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# Segmentation of Retinal Blood Vessel and Optic Disc in Retinal Fundus Images Using Image Processing Techniques

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# Segmentation of Retinal Blood Vessel and Optic Disc in Retinal Fundus Images Using Image Processing Techniques

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## Abstract

This research work focuses on the novel method of the blood vessel segmentation is by utilizing the retinal fundus image. This includes the segmentation of exudates and hemorrhage in retinal image. This is considered as the existing way to classify the vessels in the fundus image. Here, the proposed methodology is implemented with blood vessel segmentation and optic disc and cup for classification of attributes in order to diagnosis the diabetic patients. The proposed hybrid of multi-resolution curvelet Transform with normalized graph cut techniques is used for segmentation and detect the optic disk more accurately. Since optic disc is often an essential preliminary process in identification of other retinal image pathological and anatomical features. This approach detects the exact localization of Optic disc and its boundary and segments the Blood Vessels. This approach detects the exact localization of Optic disc and its boundary. The proposed method overcomes the accuracy of Optic disc detection and low cost of implementation. The Optic disc detection success rate reaches 98.3 %. The Retinal Blood Vessel segmentation success rate reaches 98.3 %.

**Key words**: Diabetic Retinopathy, Retinal image, Optic disc, Blood vessels, Optic Cup, Segmentation.

## 1. Introduction

Eyesight is one of the most essential senses that keep us in touch with the environment. The most crucial part of eye is the retina. In these, Ophthalmic disease is common. One of its major problem is known as Diabetic Retinopathy (DR) which affects vision. Image processing and computer vision techniques are increasing in prominence in Bio-medical application field. Current developments in image processing techniques relevant to ophthalmology field over the past 25 years includes the successful progress being made towards developing automated computational diagnostic systems for problems such as diabetic retinopathy and retinopathy of prematurity. The main focus of the research work is to explore the several automated computational techniques with different algorithm that can be developed to identify the retinal problems and perform disease classification.

According to recent survey report Stitt, A.W et al. (2017) [1], there are about currently 382 million patents diagnosed as diabetic and expecting this diseases reach up to 592 million by 2030 [2]. In India, the incidence of diabetes disease is increasing at a higher rate. The only way to prevent the diabetic diseases is by keep on doing regular physical activity, maintaining the healthy diet and normal body weight [3]. The risk of blindness can be reduced to 95% by timely diagnosis and treatment which require the regular screening programs from this prevent the severe damage of retina [4].

The retinal images play an essential role in the diagnosis and detection of several eye diseases such as diabetic retinopathy, glaucoma, exudates and age related macular degeneration it leads to blindness if they are not detected in early. The blood vessels appearance in the retina is a very essential factor for diagnosing many kinds of eye diseases problem. The retina is the only place where blood vessels can be directly visualized [5]. Usually Image processing in the medical domain assists in the extraction of significant expertise from the medical database and helping in the process of medical decision making related to the prognosis and treatment of any illness. The process of implementing image processing techniques for extracting significant, useful patterns and expertise from the medical data is termed image processing mining. The medical data contains characteristics such as multi-attribution, redundancy, imperfect and strongly linked with time. The present research discusses a few basic definitions such as image, digital image, and digital/virtual image processing. Also useful properties related to digital images are presented along with examples for each. The study also includes a continuum from image processing to PC visualization. Image processing involves three basic stages:

- Importing of image via image acquisition tool.

- Examining and modifying the image.

- Output with a changed image or report on the basis of image analysis.

The main objective of this research work is to detect the systematic associated diseases of Diabetic Retinopathy in diabetic affected patients.

- To detect the retinal image features more precisely in diabetic patients using image processing algorithms. To localize and detect the Optic Disc, Optic Cup and Blood Vessels of retinal image more precisely.

- To study and detect the lesion portion in retinal image such as Exudates and hemorrhage more accurately by using image processing techniques. The automatic detection of lesion portion from retinal image bring the challenges task without much computational complexity. Figure 1. Represents the fundus image, where (a) represents retinal image features; (b) DR with mild; (c) DR with moderate; (d) DR with severe.

