Artery-Vein Detection using Neural Network in Retina Images

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ABSTRACT:
Retinal veins segmentation play a vital role in the life because of entire world moves toward the digital words. The paper presents an approach to identify the blood vessels from the optically affected areas of an eye. This method is proposed as the manual extraction of vessels from the fundus image is a very tedious task also it takes higher amount of time. Therefore, the paper mainly focuses on the developing an approach for vessel extraction. The methodology reportedly excels in terms of accuracy also being simple it finds many applications in image diagnosis for predicting various pathological diseases ophthalmologically. It can create a new perspective in disease detection in a more accurate way. The input images are initially preprocessed; next the features are extracted from the images. The extracted images form the training set and the testing process is performed using the proposed methodology. Finally, the proposed work achieved 96.8% accuracy on benchmark datasets.

Keywords: Fundus images, vessel extraction, features, ophthalmologic diseases, segmentation.

1. INTRODUCTION

Day by day demands are increasing in medical sectors because of huge populations in the world [1-3]. In medical field, Retinal veins segmentation play a vital role in the life because of entire world moves toward the digital words [4]. For the most part project a minor variance outward circulation and show up as a wire work like pattern or nodes-like pattern [5-7], [17]. Their variant highlights, for example, length and width, is critical in the early location and treatment of various angiocardiopathy and visual infections, for example, stroke, vein...
impediments, diabetes and arteriosclerosis [4], [9-10], [20]. The investigation of morphological highlights of retinal veins is helpful for distinguishing and rewarding an ailment in time when it is still in its beginning phase. Since angiocardiopathy and visual illnesses seriously affect human's life, the investigation of retinal veins is of incredible hugeness in numerous clinical applications to uncover significant data of fundamental infections and bolster conclusion and treatment [11-13]. Accordingly, the necessity of vessel examination framework develops quickly, in which vessel division is the first and one of the most significant advances [14-15].

Vessel division is a first process needed for the numerical investigation of optically affected retinal pictures [10], [16-17]. The divided vascular tree can be utilized to extricate the qualities of veins, for example, length, width, stretch and edges. Besides, the vascular pattern has been received in multimodal retinal picture enlistment [18-20] and retinal mosaic [11] as the steadiest element in the pictures. In the improvement of a PC helped demonstrative framework for ophthalmic disarranges, programmed division of retinal vessels has been acknowledged as an essential and testing step [7], [21-22]. The size and shape of retinal vessels can fluctuate colossally in various neighborhoods. The width of veins frequently runs from 1 to 20 pixels, contingent upon both the anatomical width of the vessel and the picture goals. The presence of vessel intersection, fanning and centerline reflex makes it troublesome [23-25] to section the vessels precisely utilizing misleadingly structured highlights. Pathologies as sores and exudates can additionally muddle the programmed division. In the last decades, various researchers proposed different techniques and they can be partitioned into two classifications: unaided and managed strategies. The main objective of this research is to identify the artery/vein in the retinal images such that the veins can further be processed to identify the pathologies in the fundus images. These pathologies can be used for early detection of various impediments of the human body.

This paper summarizes the following information: section II represents the literature work of existing algorithms. Section III represents the proposed methodology. Section IV describes the result of the proposed methodology. Finally Section V represents the conclusion of overall framework.
2. LITERATURE REVIEW

In everyday life, medical sector play an important role because of our hectic schedule in the real life. Hence no of researcher and scientist are working in the field of retinal vain detection. Various authors done good work in the field of retinal detection and few of description are shown in Table 1.

Table 1: Literature work of Retinal Artery/Vein Separation techniques

| S.No | Name of author | Year | Methodology | Accuracy |
|------|----------------|------|-------------|----------|
| 1    | Rolando Estrada et al. [13] | 2014 | Vessel topology estimation | 92%      |
| 2    | Vinayak Joshi Joseph et al. [19] | 2014 | Graph search | 91%      |
| 3    | Qing shao, et al. [24] | 2014 | Spectral domain – optical coherence tomography (SD-OCT) | 86.4%    |
| 4    | Nima Hatami, et al. [23] | 2015 | Local binary pattern (LBP) | 75%      |
| 5    | Shishir Maheshwari et al. [15] | 2016 | Empirical wavelet transform and correntropy | 96.6%    |
| 6    | Mei zhou et al. [25] | 2017 | Luminosity and contrast adjustment | 90%      |
| 7    | Fan Huang et al. [3] | 2018 | genetic-search feature selection | 90.2%    |
| 8    | Sehrish qummar et al. [14] | 2019 | 5 CNN models ensemble (resnet50, inception v3, xception, dense121, dense169) | 85%      |
| 9    | Dong ming li et al. [8] | 2019 | dual-tree complex wavelet transform and morphology | 85%      |
| 10   | Ahmed Soomro et al. [16] | 2019 | Fuzzy c mean , CNN | 95%      |
| 11   | Pan xiuquin et al. | 2019 | Residual module and u-net network combination | 96%      |
According to the Table 1, it can be concluded that research has been performed on the retinal data which can be used to detect various pathologies. Various researchers has followed methods like vessel search topology estimation, graph search method, LBP, Genetic search, Empirical wavelet transform and core entropy etc. out of which wavelet transformation has given the maximum accuracy till now but the system complexity is more in core entropy[9].

