Segmentation of Diabetic Retinopathy Retinal Eye Image Using Ant Colony Optimization Algorithm

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Abstract— **Ant colony optimization is a technique for optimization that was introduced in the early 1990's. The inspiring source of ant colony optimization is the foraging behavior of real ant colonies. This behavior is exploited in artificial ant colonies for the search of approximate solutions to discrete optimization problems, to continuous optimization problems, and to important problems in telecommunications, such as routing and load balancing. Diabetic is one the important cost related problems. And also it gives the numerous eye problems for humans like Diabetic retinopathy. In this work a new method have been proposed to segment the eye affected by diabetic retinopathy. Segmentation is one of the important modules of any image processing technique. In this work we have proposed the Ant Colony Optimization (ACO) algorithm to segment the Human eye. The performance of the proposed system has been verified and validated with another standard algorithm. This technique is a Novel technique to segment the Diabetic retinopathy and also the proposed technique shows significant results.**

Key words: **Segmentation, Diabetic Retinopathy, Ant Colony Optimization.**

I. Introduction

Diabetes is the most common metabolic disorder in the world. The World Health Organization estimates the total number of persons with diabetes to be 171 million as of 2000. The disorder is most prevalent in south Asia, especially in India, which with, 41 million individuals with diabetes, has earned the unwelcome sobriquet of the "Diabetes Capital" of the world. More worryingly, this number is set to increase to 70 million by 2025, more than 10 million more than China, which lies in second place.

The report given by the Diabetes centre says

- Every minute, six people die due to diabetes and its complications

- Every 10 minutes, a person loses a limb due to diabetes

- In the United States, 12000 to 24000 people lose their vision every year due to diabetes

- US $ 215 to $ 375 billion is being spent annually in treating diabetes and its complications

Diabetic retinopathy is a complication of diabetes and a leading cause of blindness. It occurs when diabetes damages the tiny blood vessels inside the retina, the light-sensitive tissue at the back of the eye. A healthy retina is necessary for good vision. If you have diabetic retinopathy, at first you may notice no changes to your vision. But over time, diabetic retinopathy can get worse and cause vision loss. Diabetic retinopathy usually affects both eyes. Though in the starting stages it can be difficult to notice the changes, carrying out dilated eye test every year will help to look out for any changes to retina. The symptoms for an effective person will have blurred vision, formation of spots which is due to the leakage of fluids by swelled blood vessels. The spots slowly increase providing a deferred vision and causing severe damage to retina. If untreated at the right time, there are chances that the person will lose his vision permanently. The personal, social and economic costs of diabetes are huge and are likely to adversely affect India's economic development over the next couple of decades. Unless urgent steps are taken to thwart this burgeoning epidemic, more and more young and middle-aged Indians will fall prey to diabetes in the prime of their lives. Figure 1 shows the difference between the normal vision and also diabetic retinopathy vision.
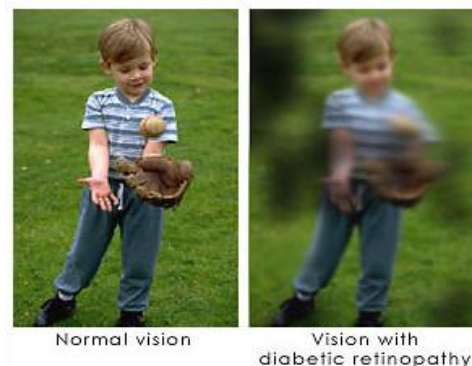
Fig .1 (a) Normal vision
(b) vision with Diabetic Retinopathy

Diabetic retinopathy has four stages:

1. Mild Nonproliferative Retinopathy: At this earliest stage, micro aneurysms occur. They are small areas of balloon-like swelling in the retina's tiny blood vessels.

2. Moderate Nonproliferative Retinopathy: As the disease progresses, some blood vessels that nourish the retina are blocked.

3. Severe Nonproliferative Retinopathy: Many more blood vessels are blocked, depriving several areas of the retina with their blood supply. These areas of the retina send signals to the body to grow new blood vessels for nourishment.

4. Proliferate Retinopathy: At this advanced stage, the signals sent by the retina for nourishment trigger the growth of new blood vessels.

