Chapter 1

Introduction

In recent years, the remarkable advances in medical imaging instruments have increased their use considerably for diagnostics as well as planning and follow-up of treatment. The concepts and techniques in medical image processing used to analyze and manipulate medical images after they have been generated or digitized.

Medical imaging is the process by which physicians evaluate an area of the subject's body that is not normally visible. Medical imaging may be "clinical", seeking to diagnose and examine disease in specific human patients. Alternatively, it may be research-motivated, attempting to understand processes in humans or animal models. Many of the techniques developed for medical imaging also have scientific and industrial applications.

In this thesis, medical image processing is used to identify the shape and the location of optic disk (OD) which is the brightest object in the healthy retinal image for helping medical doctor to diagnose the retinopathy of prematurity (ROP) disease and prevent the patient from blindness.

The developing of application software in digital image processing will help the clinicians to analyze the area surrounding the optic nerve which is predictive of the level of ROP. With the wide range and type of retinal images present a specific type of problem in the analysis of optic disk; many techniques have been purposed including detection of the OD regions by clustering the brightest pixels in retinal image and locating potential OD area. Other techniques have been recently proposed, based on a model of vascular structure by Foracchia *et al*. (2004). They use a geometrical parametric model locating at the center point of OD. Akita and Kuga (1982), trace the parent-child relationship between blood vessels segments, tracking back to the center of the optic disk. Lalonde *et al*. (2001) used pyramidal decomposition and Hausdorff-based template matching that is guided by scale tracking of large objects using multi-resolution image decomposition. This method is effective, but rather complex. In three dimensional reconstructions of conventional stereo optic disk image procedures, Kong *et al*. (2004) presented the resulting 3 dimensional contour images that show optic disk structure clearly and intuitively, helping physicians in understanding the stereo disk photograph. Cox and Wood (1991) presented a semi-automated method to indicate external points on the boundary which were automatically connected by tracing along the boundary. Morris and Cox (1993) initially presented a completely automatic method which traced between points on the boundary identified automatically by their grey level gradient properties. Sinthanayothin *et al*. (1999) used the rapid intensity variation between the dark vessels and the bright nerve fibers to locate the optic disk. However, they found that this algorithm often failed for fundus images with a large number of white lesions. Lee (1991) also applied an active contour model to high resolution images centered on the optic nerve head and his problem caused by the boundary of the pallor and by very faint or missing edges. Huiqi *et al*. (2001) used PCA and ASM technique to apply in detecting the optic disk centre and approximate the optic disk area by using “disk space” but this algorithm failed in unclear shape of optic disk. Kavitha (2005) used morphological operations and multilevel thresholding to extract the brighter regions that includes optic disk and exudates. Jelinek *et al*. (2005) used Canny edge detection, template matching and Haar transform to detect optic disk boundary. The most effective method, active contour model or snake, was used to detect the optic disk by Osareh *et al*. (2002), Mendels *et al*. (1999), Chanwimaluang and Fan (2003). Corona *et al*. (2002) used an algorithm, combining power cepstrum and zero-mean-normalized cross correlation techniques, which extract depth information using coarse-to-fine disparity between corresponding windows in a stereo pair. The gray level encoded sparse disparity matrix is subjected to a cubic B-spline operation to generate smooth representations of optic disk surface and new three-dimensional (3-D) matrics from isodisparity contours. Niemeijer *et al*. (2007) used a novel method that determines whether a macula centered retinal image is from the left or right eye and automatically detects the optic disk, the fovea and the vascular arch by inferring the location of a set of landmarks placed on these structures. Tobin *et al*. (2006) presented results for the automatic detection of the optic nerve using digital red-free fundus photography. The location of the optic disk is predicted by using a two-class, Bayesian classifier. Chrastek *et al*. (2004) presented methods for automated segmentation of the optic disk in the two imaging modalities, namely in images of scanning laser tomography in color image. These methods developed for each modality separately which link in the registration of two imaging modalities containing partly complementary information.

However, most of techniques mentioned above have been mainly focused on adult retinal images where the retina is well developed. In this thesis, we present the algorithms that automatically detect optic disk in retinopathy of prematurity(ROP), a disease cause of blindness in the infant. If appropriate treatment is given in the early stages of blindness can be prevented. The algorithm is evaluated against ROP infant database from Kingston University, UK, and Thammasat University, Thailand compared with ground truth image marked by ophthalmologist.

1.1 Motivation

The coming generation of babies, blinded with ROP, may not forgive the attitude that many ophthalmologists adopt to avoid the painstaking effort of ROP screening. The financial, social and emotional crisis of having a blind child cannot be avoided without a committed team effort, particularly by the ophthalmologist and the neonatologist from the very beginning of life. Optic disk segmentation is a necessary step in this structured analysis of ROP because the location of optic disk is essential in retinal image analysis to measure distance and identify other anatomical parts in retinal images. Pathology on or near the optic disk can have a more severe effect in vision. In the previous, identification of the optic disk from infant's retinal image was difficult due to several factors. The disk may be located in the different positions and low-contrast in the retinal image. Once the optic disk region was found, the intersecting blood vessels that converge in the middle of the disk created a heterogeneous section then the identification of OD was determined only by an expert human. That is a time-consuming, highly skilled task, susceptible to subjective variation and error. There is consequently a pressing need for reliable automated analysis of digitized fundus images. Later, most of techniques in optic disk detection were implemented but it worked pretty well in adult retinal image, a few techniques was used for infant's retinal image. Then this thesis provides purposed methods to help ophthalmologist in ROP screening that will reduce cost and time and prevent the children from losing of vision.

1.2 Objectives

According to the motivation, this research aims at the following objectives.

1. To detect the variable appearance of ODs in ROP infant's retinal images (intensity, color, contour definition, macula-centered and OD-centered images).
2. To present the purposed methods in locating the optic disk in low-contrast infant's retinal image
3. To help a medical doctor to evaluate the ROP disease in the earlier stage, that will help the childhood not lose their vision.
4. Have an efficiency and reliable result to identify and extract the optic disk.

1.3 Overview

This thesis contains six chapters. Chapter 1 gives an introduction of the research. It presents a survey on detecting the optic disk. The survey also focuses infant's retinal image. In addition, motivation, research objective and overview of thesis are included in this chapter. In Chapter 2, the background related to techniques, the characteristics of optic disk, ROP, system, materials and medical importance of optic disk detection are presented. Chapter 3 describes our purposed algorithm in Automatic Detection of Optic Disk from Fundus Images of ROP Infant Using 2D Circular Hough Transform. In this chapter, the method to detect the optic disk by using Circular Hough Transform, experimental verification, experimental results, conclusion and discussion are included. Chapter 4, the technique in Automatic Optic Disk Detection from Low Contrast Retinal Images of ROP Infant Using GVF Snake is presented. In this chapter, the method to extract optic disk by using PCA and GVF Snake, the framework, experimental verification, experimental results, conclusion and discussions are included. Chapter 5, Automatic Optic Disk Detection from Low Contrast Retinal Images of ROP Infant Using Mathematical Morphology is included, the method of mathematical morphology, experimental verification, experimental results, conclusion and discussion are purposed. A conclusion is given in the last chapter, Chapter 6, the last chapter includes the summary and the key contributions of the research. The recommendations for future study are also given.