Literature Review

Chapter 2

2.1 Design New Wavelet Filter:

There are a number of basic functions that can be used as the mother wavelet for wavelet transformation. Subsequently the mother wavelet produces all wavelet functions used in the transformation through translation and scaling, it governs the characteristics of the resulting wavelet transform. Consequently, the details of the particular application should be taken into account and the appropriate mother wavelet should be chosen in order to use the wavelet transform effectively. The wavelets are chosen based on their shape and their ability to examine the signal in a specific application. An imperative property of wavelet analysis is perfect reconstruction, which is the process of reassembling a decomposed signal or image into its original form without loss of information.

According to S. Kumari and R. Vijay, the present compression methods encompass time taking processes to find out the ideal basis. In this research paper, authors show that, Sym 5 represents the best results for compression and denoising of natural images. The performance of compression is measured in terms of compression ratio (CR) and peak signal to noise ratio (PSNR) and it is observed that with increase of filter order PSNR value increases but visual excellence of the compressed image worsens rapidly [1].

According to Baochen Jiang and et. al, Biorthogonal wavelet transform has been extensively used in the area of image denoising and image coding. This research paper proposes a new procedure to implement biorthogonal wavelet transform by using discrete cosine sequency filter. Experimental results display that whether using the discrete cosine sequency filter or the biorthogonal wavelet transform, the results of the decomposition and reconstruction are the identical [2].
Akram Aldroubi and Jill McGowan design oblique multi-wavelets bases which include the orthogonal multi-wavelets and the biorthogonal uni-wavelets of Cohen, Feauveau and Deaubechies. These oblique multi-wavelets reserve the benefits of orthogonal and biorthogonal wavelets and advance the flexibility of wavelet theory to accommodate a wider variety of wavelet shapes and properties [3].

2.2 Diabetic Retinopathy:

Diabetic retinopathy means "Retinal changes occurring in diabetes mellitus, marked by microaneurysms, exudates, and hemorrhages, sometimes by neovascularization". Diabetic retinopathy, the most common diabetic eye disease, occurs when blood vessels in the retina change. Sometimes these vessels swell and leak fluid or even close off completely.

2.2.1 Types of Diabetic retinopathy:

Clinically, the three main types of Diabetic retinopathy are:

1) Background Retinopathy

2) Preproliferative or Non- Proliferative Diabetic Retinopathy (NPDR)

3) Proliferative Diabetic Retinopathy (PDR)

2.2.2 Background Diabetic Retinopathy - The principal problem of the retina caused by diabetes involves the very fine blood vessels which nourish the nerve tissue. High blood sugar causes these vessels to become damaged and then leak fluid and fatty material into the nerve tissue of the retina. The retina becomes swollen and does not function normally. This form of retinopathy is called background Retinopathy. There are for different types of lesions in background diabetic retinopathy [4].

2.3 Non-Proliferative Diabetic Retinopathy:

Non-proliferative diabetic retinopathy, also known as background retinopathy. It is an early stage of diabetic retinopathy. In this stage, tiny blood vessels within the
retina leak blood or fluid and this leakage cause the damage of retina. The researcher are doing research for detection of non-proliferative lesions, like microaneurysms, hemorrhages, exudates and neovascularization.

Rupa V. L. and P. S. Kulkarni describes different features extraction of Fundus images like exudates, microaneurysms, optic Disc, macula, blood vessels, texture properties like entropy etc. And for classification of diabetic retinopathy lesions Genetic algorithm and Multilayer feed forward neural network is used. The paper mainly emphasizes on detection and classification. This algorithm achieves sensitivity of 80% and specificity of 83% [5].

