Similarity-Based Image Segmentation
Determination of Brain/Liquor Ratio by Alzheimer Dementia

Petra Perner

Institut für Bildverarbeitung und angewandte Informatik e.V.
Arno-Nitzsche-Str. 45, 04277 Leipzig
Email: ibaiperner@aol.com

Abstract. In the paper, we propose a similarity based image segmentation method, which takes the non-image information and the image characteristics and selects among a set of cases the case, which fits best to the current case. The segmentation parameters associated to the close case are applied to the segmentation unit and taken for segmentation of the current case. By taking into account the non-image and image information we break down our complex solution space to a subspace of relevant cases where the variation among the cases is limited. We use our approach for determination of brain/liquor ratio in CT-images. This parameter is used for diagnosis of Alzheimer disease.

Keywords: Image Segmentation, CT Image Analysis, Similarity-Based Image Segmentation, Alzheimer Demenz

1 Introduction

The complexity of the brain CT-scans is due to partial volume effects, which disturb the edges and produce contrast degradation by spatial averaging, and to the typical problems such as patient movements, beam hardening, and reconstruction artefacts. These image characteristics are responsible for the over- and undersegemented results observed when unsupervised segmentation is applied.

There are several methods for segmenting x-ray CT images recently reported in the literature: template matching [1], region oriented segmentation[2], knowledge based labeling [3], and edge-based segmentation and labeling[4].

In the paper, we propose a similarity based segmentation method, which takes the non-image information and the image characteristics and selects among a large set of cases the case, which fits best to the current case. The segmentation parameters associated to the close case are applied to the segmentation unit and taken for segmentation of the current case. By taking into account the non-image and image information we break down our complex solution space to a subspace of relevant cases where the variation among the cases is limited. We use the proposed method for labeling brain and liquor areas in CT slices. Based on this we calculate brain/liquor ration which is a parameter to determine the degree of degenerative brain disease [5].

2 The overall architecture

An overview about the architecture of the segmentation unit shows Figure 1.
A new image, which has been taken by a CT image acquisition unit, should be segmented and labeled for further calculation of brain/liquor ratio. In the following we will understand for segmentation: the definition of regions based on constant local image features, and for labeling: the classification of regions into the object classes: brain and liquor.

In the case base, there are stored formerly processed cases by their original CT images and their non-image information. The task is now to find the best segmentation for the current image by looking up the case base for similar cases. Similarity determination should be done in two phases: first it is asked for cases having similar non-image information and second among the resulting subset of close cases it is asked for the case having an image with similar image characteristics like the current case. Since also in the second step more than one case could be selected the evaluation unit will take the case with the highest similarity score. In case there are two or more cases with the same similarity score the first appeared case will be taken. After the closest case has been chosen, the image segmentation parameter associated with the selected case will be given to the image segmentation unit and the current image will be segmented.

In a further step, the area for brain and liquor will be calculated in the 2D image and after all slices for one medical treatment have been processed, the volume of brain and liquor will be calculated based on these information. The resulting brain/liquor ratio makes up the final result for the diagnosis of degenerative brain diseases and for the control of the progress of the disease [5].

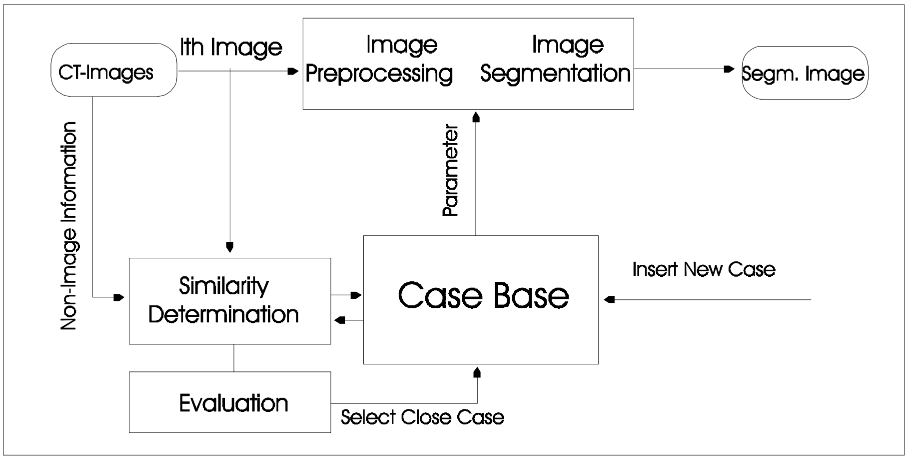

Fig. 1 Overall Architecture of Similarity Based Image Segmentation Unit

3 Case Structure and Case Base

A case consists of: the non-image information, the CT images itself, and segmentation parameter (see Sect. 4). The non-image informations are: a) Measurement parameters like e.g. slice thickness, b) Patent Specific Parameter (Age, Sex ...), c) Parameter and Information about the image processing of the acquired image done with CT-scanner, and d) slice number.

4 Segmentation Algorithm

The gray level histogram is calculated from the original image. This histogram is smoothed by some numerical functions and heuristic rules[6][7][8] to find the cut-points for the liquor and brain gray level area. The parameters of the function and rules are stored with the cases and given to the segmentation unit if the associated case is selected.

