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Automatic Identification of Abnormal Tongue Image Using Cnn with *K*-Mean and Hybrid Firefly Algorithm

Ms. Pallavi Pahadiya[1], Dr. Ritu Vijay[2], Mr. Kumod Kumar Gupta[3], Ms. Shivani Saxena[4]
[1]Phd Scholar, Banasthali Vidhyapith, Rajasthan, India and Asst. Prof SAGE University, Indore , India
[2]Professor, Electronics Department, Banasthali Vidhyapith, Rajasthan, India
[3]Phd Scholar, Banasthali Vidhyapith, Rajasthan, India and Asst. Prof Delhi Technical Campus, India
[4]Phd Scholar, Banasthali Vidhyapith, Rajasthan, India and Asst. Prof Banasthali Vidhyapith, India
pallavi_19_2000@yahoo.com[1], rituvijay1975@yahoo.in[2], kumodkumargupta@gmail.com[3], shivani.19saxena@gmail.com[4]

Abstract. Due to the fast lifestyle and less time for self monitoring through invasive methods which are accurate but needs time and costly too, research is going on to improve the accuracy of non-invasive method for disease identification. In India there is rapid increase in tongue related diseases like severe ulcers and cancer. Identification of the abnormalities at initial stage plays very important role in disease identification. Work in same field to find abnormality at earlier stage will be beneficial to patient so that if needed they may opt for invasive method for disease confirmation and its treatment at initial stage. This paper presents a hybrid algorithm using firefly algorithm and k-mean clustering algorithm along with parallel processing using CNN to identify normal and abnormal tongue images. Database of Oral cancer foundation and images available online are used and 150 normal and abnormal digital tongue images along with augmentation are used in CNN to obtain results. Results shows proposed method with CNN gives 90% validation accuracy and it is able to discriminate between normal and Normal tongue images.
Keywords: Automated tongue analysis system (ATDS), *K*-mean clustering, Firefly Algorithm, GLCM, Parallel Processing, CNN

1. Introduction:

Basically there are two methods for disease identification i.e. invasive method and non- invasive method. One of the non- invasive methods is disease identification through tongue analysis. In Tongue analysis Expert decision plays an important role for detecting the disease. The Experts judgment varies as per the knowledge of examiner [1].Tongue analysis can be done in two ways:

a. Through direct view of tongue by expert only.
b. Automatic tongue image analysis, done by dedicated hardware and software.

Some diseases of tongue like boils, ulcer and cancer are also examined by both invasive and non-invasive method. In invasive methods user has a fear of invasive techniques and they may neglect this process and the condition becomes worse after some time. In non-invasive method the lot of research is going to get the accuracy and speed of process. Non- invasive method like automatic tongue image analysis is based on different inputs like hyper-spectral image [2], fluorescent image digital image etc. As digital image are easy to take due to availability of digital camera, research in this field to get accurate result will be of great help to the patients.

The tongue image of patient is processed by the automated tongue analysis system (ATDS) [3] which, process the input image as per the software and identify the disease. Different Researchers

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has worked to make this system robust and independent of expert advice. Such systems consist of a dedicated tongue image acquisition hardware [4-7].In the tongue analysis systems first the image of tongue is captured, then it is pre-processed to eliminate noise and enhance the image processed, some color correction techniques are also used in the same [8-10]. After that segmentation technique which separates background area from tongue image also, segmentation is used to get the area/region of interest (ROI). Different clustering methods like unsupervised and supervised algorithm are used to obtain accurate ROI. Research in the field of image segmentation is going on to obtain the accurate region of interest. Since the final Results of whole process of tongue image analysis depends on accuracy of ROI, time taken for process. This paper focuses on comparison of two segmentation process those are *K*-mean clustering, Firefly algorithm (FA) along with *k*-mean clustering [11-15] to obtain Region of interest. This method also separates the abnormal area due to ulcers, boils and cancer. As detecting cancer at earlier stage is very important so, this method separates abnormal area which can be further processed or analyzed by skilled examiner to check whether abnormal area is affected or not. The speed of processing is also point of concern therefore parallel processing is incorporated to increase decrease the time to process. To get solutions so as to early detect abnormality in tongue a reliable system has to be built. This requires automatic detecting of abnormality. Basically automatic detection is done on large scale using machine learning. Convolution neural networks (CNN) are normally used for image classification, the advantage of CNN is reduction in dimensions of data, sequential feature extraction along with classification into one structure of the network[16]. This paper uses CNN for finding the abnormality in the segmented area.

