Retinal Image Segmentation by using Gradient Descent Method

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ABSTRACT
Localization and segmentation are important task in medical image analysis. As we know detection of optic nerves is also a major problem in automated retinal image analysis system. Image segmentation of medical image is very complex and crucial step, in this series segmentation of retinal image is more complex in comparison of others. For the retinal image segmentation we use gradient descent method. Recent research is focus on better accuracy rate. This paper gives a bird's eye over all the detection technique toward fair segmentation of optic nerves using gradient descent method (GDM). For initialization of local contour we use Signed pressure force function (SPF) which is region-based active contour model.

Keywords
Retinal image; Optic nerves detection; Gradient descent method; Signed Pressure Force function.

1. INTRODUCTION
The optic nerve is one of the most important organs in the human retina. The central retinal arteries are going from the central vein of the retina through the optic nerve, by the outer layers of the retina with the blood. The optic nerve also works as intermediate for the flow of information between the eye and the brain. The optic nerve can be examined in a visualization of retinal retinal images. The Retinal image is an interior surface of the eye,
including the retina, optic disc and macula etc. Retinal imaging is a common clinical procedure used to record a visualization of the retina. The image can be used for diagnosis, treatment, evaluation and maintenance of medical history.

Detection of optical nerves is an important step in the development of systems for automated diagnosis of various serious eye diseases. It is designed an important in gradient descent many pre-processing algorithms use automatically identify other properties of the retinal image. The relatively constant distance between the outer diameter and the fovea can be used to facilitate the estimation of the position of the optical disk. Models of the posterior part of the eye disease are varied and usually require identification by a qualified eye doctor as clinical human observer. The use of digital retinal imaging in ophthalmology provides us with digitized data, which could be used in connection with computer-controlled detection of the disease. Indeed, many researchers use computerized image analysis of the eye, under the guidance of a human observer [1].

The OD regions removed before identifying retinal exudates, which are used to assess macular Edema risks and quality. The dimensions of the optical disk can also be used to measure properties due to abnormal glaucoma. Glaucoma is identified by detecting changes in shape, color or depth, produced in the optic disc. Thus, the segmentation and analysis can be used to automatically detect the mark of glaucoma. OD detection is not an easy thing. Macular region, they are a major cause of treatable vision loss in the non-proliferative forms of diabetic retinopathy. It would be useful to have created an automated method for detecting retinal exudates in digital images of screening programs for diabetic retinopathy [2].

Image segmentation is a process for the separation of the image pixels based on one or more selected image, and in this case the function of the selected segmentation, the color properties. The aim is the pixels of different colors in different regions and the same time a group of pixels that are spatially connected and have a similar color to be separated in the same region. Image segmentation has always been fundamental problem and complex task in the field of image processing and computer vision. His goal is to change, to change the representation of an image into something that is more meaningful and easier to analyze.

The optical disk is located in the PCA based model. The location is used for template matching. Template is designed to adopt different image resolutions. The pixel with the minimum distance in the candidate regions at all scales is located as the center of the optic disc. PCA is a mathematical procedure that uses orthogonal transformation to a number of observations can be used with a set of variable values correlated linearly correlated variables called principal components convert. The number of principal components is less than or equal to the number of the original components.

The color retinal images are used to monitor eye disease by ophthalmologists. Develop the background image automatically eye analysis and diagnostic system is to facilitate the ultimate goal of our research to the clinical diagnosis. Extraction of normal and abnormal functions of the eye, in the color image and the background is significantly useful for understanding the automatic retinal images. Normal properties retinal images include optical disc, fovea and blood vessels. Exudates and abnormal bleeding are the main features of diabetic retinopathy are the leading cause of blindness in the population of working age [3].

Active contour model has proven to be an effective framework for image segmentation. The basic idea of the active contour model is to start with a curve around the object to be detected, and the curve moves and stops on the inside of the real normal boundary of the object on the basis of a minimization of the energy consumption model. Level set method is based on the model-based and the active contours designed to treat the segmentation of the deformable structures. Typically use the traditional active contour model wedges to the boundary of a modeled object. However, the level set method is to use a deformable front curve to approximate the boundary of an object. Of the level set, the curve passes through the origin, called a smooth, generally define the function of level adjustment means shown. Displacement curves can be done by changing the level set functions instead of jumping curves. Therefore, the level-set methods have interesting elastic behavior and can effectively manage the topological changes is also an advantage compared to classical active contour model [4].