The following steps are performed: The histogram is smoothed by a numerical function. There are two parameter to select, the complexity of the interpolation function and the interpolation width. Then the histogram is segmented into intervals such that each begins with a valley, contains a peak and ends with a valley. The peak to shoulder ratio of each interval is tested first: An interval is merged with the neighbor sharing the higher of its two shoulders if the ratio of peak height to the height of it's higher shoulder, is greater than or equal to a threshold. Finally, the number of the remaining intervals is compared to a predefined number of intervals. If more than this have survived, the intervals with the highest peaks are selected. The number of intervals depends on the number of classes the image should be segmented. The cutpoints are calculated and then applied to the image. Fig. 2 shows a histogram for an original image and also the histogram after it was processed by the algorithm. The original image and the resulting labeled images are shown in Fig. 3.

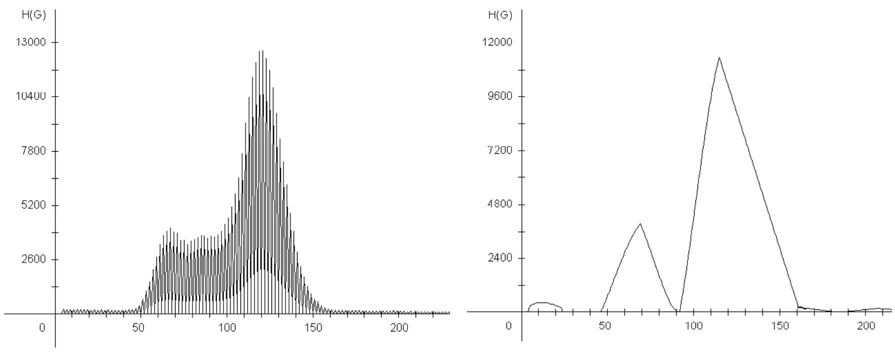

Fig. 2 Histogram of a CT-Image and refined Histogram

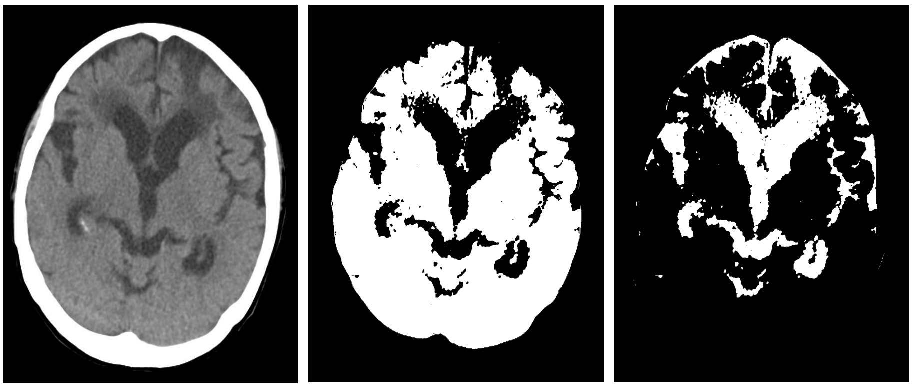

Fig. 3 Original Image, Labeled Images for Brain, and Labeled Image for Liquor

5 Similarity Determination

5.1 Similarity Measure for Non-Image Information

We use Tversky´s similarity measure for the non-image information [9]. The similarity between a Case C_i and a new case *b* presented to the system is:

$$S(C_i, b) = \frac{|C_i|}{\alpha|A| + \beta|D| + \gamma|M|} \qquad (1)$$

$$\alpha = 1, \beta, \gamma = \frac{1}{2}$$

where $|C_i|$ is the set of attributes in case C_i, A is the set of corresponding attributes in case C_i and *b*, *D* is the set of attributes having different values, and M is the set of attributes having missing values.

5.2 Similarity Measure for Image Information

Determination of similarity is done with an algorithm proposed by Zamperoni et. al [10]. The input to the algorithm are the two images that should be compared. According to the specified distance function the proximity matrix is calculated for one pixel at position r,s in image *A* to the pixel at the same position in image *B* and to surrounding pixel within the window size. The same is done for the pixel at position r,s in image *B*. Then, clustering is performed based on that matrix in order to get the minimum distance among the compared pixel. Afterwards, the average of both values is calculated. This repeats until all pixels of both images are processed. Then from the average minimal pixel distance the distance value for the whole image is calculated and this value is given to the output.

6 Results

The evaluation of our approach showed that similarity measure for comparing images and non-image information worked very well. The selected parameters for segmentation give good result for similar cases. A comparison of the automatic labeling to human labeling showed that the system is much more accurate. It is hard for a human to label all the small areas in an image.

7 Conclusion

We have presented a concept for a similarity based image segmentation. The system performs image segmentation by looking up a case base for similar formerly processed images and takes the segmentation parameters associated to the similar image in order to do segmentation of the current image. The results show the feasibility of the approach and that the results are better than human labeling. Further work will be done to compare it to other methods. The described architecture doesn't include evaluation of segmentation, updating of case base and case learning. This is left for further work.

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