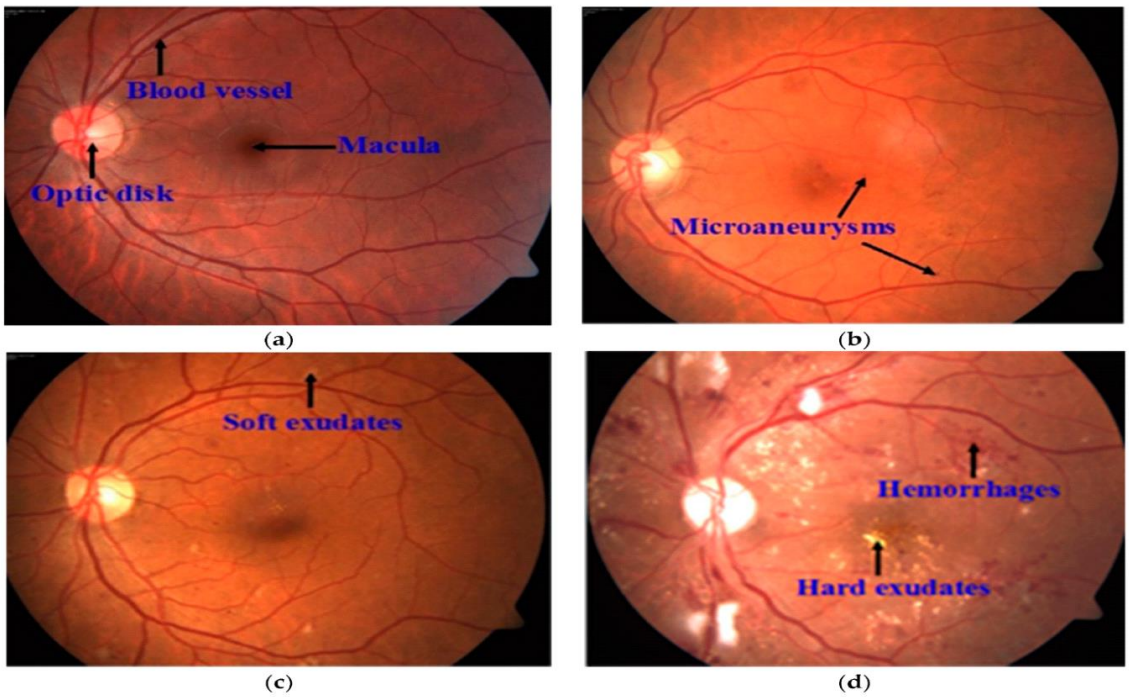

Figure 1. A fundus image, where (a) represents retinal image features; (b) DR with mild; (**c**) DR with moderate; (**d**) DR with severe.

## 2. Literature Review

The Table 1. represent the Literature Review – Recent Optic Disc and Cup Segmentations algorithms- A Brief Overview.

**Table 1. - Literature Review – Recent Optic Disc and Cup segmentations algorithms- A Brief Overview**

| **S. No** | **Author & Year** | **Algorithm Applied** | **No of Samples** | Database | Accuracy |
|---|---|---|---|---|---|
| **Optic Disc Segmentation-A Brief Overview** | | | | | |
| 1 | Harangi, B. et al (2015) | Ensemble Model | 1459 | DRIVE, DIRATEDB0, DIRATEDB1 | 98.91 |
| 2 | Dashtbozorg, B, et al (2015) | Sliding band filter | 1339 | INSPIRE-AVR, MESSIDOR | - |
| 3 | Xiong, L. et al (2016) | Active Contour Model | 59 | LOCAL DATASET, DIARETDB0, RIM-ONE | 98.2 |
| **Optic Cup Segmentation-A Brief Overview** | | | | | |
| 4 | Tan, N.M et al (2015) | Pixel classification | 650 | ORIGA | - |
| 5 | Zilly, J, et al (2017) | Convolution neural network | 50 | DRISHTI-GS | 94.1 |
| 6 | Chakravarty, A, et al (2017) | Sparse Dictionary | 1577 | ORIGA | - |
| 7 | Arnay, R et al (2017) | Ant Colony Optimization | 159 | RIM-ONE | - |
| 8 | Issac, A et al (2015) | An Adaptive Threshold method | 63 | LOCAL DATASET | 92 |