Anderson Rocha and et. al., explain an algorithm to detect the presence of diabetic retinopathy (DR) related lesions from fundus images based on a common systematic approach that is capable of identifying both red and bright lesions without requiring specific pre- or post-processing. The visual words dictionary was applied to classifying bright and red lesions with classical cross-validation and cross dataset validation to indicate the robustness of this algorithm. This algorithm obtained an AUC of 95.3% for white lesion detection and an AUC of 93.3% for red lesion detection using 5-fold cross-validation and their own data consisting of 687 images of normal retinas, 245 images with bright lesions, 191 with red lesions and 109 with signs of both bright and red lesions. For cross dataset analysis, the visual dictionary also succeeds compelling results using their DB images as the training set and the RetiDB and Messidor images as test sets. For this database, the image classification resulted in an AUC of 88.1% when classifying the RetiDB dataset and in an AUC of 89.3% when classifying the Messidor dataset, both cases for bright lesion detection. The results indicate the potential for training with different acquisition images under different setup conditions with a high accuracy of referral based on the presence of either red or bright lesions or both [6].

According to Asha G. K. and et. al., Exudates are one of the primary signs of diabetic retinopathy, which is a main cause of blindness and can be prevented with an early screening process. In this paper, authors have attempted to detect exudates using back propagation neural network. The publicly available diabetic retinopathy dataset
DIARETDB1 has been used in the evaluation process. To prevent the optic disk from interfering with exudates detection, the optic disk is eliminated. Significant features are identified from the images after preprocessing by using two methods: Decision tree and GA-CFS method are used as input to the BPN model to detect the exudates and non-exudates at pixel level. The results prove that, BPN performance with features identified by Decision tree and GA_CFS approach has outperformed the performance of BPN with all inputs. The BPN classifier best performance was found with Sensitivity of 96.97 %, Specificity of 100% and classification accuracy of 98.45% [7].

According Keith A. Goatman and et. al., Proliferative diabetic retinopathy is a rare condition likely to lead to severe visual damage. It is characterized by the development of abnormal new retinal vessels. This algorithm describes a method for automatically detecting new vessels on the optic disc using retinal photography. Vessel-like candidate segments are first detected using a method based on watershed lines and ridge strength measurement. Fifteen feature parameters, associated with shape, position, orientation, brightness, contrast and line density are calculated for each candidate segment. Based on these features, each segment is categorized as normal or abnormal using a support vector machine (SVM) classifier. Collect database from Grampian Retinal Screening Program, Aberdeen Royal Infirmary Eye Clinic and Tayside Retinal Screening Program. The system was trained and tested by cross-validation using 38 images with new vessels and 71 normal images from two diabetic retinal screening centers and one hospital eye clinic. The discrimination performance of the fifteen features was tested against a clinical reference standard. Fourteen features were found to be effective and used in the final test. The area under the receiver operator characteristic curve was 0.911 for detecting images with new vessels on the disc. This accuracy may be sufficient for it to play a useful clinical role in an automated retinopathy analysis system [8].

Saiprasad Ravishankar and et. al., explain an automated detection of lesions in retinal images can assist in early diagnosis and screening of a common disease. A robust and computationally efficient approach for the localization of the different features
and lesions in a fundus retinal image is presented in this research paper. Features like intensity properties, geometric features and correlations are used to distinguish the lesions. This algorithm propose a new constraint for optic disk detection where they first detect the major blood vessels and use the intersection of these to find the approximate location of the optic disk. This is further localized using color properties. They also show that many of the features such as the blood vessels, exudates and microaneurysms and hemorrhages can be detected quite accurately using different morphological operations. General evaluation of the algorithm on a database (Hospitals, STARE, DRIVE, Diaretdb0, Red Atlas) of 516 images with varied contrast, illumination and disease stages yields 97.1% success rate for optic disk localization, a sensitivity and specificity of 95.7% and 94.2% respectively for exudate detection and 95.1% and 90.5% for microaneurysm/hemorrhage detection [9].

Xin Zhang and Guoliang Fan present a new spot lesion detection algorithm for retinal images with background diabetic retinopathy (DR) pathologies. The highlight of this algorithm is its capability to deal with all DR-related spot lesions of various sizes and shapes that is accomplished by a unique adaptive multi-scale morphological processing technique. A scale map is generated to delineate lesion areas based an edge model, and it is used to fuse multi-scale morphological processing results for lesion enhancements. The local/relative entropy thresholding techniques are employed to segment lesion regions, and a scale-guided validation process is used to remove over-detections based on the scale map. The proposed algorithm is tested on 30 retinal images where all spot lesions are hand-labelled for performance evaluation [10].

