International Journal of Reviews in Computing

IJRIC

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

AN OVERVIEW OF COMPUTATIONAL INTELLIGENCE TECHNIQUES FOR RETINAL DISEASE IDENTIFICATION APPLICATIONS
(REVIEW PAPER)

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ABSTRACT

Computational methodologies have become a significant part of the real time applications. One specific application which highly depends on the computing techniques is the medical field. Ophthalmology is a significant branch of biomedical field which requires computer-aided automated techniques for pathology identification in human eyes. These automated techniques must be highly accurate and also converge in quick time period. Based on these criterions, several automated techniques are developed and being used for practical applications. Even though many techniques are available, it is very difficult to achieve the concept of generalization among these automated techniques. Hence, there is a significant necessity for analyzing the various techniques in order to highlight their suitability for eye disease identification applications. This research paper overcomes this deficiency by providing an in-depth analysis of the existing automated techniques. The focus of this paper is on Artificial Intelligence (AI) based techniques since these techniques are found to be superior to other computing techniques. An extensive analysis is performed to bring out the merits and demerits of various Artificial Intelligence (AI) based techniques. Thus the application of AI techniques for retinal disease identification is explored in this work. This work also indirectly suggests AI based solutions for the various stages of automated retinal disease diagnosis system.

Key Words: *Artificial Intelligence, Retinal diseases, Neural Networks & Fuzzy Theory, Optimization*

1. Introduction

Eye disease identification techniques are highly important in the field of ophthalmology. Conventional retinal disease identification techniques are based on manual observation which is highly subjective and prone to error. Hence, the necessity for automated techniques which eliminates the drawback of the conventional techniques is significantly high in the medical field. The accuracy of the automated disease identification techniques should be high. Besides being accurate, the techniques also should possess a quick convergence rate which enables them to be suitable for real-time applications. Based on these two performance measures, several automated techniques are developed and implemented successfully for retinal disease identification. These techniques are dealt in detail in the subsequent sections.

The automated disease identification system is not a single process. This system consists of various modules which is evident from the flow diagram in Figure 1. The success rate of each and every step is highly important to ensure the overall high accurate outputs. The rest of this report is organized as follows: (a) Retinal image database, (b) Image pre-processing, (c) Anatomical structure identification and feature extraction, (d) Optimization techniques, (e) Disease identification. The works available for all the above mentioned sub-sections are illustrated in this report. The merits and demerits of these various works are also explained in detail to determine the suitability of these techniques for retinal disease identification.

