# Review On Template Matching And Registration Of Retina Images For Teleophthalmology

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**Abstract**: The process of diagnosis and treatment concerned with various ailments that affects the retina and the choroid beneath it need acquiring a set of fund us images, which uses the fund us camera. Also, these images require processing for achieving a better form of diagnosis and also treatment planning. The process of retinal image template matching is highly necessary for the extraction of particular features, which may be of immense use in diagnosis and medical treatment. In addition, registration of retinal images is hugely valuable during the extraction the motion parameters, which aid in creating an entire map on the eye's retina and also in retinal tracking process. This research work presents an analysis for the image preprocessing, dimensionality reduction, template matching and registration approaches, which were reported for retinal images also.

**Index Terms**: Retinal images, Registration, Segmentation, Motion Parameter Estimation, Real Time Tracking, Template matching

## 1. INTRODUCTION

Retinal image processing is hugely necessary for the diagnosis and treatment planning of several diseases that affect the retina and the choroid element beneath it [1], [2]. Diabetic retinopathy is one among the criticalities associated with diabetes mellitus that affect the choroid and the retina. In this scenario, a network consisting of small blood vessels, known aschoroidal neovascularisation (CNV), develops in the choroid and using a part of the blood that is supplied to the retina. With the amount of blood that is supplied to the retina being reduced, the sight may be deteriorated and in critical scenarios, loss of sight may happen. The clinical experts attempt to provide treatment to this life-threatening ailment by using optical energy for the photocoagulation of the neovascularisation. For this, argon laser is employed in photocoagulation for cauterizing the small vessels that leads to an increase in the amount of blood that supplies to the retinal part and therefore the eye sight is maintained. This modality of treatment is attained in several steps. The doctor requests the patient to fix their eye in position so that the laser beam can be directed to the region affected. The present rate of success of this process is lesser than 50% for CNV treatment, after one session of treatment having a repetition and/or persistence rate of nearly 50%. The latter state needs performing the treatment again. But, a 50% failure rate is expected on repeating the treatment. In addition, various studies show that unfinished treatment corresponds to inferior prognosis rather than no treatment at all [3], [4]. As a result, there is a necessity to design an automatic laser system for treating the entire retina in just one treatment session. This system is aimed at scanning the retina and then tracking it by using the laser energy to the entire region except the delicate objects, which may be ruined by the laser beam. The system is supposed to perform this by acquiring the retinal images with a fund us camera. Later, these images need to get segmented with accuracy in order to acquire the crucial objects present in the retina like the blood vessel tree, the optic disk, the macula and the area between the optic disk and the macula. The locations of laser shots need to be disseminated in the remaining portion of the retina. In addition, a reliable registration approach has to be used for the detection of the retina's motion parameters for updating the positions of laser rays in accordance. [5]. Also, the fund us camera is able to capture an image of a part of the retina, however not the entire retina. The doctor, at times requires a full image of the retina so that a better diagnosis and therefore planning a good treatment is possible. The solution to this problem may be obtained with the help of few image processing algorithms to develop a full map of the retina. Here, in this research work, several image denoising, template matching, segmentation, dimensionality reduction and registration approaches, which were tested to offer the best performance for retinal images, are studied. These algorithms were used for the images in study for ensuring its usefulness and accuracy.


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## 2. LITERATURE SURVEY

The study clearly describes the concept of different processes of retinal images

### 2.1 Survey on Retina Image Preprocessing

An important problem faced by medical imaging systems is the impairment of visual signals acquired, owing to improper capture and transmission errors. Visual aberrations may develop owing to different factors such as time of exposure, lighting, and movement of eye and sensitivity of the imaging devices. These impact the images in terms of contrast, distortion and artifactsbrought in, blurring and contrast sensitivity. These visual variations have an adverse effect and complicate the image for understanding. This leads to image enhancement approaches to become necessary for improving quality parameters. Instances histogram equalization, image sharpening, contrast adjustment, edge enhancement and denoising. Few image preprocessing techniques are image contrast enhancement, image noise removal, threshold, edge detection and image segmentation.

