

An Intelligent Advisory System Based on Image Processing to Teeth Diseases Diagnosis

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Abstract:- This research has focused on studying an advisory system that assists in the diagnosis of teeth diseases and helps the dentist in diagnosing cases and providing appropriate treatment for patients. The proposed system consists of an image processing and an advisory system. Image processing was used two algorithms: The gray-Level Co-Occurrence Matrix (GLCM) algorithm to extract the features from x-ray images and the K-Means algorithm to classify images features, then stored in the database. The advisory system consistency of the knowledge base built with the experts of the dentist, which helps to extract the rules from the database of images, another part is responsible for the implementation of the matching between the query rule and knowledge base. When the proposed system was applied to several cases, the extracted therapeutic reports were so satisfactory.

Key words: Image processing, advisory system.

1. INTRODUCTION

Nowadays, we are living in the digital age, where digital imaging has been developed to become a widespread technology. Digital image is used as a means of pictorial information in the field of medical diagnosis. [1]

Images are two-dimensional (2D), as a picture or screen display, a two-dimensional function indicates to an image, $f(I, J)$, where I and J are spacial coordination, and the intensity or grey level of the picture at that step is defined as the amplitude of (f) with any pair of coordinates (I, J) . The image is called a digital image when I, J , and the amplitude values of (f) are all finite, distinct variables.[2] Also, an image is an array, or a matrix, of square pixels (picture elements), consists of columns and rows. [3] Many types of images are based on a grayscale as X-ray images.

2. IMAGE PROCESSING

Image processing is a form of signal processing whose input is an image, as a picture or photograph; its output is one of these two: image or set of properties or determinants regarding of image. Most of image processing techniques treat the image as 2D signal and apply standard signal processing techniques to it. Ordinarily, Image processing indicates to digital image processing. [4]

Image processing is using of computer algorithms to execute image processing on images. Digital image processing has many advantages over analog image processing as a subcategory or field of digital signal processing. [5]

Image processing entails applying mathematical processes to any type of signal processing, including region-based and boundary-based techniques. [5] Region-based techniques and boundary-based techniques are two categories of techniques in the shape of based retrieval. A region-based technique uses an entire shape region, but a boundary-based technique relies only on the border points of shapes in feature vector extraction. [6]

The multi-user technique is an epitome of a large, important image retrieval method that aided image processing in the post-store image retrieval process.

CBIR (content-based image retrieval) is a method that uses visible content to retrieve images; it is sometimes referred to as features. CBIR stands for query by image content, and it is used to search huge databases for pictures in the form of a query image. The flow chart in Fig.1 shows CBIR systems. CBIR's key low-level characteristics are color, texture, and form. Based on these low-level characteristics, a feature vector is automatically extracted for each picture in CBIR systems. The similarity distance between the query picture's feature vector and the feature vectors in the image databases is then calculated. Finally, the algorithm finds photos that are comparable to the query based on their similarity values, which are known as features. [7]

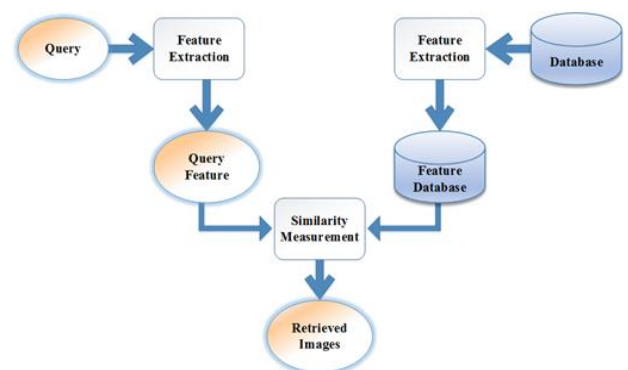


Fig.1. Flow chart of Content Based Image Retrieval

3. FEATURES EXTRACTION

Feature extraction is a CBIR starting point for gathering visual content of images for indexing and retrieval. Low level or primitive image features may be global, such as color, texture, and shape extraction, or domain particular features. [8]

Feature extraction is the operation of outputting features for using in selection and classification tasks. Feature selection decreases the numeral of features provided to the classification task. Those features which are probable to help in discernment are selected and used in the classification task. [9]

Further, each features class is split into subclasses by the type of algorithm used for building the feature vector and many methods for feature extractions are used as color features, texture features, shape features.