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

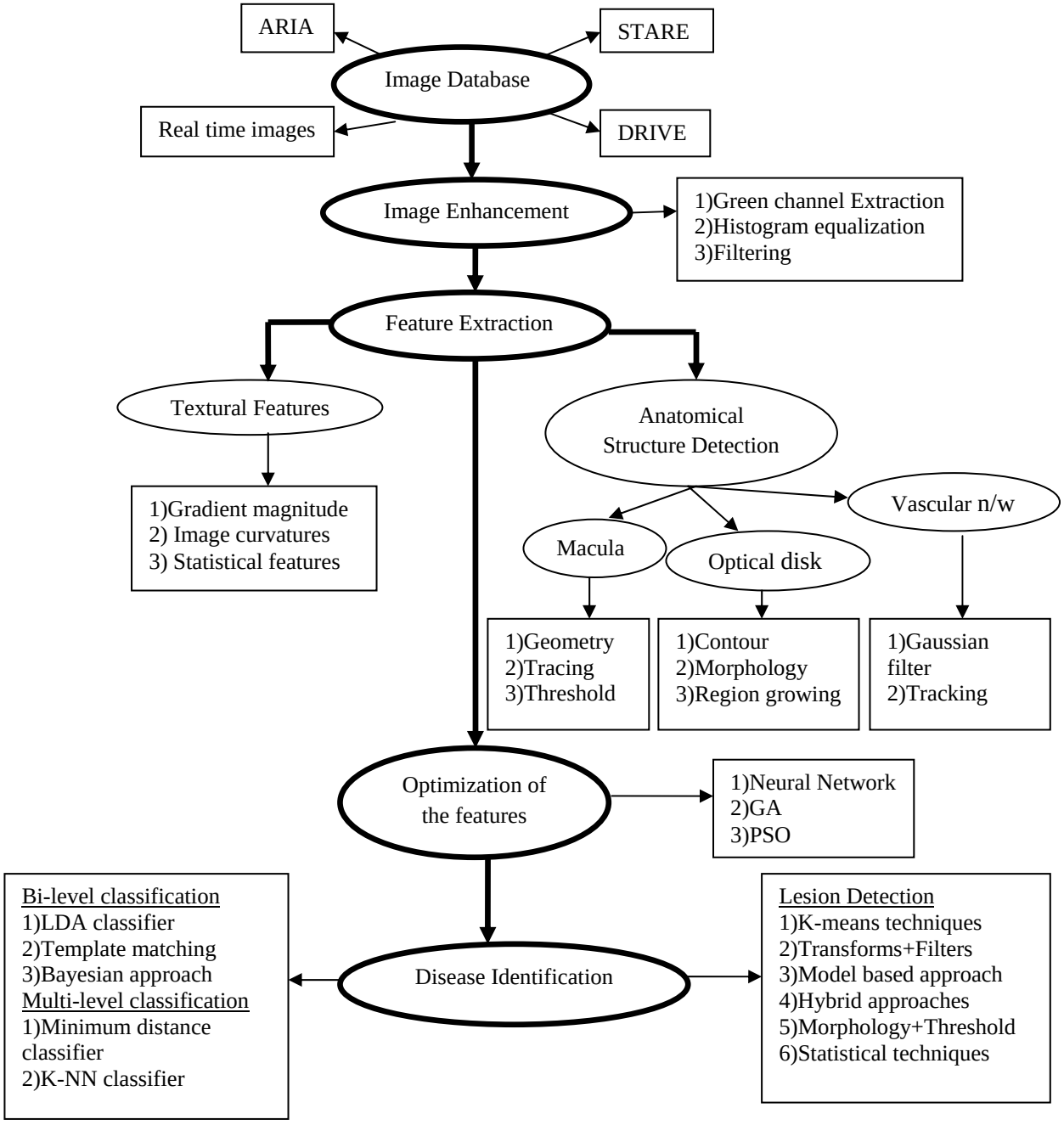

Figure 1: Framework of Literature Survey

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

2. LITERATURE SURVEY ON IMAGE PRE-PROCESSING

The preliminary step in automated retinal pathology diagnosis is image pre-processing. This includes various techniques such as contrast enhancement, foreground/background differentiation, image de-noising, etc. Several earlier research works are reported in the literature. Marco et al (2005) have used the compensation based technique for eliminating the luminosity and contrast variations in the retinal images. Normalization of these variations is performed by estimating the non-uniformity in the background part of the image. However, few zones with "non-background" dark areas larger than 50% are not affected by this normalization. Aliaa et al (2006) have presented a comparative study between various contrast enhancement techniques for retinal images. These techniques are implemented on publicly available databases and the results are tabulated. These results analyzed the merits and demerits of the various contrast enhancement techniques. Peng et al (2007) have used the transform based techniques for edge enhancement in low contrast images. The output images are based on the non-linear function which incorporates the effects of noise. A comparative analysis is also performed with other techniques. The significance of red channel for accurate color retinal image processing is explained by Nancy et al (2007).

Segmentation of retinal blood vessels is performed with red and green channels of the retinal image and the results are compared with the segmented output of the green channel of the retinal image. Experimental results have shown promising results for the usage of red channel for retinal image segmentation. A comparative analysis of the pre-processing techniques in color retinal images is performed by Salvatelli et al (2007). A solution to minimize the non-uniform lighting is proposed by Andrea et al (2008). An adaptive histogram equalization technique which is available in Matlab Toolbox is used in this work. Since an inbuilt command is used in this work, generalization is very difficult. The techniques such as homomorphic filtering, morphological filtering, etc. are analyzed in this report. The suitability of these techniques for various applications is illustrated in this report. George et al (2008) have implemented a derivative based technique for background foreground differentiation. The convolution of 2D Gaussian kernels with the second derivatives of the input image is performed to highlight the blood vessels. But the drawback of this system is the low accuracy results specified in the report.

Gopal et al (2008) have proposed a domain knowledge based blood vessel enhancement technique in colour retinal images. A correction factor is derived from the estimated degradation and used in this work to minimize the contrast and luminosity variation in retinal images. A model based vessel enhancement technique is proposed by Yuan et al (2008). The background suppression measure, smoother 'vesselness' measure and the responses at crossings are superior to the conventional methods. Directional field based retinal vessel enhancement technique is reported by Jian et al (2008). A single step brightness normalization and neighborhood enhancement is used in this work. Multi scale line operation based blood vessel enhancement is performed by Farnell et al (2008). This multi scale line operation algorithm is based on region growing technique and the results are compared with the conventional median filtering technique. The proposed technique is applicable for all retinal disease classification applications and the results also revealed that the proposed technique is much faster than the conventional techniques.