As the oral diseases are increasing and change in lifestyle choosing the dedicated invasive method or opting for disease detecting using dedicated hardware[2][4-10] is not always possible. Such hardware is also not available at remote places. If system is developed which uses simple digital images as input and guide the user about the health of tongue then it will be of great use. Lot of researches is going on in same field due to the advancement in technology. This experiment is one of the step in this field only. In this paper, we will focus on firefly algorithm, k-means algorithm and hybrid firefly algorithm with parallel K-mean clustering algorithm. In Section 2, the digital Image acquisition techniques are discussed, then Preprocessing is explained followed by that Segmentation techniques specially Firefly algorithm, *K*-mean clustering, then proposed Hybrid firefly and K-mean clustering along with parallel processing is presented. Feature extraction through GLCM is presented. In section 3 Results of these methods with different distance functions are presented. Analysis for Energy, Entropy, Auto-correlation, contrast and time to process give important concluding results. At the end of this section CNN is discussed and the Results which shows whether the input image is abnormal or normal. We conclude with future scope in section 4.

2. Method and Flow:

The abnormal conditions in tongue image like ulcers, boils, cancerous cell can be identified by some key changes as compared to normal tongue like change in color like red, yellow, purple or white spots etc. other changes like inflammation, sensation, pain. Some of the images of normal tongue and abnormal tongue due to ulcer, cancer is shown in figure 1 [17-19]. In this experiment different segmentation algorithms are compared to obtain optimized region of interest with minimum losses. Here Gray Level co-occurrence Matrix (GLCM) is used to study the energy,

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entropy, area along with mean square analysis. Basic comparison is done with K- mean clustering algorithm which is unsupervised algorithm. Different distances are also varied to get the results. For experimental purpose available images on internet are used. Process flow is discussed in different sections. Images taken by image acquisition techniques can also be taken as discussed in section 2.1. These images are segmented using different clustering methods discussed in section 2.2. Segmented images are compared on the basis of GLCM results and MSE analysis in section 2.3. Results are discussed in section 3.Future scope of this is finally discussed section 4.

Fig. 1: (a) Tongue abnormal area (b) Tongue having Squamous cell carcinoma (c) tongue having abnormal area

Digital images being available on internet and dataset are used for testing the method. Image acquisition can be done as explained in section 2.1. This image is preprocessed first as explained in section 2.2 and followed by K mean clustering method for affected tongue area segmentation explained in section 2.3.

2.1 Image acquisition:

Image acquisition plays an important role in image processing. Dedicated hardware are available [3][4][6]. Such hardware uses different types of images like hyper-spectral images [2], fluorescent images used by VELscope, digital images are also used in some hardware. Dedicated hardware incorporates preprocessing unit to enhance the input image along with color correction techniques [8-10]. Tongue image analysis is done by skilled examiner who can operate this dedicated hardware. Automated tongue diagnosis systems (TDS) [2] are designed which process the image as per the algorithm used. To detect the abnormality I tongue at initial stages algorithm used to segment the ROI and feature extraction should be very accurate. Many algorithms are available for image segmentation but digital tongue images are susceptible to noise and less clarity due to presence of salvia it get difficult to detect the small abnormal area on tongue along with inflammation.

2.2 Preprocessing and Normalization:

Before segmentation the image need to be preprocessed to meet the requirements of next steps. Preprocessing includes Gabor filtering and normalization to obtain size compatibility so, as to satisfy basic requirements and better results.

2.3 Segmentation to get Region of Interest (ROI):

Two methods are used for segmentation.

1. Simple K-mean clustering Algorithm
2. Firefly algorithm and K-mean clustering method

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3. Firefly algorithm and K-mean clustering method with parallel processing

***K*-mean clustering method:**

K-mean clustering Algorithm is very famous and can be implemented very easily. In this algorithm user has to define the number of clusters by *K* to be obtained in segmented image. Best number of clusters is evaluated through silhouette plot .Idea for number of cluster makes user easy for further processing. Silhouette plot for image1 is shown figure 2. Comparison for best clusters as per silhouette plot is also, done with other cluster numbers in results. According to the silhouette plot results for given image 1 best number of cluster are 10 and good image segmentation is observed for this value of *K*.

