ABSTRACT

Medical images are susceptible to noise, distortions and have low resolutions. These variations may be due to non-uniform illumination, presence of artifacts, acquisition angle, poor focus etc. It is important to process the medical images to improve their visual appearance, quality and identify the region of interest thereby assisting the medical specialist for easier interpretation of diseases. Image enhancement procedures are mathematical techniques used to make the given image more precise, so that the selected features of the image can be easily identified by the human eye or to be detected by automated diagnosis systems.

Application of fractional differentials to medical image processing has been gaining importance in recent years, as they preserve the low-frequency feature information of original image which is not possible by the integral differential.

The primary objective of this research is to focus on the design of new fractional differential filters for various image processing applications, especially in the field of medical imaging. The images chosen for experimentation are from standard image databases namely High-Resolution Fundus Image database, DIARETDB0 and DIARETDB1databases. The performance of the proposed methods are evaluated using standard metrics namely Information entropy, mean, Peak-Signal to Noise Ratio (PSNR), Mean square error (MSE), Structure Similarity Index (SSIM) both quantitatively and qualitatively.

The thesis starts with the introductory concepts of fractional calculus and image processing, with relevant literature review. Second chapter analyzes the effectiveness and use of Grunwald-Letnikov (G-L) fractional differential operator for retinal image enhancement. In the proposed method,

first a G-L based fractional differential mask is defined, in vertical and horizontal directions for the given fractional order. Then, the retinal images are linearly convolved with the defined mask. In case of noisy images, the size and fractional order of the mask are changed to improve the quality of enhanced images. Finally, the enhanced image for the given fractional order is displayed. The results of the proposed method are compared with the traditional enhancement methods like Histogram Equalization (HE) and Adaptive Histogram Equalization (AHE).

In the third chapter, three new hybridized fractional differential masks using Gauss interpolation, are designed to improve the performance of existing fractional differential based image enhancement operators. This is an improved hybrid version of Gauss interpolation with the existing Grunwald-Letnikov fractional differential operator, Riemann-Liouville fractional differential operator and Riesz fractional differential operator. In this chapter, a new generalized mask of size n x n is also uniquely designed for image enhancement. In the proposed method first, a mask is constructed using the coefficients of the new hybridized Gauss interpolation based fractional derivatives for the given size and fractional order. Then linear convolution of the image and the new mask is performed in two directions. The resultant of convolution is the enhanced image. The enhanced images are finally, displayed with corresponding fractional order. Comparative analysis for the three new hybridized Gauss interpolation based fractional differential operators has been done with the existing fractional differentiation method; Newton's interpolation based fractional differentiation and Gamma correction methods. It is observed that, while enhancing the high frequency components the information in the low contrast grey scale images are considerably retained, by the newly defined masks of the proposed hybrid method.

In the fourth chapter, a new hybridized image enhancement method is developed using Singular Value Decomposition (SVD) and fractional derivatives. In the proposed method, the fractional differential mask is used to smoothen the images by removing the noises. The given input image is also processed simultaneously by histogram equalization and SVD. The histogram equalized image and the smoothened image are then decomposed using SVD. The new enhancement coefficient is obtained from the average of the singular values of the smoothened image. The right and left singular vectors of the input image together with the product of the new enhancement coefficient and the singular values of histogram equalized image are used to construct the new enhanced image. The experimental results of the proposed method are compared with the existing fractional differentiation based enhancement methods.

In the fifth chapter, three new hybrid methods combining Stirling's interpolation with the existing G-L fractional differential operator, R-L fractional differential operator and Riesz fractional differential operator has been developed to enhance the low contrast images. In the proposed hybrid method, a mask is constructed using the coefficients of the new hybridized Stirling's interpolation based fractional derivatives for the given size and fractional order. The structure of the above newly constructed mask is based on the uniquely defined generalized n x n mask. Then linear convolution of the image and the new mask is performed in two directions. The resultant of the convolution process is the enhanced image. Finally, the enhanced images are displayed with their corresponding fractional order. The new generalized mask of fractional derivative not only enhances the image, but also suppresses the noises effectively. The performance of the proposed method is not deteriorated even in the presence of artifacts in the retinal images. The results of the proposed method are compared with existing enhancement methods like HE, AHE, Gamma Correction and fractional differentiation.

Finally, a summary of the major contributions of this research work and the possible directions for future work are also presented.