3. LITERATURE SURVEY ON FEATURE EXTRACTION

The second step is the feature extraction technique in which suitable feature set is extracted from the enhanced retinal images and from the detected anatomical structures. The objective of the feature extraction is twofold: (a) Generating a feature set which maximizes the within-class similarity and minimizes the between-class similarity measures & (b) Aid in dimensionality reduction which ultimately minimizes the convergence time period of the classifiers. The feature extraction techniques for retinal images are broadly divided into two classes. The first category is the direct method in which the textural features are extracted from the pre-processed images. The second category is the indirect method in which various anatomical structures are initially segmented from the pre-processed images and then features are extracted from these anatomical structures. These anatomical structures include macula, vascular network (retinal blood vessels) and the optical disk. Initially a survey on features based on

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

direct method is performed followed by a survey on features based on anatomical structures.

3.1 Literature Survey on TEXTURAL FEATURES based extraction techniques

April et al (2007) has used the textural features based on wavelet coefficients for retinal image classification. The relative homogeneity of localized areas of the retinal images is described by the wavelet coefficients. An extensive feature set is obtained by translating, scaling and rotating the textural features. But the quality of the experimental results reported in this paper is very low. Gaussian filtering based image features are used by Meindert et al (2007). The filter bank is applied on the three channels of the RGB image. Features such as the gradient magnitude, Eigen values, and local image curvature are extracted from the filtered image and used in this work.

3.2 Literature Survey on MACULA based extraction techniques

Several researchers depend upon anatomical structures for feature extraction. Macula, Vessel network and the optic disk are the commonly used anatomical structures. Gagnon et al (2001) have used the apriori geometric criteria (The macula position and the distance with respect to the optical disk is relatively constant) for macula localization. The exact center of the macula is then determined by searching the darkest pixel in the fine resolution image. Adaptive thresholding based macular segmentation in Optical Coherence Tomography is implemented by Hiroshi et al (2005). In this method, several retinal layers are combined to detect the borders of macula. This method is implemented on normal and abnormal images. The drawback is that this technique is not suitable for low quality images. Kenneth et al (2007) have proposed a parabolic model based approach for macula detection. An indirect methodology is adopted in this approach in which the macula is traced by determining the horizontal line passing through the optical nerve and fovea. Emphasis is laid on developing the parabolic model to determine the horizontal line. This technique is implemented on retinal images of different abnormal categories. This approach yields superior results with an exception for various instances of retinopathy. 3D graph search based macula detection is developed by Mona et al (2008). Initially, a 3D image is created by combining the different retinal layers. Further, graph search based technique is implemented to detect the macula region. But the selection of cost functions for the graph search method is the practical difficulty of this approach.

Sekhar et al (2008) have used the geometric relations between the optic disk (OD) and macula to detect the central region of macula which is called as fovea. The region of interest is defined as the portion of the sector subtended at the centre of the optic disk by an angle of 30 degree above and below the line from the centre of optical disk. This process is followed by thresholding and morphological operations to extract the macula region. Macula segmentation based on statistical methods is implemented by Cemal et al (2008). The various irregular sizes and shapes of macula in case of Age Related Macular Degeneration (ARMD) are detected by this approach. Tapio et al (2009) have used the intensity variation based approach for macula detection. Two segmentation algorithms are used in this work and their performance measures are analyzed in terms of convergence rate. This technique is applicable for both normal and abnormal images. Several characteristic patterns are extracted from the macula region which is then used to distinguish the normal and abnormal retinal images.

3.3 Literature Survey on OPTICAL DISK based extraction techniques

Francois et al (1999) have proposed the contour approach for optical disk detection in retinal images. The active contour used in this work is based on the concept of gradient vector flow model. Morphological operations are also used in this work to enhance the quality of the results. Lack of systematic evaluation of the results is the major drawback of this technique. Radim et al (2002) have used the nonlinear filtering technique to extract the optical disk. This approach is less susceptible to noise and filtering is followed by edge detection to extract the region of interest. But this method is not applicable for low contrast images. Snake active contour methodology for optical disk detection is proposed by Thitiporn et al (2003). The contrast of the optical disk is used as the significant feature in this work. But the initialization of size and shape of the contour is the practical

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

difficulty of this approach. Active shape model (ASM) based optical disk detection is implemented by Huiqi et al (2003). The initialization of the parameters for this model is based on Principal Component Analysis technique. The faster convergence rate and the robustness of the technique are proved by experimental results. But this technique is tested only on few images.