Arturo Aquino and et.al. have been detected optic disk in retinal image of diabetic patient with retinopathy and risk of macular edema. They have used image contrast analysis and structure filtering techniques. The location methodology obtained 98.83% success rate [11].

Clara I. S´anchez and et.al have developed an automatic image processing algorithm to detect hard exudates. Their algorithm is based on Fisher’s linear discriminant
analysis and makes use of color information to perform the classification of retinal exudates. They have prospectively assessed the algorithm performance using a database containing 58 retinal images with variable color, brightness, and quality. They have obtained a sensitivity of 88% with a mean number of 4.83±4.64 false positives per image using the lesion-based performance evaluation criterion, and achieved an image-based classification accuracy of 100%, sensitivity of 100% and specificity of 100%) [12].

Usman M. Akram and et.al have proposed a computer aided system for the early detection of DR. They start with the retinal image preprocessing to separate the background and noisy area. After preprocessing, blood vessels are enhanced and segmented by using Gabor wavelet and multilayered thresholding respectively. Then they localized optic disk using average filter and thresholding and detected the optic disk boundary using Hough transform and edge detection. Once blood vessels and Optic Disk are segmented out, dark and bright lesions are detected using hybrid fuzzy classifier. They have used four public databases DRIVE, STARE, DiaretDB0 and DiaretDB1; According to them results show that proposed system gives comparable results and can be used in a computer aided system for accurate and early detection of diabetic retinopathy [13].

Rangaraj M. and et.al has detected optic nerve head in fundus image of the retina with Gabor filters and phase portrait analysis. They have used free databases and for testing and analysis they have indicated 88.9% sensitivity at 4.6 false positive per image [14].

S.Kavitha and et.al. has detected hard and soft exudates in fundus image using color histogram thresholding. They have got 89.78% sensitivity, 99.12% specificity and 99.07 accuracy [15].

V. Vijaykumari and et.al. has developed a method for exudates detection in retinal image using image processing techniques. Here few methods are used for the detection and the performance of all techniques was compared [16].
Neera Singh and et.al. have used image analysis techniques like grey mathematical morphology, top-hat transform, fuzzy clustering etc for early detection of diabetic retinopathy [17].

P.N. Jebrani Sargunar and et.al. detected and classified exudates in diabetic retinopathy images by texture segmentation methods. They proposed a tool for the early detection using fuzzy c-means clustering, fractal techniques and morphological transformations. Here a accuracy of 85% is achieved [18].

Ahmed Wasif Reza & C. Eswaran present an automatic screening system for detecting the early stage of DR, which is known as non-proliferative diabetic retinopathy (NPDR). The proposed system involves processing of fundus images for extraction of abnormal signs, such as hard exudates, cotton wool spots, and large plaque of hard exudates. A rule based classifier is used for classifying the DR into two classes, namely, normal and abnormal. The abnormal NPDR is further classified into three levels, namely, mild, moderate, and severe. To evaluate the performance of the proposed decision support framework, the algorithms have been tested on the images of STARE database. The results obtained from this study show that the proposed system can detect the bright lesions with an average accuracy of about 97%. The study further shows promising results in classifying the bright lesions correctly according to NPDR severity levels [19].

According to Hsu W, Digital retinal imaging technologies have become an integral part of eye screening programs worldwide due to their greater accuracy and repeatability in staging diabetic retinopathy. These screening programs produce an enormous number of retinal images since diabetic patients typically have both their eyes examined at least once a year. Automated detection of retinal lesions can reduce the workload and increase the efficiency of doctors and other eye-care personnel reading the retinal images and facilitate the follow-up management of diabetic patients. Existing techniques to detect retinal lesions are neither adaptable nor sufficiently sensitive and specific for real-life screening application. In this paper, authors demonstrate the role of domain knowledge in improving the accuracy and robustness of detection of hard exudates in retinal images. Experiments on 543
consecutive retinal images of diabetic patients indicate that they achieve 100% sensitivity and 74% specificity in the detection of hard exudates [20].

