Using Artificial Intelligence Methods For Diagnosis Of Gingivitis Diseases

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Abstract. Artificial Intelligence Techniques, and image processing are playing a major role in medical science. In this paper, several methods of artificial intelligence techniques were used to diagnose Gingivitis disease. The Bat swarm algorithm, the Self-Organizing Map(SOM) algorithm and the Fuzzy Self-Organizing Map (FSOM) network algorithm were used to diagnose Gingivitis disease. Also, was used the traditional algorithm, which is the Principal Component Analysis (PCA) algorithm, for Feature Extraction of Gingivitis disease images. We compute the diagnostic accuracy on this images dataset. Next, we compared the final results of these three methods used and applied to this data. In this paper the best of these methods is the BAT, because in testing state the BAT was obtained higher accuracy for diagnose of Gingivitis disease equal (97.942%).

1. Introduction
Gingivitis Sometimes called gum disease or (periodontal disease) - describes cases of bacterial build-up in the oral cavity, which may eventually lead, if not treated properly to tooth loss, as a result of damage to the layer That covers the teeth. There are many different types of gum disease, such as: Gingival abscess: (also called lateral abscess, or peripheral abscess), is a localized group of pus (i.e. abscess) within the gum tissue. It is a type of dental abscess[1]. Hereditary Gingival Fibromatosis (HGF): Also known as idiopathic gingival enlargement, it is a rare case of periodontal overgrowth. HGF has benign, slowly gradual, non-hemorrhagic, fibrous enlargement of the keratinized gum. It can cover teeth in different degrees[2]. Gingival hyperplasia: It is enlarged gums due to its inflammation [3]. Oral Lichen Planus: This disease is found in the oral cavity [4]. Gingival melanoma: The oral cavity is a common site of pigmented lesions, most of which are benign. Oral malignant skin cancer is
extremely rare[5]. Gingival pigmentation: Black spots or spots on the gums that are consist of melanin. Melanin in the skin is very common in populations in many parts of the world due to genetic factors. Melanin pigmentation in the skin and oral mucosa Certain toxic factors associated with melanin that transfer from tissues are associated with aging cells and are expelled to the tissue surface. Also in the gums and oral mucosa visible pigmentation often occurs due to hereditary factors, but also because of tobacco smoking or in a few cases by long-term use of some medications[6]. Gingival recession: The cause is gum tissue loss [7]. Mouth ulcer: Disease affecting the oral cavity as a result of sores being exposed by the mucous membrane [8].

In this paper, image dataset which represents these eight types of Gingival disease, both training and testing cases are used, and AI techniques have been applied in many medical problems, one of these applications is data diagnosis and detection. In this research, the PCA algorithm was applied to extract the features of gingival images, and for diagnose we using the bat swarm algorithm, due to its having the distinctive characteristic to reach the optimal solution in the fastest time, and SOM neural network was used to distinguish it in making the classifications correctly and completely, as indicated by the results that were reached by induction, and then we was hybridization by adding a fuzzy membership function to SOM network and obtaining a new method, namely, the FSOM neural network, to diagnose and discover this data set according to the type of Gingival disease.

2. Previous Work

In particular several artificial intelligence algorithms based methods were employed for processing of Gingival diseases images, such as: in 2011 Vijay K., Anjali M. presented "Fuzzy Expert System" for decision on mobile Tooth. the inputs of this system are some parameters like infection, pain, and etc whose membership values are in between [0, 1] which got it by different functions using "IF- THEN rules" and FISM, and used Mamdani method from Fuzzy Inference System; and done Defuzzification by centroid method, by using "chi square test" was tested the performance of the system by using dentists’ opinion. This method which was used in this paper has Obtained good results[9]. in 2014 Georgios P., KeisoT. implemented Artificial Neural Networks for classification and Diagnosis of chronic Periodontitis. the input is Different samples for Periodontitis. ANNs obtained accuracy 90% in classifying patients[10]. in 2014 Ali A., Osama A. by using Optimized ANN and genetic methods, the accuracy more than 80% was predicted for Tooth surface loss. and to construct ANN the dataset were taken is of 46 patients, and in testing phase taken 15 patients data. The dataset includes some parameters such as Age, type of brush tooth, smoking status, bruxism, frequency of brushing, drinking fizzy drink, eating dried seeds, pickles, citric fruits. The accuracy was obtained is 73.3% [11]. Thafar S., Fawziya M., in 2016 worked on Meta Firefly Personal identification System to
recognize teeth images and obtained on accuracy equal 97.7% [12]. In 2018, researchers Wen, Yiyang C., Leiying M., Mackenzie B., Weibin S. used an extreme learning machine (ELM) algorithm. To identify periodontal disease, 28 pictures of periodontal disease were taken for the training phase and 5 pictures for the testing state. The accuracy rate for identifying the gum disease obtained was 71% [13].

