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A Survey of Soft Computing Techniques for Dental Disease Analysis

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Abstract

Nowadays a research on dental disease is very helpful in the clinical sections for automatic interpretation of disease within a short time and with accurate results. The objective is to study and identify the types of teeth diseases and to develop a robust, simple, cost effective and accurate soft computing algorithm. Dealing properly with dental cavities and taking an urgent treatment is always recommended to avoid more damage to the teeth. Dentists recognize the caries in patients' teeth by looking directly with eyes and sometimes with help of X-ray (radiograph) of teeth. This automated system would help the dentist to identify the caries in teeth by making use of X-ray. This paper proposes a model to detect the teeth disease using x-ray images by making use of various image processing techniques, involving Pre processing, Segmentation, Feature extraction and Classification. Dental x-ray images are usually taken with low radiation dosage and are often presented as dark, low in contrast and with noise. These all the problems are usually solved with image enhancement techniques. However, choosing an appropriate technique is not an easy task especially for the purpose of the disease diagnosis of periodical related lesion.

IndexTerms*—Dental Disease, Preprocessing, Morphological Segmentation, GLCM and statistical Features, ANN Classifier.*

1. Introduction

Author in this paper (ŞtefanOprea & CostinMarinescu, 2008) Medical imaging technology is used to analyze the healthcare and to related datasets. Medical Imaging is increasingly playing a vital role in areas like ophthalmology, cardiology, gynecology, orthopedics, dentistry and neurology. In the recent years, different techniques of processing on image have been actively used for the diagnosis of oral diseases in dentistry.

Author in this paper (Villette, A., 1992) a human tooth is a structure made up of dentin, pulp and enamel.

Mouth normally consists of various types of bacteria; they cause infection in the human teeth. These are infections generally termed as dental caries. Caries may damage the teeth permanently and results in tooth cavity. It is a very common disease found in the world. About 60 to 90% of school children and nearly all adults have dental cavities. Dental cavity affects the daily task of teeth by weakening the biting capacity, increased sensitivity and tooth ache. When after meals, if the mouth is not washed properly, the food stays in the corners of the teeth, this deposited food generates acid. Such type of acid and sugar on teeth cover produces bacteria and it leads to the breakdown of the tooth enamel (hard tissue of the teeth). This causes caries in teeth, and if ignored at initial stage, caries can harm the neighboring teeth and go deeper inside the teeth till the pulp inside the teeth and can cause severe toothache.

Dentists normally treat their patients with caries by with the radiographs (x-ray) of their tooth jaw and spot the cavities by observing the x-ray with naked eyes. This could lead to miss a few cavities which are at an early stage or which are not properly recognizable. Hence, there is a need of automation due to many reasons such as, lack of dental experts, different levels of expertise in each dentist and for a second opinion which is always helpful to confirm decision making.

By using the radiographs of teeth, experts can find the number of diseases. Such as, Fracture of tooth, Abrasion, Dental Caries, Attrition, Gingivitis, Periodontitis, Abscess, Interdental bone Loss, Supernumerary Teeth, Impacted teeth, Cysts, Malignancies, Developmental defects, Future Malocclusion etc.

Preliminary stage detection of teeth caries is very important for disease diagnosis. There are three types of dental caries; the first type is the Enamel Caries that is preceded by the formation of a microbiologically dental plaque. Secondly the Dentinal Caries which begins with the natural

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spread of the process along with the great numbers of the dentinal tubules. Thirdly the Pulpits that correspond to the root caries or root surface caries. This paper proposes a novel technique to use a combination of various soft computing techniques for the automatic detection of teeth diseases for effective diagnosis to help the doctors.

2. Modules:

2.1 Image Acquisition

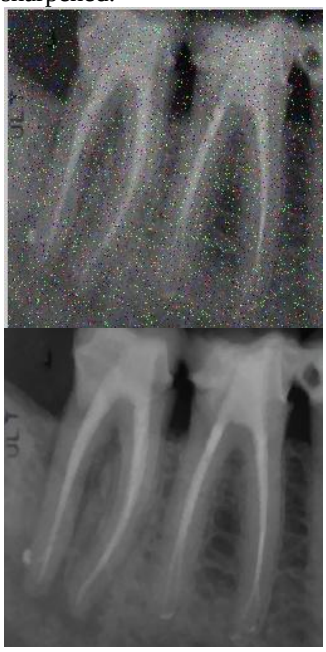
The dentists normally don't use any tools for finding the disease in teeth. Caries are not seen easily with eyes it can be captured effectively only with the use of X-ray images of teeth. In X-ray, a healthy tooth is normally seen in a white color and the other area such as soft tissue; jaw and mouth are seen in dark shades. The cavities and caries are also seen with the specific shades and the structure. X-ray images when captured, they might have lots of different shades from bright to dark formed due to light at x-ray center or the position of teeth from the X-ray plate.

