Automated Fundoscopy for Glaucoma Detection and Classification

Syed Akhter Hussain, Deshmukh R. R.

Abstract: glaucoma is leading chronic eye diseases in the world that leads to vision lost. The main cause of Glaucoma is intrinsic deterioration of the optic nerve which leads high intraocular pressure of the eye. Manually detection of glaucoma is tedious and costly. In our work we are providing automated system for glaucoma detection which is based on fully connected conditional random filed (FC-CRF) model, it works on long and thin structure. Conditional random filed provide a platform for structure prediction. Taking benefit of current results, validating assumption and parameters of our system learned automatically with the help of structured output support vector machine. Our system trained both quantitatively and qualitatively on publically existing data sets: DRIVE, STARE, CHASEDB1 and HRF. Once we obtain segmentation results further classification is done by SVM and K-NN classifier results of our proposed system is analyzed with gold standard labeling provided each data sets in terms of TP, TN, FP and FN. importance of our proposed system is it works for enlarge structure which can provide a platform to other biomedical and biological applications.

Keywords:-vessel segmentation, fundus image, k-NN, SOSVM, CRF.

I. INTRODUCTION

Retina is a part of central nervous system resides in peripheral location represents the neural portion of human eye. Detecting macular degeneration (ARMD) which may result total vision lost or blurred vision, diabetic Eye or diabetic Retinopathy(DR) occurs due to diabetic mellitus, and retinopathy of prematurity(ROP) occurs due to unwanted growth of retinal vessels, segmentation of blood vessels contains elementary role in diagnosis of eye syndromes. Segmentation is an important step in visualization of programs for primary detection of eye syndrome. The development of Automated detection system is beneficial it simply means the system combine all screening programs in a single system to provide accurate results. The idea behind developing automated system is ophthalmologist unable to detect exact results in a single screening hence it is not feasible to get results in time [1]. These systems usually perform morphological operations on retinal structure of blood vessels this immense information will help us for further examination and treatment [1]. For diabetic retinopathy early detection plays a vital role to avoid vision lost [2].
Additionally, we validate our results, quantitatively and qualitatively on freely existing standard datasets (DRIVE, STARE, CHASEDB1 and HRF). Our system performs on multiple quality measures to obtain accurate results.

II. METHODOLOGY

In our proposed work we are providing automated fundoscopic system for glaucoma detection by discriminatively fully connected conditional random filed (FC-CRF) model. It can graphically plot retinal images, it means we used pixel as node having connection with an edge to its very closest neighbors. Using this technique we are able to get detailed information of neighbor pixels as well as interface between elongated pixels. Using this technique we obtain exact segmentation result but it is time consuming because it is computationally complex at the training phase. This problem is overcome by defining pairwise edge potential in the form of linear combination of Gaussian kernels [30], it means it uses approximate mean arena of the primary CRF, capable towards exact segmentations within fraction of second.

• FC-CRF Segmentation of retinal vessels

To understand this technique we are having certain mathematical formulations as we know here we are going to apply energy minimization on conditional random field. This process is carried out using features of unary and pairwise potentials. Simply unary potential encode local information of pixel and pairwise potentials. Simply unary potential encode local information of pixel and pairwise potential assign labels to two neighbor pixels in our case it define inference.

\[ E(y) = \sum_i^i \psi_u(y_i, x_i) + \sum_{i<j}^j \psi_p(y_i, y_j, f_i, f_j) \]  

Where \( \psi_u \) is unary energy function

\[ \psi_u(y_i, x_i) = -(w_{u,y_i} x_i - \beta_{y_i}) \]  

\( \Psi_p \) is pairwise energy.

\[ \psi_p(y_i, y_j, f_i, f_j) = \mu(y_i, y_j, f_i, f_j) \]  

By adding equation (2) and (3) we get energy function.

\[ \Psi_{u,p} = \text{pairwise energy.} \]

After getting energy function we need pixels those differs form mean value of the group to obtain this we use Gaussian kernel which is mathematically depicted as follows.

\[ k^{(m)}(f_i^{(m)}, f_j^{(m)}) = \exp \left( -\frac{(p_i - p_j)^2}{2\sigma^2} \right) \]  

Where \( k^{(m)} \) is kernel \( f^{(m)} \) is random feature, \( W_p^{(m)} \) group of linear weight and \( \mu(y_i, y_j) \) label compatible function.