### 3. SYSTEM MODEL

A novel CNN algorithm is proposed, in order to eliminate the complexity as well as improve the accuracy of Retinal Artery model. Input image has been taken from the standard benchmark database as an RGB image. The features maps are obtained through CNN Algorithm as shown in the Figure 1.

#### 3.1 Pre-processing:

The input image is fed to the processing unit. Since the inserted image will be a complex image, it must be converted to a grayscale image. This process is called pre-processing. The next step is to remove noise in the input image using an adaptive median filter.
3.1.1 Adaptive Median Filtering:

In real time applications, the input images are generally associated with the noise components which cause some complexity in the analysis of the system and hence the noise has to be removed. The process has to be done such that the mean square error is minimal. The most traditional way of removing noise is by using median filter which generally uses bubble sort. The number of computations used here increases as the dimension of the frame changes, also the dimension of for every application is fixed. For instance, if a window of size 3*3 is used then it requires 30 computations to calculate the median of the sorted array.

The adaptive median filter is made to eliminate errands with a standard median filter. The variable dimensions of the mask are the main distinction between the two filters. This difference is based on the average pixels in the current mask. If the average value is shot noise, the dimension of the window will expand. Otherwise, the image performs additional processing within the specifications of the current window.

Accordingly, the Adaptive Media Filter eliminates the image point noise and reducing image degradation. It can handle the damaged image filtering process with a potential
noise impulse higher than 0.2. In particular, if the pixel p satisfies \( I(s,t) = I_{\text{max}} \) or \( I(s,t) = I_{\text{min}} \), hence point p is considered as impulse point, for by and large the value of noise is neighborhood greatest or nearby least. If \( I(s\pm m,t\pm n) \) point is valid pixels, \( I(s\pm m,t\pm n)<a \) and \( I(s\pm m,t\pm n)>b \) assign its position \((m,n)\) and find the distance from the origin \( I(s,t) \) denoted by \( r \), and it can be represented by

\[
\begin{align*}
  r &= \left\{ \begin{array}{ll}
          |s-m|, & |s-m| \geq |t-n| \\
          |t-n|, & |s-m| < |t-n| \end{array} \right. \\
\end{align*}
\]

where \( a \) and \( b \) are the probabilities of noise and \( m,n \) are the coordinates of the pixel values.

Once the \( r \) value is calculated for one origin pixel, the same process is continued for all the window sizes and the most repeated value is takes as the magnitude. And the window size is \( 2r+1 \). After the calculation of the window size, the median value is now calculated for the sorted sequence.

**Algorithm: AMF**

1. Check if intensity of the pixel is equal to the max of min values
2. Compute the distance of the pixel from the origin if it is a valid pixel and if it lies between the noise probabilities
3. Let the distance be \( r \)
4. The window size is now assumed to be \( 2r+1 \)
5. The median is computed after the window size is computed.

### 3.2 CNN Modeling:

CNN includes the knowledge of biology, mathematical modeling and computer sciences attached to it. CNN comes under the class of deep learning or deep neural networks that is most commonly applied to access medical images.

CNN handles the tasks of image recognition and image classification. CNN classifications used an input image, analyses it and distinguish it under certain categories. A computer sees an input image as array of pixels and it depends on the image resolution. CNN working procedure can be classified as 2 basic steps. They are:

- Feature learning
• Connected layers

There are four main layers in CNN. They are conversion convolution layer, pooling layer, activation functional layer and fully connected layer as shown in Figure 2.

![Architecture of the Proposed Methodology](image)

**Figure 2: Architecture of the Proposed Methodology**

### 3.2.1 Convolution + Relu

Convolution is the primary process to calculate the properties of an retinal portion of the eye. Convolution captures the information between pixels by stored picture properties utilizing minimum masks of data. It is a quantitative analysis which uses two information sources, for instance, image matrix and a filter or kernel. The matrix multiplication operation can be done between input (p) and filter (k) of the image. The deep convolution filter should match with the depth of the image. Higher the number of different filters higher the feature maps. All this conversation operations text at a place known as receptive field. The processor performs image classification by considering low level features such as edges and curves, and then creating more detailing concepts by a series of convolution layers. That is, by change of filter matrix we can obtain the edges, blur and sharpening etc. and if a filter does not match
perfectly padding can be used ReLu can be modeled as noisy ReLUs by the following mathematical model

\[ f(i) = \max(0, i + N) \text{ with } N \sim \text{Noise}(0, \sigma(x)) \]

### 3.2.2 POOLING:

According to Max-Pooling layers, it takes the biggest value in the window size (m,n) for the further procedure as shown in Figure 3 and it also performs noise suppressant. While down sampling, it discards the noise value through activations function. Hence, this process also covers dimensionality reduction. This convolution and pooling is repeated for several times until the required level is reached which is already pictured in the structure.

