

## Research Paper

# Cuckoo's Search Algorithm based Technique for Exudates Detection in Diabetic Retinopathy

## ABSTRACT

This paper presents the work done on the new metaheuristic ~~Cuckoo's algorithm~~ <sup>available</sup> for the exudates <sup>the results from</sup> detection in diabetic retinopathy using multi-level thresholding. The algorithm is coded in matlab despite the fact that there is no ~~availability of~~ help in matlab for this new optimization Cuckoo's algorithm. The method is applied for edge detection in matlab and the results were compared with the existing methods. It has been found that the Cuckoo's algorithm method has demonstrated better performance and accuracies than the existing methods. <sup>the results from</sup> The proposed metaheuristic optimization algorithm is devoted to segment the retinal images which would help in making medical decisions in diabetic retinopathy.

**Keywords:** Eggs (Solutions), Cuckoo's algorithm (CA), Diabetic retinopathy (DR), Stationary wavelet transform (SWT).

## 1. INTRODUCTION

In the field of image analysis, segmentation has played an important role. One of the best ways to achieve segmentation is by means of threshold selection, where each pixel is labelled according to the selected threshold to its appropriate class, giving as a result pixel groups that share visual characteristics in the image. In this work, multi-level thresholding compared with gradient value of pixels is used for representing a pixel class and therefore a threshold point, where threshold parameters are calculated using CA.

Cuckoo's algorithm is a novel evolutionary algorithm, suitable for continuous nonlinear optimization problems inspired by the life of a bird family, called Cuckoo. Some ~~of the~~ <sup>s</sup> concept of evolution theory has been used in algorithms to search for solutions to problems in a better way. Firstly, different possible solutions/nests of problem are created (cuckoo's will lay eggs in host bird nests). Then these solutions are tested based on their performance i.e best nests will be selected using Levy's flight. Among all achievable solutions/nests, a part of good solutions are selected, and others are eliminated (best nests with high quality of eggs will be carried to next generation). This shows the survival of fittest in CA.

In case, host bird (probability of detection) is able to detect alien eggs, then either the host bird will throw away alien eggs or will abandon the nest. The best solutions that are not detected by the host bird will further be allowed to grow. These solutions will be carried to next generation which will perform better than the previous solutions. This process of production of new generations and its evolution is continual unless there is convergence of generation.

This work gives a good picture of CA for the exudates detection as shown in Fig.1 in diabetic retinopathy using multilevel thresholding. Hence, the problem of diabetic retinopathy can be appropriately solved by Cuckoo's method, which gives better results than other optimization methods. The problem chosen for the algorithm is simple and the beginners may get exposed to CA in exudates detection.

## 2. REVIEW OF PRIOR WORK

Thomas-Walter, et.al [1] presented a computer assisted detection of exudates in color fundus images of the human retina in diagnosis of retinopathy. G-I. Sanchez, et.al [2] proposed an automatic method to detect hard exudates, a lesion associated with diabetic retinopathy. For the first time an integrated approach using dynamic thresholding and edge detection (IDTED) for automatic detection of exudates in digital fundus retinal images was proposed by Anantha Vidya-Sagar, et.al in 2007 [3]. Doss Youssef, et.al [4] proposed a method based on segmenting all objects that have contrast with the background including the exudates. The exudates could then be extracted after eliminating the other objects from the image. One of the objects is blood vessels can be extracted as follows [4]:

```

 $I_{in} = I_{in} + \gamma_{TH}(I_{in}) - \phi_{TH}(I_{in})$ 
 $I_{out} = \text{zeros}(\text{size}(I_{in}))$ 
for  $\Theta = 0: 180: \text{step } 15$ 
    Temp1 = I Morpho icalClose ( $I_{in}, b_1$ )
    Temp2 = I Morpho icalClose ( $I_{in}, b_2$ )
    Temp = ( Temp2 – Temp1)  $\geq$  threshold
    rotate( $b_1, \Theta$ )
    rotate( $b_2, \Theta$ )
     $I_{out} = I_{out} + \text{Temp}$ 
endFor
 $I_{out} = \text{MorphologicalOpen}(I_{out})$ 

```

where:

$I_{in}$  is the original image,  $I_{out}$  is the output image,  $b_1$  and  $b_2$  are two structuring elements ( $b_2$  is longer than  $b_1$ ),  $\gamma_{TH}$  is the image result after applying top-hat by opening,  $\phi_{TH}$  is the result of applying top-hat by closing and angle  $\Theta$  ( $0 \leq \Theta \leq \pi$ ).