2. RELEATED WORK

The optic disk localization and segmentation are important tasks in an automated retinal image analysis. The system often condemned edge detection algorithms for general use to failure Segment of the optical disk by fuzzy boundaries, inconsistent Image contrast or missing features.

Jihene Malek Presents a method to automatically locate and boundary detect of the optic disk [1] which comprises two independent methodologies ie location methodology & boundary segmentation methodology and achieved 89% correct detection and 95.05% average accuracy in localizing the optic disc boundary.

M. Foracchia was presented a geometrical parametric model [8] based on vascular structure, are dependent on the availability of a good portion of this structure in the image, and independent of the actual visibility (or even presence) of the OD. The data samples of vessel centerline points and corresponding vessel directions, provided by any vessel identification procedure, model parameters. The availability of a vessel extraction procedure is a necessary prerequisite for our technique. The OD position was correctly identified in 79 out of 81 images (98%), even in rather difficult pathological situations. However, the remarkably good results we obtained using the data provided by either procedure used in this work, which were algorithmically different and independently developed, suggest that this is not a critical issue.

Huiqi Li described an approach [5] which is automatically extract the main features and robustly in color Retinal images based on methodology like optic disc localization and optic disc shape detection by two different methodologies. The localization is provide a better description of the feature in Retinal images or interior surface area of eye. The success rates achieved are 99%, 94%, and 100% for disk localization, disk boundary detection, and fovea localization respectively. The sensitivity and specificity for exudates detection are 100% and 71%. The success of the proposed algorithms can be attributed to the utilization of the model-based methods.

Adam Hoover [7] described an automated method to locate the optic nerve in images of the ocular fundus. They presented a new method to automatically locate the optic nerve in a retinal image. These methodologies used the convergence of the blood vessel network as the primary feature for detection, in conjunction with the brightness of the nerve as secondary properties. Above methods successfully detect the nerve in 89% of the cases, and in 100% of the healthy cases. For finding the convergence of the blood vessel network is based upon algorithm called fuzzy convergence. Unlike least-squares and Hough-space-based solutions, fuzzy convergence uses the endpoints of the linear shapes in case of blood vessel segment to help find the solution. Identifying the intersection of a number of lines (a convergence) is a fundamental geometric problem, with applications ranging from astronomy to engineering, such as model fitting and prediction.

Aliaa Abdel-Haleim Abdel-Razik Youssif are presents a method [9] to automatically detect the position of the OD in digital retinal Retinal images. This includes the interior surface of the eye, macula, retina etc. The OD detection algorithm is based on matching the expected directional pattern of the retinal blood vessels. A simple matched filter is roughly used to match the direction of the vessels at the OD vicinity. The retinal vessels are segmented using a simple and standard 2-D Gaussian matched filter. The segmented vessels are then thinned, and filtered using local intensity, to represent finally the OD-center candidates. The difference between the proposed matched filter resized into four different sizes, and the vessels' directions at the surrounding area of each of the OD-center The OD center was detected correctly in 80 out of the 81 images (98.77%). In addition, the OD-center was detected correctly in all of the 40 images (100%) using the publicly available DRIVE dataset.

3. METHODS USED

There are various methodologies which are used earlier for optic disc boundary detection. A principal component analysis (PCA)-based model was chosen to serve this purpose.

3.1 Method use for automatic location of optic disc:

Principal component analysis (PCA) is a mathematical method using orthogonal transformation, a set of correlated variables observed in a group of values of uncorrelated variables called substantially linear transform components. The number of principal components is less than or equal to the number of the original variables. Then the model approach PCA (Principal Component Analysis) is applied to the candidate regions to give the final placement of the optical disk. First, a simple method for grading the intensity image to the candidate regions where the plate appear and then PCA is applied only to the candidate regions to locate the papilla can find. PCA is a powerful tool in the recognition of identical shape shaped shapes CPA-based approach consists of three steps. Figure.1 presents the set of input retinal images where they Firstly, the eigenvectors of the training images are calculated. Then, a new image of the retinal is projected specified by the eigenvectors. Finally, the distance between the image of the fundus and its projection is calculated.

