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Different Exudates Segmentation Techniques in Fundus Images of Diabetic Retinopathy

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Abstract

Now a day's Diabetic retinopathy is a serious medical issue that mainly harm the human retina and finely vision blindness. The analysis of the Retinal images is done through different diagnosis methods in modern Ophthalmology. There are different methods available for segmentation of the exudates in the fundus retinal images. These methods are used for non-intrusive diagnosis for the eye diseases. Exudates are the manifestations of DR. This paper has demonstrated different methods of exudates segmentation with its advantages and constraints. Accordingly in this paper overview the various main elements of the retina. All examined systems have enhanced the execution in terms of accuracy, specificity and sensitivity. The examination has demonstrated that ant colony optimization based segmentation has better outcomes over each systems.

Keywords*: Exudates Segmentation, Fundus Images, Blood Vessels.*

INTRODUCTION

Diabetic Retinopathy (DR) is a standout amongst the most genuine difficulties of diabetes and a noteworthy reason for visual horribleness. It is a dynamic sickness grouped by the nearness of different clinical variations from the normal. DR is the most common cause of blindness in people aged 30–69 years. One-fifth of patients with newly discovered type II diabetes have retinopathy at the time of diagnosis. After 15 years, however, almost all patients with type I and two-thirds of those with type II diabetes have background retinopathy [1].

Diabetes is the most common medical disorder in the world. The World Health Organization has some review of diabetic patients. The World Health Organization got the total number of persons with diabetes to be 171 million as of 2000. The disorder is most found 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 [16]. 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 center 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

Manual revelation of exudates through ophthalmologists is arduous as they should invest a considerable measure of energy in the investigation and analysis of retinal images. Computerized screening strategies for exudate discovery have great importance throughout saving price, time as well as labor. Image processing strategies for exudate discovery can help in extracting the place, size and also severity level of exudates in the retinal fundus images [3].

Diabetic retinopathy has primarily 2 stages. To start with is non-proliferative stage and the second is the proliferative stage. Exudates found in the non-proliferative stage are specified as delicate (soft) exudates proliferative stage. Exudates found in the non-proliferative stage are mentioned as soft exudates and exudates in the proliferative stage are called as hard exudates [2]. Fundus image with main characteristics is shows in Fig.1.

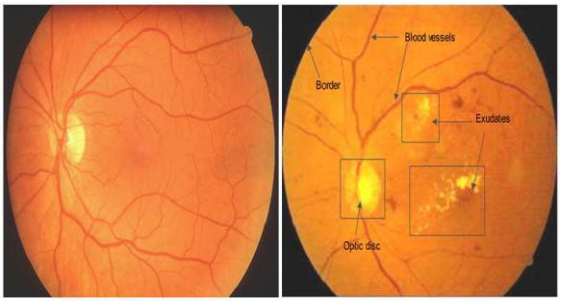

Fig.1: *Retinal Fundus Image and its Main Characteristics*

Fundus is nothing but the part of hollow organ that is furthest from the opening. Hence the fundus is inner portion of the eye which contains the blood vessels, optic disc, macula and fovea. Some of the retinal elements are described below with their functionality and their characteristics [4]. Exudates have been distinguished by various techniques like portioning the picture by region based segmentation, morphological process, markovain segmentation model, genetic algorithm, ant colony optimization and so forth. For the guess of the diabetic-related segmentation it is vital to discover the exudates. Exudates can be recognized by various distinctive approaches like watershed division, split and marge algorithm. If there should arise an occurrence of dim injuries like exudates this undertaking is troublesome in light of these reasons: First, on Account of closeness of anatomical structures like vessels, optic circle that have comparable data of force, surface with those of the injuries, second the light changeability cause imaging effect and third the eye advancement and difference in head positions. There is electronic methodology which perceives the diabetic retinopathy by recognize exudates through morphological technique in shading fundus retinal pictures and afterward portions these injuries or exudates. In head positions. There is electronic methodology which perceives the diabetic retinopathy by recognize exudates through morphological technique in shading fundus retinal pictures and afterward portions these injuries or exudates.

LITERATURE REVIEW

In table I, compared 5 papers, each paper segment the exudates in fundus images but the segmentation techniques used in all 5 papers is different.

