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IR Imaging for Dental Caries

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Abstract-- our vision of the paper states that early detection of dental caries in the inter proximal contact sites between them. In this, a near –IR imaging system operating at 940nm was used to acquire images through tooth sections of varying thickness and whole teeth in order to demonstrate the utility of near-IR dental transillumination system for the imaging of early dental caries. This paper clearly demonstrates that the IR transillumination system has considerable potential for the imaging of early dental decay. Dental enamel manifests high transparency in the near-IR. The most new dental decay occurs in the pits and fissures of the occlusal surface of the posterior teeth. These caries lesions cannot be detected by X-ray during the early stages of decay due to the overlapping topography of the crown of the tooth. A near-IR imaging system operating at 940nm was used to acquire occlusal image by launching the near-IR light into the buccal surface of the teeth just above the gingival margin. The near –IR light diffuses through the highly scattering dentin providing uniform back illumination of the enamel of the crowns allowing imaging of the occlusal surfaces. The near-IR images show high contrast between sound and demineralised areas. Moreover, the high transparency of the enamel enables imaging at greater depth for the detection of surface decay hidden under the enamel. A 940nm LED is used as the source illumination. NOIR camera is used for better resolution. It connects to Raspberry Pi by way of a short ribbon cable. The camera is connected to the BCM2835 processor on the Pi via the CSI bus. This bus travels along the ribbon cable that attaches the camera board to the Pi. It also weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. The Raspberry Pi is a series of small single-board computers. The image sensor used is a red green blue – infrared micro-camera controlled by a Raspberry Pi board where a basic image processing algorithm has been programmed. These early images suggest that the near-IR offers significant advantages over conventional visual, tactile and radiographic caries detection method**.**

Keywords: Caries detection, Dental caries, Near-IR imaging, occlusal surfaces, Transillumination.

1 INTRODUCTION

Dental caries, more commonly known as cavities or tooth decay, is one of the most prevalent clinical conditions in the world. The World Health Organization estimates that 60-90% of school children and nearly 100% of adults have or have had caries, with indications that global incidence rates are increasing. Tooth decay is the predominant chronic health condition amongst persons aged 6-19. While it is assumed that industrialized nations have better oral hygiene due to implementation of public health measures and improved living conditions, some developed Nations have caries incidence rates greater than those of resource-limited settings. Tooth decay occurs when oral bacteria metabolize sugars and starches found in food and produce acids that erode the enamel of the tooth. Caries are strongly correlated with the presence of dental plaque which is produced by the same antagonizing bacteria. With time, the enamel layer is compromised and the acids attack the inner dentin and eventually the soft pulp, causing pain, sensitivity, stains, and halitosis. Tooth decay can also contribute to infection and inflammation of the surrounding gingival [1].

Dentists treat caries by manually removing the compromised tooth material and filling the remaining void [3]. To help locate and determine the depth of the decay, dental professionals commonly rely on radiographs in conjunction with white light visual examination. The most popular radiographic views are bitewing and occlusal views. Because traditional radiographs capture a two-dimensional Projection of all superimposed material between the film and source, there is attenuation of finer detail. The orientation and severity of the feature directly affects its radiographic visibility; As such, some incipient caries, early demineralization, and cracks will not appear on the X-rays. Caries adjacent to and within direct line-of-sight of opaque amalgam fillings, such as instances of secondary caries, may also not be visible. Furthermore, modern radiographs generate concern among patients who seek to reduce their exposure to ionizing radiation [2].

It is not uncommon for patients to refuse radiographs despite the wishes of dental professionals. Dentists who lack radiographs of a patient are denied valuable diagnostic information. The scattering properties of enamel and dentin in the NIR range were first characterized by Fried et al. in 1995. Depending on the wavelength, most NIR light can be transmitted across healthy enamel with marginal scattering; 1310 nm light represents an optimal imaging wavelength as it strikes a balance between enamel and water attenuation [3]. However, dental caries and demineralization scatter transiting NIR light and appear as dark areas. At 1310 nm, mild fluorosis and other shallow defects may be discernable depending on their severity, geometry, and method of imaging; Hirasuna, et al. suggest multimodal NIR imaging as a potential means for differentiating between mild fluorosis and deeper caries. Taken altogether, NIR dental imaging has produced condition-dependent applications that challenge or exceed [4].

