Chapter 4

Significant Enhancement of Segmentation Efficiency of Retinal Images Using Texture-Based Gabor Filter Approach Followed by Optimization Algorithm

Upendra Kumar
Dr. A. P. J. Abdul Kalam Technical University, India

ABSTRACT

Considering Retinal image as textured image, its texture based segmentation is required to identify the presence of retinal diseases. This pre-processing is important in automatic detection system for recognizing the abnormality present in the retinal images. Likewise, the proposed system mainly focused on diabetic retinopathy disease caused into eye–retina, generally leads to eye-blindness. Inspired from robust human’s texture based segmentation capability, a mathematical model of the eye was formulated. A texture based Gabor filter was applied to get the output feature helping in detecting the abnormality and deriving statistical properties, further used in segmentation and classification. This work deals with the better separation of various clusters of Gabor filter output features, in order to get better segmentation efficiency. This was also followed by formalizing an objective function to tune filter parameters with Gradient descent and further Genetic Algorithm. This paper showed both qualitative and quantitative segmentation results with improved efficiency.

INTRODUCTION

Segmentation is an important step which is required in many image processing applications to extract useful information. In medical imaging field, segmentation is required to identify the disease embedded in particular organ, e.g. it helps in early diagnosis of diseases like glaucoma, diabetic retinopathy and...
macular degeneration by segmenting retinal images (Sinthanayothin et al., 2002; Ahmed et al., 2008; Dey et al., 2012). Glaucoma is one of the most common diseases and if it is not early detected, may have serious cost, can even lead to eye blindness. Most of the existing detection and assessment methods of diabetic retinopathy are manual, costly affair and also require trained ophthalmologists (Teng et al., 2002; Olson et al., 2003).

Morphological feature of retinal blood vessel may be utilized as a vital sign for various retinal diseases such as diabetes, arteriosclerosis and hypertension. The geometrical changes in veins and arteries of the retinal images can be measured and applied to a variety of clinical studies to develop automatic diagnostic system for early detection of diseases (Palomera-Perez et al., 2010). Segmentation of retinal blood vessels suffers from two kinds of problems, one is the presence of a wide variety of vessel widths and the other is heterogeneous retinal background (Hol & Pail, 2011). Many research works on segmentation of retinal images were done by various researchers and shown its importance in medical diagnosis system (Huang et al., 2006). Huang et al. applied maximal entropy thresholding to segment out the retinal blood vessels and got moderate results. They have not shown any quantitative results for comparative study with this paper work. Medhane and Shukla (2016) worked on automated approach for artery–vein classification by analyzing graphical vasculature tree and also intensity based features extracted from DRIVE retinal image database. Osareh and Shadgar (2010) worked on segmentation of retinal images to classify the retinal pixels as vascular and non-vascular. They applied various machine learning algorithms as classifiers to obtain moderate segmentation and classification results. The study done by Lili and Shuqian (2010) showed that morphological changes occurred in retinal images towards blood vessels are important indicators for diseases like hypertension, diabetes and glaucoma and concluded that the accurate segmentation of blood vessel has significant diagnostic value for the purpose of implementation of diagnosis system. The proposed model was applied and tested on DRIVE database (used in this work also), and showed average sensitivity as 77% while the average accuracy as 93.2%. Zhen et al. (2014) worked on automatically identifying retinal vessels from fundus images using multiscale directional contrast quantification (MDCQ) strategy and obtained moderate segmentation results on various retinal image databases.

The analysis of retinal image based on computer-aided techniques, plays a key role in diagnostic procedures. However, automatic retinal segmentation process suffers from various drawbacks, i.e. the retinal images are often poorly contrasted, noisy and also the widths of retinal vessels may vary from very large scale to very small value. Therefore, in this work the images were preprocessed using adaptive thresholding and contrast enhancement techniques. Detection and assessment of blood vessels has been the area of research in medical imaging for the past few years. This work includes some algorithms that usually use some kind of vessel enhancement before applying segmentation techniques. The current methods producing high accuracy for retinal image with thick vessels requires high computational cost. The use of proposed methods in this work makes it possible to detect these vessels faster, while preserving a high accuracy.

This work proposed a texture based segmentation method inspired from texture based segmentation capabilities of human beings. Following this an attempt was made to formulate a mathematical model of the human beings’ eye, leading discovery of the band-pass filter-bank characteristics of the eye. The transfer function used by these filters is formulated by the Gabor elementary functions. The outputs produced by Gabor filters applied on differently textured images are significantly distinct for the differently textured regions. Utilizing the discontinuities present in the outputs of filters used and their statistical properties obtained from mathematical formulation help in segmentation and classification of a given