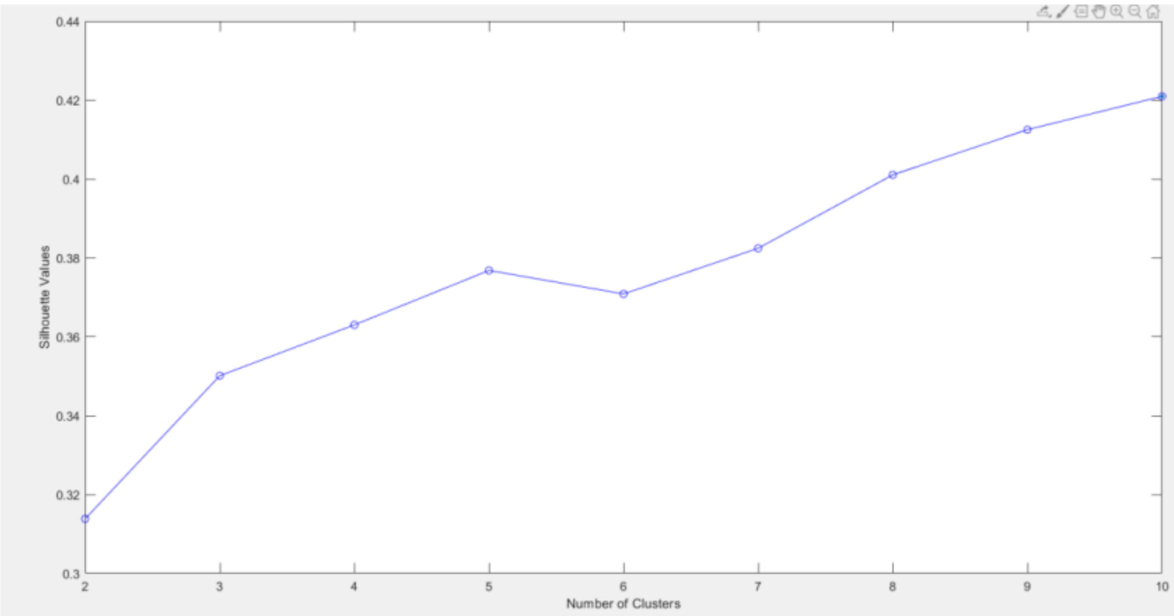

Fig. 2: Silhouette Plot for image1

Need of seed, providing seed by prior knowledge of abnormal area is difficult in every operation. In the initialization process there are two ways of initial centroid selection, in one method it is selected randomly by default algorithm but it suffers from drawback of trapping in local minima so, to overcome seed selection algorithm like firefly algorithm[20], particle swarm optimization algorithms[21], genetic algorithm[22] are used. Providing initial centroid value as seed gives results fast and avoids local trapping. After initial centroid initialization the algorithm itself find the best centroids by repeating these steps:

1. Assign data points which are closest to centroid.
2. Recalculate the new centroid of all clusters. This done by finding the mean value of all the data points in given cluster.
3. At last the algorithm ends if maximum number of iteration achieved or the small value of within cluster distance is achieved.

Normally *k*-means algorithm works to minimize the sum of squared Euclidean distance between instances inside each cluster and their centroids. This distance can be cosine, Euclidean, city-block etc. K-mean clustering [23-25] done after the Gabor filtering [26] to reduce noise. In this experiments these three distance measure are also compared by using inbuilt k-mean clustering function of MATLAB, whose formula is given in table 1.

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Table 1: Description of inbuilt distance functions i.e. City-block, Cosine and Euclidean

Distance Metric	Formula
cosine	$d(p,r) = 1-\frac{pr'}{\sqrt{(pp')(rr')}}$
City-block	$d(p,r) = \sum_{i=1}^{j} \lvert(p_i - r)\rvert$
euclidean	$d(p,r)=(p-r)(p-r)'$

Need of seed/initial centroid: The value of seed affects the cluster formation and avoids local trapping. For seed selection prior knowledge of abnormal area I should be known and it is difficult in every operation.

2.4 Firefly Algorithm:

One of the important stochastic algorithms which are used for optimization is Firefly Algorithm (FA). Here the flashing nature of firefly is made into consideration where the brightness is considered as luminance. Every firefly can send luminance signals to other firefly. Brightness and attractiveness are two important parameters of Firefly algorithm [27].Firefly algorithm has specific rules based on fireflies:

1. All fireflies can attract others due to unisex factor.
2. Attractiveness is directly proportional to intensity of light so low intensity fireflies will get attracted towards brighter ones.
3. Searching is done by using cost function or fitness function which depends on brightness.