This condition is called proliferate retinopathy. These new blood vessels are abnormal and fragile. They grow along the retina and along the surface of the clear, vitreous gel that fills the inside of the eye. Figure 2 shows the normal eye anatomy. Figure 3 shows the normal retina. Figure 4 shows the Retinal Image of Non – Proliferative Stage and Figure 5 shows Retinal Image of Proliferate Stage
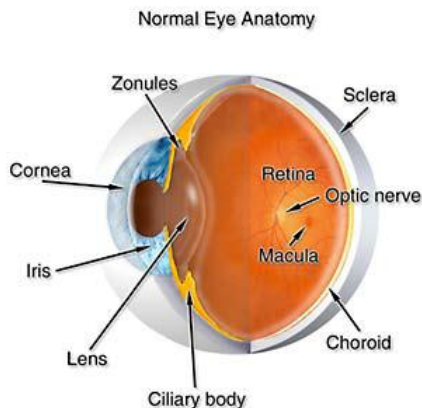
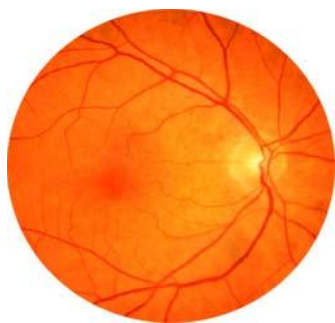Fig.4. Retinal Image of Non – Proliferative Stage

Fig.2.Normal Eye Anatomy
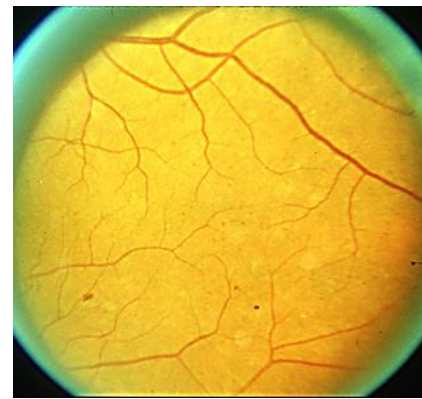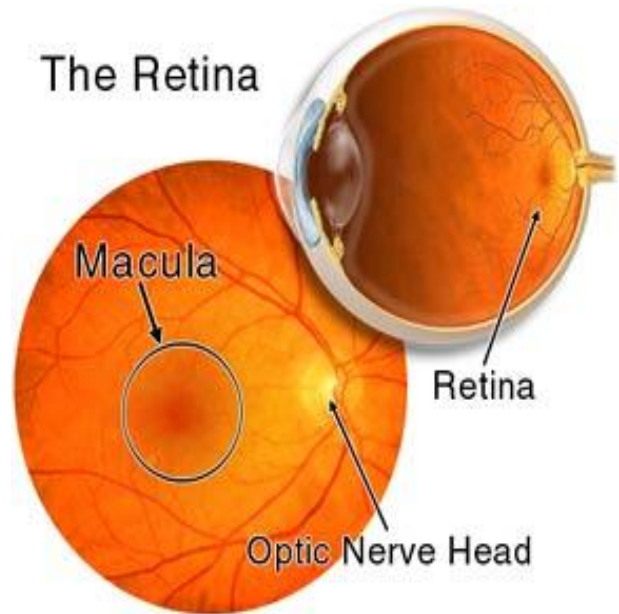
Fig.5. Retinal Image of Proliferate Stage

Fig.3. Image of the Normal Retina

By themselves, these blood vessels do not cause symptoms or vision loss. However, they have thin, fragile walls. If they leak blood, severe vision loss and even blindness can result. Blood vessels damaged from diabetic retinopathy can cause vision loss in two ways:

1. Fragile, abnormal blood vessels can develop and leak blood into the center of the eye, blurring vision. This is proliferate retinopathy and is the fourth and most advanced stage of the disease.

2. Fluid can leak into the center of the macula, the part of the eye where sharp, straight-ahead vision occurs. The fluid makes the macula swell, blurring vision. This condition is called macular edema. It can occur at any stage of diabetic retinopathy, although it is more likely to occur as the disease progresses. About half of the people with proliferate retinopathy also has macular edema.