In the analysis of statistical texture, texture features are calculated from the statistical distribution of observed groups of intensity in the positions defined for each other in an image. The texture is defined not only by the grey value at a particular pixel but also through grey value in the area surrounding the pixel, wherever the brightness level at a point is determined by the brightness levels of the points around it. The statistics are divided into first-order, second-order, and higher-order statistics based on the numeral of density points (pixels) in each collection. [8]

3.1. Gray-Level Co-Occurrence Matrix (GLCM) algorithm

The Gray Level Co-occurrence Matrix (GLCM) is a technique for extracting statistical texture features of second-order. [8]

The GLCM contains 14 feature extracted and calculated by using the following equations:

- **Contrast equation is :**

$$Contrast = \sum_{i,j=0}^{n-1} (i - j)^2 P(i, j) \quad (1)$$

Contrast is known as the separation between the darkest and brightest region. It's the difference between a contiguous collection of pixels' highest and lowest values. [10]

- **Correlation equation is :**

$$Correlation = \sum_{i,j} P_{i,j} \frac{(i - \mu_i)(j - \mu_j)}{\sigma_i \sigma_j} \quad (2)$$

Correlation is a measurement of grey tone linear relations in an image; in specially, the direction under realization is the same as vector displacement. [10]

- **Homogeneity equation is :**

$$Homogeneity = \sum_{i,j=0}^{n-1} \frac{P(i, j)}{1 + |i - j|} \quad (3)$$

Homogeneity gives information about how little change there is in an image. It is defined as the quality or state of being homogeneous. [10]

- **Energy equation is :**

$$Energy = \sum_{i,j=0}^{n-1} P(i, j)^2 \quad (4)$$

Energy parameters are called as Uniformity. Energy is a feature that measures the softness of the image. [10]

- **Angular Second Moment equation is**

$$ASM = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} P^2(i, j) \quad (5)$$

In this feature, the image homogeneity is measured by the sum of squares of inputs in the GLCM of Angular Second Moment. [8]

- **Inverse Difference Moment (IDM) equation is**

$$IDM = \sum_{i,j=0}^{n-1} \frac{P_{ij}}{1 + (i - j)^2} \quad (6)$$

IDM stands for local homogenization. It is high when the local grey level is consistent and the GLCM is high reversed. [8]

- **Entropy equation is :**

$$Entropy = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} P(i, j) \log P(i, j) \quad (7)$$

Entropy shows and measures the quantity of the image information required to compress of the image. The loss of information or message in the delivered signal is measured by entropy. [8]

- **Sum of Squares, Variance equation is :**

$$Variance = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} (i - \mu)^2 P(i, j) \quad (8)$$

This feature gives the items that differ of the average value of P (i, j) a lot of weight.

▪ **Sum Average equation is :**

$$Average = \sum_{i=0}^{2n-2} iP_{x+y}(i) \quad (9)$$

▪ **Sum Entropy equation is :**

$$SENT = \sum_{i=0}^{2n-2} P_{x+y}(i) \log(P_{x+y}(i)) \quad (10)$$

▪ **Difference Entropy equation is :**

$$DENT = \sum_{i=0}^{n-1} P_{x+y}(i) \log(P_{x+y}(i)) \quad (11)$$

▪ **Inertia equation is :**

$$Inertia = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} \{i - j\}^2 \times P(i, j) \quad (12)$$

▪ **Cluster Shade equation is**

$$Shade = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} \{i + j - \mu_x + \mu_y\}^3 \times P(i, j) \quad (13)$$