Combined region growing and edge detection is employed for OD detection by Huiqi et al (2004). Experimental results have revealed the superior nature of the proposed approach for fovea localization and disk boundary detection in terms of sensitivity and specificity. But the necessity for accurate selection of seed points for region growing is the major drawback of this approach. Lowell et al (2004) have proposed the template matching based OD detection technique. This technique is implemented on normal and abnormal images. Experimental results concluded that the proposed algorithm is suitable even for blurred images. Hough transform is used for OD detection by Chrastek et al (2005). The detected optical disk features are supplied as inputs to the classifiers to detect glaucoma in retinal images. This work has highlighted the applicability of OD detection techniques to differentiate the normal and the abnormal images. But low quality images are not included in this experiment. Seng et al (2005) have used the unsupervised color thesholding technique for optic disk detection. Yellow color and small size of the OD is used as significant features for exudates identification in this work. These features have clearly revealed that the color, size and shape of the OD are different for normal and abnormal images. Clustering algorithm based OD detection is performed by Blanco et al (2006). Initially, localization is performed using the clustering algorithm and then extraction of OD is carried out via fuzzy circular Hough transform. Validation of the results is done by ophthalmologists. A hybrid parabolic and Markov model based optic nerve head detection is demonstrated by Kim et al (2006). The extracted OD is used to differentiate the normal and pathological eyes. Experimental results have revealed the superior nature of the proposed approach.

Virance et al (2007) have detected the optical disk from low contrast images using deformable model based approach. The results of the proposed approach are compared with the results of Hough transform based detection. But the proposed algorithm proved to be much better than the transform based approach. Abramoff et al (2007) have employed the K-Nearest Neighbour classifier for OD detection. This algorithm is a pixel based classification approach in which intensity, simple edges, Gaussian filter outputs and Gabor wavelets are used as the feature set. The performance measure used in this work is accuracy and experimental results have yielded accurate results. Juan et al (2007) have detected the optic disk via deformable model technique. Knowledge based clustering technique is also involved in this approach to obtain enhance results. The output of the proposed approach is compared with the results of Snake method and ASM method. The algorithm used in this work has outperformed other techniques in terms of success rate. Eigen vector based OD detection is implemented by Anantha et al (2007). The Eigen vectors are calculated from the covariance matrix of the training images and the disk region is constructed from the Eigen vectors. The candidate image patch is projected on to the disk space and the distance between the image and the projections is calculated. The region with the minimum distance is grouped as optical disk. But this approach is implemented only on few images. Juan et al (2007) have used a modified active contour model for OD detection. The smoothing update equation of snake model is modified and used in this approach for performance enhancement. Robustness and the immunity to noise characteristics are highly improved due to these modifications. A comparative analysis with the conventional methods is also illustrated in this report. Sun et al (2007) have used the warping technique for disc segmentation. This work is used to distinguish the normal and the abnormal glaucoma images. Experimental results are analyzed in terms of sensitivity and positive predictability. Huajun et al (2007) have proposed the histogram based OD segmentation technique. This approach also involved the concept of fractal analysis. This report also concluded that the proposed approach is computationally inexpensive and highly robust. Juan et al (2008) have developed an automated assessment method for segmented optical disks. Several assessment measures are illustrated in this report. This work also highlighted the developed software to estimate the various performance measures.

Vijaya et al (2008) have analyzed the various techniques used for OD detection. The

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

merits and demerits of various techniques are analyzed in detail and the application of various techniques is also suggested in this report. This report also has explained the application of intelligent systems for OD detection. Genetic Algorithm (GA) based optic disk detection is reported by Enrique et al (2008). GA is used to determine the optimal number of hypothesis points which is used to construct the ellipse for OD detection. Experimental results have encouraged the usage of GA for OD detection. But the high computational cost of GA is the major drawback of the proposed approach. Neimeijer et al (2008) have integrated the local vessel geometry and image intensity features for optic disk localization in retinal images. K-NN classifier is then used to segment the optic disk from the retinal images. But the proposed approach has failed to segment the OD in low contrast images. Topological Active Nets (TAN) are used for optic disk localization by Novo et al (2009). GA is also used to optimize the network topology in this work. This approach is devoid of pre-processing step which is an added advantage of this work. The inclusion of multi objective optimization may enhance the performance of the proposed network. K-NN classifier is used for OD localization by Meindert et al (2009). This approach has claimed to possess faster convergence rate than the conventional techniques. This method is implemented on a large data set which shows the robustness of the proposed algorithm. Daniel et al (2010) have utilized the adaptive morphological approaches for OD detection. Dilation, top-hat operation, skeleton operations and pruning operations are used as morphological operators in this work. This technique is applicable for all retinal images of varying illumination. The time taken by this algorithm is also very low. Ahmed et al (2010) have used the watershed segmentation technique for OD detection. Average filtering and Contrast enhancement are used as pre-processing steps in this work. This technique is tested on publicly available databases and the sensitivity of the experimental results is superior to the conventional techniques. Huiyu et al (2010) have used the modified gradient vector flow algorithm for OD segmentation. This report have highlighted the drawbacks of the conventional technique and also suggested a solution to overcome it.

