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Identification of Early Caries in Human Tooth Using Histogram and Power Spectral Analysis

[1]*T. Saravanan,* [2]*M. Sundar Raj and* [1]*K. Gopalakrishnan*

[1]Department of ETC, Bharath University, Chennai, India
[2]Department of BME, Bharath University, Chennai, India

Abstract: This paper deals with the detection of caries in its early stage using histogram and power spectral analysis. The materials required include X-ray images of normal and decayed teeth of individuals that are analyzed using MATLAB signal processing tool. The x-ray images of normal and decayed teeth of individuals are analyzed using MATLAB signal processing tool. For each image the histogram and power spectrum are calculated. Then a detailed study is made. It is found that, in a histogram the pixel intensities are concentrated in different ranges for normal and decayed teeth. It is also found that there are distinct differences in the spectral components obtained, between normal and decayed teeth. The spectrum of a decayed tooth has high frequency components compared to the spectrum of the normal tooth. Further the GUI implementation makes it simpler and interactive to the user. This method is very useful for the dentists to detect the caries in its early stage.

Key words: Dental Caries · Histogram · Power spectrum · GUI · Pixel intensities

INTRODUCTION

Dental caries, also described as tooth decay or dental cavities, is an infectious disease which damages the structures of teeth. The disease can lead to pain, tooth loss, infection and, in severe cases, death. Tooth decay is caused by certain types of acid-producing bacteria which cause the most damage in the presence of fermentable carbohydrates such as sucrose, fructose and glucose [1]. The resulting acidic levels in the mouth affect teeth because a tooth's special mineral content causes it to be sensitive to low pH [2]. An estimated 90% of schoolchildren worldwide and most adults have experienced cavities. In the United States, dental caries is the most common chronic childhood disease, being at least five times more common than asthma. It is the primary cause of tooth loss in children. Between 29% and 59% of adults over the age of fifty experience caries. Generally, there are two types of caries when separated by location: caries on smooth surfaces and caries in pits and fissures [3].. Proximal caries are the most difficult type to detect [3]. Frequently, this type of caries cannot be detected visually or manually with a dental explorer. Pits and fissures are anatomic landmarks on a tooth where tooth enamel infolds creating such an appearance. Fissures are the grooves located on the occlusal (chewing) surfaces of posterior teeth and lingual surfaces of maxillary anterior teeth.

Existing Methods of Caries Detection: In order to conserve tooth structure and perform minimally invasive dentistry, carious lesions must be detected at the earliest possible time. When carious lesions are detected in their earliest stages, the caries progress can be arrested, thus avoiding a more invasive operative intervention. Some of the existing methods are probing with a sharp explorer, Visual assessment, radiographs etc. Accurate diagnosis of the noncavitated lesion is extremely valuable because an increased prevalence of difficult to diagnose caries can be an indication of high caries activity, a circumstance that must be treated with a more aggressive preventive program [4].

Corresponding Author: T. Saravanan, Department of ETC, Bharath University, Chennai, India.

Method Proposed by this Project: This project proposes the use of digital intraoral radiograph images with processing using specialized software which is an excellent method to evaluate for caries. The x-ray images of normal and decayed teeth of individuals are analyzed using MATLAB signal processing tool. For each image the histogram and power spectrum are calculated and a detailed study is made.

Histograms: Histogram shows the distribution of data values. The histogram evolved to meet the need for evaluating data that occurs at a certain frequency. This is possible because the histogram allows for a concise portrayal of information in a bar graph format. The histogram is a powerful engineering tool when routinely and intelligently used. The histogram clearly portrays information on location, spread and shape that enables the user to perceive subtleties regarding the functioning of the physical process that is generating the data. It can also help suggest both the nature of and possible improvements for, the physical mechanisms at work in the process. Histogram, or Frequency Histogram is a bar graph. The horizontal axis depicts the range and scale of observations involved and vertical axis shows the number of data points in various intervals i.e., the frequency of observations in the intervals. Histograms are popular among statisticians. Though they do not show the exact values of the data points they give a very good idea about the spread of the data and shape.

Finding the Histogram of Images: A collection of 350 tooth images are taken for analysis. The areas that are to be analyzed are extracted for all the images. They are then resized to square images. The square images are then converted to gray scale images. The histograms of these images are taken and a thorough analysis is made. Depending upon the concentration of pixel intensities in different ranges, we classify them into the various stages of caries.