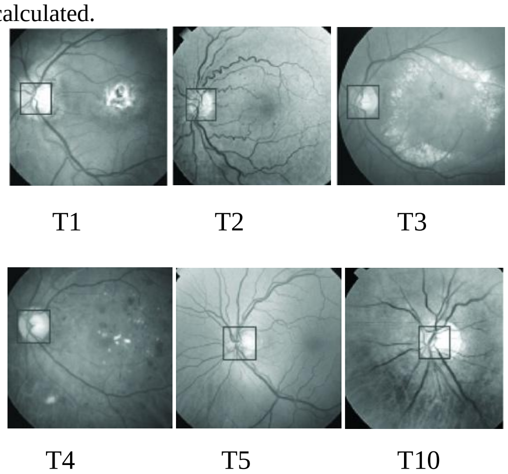

Fig 1: Input Retinal image

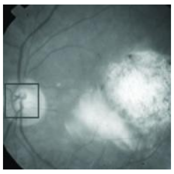

Fig 2: Average vector image

Figure.2 shows the average vector image obtained from training set image through the equation no. (1) and set of derivation of average vector is derived from equation no. (2)

$$\Psi = \frac{1}{M}\sum_{i=1}^{M} Ti \ldots\ldots\ldots (1)$$

$$\Phi_i = T_i - \Psi \ldots\ldots\ldots\ldots (2)$$

The subspaces defined by the eigenvector Φ_i, is called as disk space and eigenvector as Eigen disk. The eigenvector Φ_i, is a linear combination of the original training-image vectors and arranged in descending order according to its associated Eigen value.

3.2 Methodology for detection segmentation of optic disc:

After finding the center of OD, we still see its outline. The proposed process is, in the region of the applied DO limited to the RGB image to increase the accuracy and robustness of the method. The adaptive active contour model based on regions in evolution: region based level set formulation model (RSF) are used as model uses information from the intensities in the area recognize the limits of OD based. The method proposed in this work is carried out on a subset of the original RGB image . In this manner, the robustness and efficiency is increased in OD segmentation, because it reduces the search space, and reduces the number of objects and the present distracter entire image.

The technique of active contours has become quite popular for a variety of applications, including image segmentation and motion tracking during the last decade. This method relies on the use of deformable contours based with various objects Shapes and movements. There are two main approaches in active contours on the implementation of the mathematical work is based: snakes and level sets model. Snakes move explicitly points based on predefined snake energy Minimization scheme, while the lugs move contours implicitly set level than a certain level of Function. Region-based active contours use the statistical information of image intensity within each subset instead of searching geometrical boundaries. Most models of region-based active contours consist of two parts: the regularity, determining the shape and the smooth contours to minimize the energy that searches the uniformity of a desired characteristic within a subset. A nice feature of region-based active contour is the first contour be located anywhere in the image area based on Segmentation based on the minimization of the total energy, rather than based local energy minimization. Therefore, less prior knowledge is necessary for edge-based active contours.

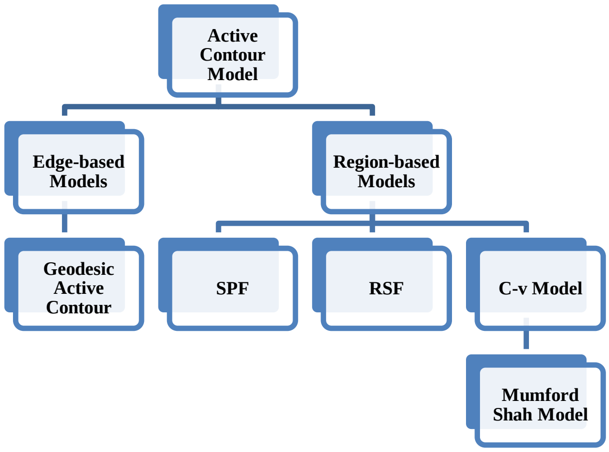

Fig 3: hierarchy of active contour model

Active contour model has been proven to an efficient framework for image segmentation. Active contour model is start with curve around the object to be detected, and this curve is moves towards its interior and stops until the true boundary of object which is based on energy- minimizing level. ACM is categorized into two parts for image segmentation is like, first is Edge-based models and second is Region-based models which are shown in figure.3. Region based model has many advantages over Edge-based models. All region-based models are used for curve evolution based on energy minimization via energy function.