3.4 Literature Survey on VASCULAR NETWORK based extraction techniques

Fredric et al (1977) proposed the morphological operations based vessel segmentation technique. This technique also incorporated the advantages of differential operators. Subhasis et al (1989) have used the matched filters to detect the vascular network. The properties of optical and spatial properties of the retinal images are used in this work. But the requirement for huge convergence time period is the major drawback of this technique. Riccardo et al (1997) have used the Gaussian kernels based filtering approach for retinal vessel segmentation. Hysteresis combined with thresholding is used in this approach after the filtering technique. The convergence rate of the proposed approach is very high but the accuracy reported in the paper is very low. Chutatape et al (1998) have proposed a hybrid approach for vascular network detection. The advantages of tracking and filters are combined in this technique. Selection of seed pixel for the tracking algorithm is the major drawback of this method. Edge thinning combined with Sobel operators are used for vessel detection by Yiming et al (1998). The proposed method also incorporated the concept of local thresholding. Experimental results revealed the high convergence rate of the proposed approach.

The application of vessel detection for image registration is explored by Zana et al (1999). The Hough transform with Bayesian approach is used for vessel segmentation in this approach. Ali et al (1999) have used the tracing method to detect the vascular network of the retinal images. This approach is based on the recursive procedure to determine even the finest blood vessel. This technique is also applicable for images with discontinued blood vessels. But the selection of seed pixel for the tracing procedure is the practical difficulty of this approach. Cristian et al (2000) have used the watershed technique for blood vessel segmentation. The selection of initial seed points for watershed segmentation is the major disadvantage of this approach. Huiqi et al (2000) have used the edge detection technique to extract the blood vessels. A threshold is further used to enhance the blood vessels. This technique is implemented on green channel of the input RGB image. Jorge et al (2001) have used the concept of wavelet transform to extract the blood vessels.

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Morphological operations are also used in this work to extract the thin blood vessels. Experimental results suggested the superior nature of the proposed approach. Gaussian filter approach is used for retinal vessel detection by Luo et al (2002). The vessel width measurement is incorporated in this technique which yields superior results than the matched filter approach. Entropy thresholding based vessel detection algorithm is demonstrated by Thitiporn et al (2003). The concept of filtering and thresholding is used in this work. The usage of non-adaptive thresholding technique is the major drawback of this approach.

Thitiporn et al (2003) have used the local entropy thresholding technique for efficient blood vessel detection. The concept of matched filtering and length filtering is also involved in this approach. But the proper selection of threshold value is the major drawback of this approach. Model based vessel segmentation technique is illustrated by Li et al (2003). The Gaussian model is used in this work for feature extraction. The proposed approach is inexpensive and highly robust. Ridge based vessel segmentation technique is proposed by Joes et al (2004). The image ridges coincide with the vessel centerlines and this concept is used for segmentation in this work. A comparative analysis with the conventional methods is also reported in this work. Sequential forward feature selection is used in this work. A spatial referencing algorithm for vasculature extraction is reported by Gang et al (2004). This technique is based on tracing methodology to extract the features from the retinal blood vessels. This method is then compared with other techniques such as random scheduling to show the superior nature of the proposed algorithm.

A hybrid approach with Laplacian operators and thresholding for retinal blood vessel detection is proposed by Vermeer et al (2004). Experimental results are analyzed in terms of sensitivity and specificity. This method is capable of detecting blood vessels even in images with specular reflection. A comparative study of retinal vessel segmentation techniques are reported by Niemeijer et al (2004). Five different algorithms are analyzed in this approach. The conclusion of this report is that the performance of the pixel classification methods is better than the other techniques. Cree et al (2005) have used the model and tracking based approach for retinal vessel segmentation. The model aided in accurate tracking of the blood vessels. But the selection of initial seed point is the drawback of this approach. Morphology and matched filters are collectively used for vessel segmentation by Dietrich et al (2005). This technique is used to detect the glaucoma eye disease. Comparative analysis and future scope of the work is also discussed in this work. Andrew et al (2005) have used the tram-line filtering technique for retinal vessel segmentation. The proposed approach is a non-linear approach which is highly robust in nature. The usage of blood vessel extraction technique for Diabetic Retinopathy detection is demonstrated by Cornforth et al (2005). The concept of wavelet transforms is used in this work for segmentation. But this approach is not applicable for images with noisy background.