▪ **Cluster Prominence equation is**

$$PROM = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} \{i + j - \mu_x + \mu_y\}^4 \times P(i, j) \quad (14)$$

In this work, four significant features were chosen: Contrast, Homogeneity, Energy, and Correlation to extracting image features. It uses the following equation to get the best results:

$$Im_F = \{ Im_{F.cont}^1, Im_{F.cont}^2, \dots, Im_{F.cont}^n, Im_{F.corr}^1, Im_{F.corr}^2, \dots, Im_{F.corr}^n, Im_{F.homo}^1, Im_{F.homo}^2, \dots, Im_{F.homo}^n, Im_{F.ene}^1, Im_{F.eng}^2, \dots, Im_{F.eng}^n \}$$

After extraction; features are stored in the database and classified as image features depending on the massive size of knowledge previously stored within the database.

4. IMAGES CLASSIFICATION

Classification of things is a simple activity for humans, but it has proven to be a difficult challenge for machines. The task of image classification requires a description of different images with values patterns, and the conversion of the problem into that pattern recognition. [11] Classification methods are used in many fields as data mining, signal decoding, finance, voice recognition, natural language processing and medicine.

Classification algorithms methods assume that the subtype image shows one or more features, such as spectral regions. The classes can be provided a priori by an analyst or automatically grouped into sets of prototype classes, where the analyst just provides the required number of categories and that each of these features belongs to one of many unique classes. [12]

The following pseudocode shows the steps of the algorithm:

```

Let m is the required number of clusters.
Let Z denote the set of feature vectors (where |Z| denotes the set's size).
Let D is the collection of related clusters for every feature vector
Let sim(x, y) is the likeness function
Let c[m] is our clusters' vectors.
initial:
Let Z' = Z
//select m random vectors to begin our clusters
For i=1 to m
j = rand (|Z'|)
c[m] = Z'[j]
Z' = Z' - {c[m]}
// Delete that vector from Z' so that we won't be able to select it again.
End
// assign the first clusters
For i=1 to |Z|
D[i] = argmax (j = 1 to m) { sim(Z[i], c[j]) }
End

Run:
Let change = true
While change
change = false //assume nothing has changed
//reassign feature vectors to clusters
For i = 1 to |Z|
a = argmax (j = 1 to m) { sim(Z[i], c[j]) }
If d! = D[i]
D[i] = d
change = true //a vector's associations have changed--
so we need to
//recalculating our cluster vectors and run again
End
End
//recompute cluster placement if a change occurred
For i = 1 to m
mean, count = 0
For j = 1 to |Z|
If D[j] == i
mean = mean + Z[j]
count = count + 1
End
End
c[i] = mean/count
End
End
    
```

Classification is the process where a given test sample is assigned a class on basic of knowledge obtained by the classifier during training. [10]

Image classification analyses the numerical characteristics of distinct image features and categorizes data. Classification algorithms are generally processed in two stages: training and testing. During the first training phase, typical image feature characteristics are isolated and based on these a unique description is created for every classification category, i.e. training class. In the testing phase, these feature-space partitions are then utilized to categories image features. There are several types of classifiers that may be employed in the image classification, similar to feature extraction. K-Nearest-Neighbor, Nave Bayes, Decision Tree, Support Vector Machine (SVM), and K-means [13] are just a few examples. K-means is the classifier we've chosen. This is owing to its ease of use and simplicity in data set training.

4.1. K-Means algorithm

The K-Means algorithm, often known as the Hard C Means algorithm, is a well-known clustering technique. This method divides an image into several clusters of pixels in the feature space, each specified by its center. Each pixel in the picture is initially assigned to the closest cluster. The new centers are then calculated using the new clusters. This process is continued until convergence is achieved. To begin, we must first calculate the number of clusters K. The centroid for these clusters will then be assumed. We could use random objects as starting centroids or the first K items in a series as initial centroids. [14] The K-Means is also the most often used partitioning-based clustering technique. It is a clustering algorithm that uses an unsupervised approach. It intelligently selects the centroid, compares the centroid to the data points based on their intensity and features, and calculates the distance; data points that are comparable to the centroid are allocated to the cluster with the centroid. By identifying the data points closest to the clusters, new 'k' centroids are calculated, and k-clusters are produced. [15]

5. AIDE DENTIST SYSTEM (ADS)

As shown in **Fig.3**, an Aide Dentist System (ADS) mainly consists of two stages: image processing and the advisory system.