According to above methodology we concluded that automatically detection of location of optic nerves was done though principal component analysis we will use Signed pressure force function is used for boundary detection of optic nerves which is region based level set formulation model because SPF function is which can efficiently stop the contours at weak or blurred edges. Second, the exterior and interior boundaries can be automatically detected with the initial contour being anywhere in the image. Third, the proposed ACM with SBGFRLS has the property of selective local or global segmentation. It can segment not only the desired object but also the other objects. Fourth, the level set function can be easily initialized with a binary function, which is more efficient to construct than the widely used signed distance function (SDF). The computational cost for traditional re-initialization can also be reduced. Finally, the proposed algorithm can be efficiently implemented by the simple finite difference scheme. Use gradient descent method terms of both efficiency and accuracy. Chan-Vase proposed an ACM which can be seen as a special case of the Mumford–Shah problem. The C–V model is formulated by minimizing the energy functional. Mumford shah model is used to establish an optimally creation for segmenting an image into sub-regions. An image is modeled as a piece-wise smooth function.

4. PROPOSED METHOD

Detecting the accurate boundary of optic nerves is the important detection and diagnosis of glaucoma, wherein the change in the shape and size of the optical nerves is used for detecting and measuring the severity of the disease. The boundary of the optic nerves is very complex as compare to others due to its highly variable appearance of retinal images. Region-based segmentation looks for uniformity within a sub-region, based on a desired property, e.g. intensity, color, and texture.

For detection of localization and segmentation of optic nerves use different approaches which is presented in figure.4 proposed flow chart in sequential steps like Euler or Gaussian function for remapping retinal image which is used for smoothing blurred images. After remapping image initialize active contour on image for introducing curve around object which is to be detected. This is used gradient descent method to utilize image based on Boolean force for segmentation of retinal image. Region based model is used for utilize the statistics information inside and outside the contour to control the evolution. Level set formulation based on SPF (Signed pressure force function) function region based active contour model. Where energy function is minimized and maximized by global and regularization term of energy function after that gradient descent method for optimize initial contour. Define convergence ratio of gradient descent method for obtaining finial image and apply on gray level set. Our methodology provides which gives better results as compare to previous methods these result in accuracy for identification and accuracy for localizing the optic nerves boundary.

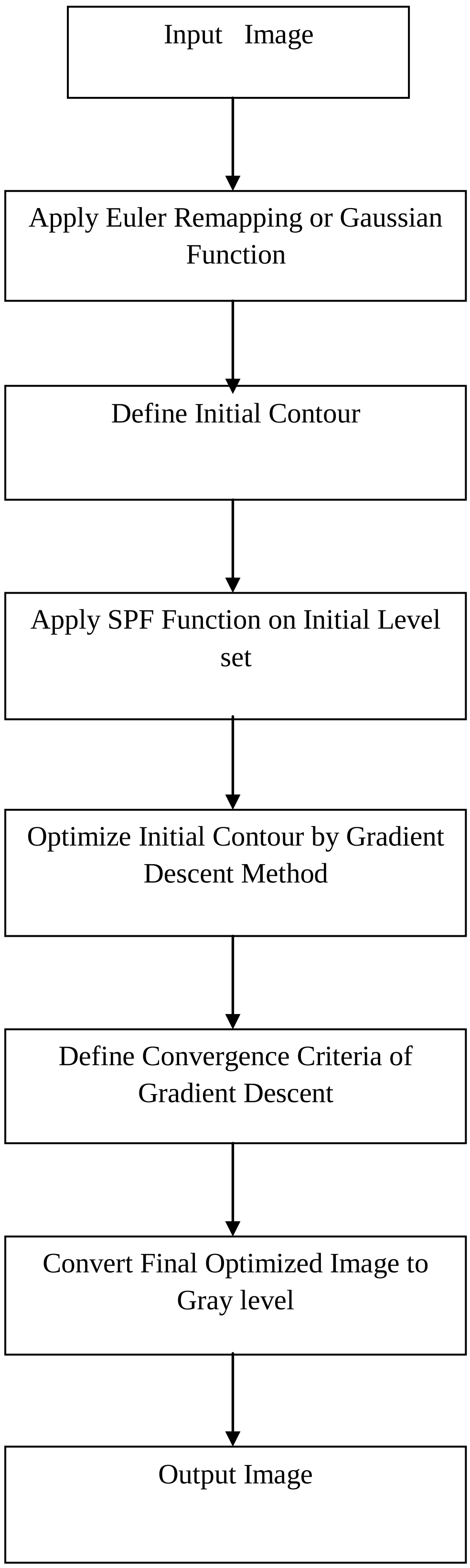

Fig 4: Proposed flow chart

Proposed Algorithm:

The propose algorithm is described as follows:

1. First take input image as jpeg format for segmentation and localization of optic nerves of retinal image.
2. Apply Euler remapping or Gaussian function as smoothing filter for removing noise and blur reassembling.

$$e^{\theta i} = \text{Cos}\,\theta + i\,\text{Sin}\theta$$

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Where, σ is standard deviation of Gaussian distribution, x is distance from the origin in horizontal axis, y is distance from the origin in vertical axis, e is Euler no.