## 3. Proposed Image Processing Methodology

Initially, the actual data collected tends to be incomplete, noisy and is not consistent. The noisy data is detected and rectified; while identifying the outliers, that data that is inconsistent and incomplete is also corrected. Noise represents the variance or error that occurs randomly in the data. Various techniques can be employed for noise removal and smoothing of data. The computer and human check techniques are merged by employing the segmentation approaches, thereby generating the group of data sets. Human can carry out pattern classification from the list for identifying the genuine or crap ones. This tends to be quiet prompt in contrast to manual search across the entire database.

Segmentation aims to alter or/and simplify the image representation to something which is notably significant and simple to examine. The approach of Image segmentation helps in locating objects and boundaries (lines, curves, etc.) of a given image. That is, it involves designating a label to each pixel of the image so that pixels having matching label can share specific visual features. The image segmentation output represents a group of segments that cover the complete image jointly, or a set of contours retrieved from the image (edge detection). All pixels within an available region are equivalent in regard to some feature or calculated property, like for instance intensity, colour or texture. Neighboring regions considerably vary in accord with the similar characteristic(s). Segmentation algorithms rely upon any of the two general properties of intensity values: similarity and discontinuity. The first category involves partitioning the image depending upon sudden changes in intensity, like the edges in an image. The second category relies upon partitioning the image into regions that are equivalent to a predefined condition. Approach of histogram thresholding resides in this category.

The next section presents improving the prevailing ROI segmentation by making use of intelligent agents along with various terms and formulas. Here the focus is on extracting the Optic disc and blood vessel area from the retinal fundus image. Extracting precise features like ROI from the retinal image generate better classification accuracy. Using preprocessing precise retinal image affected regions can be acquired from the available image for effective feature extraction. Additionally, such feature extraction eliminates the changes caused due to rotation and translation. For every retinal image affected region/sub bands, the statistical features are computed thereafter computation of energies is done for minimizing the no: of coefficients. Figure 2. represent the Final Pre-Processing Results. Figure 3. Represents the Segmentation of Blood Vessel. Figure 4. Illustrate the Optic Disc Segmentation. Figure 5. Illustrate the segmentation of Exudates.