Movement calculation is done by using equation 1. Consider two firefly ‘p’ and ‘s’. Now the intensity of both fireflies is compared. Say the intensity of firefly ‘p’ is more than firefly ‘s’ then the firefly ‘s’ is moved towards the firefly ‘p’.

$$f'_p = f_p + \beta_0\, e^{-\Upsilon r_{ps}^2} + \alpha(\text{rand} - \tfrac{1}{2}) \quad (1)$$

where, f_p is the location of the firefly ‘p’ that is attracted to another more brighter firefly ‘s’ at location f_s, f'_p is the new location the firefly ‘p’, and $\beta 0$, Υ and α are constant values, rand is a value that varies from 0 to 1 and rps is the difference between f_p and f_s.

2.5 Proposed Firefly and k-mean algorithm with Parallel Processing:

K-mean clustering is generally used for image segmentation or clustering problems. But it faces two problems that is initialization of seed value and converges at local minima. Using firefly algorithm value of initial centroid/seed can be obtained and these initial centroid values are used in *k*-mean clustering method. Thus firefly algorithm helps to overcome its one problem of initialization. In *k*-mean clustering the distance measure been used can be varied say cosine, city block, Euclidean, correlation. This hybrid algorithm firefly and *k*-mean clustering uses advantages of firefly algorithm for searching the best solution and segments the image using this solution as a

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initial centroid value. *K*-mean clustering is used with parallel processing to speed up the process. In parallel processing Consider ‘n’ data points each of it is vector and ‘P’ processors. The flow chart for hybrid *k*-mean algorithm with Firefly Algorithm is shown in figure 3 and the algorithm steps are shown below:

Algorithm 1. F*K* with parallel processing algorithm()

Input: Input Image I

Output: clustered Image I’

1: MSE = Inf.

2: OldMSE = 0

3: Let MSEp is the partial MSE computed from processor p

4:

5: **procedure** F*K*_parallel_*K*_Means

6: i = 0, o* = NULL;

7: a$^{(0)}$ = InitializeFireflies(); // generate the initial firefly population

8: **while** (i < I) **do**

9: ComputeFitness(a$^{(i)}$, f(o));

10: a$^{(i+1)}$ = MoveFireflies(a$^{(i)}$); // update the position of fireflies

11: o* = FindBestFirefly(a$^{(i)}$, f(o)); // best solution o*

12: i = i + 1;

13: **end while**

14: Assign n/P instances to processor i // processors compute the closest centroid each instance in a parallel fashion.

15: Assign k/P centroids to processor i // the task of calculating the new cluster centroids in parallel fashion

16: **for** each Processor p ∈ P **do**

17: RunKmeans(o*); // Execute K-mean algorithm for the best solution of firefly algorithm

18: WAIT ALL Processor and LOCK MEMORY MSE

19: **for** each Processor p ∈ P **do**

20: Add(MSE, MSEp) // update MSE with addition of MSEp

21: **end for**

22:**end for**

23: WAIT ALL Processor and UNLOCK MEMORY MSE

24: return I’;