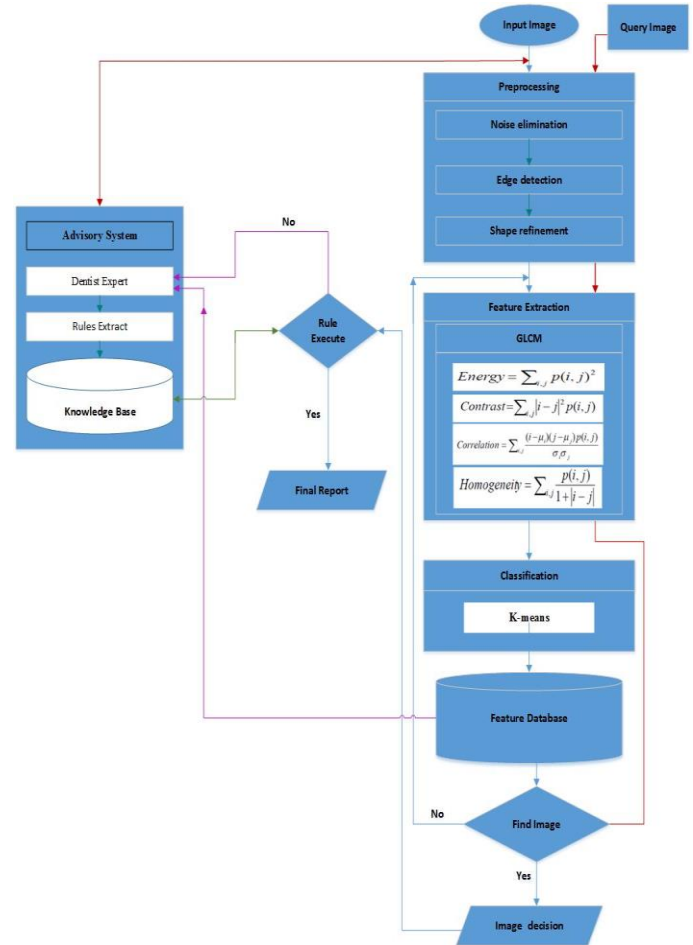



Fig.3. Flow chart of advisory system

In the first stage, image processing is applied to extract the basic features from the image and to create a classified features database. In the second stage, advisory system is consists of expert dentist that helps to building rules from image decision. A knowledge base is used to store the extracted rules as shown in Table.1.




Table.1. Example of Extract Rules and Execute Rules

Extract Rules	Execute Rules
If Image belongs to Cluster (Cl _n).	Im ₍₇₎ belongs to Cl ₈
And	
Then Therapeutic report is (TR _s)	
	Then TR ₈ Diagnosis : Deep caries of upper 5 Treatment : Extraction and Implant of upper 5

6. EXPERIMENTAL AND RESULT

To evaluate an aide dentist system (ADS), samples of X-Ray images were collected and collected treatment reports were assisted by an expert dentist as shown in **Table.2**

Table.2. samples of X-Ray images and treatment reports

Image	Diagnosis	Treatment
	Deep caries of upper 5	Extraction and Implant of upper 5
	Impacted of lower 7	Extraction of lower 7
	Skeletal Class II maxillary protrusion	High pull headgear to restrict maxillary growth

Aide Dentist System (ADS) is logged by inputting the patient's personal data as shown in the Fig. 4.



Fig.4. login to proposed system

As shown in Fig.5, images are input into ADS. Subsequently, the image processing phase is used to extract image features. After that, the image features are saved in the image database, Fig.6 shows a confirmation message to store the image features successfully.