II. Proposed Work Sequence

The Block diagram of the proposed system of Segmentation of diabetic retinopathy is shown in Figure 6. The different process sequence is involved in this process is also given in below. The Original image is obtained from the image centre and then it will be incorporated by using pre processing algorithm using density and magnitude. The proposed method flow diagram is shown in Figure 6 in a sequence manner.
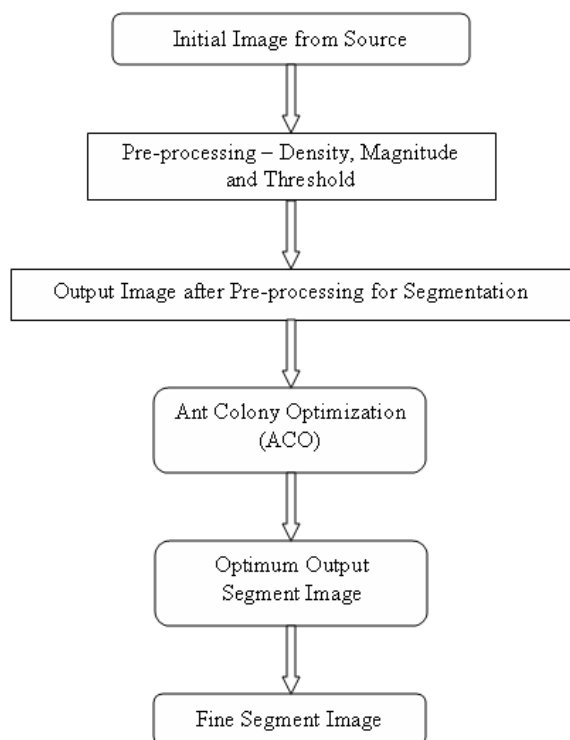

Fig. 6. Work Sequence flow chart

III. Pre-Processing

Step 1: Calculate the average magnitude

$$M(1,2) = \frac{1}{M} \sum_{(1,2)}^{n} \sqrt{Mx(1,2)^2 + My(1,2)^2} \qquad (1)$$

Step 2: Calculate the density of the edge length. The density of the edge length is calculated from

$$L(1,2) = \frac{C(1,2)}{\max C(1,2)} \qquad (2)$$

Where $C(i,j)$ is the number of connected pixels at each position of pixel.

Step 3: Calculate the Initial position of map from summation of density of edge Length and average magnitude.

$$P(1,2) = \frac{1}{2(M(1,2) + L(1,2))} \qquad (3)$$

Step 4: Calculate the thresholding of the initial position map. If

$$P(1,2) > T_{max} \qquad (4)$$

Then P(1, 2) is the initial position of the edge following. And then we obtained the initial position by setting T_{max} to 90% of the maximum value.

IV. Ant Colony Optimization

Through some biologist's view, it is quite known that the visual the visual sensory organs of the real world ants are rudimentary by nature and in some cases they are completely blind. Foraging behavior of ant species is also based on the indirect communication possibly done by pheromones. During their walking from the food sources to the nest, the ants are depositing pheromone on the ground, forming in this way, a pheromone trail. The mathematical modeling for segmentation of diabetic retinopathy eye image using the algorithm is formulated as below.

$$p_{i,j}^{(n)} = \frac{\left(\tau_{i,j}^{(n-1)}\right)^\alpha (\eta_{i,j})^\beta}{\sum_{j \in \Omega_i} \left(\tau_{i,j}^{(n-1)}\right)^\alpha (\eta_{i,j})^\beta}, if \ j \in \Omega_i \qquad [5]$$

Ant colony optimization is a technique for optimization that was introduced in the early 1990's. The inspiring source of ant colony optimization is the foraging behavior of real ant colonies. This behavior is exploited in artificial ant colonies for the search of approximate solutions to discrete optimization problems, to continuous optimization problems, and to important problems in telecommunications, such as routing and load balancing. First, we deal with the biological inspiration of ant colony optimization algorithms.

Figure 7 shows the model ant roots. Pseudo code also given above the figure 7.

Pseudo code:
Initialization

Set for every pair (i, j): $\tau_{ij} = \tau$ ()

Set N=1 and define a η_i, η_j

While

$\eta_i = \eta_j$

Build a complete trail

For i = 1 to n, j = 1 to n

Choose the alternate node and pair

Update the equation

Update the tabu list

Analyze the problem

For i = n-1, j = n-1

Compute the performance

Update the equation

End
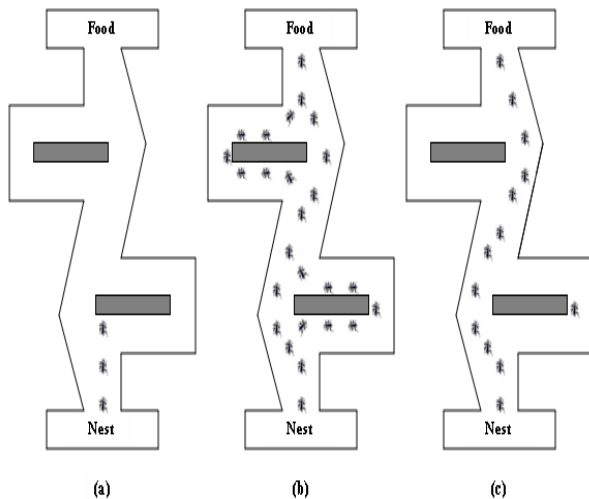--

Fig.7. Three different roots of ants form Nest to Food

V. Results and Discussion

To further evaluate the efficiency of the proposed method in addition to the visual inspection, the proposed boundary segmentation method numerically using the Hausdorff distance and the probability of error in image segmentation.