Two-dimensional radiographs without the use of ionizing radiation, and work have been done to compare the diagnostic capabilities of both technologies. While much of the research into NIR dental imaging occurs around 1310 nm, neighboring NIR wavelengths have also demonstrated potential application depending on the illumination mode and target feature, and it is not uncommon for researchers to image the tooth across the NIR range and into the short-wavelength infrared range [5].

2.LITERATURE REVIEW

The main goal is to establish a transillumination system using near-infrared (NIR) light for the detection of early approximal enamel caries lesions.

Daniel fried developed NIR imaging hand-pieces and attached to a compact InGaAs focal plane array and subsequently used to acquire in vivo NIR images of 33 caries lesions on 18 test subjects. The aim of the device to acquire an image of dental caries in the near-IR (NIR) light at 1310nm without the use of ionizing radiation. They employed to imaging probes to acquire images from either the occlusal surface or the outer facial or inner lingual of teeth.

A high sensitivity InGaAs imaging camera used to collect all the images. NIR images were acquired in vivo from three directions and the majority of lesions examined were two small to require restoration, based on bitewing radiograph criteria. All but one of the 33 lesions examined were successfully imaged from at least one direction. The result of this study highlight that NIR imaging has great potential as a screening tool for the detection of approximal lesions without the use of ionizing radiation[6],[7].

3.HARDWARE DESCRIPTION

A. RASPBERRYPI

The Raspberry Pi is a series of small single-board computers. Processors speed range from 700 MHz to 1.2 GHz for the Pi 3; on-board memory ranges from 256 MB to 1 GB RAM. SD cards are used to store the operating system and program memory in either SDHC or Micro SDHC sizes. The board has one to four USB ports. The B-models have an 8P8C Ethernet port.

The Raspberry Pi 2 (model B), showing an HDMI port, audio/video port, Micro USB power input and two ribbon connectors. The raspberry Pi 2 is an inexpensive and self-contained micro-computer that features a 900 MHz, 2-bit-quard-core ARM processor and 1 GB of RAM.

Fig.1 Raspberry Pi

B.NOIR CAMERA

The Raspberry Pi NOIR Camera Module is a custom designed add-on for Raspberry Pi that does not have an 'IR cut filter' installed. Like the regular Pi camera, it attaches to Raspberry Pi by way of one of the two small sockets on the board upper surface.

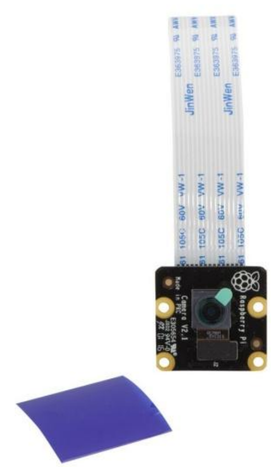


Fig.2 NOIR Camera

The board itself is tiny, at around 25mm x 24mm x 9mm. It also weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. It connects to Raspberry Pi by way of a short ribbon cable. The camera is connected to the BCM2835 processor on the Pi via the CSI bus, a higher bandwidth link which carries pixel data from the camera back to the processor. This bus travels along the ribbon cable that attaches the camera board to the Pi. The sensor itself has a native resolution of 5 megapixel, and has a fixed focus lens onboard. In terms of still images, the camera is capable of 2592 x 1944 pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video. A small piece of blue filter plastic is included; this filter can be used for hyper spectral imaging experimentation.

C.IR LED EMITTERS

Infrared emitting diode is a high intensity diode. The device is spectrally matched with phototransistor, photodiode and infrared receiver module. The wavelength range is 850nm ~ 940nm. The features are high radiant intensity, 5mm through-hole packages; 2.54mm lead spacing and low forward voltage.

Fig.3 IR LED

4.MATLAB

The image is captured once the image of tooth is clearly visible. The image captured is processed using MATLAB for image analysis using histogram plot and segmentation.

A. HISTOGRAM PLOT

A collection of 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 caries affected or not[10].

Fig.5 Normal tooth Fig.6 NIR image

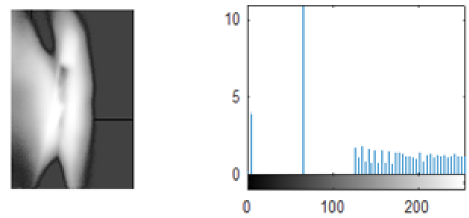


Fig.7 Histogram equalization

B. IMAGE SEGMENTATION

The tooth image is segmented using the Otsus' method. The Otsus' method is a global thresholding selection method, which is widely used because of its simplicity and effectiveness. In Otsu's method, it exhaustively searches for the threshold that minimizes the intra-class variance.