Image pre-processing is regarded to be the foremost process of digital fund us image. There are two drawbacks encountered owing to the noise present in the medical images. They deteriorate the image quality and blur the significant information necessary for performing the diagnosis accurately. Both imply critical effect during analysis and need to be dealt efficiently. Therefore, all the medical images require an algorithm to boost the image and be useful to the medical experts in a rapid and efficient diagnosis. Marco et al.

(2005) [6] has employed compensation based approach for removing the illumination and contrast differences present in the retinal images. Normalizing these changes is carried out through the estimation of the irregularity observed in the image's background portion. But, this normalization does not affect some zones with "non-background" dark regions greater than 50%. Aliaa et al. (2006) [7] performed a comparative analysis between different contrast enhancement methods employed for retinal images. The implementations of these approaches are done on public databases and their results are provided. These results evaluate the advantages and drawbacks of different contrast enhancement approaches. Peng et al. (2007) [8] has applied transform based methods for enhancement of edge in images with lesser contrast. The resultant output images depend on the non-linear function that includes the noise effects. A comparative study is also carried out with few other methodologies. Nancy et al. (2007).has described the importance of red channel for accurate color retinal image processing is described. The segmentation of the blood vessels in the retina is carried out with the help of red and green channels of the retinal image and the outcomes are then compared with the segmented result obtained of the green channel pertaining to the retinal image. The outcomes of experiments are found to be promising for using the red channel for retinal image segmentation. Salvatelli et al. (2007) [9] has carried out a comparative study of the pre-processing approaches in color retinal images. et al. (2008) [10] suggested the implementation of a derivative based approach for background foreground separation. The 2D Gaussian kernels are convoluted with the second derivatives obtained of the input image for highlighting the blood vessels. However, less accuracy is the disadvantage of this system as mentioned in the report. Gopal et al. (2008) [11] has introduced a domain knowledge dependent blood vessel enhancement approach over colour retinal images. A correction factor is obtained from the estimated damage and utilized in this research work to reduce the contrast and illumination changes in retinal images. Yuan et al. (2008) [12] proposed a model that depends on vessel enhancement approach. The background suppression measure, smoother 'vesselness' measure and the responses at the crossings are much better than the traditional techniques. Jian et al. (2008) [13] reported a Directional field based retinal vessel enhancement approach. A single stage brightness normalization and neighbourhood enhancement is utilized in this research article. Farnell et al. (2008) [14] presented Multi scale line operation that depends on blood vessel enhancement. This multi scale line operation algorithm is dependent on the region growing method and the outcomes are then compared with the traditional median filtering methodology. The novel approach is suitable for every retinal disease classification application and the outcomes also show that the newly introduced approach is quicker compared to the traditional methods. During the last few decades, several techniques have been introduced to deal with the medical image segmentation problems employing unsupervised clustering techniques. But, these approaches face few drawbacks to get over the problems in image like intensity non-uniformity, partial volume effect, high impact noises and other artifacts during the procedure of segmentation. Amongst all other mathematical based segmentation techniques, Fuzzy C-Means has gained much focuses it obtains the actual information from the image itself and it does not need any information beforehand for processing the segmentation system. Fuzzy C-Means is a kind of fuzzy clustering. Fuzzy clustering is one among the primary approaches in cluster analysis. Lately, there are several mechanisms and methodologies have been designed for carrying out cluster analysis. Many conventional cluster analysis techniques involve crisp partitioning, in which each object is strongly categorized into a particular class. But, practically, the class attributes of many of the objects are not rigid and also unclear; therefore it is not desirably for hard partitioning. Lotfi. A. Zadeh [15] proposed the fuzzy set theory. It is an extended form of traditional set theory, and it yields a potential tool that can be used for soft partitioning. Ruspini [15]first introduced the concept of making use of fuzzy set theory [5] for clustering. As fuzzy clustering gets the degree of unpredictability of samples that belong to every group and defines the intermediate characteristic of their memberships, it can be more useful in objective depiction of the practical issues. Lately, Fuzzy clustering approach [16] is extensively used in several applications like clinical diagnosis, pattern identification, data analysis and image segmentation. As it does not need any previous knowledge on the objects of data and any personal intrusions of images, it is considered to bean essential tool used in evaluating the behavior and structural complications of images used in medical image segmentation [17]. The process of fuzzy clustering is performed with efficiency by employing FCM algorithm [18].