The objects surrounded by the contours obtained using the five snake models and the proposed method are compared with that manually drawn by skilled doctors from the Medical Hospital. Showing the results it shows the Error difference value is very minimal and also negligible. So the proposed techniques produced nearer to the optimal value. Fig.8 shows the output results of the proposed technique and Fig.9 shows the fine filtered segmented image.
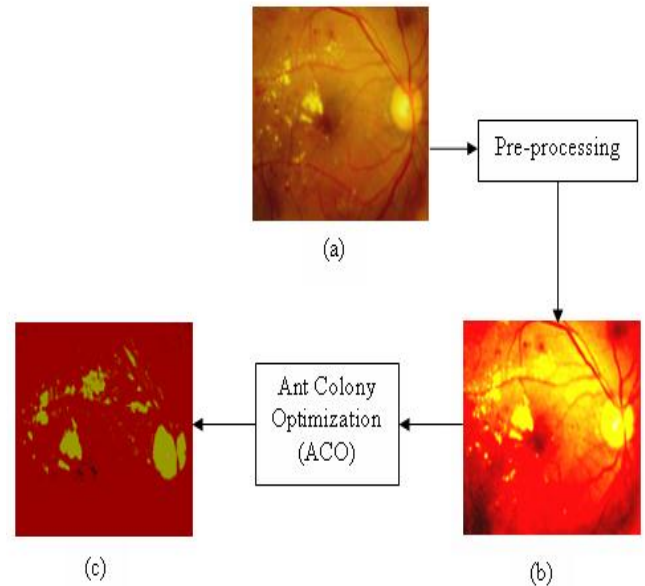

Fig. 8. Output Result (a). Original Image (b). Pre-Processing (c). Output of Pre-Processing (d). Segmentation – ACO (e). Segmentation – Output
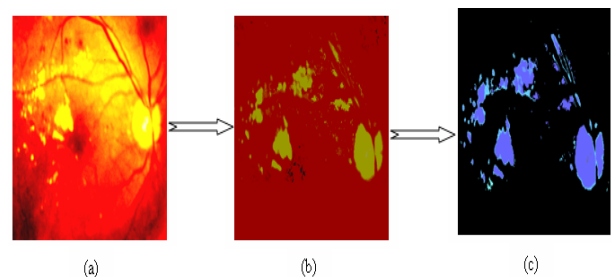

Fig. 9. Ant Colony Algorithm
(a). Pre-Processing image output
(b). Segmentation Output
(c). Segmentation– Output Fine filtering

Then the output image after obtained from the MAT Lab software, for analyzing the output image noise signal graph for population Vs time also plotted using the same software. The graph shows the 90% significant results. It is shown in Fig. 10.
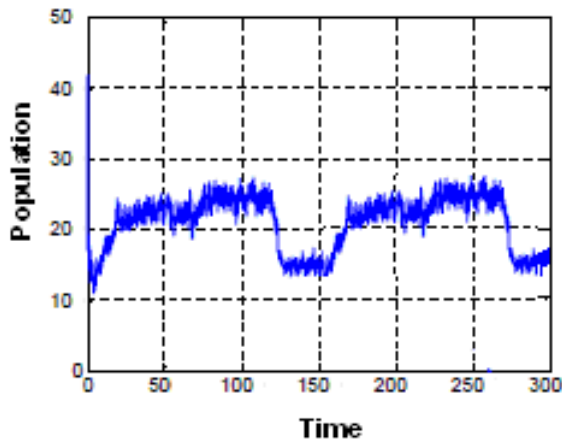
Fig. 10. MAT Lab Output Population Vs Time

VI. Conclusion

Segmentation is one of the important modules of any image processing technique. In this work we have proposed the Ant Colony Optimization (ACO) algorithm to segment the diabetic retinopathy Human eye. The performance of the proposed system has been verified and validated with existing problem. This technique is a novel technique to segment the eye and also the proposed technique shows significant results and compared with the other conventional techniques. The graphics output from the MAT Lab software also plotted. It shows the 90% significant results. In future we have a proposal to implement other algorithms to segment the same eye image and also to compare with the results of each other.

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