Bevilacqua et al (2005) have used the combined morphology and filtering techniques for retinal feature extraction. Emphasis is laid on cluster filter to extract the blood vessels. Skeleton process and median filtering is used to enhance the blood vessels. Experimental results have suggested the superior nature of the proposed algorithm. A survey of different retinal image segmentation techniques are reported by Mai et al (2006). The merits and demerits of various segmentation techniques are analyzed in detail in this report. This work also suggested suitable techniques for various applications. Matched filter approach based retinal vessel extraction technique is proposed by Michal et al (2006). The experimental results are analyzed in terms of confidence and edge measures. But the low contrast vessels are not detected by this approach. Morlet wavelet transform based retinal vessel segmentation is performed by Joao et al (2006). Features are constituted from the wavelet transform and pixel based classification is further performed to segment the blood vessels. But addition of noise to the image degrades the quality of the output. The hybrid approach of multiscale analysis and adaptive thresholding is used by Qin et al (2006). Gabor filter approach is used in this work for segmentation. Small and thin blood vessels are also detected by this method. Ana et al (2006) have used the morphological operations for the segmentation of retinal blood vessels. Changhua et al (2007) have used the probabilistic methodology for retinal vessel segmentation. The advantage of this approach is that it is independent of vessel constraints. This approach is also capable of enhancing the vessel junctions.

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

Elena et al (2007) have used the multiscale feature extraction principle for retinal vessel segmentation. The main advantage of this approach is that it is able to detect the blood vessels with different widths, lengths and orientations. Support Vector Machine (SVM) based retinal blood vessel segmentation is proposed by Elisa et al (2007). The results are compared with the line detector technique which employed the concept of thresholding. Incapability of thin vessel detection is the demerit of this approach. The lack of a proper performance measure is another drawback of this approach. Joao et al (2007) have used the wavelet features and the supervised classifier to segment the blood vessels. The classifier used in this work is the Gaussian model classifier. Experimental results are also compared with the conventional K-NN classifier. But the proposed approach outperform the K-NN classifier in terms of computation time period and accuracy. The advantages of using structural features are demonstrated by Harihar et al (2007). The structural features used in this work are extracted from the vascular network. The structural features are then used as input for the SVM classifier to distinguish the various types of blood vessels. But the system failed in case of thin blood vessels.

Saurabh et al (2007) have used the unsupervised curvature based retinal vessel segmentation technique. The region growing method is used for extracting the blood vessels. The random selection of initial seed point is the major drawback of this approach. Salem et al (2007) used the nearest neighbor clustering algorithm for blood vessel segmentation. The features used for this clustering approach are based on gradient magnitude and Eigen values. The results are compared with the conventional K-NN classifier to show the superior nature of the proposed method. A modified matched filter approach is demonstrated by Mohammed et al (2007). Modifications are performed in the fixation of filter parameters which yielded enhanced results. A comparative analysis with the conventional technique is also provided in this approach. The application of Genetic Algorithm (GA) for retinal blood vessel segmentation is explored by Mohammed et al (2007). GA is used for optimizing the various parameters of the matched filter. Experimental results suggested the superior nature of the optimized filter over the un-optimized filter. Unsupervised segmentation of retinal blood vessels is proposed by Nancy et al (2007). The unsupervised technique used in this work is the clustering algorithm combined with the Hessian matrix. Experimental results are compared with the piecewise threshold probing method to show the superior nature of the proposed approach.

Alauddin et al (2007) have used the unsupervised texture classification technique for blood vessel segmentation. Color and contrast are used as textural features in this work. FCM algorithm is then used for segmenting the blood vessels. Filtering approach is demonstrated for blood vessel segmentation by Changhua et al (2007). The Eigen vectors are extracted from these images and used for vessel segmentation. The proposed approach is tested on DRIVE database to evaluate the segmentation algorithm. Yong et al (2008) have used a hybrid method for retinal blood vessel extraction. The concept of morphology and fuzzy clustering algorithms are used in this work. But few post-processing procedures are required to preserve the weak edges. Divergence of the vector fields based vessel segmentation algorithm is implemented by Benson et al (2008). Laplacian operators are used in this work for segmentation. But spherical shaped vessels are not detected by this approach. Deformable contour model based retinal vessel segmentation is proposed by Espona et al (2008). The topological properties of the blood vessels are incorporated in this approach. The performance measure used in this work is arteriovenous index which is essential for pathology classification. Supervised linear classifier based retinal image segmentation is performed by Alexandru et al (2009). Feature vectors obtained from the blood vessels are used as inputs for the linear classifier. Experimental results suggested the superior nature of the proposed approach in terms of convergence rate.

Muhammed et al (2009) combined the Ant Colony (ACO) approach with the matched filter for blood vessel detection. The parameters are optimized using ACO and a comparative analysis is performed with the un-optimized network to show the superior nature of the proposed approach. Retinal vessel graph based vascular network detection is implemented by Bashir et al (2009). The algorithm used in this work is a junction resolution algorithm which forms the complete graph of the blood vessels. But the low accuracy due to many training error is the major drawback of this work. Multi scale quadrature filtering based retinal blood vessel detection is proposed by Gunnar et al (2009).

