An Image Segmentation Based Clustering Technique Applied on Dental Images

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Abstract – Images play a crucial role in various applications of engineering and sciences. With advancements in image capturing devices such as digital cameras, image scanners, most of the data is analyzed from digital images. Users in the fields of medical and dental sciences are exploiting the opportunities offered by the ability to access and manipulate X-ray images in all possible ways.

Index Terms – Digital Images, X-rays, Dental Carie, Clustering.

1. INTRODUCTION

1.1. Why Study Dental Caries?

The detection of dental caries, in early stage is very important. It is also known as dental decay or tooth decay. Primary diagnosis involves inspection of all visible tooth surfaces using basic tools including a good light source, explorer and dental mirror. Dental radiographs, or Dental X-rays, may show dental caries between the teeth, before it is visible through naked eye. Dental X-ray image analysis is major area of Digital Image processing [1].

1.2. What is Dental carie?

Dental caries and periodontal diseases are the most common dental diseases. If they are not treated in early stages, they may lead to progressive distraction of tooth and infection of the dental pulp.

1.3. How to obtain Dental Images?

Dental images are generated simply by placing the patient between an X-ray source and a film sensitive to X-ray energy. In digital radiography, digital images are obtained by one of two methods: by digitizing X-ray films; or by having the X-rays that pass through the patient fall directly onto devices that convert X-rays to light. The Light-sensitive digitizing system is used to capture light signal. Different X-ray images have different resolutions, luminance content and orientations, depending on the X-ray machine and the dentist who took it.

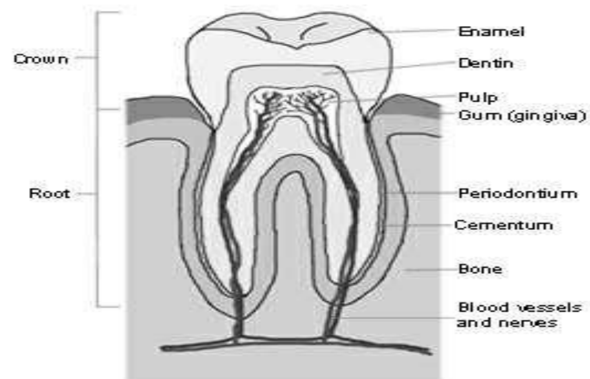

Figure 1 : Tooth Structure

1.4. Problems associated with dental Images

Several images suffer from low resolution and lighting which would affect the quality of the desired dental feature recognition and labeling of individual tooth or major parts such as crown and root of the tooth. Each tooth or the desired object extracted from the image represents Region of Interest that contains important data used for later steps.

Classification of dental diseases is decided based on whether the lesion is within the enamel, dentin or whether it touches the pulp [1]. Based to the extent of attack dental caries may be classified as- Enamel, Dentinal and Pulpal caries. In enamel the caries have affected the outer enamel portion alone and the inner dentine and pulp regions are healthy. In Dentinal, the lateral spread at the dentino-enamel junction occurs with involvement of underlying dentin. In Pulpal, the micro-organisms have spread to root surface and affected roots.

2. LITERATURE REVIEW

The objective behind this study is to enhance the quality of input x-ray image for segmentation and finally extract the set of textural features of dental images for each X-ray image.

Anil K [3], proposed a semi-automatic contour extraction method for tooth segmentation by using integral projection and Bayes rule, in which the integral projection is semi-automatically applied for tooth isolation since an initial valley gap point is required. Jindan Zhou and Mohamed Abdel-Mottaleb [6], presented a segmentation method that consists of three steps: image enhancement, region of interest localization, and tooth segmentation by using morphological operations and Snake method. Omaima Nomir, and Mohamed Abdel-Mottaleb[2], developed a fully automated approach based on iterative thresholding and adaptive thresholding for dental X-ray image segmentation. Keshtkar and Gueaieb [5], introduced a swarm-intelligence based and a cellular-automata model approach for segmenting dental radiographs. Eyad Haj Said, et al. [4], offered a mathematical morphology approach to the problem of teeth segmentation, which used a series of morphology filtering operations to improve the segmentation, and then analyzed the connected components to obtain the desired region of interests (ROIs). Li, et al. [7], proposed a semi-automatic lesion detection framework by using two coupled level set functions in which initial contour are derived from a trained support vector machine to detect areas of lesions from dental X-ray images.