According to Vallabha and et. al., the Diabetic retinopathy is a progressive ocular disease. The disease may advance from mild to severe non-proliferative diabetic retinopathy. This paper proposes a method for automated detection and classification of vascular abnormalities in diabetic retinopathy. The vascular abnormalities are detected using scale and orientation selective Gabor filter banks. The proposed method classifies the retinal image as mild or severe case based on the outputs obtained from Gabor filters [21].

According to Walter T and et. al., the presence of exudates within the macular region is a main hallmark of diabetic macular edema and allows its detection with a high sensitivity. Hence, detection of exudates is an important diagnostic task, in which computer assistance may play a major role. Exudates are found using their high grey level variation, and their contours are determined by means of morphological reconstruction techniques. The detection of the optic disc is indispensable for this approach. Detect the optic disc by means of morphological filtering techniques and the watershed transformation. The algorithm has been tested on a small image data base and compared with the performance of a human grader. As a result, they obtain a mean sensitivity of 92.8% and a mean predictive value of 92.4% [22].

Reza AW and Eswaran C present an automatic screening system for detecting the early stage of DR, which is known as non-proliferative diabetic retinopathy (NPDR). The proposed system involves processing of fundus images for extraction of abnormal signs, such as hard exudates, cotton wool spots, and large plaque of hard exudates. A rule based classifier is used for classifying the DR into two classes, namely, normal and abnormal. The abnormal NPDR is further classified into three levels, namely, mild, moderate, and severe. To evaluate the performance of the decision support framework, the algorithms have been tested on the images of STARE database. The system can the bright lesions with an average accuracy of about 97% [23].
P. Kahai, K. R. Namuduri, and H. Thompson, propose a decision support system (DSS) for automated screening of early signs of diabetic retinopathy. Classification schemes for conclusion the presence or absence of DR are developed and tested. The detection rule is based on binary-hypothesis testing problem which simplifies the problem to yes/no decisions. An analysis of the performance of the Bayes optimality criteria applied to DR is also presented. The proposed DSS is evaluated on the real-world data [24].

Noronha K, Acharya UR, Nayak KP, Kamath S and Bhandary SV, used discrete wavelet transform and support vector machine classifier for automated detection of normal and diabetic retinopathy classes. The wavelet-based decomposition was performed up to the second level, and eight energy features were extracted. Two energy features from the approximation coefficients of two levels and six energy values from the details in three orientations (horizontal, vertical and diagonal) were evaluated. These features were nourished to the support vector machine classifier with various kernel functions (linear, radial basis function, polynomial of orders 2 and 3) to evaluate the highest classification accuracy. They obtained the highest average classification accuracy, sensitivity and specificity of more than 99% with support vector machine classifier (polynomial kernel of order 3) using three discrete wavelet transform features [25].

Reza AW, Eswaran C, and Hati S, design a novel approach to automatically segment the OD and exudates. The proposed algorithm use the green component of the image and preprocessing steps such as average filtering, contrast adjustment, and thresholding. The other processing techniques used are morphological opening, extended maxima operator, minima imposition, and watershed transformation. The proposed algorithm is evaluated using the test images of STARE and DRIVE databases with fixed and variable thresholds. The images drawn by human expert are taken as the reference images. The proposed method yields sensitivity values as high as 96.7% [26].

Niemeijer M, Abramoff MD, and van Ginneken B, presented an automatic system is to find the location of the major anatomical structures in color fundus photographs,
the optic disc, the macula, and the vascular arch. These structures are found by fitting a single point-distribution-model to the image that contains points on each structure. The method can handle optic disc and macula centered images of both the left and the right eye. The system uses a cost function, which is based on a combination of both global and local cues, to find the correct position of the model points. The global terms in the cost function are based on the orientation and width of the vascular pattern in the image. The local term is derived from the image structure around the points of the model. To optimize the fit of the point-distribution-model to an image, a sophisticated combination of optimization processes is proposed which combines optimization in the parameter space of the model and in the image space, where points are moved directly. The system was developed and trained on a set of 500 screening images, and tested on a completely independent set of 500 screening images. In addition to this the system was also tested on a separate set of 100 pathological images. In the screening set it was able to find the vascular arch in 93.2%, the macula in 94.4%, the optic disc location in 98.4% and whether it is dealing with a left or right eye in 100% of all tested cases. For the pathological images test set, this was 77.0%, 92.0%, 94.0%, and 100% respectively [27].

