Multiregion Image Segmentation by Graph Cuts for Brain Tumour Segmentation

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Abstract. Multiregion graph cut image partitioning via kernel mapping is used to segment any type of the image data.The piecewise constant model of the graph cut formulation becomes applicable when the image data is transformed by a kernel function. The objective function contains an original data term to evaluate the deviation of the transformed data within each segmentation region, from the piecewise constant model, and a smoothness boundary preserving regularization term. Using a common kernel function, energy minimization typically consists of iterating image partitioning by graph cut iterations and evaluations of region parameters via fixed point computation.The method results in good segmentations and runs faster the graph cut methods. The segmentation from MRI data is an important but time consuming task performed manually by medical ex- perts. The segmentation of MRI image is challenging due to the high diversity in appearance of tissue among thepatient.A semi-automatic interactive brain segmentation system with the ability to adjust operator control is achieved in this method.

Keywords: Kernel function, Graph cuts, Image segmentation, Brain tumour.

1 Introduction

Image segmentation is refers to the process of partitioning a digital image into multiple. Energy minimization formulations can be divided into two categories: continuous and discrete. Continuous formulations, which seek a partition of the image domain by active curves via a level set representation, have segmented accurately a variety of difficult images. Discrete formulations use objective functions which contain terms similar to those in continuous formulations, generally a data term which measures the conformity of segmentation to the image data, and a regularization term. Image segmentation occurs in many important applications[1]. Energy minimization formulations have led to flexible, transparent, and effective algorithms. The piecewise constant data term model, and it's Gaussian generalization, have been intensively used in the context of unsupervised graph cut methods because user intervention is not required and especially, the data term can be written in the form required by the graph cut algorithm. Minimization by graph cuts of objective functional with a piecewise constant data term produce nearly global optima and less sensitive to

V.V. Das and J. Stephen (Eds.): CNC 2012, LNICST 108, pp. 329–332, 2012.

initialization[3]. Several interactive graph cut methods have used models more general than the Gaussian by adding a process to learn the region parameters at any step of the graph cut segmentation process.

2 Graph Cut Segmentation

Discrete formulations view images as discrete functions over a positional array. Combinatorial optimization methods use graph cut algorithms as an efficient method. Very fast methods have been implemented for image segmentation motion and stereo segmentation and region is a group of connected pixels with similar properties. Graph cut is a partition of the vertices in the graph. The graph cut algorithm assigns each pixel as a grey level label in the set of all possible labels. Graph cut objective functional typically contain a data term to measure the conformity of the image data and it can minimizes an energy functionof data term[2,4].

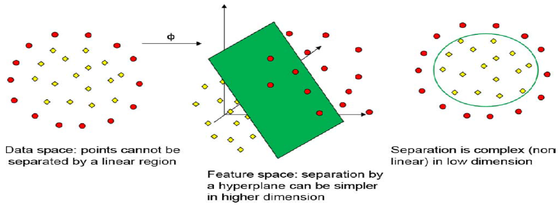

Fig. 1. Illustration of Nonlinear 3-D Data Separation with Mapping.Data is Nonlinearly Separable in the Data Space. The Data Is Mapped To A Higher Dimensional Feature (Kernel) Space So As To Have A Better Separability

Using a common kernel function, the minimization is carried out by iterations of two consecutive steps: 1) Minimization with respect to the image segmentation by graph cuts and 2) Minimization with respect to the regions parameters via fixed point computation.

3 Segmentation in the Kernel Induced Space

The use of kernel functions is to transform image data rather than seeking accurate (complex) image models and addressing a non linear problem. Using the Mercer's theorem, the dot product in the feature space suffices to write the kernel-induced data term as a function of the image, the regions parameters, and a kernel function.

3.1 Proposed Functional

Graph cut methods states image segmentation as a label assignment problem. A data term to measure the conformity of image data within the segmentation regions to a stastical model and a regularization term (the prior) for smooth regions boundaries.

The kernel trick consists of using a linear classifier to solve a nonlinear problem by mapping the original nonlinear data into a higher dimensional space. Following the Mercer's theorem,this states that any continuous, symmetric, positive semi definite kernel function can be expressed as a dot product in a high-dimensional space[5].

3.2 Optimization

Function is minimized with an iterative two-step optimization strategy .Using a common kernel function, the first step consists of the fixing the labeling (or the image partition) and the second step consists of finding the labelling of the image. The algorithm iterates these two steps until convergence. The algorithm is guaranteed to converge at least to a local minimum. The steps are:

1) Update of the Region Parameters
2) Update of the Partition with Graph Cut Optimization

Let g =(v,e) be a weighted graph, where v is the set of vertices (nodes) and e the set of edges, it contains a node for each pixel in the image and two additional nodes called terminals. Commonly, one is called source and the other is called sink.The minimum cut problem consists of finding the cut, in a given graph, with the lowest cost. The graph weights need to be set dynamically when ever region parameters and pair of labels changes.

4 Results

The kernel method is used for segmenting various types of images. Inthis paper thegraph cut method is tested over medicalimages.

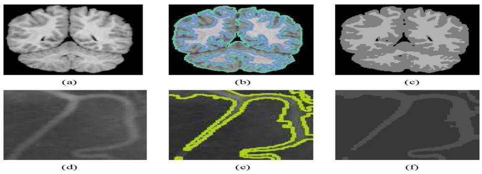

Fig. 2. Brain and vessel images.(a), (d)original images.(b),(e)segmentations at convergence. (c), (f) final labels

The brain image, shown in Fig. 2(a), was segmented into three regions. In this case, the choice of the number of regions is based upon prior medical knowledge. Segmentation at convergence and final labels are displayed as in previous examples. Fig. 2(d) depicts a spot of very narrow human vessels with very small contrast within some regions. These results with gray level images show that the proposed method is flexible. Detection of anatomical brain tumours plays an important role in the planning and analysis of various treatments including radiation therapy and surgery.

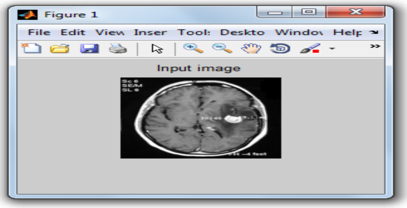

Fig. 3. Input Image

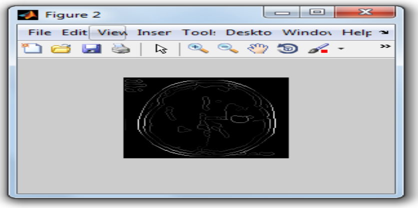

Fig. 4. Labelled Image

Fig. 5. Edge Detection

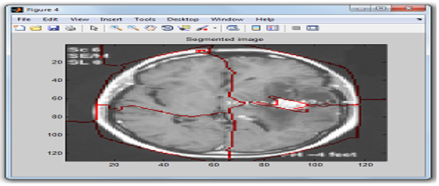

Fig. 6. Segmentation Boundary at Convergance

Thus by using MATLAB SOFTWARE and utilities segmentation and detection of biological images can be made. This work presents a computationally efficient method designed for a segmentation of images with varied complexities.

5 Conclusion

The multiregion graph cut image segmentation in a kernel-induced space method consists of minimizing a functional containing an original data term which references the image data transformed in a kernel function. The optimization algorithm iterated two consecutive steps: graph cut optimization and fixed point iterations for updating the regions parameters. The flexibility and effectiveness of the method were tested over medical and natural images.A flexible and effective alternative to complex modelling of image data. Performance can be improved for specific applications.

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