

Notice: There are 5 questions.

1. Below you see a list of different image analysis operations/tools and tasks that you should solve. Link each operation/tool to the most appropriate task in such a way that each operation/tool is used and each task is solved. In practice, certain tools could be used in multiple tasks and solving one task may need several tools.

**Operation/Tool**

- A. Non-local means algorithm
- B. Atlas-based segmentation
- C. Convolutional neural network
- D. Hough-transformation
- E. Fitting a polynomial to intensities
- F. Watershed-segmentation
- G. Histogram equalization
- H. Registration using normalized mutual information
- I. Level sets-segmentation
- J. PCA-based point distribution model
- K. Dice-index
- L. Registration using external landmarks

**Task**

- 1. Improve contrast of image G
- 2. Detect the pectoral muscle from a mammography image D
- 3. Align CT- and MRI-images H
- 4. Segment abnormal lesions from MRI-images C
- 5. Remove intensity inhomogeneity from MRI-images E
- 6. Segment sub-cortical structures from MRI-images F
- 7. Remove noise from MRI-images A
- 8. Validate a segmentation method K
- 9. Measure if the shape of the heart is pathologic J
- 10. Align MRI- and SPECT-images L
- 11. Segment blood vessels from MRI-images I
- 12. Count cells from microscopic images B

2. The following image contains pixels from three different tissue types.

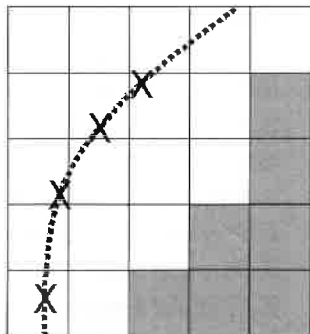
236	229	238	242	239
240	22	21	23	231
240	11	26	27	237
246	23	28	30	237
244	237	240	235	238

a) Segment the given image using K-means clustering. Use shaded pixels to initialize the K-means. (4 points)

b) For visualization purposes, use intensity windowing to enhance the contrast in the center part of the image. Use  $w_{min}=10$ ,  $w_{max}=40$ . The range of possible intensity values is  $[0,255]$  Calculate and give the new intensity values. (2 points)

3. You should calculate volumes for the gray matter, white matter and cerebrospinal fluid from brain MRI images. Describe the method for calculating the volumes when using the expectation maximization algorithm.

4. The following 5x5 image contains a border of two regions: white pixels belong to the object and grey pixels to the background. Define to which direction the contour (black dotted line) should be moved in rigid registration to minimise the energy computed using the distance map. Calculate the energy on the contour points indicated by the crosses. Use the gradient descent method to define the direction.



5. To which registration transformations and to which registration problems external landmarks (extrinsic markers) are useful? What should you consider when designing the markers and when imaging a patient knowing that such registration is needed?

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