Mendonca A M, and Campilho presents an automated method for the segmentation of the vascular network in retinal images. The algorithm starts with the extraction of vessel centerlines, which are used as guidelines for the subsequent vessel filling phase. For this purpose, the outputs of four directional differential operators are processed in order to select connected sets of candidate points to be further classified as centerline pixels using vessel derived features. The final segmentation is obtained using an iterative region growing method that integrates the contents of several binary images resulting from vessel width dependent morphological filters. This algorithm tested on two publicly available databases [28].

J. Staal and et. al., presented automated segmentation of vessels in two-dimensional color images of the retina. The system is based on extraction of image ridges, which coincide approximately with vessel centerlines. The ridges are used to compose primitives in the form of line elements. With the line elements an image is partitioned
into patches by assigning each image pixel to the closest line element. Every line

element constitutes a local coordinate frame for its corresponding patch. For every

pixel, feature vectors are computed that make use of properties of the patches and the

line elements. The feature vectors are classified using a KNN-classifier and

sequential forward feature selection. The algorithm was tested on a database

consisting of 40 manually labeled images. The method achieves an area under the

receiver operating characteristic curve of 0.952. The method is compared with two

rule-based methods of Hoover et al. and Jiang et al [29].

Harangi B, Antal B and Hajdu proposed a method for exudate detection which

performs with high accuracy. Firstly they identify possible regions containing

exudates using grayscale morphology. Then, extract more than 50 descriptors for

each candidate pixel to classify them. Analyzed the information content of the
descriptors and selected the most relevant ones. The selected features are used to

train a boosted naïve Bayes classifier. Tested this approach on the publicly available

DiaretDB color fundus image database [30].

Diabetic retinopathy is one the most common cause of blindness in the world.

Exudates are among the early signs of this disease, so its proper detection is a very

important task to prevent consequent effects. In this paper, we propose a novel

approach for exudate detection. First, we identify Harangi B, Lazar I, Hajdu A, apply

an active contour based method to minimize the Chan-Vese energy to extract

accurate borders of the candidates. To remove false candidates use a region wise
classifier. Extract several shape features for each candidate and let a boosted Naïve
Bayes classifier eliminate the false candidates. Use the publicly available DiaretDB1
color fundus image set for testing [31].

2.4 Proliferative Diabetic Retinopathy:

The retinal blood vessels are impassable, leading to the development of new vessels

which are abnormal and fragile. This may cause to rupture of the vessels, in the eyes

and that affect a sudden vision loss. In some cases, scar tissue develops. The scarring
will pull and distort the retina. This may cause the retinal to detach, resulting in a more severe loss of vision.

**Summary:**

Non-proliferative diabetic retinopathy (NPDR) is the initial stage of diabetic retinopathy. With this condition, damaged blood vessels in the retina begin to leak extra fluid and small amounts of blood into the eye. Non-proliferative diabetic retinopathy is mainly categorized into three categories, such as Mild, Moderate and Serve. In this chapter, the researchers are explain how they have detected the non-proliferative diabetic retinopathy lesions. Such as microaneurysms, hemorrhages, exudates and blood vessels using different kinds of image processing techniques and multi resolution analysis using wavelet approach. For result analysis authors have used the online databases like STARE, DRIVE, DiaretDB0, DiaretDB1 RetiDB, Messidor and also local databases from ophthalmologist. For classification, authors have used some classification techniques such as, neural network models like artificial neural network (ANN), multi-layer perceptron (MLP) are used for classification and for grading of non-proliferative diabetic retinopathy lesions. Also receiver operating characteristic curve is used for calculating the performance analysis of the algorithm.

**References:**


4. “Diabetic Eye Disease” by Dr. Prema Abraham, MD (Director of vitreoretinal and retinovascular services) Black Hills Regional Eye Institute, in Rapid City, South Dakota, 2005.