A. Learning of Structured support SVM through conditional random field

It is a machine learning algorithm mostly used in binary classification. SVM works on linearly separable points (features), means it contain a hyperplane that separate the points (features) in the single category. In our case this condition doesn’t satisfied because we are having multiple features, to overcome this we apply 1-slack formulation (slack variables are responsible for measuring distance between point to its marginal hyperplane). Using this technique we learn vector \( W \) having different unary features with respect to bias and pairwise kernels. By using mathematical formulation we calculate weights \( W \).

\[ \min \frac{1}{2} \|W\|^2 + C \xi \]  

Where C can defined as regularization constant.

B. Classification

In this work we are having two types of classifiers SVM and k-NN for classification.

- SVM

In our work we can define support vector machine as a support vector classifier. Here kernels (similarity quantifier) extend the feature space. It is supervised learning technique classification and regression analysis is done by analyzed data. In our case we need non-linear classification to deal high dimensions for this purpose we tune the following parameters.

a) Kernel parameter: responsible for linear or non-linear separation.
b) Regularization parameter: Responsible for svm optimization in training phase by measuring the quantity of misclassifying avoided points.
c) Gamma parameter: defines the low (far), high (close) influence in training phase.
d) Margin parameter: -line separation for high class points.

- k-NN

It is distribution free means depends on observations means here we don’t know target variable. Related identified neighbors are defined by number \( K \) we get closest training samples using \( K \) factor, when \( k=1 \) we call it nearest neighbor algorithm.

a) Implementation of k-NN model

Step1: data loading.
Step2: initialization of k factor.
Step3: class prediction.
Step4: distance calculation between test and training data.
Step5: ascending order sorting of calculated distance values.
Step6: find highest k rows.
Step7: find recurrent class of k rows.
Step8: return the predicted class.

III. EXPERIMENTAL RESULTS

(a) (b)
In our system we select one image from CHASEDB1 database our system converts that image into grayscale image then after for image enhancement our system apply Eigen vector .after that system can take mean to remove noise from a image by subtracting background of enhanced image using filters in the last system apply wavelet transformation using canny edge transformation to get normalization of image finally our system obtain segmentation using FC-CRF and using SVM and K-NN features we get results if any injury or daises occurs we get bulged pattern of nerves.

To better understand our experimental results we have to go through operational flow diagram of our system which is shown in figure 2.

**Fig.2. Operational flow diagram**

- Validation of results
  We compare our segmentation results quantitatively with respect to accuracy, specificity and sensitivity in terms of TP, TN, FP and FN.

  \[
  S_e = \frac{TP}{TP+FN}, \quad S_p = \frac{TN}{TN+FP}, \quad P_r = \frac{TP}{TP+FP}
  \]

  \[
  \text{Acc} = \frac{(TP+TN)}{(TP+TN+FP+FN)}
  \]

  \[
  S_e: \text{ defines sensitivity} \quad S_p: \text{ defines specificity} \quad P_r: \text{ defines precision respectively} \quad \text{Acc: defines accuracy. We can also use several other performance measurements like} \quad \text{G-mean, F1-score and MCC (Mathew’s correlation coefficient).}
  \]

  \[
  F1 = \frac{2 \cdot P_r \cdot S_e}{P_r + S_e}
  \]

  \[
  G = \sqrt{S_e \cdot S_p}
  \]

  \[
  MCC = \frac{TP/N - S \cdot P}{\sqrt{P \cdot S \cdot (1 - S) \cdot (1 - P)}}
  \]
Table: I performance analysis for SVM

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<th>S_t</th>
<th>S_p</th>
<th>Acc</th>
<th>Result</th>
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<td>.909</td>
<td>.856</td>
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Table: II performance analysis for k-NN

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</table>

Fig. 3. Performance graph of classifiers

IV. CONCLUSION

This study proposes a blood vessel segmentation system to detect different eye diseases, our system performs segmentation and classification for segmentation. We use the FC-CRF model. The advantage of FC-CRF is that we get retinal vasculature accurately and then unary potential. We use two classifiers K-NN and SVM for best results. The benefit of our system is that it works under dense potential, and it also benefits other biomedical and biological applications.

REFERENCES


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**Syed Akhter Hussain** Recieved a Bachelor’s degree in information technology and Master’s degree in CSE from Dr.B.A.M University Aurangabad (MS) India. He is pursuing a Ph.D Degree in computer science and engineering from Dr.B.A.M University Aurangabad. His research includes image processing and biomedical image processing.

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