

Detection of Retinal Hemorrhage Using Splat Feature Classification Technique

Athira R V, Ferlin Deva Shahila D

PG student,Loyola institute of technology and science Kanyakumari,india
Faculty,Loyola institute of technology and science Kanyakumari,india

ABSTRACT

In the automated fundus image screening system, reliable detection of retinal hemorrhage is required. Retinal hemorrhages are produced by diabetic retinopathy and hypertension. In our approach, a splat feature classification technique can be used to detect large irregular retinal hemorrhages with high accuracy. In this technique, the retinal images are partitioned into non overlapping segments called splat. Splat contains pixels with same color and spatial location. From each splat wide range of features are extracted based on interaction of each splat with its neighbor .The mean filter approach can be used to select desired splat feature. Performance of the hemorrhage detector can be evaluated from the receiver operating characteristic curve.

Keywords: splat, fundus image retinal hemorrhage, KNN classifier, Watershed segmentation.

I. INTRODUCTION

Retinal hemorrhage is the abnormal bleeding of blood vessels in the retina, the membrane in the back of eye. Blood flow to the retina is maintained by the retinal vein and artery and a dense network of small blood vessels called capillaries. These blood vessels can become damaged by injuries and tends to bleed. This results in temporary or permanent loss of vision. Early diagnosis through regular screening and timely treatment is essential to prevent visual loss and complete blindness. Digital color fundus photography can be used to produce digital fundus images from which the retinal hemorrhages can be diagnosed. Diabetes is the major cause of blindness in patients between the age group of 30-60. Diabetic retinopathy is a complication of diabetes mellitus. Diabetic retinopathy produce large irregular hemorrhages which are difficult to diagnose as the boundaries of hemorrhages are not preserved when they are in contact with blood vessels. Diabetic retinopathy can be non proliferative and proliferative. Non proliferative retinopathy is the early stage of diabetic retinopathy and can be viewed only by high resolution fundus photography.

Proliferative retinopathy is the later stage of diabetic retinopathy. Here dark red blood spots appear in the eye due to the bursting of fragile blood vessels of the retina. Automatic retinal hemorrhage detector with splat features can be used to detect irregular retinal hemorrhages with less probability for false positive. Splat are the non overlapping retinal image segments. It contains pixels with similar color and spatial location. In the splat based detection technique the retinal information from the samples are encoded with fewer disturbances from pixel level

noise. From the splat segments, hemorrhage region and retinal background can be separated by setting a threshold where hemorrhage splat have high probability than non hemorrhage splat. The splat feature classification technique assigns 1 for hemorrhage splat segment and 0 for non hemorrhage splat segment.

II. STEPS INVOLVED IN RETINAL HEMORRHAGE DETECTION

The steps involved in retinal hemorrhage detection using splat feature classification technique are as follows:

1. Read fundus image.
2. Splat segmentation.
3. Splat feature extraction
4. Splat feature selection.
5. Estimate posterior probability.
6. Post processing.

A. Read Fundus Image

Retinal images are obtained from the fundus photography technique. Fundus photography requires large instrument but has the advantage that it can be examined by optometrist at any time. Fundus imaging is the technique of obtaining 2D representation of 3D retinal semi transparent tissues of eye [1]. Here the image intensities represent the amount of reflected quantity of light from the eye.

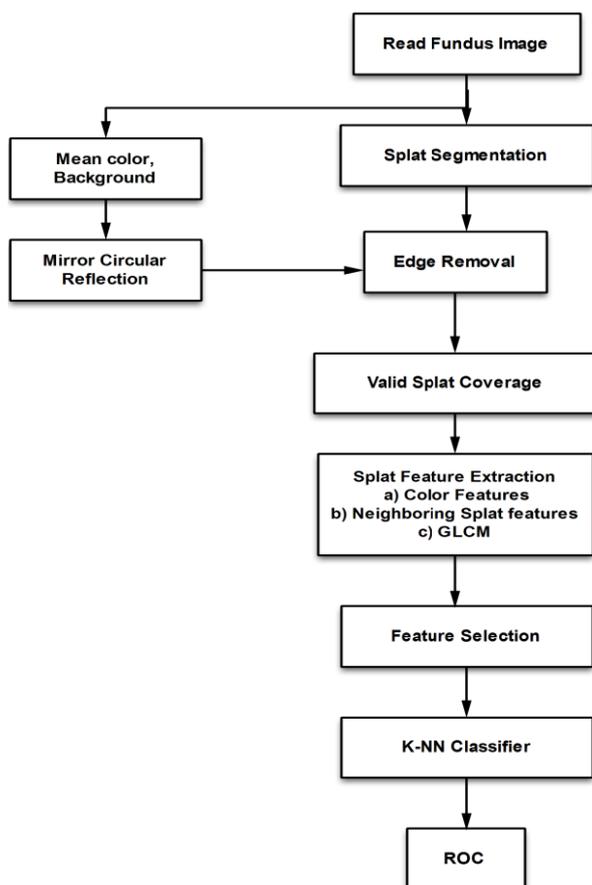


Figure1: Flow Chart of Retinal Hemorrhage Detector

Imaging technique can be used for diagnosis, treatment evaluation and keeping the patient history.