![Pooling mechanism](image)

### 3.2.3 Activation Functional Layer & Fully Connected Layer

It gives a curvilinear connection among input and output layers. This layer influences the system execution. Non-direct learning of the system happens through activation function. There are various kinds of enactment capacities, for example, Linear, Sigmoid, tangent, however the nonlinear ReLU (Rectified Linear Unit) actuation work is normally utilized in CNN. At last, fully connected layers required for classification of the retinal veins.

Assume a CNN with Y layers where the final 3 layers are fully connected layers. Likewise assume \( \alpha_l \) mean the pace for \( y^{th} \) layer in the system. It calibrates just the updated part of the system for \( \alpha_l = 0 \) and \( y \neq Y \). The degree changes relates to preparing a
linear classifier with the features created in layer Y-1. Similarly, the last 2 layers of the system can be calibrated by setting $\alpha_l = 0$ for $y \neq Y, Y-1$. This degree of adjusting relates to preparing a counterfeit neural system with 1 concealed layer, which can be seen as preparing a nonlinear classifier utilizing the highlights created in layer Y-2. Also, adjusting layers Y, Y-1, and Y-2 are basically comparable to preparing a artificial neural system with 2 hidden layers. Counting the past convolution layers in the update procedure further adjusts the pre-prepared CNN to the current application however may require increasingly marked preparing information to abstain from over fitting. By and large, the early layers of a CNN learn low level picture features, which are relevant to most vision assignments, yet the late layers learn significant level features, which are explicit to the current application.

To close, with recovery of CNNs attributable to the improvement of incredible processing strategies, the clinical imaging writing has seen another age of computer- aided identification frameworks that show improved execution. Examples: polyp discovery for colonoscopy recordings, PC helped location of aspiratory embolism (PE) in CT datasets, programmed recognition of mitotic cells in histopathology pictures, PC supported identification of lymph hubs in CT pictures, and PC supported life systems location in CT volumes. Utilizations of CNNs in clinical picture examination are not restricted to just computer-aided detection systems, in any case and thus is utilized in arrangement of retinal veins.

3.2.4 Softmax function:

It is a normalized exponential function. It is used as an activation function to normalize the output in the form of probability distribution. The softmax function $\sigma$ for the input vector $x$ of $k$ real numbers is defined as:

$$\sigma(x_i) = \frac{e^{x_i}}{\sum_{j=1}^{k} e^{x_j}} \text{ for } i=\ldots,k \text{ and } x=(x_1,\ldots,x_k) \in \mathbb{R}^k$$

3.3 Post Filtration:

At last the post-filtration operations applied on the processed image so that the output is much presentable and is easy to be understood by the end user. This includes the background exclusion also.
4. NUMERICAL RESULTS

4.1 Data Sets & Evaluation Parameter:

The data sets used for the experimentation are DRIVE and STARE. The images used in this data set are of JPEG standards. The images were provided by the screening program in Netherlands. The program constituted of the data from the people belonging to the age group of 25-40 years. The images are 8 bit images with 768*584 dimensions. The Stare database was provided by university of California. Blood vessel segmentation datasets consists of images from 30 people. Out of the total samples present in the database 70% of the images were the training samples and 30% were used as test samples.

Evaluation parameters used is

\[ \text{ACCURACY} = \frac{TP + TN}{TP + TN + FP + FN} \]

where TP, FN, FP and TN represent the number of true positives, false negatives, false positives and true negatives, respectively.

4.2 Comparison of Results:

The entire experiment is performed on a PC setup having compatibility of 8GB RAM and NVIDIA graphic card interface. The images were processed in MATLAB 2015 software.

![Figure 4: (a) Input image (b) Pre-processed image (c) Segmentation Results](image)

Table 2: Comparison of Proposed work with existing methodology
| S.No | Name of author          | Methodology                                      | Accuracy |
|------|-------------------------|--------------------------------------------------|----------|
| 1    | Nima Hatami, et al. [23], 2015 | Local binary pattern (LBP)                       | 75%      |
| 2    | Shishir Maheshwari et al. [15], 2016 | Empirical wavelet transform and correntropy     | 96.6%    |
| 3    | Mei zhou et al. [25], 2017 | Luminosity and contrast adjustment               | 90%      |
| 4    | Fan Huang et al. [3], 2018. | genetic-search feature selection                 | 90.2%    |
| 5    | Dong ming li et al. [8], 2019 | dual-tree complex wavelet transform and morphology | 85%      |
| 6    | Ahmed Soomro et al. [16], 2019 | Fuzzy C Mean                                     | 95%      |
| 7    | **Proposed Work**        | **CNN**                                          | **96.8%**|

Figure 5: Segmentation Results
5. CONCLUSION

In this paper, the proposed work used AMF & convolution based network to improve the accuracy of vein detection. The proposed method was estimated on publically available DRIVE and STARE benchmark databases. Finally, the proposed work gives better results on vein detection as compare to existing methods. Overall, the proposed work achieved 96.8% accuracy on benchmark datasets. In future, we want to improve the algorithm with deep learning process so that retinal based module will be more efficient & precise in the real life.

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