Spectrum: The power spectrum is a measure of the distribution of signal energy as a function of energy and graphs of the spectrum are commonly used to visually analyze the frequency content of a signal or the frequency response of a system. The power spectrum is defined as the squared magnitude of the discrete Fourier transform of a signal. The power spectrum is a representation of the magnitude of the various frequency components of a 2D image that has been transformed with the FFT command from the spatial domain into the frequency domain. Different frequencies in the power spectrum are located at different distances and directions from the origin. (The origin is customarily located in the center of the power spectrum.) Higher frequency components of the image will be located at greater distances from the origin. Different directions from the origin will represent different orientations of features in the image.

The power at each location in the power spectrum is an indication of the frequency and orientation of a particular feature in the image. Evaluating the power spectrum is an excellent way to isolate periodic structural features or noise in the image. Since the power can vary by orders of magnitude in an image, the power spectrum is usually represented on a log scale.

Finding the Spectrum of Images: After the histograms are analyzed the spectrum is calculated for all the resized, gray scale images. For the spectrum calculation we first transform the images from their time domain into their frequency domain using Fourier transform. The magnitude and phase values are found. From the phase information we obtain the frequency. We then plot the spectrum using the magnitude and frequency values. The spectrums of all the images are taken and a thorough analysis is made. Depending upon the range of the magnitude values, we classify them into the various stages of caries.

Implementation in Gui: A graphical user interface (GUI) is a user interface built with graphical objects, such as buttons, text fields, sliders and menus. Applications that provide GUIs are generally easier to learn and use since the person using the application does not need to know what commands are available or how they work. The action that results from a particular user action can be made clear by the design of the interface [5].

RESULTS

Histogram of a Normal Tooth: The figures 1a and 1b show the x-ray image of a normal tooth and its corresponding histogram.

The histogram of a normal tooth shows that the pixel intensity is centered on the 200 to 250 range and the peak value of the number of pixels lies in this range. This indicates the presence of more number of white pixels for a normal tooth. And it is also found that the numbers of black pixels are very minimal [6-15].

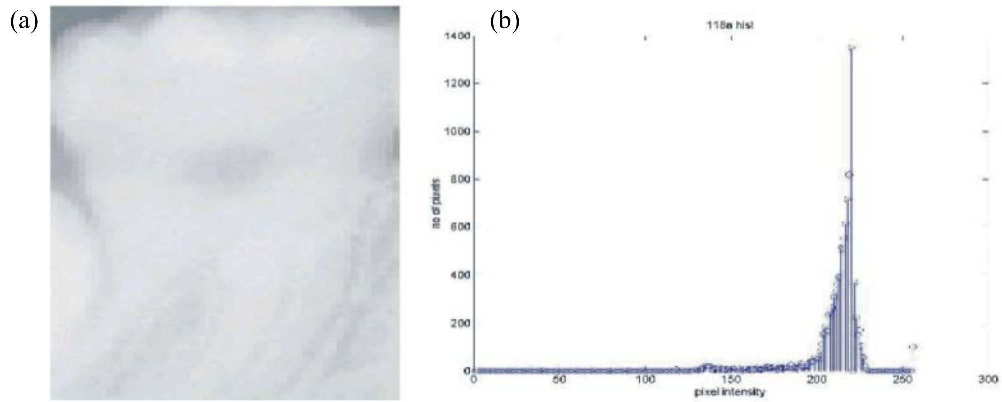

Fig. 1a,b: a: X-ray of a normal tooth, b: Histogram of a normal tooth

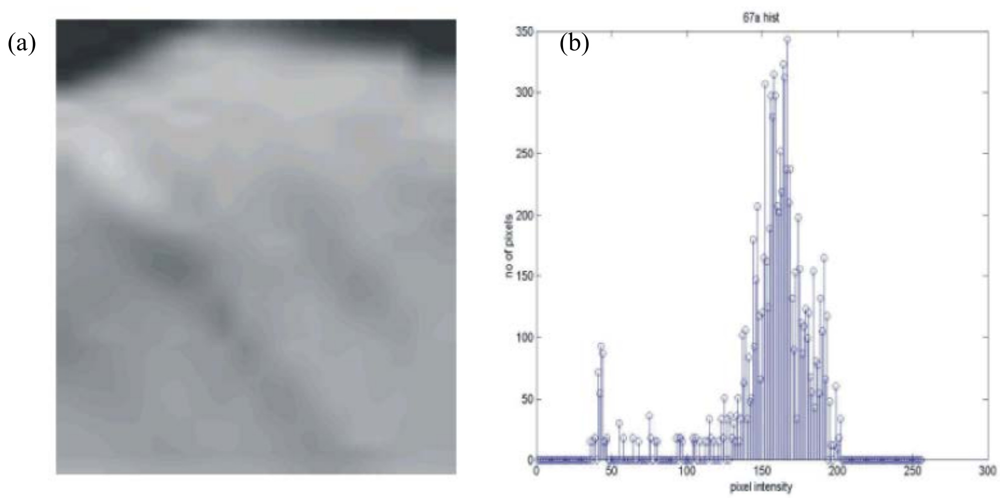

Fig. 2a,b: a: X-ray of a tooth in its early stage of decay, b: Histogram of a tooth in its early stage of decay