Fundus photography requires a specialized low power microscope with a fundus camera. Fundus photographic equipment performs the operation of illuminating retina with white light and is then examined in full color. Imaging light is filtered to remove red color which in turn improves the contrast of the blood vessels.

B. Splat segmentation

Segmentation plays an important role in image processing. Segmentation can be performed to determine the distribution of pixel properties such as intensity and color in an image. There are different types of segmentation such as region based and morphological watershed based segmentation.

Watershed segmentation is most popularly used segmentation algorithm for medical imaging application because boundaries of the segmented regions are preserved. It is then applied to gradient magnitude image to obtain the meaningful segmented results [2]. The magnitude of the image is given by,

$$|\nabla I(x, y; s)| = \sqrt{I_x(x, y; s)^2 + I_y(x, y; s)^2} \quad (1)$$

Where, I_x - component along x axis. I_y - component along y axis.

Gradient operators are used to attain high noise suppression. Noise suppression is important in dealing with the derivatives that are used for image smoothing. During segmentation and mirror circular reflection of fundus images edge effects are introduced. It is due to vignetting artifacts that are removed by proper illumination of light.

C. Splat feature extraction

Splat features are extracted from the splat segments by considering descriptors such as color and intensity values. Usually RGB color space is considered for splat. From the color variation based on intensity the desired splat are extracted. Gradual intensity variation across neighboring splat can be determined from the histogram. Gaussian kernels can be used to extract regions with sharp and soft edges. splat features are also extracted from the filter banks used for extracting the features. Some of the most commonly used filter banks are Schmid filter bank, Gaussian filter bank and steerable filter bank. Gaussian filter bank have the property of having no overshoot to step function thus minimizing rise and fall time. Schmid filter bank consist of 13 rotationally invariant kernels and is applied to the openness images.

A steerable filter is an orientation selective convolution kernel used for image enhancement and feature extraction. Images can be obtained as a linear combination of set of rotated version. First order derivative can be obtained by taking dot product of unit vector in a specific direction with gradient. Edge detection and texture analysis can be performed using steerable filters. Texture analysis of the segmented image can be used to extract the splat features. Texture analysis refers to characterize image by texture content of intensity and gray level values. Gray level Co occurrence matrix can be used to perform texture analysis.

D. Splat feature selection

Splat features are selected by two feature selection techniques. Preliminary features are selected by the filter approach which is followed by wrapper approach [3] that selects the most relevant features. The feature subset selection algorithm conducts a search for a good subset selection using induction algorithm as a part of function evaluating feature subset.

Filter approach can be used to select features based on two algorithms namely focus and relief algorithm. Focus algorithm examines all subsets of features selecting minimal subsets of features to determine label values for training sets. In medical diagnosis a set of features are described using

patients Social Security Number. In relief algorithm a relevant weight is assigned to each feature. Relief is a randomized algorithm that samples instances from the training set. Relief algorithm was improved by using nearest neighbor approach.

Wrapper approach conducts a search in the space of possible parameters. It requires a state space, initial state, termination condition and a search engine. Each state in a search space organization represents a feature subset. There are n states for n features which denote whether a feature is present or absent. Operators are used to determine connectivity between different states. The goal of search is to find state with highest evaluation using a heuristic function. There are two types of searches namely forward selection search that begins at the empty set of features and backward elimination search that begins at the empty set of features. Accuracy of feature selection is improved by search method used in wrapper approach.

E. Estimate posterior probability

The posterior probability of the hemorrhage splat can be determined by considering the hemorrhage neighbor and distance between each splat. KNN classifier is used to estimate distance between neighboring splat. It is one of the widely used machine learning algorithm. Distance is the main feature considered in this algorithm. Each object in the space is denoted by position vectors in a multidimensional feature space. The training process for KNN consists only of storing the feature vectors and class labels of the training samples. Large values of K are chosen to reduce the effect of noise on classification. When n neighbors were labeled as hemorrhage splat, then the posterior probability is given by $p = n/k$. Distance for nearest neighbor is measured using Euclidean metric.

F. Post processing

In the post processing, the hemorrhages map is created after determining the posterior probability of each splat. Threshold value h_0 is chosen according to the training set collected based on the probability.

III. CONCLUSION

Splat feature classification technique can be used to detect large irregular retinal hemorrhages with less probability for false positive. Large hemorrhages are irregular in shape with wide range of characteristics. Many of the hemorrhage splat overlaps with the blood vessels and results in misclassification. Splat based image representation makes it easier for clinicians to annotate the boundaries of target objects which may lower the cost of acquiring reference standard data for training.

Aggregating features within splats improves their robustness and stability, as it is resistant to pixel level noise and intensity bias. Splat-based feature classification is able to model shapes of various lesions efficiently regardless of their variability in appearance, texture or size. A variety of lesion detection tasks can therefore be generalized into exactly the same framework by training classifiers with optimal features learned from available examples projected onto a sub-feature space which maximizes the inter-class distances while minimizes the intra-class distance.

AUTHORS PROFILE

Athira.R.V

Pursuing M.E(Master of Engineering) in applied electronics from Loyola institute of technology and science. She has received her B.E in Electronics and Communication from Narayanaguru college of Engineering , Anna University. Her areas of interests include image processing.

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