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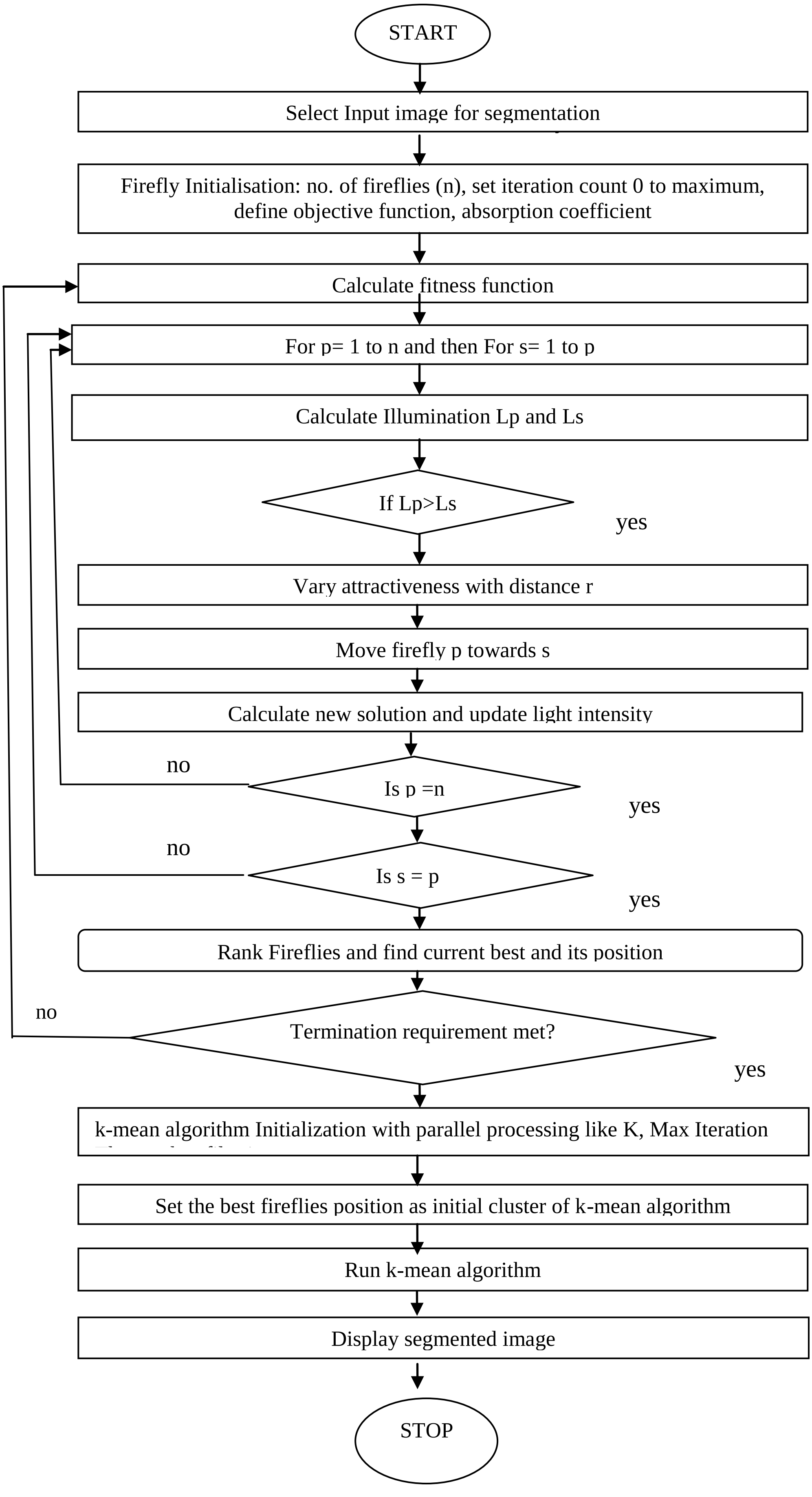

Fig. 3: Flow chart for the hybrid *k*-mean algorithm with Firefly Algorithm

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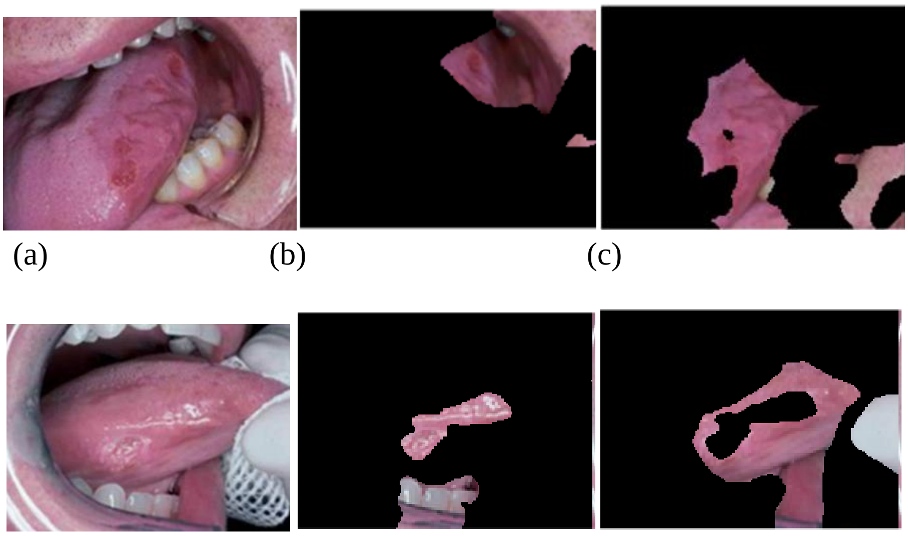
2.6 Extraction of texture features using GLCM:

Gray level co-occurrence matrix (GLCM) is used to calculate the spatial dependence of gray levels in an image. The features calculated using the GLCM are Autocorrelation, contrast, energy and entropy [28-32]. Area is calculated by the extraction of shape feature using connected pixels [33].