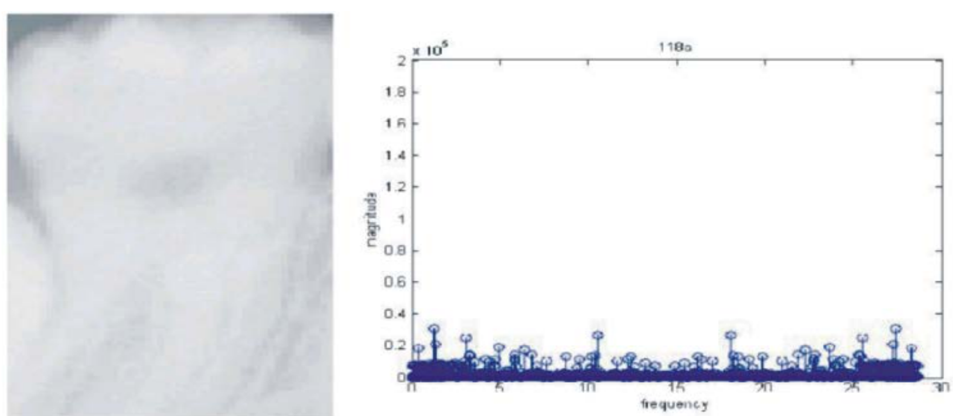

Fig. 3a,b: a: X-ray of a normal tooth, b: Spectrum of a normal tooth

Histogram of Early Stage of Caries: The figures 2a and 2b show the x-ray image of a tooth in its early stage of decay and its corresponding histogram.

The histogram of a tooth in its early stage of decay shows that the pixel intensity is centered on the 175 to 225 range and the peak value of the number of pixels lies in this range. This indicates that there is less number of white pixels than a normal tooth. And it is also found that the numbers of black pixels are more. The histogram of a tooth in its intermediate stage of decay shows that

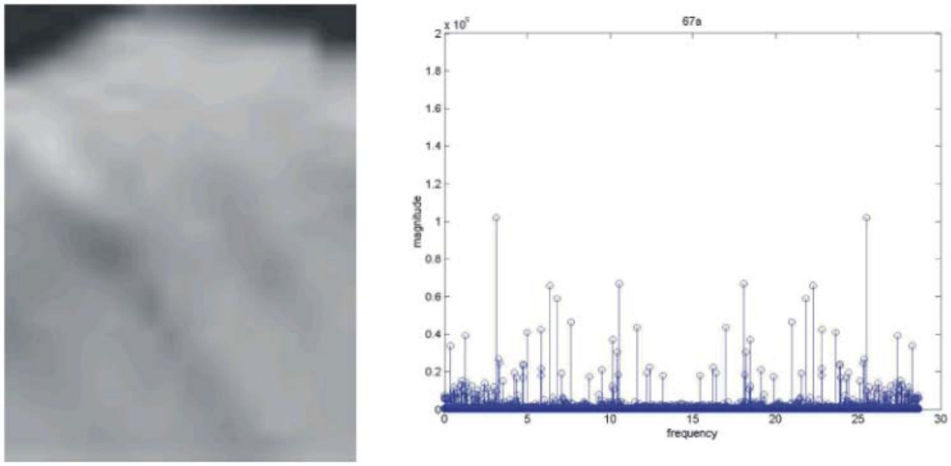

Fig. 4a,b: a: X-ray of a tooth in its early stage of decay, b: Spectrum of a tooth in its early stage of decay

the pixel intensity is centered on the 100 to 175 range and the peak value of the number of pixels lies in this range. The histogram of a tooth in its severe stage of decay shows that the pixel intensity is centered on the 0 to 150 range and the peak value of the number of pixels lies in this range. The pixel intensities are distributed widely which depicts the presence of severe caries.

Spectrum of a Normal Tooth: The figures 3a and 3b show the x-ray image of a normal tooth and its corresponding spectrum.

The spectrum of a normal tooth shows that the maximum magnitude value is less than 600.

Spectrum of Early Stage of Caries: The figures 4a and 4b show the x-ray image of a tooth in its early stage of decay and its corresponding spectrum.

