Medical Imaging Lab 1: Algorithm evaluation

Master IN COMPUTER VISION AND ROBOTICS
Centre Universities Condorcet, Le Creusot, France, 04-April-2017

Aim and objective:

The homework is targeting several objectives including understanding segmentation, evaluation measure for segmentation and to understand the different ways to evaluate a result such as overlap measures and distance measures.

Step of doing homework:

Segmentation: Image segmentation in computer vision is the process of partitioning a digital image into multiple segments (sometimes known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Of Most of the time, segmented image is considered as a preprocessing step for main process (tracking, localization, classification and so on) in a long image processing chain. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. An example of segmented image (right) for a given image (left) is shown in Fig.1

Fig.1 example of segmented image (right) for a given image (left)

When we are using an algorithm not all the pixels are correctly labeled. For instance, as seen in Fig.1 the handle of couple has been distinguished and labeled as a separate object with different label while as we know, the couple and its handle are considered one object in reality. Therefore, these types of miss-classifying image pixels create certain amount of error comparing to ground-truth segmentation (we create ground-truth usually with hand). But there are four possibilities in general as shown in Fig.2. Suppose we have two objects in a given image (object 1=12pixels, object 2=10 pixels) and we are planning to label the pixels belongs to object 1 by using an algorithm. If the algorithm labels only 8 pixels as object 1 wile mistakenly takes 3 pixels from object 2 (false positive=FP), meaning 5 pixels are correctly label (true positive=TP). The 7 remaining pixels from object 1 which has been left aside are not correctly labeled (false negative=FN) and 7 remaining pixels of object 2 are correctly kept aside (true negative=TN). Then the precision, specificity and sensitivity are defined as follows:

$$precision = \frac{TP}{TP + FP}$$

$$sensitivity = \frac{TP}{TP + FN}$$

$$specificity = \frac{TN}{TN + FP}$$

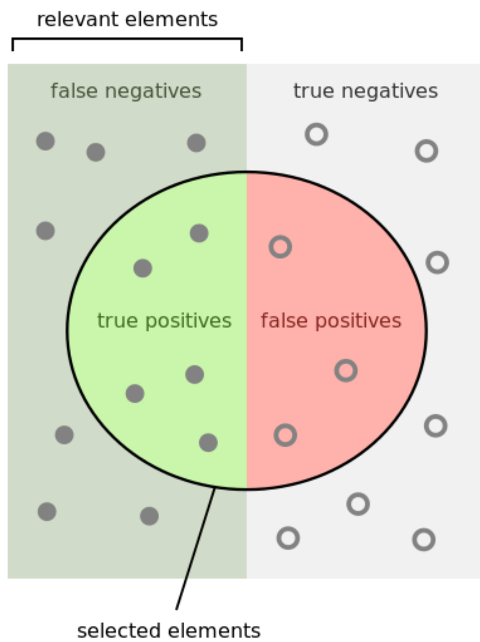

Fig.2 true and false positive concept

We will use above for concepts (TP, TN, FP, FN) and two definition (precision, sensitivity, specificity).

ROC: TP (sensitivity) can then be plotted against FP (1 – specificity) for each threshold used. The resulting graph is called a Receiver Operating Characteristic (ROC) curve (Figure 2). ROC curves were developed for use in signal detection in radar returns in the 1950's, and have since been applied to a wide range of problems. In our problem we will call this method segmentation algorithm evaluation in 2D.

Evaluation of segmentation algorithm in 2D:

If we open the mammogram images, which have been provided a long with homework and apply segmentation algorithm, automatically segmented image, and ground truth, its manual segmentation, and calculate the different they will be as shown in Fig.3.

Obtaining the ROC curve and the area under the curve for each segmentation algorithm:

To compute the ROC curve, we threshold the probability images at different levels the true positive rate against the false positive rate at each level is plotted. The Jaccard and Dice coefficients are measured at the best threshold (must be the same for all the images of an algorithm). Then the Hausdorff distance is computed at this threshold. The MATLAB code for plotting the ROC curves for each algorithm and calculating the evaluation measures; Jaccard, Dice and Hausdorff distances is given in the folder attached.