There is a need of designing a system which is capable to detect the abnormalities of tongue at an initial stage. Work is going on for designing low-cost portable imaging system[34]. Some automated systems use fluorescent images [35]. This experiment is towards a step to design a digital tongue image analysis system which can identify abnormalities in tongue at initial stage so, that if the abnormality observed is severe then patient may be asked for go for invasive pathological methods to confirm its disease and start treatment at earlier stage only.

2.7 Experimental work and initial values:

The main objective of this experimental work is to segment the smallest abnormal area in tongue image analysis. As tongue is normally coated with saliva so, it is quite difficult to differentiate the abnormal area. This method uses hybrid Firefly algorithm along with *k*-mean clustering method with constant being defined later in this section to segment the abnormal tongue area. For this experiment system used is Intel CORE i5, 8 GB RAM, Matlab 2019b. Parameters used for *k*-mean clustering are *K*= 6,10,15. Maximum iteration=1000, Replicate=3. Parameters used for Firefly algorithm are maximum iteration 100, number of fireflies= 20, gamma=1, beta=2, alpha=0.2, coefficient of damping ration=0.98. The output image after segmentation and cluster of interest are shown in figure 4.



(a) (b) (c)

(d) (e) (f)

Fig. 4: Results of image segmentation using 15 clusters. (a) and (d) are input images. (b) and (c) are the two cluster of interest for image(a). (e) and (f) are the two cluster of interest for image(d).

3. Results and Conclusion:

In this experiment both k-mean clustering algorithm and hybrid firefly algorithm with k-mean algorithm is compared for different parameters like MSE, entropy, autocorrelation and time to process. Then the hybrid firefly algorithm with k-mean algorithm is used along with CNN to identify normal or

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abnormal tongue images.

3.1 Comparison of k-mean clustering algorithm and hybrid firefly algorithm: Comparison of *k*-mean clustering algorithm and hybrid firefly algorithm with k-mean algorithm is done for image1 and 2. Results are given in table 2 and 3. Parameters being compared are:

1. Area of both clusters of interest. For variable number of clusters i.e.6,10,15.
2. MSE between input image and output image. For variable number of clusters i.e., 6,10,15.

Table 2 shows the comparison of area for two clusters of interest and MSE (Mean square error) and Table 3 shows the comparison of energy, entropy, contrast and autocorrelation for different value of clusters.

Table 2: shows the comparison of area for two clusters of interest and MSE

S.no.		**Method**	**cluster1 area**	**cluster 2 area**	**number of cluster(k)**	**MSE**
1	Image 1	*K* -mean	9357	9556	10	14346.9
2		*K*-mean+ firefly	9361	9160	10	14493.97
3		*K* -mean	14780	9896	6	12772.75
4		*K*-mean+ firefly	11045	8985	6	13478.57
5		*K* -mean	4146	3043	15	14144.47
6		*K*-mean+ firefly	5138	4439	15	15375.74
7	Image 2	*K* -mean	_	20212	6	16498.86
8		*K*-mean+ firefly	_	20212	6	16551.88
9		*K* -mean	3366	10484	10	14372.38
10		*K*-mean+ firefly	3366	10484	10	17941.04
11		*K* -mean	3065	7428	15	16958.5
12		*K*-mean+ firefly	3034	7358	15	18107.43

As per silhouette plot the Number of clusters for image1 is *k*= 10 and for image2 is *k*=6,10. As per the results the area obtained for best number of clusters given from Silhouette plot is nearly same. Also, the MSE for the image1 *k*=10 and image2 *k*=6 is quite similar. But it is been observed that the MSE for simple *K*-mean clustering algorithm is less as compared to the *K*-mean+ firefly algorithm.