The spectrum of a tooth in its early stage of decay shows that the maximum magnitude value lies between 600 and 800. The spectrum of a tooth in its intermediate stage of decay shows that the maximum magnitude value lies between 800 and 1000. The spectrum of a tooth in its severe stage of decay shows that the maximum magnitude value is greater than 1000.

CONCLUSION

The results obtained from the histograms show that the pixel intensities are centered on different ranges depending upon the stage of caries, for e.g., it's confined for a normal tooth and is distributed for a severe tooth. The results obtained from the spectrums show different magnitude values for different stages of tooth decay. The classification of the different stages of decay is done based on the region of concentration of pixels with regard to the histogram and based on the magnitude values with regard to the spectrum.

MATLAB GUI is a very powerful tool when used correctly. Simplicity in design is our chief goal. A simple GUI has a clean look and a sense of unity. Consistency makes it easier to move from one demo to the next by generating a sense of familiarity, which also leads to the next theme. If the GUI that you create is in some sense familiar to its users, then they can generally learn how to use it more quickly.

This project is very useful for the clinicians to detect the caries in its early stage. The future scope of this project is that it can be extended using neural networks which automatically identifies the stage of caries.

REFERENCES

1. Strassler, E., 0000. New Concepts in Caries Detection of Pit and Fissure Lesions Howard University of Maryland Dental School.
2. Jeffrey A. Webb, 0000. Creating Graphical User Interfaces (GUI's) with MATLAB, pp: 2-36.
3. Saravanan, T. and R. Udayakumar, 2013. Comparision of Different Digital Image watemarking techniques, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 15(12): 1684-1690.
4. Summit, James B., J. William Robbins and Richard S. Schwartz, 2001. Fundamentals of Operative Dentistry: A Contemporary Approach, Carol Stream, Illinois, Quintessence Publishing Co, Inc, 2: 30.

5. Gopalakrishnan, K., G. Saritha and T. Saravanan, 2013. Simulation, Analysis And Design Of An Active Bridge For Sensor Capacitance Measurement, Using Matlab, Middle-East Journal of Scientific Research, ISSN:1990-9233, 16(12): 1744-1747.
6. Hardie, J.M., 1982. The microbiology of dental caries, Dental Update, pp: 199-208.
7. Holloway, P.J., 1983. The role of sugar in the etiology of dental caries, Journal of *Dentistry*, pp: 189-213.
8. Gopalakrishnan, K., G. Saritha and T. Saravanan, 2013. Wavelet Based Loseless Huffman Compression Algorithm For Effective Abnormality Extraction In Medical Thermograms, Middle-East Journal of Scientific Research, ISSN:1990-9233, 15(12): 1779-1783.
9. Gopalakrishnan, K., M. Prem Jaya Kumar, J. Sundeep Aanand and R. Udayakumar, 2013. Optical Performance of Doped Azopolyester and its Application, Indian Journal of Science and Technology, ISSN: 0974-6846, 6(6): 4783-4788.
10. Saravanan, T. and R. Udayakumar, 2013. Optimization of Machining Hybrid Metal matrix Composites using desirability analysis, Middle-East Journal of Scientific Research, ISSN:1990-9233, 15(12): 1691-1697.
11. Saravanan, T. and R. Udayakumar, 2013. Simulation Based line balancing of a single piece flow line, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 15(12): 1698-1701.
12. Saravanan, T., R. Udayakumar and G. Saritha, 2013. Simulation Based line balancing of a single piece flow line, Middle-East Journal of Scientific Research, ISSN:1990-9233, 16(12): 1790-1793.
13. Saravanan, T., V. Srinivasan and R. Udayakumar, 2013. Images segmentation via Gradient watershed hierarchies and Fast region merging, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 15(12): 1680-1683.
14. Srinivasan, V., T. Saravanan, R. Udayakumar and G. Saritha, 2013. A Novel Mechanism For The Treatment Of HIV Using Soc, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 16(12): 1801-1806.
15. Srinivasan, V., T. Saravanan, R. Udayakumar and G. Saritha, 2013. Specific Absorption Rate in the Cell Phone User's Head, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 16(12): 1798-1800.
16. Srinivasan, V., T. Saravanan and R. Udayakumar, 2013. A Novel mechanism for the treatment of HIV using SOC, Middle-East Journal of Scientific Research, ISSN:1990-9233, 15(12): 1799-1802.
17. Srinivasan, V. and T. Saravanan, 2013. Sophisticated Technologies in Power Transmission Structure, Middle-East Journal of Scientific Research, ISSN: 1990-9233, 15(12): 1809-1812.