For plotting the ROC curves, sensitivity values and the false positive rates were calculated for 40 threshold values starting from 0.025 and going till 1 with a step size of 0.1. The ROC curve of all 6 algorithms at all thresholds can be plotted by running ‘Script.m’. Fig.4 shows the entire ROC curves for the 6 algorithm.

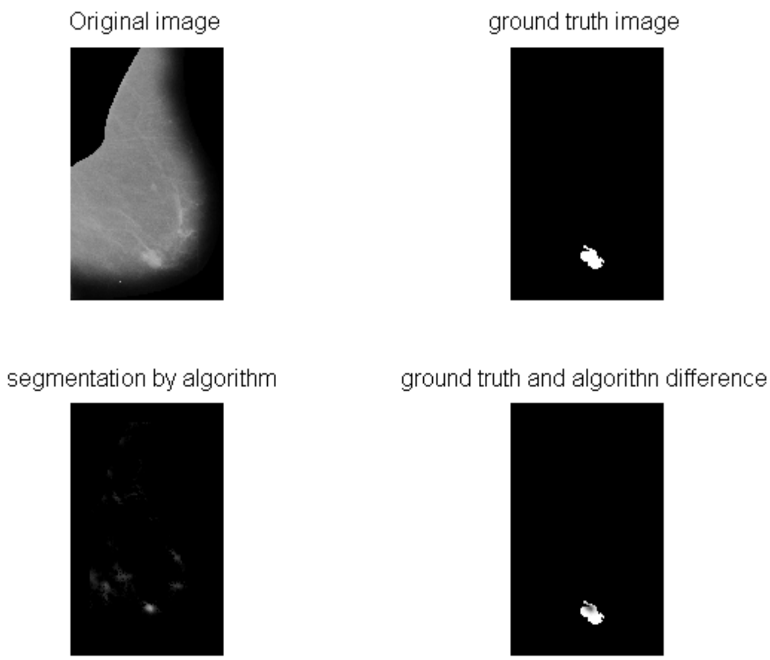

Fig.3 Different images used to study algorithm accuracy

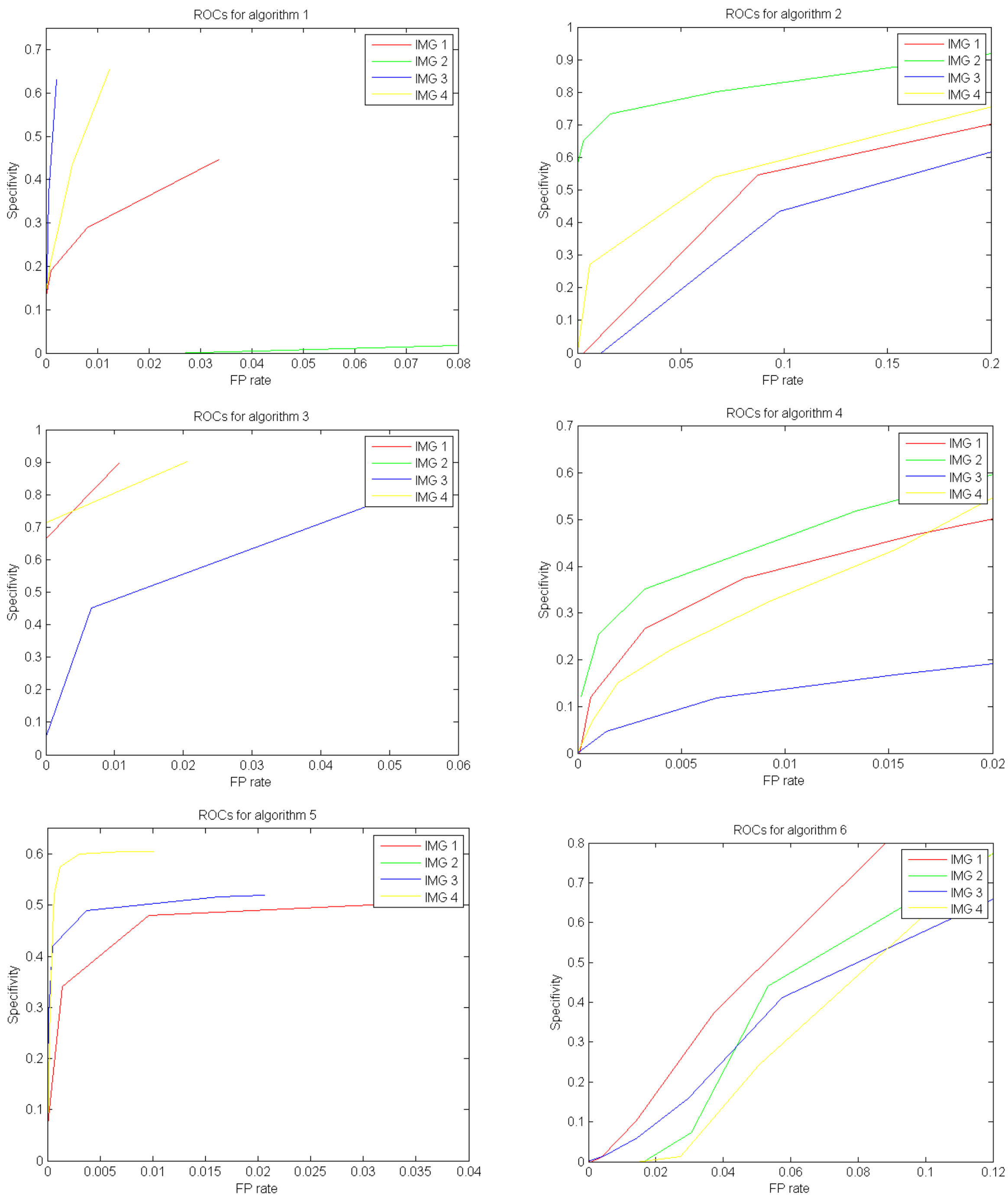

Fig.4 ROC curve associated with 6 different segmentation algorithms

The range of the parameter was kept as ROC curve but the step has changed to 0.025 and again ROC were plotted and saved in the repository and distances were calculated. To study the performance of all our Algorithms, Jaccard, Dice and Hausdorff distances were calculated for each Algorithm at the best threshold value. The optimal threshold value is chosen by just looking at the plots. A good value is the one which gives the maximum sensitivity value while keeping the false positive rate minimum.

	IMAGE 1	IMAGE 2	IMAGE 3	IMAGE 4
Algorithm 1 (at 2.5 %)	0.0869	0.0009	0.5714	0.3689
Algorithm 2 (at 27 %)	0.0253	0.012	0.0349	0.0353
Algorithm 3 (at 7.5%)	0.6749	0	0.3487	0.7108