### 2.2 Survey on template matching and registration of retinal images

Various works on template matching of retinal images depends on more generic level image registration techniques that have been extensively analysed recently. But, the common retina registration techniques are focused on matching the image pairs, which both exhibit a big FOV with localized distortions or various image modalities. The available retinal template matching algorithms are confined to the detection of particular objects in the image, where the template usually has a particular characteristic, including the optic disc, exudates and artifacts [19]–[20]. Registration of retinal image, as it is a huge challenge: the nonvascular surface of retina exhibits homogeneity in normal healthy retinas, when having multiple pathologies in unhealthy retinas [21]. Retinal images acquired by adapter-based optics yield lesser information and exhibit inferior image quality, which leads to further increase in the tediousness involved with template matching. It is informative to introduce the present retina image registration techniques that could be utilized for template matching and their viability in dealing with the issue considered. Retinal image registration techniques can be categorized into area-based and feature-based techniques. Feature based approaches help in optimizing the association between the extracted important objects in retina images [21]. Generally, bifurcations, fovea, and the optic disc are the general features that are utilized for the registration of retinal image. A smaller FOV template exhibits very less probability of having particular marks on the retina, and therefore the fovea and optic disc are not desirable. Vascular bifurcations are hugely prevalent, when in the same way; the small number of divisions in the template cannot become the base for a reliable registration. In addition, the extraction process of the vascular network in images with less quality is hard. It can result in unclear vascular directions once the bifurcations are labelled. The common feature point based techniques are also realized in retinal registration, like SIFT-based [22] and SURF based techniques [23]. These techniques can perform the registration of the images in complicated cases and are useful computationally. They suppose that the feature point pairs can be robustly identified and then matched for the transformation estimation. Even though it is viable in several scenarios, the process can be a failure on low-quality retina images with no sufficiently unique features. Area-based techniques perform matching of the intensity dissimilarities in an image pair under a similarity measure, like SSD (sum of squared differences) [24], CC (Cross-Correlation) [25] and MI (mutual information) [26], then the similarity measure is optimized by conducting a search through the transformation space. Omitting the feature detection at the pixel level, such kind of techniques is strict towards inferior quality images compared to feature-based techniques. But, retina images having sparse features and identical backgrounds possibly make the optimization slip into local extreme. As ophthalmology is hugelybased on visual data, it is a desirable feature for telemedicine [27]. Digital acquisition of images and the capability for transmitting these images by electronic transfer across extensive distances with the next level subsequent image analysis makes the efficient usage of clinical resources in huge, rural areas possible, which may otherwise face hard time getting necessary help [28]. The most popular system used in 'tele-ophthalmology' is "store-and-forward", where the images get acquired, and are then transmitted by electronic means so that their analysis can be performed at a later point of time. This is in contrary to live video-conferencing, presently restricted by electronic transmission rates. "Tele-ophthalmology" can be used between primary health care specialists, optometrists and ophthalmic experts, or in between various ophthalmic units. Telemedicine has even been utilized for helping the medical officers (prison) in the diagnosis of ophthalmic patients, and thereby minimizing costs and probable serious conditions of prisoners, who reach out to specialist medical centres [29]. In a coordinated international project, telemedicine has been observed to be cost efficient in minimizing the difficulty of eye-disease, and that affluent nations may help in resource development of health care systems of non-affluent nations. Nations having extensive areas and also sparsely populated communities like Canada, Australia and India may reap huge advantage in terms of health care provisioning to these regions. Telemedicine plays a strong role in diabetic screening. Kawasaki et al. (2003) [30] stated that a consultant ophthalmologist had successfully assessed 1076 out of 1170 eyes' fundal images, when the images were transmitted over electronic mail. Lin et al. (2002)[31] mentioned that single non-mydriatic monochromatic wide-field digital photography of the disc and macula to offer more sensitivity for diabetic retinopathy screening compared tomydriatic ophthalmoscopy, during the electronic transmission to a reading zone. Once settled with a standardized seven-field colour photographs, the greater sensitivity of digital photography basically showed the decreased sensitivity associated with ophthalmoscopy in the detection of early retinopathy. The development of TOSCA (Tele-Ophthalmological Services Citizen-Centred Application) happened in Europe in the form of a project to minimize the occurrence of blindness resulting due to diabetic retinopathy (Luzio et al., 2004) [32]. Telemedicine has been investigated in screening for ROP. Yen et al. (2002)[33] discovered RetCam (Massie research Laboratories, Inc., Dublin, CA) images shot by a neonatal nurse were comparable with investigations carried out by an expert ophthalmologist having better sensitivity, but just medium rate specificity. Moreover, teleophthalmology has been used in macular diseases. Eikelboom et al. (2000)[34] analysed the impact of JPEG and wavelet digital image compression over the image quality used for telemedicine. The process of JPEG image compression divides the image into blocks consisting of 8×8 pixels and transforms these blocks into spatial frequency elements. Sampling this frequency domain information by close preservation of the low-frequency components and then approximation of the high-frequency components is carried out and the amount of information removed decides the compression extent. Wavelet uses band filters and low pass filters for the pixel rows and columns present in an image. This generates information over the low-frequency components of the image and the horizontal, vertical and diagonal details of the image, which consumes more time for computation). Eikelboom et al. observed that wavelet compression to about 15 KB for transmitting the images digitally was ideal if time and expenses have to be reduced. As to the reduction of computational time, the usage of JPEG compression to about 29 KB was a better alternate. All recent analysis that uses telemedicine in ophthalmology has not broadened the digital processes to digital image analytical methods. This might be hard owing to the necessity for considerably high-resolution images for carrying out quantitative digital image assessment. Transmitting these high-resolution images is presently not feasible for telemedicine. But, image compression algorithms are still in the evolution stage currently and with technology improvement, transmission of adequately high-resolution images for facilitating in digital image analysis may become possible.