Hussain F. Jaafar, et.al [5] presented an automated method for the detection of bright lesions (exudates) in retinal images. In this work, an adaptive thresholding based on a novel algorithm for pure splitting of the image is proposed. Lili Xu, Shuoqian Luo [6] in their work presented a feature combination based on stationary wavelet transform (SWT) and gray level co occurrence matrix (GLCM) used to characterize hard exudates candidates. Balazs Harangi, et.al [7] proposes a method for exudates detection in which they have analyzed the information content of the descriptors and selected the most relevant ones.

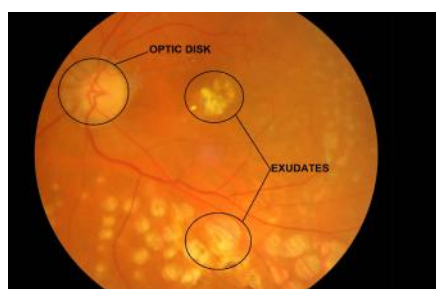


Fig.1 Diabetic retinopathy image showing exudates

C.JayaKumari, R.Maruthi a [8] studied a state-of-art image processing techniques to automatically detect the presence of hard exudates in the fundus images.

## 3. CUCKOO'S SEARCH

This method is developed by Yang and Deb and has undergone a substantial development. This method is very different from other metaheuristic optimization algorithm. The authors basically

stressed on the fact that the existence of all living things is based on the rule of “survival of the fittest” which is a Darwin’s famous theory. CA is based on the cuckoo’s bird behaviour of their destructive reproduction strategy. Some cuckoos lay their eggs in communal nests, though they may remove others eggs to increase the hatching possibility of their own eggs. Such communal nests are selected by Levy’s flight. If a host bird discovers the eggs are not its own, it will either throw these alien eggs away or simply abandons its nest and builds a new nest elsewhere [42]. The CA essentially works with three important components: selection of the best by keeping the best nests or solutions; Levy’s flight search pattern for replacing the host eggs with respect to the quality of the new solutions or Cuckoo eggs produced; and discovery of some cuckoo eggs by the host birds and replacing those eggs according to the quality of the local random walks.

CA is a modern metaheuristic algorithm which has been developed with an aim to carry out global search of retinal exudates. The efficiency of metaheuristic algorithm can be attributed to the fact that they imitate the best features in nature, especially the selection of the fittest in biological systems which have evolved by natural selection many years ago.

## 4. METHODOLOGY

DR damages small blood vessels in the retina and it may lead to the loss of vision. This diabetes causes yellow patches in the retina known as exudates. If symptoms of DR are visualized then it could be seen that there is no pain, no blurred vision, and no ocular inflammation in this disease. In fact, some people do not develop any visual impairment until the disease has advanced well into its proliferative phase. At this stage of disease, the vision that has been lost cannot be restored. Early detection of DR has been identified as the best way to achieve reduction in the percentage of visual impairment, with more emphasis on routine medical check-up. This routine check-up may increase the tension for the medical personnel as this will be a time consuming process [9]. The proposed method focuses on to mitigate the problems of medical check up.

In the present work, technique based on optimization and CA with multilevel thresholding is applied. Optimization is aimed to obtain best parameter values which enable an objective function to generate the minimum or maximum value. For the thresholding work, the choice of objective function turns out to be gradient value of each pixel as discussed below:

### 4.1. Objective Function

In order to find edges gray scale intensity is to be determined. Hence, the gray scale intensity of the image can be determined by finding the gradients of the image. So, the objective function used in this research paper is gradient value of the pixels.

$$|G| = \sqrt{G_x^2 + G_y^2} \quad (1)$$

where:

G<sub>x</sub> and G<sub>y</sub> are the gradients in the x and y directions respectively.

eqn. 1 shows gradient magnitude (also known as the edge strengths).