The first paper is “Exudate segmentation in fundus images using an ant colony optimization approach”. Contribution of this paper is to segment exudates in fundus images using ant colony optimization algorithm, in this paper classification of exudates is not specified.

The second paper is “An Integrated Approach for Diabetic Retinopathy Exudate Segmentation by Using Genetic Algorithm and Switching Median Filter”. Exudates segmentation is perform in this paper using genetic algorithm and classification of exudates is not done.

The third paper is" Detection of Exudates from Digital Fundus Images Using a Region based Segmentation Technique". Contribution of this paper is Classification of exudates from non-exudates using rule based classifier and segmentation of exudates using region based segmentation model.
Fourth paper is "Morphological Process based Segmentation for the Detection of Exudates from the Retinal Images of Diabetic Patients. In this paper exudates segmentation is perform using morphological segmentation model and classification of exudates from non-exudates is done by using cascade neural network.

Fifth paper is "Detection of Exudates in Fundus Images Using a Markovian Segmentation Model. Contribution of this paper is to segment exudates using markovain segmentation model and support vector machine algorithm is used for classification of exudates. All 5 papers main aim is to exudates segmentation but techniques used in all paper is different. Classifier used in all 5 papers also different. Comparative study will be done on the bases of different characteristics of all 5 algorithm which are used in 5 papers.

Table I. *Literature Survey*

Paper No.	Name Of Paper	Contribution
1.	Exudate segmentation in fundus images using an ant colony optimization approach	Ant Colony Optimization for edge detection and no classification is used
2.	An Integrated Approach for Diabetic Retinopathy Exudate Segmentation by Using Genetic Algorithm and Switching Median Filter	Genetic Algorithm and Switching Median Filter Classification Not Done
3.	Detection Of Exudates From Digital Fundus Images Using A Region based Segmentation Technique	Region Based Segmentation Rule based classifier used
4.	Morphological Process based Segmentation for the Detection of Exudates from the Retinal Images of Diabetic Patients	Morphological Process CNN Classifier used
5.	Detection of Exudates in Fundus Images Using a Markovian Segmentation Model	Markovian Segmentation Model SVM Classifier used

ALGORITHM AND METHODOLOGIES

Segmentation is a technique of dividing given image into numerous sectors. Its objective is to categorize image into various regions in such a way that every potential object in image get individual sector. Instinctive recognition of diabetic retinopathy wounds, like exudates can provide opportunity to identify certain diseases. Recently, several methods of fundus extraction techniques are proposed which can detect the exudates in fundus images in more promising manner. Image segmentation is a procedure of partitioning a paired picture into various sub-pictures which are a gathering of pixels which are comparable in light of certain homogeneity paradigm for example shading, power and surface of the picture, to discover and find objects also, limits inside a picture. This is utilized to recognize protest of enthusiasm for the parallel image. Fundamental objective of Image preparing is to recover required data from the picture such that it won't influence different highlights of the

picture. Different techniques for segmentation as in Fig 2.

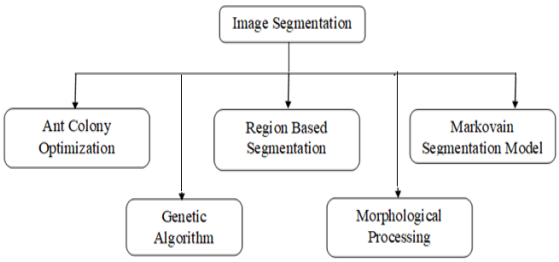

Fig.2: *Segmentation Techniques*

Ant Colony Optimization

Ant Colony Optimization (ACO) is a probabilistic technique for solving computational problem which can be reduced to finding good paths through graphs. The aim of ACO is to search for an optimal path in a graph, based on the behavior of ants seeking a path between their colony and a source of food. The behavior of real ants shown in Fig.3. Ant colony optimization (ACO) is a population-based technique that can be used to find approximate solutions to difficult optimization problems.