### 2.3 Dimensionality reduction on retinal Images

Several dimensionality reduction approaches are available. They can be divided into two important groups, which include the linear techniques which help in the linear transformation of input feature space and non linear techniques. Non linear approaches presume the availability of low dimensional manifolds based on which the localization of the input data is done and the modified data is described using their positions on the manifolds that are found.The most popular examples of linear techniques include: 1) Principal Component Analysis (PCA) [26], which discovers the linear combinations of input variables having the highest variances, 2) Independent Component Analysis (ICA) reducing the statistical dependency between the components that are transformed [27], and 3) Linear Discriminant Analysis (LDA). LDA is a supervised technique, implying that the input data needs to be categorized into groups. LDA gets the linear combinations with best probable differentiation between the input vectors of various groups [28]. It is highly associated with the categorical preferences and cannot be carried out automatically, indicating that the multispectral images need to be marked using class values, before the minimization takes place. Kernel Principal Component Analysis (KPCA) extends PCA. KPCA performs the mapping of the actual space based on the kernel function, which permits to consider its non linear characteristics [29]. The most frequently employed nonlinear reduction techniques include Isomap and Local Linear Embedding (LLE). Isomap uses Multidimensional Scaling (MDS) that in turn maintains the distances between objects present in the lower dimensional spaces. Isomap considers the geodesic distances in the actual space. LLE presumes the local linearity exhibits the input space and re-builds every sample by linear means combining its neighbors. In the last step of LLE, the weights decided get mapped onto the enclosing global coordinates. The machine learning approaches need a train set, the set forming the basis for the examination and data mining of the input feature space. As to the linear dimensionality minimization, it decides the coefficients of linearity transformations and in the case of the non linear reduction it permits the discovery of manifolds. There are several applications of dimensionality reduction for the multispectral space reduction. Just some of them have been briefly described. In [30] and [31] the linear PCA and ICA techniques are utilized for the motion capture skeleton model parameters and binary silhouettes obtained from the visual images. In [32], Isomap reduces the silhouettes. The series of minimized human poses are categorized using Dynamic Time Warping, Hidden Markov Models and based on sequence features extracted. The usage of Kernel PCA to perform classification is introduced in [33]. Dimensionality reduction is an important stage in most of the systems of face detection, including linear [34] and non linear [35] techniques are brought into use. Dimensionality reduction is also used in domains including: the stock market analysis [36], detection of the network threats [45], analysis of biomedical datasets [37], palm print identification [38], hand and finger tracking [39] and several more. There are practically several examples of spectral dimensionality reductions. In [40] PCA transforms the spectrally segmented zones of hyper spectral plant images for the classification process further. In [41] ICA technique is utilized for the hyper spectral remote sensing imagery classification. Identical schemes devoted to land cover detection and geological examinations using Isomap and LLE are studied in [42] and [43]. The traditional linear Principal Component Analysis and nonlinear Kernel Principal Component analysis are applied here. The Isomap and LLE are not accepted due to the drawbacks that come in hand with the global train set.