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

This approach combined the concept of both line and edge detection. The experimental results claim that the proposed approach is highly robust in nature. Line tracking based retinal vessel segmentation is implemented by Marios et al (2009). This method is also used on images with Gaussian noise and salt & pepper noise. The major drawback of the proposed algorithm is the high misclassification rate of the optic disk. Fourier cross-sectional profile is formed for vessel detection by Tao (2010). An extensive analysis is performed by changing the nature of the profiles such as Gaussian profiles. This technique also preserves the information available in the blood vessels. Bob et al (2010) have used the concept of matched filter combined with the first order derivative of Gaussian filter for retinal vessel extraction. A threshold is also used for post processing in this work. This technique is also implemented on pathological retinal images. But this technique is not suitable for noisy images.

4. LITERATURE SURVEY ON OPTIMIZATION TECHNIQUES

All the extracted features do not guarantee high accuracy. The presence of insignificant features reduces the output accuracy besides increasing the computational time period. Since both these parameters are highly essential, a methodology must be framed to eliminate the insignificant features. This technique of selecting an optimal feature set is called as feature selection. Though it is an optional step, many earlier works reported the usage of feature selection techniques to enhance the quality of the output. The applicability of Genetic Algorithm (GA) for pattern classification is explored by Kishore et al (1999). The samples belonging to the same class are accepted by this GA approach and the other samples are rejected based on the strength of association measure. A comparative analysis is also performed with the maximum likelihood classifier. Marco (2000) has demonstrated the selection of optimal fuzzy rules for a complex model using Genetic Algorithm (GA). A comparative analysis with the unoptimized model suggested that the learning time has been reduced significantly because of genetic based optimization.

Optimal fuzzy rule selection for classification is also implemented by Debrup et al (2003). A hybrid neuro fuzzy approach is used in this work with the architecture performing the selection procedure. But this technique is highly sensitive to change in the parameters of the membership functions. Yas et al (2003) have proposed a hybrid approach involving MLP and GA for pattern recognition. GA is used for optimizing several parameters of the neural network to improve the performance in terms of accuracy and convergence time period. Maximum output information based optimal feature set selection is performed by Vikas et al (2004). This feature selection is performed for improving the performance of Multi layer Perceptron (MLP) classifiers. The features for which the classifier outputs are high are selected as the optimal feature set. The output of the classifiers is estimated with mutual information and entropy.

5. LITERATURE SURVEY ON RETINAL DISEASE IDENTIFICATION TECHNIQUES

The concept of multimodal registration is used for Glaucoma detection by Paul et al (2002). The performance comparison of different techniques is analyzed in detail. Support Vector Machine (SVM) based exudates classification system is proposed by Alireza et al (2002). A comparative analysis with the neural classifier is also reported in this work. The experimental results claim that the neural classifier performs much better than the SVM classifier. Conor et al (2002) have used the skeleton operations to determine the change in retinal anatomy for DR detection in abnormal images. The features used in this work are vessel width and tortuosity. The experiment is analyzed in terms of accuracy. Agostino et al (2003) have used the neural network methodology to detect the keratoconous abnormal retinal images. Experimental analysis is performed in this work based on sensitivity and specificity. An extensive quantitative analysis is also yielded in this report. Alireza et al (2003) have used the combined FCM and neural techniques for exudates detection in diabetic retinal images. This methodology is implemented on color retinal images. The convergence rate reported in this work is also significantly high. Koen et al (2005) have developed a model to determine the changes in the retinal images for Glaucoma detection. The results are analyzed in terms of sensitivity and specificity.

Harihar et al (2005) have used the Bayesian algorithm for abnormal retinal image

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

classification. Multi-level classification is performed in this work with five classes. The concept of Markov random field is also used in this automated system. A better quality classification accuracy results are reported in this method. A comparative analysis on various automated drusen detection techniques are reported by Saurabh et al (2006). Contrast normalization method based microaneurysm detection in retinal images is performed by Alan et al (2006). This detection is based on the width of the detected blood vessels. Experimental results are analyzed in terms of sensitivity and specificity. But this method failed in case of small size abnormalities. Multifractal analysis of human retinal images is performed by Tatijana et al (2006). This approach is mainly used to detect the blood vessels which further aid in differentiating the different abnormal images. Texture based techniques and model based techniques are analyzed in detail in this report. Lack of quantitative analysis is the major drawback of this automated system. An automated system for glaucoma detection in retinal images is proposed by Kolar et al (2006). The fused images are used as input for this system. Fusion is performed through multimodal registration method. Analytical approaches are used to distinguish the normal and abnormal images. Xin et al (2006) have used the morphological operations for lesion detection in retinal images. Thomas et al (2007) have utilized the kernel density estimation method for microaneurysms detection in color fundus images. An automatic thresholding technique is also used in post processing to yield accurate results. Lack of robustness is the major drawback of this approach.