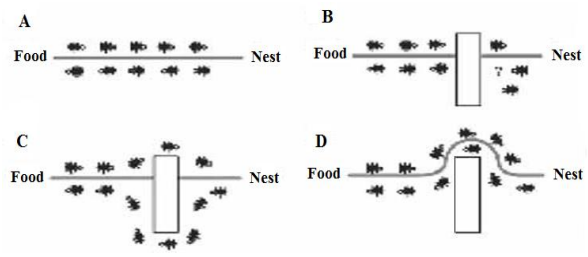

Fig.3: *Ant Behavior*

ACO is an iterative algorithm. At each iteration, a number of artificial ants are considered. Each builds a solution over the solution space through their movements and by updating pheromone information. The process starts with an initialization stage, and then runs for N iterations to construct the pheromone matrix by iteratively performing construction and update processes [5]. Suppose that K ants are used to find the optimal solution (image edges) in a space v; that is, in a sub-image I with size M1 _ M2, and where each pixel can be viewed as a node, the ACO algorithm implemented could be summarized as follows:

1. Determine the heuristic information and initialize the resultant image Ires = 0
2. For each original 128 _ 128 image window

a. Randomly initialize the positions of the K ants and the pheromone matrix s(0).

b. For the construction step index n = 1:N

i. For the ant index k = 1:K

1. Consecutively move the kth ant for L steps, according to the probabilistic transition matrix p(n) (with a size of M1M2 _ M1M2).

2. Local update of the pheromone matrix

ii. End For

iii. Global update of the pheromone matrix

c. End For

3. Assign pheromone matrix s(N) to the correspondent window on the resultant image

4. End For

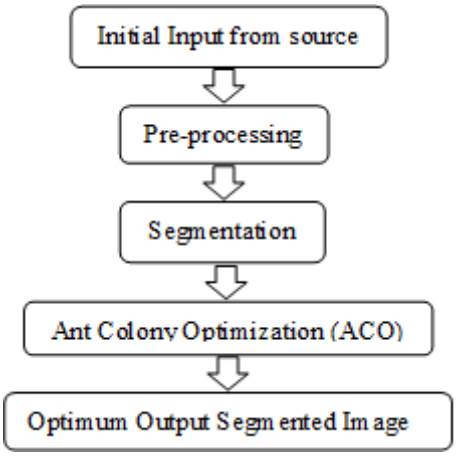

Fig.4: *System flow using ACO*

The flow of the system is as shown in Fig 4. This algorithm contains two crucial issues that have to be considered in the ACO process: the establishment of the probabilistic transition matrix p(n) and the pheromone matrix update. For the former, a probabilistic action rule determined by Dorigo et al [5].

Genetic Algorithm

Genetic algorithm (GA) is a method for solving both constrained and unconstrained optimization problems based on a natural selection process that mimics biological evolution.

Basic Mechanics of Genetic Algorithms

Reproduction: The act of making a copy of a potential solution

Crossover: The act of swapping gene values between two potential solutions, simulating the "mating" of the two solutions.

Mutation: The act of randomly altering the value of a gene in a potential solution.

Genetic algorithm is one of the most widely used optimization technique which helps in better segmentation in human retinal images. Genetic algorithm which was given by John Holland in 1978 most widely used optimization technique. It arbitrarily generates the set of probable solution by using the operators named as selection, reproduction, crossover and mutation Genetic algorithm has great development in retinal image processing applications [6]. GA randomly generates the set of possible solution by using the operators named as reproduction, crossover and mutation. The various steps involved in genetic algorithm are as:

1. Randomly initialize the population.
2. The algorithm creates a sequence of new populations. At each step, it uses the individuals in the current generation to create the next population. It performs the following steps:

• Calculate the fitness or objective value of each member of current population.

• Scale the temporary fitness scores to convert them into a more valid range of values.

• Select members (parents) based on their fitness.

• Production of children from the parents. Children are produced either by random changes to a single parent (mutation) or by combining entries of a pair of parents (crossover).

• Replacement of the current population with the children to make the next generation.

