A New Retinal Imaging Approach to Computer-aided Eye Care (PI: Prof. You Jia Jane; 2009/10)

Retinal diseases and anomalies impose serious attacks to the eye which may lead to the loss of vision or even blindness. Such retinal disorders include glaucoma, diabetic retinopathy, macular degeneration, retinal detachments, acute retinal necrosis and other vision threatening conditions. The early diagnosis is vital to the timely treatment to minimize further damages and deterioration. Recent advances in optical instrumentation such as adaptive optics (AO), scanning laser ophthalmoscopy (SLO), optical coherence tomography (OCT) and non-mydriatic retinal cameras provide high resolution photos of the delicate structures of the eye. These high resolution retinal images with details of photoreceptors and vascular flow help clinicians to make early diagnosis of diseases. However, the traditional diagnosis approach is based on individual doctor's experience and judgment, which may not be consistent and accurate. It is also time consuming and labor intensive for mass screening of any possible lesions among large population. Thus, it is essential to develop a computerized method for eye care with new and effective retinal imaging techniques.

Retinal imaging which combines image processing, analysis, computer vision and pattern recognition techniques has emerged as an exciting technology and made important contribution to modern ophthalmology over the past decade. Since retinal microvasculature is the only part of the human circulation that can be visualized non-invasively in vivo, readily photographed and quantitatively analyzed, the development of automated diagnostic systems for conditions such as diabetic retinopathy, age-related macular degeneration and retinopathy of prematurity offers great potential to be used in large-scale screening programs with significant resource savings, free from observer bias and reliable aid in clinical decision-making for telemedicine. However, most of the current research on retinal imaging has been focused on the diagnosis aspect by detection of landmark features of the fundus, such as the optic disc, fovea and blood

vessels in static retinal images. Not much work has been reported on the monitoring aspect by automatic detection and classification of longitudinal changes in the same retina over time due to treatments and/or disease progression. It remains a challenging task to develop a comprehensive computer aided system to overcome the limitations of the current systems and facilitate clinical procedures for retinal disease diagnosis and monitoring with high performance.

This project aims to develop a new retinal imaging approach to diagnosis and monitoring of retinal diseases for computer aided eye care. We propose to investigate, design, analyze, implement and evaluate new algorithms for feature extraction and change detection in time series of retinal images for retinal disease diagnosis and monitoring. The proposed algorithms include a hierarchical structure for red lesion detection and bright lesion classification by multiscale correlation filtering and controlled morphological reconstruction, a dynamic boundary tracking and alignment algorithm for disease analysis, a texture-based competitive retinal coding scheme for effective disease monitoring and a general hierarchical correlation approach for classification. Our previous work on image processing, pattern recognition and visual computing has laid the basis for further development of the relevant research issues of this grant application. The findings throughout this proposed project will be not only beneficial to clinical ophthalmology and other medical applications, but also important to multidisciplinary research in a diversity of areas including imaging, multimedia information systems, computer vision and pattern recognition with excellent application potentials. The feasibility of the proposed algorithms will be demonstrated by detecting and analyzing changes in retinal images over time for retinal disease screening and monitoring.