3. Principal Components Analysis (PCA)

Principal components analysis is a standard technique used to recognize patterns and signal processing, and it is a statistical method used to reduce data dimensions and to extract features, which is an essential step in recognizing images. The PCA algorithm is one of the best methods that are used to identify the image, and it is used to limit large dimensions of data to smaller dimensions in the workspace, i.e. representation of data in a small amount, so it is more economical in dealing with data. The primary goal of the PCA algorithm is to reduce the dimensions of the data, while preserving as much as possible the important information from the original data.

Mathematically, the Principal components of the images are found using the Eigen values, Eigen vector methods. Eigen vector is found for the variance matrix of a set of images used in training and testing, and then arranged in descending order according to Eigen values. The main benefit of the PCA is that it helps reduce the database size required to diagnose images. When the data to be processed is loaded, then the mean is subtracted from the original dataset and then the covariance matrix of the data is found. Then find the Eigen vectors with the greatest Eigen values[14]. And the flowchart of Principal components analysis is in Fig. 1 [15]:

![Flowchart of Principal Components Analysis](image)

Figure 1: flowchart of Principal components analysis PCA
4. BAT Algorithm

The bat algorithm was proposed by Shen Shi in Yang in 2010, based on echo positioning for small bats and usually used echo locator to find food. Swarm Intelligence represented of the Meta-Heuristic algorithms that inspired by nature and adopts the method of swarm[16, 17]. The Bat algorithm is a meta-heuristic Algorithm. There are three ideal rules for describing the behavior of small Bats:

• To sense distance all the Bats use echo location, Also bats can distinguish between prey, food and hindrance.

• Bats randomly fly at velocity \(v_i\), fixed frequency \(f_{\text{min}}\), position \(x_i\), loudness \(A_i\), and wavelength \(\lambda\), to a search of prey. The bat can adjust the frequency (wavelength) automatically of its pulses emitted, and adjust the rate of pulse emission, depending on the target's proximity to it.

• Although loudness differs in several ways, loudness is assumed to be limited, and varies from a positive large constant value \(A_i\) to a constant minimum value \(A_{\text{min}}\).

Virtual Bats positions can be adjust by following Eq. (1), Eq. (2) and Eq. (3):

\[
F_h = F_{\text{min}} + (F_{\text{max}} - F_{\text{min}})\beta \quad (1)
\]

\[
V_{i}^{t} = V_{i}^{t-1} + (X_{i}^{t} - X^{*})F_{i} \quad (2)
\]

\[
X_{i}^{t} = X_{i}^{t} + V_{i}^{t} \quad (3)
\]

\(\beta \in [0,1]\) represent a random vector that taken from a regular distribution, \(X^{*}\) denote of best current general site that falls after comparing all solutions between bats \(n\), \(F_{\text{min}}\) and \(F_{\text{max}}\) it represents the minimum and maximum random frequency for each bat. And velocity vector represented by \(V_{i}\). As for the part of local search, by identifying one of the solutions among the best current solutions. A new solution is created for each bat locally using a random path as in Eq. (4).

\[
X_{\text{new}} = X_{\text{old}} + \varepsilon A' \quad (4)
\]

\(A'\) It represents the loudness rate for all bats at this time, i.e. in the time step and \(\varepsilon\) is a random number within the range [-1, 1]. This equation can be considered a form of local search. \(r_i\) Controls the local search process as shown in Eq. (5)

\[
r_{i}^{t+1} = r_{i}^{t}[1 - \exp(-\gamma t)] \quad (5)
\]

Local search should be the most driving force in the improvement process so that this modernization mechanism applies to the rate of bat pulse as decreases of pulse rate over time. \(r_i\) it is constant greater than 0 and it is denote of the initial pulse emission rate. It can be chosen \(A_i = 1, A_{\text{min}} = 0\), when
\[ A_{\min} = 0 \] assume that the bat has found prey and pauses the transmission of any sound. The loudness rate and pulse emission rate are updated. When bats approach their prey, the loud sound usually decreases and the pulse emission rate increases, and the loudness is updated using Eq. (6).

\[ A_{\text{new}} = \alpha A' \]  

\( \alpha \) It is a constant that is chosen experimentally. Each bat at begin must have, different values for pulse emission rate and loudness rate, by random distribution. This can be achieved, and sound and emission rates will not occur unless new solutions are improved, which means that these bats Moving towards an optimal solution [18, 19].

