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Analysis of Retinal Fundus Images using Power Spectrum Fractal Dimension and Texture Feature: An Application for the Detection of Diabetic Retinopathy

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Diabetic retinopathy is a common retinal disease in individuals with diabetes and is a major cause for permanent vision loss. Early identification of diabetic retinopathy is highly beneficial for preventing the progression of disease. In fundus images, appearance of blood vessels and retinal surface is a good ophthalmological sign of diabetic retinopathy. Currently, ophthalmologists detect disease through segmenting and enumerating microaneurysms, hard exudates and hemorrhages. But this technique is laborious, erroneous and inaccurate. Also, there is no general segmentation algorithm to segment microaneurysms, hard exudates, hemorrhages and other lesions of retina. In this paper, a novel approach has been proposed for diagnosis of diabetic retinopathy. It presents two approaches for detection of diabetic retinopathy. The first approach deals with usage of fractal dimensions for automated detection of diabetic retinopathy. Fractal dimension of lesions is estimated by applying power spectral fractal dimension algorithms. For healthy retinas, fractal dimensions are found to in the range of 2.00 to 2.069, whereas for retinas with diabetic retinopathy, fractal dimensions exceed upper limit. In the second approach, Gray Level Co-occurrence Matrix (GLCM) method is used to analyze the extracted regions from healthy and diabetes affected fundus retinal images. Texture features such as entropy and contrast are computed for healthy and unhealthy regions. These texture features are compared with fractal dimensions. The authors observed positive correlation between entropy and fractal dimensions, whereas negative correlation with contrast and fractal dimensions. Detail implementations of the proposed work are presented.

Keywords : Diabetic Retinopathy, Entrophy, Fractal Dimension, Gray Level Co-occurence Matrix.

1. INTRODUCTION

During image formation in human eye, reflected light from the object falls on retina through lens structure. The receptor and neural cells send these image signals in the form of electrical signals to brain for image perception. Such an elevated cellular activity in retinal tissue requires lot of oxygen supply. Because of this the retinal tissue is highly vascularized with many tiny blood vessels supplying nourishment. Hence, study of geometric description of vasularization of retina is of great importance to understand and treat many diseases related to eye. Diabetic retinopathy is a condition occurring in individuals associated with diabetes, which causes damage of retina progressively. The blood vessels that nourish retina is damaged due to prolonged and uncontrolled diabetes, finally leading to diabetic retinopathy. These impaired blood vessels leak blood and other fluids that cause swelling of retinal tissue and clouding of vision. Background or NonProliferative Diabetic Retinopathy (NPDR) and Proliferative Dia-

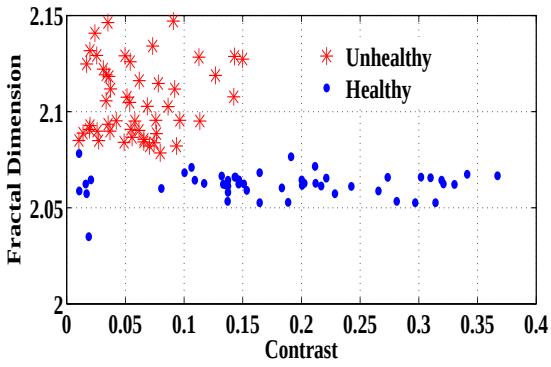

Figure 14. Graphs Plotted Contrast Vs. FD

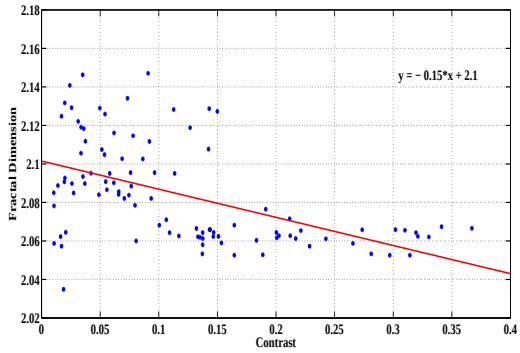

Figure 15. Graph Shows Linearity between Contrast and FD

Table 3
Statistical Values of Healthy Retina

SL.	Attribute	Contrast	Entropy	FD
1	Min	0.0104	0.3373	2.035
2	Max	0.1634	0.7281	2.078
3	Avg	0.06369	0.5622	2.062
4	Med	0.0569	0.4989	2.062
5	Mode	0.0104	0.498	2.053
6	SD	0.03757	0.08311	0.0067
7	Range	0.153	0.3908	0.0433

Table 4
Statistical Values of Severe Loss Retinopathy

SL.	Attribute	Contrast	Entropy	FD
1	Min	0.0106	0.1161	2.079
2	Max	0.3671	0.498	2.147
3	Avg	0.1791	0.3337	2.106
4	Med	0.1726	0.3373	2.103
5	Mode	0.1374	0.3373	2.082
6	SD	0.0903	0.06485	0.01919
7	Range	0.3565	0.3819	0.0686

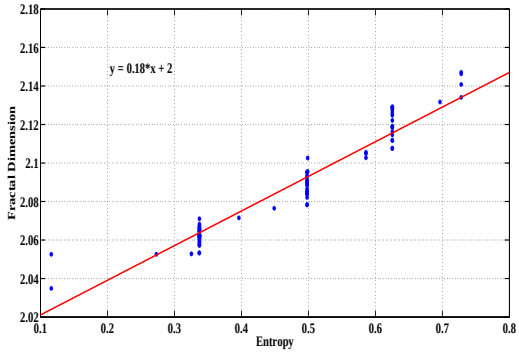

Figure 13. Graph Shows Linearity between Entropy and FD

analyzed for classification of degree of complexity connected with distribution of blood veins in retina. In this article two approaches were proposed for detection of diabetic retinopathy. In first approach, each of fifty DR and healthy subjects are analyzed for classification. In second approach, texture features such as entropy and contrast are evaluated for ROI of DR and NDR subjects. Finally, texture feature values are compared with fractal dimension as was shown from Figure 12 to Figure 15. The fractal dimension, entropy and contrast can be used as diagnostic parameters to identity diabetic retinopathy from healthy retina. The present method is very attractive for ophthalmologist during the diagnosis of retinal fundus images since information obtained from proposed method can be used as additional information to increase the accuracy for detection of diabetic retinopathy.

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