

Automation of Segmentation of MRI Images in the Presence of Intensity Inhomogeneity by the Application of Probabilistic Neural Network

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Abstract

This paper presents a different approach by employing probabilistic neural network (PNN) with level set method for segmentation of intensity inhomogeneous magnetic resonance images (MRI). The input image is classified by PNN, and initialise the image with initial zero level set contours. A cascade approach is used in which after processing image by PNN, the output of PNN is fed into Level Set Method (LSM) Algorithm. The LSM is used to perform the segmentation and to estimate bias field.

Keywords: Probabilistic Neural Network; Level Set; MR Image; Bias correction; Intensity Inhomogeneity; Segmentation.

1. Introduction

The role of image segmentation is vital in the field of image analysis, and pattern identification. Segmentation of Magnetic resonance imaging (MRI) is crucial for medical examination and diagnosis of disease. MR images often suffer from Intensity inhomogeneity due to which segmentation becomes a tedious task as the intensity overlaps in the regions of interest. In general, segmentation of intensity inhomogeneous image is challenging. Initialization of zero level contours is also major factor that affects segmentation process and makes it a challenging task. Various Level set method and there variants are proposed previously [1][2]. But there is some scarcity in the previous methods. If the initial evolution contour is too large or too small, it will cause the convergence of evolution curve to the contour of object incorrectly and also raise the iteration time to a great extent [3].

In this paper Probabilistic neural network is employed for the classification of input image and initialization of zero level contours for the image which is followed by segmentation by using level set method for contour evolution.

1.1 Methods

Probabilistic Neural Network

The Probabilistic Neural Network which was developed by Specht[4] is a multi-layer feed forward network in which operations are organised into 4 layers: Input layer, two hidden layers known as Pattern & Summation layer and one Output layer. The architecture of a Probabilistic Neural Network is illustrated in figure 1. Typically in PNN, there is a pattern unit corresponds to a training sample, i.e. pattern neurons in numbers are equal to training samples. The output of every pattern neuron belong to same category are fed into single summation unit.

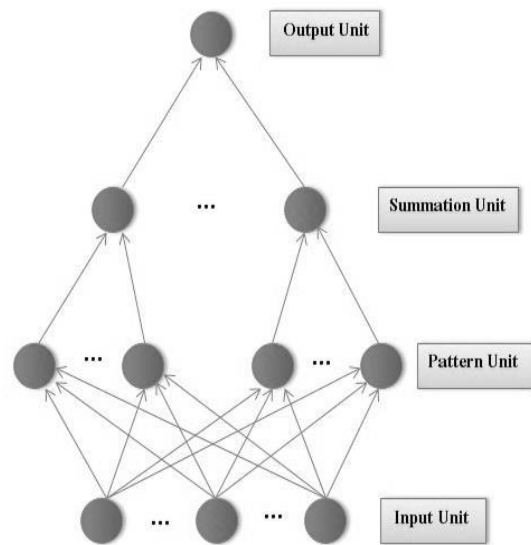


Figure 1. Architecture of Probabilistic Neural Network

In PNN, classification decision is given by-

$$h_j c_j f_j(x) = h_i c_i f_i(x), \text{ all } j \neq i$$

which follows Bayes optimal decision rules.

Where,

h_i , is prior probability of an unknown,

c_i , is cost of misclassification or incorrectly classify an unknown and

f_i , is probability density function (PDF) for each known population.

1.2 Level Set Method

Osher and Sethian in [5] invented level set method to hold the topology changes of curves. A simple representation is that when a surface intersects with the zero plane to give the curve when this surface changes, and the curve changes as the surface changes. The spirit of the level set method is the implicit representation of the interface. A novel method is proposed by Chunming Li [6] for the segmentation of MR images, which is clever to deal with Intensity Inhomogeneous image. A variational level set formulation is proposed [7] for joint segmentation and bias field estimation which is defined by

$$F(\phi, c, b) = \varepsilon(\phi, c, b) + \nu L(\phi) + \mu R_p(\phi)$$

where $L(\phi)$ and $R_p(\phi)$ being the regularization terms as defined below.

The energy term $L(\phi)$ is used to smoothen the contour by computing the arc length of zero level contour of ϕ and by penalizing it.

$L(\phi)$ is defined by

$$L(\phi) = \int |\nabla H(\phi)| dx$$

The energy term $R_p(\phi)$ is defined by

$$R_p(\phi) = \int p(|\nabla \phi|) dx$$

with a potential (energy density) function $p: [0, \infty) \rightarrow \mathbb{R}$ such that $p(s) \geq p(1)$ for all s , i.e. $s = 1$ is a minimum point of p .

We can obtain the segmentation result given by the level set function ϕ and the estimation of the bias field b by minimizing the total energy $F(\phi, c, b)$.