3. TOOLS AND TECHNIQUES AVAILBLE

3.1. Clinical Tools Available

The diagnosis of carious lesions has been primarily a visual process, based principally on clinical inspection and review of radiographs. Tactile information obtained through use of the dental explorer or “probe” has also been used in the diagnostic process. The development of some alternative diagnostic methods, such as fiber optic trans illumination (FOTI) and direct digital imaging continue to rely on dentists’ interpretation of visual cues, while other emerging methods, such as electrical conductance (EC) and computer analysis of digitized radiographic images, offer the first “objective” assessments, where visual and tactile cues are either supplemented or supplanted by quantitative measurements.

3.2. Computer Based Feature Extraction

The features consists in five groups,

- Features based on the image characteristics like pixel intensity, maximum pixel intensity, etc.
- Statistic features as the entropy, mean, variance and more. Region based features such as the Hu moments, the Zernike moments, area, perimeter, etc.
- Features based on the region segmented boundary, like chain code, Fourier descriptors, signature, angular function, among others.
- Finally features based on the image texture[8], like the energy, third moment, etc.

There are several features that can be extracted from the image

Properties,

- Maximum pixel value corresponds to the maximum pixel value in the input image.
- Minimum pixel value corresponds to the minimum pixel value in the input image.

3.3. Statistical Features based on the image properties

The statistical characteristics of our input images is to extract the information that exists which maybe valuable for the detection of dental caries. For this is to highlight the fact that all the statistical features [9] that are extracted have a great emphasis on literature as well as the first option in many of the problems of pattern recognition and the like.

Such features include a large number of applications, in our work we use several times this type of characteristics for different groups of features that we extracted from our images. For example for the characteristics based on the border, or the tooth boundary, when using this type of characteristics it enables the retrieval of some information that is present in the tooth contour or in the tooth boundary.

Methodology used

Stage 1: Select the region of interest (ROI).

Stage 2: Transform the color space from RGB to HSI. And obtain individual component hue, saturation and intensity image respectively

Stage 3: Apply the clustering Algorithm

Stage 4: Compute the area percentages of tooth surface covered by dental carie (not include background).

4. CLUSTERING METHOD

There are numerous clustering algorithms that can be used to determine the natural spectral grouping present in a data set. One common form of clustering, called k-means approach, accepts from the analyst the number of clusters to be located in the data. The algorithm then arbitrarily “seeds” or locates, that number of cluster centers in the multidimensional measurement space. Each pixel in the image is then assigned to the cluster whose arbitrary mean vector is closest. After all pixels have been classified in this manner, revised mean vector for each of the clusters are computed. The revised means are then used as the basis to reclassify the image data. The procedure continues until there is no significant change in the location of class mean vectors between successive iterations of the algorithm.

4.1. K-MEANS ALGORITHM

Step 1: Initializing cluster centers randomly.

Step 2: a. Computation of Euclidean distance between the cluster centers.

b. Grouping the pixel to those clusters whose center yields the minimum distance from the feature vector.

Step 3: Updating the cluster centers by computing the mean of the feature vectors of the pixels belonging to that cluster.

Step 4: Assessing the changes, so as to decide on the continuance of iteration. This process is continued until convergence occurred otherwise it is repeated.

In figure 1, Using K-means clustering the carie portion is highlighted using pseudo coloring to improve the visibility.

5. PROPOSED METHOD OF SPATIAL CLUSTERING

5.1. Feature selection/extraction

Feature selection consists in identifying a subset of the original features. *Feature extraction* consists in applying one or more transformations of the input features to produce new salient features. Either or both of these techniques can be applied to obtain the most effective set of features to be used in clustering.

5.2. Similarity measure

Clustering aims at grouping pixels, so that pixels belonging to the same cluster are spectrally similar. To quantify this relationship, a similarity measure must be chosen. Proximity between pixels is usually measured by a distance function defined on pairs of spectral values. A simple distance measure like the Euclidean distance is often used to measure similarity between vectors.

5.3. Grouping

In this step, pixels are grouped into clusters. Partitional [11] clustering algorithms identify the partition that optimizes a clustering criterion (deducted from the similarity measure step).