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Analysis for Energy, Entropy, Auto-correlation, contrast:

Table 3(a): shows the comparison of energy and entropy for *k*=10

input image	type of algorithm	Distance	I/P image energy	O/P image Energy	I/P image Entropy	O/P image Entropy
Image 1	*K*-mean	eucledian	0.16	0.84	2.25	0.5
	K-mean	cosine		0.89		0.32
	K-mean	cityblock		0.79		0.5
	K-mean +FA	eucledian		0.77		0.58
	K-mean +FA	cosine		0.82		0.49
	K-mean +FA	cityblock		0.83		0.53
Image 2	*K*-mean	eucledian	0.12	0.81	2.52	0.54
	K-mean	cosine		0.78		0.63
	K-mean	cityblock		0.87		0.41
	K-mean +FA	eucledian		0.8		0.56
	K-mean +FA	cosine		0.84		0.49
	K-mean +FA	cityblock		0.61		1.02

Table 3(b): shows the comparison of contrast and autocorrelation for *k*=10

input image	type of algorithm	Distance	I/P image Auto-correlation	O/P image Auto-correlation	I/P image Contrast	O/P image Contrast
Image 1	*K*-mean	eucledian	17	2.52	0.23	0.16
	K-mean	cosine		1.98		0.08
	K-mean	cityblock		2.44		0.08
	K-mean +FA	eucledian		3.07		0.07
	K-mean +FA	cosine		1.79		0.05
	K-mean +FA	cityblock		2.69		0.1
Image 2	*K*-mean	eucledian	21.52	3.08	0.29	0.07
	K-mean	cosine		4.3		0.07
	K-mean	cityblock		2.05		0.06
	K-mean +FA	eucledian		3.18		0.07
	K-mean +FA	cosine		2.33		0.06
	K-mean +FA	cityblock		7.08		0.15

As per the above results for both images k-mean algorithm gives more energy value and entropy value in output image for different distance measures. Autocorrelation value is higher for K-mean and firefly algorithm. Contrast value is low for k-mean and firefly algorithm.

3.2 Analysis for Time to process: Time required to execute the algorithm is different. In the k-mean algorithm if the proper seed value is provided as initial centroid, then the time needed to execute algorithm is different from default algorithm. The time required to process Image 1 using different algorithm is shown in table 4.

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Table 4: Time required for different algorithms

Algorithm→	*K*-mean	*K-mean* with parallel processing	*K*-mean +FA	*K*-mean with parallel processing + FA	No. of clusters
Time (sec)	1.815	2.57	1.549	3.288	4
	3.585	2.695	2.586	3.343	6
	2.678	2.395	2.758	3.055	8
	2.200	2.134	2.299	3.043	10
	5.196	5.192	4.312	4.338	12
	4.782	4.091	3.953	5.620	14
	6.088	4.832	6.015	7.858	15
	6.74	4.92	7.312	5.742	20
	6.35	5.962	8.13	6.652	30
	9.017	8.75	10.001	8.475	40

As per the above results the time to process the image by the initial cluster value using firefly algorithm is less than simple k-mean algorithm. Since the initial centroid/ seed value is given by firefly algorithm. K-mean combined with parallel processing takes less time to process if number of clusters are more [36]. For the number of cluster k=10 the time taken for each algorithm is less and it is shown in silhouette chart too for this image number of cluster k=10 has higher value.
Analysis on 25 different images is done and the average time taken v/s number of clusters is shown in figure 5.

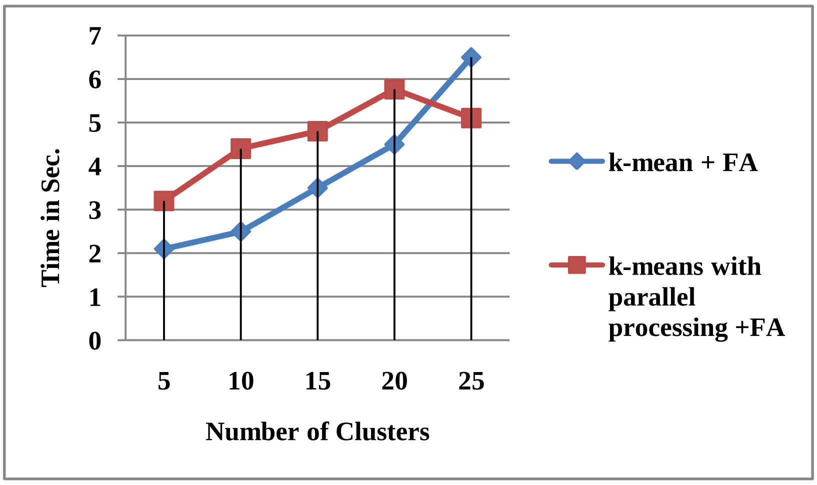

Fig. 5: Comparison between Firefly with k-mean algorithm and Firefly with k-mean algorithm along with Parallel Processing on the basis of number of clusters and time to process.