1.3 Proposed Methodology

We propose a cascade approach by employing PNN as classifier to classify the input MR image. Training data helps to estimate the probability density function (PDF) of

different class of inputs. Based on the classification results, an initial contour is extracted that will act as the initial zero level contour for the level set evolution. After that Chunming Li algorithm [6] of level set method for segmentation in the presence of Intensity Inhomogeneity are used for actual segmentation and bias field estimation of MRI. The flow of proposed operation is shown in figure 2.

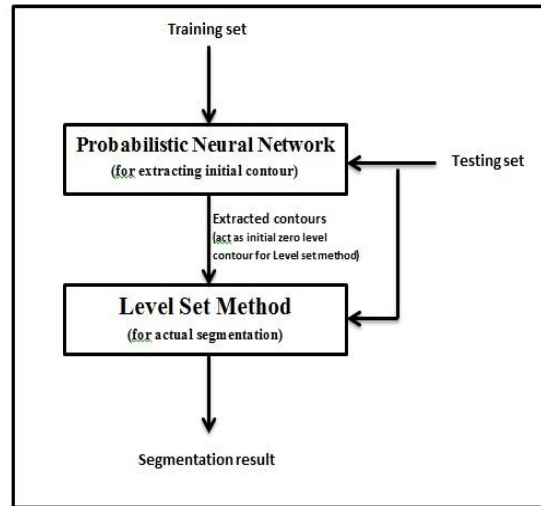


Figure 2. Proposed Operation Flow

3. Experimental Results

Figure 3(a) shows original MR Image of Brain that suffers from Intensity Inhomogeneity. PNN process the original image and find the initial contour. Extracted initial contour is shown in figure 3(b). A variational level set Method is applied for curve evolution which perform the actual segmentation shown in figure 3(f) and gives a bias corrected image shown in figure 3(e) by estimating bias field shown in figure 3(d).

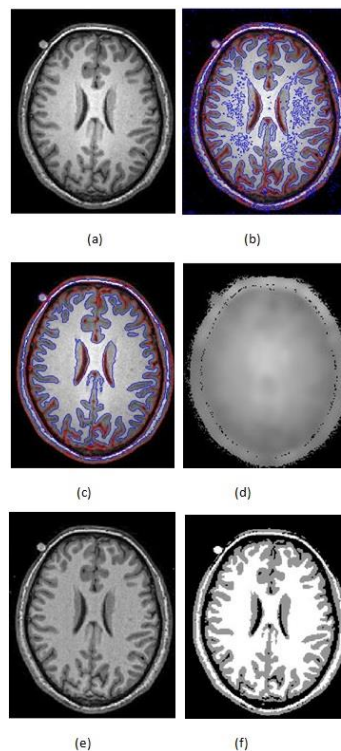


Figure 3. Segmentation of MR Image, (a) Original Image, (b) Extracted Initial Contour, (c) Curve Evolution, (d) Estimated Bias Field, (e) Bias Corrected Image, (f) Segmented Image

I. Conclusions

In this paper a cascade approach is proposed for the segmentation of MRI which is suffering from Intensity Inhomogeneity. The experimental results shows that the proposed approach work well with good results. PNN correctly classify the input image and extract contour and segmentation algorithm correctly estimate the bias field and perform segmentation. As an application, our method has been applied for the segmentation of all MRI and images suffering from Intensity Inhomogeneity.

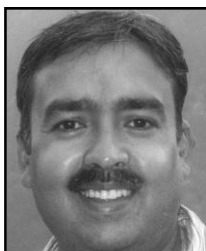
References

- [1] J. S. Suri, K. Liu, S. Singh, et al, "Shape recovery algorithms using level sets in 2-D/3-D medical imagery: a state-of-the-art review", IEEE Transaction on Information Technology in Biomedicine, vol.6, (2002), pp.8-28.
- [2] N. Paragios, "A level set approach for shape-driven segmentation and tracking of left ventricle", IEEE Transaction on Medical Image, vol.22, no.6, (2003), pp.773-776.
- [3] C. Z. Huang, B. Yan, H. Jiang, et al, "MR Image Segmentation Based On Fuzzy C-means Clustering and The Level Set Method", International Conference on Fuzzy System and Knowledge Discovery, vol.1, (2008), pp.67-71.
- [4] D. F. Specht, "A General Regression Neural Network", IEEE Transactions on Neural Networks, vol.2, (1991), pp.568-576.
- [5] S. Osher and J. A. Sethian, "Fronts propagating with curvature dependent speed: algorithm's based on the Hamilton-Jacobi formulation", Journal of Computational Physics, (1988), pp.12-49.
- [6] C. Li, R. Huang, Z. Ding, C. Gatenby, D. N. Metaxas and J. C. Gore, "A Level Set Method for Image Segmentation in the Presence of Intensity inhomogeneity with Application to MRI", IEEE Transactions on Image Processing, vol.20, no.7, (2011), pp.2007-2016.
- [7] C. Li, R. Huang, Z. Ding, C. Gatenby, D. Metaxas and J. Gore, "A variational level set approach to segmentation and bias correction of medical images with intensity inhomogeneity", in Proc. Med. Image Comput. Comput. Aided Intervention, (2008).

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