## 3. INFERENCE FROM EXISTING WORKS

The eye renders a distinctivepossibilityfor imaging the inherent biological tissue in vivo and the diagnosis and monitoring of several diseases can be done with the help of ocular imaging. For instance, diabetic retinopathy is a general retinal problem related to diabetes, resulting in micro aneurysms, exudates and haemorrhages on the retina [2]. Variations of retinal arteries and veins, and also their ratios, can indicate hypertension [3]. Detecting these pathological variations using periodic retinal screening in a timely manner as well as analysing them is particularly vital for diagnosis and treatment in the early stages. High quality fund us images of the retina are classically obtained in an experimental lab setup with costly and heavy duty equipments. Capturing high quality fund us images imposes a problem for people residing in the remote and other undeveloped regions who need togo through many difficulties to obtain periodic checkups in the hospital. Visit to an ophthalmologist frequently is not easy for patients residing in the urban regions also. On the contrary, developing small and inexpensive fund us cameras permit quick, practical imaging of the retina, in spite of a reduction in image quality. Making use of compact fund us cameras present external to the clinic connects remotely located patients with their physicians [4], [5]. Through regular retinal monitoring and trend analysis of the data, ocular disease may no more be regarded to be the silent-killer disease, since early signs can be possibly be detected and also forecasted [6]. A common instance of such kind of fund us cameras is clip-on lens adapters, which is fixed to smart-phone systems [4], whereas these consumer-level optical devices exhibit two important drawbacks: small FOV and inferior image quality compared to lab-dependent fund us cameras. These drawbacks can be avoided with the help of template matching and registration process. Retinal template matching and registration is a significant problem in teleophthalmology using inexpensive imaging samples. Therefore, the efficiency of retinal match tends to become a more tedious task. Also, with noise that exists in the images, retinal matching is hard to be analyzed. Therefore, further research is carried out with the help of novel image denoising mechanism that depends on the clustering algorithm. Moreover, newly introduced work acquires the closest template of the retina image with the help of different techniques and it is utilized with area-based registration, rendering a much reliable technique. As far as the best of knowledge goes, this is considered to be the first template matching algorithm designed for retina images with smaller template images from unlimited retinal regions.

## 4. CONCLUSION

This research work provides a survey on the retinal image segmentation and registration techniques that are used on retinal images and are a useful tool in the diagnosis and treatment of retinal ailments. As a first step, various segmentation algorithms are used on the reference images for extracting the delicate objects that include blood vessel tree, optic disc and macula and the region present between them. Thereafter, a binary image is developed that has the delicate objects in the form of white objects in a black background. Next, several registration algorithms were applied for detecting the motion parameters associated with the retinal images yielding a less amount of time and yields superior accuracy.

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