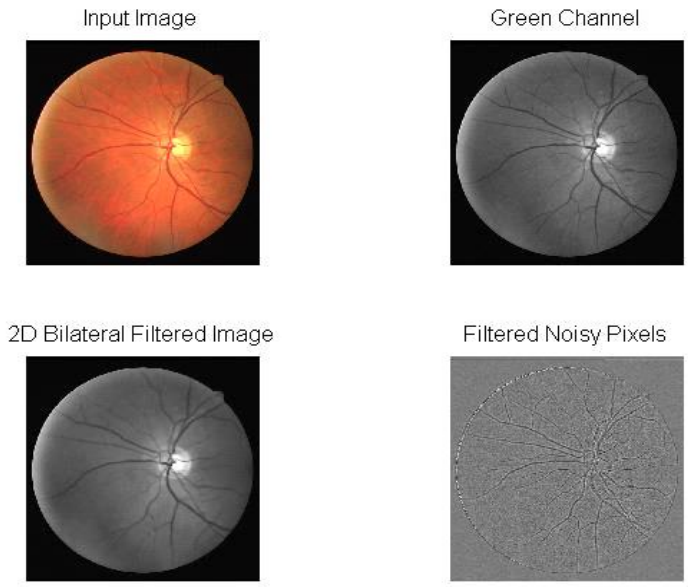


Figure 2. Pre-Processing Results

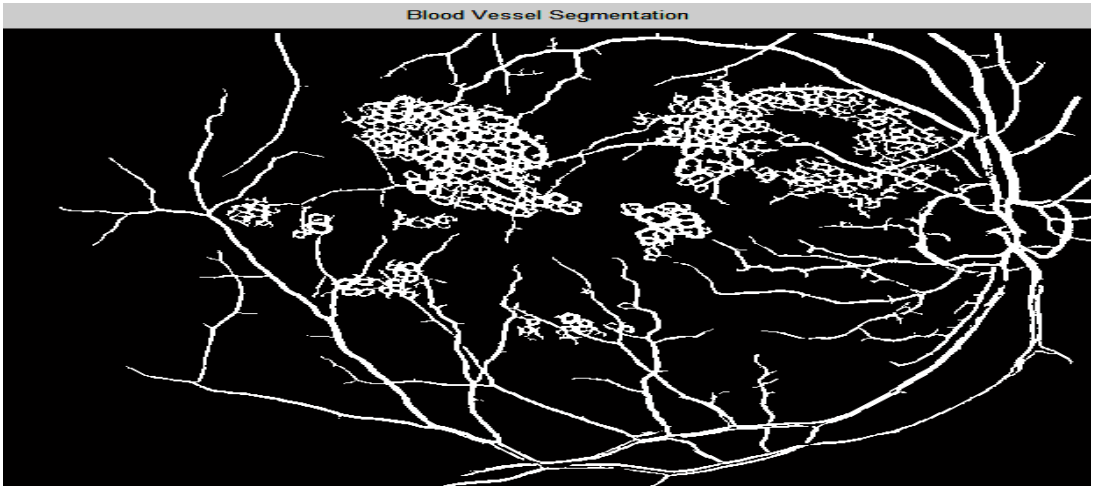


Figure 3. Segmentation of Blood Vessel

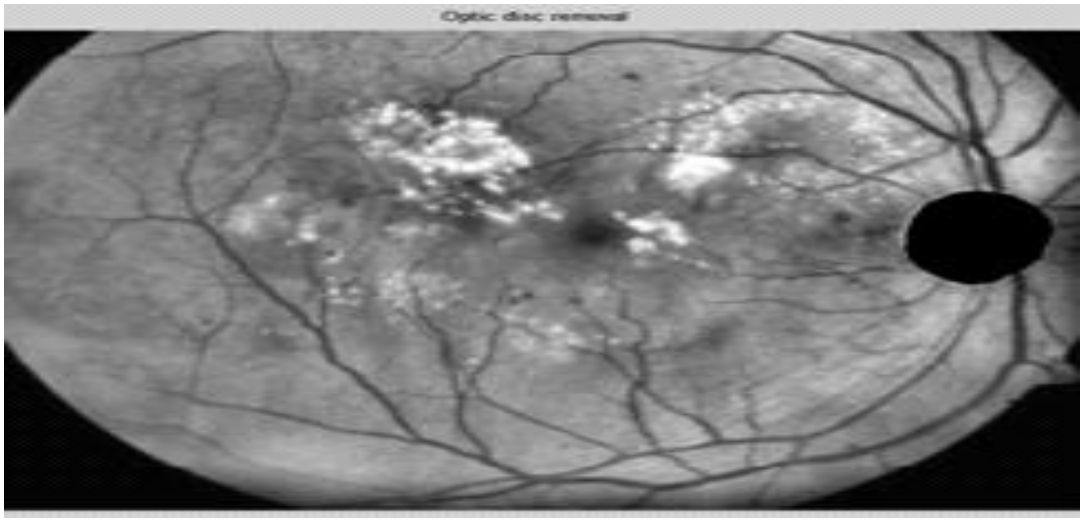

Figure 4. Optic Disc Segmentation

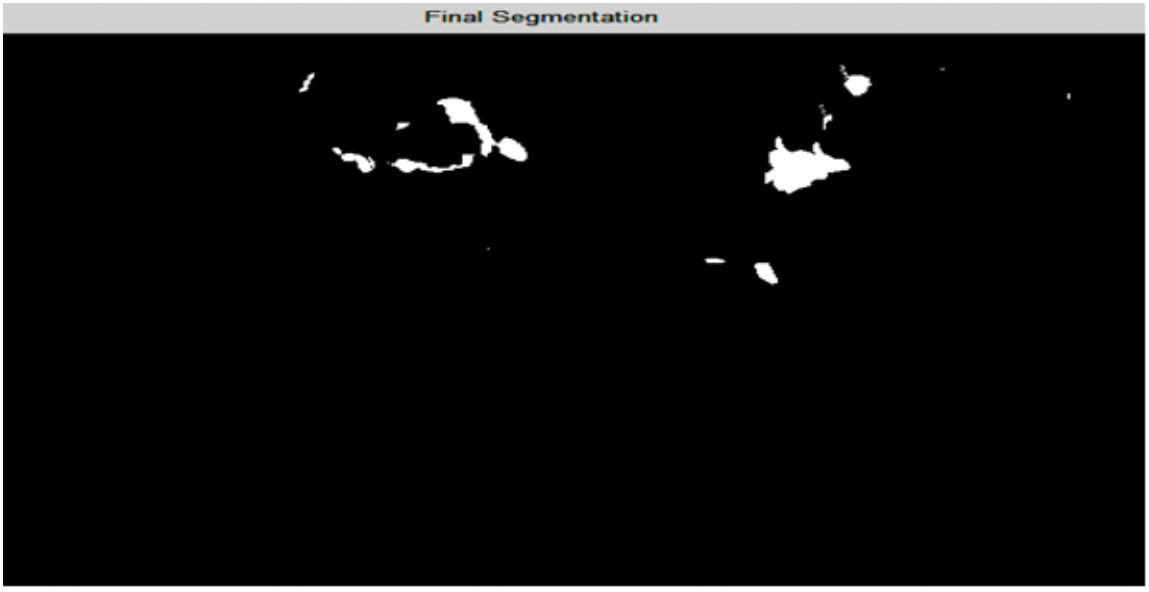


Figure 5. Exudates segmentation

## 4. Results and Discussion

### 4.1 Optic Disc Segmentation

The proposed method overcomes the accuracy of Optic disc detection and low cost of implementation. The Optic disc detection success rate reaches 98.3 %. (Out of 120 retinal image 118 is correctly identified). The Table 2. Represents the Performance Results of Optic Disc. Performance Graph is obtained in Figure 6.

Table 2. Performance Results of Optic Disc

| Author and Year | Techniques Applied | No of Samples | Database | Accuracy |
|---|---|---|---|---|
| Bharkad, S et al (2017) | Finite Impulse Response Filer | 369 | DRIVE, DIRATEDB0, DIRATEDB1 | 98.95 |
| Alshayeji, M. et al (2017) | Edge Detection Method | 303 | STARE, DRIVE | 95.91 |
| Sarathi, M.P et al (2016) | Region Growing Method | 1384 | DRIVE, LOCAL DATASETS | 91 |
| Singh, A et al (2016) | Wavelet Feature Techniques | 63 | LOCAL DATASETS | 94.7 |
| Abed, S.E et al (2016) | Swarm Intelligence Techniques | 318 | STARE, DRIVE | 98.45 |
| Díaz-Pernil, D et al (2016) | Hough Transform Techniques | 129 | DRIVE, DIRATEDB1 | 99.6 |
| Harangi, B. et al (2015) | Ensemble Model | 1459 | DRIVE, DIRATEDB0, | 98.91 |

| | | | | |
|---|---|---|---|---|
| | | | DIRATEDB1 | |
| Dashtbozorg, B, et al (2015) | Sliding band filter | 1339 | INSPIRE-AVR, MESSIDOR | - |
| Xiong, L. et al (2016) | Active Contour Model | 59 | LOCAL DATASET, DIARETDB0, RIM-ONE | 98.2 |
| **Proposed** | **Curvelet Transform based Normalized Graph Cut Segmentation** | **120** | **STARE** | **98.3** |

