Multi-criteria seeded region growing for multi-contrast MRI

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Purpose of the study

In many application fields and especially in medical imaging, the segmentation of an object or organ requires to take into account a great number of criteria of several types: morphological, statistical, geometrical... Considering the attributes extraction step solved, the underlying question is that of the adaptation of standard segmentation algorithms acting on gray-scale images to multi-valued images or vectorial images. In this abstract, we propose to solve this question with the seeded region growing algorithm (*SRG*). The procedure we proposed is called multi-criteria seeded region growing (*MSRG*); it is illustrated and discussed on several examples. This algorithm is especially adapted for MRI due to the large number of different weighted images that can be acquired from the same location. The MSRG has been developed as an ITK filter and added to the free DICOM viewer, OsiriX[1] allowing everybody to test and evaluate the new possibilities of the MSRG.

Multi-criteria seeded region growing algorithm

The seeded region growing technique was presented by Adams and Bischof [2]. Basically, seeds being imposed in the image neighboring points are progressively added to the seeds, beginning by the points of lowest priority. The priority is defined by a distance function. In [2] the distance of a pixel to an adjacent region is defined by:

$$\delta(x, R_k) = |I(x) - mean_{y \in R_k}(I(y))|$$

where $I(x)$ is the image I value in x and R_k the region number or label k. The derived segmentation is naturally dependent on the choice of the distance. We propose to change the distance to allow the evolution in a multi valued image to easily integrate additional information (new criterion). We have demonstrated that if we made the hypothetisis that anatomical region are globally homogeneous we find the Mahalanobis distance:

$$[x - m_X]^T \Sigma_X^{-1} [x - m_X]$$

This term represents the distance of vector x (current point) to the mean m_X and covariance matrix $\sum_X$ of region X. We compute this distance for each region to find the point with the smallest distance. Using this distance our SRG grow on multi-criteria as we could have with MRI T1 and T2. This algorithm allows new perspective by doing segmentation with multiple acquisitions instead of working with only one, as we usually do.

OsiriX integration and results

We have developed the MSRG in ITK allowing other groups to use the algorithm in their own software. We also propose a free full testing environment based on OsiriX. We have created all the necessary tools (plain ROI, brush palette, …), needed to use the MSRG.

- Example with 3 criteria (R, G, B image), segmentation of the visible woman eye from the ITK website.
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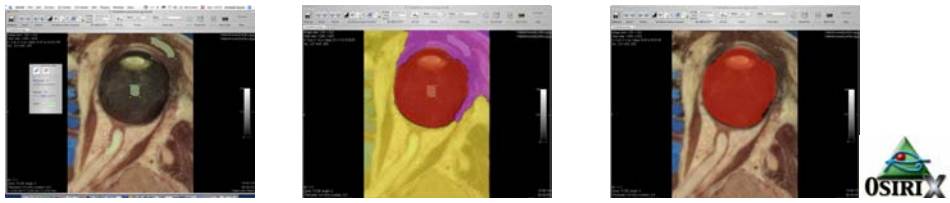
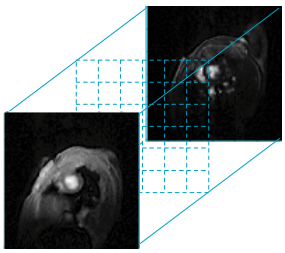


Figure 1: Inside OsiriX, the user initializes the original seeds with the brush palette, and then starts the MSRG.

- Heart segmentation based on 2 cine MRI acquired with different flip angles (10° and 30°).



The endocardium is delineated easily with only two markers (one inside, and one outside). For the epicardium we have to add more markers, one marker in each connected region.

Conclusion

In this abstract we have presented the multi-criteria seeded region growing algorithm. The seeds growing procedure is governed by the Mahalanobis distance; it allows to work on vectorial (or multi-valued) images. The segmentation paradigm consists in selecting criteria (MR T1,T2, texture, color, gradient, …) which will favor the growing process of the region. Working on multi-valued images offers interesting perspectives in image segmentation, and especially in medical applications using MRI due to the large numbers of contrasts that could be generated. The algorithm is available in OsiriX for testing.

[1], A. Rosset, and all (2004). "OsiriX: an open-source software for navigating in multidimensional DICOM images" Digit Imaging Sep;17(3):205-16
[2], R. Adams, and L. Bischof (1994). "Seeded region growing" Pattern Analysis and Machine Intelligence, IEEE Transactions on **16**(6): 641-647.
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