### 4.2. CA applied to edge detection

In the CA developed, the population is initialized as binary with solution length of 16-bit for each upper threshold and lower threshold value. Initial population size is 20 for each upper threshold value and lower threshold value. To generate new solution Levy’s flight is performed. Random walk via Levy’s flight is performed in exploring the search space, as it will be more efficient in exploration due to its larger step length. The probability of discovery of cuckoo’s egg by the host bird is 0.25.

## 4.2.1 Initialization of population

Two population are initialized, one for upper threshold and other for lower threshold, each having binary coding and 16-bit solution length each. Population size is 20 for each of upper and lower threshold values. In a solution length first 8-bit length is defined as rational part and another 8-bit as integer part.

## 4.2.2 Generate solution via Levy's flight

The upper threshold value and lower threshold value are used for calculating the threshold value via Levy's flight and then the solutions are evaluated. This threshold value will be compared with objective function (gradient value) to obtain white pixels on the edges and black pixels at the background.

## 4.2.3 Some solutions are detected and killed

The probability of detection of eggs by host bird is 0.25. A fraction of worst nests will be abandoned and new solutions will be generated. Keep the best quality solution and rank the solution to obtain current solution. This output solution will again be evaluated and recirculated for the whole process of CA until the stopping criteria is met.

## 4.2.4 Stopping criteria

When the average fitness in successive iterations stops growing the CA also stops and it gives output in the form of threshold value. The threshold value obtained from CA will be compared with gradient value of each pixel to obtain white pixel at the edges and black pixels at the background. The exudates detected are shown in Fig.2.



Fig.2 CA result obtained

## 5. RESULTS AND ANALYSIS

The CA runs in matlab for many times and the results obtained are compared with otsu's and kanur's method to obtain the comparison of performances. Performance of the proposed method was assessed quantitatively by comparing the results with the existing methods. Four types of pixels are considered in the method evaluation: true positive (TP), false positive (FP), false negative (FN), and true negative (TN). These quantities were computed with each individual image to measure [5]:

$$\text{Sensitivity} = \text{TP} / (\text{TP} + \text{FN})$$

$$\text{Specificity} = \text{TN} / (\text{TN} + \text{FP})$$

$$\text{Accuracy} = (\text{TP} + \text{TN}) / (\text{TP} + \text{FP} + \text{TN} + \text{FN}).$$

The result for sample run of CA is given below:

Input the Upper threshold value and Lower threshold value.

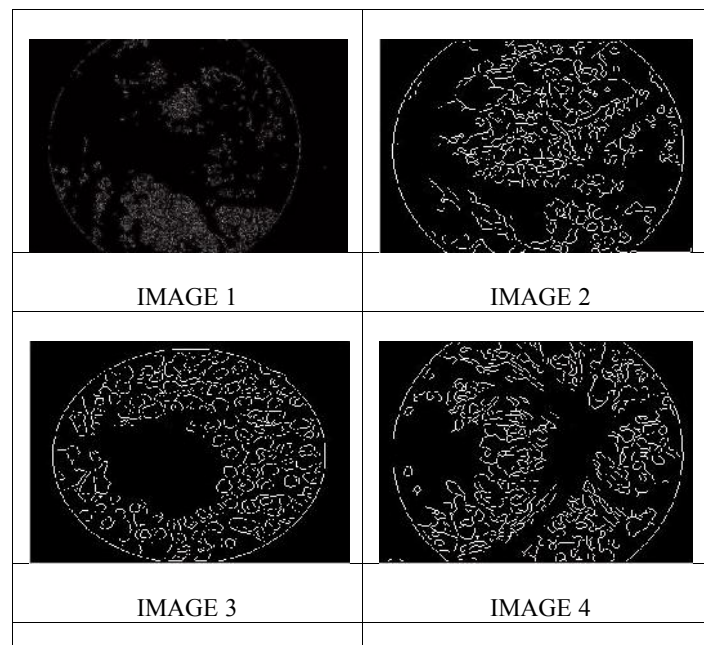
Upper threshold value = 0.03

182 Lower threshold value = 0.013  
 183 The threshold value obtained is compared with gradient value to obtain the properly detected edges in  
 184 an image.  
 185 Six retinal images (Fig. 2): were taken to demonstrate the efficiency of proposed method. Table 5.1  
 186 shows comparison between the performance measures of the proposed method with that of otsu's  
 187 and kapur's method.  
 188  
 189

| Method          | Sensitivity (%) | Specificity (%) | Accuracy (%) | Test set |
|-----------------|-----------------|-----------------|--------------|----------|
| OTSU            | 93.6            | 94.9            | 96.3         | 6        |
| KAPUR           | 0.35            | 1               | 3            | 6        |
| Proposed METHOD | 94.3            | 95.4            | 97.9         | 6        |