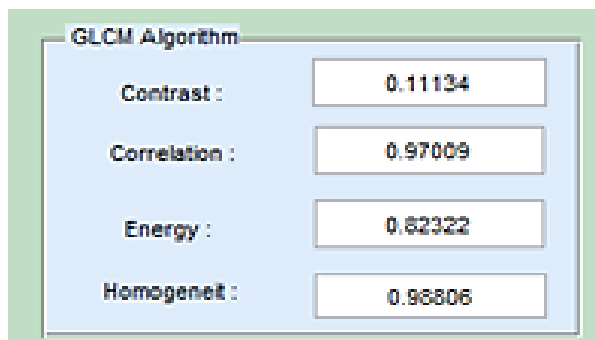


Fig.5. example of Image features extraction

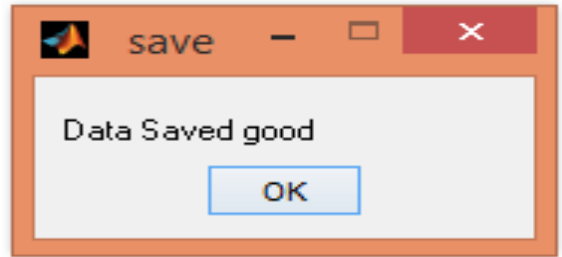


Fig.6. Confirm message store image features

As shown in Fig.7, image features are divided into classes. Thus, images can be retrieved easily through the query, also aide dentist system (ADS) confirms of the classification as shown in Fig.8.

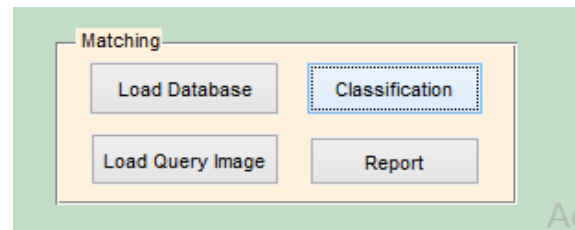


Fig.7. query and classification button

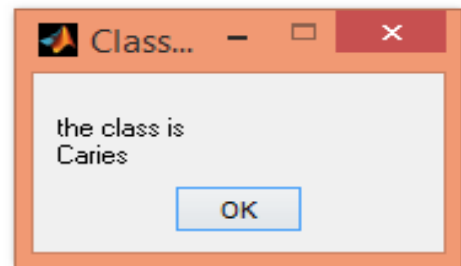


Fig.8. confirm classification message

Then, the query image and the knowledge base are matched. In the case of the matching, the therapeutic report of the case is extracted as shown in Fig.9.

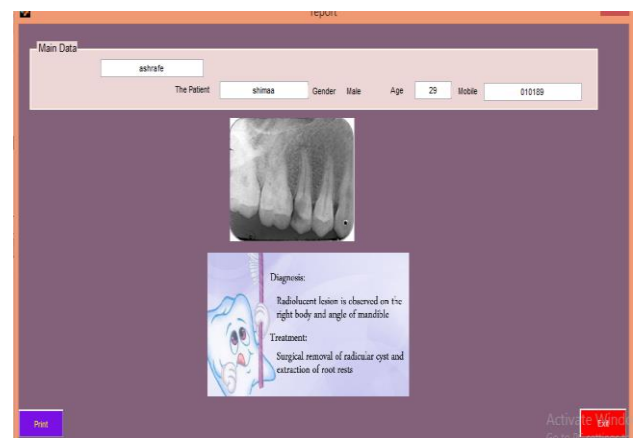


Fig.9. Therapeutic Report

7. CONCLUSIONS

This paper attempts to present a proposed system based on image processing to help dentists in diagnose of teeth diseases where is the experimental results extracted from the aide dentist system (ADS) showed it was very

convincing and satisfactory and when the system were applied to several cases, the extracted therapeutic reports matched with the experts in the field.

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