A hybrid approach of fuzzy theory and ART neural network is used by Jayakumari et al (2007). Hard exudates are detected from the abnormal DR images using this approach. The proposed methodology is tested on very less images which are the major drawback of this approach. Supervised algorithm for differentiating different retinal diseases is designed by Meindert et al (2007). This work is based on the pixel classification technique. This method is tested on a huge dataset which shows the robust nature of this approach. Morphology based disease detection is performed by Raghu et al (2007). Operators such as slicing, erosion are used in this automated system. Lack of quantitative analysis is the major drawback of this approach. Acharya et al (2007) have used the RBF classifier for disease identification in abnormal retinal images. Features are extracted using the fuzzy k-means algorithm and then supplied to the classifier. This automated system is tested on five different types of abnormal images which prove the generalizing capability of this system. Povilas et al (2007) have used the multi layer perceptron for ophthalmologic disease classification. Initially, features are extracted and then Principal Component Analysis is used for feature reduction. But the success rate of this methodology is based on input feature set. Wavelet based microaneurysms detection in retinal images is performed by Gwenole et al (2008). This sytem also involved the concept of template matching. Images from different modalities are used in this work and a comparative analysis reveals the superior nature of the proposed approach.

Linear Discriminant Analysis based abnormal retinal image classification is performed by Clara et al (2008). Different varieties of abnormal images are used to check the applicability of this approach. But the database used is not large enough to ensure the robustness of the proposed technique. Morphological operations based DR detection is implemented by Jagadish et al (2008). The features extracted using morphological operators are then used as input for the neural classifier. Only bi-level classification is reported in this paper. Wong et al (2008) have differentiated different stages of Diabetic Retinopathy (DR) retinal images. Back Propagation Neural Network (BPN) is used as the classifier in this work. A specificity of 100% is reported in this work. Cemal et al (2008) have used the inverse segmentation method for macular degeneration detection in retinal images. Various qualities of retinal images are used in this work and the proposed system yielded superior results for the entire data set. Mathematical morphology methods based DR exudates detection is performed by Akara et al (2008). Different morphological operations are used in this work and the effect of these operators for exudates detection is analyzed in detail. But accurate detection of blood vessels is required to ensure the high success rate of the proposed system. Rajendra et al (2008) have used the higher order spectral features for DR identification in retinal images.

The fuzzy clustering approach has been used for exudates detection in DR images by Akara et al (2009). Fuzzy C-Means (FCM)

ISSN: 2076-3328 www.ijric.org E-ISSN: 2076-3336

algorithm is used in this work for the detection of the abnormal region. Several performance measures are used in this work for quantitative analysis which is an added advantage of this work. Information fusion for DR detection in retinal images is performed by Meindert et al (2009). Different fusion methods are analyzed in this work through different experiments. The quantitative results are estimated and a comparative analysis is performed in this work. Indirect DR identification through optical disk detection is implemented by Arturo et al (2009). Analytical concepts such as filtering techniques, Hough transform are used in this system for DR detection in retinal images. The system is tested on a large dataset which is an added advantage of this technique. Model based exudates detection technique is implemented by Clara et al (2009). Edge detection is used as the post-processing technique in this approach. The performance measures used in this work are sensitivity and specificity. But the concept of spatial correlation is not incorporated in this system.

The application of multi-layer perceptron for hard exudates detection in retinal images is explored by Maria et al (2009). A comparative analysis with Radial Basis Function (RBF) neural networks and Support Vector Machine (SVM) is also provided in this report. Winder et al (2009) have extensively compared the different segmentation techniques for DR detection in retinal images. The performance comparison of the techniques on different data sets is reported in this work. This report also clearly reveals the merits and demerits of the various techniques available in the literature. Level set method based lesion detection is implemented by Elizabeth et al (2009). A comparative analysis with other segmentation techniques is also provided in this work to show the superior nature of the proposed algorithm. Auto associative neural network based retinal disease identification is implemented by Jayanthi et al (2010). A suitable feature set is extracted from the pre-processed images and supplied to the neural classifier fro classification. Lack of quantitative analysis is the major drawback of this approach. Carla et al (2010) have used the multiscale method for lesion detection in retinal images. Multi-level classification with four classes is used in this work. Distance metrics are used to measure the inter-structure similarity in this approach.

6. CONCLUSION

The merits and demerits of the existing techniques are exposed from this literature survey and hence suitable techniques are to be developed to maximize the performance measures of the automated systems. This survey also paves way for new innovative approaches such as hybrid techniques for performance enhancement. Finally, this work also suggests suitable methods for application in various stages of automated abnormality diagnosis systems.

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