(a) (b)
Figure.1 a).Normal teeth b). Abnormal teeth

Figure.1 shows the normal and abnormal input X-ray images for the process of detection of teeth disease using soft computing techniques.

2.2 Image Preprocessing:

Author in this paper (Sakata .M & Ogawapp .K, 2009) The pre processing images have some noise which should be removed for the further processing of the image. Image noise is the most apparent in image regions with the low signal level such as shadow regions or the under exposed images. There are so many types of noise like salt – and – pepper noise, film grains etc., All these noise are removed by using filtering algorithms. Among the several filters, Weiner filter is used. In preprocessing the module image acquired will be processed for correct output. Pre-processing is usually done by using some algorithm. For all images the pre-processing should be done so that the result can be obtained in a better way. To find out the transformation between two images precisely they should be pre processed to improve their quality and accuracy of result. If these images are too noisy or blurred, they should be filtered and sharpened.



(a) (b)
Figure.2 a). Salt and pepper noise image
b). Noise Removed Image

Figure.3 shows the salt and pepper noise images and noise removal using filtering techniques for improve the efficiency of the process. Pre processing is a common name for operations with the images at the lowest level of abstraction both for input and output images. The aim of pre processing is an improvement of image data that suppresses unwanted image data distortions or enhance some image features important for further processing.

Four categories of image pre-processing methods according to the size of pixel neighborhood is used for the calculation of new pixel brightness:

1). Pixel brightness transformations
2). Geometric transformations
3). Pre-processing methods use a local neighborhood of processed pixel,
4). Image restoration that requires knowledge about the entire image

If pre processing aims to correct some degradation in the image, the nature of a priori information is important: **1.Knowledge about the nature of the degradation**; only very general properties of the

degradation are assumed,
2. Knowledge about the properties of the image; acquisition device, the nature of noise (usually its spectral characteristics) is sometimes known,
3. Knowledge about objects that are searched for in the image; which may simplify the pre-processing very considerably .If knowledge about objects is not available in advance it can be estimated during the processing.

2.3 Segmentation:

Image segmentation is a process of partitioning a digital image into the multiple segments (sets of pixels, also known as super-pixels). The aim of the segmentation is to simplify and/or change the recognition of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate the objects and boundaries (lines, curves, etc.) in images. More precisely, image separation is the process of allocating a label to every pixel in an image, such that values with the same label share certain characteristics.

The result of the image separation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each and every pixel in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with the respect to the same characteristic(s).

Several general-purpose algorithms and techniques have been developed for using image segmentation. To be useful these techniques must be typically joined with a domain's of the specific knowledge in order to effectively solve domain's segmentation and the problems. In this paper Morphological Segmentation is used for extracting the teeth disease.

Morphological Segmentation for teeth disease Extraction:

In this paper the author (AzamAminiHarandi & HosseinPourghassem, 2011) presents teeth disease is extracted using morphological based segmentation. Morphology is a broad set of the image processing operations that process images based on structure. Morphological operations apply a structuring element to an input image and creating an output image of the same size. In a morphological operation, can be the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with the neighbors. By selecting size and the shape of the neighborhood, you can build a morphological operation that is sensitive to specific shapes in the input image.

Figure.3 Morphological operations on teeth Images

Figure.3 shows the morphological segmentation results of the normal and abnormal teeth images. The most basic morphological operations are the dilation and erosion. Dilation adds pixels to the boundaries of the objects in an image, while erosion removes pixels on object boundaries. The number of pixels included or deleted from the objects in an image depends on the size and the shape of the structuring element is used to process the image. In a morphological dilation and erosion operations are the state of any given pixel values in the output image is determined by adding a rule to the corresponding the pixel and its neighbors into the input image. The rule is used to process the pixels determined the operation as dilation orerosion.

Dilation The value of the output pixel is the maximum value of the entire pixels in the input pixel's neighborhood. In a binary image, the value of the pixels is set to the value 1; the output pixel is set to 1.

Erosion The value of output pixel is the minimum value of the entire pixels in the input pixel's neighborhood. In a binary image, the value of the pixels is set to 0; the output pixel is set to 0.

2.4 Feature Extraction:

In machine learning is the structure identification, image processing, feature extraction initialize from an first set of measured data and the constructs derived values (features) intended to be informative and non-redundant, smoothing the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction.

Author in this paper (FarzanaShaharBanu.A & Kayalvizhi .M, 2014)When an input data to the algorithm is too large to be processed and it is suspected to be redundant (For example the same measurement in the both feet and the meters, or the repetitiveness of images presented as pixels), then it can be transformed into a reduced set of features (also named as a feature vector). Determining the subset of initial features is called feature selection. This method involves Statistical and GLCM for teeth disease Classification.