5. Self Organization Feature Maps (SOM) Neural Network Algorithm

training process by using artificial neural networks one of the best ways to achieve many goals in many applications. SOM network is one of the networks that training without supervision, any of the type of self-training, meaning there is no Desired output given to the network as in the case of training by a teacher. The SOM network consists of two layers, the input layer which consists of a group of neurons and each of the input cells is linked to all cells in the output layer by weights of the connections between cells. The SOM algorithm depended to determines the winning cell based on the calculation of the Euclidean distance between the input cells and the output layer cells. The cell in the output layer that holds the lowest value for the distance is the winning cell. and the steps of SOM algorithm as follows:

Step 1: Choosing random values for vectors or matrix weights \( w \).

Step 2: Building the network and entering the sample vector \( x \) from the input samples or the input space.

Step 3: Calculate the distances between the input pattern and the weights of all the output cells, and the cell that has the lowest distance is the winner, using equation 7, which calculates the Euclidean distance:

\[ d_i = \sqrt{\sum_{j=1}^{N} (x_j - w_{ij})^2} \]  

\( d \), It represents the distance between the input cells and the output layer.

Step 4: Updating the weights of all cell associations based on the following Eq. (8):

\[ w_{y}^{\text{new}} = w_{y}^{\text{old}} + \alpha (x_i - w_{ij}) \]  

Where \( w_{y}^{\text{new}} \) represent the new weight, \( w_{y}^{\text{old}} \) the old weight, \( \alpha \) the learning rate, \( x_i \) the input pattern, and \( w_{ij} \) the weight between the input and the output layer.
Step 5: Return to the step 2 until the condition Average Distance < Possible Distance.
is satisfied[20, 21].

6. Fuzzy Self Organization Feature Maps (FSOM) Neural Network Algorithm

The steps of the FSOM network are the same as the steps of the SOM network only
The difference in step 4 in which the membership function was added to the equation for adjusting weights as shown in
equation 9 and produced a new method called the FSOM neural network that performed better than the
usual networks.

Updating the weights for each cell and adjusting the weight is accomplished using the following
update in equations:

\[ W_{i}^{(t+1)} = W_{i}^{(t)} + \alpha z_i[x - W_{i}^{(t)}] \]  

As the membership function \( z_i \) is calculated as follows[20]:

\[ z_i = (\mu_{ik})^{f_m} \]  

\[ \mu_{ik} = \frac{\left(1 \over D_k\right)^{1 \over \alpha z_i}}{\sum_{j \neq i} \left(1 \over D_{ij}\right)^{1 \over \alpha z_i}} \]  

\[ D_k = d(x_i, w_i) \]  

The coefficient of the Function \( z_i \) depends on \( f_m \) that is the fuzzy generator that is an actual number
larger than one, and the nearest input cell has the largest membership function[22].

7. Experimental Results

In this paper, the methods were used are PCA, BAT swarm algorithm, SOM network, and combined
the fuzzy membership function with SOM neural network to produce a new method called Fuzzy Self
Organization Feature Maps neural network FSOMNN method. Dataset were used consist of (120)
images for eight type of Gingival diseases. Fig. 2 show the samples of the 8 types of Gingival diseases
were used in training and testing phase.
To evaluate the performance of system, we conducted several experiments, as well as to verify the effect of the parameters of the bat algorithm and networks parameters SOM, FSOM.

Fig. 3 shows The Dataset were used that consist of (120) images, for Training (65) image and for testing (55) image. The images dataset contain of 8 type of the Gingival diseases images. A number of samples In Each type as shown below in Table 1.

| Type of samples for Gingival diseases | dataset of Training | Dataset of Testing |
|--------------------------------------|---------------------|---------------------|
|                                      | samples no.         | samples rate | samples no. | samples rate |
| Gingival abscess                      | 9                   | 13.85         | 7           | 12.73        |
| HGF                                  | 6                   | 9.23          | 5           | 9.09         |
| Gingival hyperplasia                 | 8                   | 12.31         | 7           | 12.73        |
| Oral Lichen Planus                   | 10                  | 15.38         | 9           | 16.36        |
| Gingival melanoma                    | 8                   | 12.31         | 5           | 9.09         |
| Gingival pigmentation                | 7                   | 10.76         | 8           | 14.55        |
| Gingival recession                   | 9                   | 13.85         | 6           | 10.90        |
| Mouth ulcer                          | 8                   | 12.31         | 8           | 14.55        |
| Total                                | 65                  | 100%          | 55          | 100%         |

Table1. samples number for Gingival diseases images dataset, with number of image for each Gingival diseases type.
After resize the Gingival diseases images for training and testing to size (64x64) pixels, we applied PCA algorithm to extract features of this images. And after extracting the features of these images, a data Normalization is done, that is, for the features that extracted from implement PCA algorithm and making the values of these data close, where these values are between (0 and 1). As in this equation:

\[ \text{norm} = \frac{y - mi}{mx - mi} \]  

(13)

Where, \( \text{norm} \) denote numerical value, \( mx \) represent the maximum value for attribute that \( y \) belongs to \( mi \) is a minimum value for attribute that \( y \) belongs to \[23\].