3. Define initial level contour for introducing curve around the object to be detected.

$$\{\,(x)\ \emptyset\,(x; t = 0) = 0\}$$

4. Apply SPF function on initial level set for modulates the sign of pressure force inside and outside the region of interest based on minimizing and maximizing the energy function of curve.

$$\text{SPF}(I(x)) = \frac{I(x) - \frac{C1+C2}{2}}{\text{Max}\left(\left|I(x) - \frac{C1+C2}{2}\right|\right)}$$

$$\text{Min}(I(x)) < \frac{C1+C2}{2} < Max(I(x)),\ x \in \Omega$$

$$\frac{\partial\emptyset}{\partial t} = \text{SPF}\,(I(x)).\left[\text{div}\left(\frac{\nabla\emptyset}{|\nabla\emptyset|}\right) + \alpha\right]\ |\nabla\emptyset| + \nabla\text{SPF}\,(I(x)).\nabla\emptyset\,, x \in \Omega$$

Where,C1, C2are two constants which are the average intensities inside and outside the contour, Ω is planer curve, ∇ is gradient operator

$$C1(\emptyset) = \frac{\int_\Omega I(x).\ H(\emptyset)\,dx}{\int_\Omega H(\emptyset)\,dx}$$

$$C2(\emptyset) = \frac{\int_\Omega I(x).\ (1 - H(\emptyset))\,dx}{\int_\Omega (1 - H(\emptyset))\,dx}$$

$H(\emptyset)$ Is Heaviside function.

5. Optimize initial contour of Gradient Descent method for local minimization of function.

$$b = a - r\nabla f(\emptyset)$$

$$f(\emptyset) = \alpha(x_i - y_i)^2 + \beta(y_i - y_{i+1})^2 + \beta(y_i - y_{i-1})^2$$

Minimize with Gradient descent

$$\emptyset' = y_i + \alpha\,(x_i - y_i) + \beta[y_{i+1} + y_{i-1} - 2y_i]$$

Where x, y are pixel, y_{i+1} pixel at next level, y_{i-1} pixel at previous level.

6. Define Convergence criteria of gradient descent through convergence ratio

$$\nabla\,\emptyset(t_n) = \frac{\emptyset(t_{n+1}) - \emptyset(t_n)}{\Delta t}$$

Where, $\emptyset(t_{n+1})$ is level set of (n+1)th level, $\emptyset(t_n)$ is level set of nth level, Δt is difference between t_{n+1} and t_n .

7. Convert final optimized image to gray level level set

$$\emptyset(I) = \frac{1}{1 + (\nabla I * + \emptyset).2}$$

$\nabla I *$ = difference of smoothened image

8. Finally obtained output image

5. EXPERIMENTAL RESULTS

To illustrate the behavior of our method, we use two medical images with blood vessels. The first is a retinal image in TIF from the DRIVE database and apply it on filtering function shown in figure 5

Fig 5: Input images

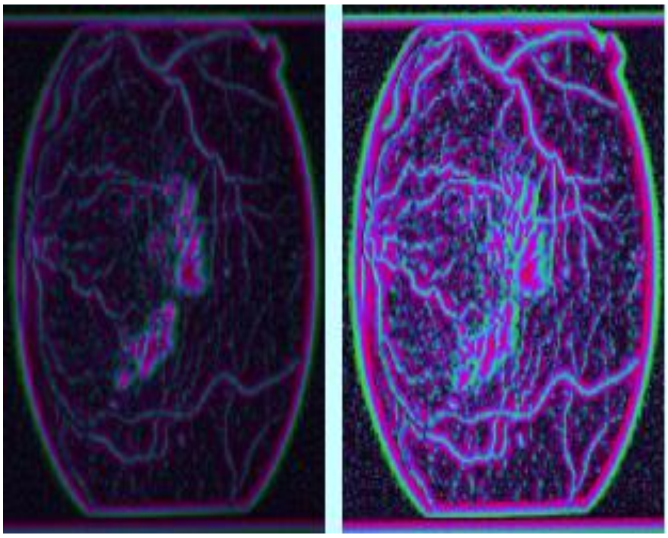

Fig 6: Images filtering and normalization result after applying Gaussian filtering or Euler filtering function.