Algorithm 4 (at 32.5 %)	0.1038	0.086	0.1024	0.2542
Algorithm 5 (at 20 %)	0.1707	0	0.3929	0.4043
Algorithm 6 (at 5 %)	0.0673	0.0271	0.0884	0.0938

Table 1: Jaccard Distances

	IMAGE 1	IMAGE 2	IMAGE 3	IMAGE 4
Algorithm 1 (at 2.5 %)	0.1598	0.0018	0.7272	0.539
Algorithm 2 (at 27 %)	0.0493	0.0238	0.0674	0.0682
Algorithm 3 (at 7.5%)	0.8059	0.0000	0.5170	0.8309
Algorithm 4 (at 32.5 %)	0.1881	0.1584	0.1857	0.4054
Algorithm 5 (at 20 %)	0.2916	0.000	0.5641	0.5758
Algorithm 6 (at 5 %)	0.126	0.0528	0.1625	0.1716

Table 2: Dice distances

	IMAGE 1	IMAGE 2	IMAGE 3	IMAGE 4
Algorithm 1 (at 2.5 %)	13.19	12.17	7.87	8.43
Algorithm 2 (at 27 %)	22.87	20.88	19.90	21.00
Algorithm 3 (at 7.5%)	4.47	7.68	11.27	6.40
Algorithm 4 (at 32.5 %)	12.92	12.92	14.87	9.90
Algorithm 5 (at 20 %)	9.64	10.10	10.15	6.63
Algorithm 6 (at 5 %)	6.93	8.72	11.75	9.27

Table 3: Hausdorff Distances

The function ‘coefficients.m’ returns the Jaccard and Dice coefficients and ‘hausdorf.m’ calculates the Haurdoff distances. the Jaccard distance (table 1), Dice distance (table 2) and Hausdorff distance (table 3) for all images for all 6 algorithms at selected threshold values (percentages) with the step 0.025 is given for further comparison.