Chapter 22
Intensity-Based Classification and Related Methods in Brain MR Images

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ABSTRACT

Today, medical image processing and analysis are highly active research fields boosted by rapid technical developments in medical imaging field. This chapter describes common procedures such as thresholding methods and clustering algorithms (both non-hierarchical and hierarchical approaches) used for digital image processing, with specific reference to brain magnetic resonance images. These techniques represent starting points for other sophisticated methods such as segmentation and classification. The results, which are an outcome of these methods, are used for classification of neurodegenerative diseases such as Alzheimer, Pick's, Huntington's or cerebral calcinosis. A number of applications together with the code listing are provided with the aim to make the subject accessible and practical. The MATLAB software will help the readers to identify and choose the best solution for a particular problem.

INTRODUCTION

Images contain plenty of objects and patterns that are actually embedded with valuable information essential for medicine, biology, photo or video areas. In image analysis, inputs are images and outputs are measured data or information extracted from those images. The final goal of image analysis is to take action or to make sense of gathered data through recognized or classified objects (or classes or attributes).

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Basically, segmentation means to separate an image into regions by finding contours that correspond to objects embedded in the image. These regions are segmented either based on some common features or on differences between edges at objects' boundaries. One of the most difficult tasks in image processing is the fully automatic segmentation. The quality of segmentation will guarantee the accuracy of objects recognition, feature extraction or classification.

The main goal of this chapter is to provide advanced methods and algorithms in the area of intensity-based image segmentation and classification. In this context, thresholding methods based on histogram and binarization techniques are presented. *K*-means, *c*-means clustering and dendrograms as hierarchical methods for classification and their applications mainly for medical image segmentation are also discussed. In order to explain some concepts in image processing and analysis, two threshold methods are presented. One is based on adaptive thresholding and global binarization and the other is based on dendrograms. They are the starting point for the classification process based on clustering analysis. The cluster validity and classification accuracy are evaluated by using the Euclidean distance as a similarity measure between clusters.

Thresholding is an important approach in image segmentation. Some binarization methods for segmentation, via thresholds, based on the distribution of pixel properties such as intensity values, are presented. Also, cluster technique as another way of determining the optimal threshold is discussed. Optimal threshold for classification allows differentiating classes of objects between them.

Classification assigns particular objects to the existing groups of objects into image. These groups were obtained through clustering operations. In this context, clustering can be interpreted as a form of classification. Generally, classification techniques include supervised and unsupervised classification. Unsupervised classification provides outcomes based on the software analysis without any human implication. It allows an objective classification but it takes no advantage of previous information known to the user. Unlabeled objects are assigned to a group or cluster by using a model developed based on *a priori* knowledge on the relevant characteristics of the objects that already belong to that group. In supervised classification, the user can select certain features or qualitative descriptors that are representative for objects in order to build the training sets for classification. Also, the user can impose the number of clusters or groups for classification. Hierarchical clustering is one of the most common unsupervised classification methods. Its graphical representation is a dendrogram or a tree structure. Various supervised classification algorithms such as naïve Bayes derived from Bayesian classifiers, C4.5 derived from classification tree, K-nearest neighbors, multilayer perceptron, neural networks or logistic regression have found many application in medical imaging.

The evaluation of cluster validity and classification accuracy is done by two approaches. The first technique assesses the extent to which a cluster contains objects belonging of a single class. The second approach uses the Euclidean distance to measure the distance between clusters as a similarity measure between clusters.

In this study, 2D MRI images that belong to the Harvard Medical School database are used. They are freely available at http://www.med.harvard.edu/AANLIB/home.html. For comparison purposes, the same test image is used across this work. MATLAB programming language is used to demonstrate some practical image processing techniques. The operations have been implemented using the Wavelets and Image Processing tools for MATLAB R2014a software. Some examples of code listing of MATLAB algorithms for image manipulation are presented.

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