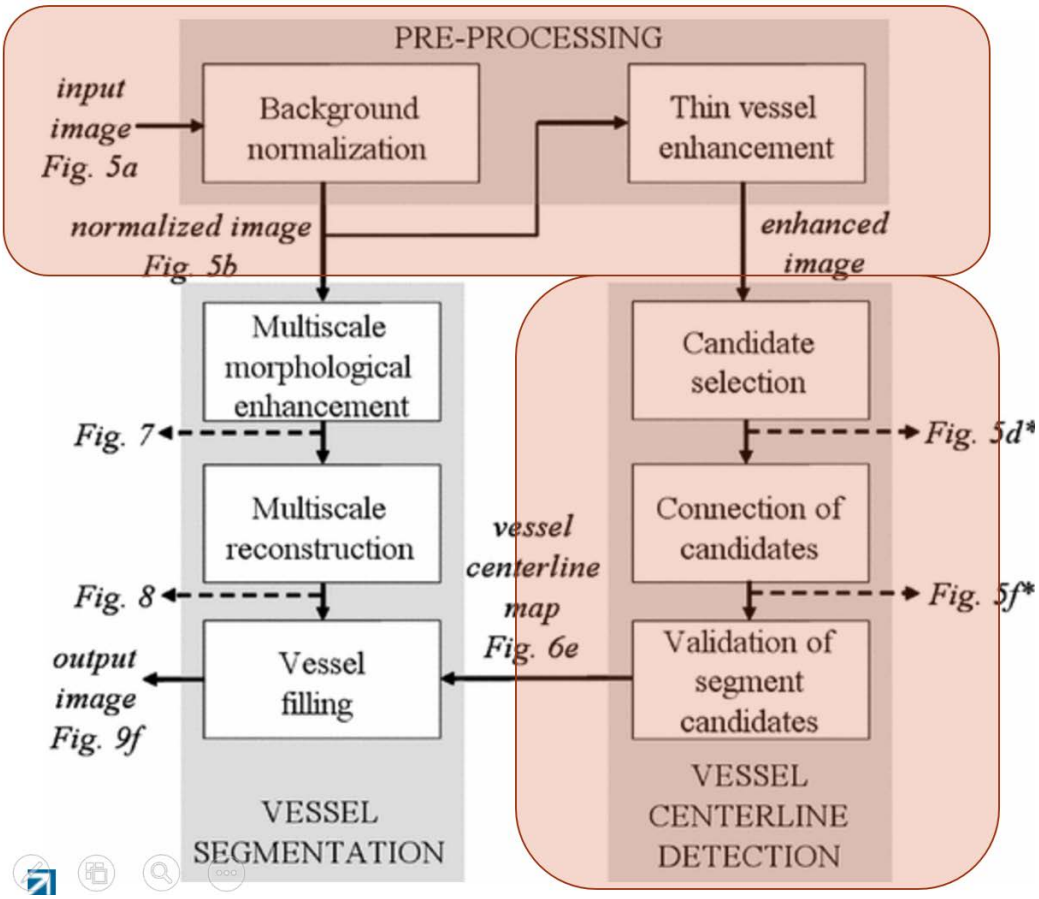


Figure 2. Retinal vessel segmentation functional diagram

Algorithm Evaluation:

The algorithm should be evaluated on DRIVE Database of Retinal Images. 10 images of DRIVE database are included within the ZIP file.

Submission Instructions

1. The sample code for reading images is provided as main_prog.zip.
2. You should read the retinal images from "/images" folder placed in the parent directory of your code file.
3. You need to submit the Fully documented Matlab Code / Python Code.
4. If you have written multiple code files, Create a ZIP file and Name it as YOUR NAME.ZIP and upload it on LMS.
5. One file should be Main.py or Main.mat; from which the code can be run.

6. The vessel centerline images should be written in the "./output_images_yourname/" folder which should be located in the same directory where your code files are located.
7. You code should write the output in the above specified directory
8. You should submit your MATLAB/Python code only. The name of submission file MUST BE your complete name.
9. I will run your code. In order to run your code seamlessly, you should read the images as described in previous point.
10. The code should be fully documented explaining each step you had implemented to earn the credit.

Failing to follow naming and coding conventions and failing to run the code seamlessly will result in ZERO credit.