3. If the end condition is satisfied, terminate and return the best solution in current population.

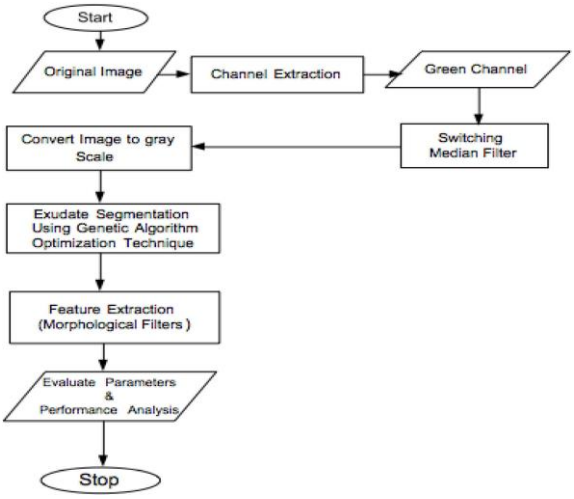

Fig.5: *System flow using GA*

The whole process is demonstrated in Fig. 5 and step-wise details are explained below:

Step 1: First of all, take a colored RGB human retinal image.

Step 2: Extract green channel component from RGB component of that image.

Step 3: Apply Switching Median Filter to remove noise from image.

Step 4: Convert the filtered image into Gray Scale Level.

Step 5: Apply Genetic Algorithm Optimization technique for exudate segmentation.

Step 6: Apply Morphological filters for feature extraction.

Step 7: Evaluate the parameters.

Step 8: Finally higher values of accuracy, sensitivity and lower value of error rate are obtained.

Region Based Segmentation

Region growing is a simple region-based image segmentation method. It is also

classified as a pixel-based image segmentation method since it involves the selection of initial points. This approach to segmentation examines neighboring pixels of initial seed points and determines whether the pixel neighbors should be added to the region. A general discussion of the region growing algorithm is described below.

- Divide image into an initial set of regions.
  - One region per pixel.
- Define a similarity criteria for merging regions.
  - Merge similar regions.
- Repeat previous step until no more merge operations are possible.

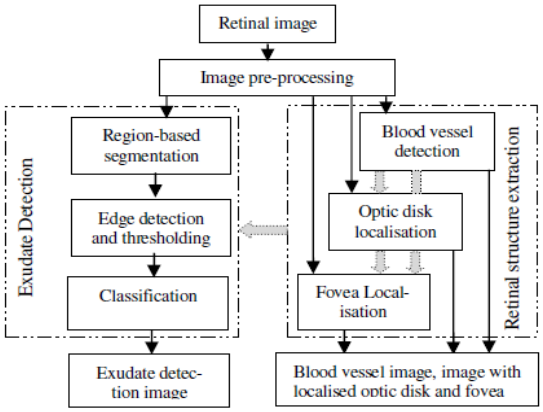

Fig.6: *System flow using Region Based Segmentation*

Even after the operation of pre-processing, most of retinal images may not be sufficiently uniform illuminated for global thresholding. Fig.6 shows the system flow using region based segmentation. With such concern, a region-based segmentation can offer a suitable solution by splitting the image into a number of homogeneous sub-images before the global thresholding. A novel region-based segmentation using a new split-and-merge algorithm has been proposed in our previous work. For showing signs of improvement execution and speedier calculation, we have utilized an unadulterated part technique as opposed to the split-and-union strategy to keep away from the downside of tedious caused by blending operations. In the proposed technique the picture is progressively divided into four quadrants to accomplish homogeneous sub-pictures in light of predefined criteria [7].

In this stage, we used the pre-processed image (G) after removing the detected OD. For this, an OD mask (O*d*) is used to mask its OD location on the pre-processed image by a color equal to the average intensity of the pre-processed image (I*av*) to get a new image (G*1*), as follows:

$$G_1(i,j) = \begin{cases} I_{av} & if\ O_d = 1 \\ G(i,j) & Otherwise \end{cases}$$

The end of successive partitioning relies on two factors: the homogeneity test and a predefined smallest size. This size must follow threshold (e) to avoid over-partitioning and then complex computation, where _ is dynamically calculated based on the statistical information of the whole image G*1* namely the mean and the standard deviation. For homogeneity test, we followed a method based on features analysis, described by Chen *et al.* [7].