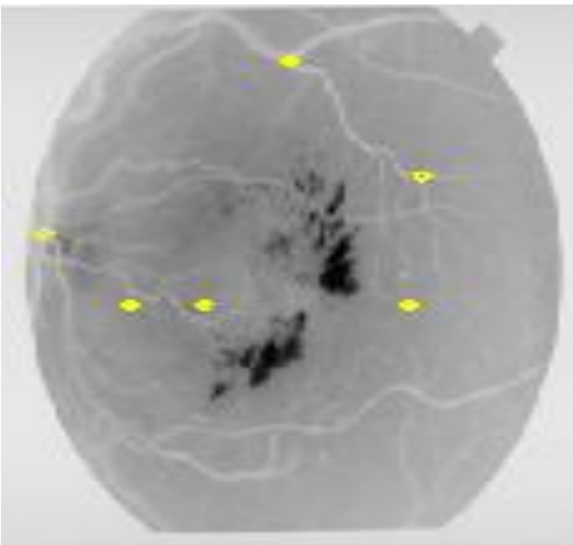

Fig 7: Define Initial Contour

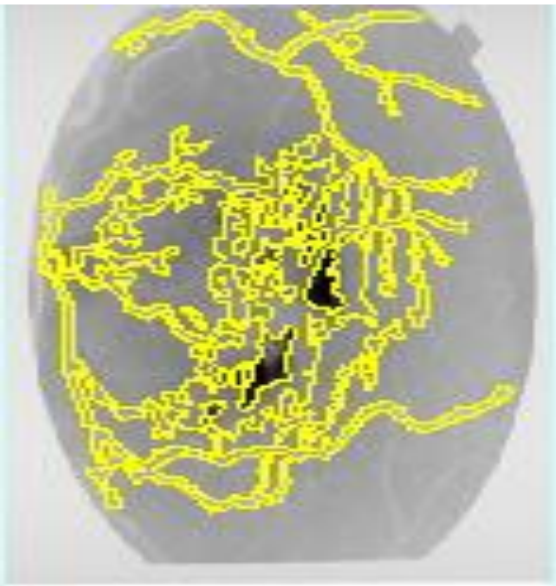

Fig 8: The Iterations on the retinal image using conventional gradient descent

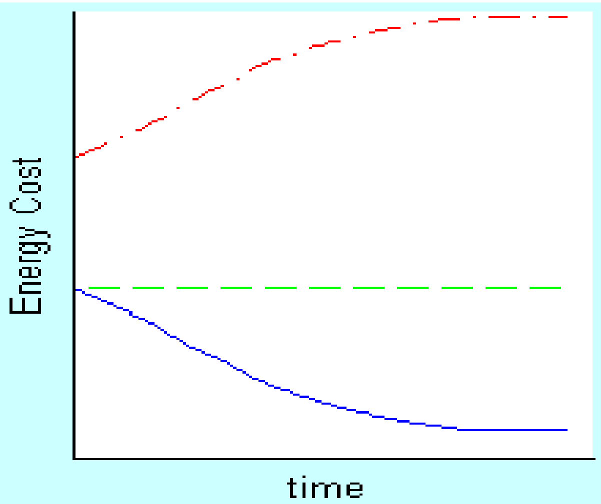

Fig 9: The Plots the graph between time, energy cost function, length penalty function, target function for synthetic test image.

6. CONCLUSION

This paper shows the brief description of all detection techniques that has been recently introduces for localization and segmentation of optic nerves and analysis the automatically locate and boundary detection to the optic nerves. A data fitting energy is defined in terms of a contour and two fitting functions; that approximate the image intensities on the two sides of the contour. This energy is then incorporated into a variation level set formulation, from which a curve evolution equation is derived for energy minimization. The results from the SPF method were compared with conventional optic disk detection using an active contour model (ACM) and later verified with hand-drawn ground truth. Results indicate 92% accuracy for identification and 97.15 % average accuracy in localizing the optic disc boundary. In future we may negotiate the results found in study of identification and accuracy of localizing the boundary of optic nerves and achieve it up to 100%.

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