The enhanced tooth image is segmented using the Otsus' method. Otsu method shows that minimizing the intra-class variance is the same as maximizing inter-class variance. By this the caries affected region can be separated from the other region of the tooth[11].

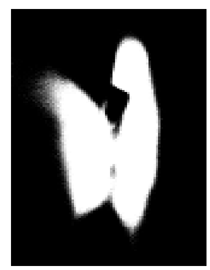


Fig.8 Segmented image

5. BLOCK DIAGRAM

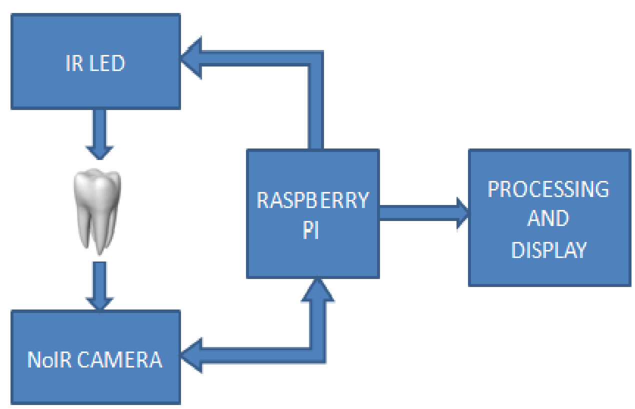


Fig.4 Block diagram

6. EXPERIMENTS

The NIR imaging system is composed of three unique components, and such as NIR light source, an IR camera to acquire the image, and software for image processing. The light source consists of 950 nm range light emitting diodes which is mounted along with the camera for maximum illumination on the tooth. The camera plays a very crucial role in the caries detection system. The camera used in this system requires a standard procedure to make it as an IR camera. This is achieved by using NOIR camera with filter which allows infrared[8],[9].

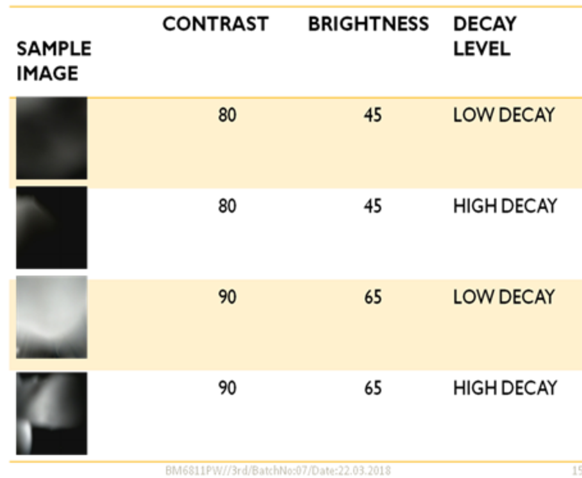
To capture the tooth caries image the light source must be focused on appropriate location and the image is captured and stored in a computer for further processing. The image sensor used is a red green blue – infrared micro-camera controlled by a Raspberry Pi board where a basic image processing algorithm has been programmed. The low cost and size of the camera module connected to Raspberry Pi provides a compact instrument for general purpose.

7.RESULTS AND CONCLUSION

The images captured by the NIR system revealed clinical conditions, including caries, demineralization, fractures, cracks, and craze lines. The lesions appear darker in transillmination and fluorescences.

The NIR system was capable of displaying subsurface caries, including those around fillings, demineralization, fractures, and cracks, all without the use of ionizing radiation. The superb detail of the images, primarily in comparison to conventional radiographs, potentially grants the clinician greater diagnostic power. Furthermore, the inexpensive cost of the components required to produce such high quality images adds a new dimension that is in contrast to conventional imaging approaches [12].

8.TABULATION:



DECAY LEVEL OF THE TEETH

SAMPLE IMAGE	CONTRAST	BRIGHTNESS	DECAY LEVEL
	80	45	LOW DECAY
	80	45	HIGH DECAY
	90	65	LOW DECAY
	90	65	HIGH DECAY

using trial and error method the decay of caries can be found.

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