From all the result of above experiment the conclusion is that the firefly algorithm combined with k-mean algorithm gives output fast as the initial centroid value given by it. In some cases, energy value is some lower. Proposed method that is k-mean with parallel processing along with firefly algorithm speed up the process more for higher number of clusters. For images having higher size

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parallel processing gives result fast. But for less size it consumes time. The main aim of his experiment is to detect the minor abnormal area in digital tongue images. For detecting minor size of abnormality cluster size needs to be higher. Fast and better results are obtained for tongue image segmentation having minor abnormal area using firefly algorithm along with k-mean algorithm along with Parallel Processing if number of clusters are more. Otherwise for a smaller number of clusters firefly algorithm along with k-mean algorithm is better. It is been observed that for the first-time parallel processing is been opted then it takes more time then after time is reduced.

3.3 Convolution Neural network: Convolution neural network (CNN) gives better result for image classification and image recognition. Comparing with conventional method it has advantages like reduction in data dimension, classification, extraction of features especially for recognition of pattern [37-39]. Thus, in this paper CNN is used to distinguish between normal and abnormal tongue images. Availability of Digital Images dataset is the constraint of our analysis since research is going on for digital images. Thus,a smaller number of images are available. Oral cancer Dataset is used along with available online images, as numbers of images are less so, Augmentation is used in CNN. In that rotation [-20,20], XTranslation [-3,3], YTranslation [-3,3] is used.

In this experiment MATLAB –R2019b is used with windows 10, intel CORE i5 processor, 8GB RAM. Image size of 205X 280X3 is used with 15 epoch. $\alpha = 1$.CNN is applied on data set with 150 images along with augmentation is used. Here 2D convolution layer with filters of size [3 3] in three layers and same padding along with max pooling layer having pool size [2 2] and stride [2 2] is used. The accuracy comes out to be 90.00%. Validation accuracy remains 90% for Epoch 10 and above till 1000.

CNN is used to identify the whether the input tongue image is normal or abnormal. Segmentation and region of interest is obtained by K-mean clustering and hybrid firefly algorithm. Final Images with label normal/ abnormal are shown in figure 6.

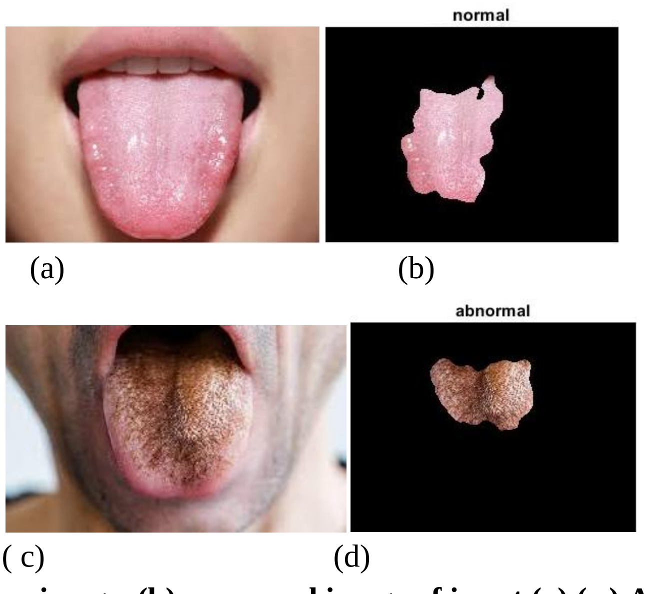

Fig. 6: (a) Normal tongue image, (b) processed image of input (a),(c) Abnormal input image (d) processed image of input (c).

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Both the images (a) and (c) of figure 4 are input images which are segmented in 10 segments through above hybrid algorithm and CNN is used for identification. (b) and (d) are processed images. This method is useful to identify whether input tongue image is normal or abnormal.

4. Future scope:

Identification of abnormal area at initial stage becomes very important in the disease like ulcers, tumors and cancer. As tongue image analysis can be done through digital images and finding the abnormal area is quite difficult due to the presence of saliva coating and other fur like tissue over the tongue surface. This experiment is one step to segment the smaller abnormal areas through hybrid firefly and K-mean clustering method. Using CNN abnormal and normal tongue images can be distinguished as shown in paper. This work can be future continued with feature extraction for identification of minor abnormalities in tongue. Also, in case of abnormal tongue image patient can be asked for future analysis using pathological methods.

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