Morphological Process

Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. A morphological process is a means of changing a stem to adjust its meaning to fit its syntactic and communicational context. The method attempts to detect the exudates consists of the following steps: 1) Image Acquisition. 2) Pre-processing. 3) Detection of Exudates. 4) Feature extraction. 5) Assessment of severity level of exudates.

The publicly available diabetic retinopathy dataset MESSIDOR has been used in the evaluation process. The MESSIDOR database has been established to facilitate studies on computer-aided diagnosis of DR. The database consists of 1200 eye fundus color images of the posterior pole. The included patients were randomly picked among the diabetic patients from the ophthalmologic departments involved in the MESSIDOR project. The input image is applied for pre-processing which involves gray scale conversion, median filtering and histogram equalization using CLAHE. Gray scale conversion of a digital image is to convert a color image into gray scale picture in which the worth of every pixel is a single sample, that is, the quality of each pixel is a solitary specimen, that is, it conveys singularly force illumination [8].

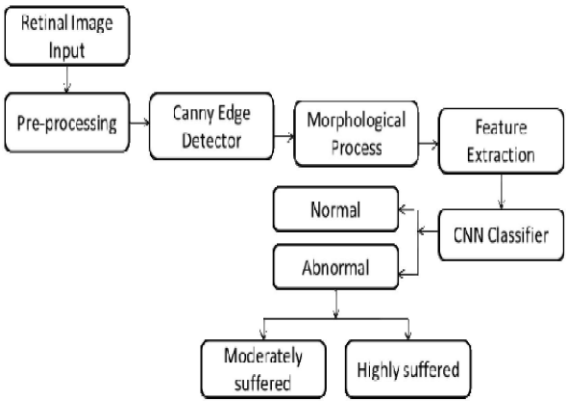

Fig.7: *System flow using Morphological Process*

In Fig.7 Images is made independently of shades of cinder, variable from dull at the weakest power to white at the most grounded. Powder scale pictures have various shades of light dark in the middle. Thus the information retinal shading picture is changed over into the dim scale picture. The dark scale transformation is favored here on the grounds that handling of single specimen is less demanding than preparing of three examples (RGB) in shading pictures. At that point the dim scale picture is connected for the clamor expulsion utilizing the middle channel. The middle channel is utilized to modify the complexity power and little pixels thought to be clamor are expelled. After the evacuation of clamor, the resultant picture is enhanced for picture improvement. Since, the complexity of the fundus pictures has a tendency to be brilliant in the inside and decrease along the edge, subsequently Histogram Equalization is basic to limit this impact and have a more uniform picture.

The feature selection process can also reduce noise and enhance the classification accuracy. Then the extracted features are given to the CNN classifier to assess the severity level. Cascade Neural network is a new design and supervised learning algorithmic rule for Artificial Neural Networks. Rather than simply adjusting the weights during a network of mounted topology, Cascade-Correlation begins with a token network, then mechanically trains and includes new shrouded units one by one, making a multi-layer structure [8]. A programmed system to discover Diabetic retinopathy eye maladies utilizing Morphological methodology is proposed. There are two modules in this work, one that performs picture division which incorporates the division of optic circle, veins and exudates and other one that performs order utilizing Cascade Neural Network classifier. Preprocessing with complexity improvement is connected before three characteristics, to be specific optic plate, veins and exudates are concentrated to supply as info parameters to coarse segmentation using Morphological process.

Markovain Segmentation Model

Image segmentation is an important early vision task where pixels with similar features are grouped into homogeneous regions. Markov Random Field (MRF) provides a robust tool to find exact boundaries of exudates by minimizing a

specific energy function. MRFs are a kind of statistical model. They can be used to model spatial constrains.

Walter et al. [10] proposed an exudate segmentation method using grayscale morphology operators. Namely, high local contrast and intensities as the most typical features of exudates are considered. The vascular system is eliminated through a grayscale morphological closing. Then, in the vessel-free image, local variation is calculated at each pixel using its local neighborhood. The regions with low local variation are also eliminated. Moreover, the shapes of the candidates are not accurate due to the applied structuring elements. To overcome these deficiencies, we will propose a Markovian segmentation model and a region-wise labeling [9].