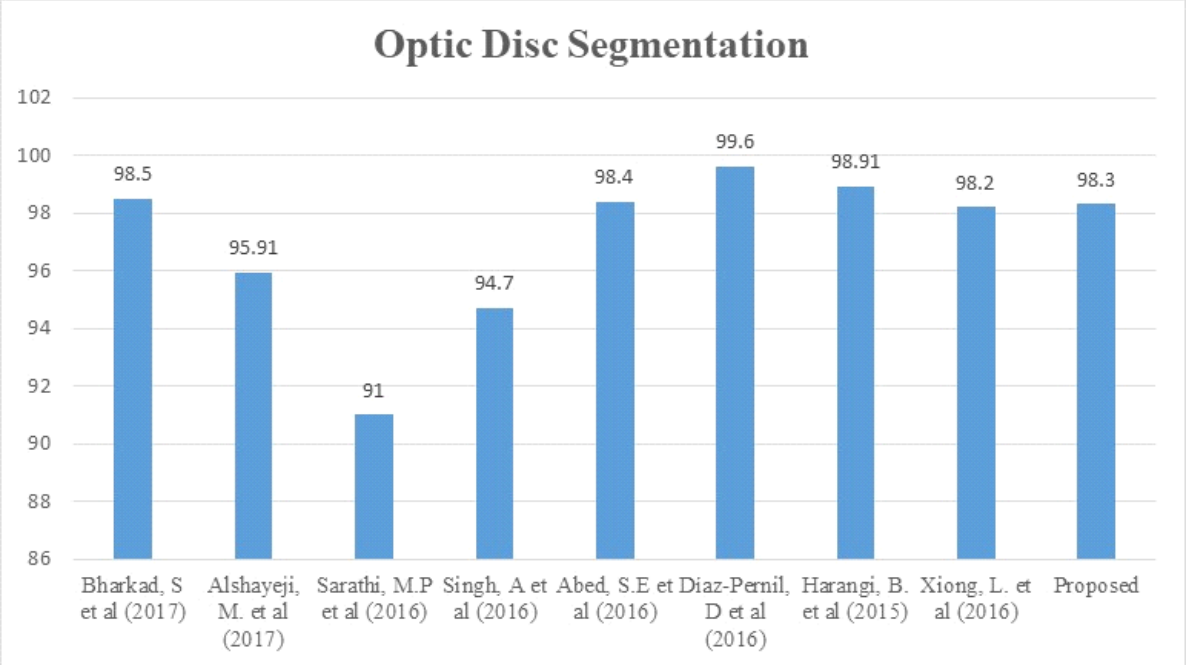


Figure 6. Performance Graph of Optic Disc with state of art methodology

### 4.2 Retinal Blood Vessel Segmentation

The Retinal Blood Vessel segmentation success rate reaches 98.3 %. (Out of 120 retinal image 118 is correctly identified). The Table 3. Represents the Performance Results of Retinal Blood Vessel Segmentation and Performance Graph is obtained in Figure 7.

Table 3. Performance Results of Retinal Blood Vessel Segmentation

| Author Name & Year | Image Processing Techniques | No of Samples | Database | Accuracy Rate |
|---|---|---|---|---|
| Neto, L.C et al (2017) | Gaussian filter on a green channel applied for noise removal, morphological top-hat | **60** | STARE, DRIVE | 87% |

| | | | | |
|---|---|---|---|---|
| | applied for enhancing the vessel pixels | | | |
| Zhang, L et al (2015) | vessel feature extraction by Gabor filter | **40** | DRIVE | 95.05% |
| Tan, J.H et al (2017) | LUV model, luminance channel, L, based on RGB conversion, contrast enhancement applied for vessel pixel. | **40** | DRIVE | 94.54 |
| Pandey, D et al (2017) | Global threshold mechanism applied for ROI extraction | **60** | STARE, DRIVE | 96% |
| Farokhian, F et al (2017) | For smoothing, Morphological operations and suppressed the background | **40** | DRIVE | 93% |
| Proposed | **Curvelet Transform based Normalized Graph Cut Segmentation** | **120** | **STARE** | **98.3%** |

