Chapter 11
A Software System for Grading Diabetic Retinopathy by Analyzing Retinal Images

M. Usman Akram
Bahria University, Pakistan

Shehzad Khalid
Bahria University, Pakistan

ABSTRACT
Medical imaging is very popular and is vital in designing Computer-Aided Diagnosis (CAD) for various diseases such as tumor detection using MRI. Diabetic retinopathy is an eye disease that is caused by the increase of insulin in blood in diabetic patients. It can cause total blindness if not detected and treated in time. The disease affects human retina and shows different signs on retinal surface as time passes. In this chapter, the authors present a software based on novel algorithms for early detection of diabetic retinopathy. It detects dark (Microaneurysms, Haemorrhages) and bright (hard exudates, cotton wool spots) lesions from retinal image. The algorithms consist of retinal image preprocessing, main component extraction, detection of candidate lesions, feature extraction, and finally classification using modified m-medoids based classifier. The proposed system is evaluated using publicly available retinal image databases, and results demonstrate the validity of proposed system.

1. INTRODUCTION

Diabetes is a disease that occurs when the pancreas does not secrete enough insulin or the body is unable to process it properly (Amos, McCarty, & Zimmet, 1997). Insulin is the hormone that regulates the level of sugar (glucose) in the blood. Diabetes can affect children and adults. Patients with diabetes are more likely to develop eye problems such as cataracts and glaucoma, but the disease’s affect on the retina is the main threat to vision (Kohn, et al., 1998). Most patients develop diabetic changes in the retina after approximately 20 years. The effect of diabetes on the eye is called Diabetic Retinopathy (DR). DR
is the newly emerging research area in medical image processing and has real time application in assisting the ophthalmologists for improved and efficient diagnosis of retinopathy (Amos, McCarty, & Zimmet, 1997). Figure 1 shows the difference in vision from a healthy and an affected retina.

Human retina has mainly two parts i.e. macula and peripheral retina. Macula is the main central part of retina which is used in order to see fine details whereas peripheral part is responsible for side vision which is also known as peripheral vision. Macula is very small part of retina as compared to peripheral but still it is too more sensitive to give details than peripheral. Other than these, a healthy retina consists of blood vessels, Optic Disc (OD) and fovea as well. Fovea is the central part of macula and it is responsible for sharp vision. Blood vessels are used to provide blood, oxygen and nutrition to retina and they originate from OD which is the brightest circular region of retina (Molven, et al., 2008). Figure 2 shows main components of retina.

Diabetes affects the blood vessels of the retina as time passes which causes DR. Early stages of DR are known as Non-Proliferative Diabetic Retinopathy (NPDR) (Lee, Lee, Kingsley, Wang, Russell, Klein, & Wanr, 2001). In DR the blood vessels of the retina become weak and develop tiny leaks. These leaks cause fluid or blood to seep into the retina. The retina then becomes wet and swollen and cannot work properly. NPDR contains the earliest changes in retina due to diabetes and is important to detection in its early stages. Different lesions (abnormalities) which may occur in NPDR are Microaneurysms (MAs), Haemorrhages (HM), Hard Exudates (HE), and Cotton Wool Spots (CWS) (Lee, Lee, Kingsley, Wang, Russell, Klein, & Wanr, 2001).

MAs are basically red dots that appear in retinal capillaries and are usually 10 to 100 microns in diameter. They are usually seen at the posterior pole especially temporal to the fovea. MAs are the first detectable change in retina due DR. Retinal HM is formed when the wall of a capillary or MA becomes weak and gets ruptured. The deep HM is usually round or oval and it is also called blot or dot HM. Dot HMs appear as bright red dots and are of same size as that of large MAs. Blot haemorrhages are larger lesions and they are located within the mid retina and often within or surrounding areas of ischemia. HE are the yellow deposits of lipid and protein present in the retina represent hard exudates. These deposits of lipid and proteins leak from surrounding capillaries and MAs and form circular patterns in the retina. In addition to this, small and thin blood vessel may

Figure 1. Visions from a normal and an affected retina