Statistical features:

Statistics is the study of collection, organization, evaluation, and interpretation of data. It deals with the all aspects of this, including planning of data collection in terms of design of surveys and the experiments. This is the meaning of statistics. Statistical feature of image contains

- Mean
- Variance
- Skewness
- Standard deviation

GLCM:

Texture Analysis Using the Gray-Level Co-Occurrence Matrix (GLCM). Analyzing numerical data in large quantities method of texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM), also known as the gray-level spatial dependence matrix.

For statistical confidence is estimation of the joint probability distribution, and the matrix must contain a reasonably large average occupancy level achieved either by

(a) Restrict the number of amplitude positive values (Predicts loss of accuracy for low-amplitude texture),

(b) Using large measurement window. (Causes errors if texture modifications over the large window). **Typical compromise**: 16 gray values and window size of 30 or 50 pixels on each and every side. Now it can be analyzed as

• Maximum probability entry

• Element difference moment of order k: $P_I P_j (i - j)$ k Cij This descriptor has relatively low values when the high values of C are near the main diagonal. For this kind of position the operator, high pixels consider near the main diagonal would indicate that bands of constant intensity running "1 pixel to the right and 1 down" are likely. When the k = 2 it is called the contrast:

• Contrast = $P_i P_j (i - j)$ 2 Cij

• Entropy = $- P_i P_j$Cij log Cij this is a measure of randomness, having its highest value when the elements of C are all equal.

• Uniformity (also called Energy) = $P_i P_j$ c 2 ij (smallest value when all entries are equal)

• Homogeneity = $P_i P_j$Cij $1+|i-j|$ (large if big values are on the main diagonal)

The gray-level co-occurrence matrix can reveal certain properties about the structural distribution of the gray levels in the texture image. For example, the most of the entries in the GLCM are focused along the diagonal; the texture is coarse with respect to the specified offset.

2.5 Artificial Neural Network:

Author in this paper (Thamarai .M & Kalpa .M, 2014)Artificial Neural Network is used for classifying the normal and abnormal tooth images using extracted features.A neural network has several inputs, hidden, and output nodes. Each node applies a function some data (could be softmax, linear, logistic), and returns an output. Every node in the proceeding layer takes a weighted average of the outputs of the previous layer, until an output is reached. The reasoning is that multiple nodes can collectively gain insight about solving a problem (like classification) which an individual node cannot. The cost function differs for this type of model -- the weights between nodes adjust to minimize error.

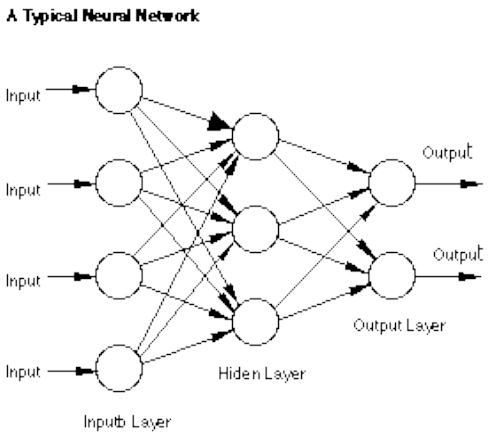


Figure.4 Architecture of ANN

Figure.4 shows the architecture of the artificial ANN. ANN is relatively crude electronic networks of neurons based on the neural structure of the brain. The errors from the starting classification of the initial record is fed back into the network and used to modify the networks algorithm for further iterations.
A neuron in an artificial neural network is
1. A set of input values (xi) and associated with weights (wi).
2. A function (g) that sums the weights and the maps, finally results to an output (y).

Neurons are organized into layers that like input, hidden and output. The input layer is collected not of full neurons but rather consists simply of the record's values that are inputs to the next layer of neurons. The next layer is the hidden layer. Several hidden layers can be existing on one neural network. The final layer is called the output layer where there is one node for each class. A single sweep forward through the network results in the assignment of a value to each output node, and the record is assigned to the class node with the highest value.

3. Conclusion:

Most researchers make use of Thresholding and morphological operation for feature extraction and segmentation. Much of the works have been done for teeth segmentation, but very few researchers have applied and realized the methods for diagnosis purpose. Interactive portions of X-ray selected for further processing specifically for the purpose of diagnosis is the need of the hour as it would help both the doctor and the patient to understand the problem and depth of the disease. This paper may help to concentrate on image enhancement or segmentation for extracting features for forensic sciences. Automated or semi-automated diagnosis of aforesaid objectives would be quiet useful for the doctor as well as the patient.

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