5.4. ISODATA Algorithm

As described in, the simplest and most frequently used criterion in partitional clustering is the squared-error criterion, which is the most suitable in the case of isolated and compact clusters. The squared error for a clustering Y of a set X into C clusters is defined as where μc is the centroid of the cluster c. ISODATA [10] clustering is a well-known algorithm introduced by Ball and Hall which uses the squared-error criterion. It starts with a random initial partition of the pixel vectors into candidate clusters and then reassigns these vectors to clusters in such a way that the squared error is reduced at each iteration, until a convergence criterion is achieved. The algorithm permits splitting, merging, and deleting of clusters at each iteration in order to produce more accurate results and to mitigate dependence of results on the initialization.

5.5. EM Algorithm

While ISODATA is a deterministic clustering approach, the EM algorithm [10] belongs to the group of statistical algorithms that assume a statistical model that characterizes. The Cluster assignment step of EM algorithm is as follows

Step 1. Assign each pattern in X to one of the clusters according to the maximum probability criteria

Step 2. Eliminate cluster, if c is less than the dimensionality of patterns, $c = 1, 2, \dots, C$. The patterns that belonged to the deleted clusters will be reassigned to the other clusters in the next iteration.

Step 3. If the convergence criterion is not achieved, return to the parameter estimation step. The total number of parameters to be estimated is

$$P = (B(B + 1)/2 + B + 1)C + 1,$$

Where B is a dimensionality of feature vectors. If the value of B is large, P may be quite a large number.

6. RESULTS

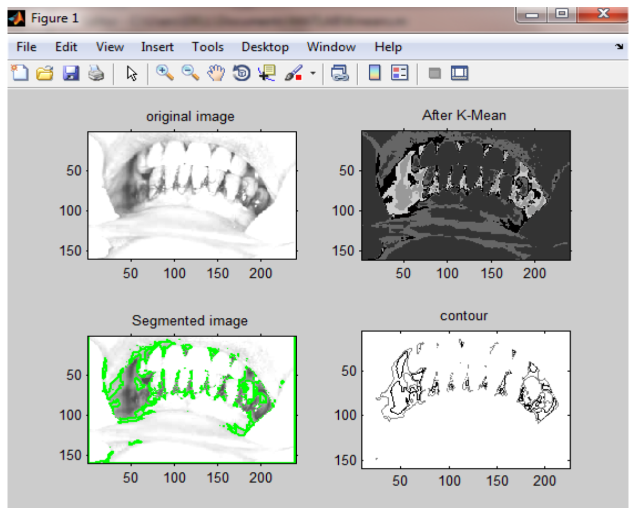

Fig-1 Dental Image Segmentation based clustering

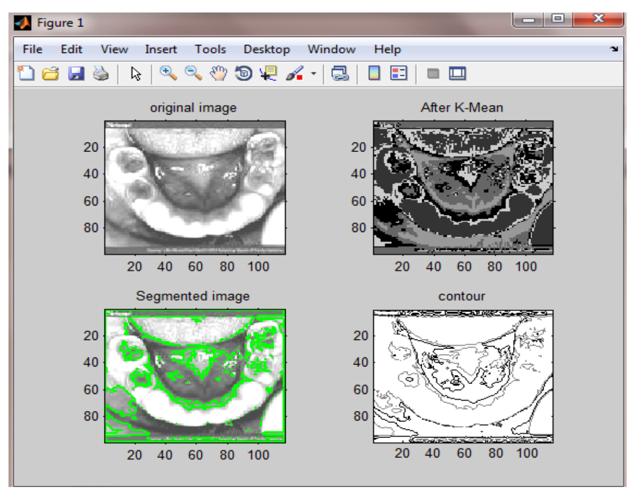

Fig-2 Dental Image Segmentation based clustering, Second case

7. CONCLUSION

The paper discussed the various tools present for the detection of dental diseases whether computer based or through visual inspection in dental clinics. The various feature extraction and segmentation methods were discussed to reduce the noise present with in the dental X-ray images and hence to improve the visibility of the image and to extract the required features from among the region of interest. Last but not least a dental image was segmented using K-Means clustering algorithm.

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