190  
 191 Table 5.1 COMPARISONS OF PERFORMANCES WITH DEFERENT TEST SETS  
 192

193 As observed in above table segmentation results shows that accuracies for Otsu's, Kapur's and  
 194 Cuckoo's method are found to be 96.3%, 3%, and 97.9% respectively. These results indicate that the  
 195 proposed method is performing better than existing methods.  
 196



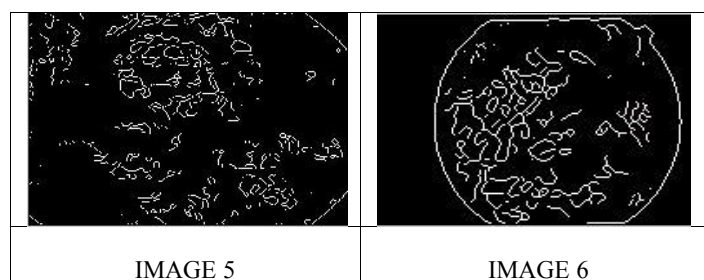


Fig. 2 Six retinal images

## 6. CONCLUSION AND FUTURE SCOPE

The present work is devoted to segment the retinal images, which would be helpful in making medical decisions. The accuracy of CA segmentation obtained is 97.9% while those obtained from otsu's method and kapur's method are 96.3% and 3% respectively.

In future, we intend to extend our work and test the feasibility of our proposed algorithm for the detection of Haemorrhages and Microaneurysms in DR and aim to compare the performance of our proposed algorithm with other conventional image segmentation algorithms.

## REFERENCES

1. Thomas Walter, et.al., "A Contribution of Image Processing to the Diagnosis of Diabetic Retinopathy—Detection of Exudates in Color Fundus Images of the Human Retina," *IEEE Transactions on Medical Imaging*,
2. C. I. Sanchez, et.al., "Retinal Image Analysis to Detect and Quantify Lesions Associated with Diabetic Retinopathy," *Proceedings of the 26th Annual International Conference of the IEEE EMBS San Francisco, CA, USA • September 1-5, 2004*, 0-7803-8439-3/04/ ©2004 IEEE.
3. Anantha Vidya Sagar, et.al., "A Novel Integrated Approach using Dynamic Thresholding and Edge Detection (IDTED) for Automatic Detection of Exudates in Digital Fundus Retinal Images," *Proceedings of the International Conference on Computing: Theory and Applications (ICCTA'07)*, 0-7695-2770-1/07 © 2007.
4. Doaa Youssef, et.al., "New Feature-Based Detection of Blood Vessels and Exudates in Color Fundus Images," *Image Processing Theory, Tools and Applications*, 978-1-4244-7249-9/10 ©2010 IEEE.
5. Hussain F. Jaafar, et.al., "Detection of Exudates in Retinal Images Using a Pure Splitting Technique," *32nd Annual International Conference of the IEEE EMBS Buenos Aires, Argentina, August 31 - September 4, 2010*, 978-1-4244-4124-2/10/ ©2010 IEEE.
6. Lili Xu, Shuqian Luo, "Support Vector Machine based Method for Identifying Hard Exudates in Retinal Images," *School of Biomedical Engineering of Capital Medical University*, 978-1-4244-5076-3/09 ©2009 IEEE.
7. Balazs Harangi, et.al., "Automatic Exudate Detection with Improved Naive-Bayes Classifier," *University of Debrecen, Faculty of Informatics*, 978-1-4673-2051-1/12/ © 2002 IEEE.
8. C. JayaKumari, R. Maruthi a, "Detection of Hard Exudates in Color Fundus Images of the Human Retina," *International Conference on Communication Technology and System Design 2011*, 1877-7058 © 2011 Published by Elsevier Ltd.
9. Xin-She Yang, Suash Deb, "Engineering Optimisation by Cuckoo Search," *arXiv:1005.2908v3 [math.OC]*, 23 Dec 2010.