R.A. Yusuf H. Şahin
sahinyu@itu.edu.tr

Part 1 : Hough Circle Detection - Problem Construction (20 pts.)

Construct the geometric equation of a circle. Write down the least squares problem to solve the parameters of a circle. Write the algorithm pseudo-code to detect circles in a given image.

Part 2 : Hough Circle Detection - Implementation (30 pts.)

In early 2000s, Siemens Corporate Research developed a marker system called SCR[1], in which each marker has 16 slots for circle placement. An example SCR marker is given in Figure 1.

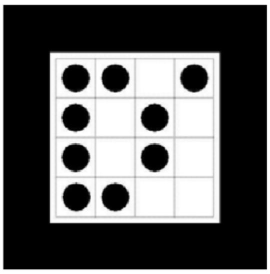

Figure 1: An example SCR marker

Implement a Python code to detect the circles from the image given below. Suppose that the diamond and ellipse shapes are noises.

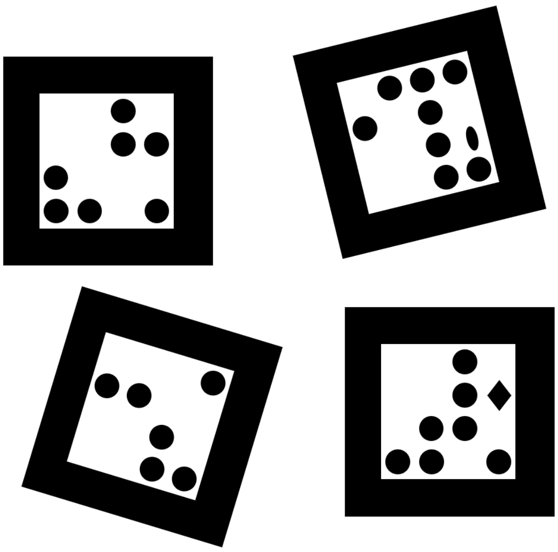

Figure 2: Different SCR markers

[1]X. Zhang, Y. Genc, and N. Navab. Taking AR into large scale industrial environments: Navigation and information access with mobile computers. In IEEE Int. Symp. on Augmented Reality, 2001.

Part 2.5 : BONUS (30 pts.)

After detecting the circles, use your findings from the previous homework to;

♦ Find contours in the image.
♦ Using the contour information, find out the marker locations (For every marker border, there is a rectangle inside another rectangle).
♦ After finding out marker borders, define the markers according to 4 different orientations. For example, the marker at the top-left corner can be defined as {0010001110001101, 0101110000010011 etc. }

Part 3 : 3D Image Segmentation (50 pts.)

With the homework document, I've also uploaded a 3D image and its segmentation. An example look of the image is given in Figure 3. As stated by Jerman et. al[2], in medical imaging, scans are generally corrupted by a Poisson noise. Thus, to obtain a reliable synthetic image (e.g. to test a vessel segmentation algorithm), a certain Poisson noise may be applied. Thus, I applied a Poisson noise with ($\lambda = 1$) onto the image.

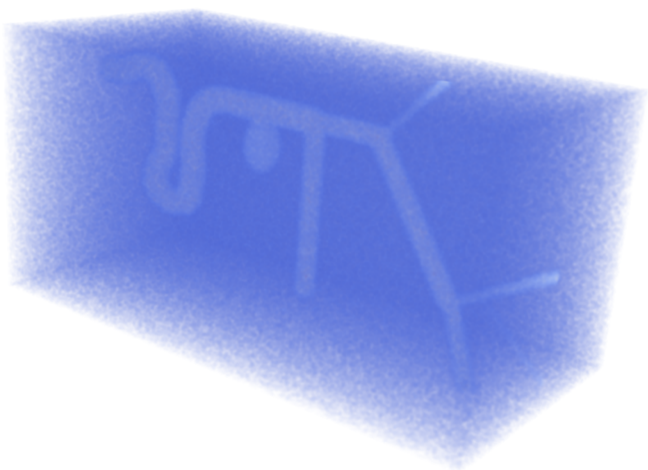

Figure 3: The example tubular structure of which we will find the segmentation map

In this part, you will implement region growing algorithm using different parameters and approaches. You should use intensity difference as the growing criteria. However, you are responsible to decide on the threshold value. To evaluate the performance of the algorithms, you will use Dice coefficient;

$$Dice(X_{seg}, X_{gt}) = \frac{2 * |X_{seg} \cap X_{gt}|}{|X_{gt}| + |X_{seg}|} \tag{1}$$

where X_{seg} represents the algorithm's segmentation results and X_{gt} represents the ground truth.

The provided files are in NIfTI file format, which is widely used in medical imaging. You can use **nibabel** library [3] to read and write NIfTI files. Also to visualize the the image and your results,

[2] Jerman, T., Pernuš, F., Likar, B., Špiclin, Ž. (2015). Blob enhancement and visualization for improved intracranial aneurysm detection. IEEE Transactions on Visualization and Computer Graphics, 22(6), 1705-1717.

[3] https://nipy.org/nibabel/

you can benefit from Aliza[4] (2D slices and 3D look of the image) and ITK-Snap[5](2D slices and some interactive operations).

a) (10 pts) Implement region growing algorithm to obtain a segmentation output similar to the given ground truth. Obtain independent results for each axial (z-dimension) slice. Use 8-neighborhood. Calculate the Dice score.

b) (10 pts) Reimplement the approach in part A, but use 4-neighborhood.

c) (10 pts) Implement the region growing algorithm in 3D. Use 26-neighborhood. Calculate the dice coefficient.

d) (10 pts) Reimplement the approach in part C, but use 6-neighborhood.

d) (10 pts) Evaluate your algorithms according to Dice scores. What kind of preprocessing step may be done to obtain better results?

[4] https://www.aliza-dicom-viewer.com/

[5] http://www.itksnap.org/pmwiki/pmwiki.php