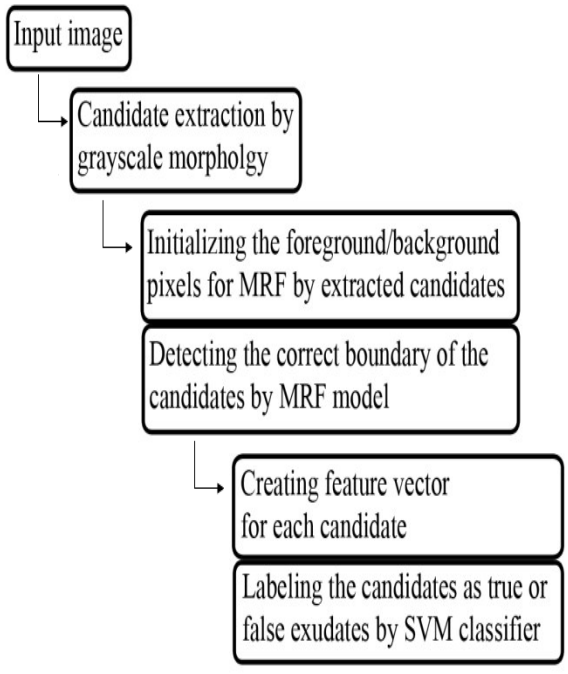

Fig.8: *System flow using Markovain Model*

Based on our experiments as in Fig.8, the MRF model provides the most precise boundaries of candidates, when the foreground pixels are defined by after applying morphological opening with a structuring element of size *3 x 3* pixels. For the assignment of the background pixels, we invert and perform an opening operation with a structuring element of size *7 x 7* pixels. The result of the MRF model initialized automatically.

Markov Random Field (MRF) provides a robust tool to find exact boundaries of exudates by minimizing a specific energy function. To find the global minimum for the usual energy function is an *NP*-hard problem, however, certain energy functions can be minimized in polynomial time by graph cuts. Lesko et al. [11] proposed a segmentation algorithm, which requires user interaction to mark an initial set of foreground/background pixels. Then, segmentation is performed via graph cut in real time.

To label the remaining candidates as true or false ones, we collect certain features for each candidate and apply an SVM supervised classifier. For feature extraction, we consider the green intensity channel I*G* of the RGB fundus image, since it contains the most information about the lesions and anatomical parts of the retina. Moreover, to enhance the local contrast of exudates, we apply a contrast-limited adaptive histogram equalization on I*G* to obtain I*CLAHE* [9]. To construct a feature vector for a candidate, we extract some intensity based statistical descriptors from the pixels composing the candidate using I*G* and. I*CLAHE* We also extract some shape descriptors from the precisely detected candidate region.

COMPARATIVE STUDY

Table II shows that comparative study of these 5 algorithms of exudates segmentation. On the basis of accuracy, specificity, sensitivity, database these algorithms are studied & we found that Ant Colony Optimization Algorithm gives better results for segmentation of exudates.

Table II. *Segmentation Algorithm Comparison*

Parameters	Paper1	Paper2	Paper3	Paper4	Paper5
Pre-processing	Median Filter	Median Filter	Morphological Filter	Median Filter	Morphological Filter
Segmentation	Ant Colony Optimization	Genetic Algorithm	Region Based Model	Morphological Processing	Markovian Model
Classifier	NA	NA	Rule Based	CNN	SVM
Database	HEI-MED	CHASE	DIARET DB1	NA	DIARET DB1
Accuracy	98%	97%	98.3%	96%	95%
Sensitivity	93%	98%	80%	85%	90%
Specificity	99%	NA	99.2%	98%	NA

CONCLUSIONS

Early acknowledgment of Diabetic retinopathy is exceptionally fundamental for vision powerful treatment. Exudates segmentation technique is still an open area of research in digital image processing and it has found to be challenging task in vision research.

This paper has indicated various systems of exudates segmentation with its merits and demerits. Although ACO based segmentation has shown better results in finding exudates but still it has some limitations.

The study focus on various techniques for exudates segmentation. The basic Evaluation of study is as:

ACO – High Performance and not considered noise effect.
GA – High speed up but suffer from noise.
Region Based – Time Consuming.
Morphological Process – Suffer from noise effect.
Markovian Model – Low speed.

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