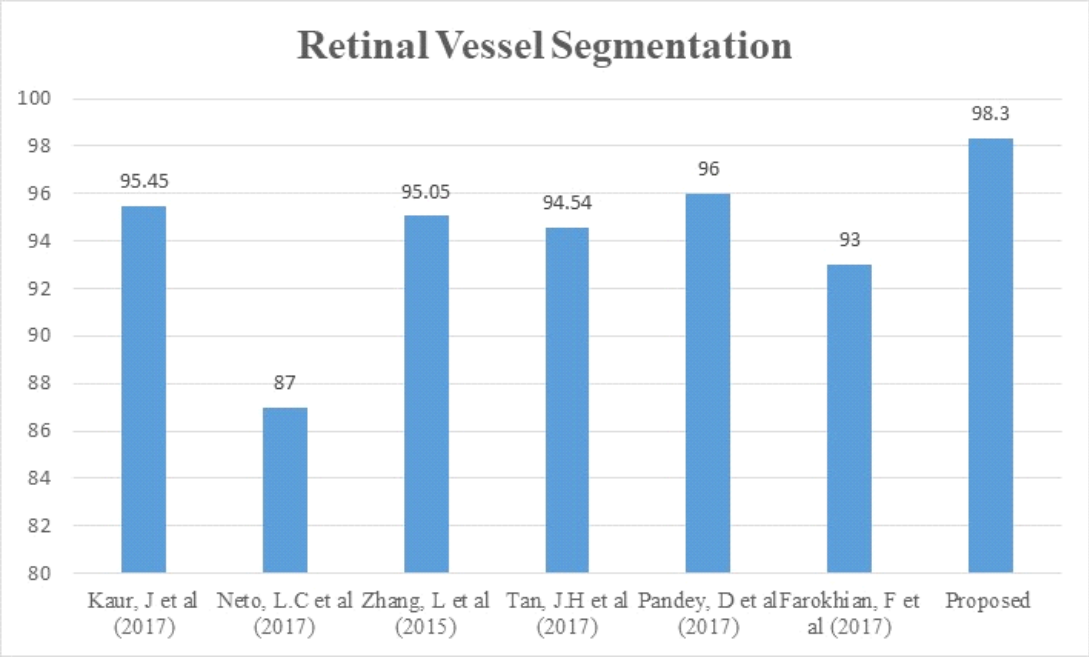


Figure 7. Performance Graph of Retinal Vessel Segmentation

As merely by analyzing visually any sort of disease related changes may not be detected, the results generated must be analyzed and verified using different methods for identifying any sort of alterations in cell images. The existing research's prime focus being identifying or detecting diabetic disease experiments were performed for the same purpose.

Enhanced accuracy was obtained in the given time span with better image quality and minimum time. MATLAB Environment was utilized for the implementation of the proposed system.

## 5. Conclusion

Here, the proposed methodology is implemented with blood vessel segmentation and optic disc and optic cup for classification of attributes in order to diagnosis the diabetic diseases. The proposed hybrid of multi-resolution curvelet Transform and normalized graph cut techniques is used for segmentation and detect the optic disk more accurately. Since optic disc is often an essential preliminary process in identification of other retinal image pathological and anatomical features. This approach detects the exact localization of Optic disc and its boundary. The proposed method overcomes the accuracy of Optic disc detection and low cost of implementation. The Optic disc detection success rate reaches 98.3 %. The Retinal Blood Vessel segmentation success rate reaches 98.3 %. In future, this work can be extended to minimize the computational overhead by deep learning approach.

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