These features were taken as an input to the Bat algorithm, SOM and FSOM, were applied these algorithms to these features to diagnose and detect Gingival disease images. In training state we use (65) Gingival disease images dataset, all algorithms got the results of diagnose accuracy and classifying is 100%. In testing state, we used Gingival disease images that content of (55) Gingival disease images, and applied Bat algorithm, SOM and FSOM, on this dataset. The size of the images that were taken in the testing stat (64 x 64) and by using the PCA algorithm 16 features were extracted and these extracted features were used as input to the BAT SOM FSOM algorithms and also the PCA algorithm was applied to the set of test images and 10 features and 5 features were extracted.

Table 2 shows the results of the algorithms (BAT, SOM, FSOM) in training state of diagnoses gingival disease dataset. In this table, The bat algorithm diagnosed Gingival disease faster than SOM,FSOM algorithms because it took a less time and took a few iterations number in the diagnostic process compared to other algorithms.
| Type of algorithms | Iteration no. | Time    |
|-------------------|--------------|---------|
| SOM               | 150          | 10.289 sec. |
| FSOM              | 90           | 8.047 sec.  |
| BAT               | 65           | 3.7866 sec. |

Table 2: the results of (SOM, FSOM, BAT) for diagnoses gingival disease dataset in training state.

Figure 4: Relationship between the Algorithms (SOM, FSOM, BAT) with Number of iteration for training stage.

Fig. 4. shows the relationship between Number of iteration and algorithms were used. In testing stage, the extracted features were also used It on the methods of SOM, FSOM, and BAT. The Bat swarm method obtained the highest diagnostic accuracy for Gingival disease when we took the number of features (5) which is equal (97.942%). Table 3 shows results of testing using BAT, SOM, and FSOM algorithms with the diagnose accuracy rate. With different number of features that extract by used PCA algorithm. And Figure 5. shows the relationship between the Algorithm (BAT, SOM, FSOM) with Diagnostic accuracy, number of feature extraction from PCA.

| Features number | diagnose accuracy rate |
|-----------------|-----------------------|
|                 | SOM                   | FSOM                  | BAT       |
| 16              | 82.941%               | 89.991%               | 95.0%     |
| 10              | 85.729%               | 92.0%                 | 95.993%   |
| 5               | 89.306%               | 93.859%               | 97.942%   |

Table 3: results of testing Gingival disease images dataset by using SOM, FSOM, BAT.
Table 4 shows the results of the algorithms (SOM, FSOM, BAT) in testing state of diagnoses gingival disease dataset. In this table, Table 4 shows the results of the algorithms (SOM, FSOM, BAT) in testing state of diagnoses gingival disease dataset. The bat algorithm diagnosed disease faster because it took short time compared to other methods.

| Type of algorithms | SOM           | FSOM          | BAT           |
|--------------------|---------------|---------------|---------------|
| Time               | 1.8942 sec.   | 1.6631 sec.   | 1.1834 sec.   |

Table 4: the results of (SOM, FSOM, BAT) for diagnoses gingival disease dataset in testing state.

Finally, Table 5 shows the comparisons results of the three algorithms SOM, FSOM, BAT with the previous work.

| Algorithm type | ELM [13] | Meta Firefly [12] | ANN with genetic | ANN (MLP) [11] | MIP-ANNS [10] | SOM | FSOM | BAT |
|----------------|----------|-------------------|------------------|----------------|---------------|-----|------|-----|
| Accuracy       | 71%      | 97.7%             | 80%              | 73%            | 90%           | 89.306 | 93.859% | 97.942% |

Table 5 comparison results of SOM, FSOM, BAT algorithms with previous work.

8. Conclusion

In this research, three methods are implemented (SOM, FSOM, BAT) to diagnose gingival disease. Where eight gingival diseases were taken. Initially, the features were extracted by using (PCA) algorithm for images of gingival diseases for training and for testing, and the dimensions of these...
images are (64x64) pixel. And several matrices were produced for us. 16 features were extracted for each of the training and testing images. Also 10 and 5 features were extracted by using PCA algorithm. We got matrices with dimensions of (65x16), (65x10), (65x5), (55x16), (55x10), (55x5), and also got One-dimensional matrix consist of (16, 10, 5) features for each image of the training and testing image data respectively. These extracted features were taken as an input to the algorithms (SOM, FSOM, BAT) and the implementation of these three methods to detect and diagnose Gingival disease. The Bat swarm method obtained the best performance, as it obtained the highest diagnostic accuracy of these three methods.

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