CHAPTER 1

INTRODUCTION

Vision is the most advanced of our five senses and a significant portion of our brain is entirely devoted to visual processing. Hence eye related ailments have been studied widely over the past several decades. In the recent past, development of automatic screening systems for eye related pathologies have received considerable attention from the research community. A lot of commercial interests are also there in the classification of the fundus images of the human retina. There are certain features present in the normal physiology of the retina which have to be differentiated from abnormal pathology before attempting the detection of abnormalities. This research is aimed at developing an automatic system that detects and extracts the landmark features such as optic disc, macula and retinal vasculature from colour fundus images of the human retina.

Diabetic retinopathy (DR) is globally the primary cause of blindness not only because it has the highest incidence but it often remains undetected until severe vision loss occurs. It is manifested by changes in the retina along with microaneurysms, intraretinal microvascular abnormalities, venous bleeding and neovascularisations together with hemorrhages, exudates and retinal edema. The effectiveness of treatment for many eye related diseases lies in the early detection through regular screenings. But, screening a large number of patients is a significant problem faced by medical

practitioners in populous developing countries like India. Also there are large influences of human errors and subjectivity on the results of inspection by a human expert. This fact opens up the possibility of applying digital image processing techniques in ocular fundus images to facilitate and improve diagnosis in different ways. First, manual analysis by an expert can be improved by using image enhancement methods. Second, the problem of early detection of abnormalities like Diabetic Retinopathy, glaucoma and Macular degeneration may be resolved by a computer aided mass-screening approach. Third, image registration techniques can be used in order to compare images taken at different examinations quantitatively. This comparison is inevitable for monitoring of the disease and assessing the improvements due to treatment. Unfortunately, the presence of factors such as noise, non-uniform illumination and variety of defect types in retinal imagery make the automatic detection of features a challenging problem.

1.1 MOTIVATION

Colour fundus images of the human retina continue to be an important avenue for medical practitioners in general and ophthalmologists in particular to probe and monitor various diseases. Cardiovascular diseases are the leading causes of morbidity and mortality worldwide and narrowing of the retinal arterioles has long been recognized as an early feature of hypertensive retinopathy and has been suggested to predict cardiovascular diseases and mortality. Digital retinal images are widely used in the diagnosis and follow-up management of patients with eye disorders such as glaucoma, diabetic retinopathy (DR) and age-related macular degeneration (AMD). Automatic screening systems to probe for abnormalities in retinal images have been a long felt need in the healthcare community. But manual methods by an expert

ophthalmologist are still preferred since an automatic system versatile enough is not available yet.

According to WHO (World Health Organization), there will be 79 million people with diabetes by 2030, making India the highest in the world. India continues to be the "diabetes capital" of the world, and by 2030, nearly 9 per cent of the country's population is likely to be affected from the disease (World Diabetes Atlas , IDF 5th ed,2012). Up to 80% of patients with diabetes tend to develop DR over a 15 year period. Worldwide, DR is a leading cause of blindness today. DR is also the most frequent microvascular complication of diabetes. The eye is one of the first places where microvascular damage becomes apparent. Though diabetes is still incurable, treatments exist for DR, using laser surgery and glucose control routines. But early detection is the key to ensure successful treatment.

Hence, automated screening programmes are necessary in addressing this problem when working to eradicate preventable vision loss. The main challenge in developing an expert system for this purpose is the automatic and reliable extraction of the normal features from the retinal imagery. The temporal registration of retinal images provides an important groundwork for healthcare experts to monitor the progress of various ailments. Retinal image registration also requires accurate identification and extraction of the important landmark features in fundus images. An attempt is made in this work to develop novel and reliable algorithms for the localization and extraction of important normal features of the retina.

1.2 OBJECTIVES OF THIS WORK

The main objectives of this research are:

1. To develop an automated system for the detection and extraction of landmark features from fundus images of the human retina such as.
   (i) Optic Disc
   (ii) Macula and
   (iii) Retinal vasculature
2. Testing and validating the algorithms using multiple datasets .
3. Comparing with currently existing methods.
4. To make suggestions on the future improvement of this work.

My contribution to this work is

1. To develop novel and efficient methods for the localization and extraction of major retinal features using *MATLAB* environment.
2. To find suitable features for improving the performance of automated diagnostics in retinal fundus images.
3. To demonstrate the applications of bitplane decomposition, mathematical morphology and contrast limited adaptive histogram equalization(CLAHE) in automatic screening of fundus images.

1.3 OVERVIEW OF THE THESIS

The thesis is organized into the following 9 chapters:

Chapter 2 sketches the structure of human eye, its important parts and current imaging modalities used for the ocular fundi. Further, abnormalities in retinal imagery are briefly treated towards the end of the chapter.

Chapter 3 presents a literature survey on fundus image pre-processing, OD detection and localization, detection and extraction of macula and fovea and segmentation of retinal vasculature.

Chapter 4 begins with the aspects pertaining to the preprocessing operations like illumination correction, colour channel separation, detection of poor image quality and contrast enhancement using tophats. As the chapter proceeds, the theory and methods behind the algorithms used in thesis like bitplane decomposition, Contrast limited adaptive histogram equalization (CLAHE) and Mathematical Morphology (MM) are discussed in detail. Finally at the end of the chapter, an overview of the publicly available retinal image databases are given.

Chapter 5 deals with materials and methods behind the process of optic disc (OD) detection, detection of macula /fovea and extraction of retinal vasculature. This chapter begins with the importance of OD detection and proceeds with the proposed method. Only limited number of attempts can be found in the literature for addressing the problem of macula detection. A brief mention of challenges in the extraction of retinal vasculature is also presented in this chapter . The algorithms proposed in the thesis for addressing the problem of detecting the normal fudus features of the retina is explained in detail along with relevant intermediate results.

In Chapter 6, the results we have obtained by using our algorithms for OD detection, macula segmentation and extraction of vasculature in three public retinal image databases are given. A number of tables and graphs are used to compare the performance of different algorithms.

Chapter 7 summarizes the conclusions of this research work. The suggestions for future improvement of this work are also presented in this chapter.