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Quality Analysis of Dental Radiographs by Digital Image Processing

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Abstract: The importance of digital image processing is crucial in medical field. There are several platforms where image processing is playing a key element. One of the main are of application is dentistry. In this dental radiograph are more useful for dentist to evaluate and or examine patient tooth related abnormalities. The proposed work is carried out to enhance the quality of dental radiographs. Here we are focusing on Intraoral Periapical IOPA films. Proposed system is based on image processing. In this paper we are focusing the dentistry related imaging techniques and proposed system to enhance conventional film quality. Dental imaging also a broad area of research work in medical field. In dentistry the work starts from conventional x-ray film-based technique (2D imaging) to recently digital imaging techniques (3D imaging). As no doubt digital techniques are giving more quality and providing high resolution digital images like computed tomography, MRI, CBCT etc to regularize treatment. We are focusing on conventional method which is again preferable by dentist in remote areas and villages. The aim of proposed system is to enhance the quality of film up to a certain proper diagnose level at same end.

Keywords: Dentistry, Dental Radiographs, Patient Tooth, Intraoral Periapical, Image processing.

I. INTRODUCTION

Dental imaging also a part of medical imaging where researchers and radiologist find more space to enhance the quality and accuracy of technology used for particular clinical applications. The treatment is directly associated with the degree of certainty in diagnosis. Hence the imaging of teeth plays crucial role here. The dental imaging could be 2- Dimensional or 3-Dimensional. For erupted and non-erupted teeth 3-D imaging is desirable. Also, in surgical implants the 3-D imaging is most desirable as far as the accuracy is concerned. There are various techniques used for 3D imaging in such as Magnetic Resonance imaging, computer tomography and many more. Dental radiography has been used since the beginning of radiology. The first dental x-rays taken by Dr. Otto Walkhoff in January 1896.

He uses own mouth for an exposure of x-rays for 25 min [1] after this experimentation the revolution in dentistry started. The word imaging implies to different methods and techniques which are used to view a single part and or whole human body in order to diagnose, monitor, or treat medical conditions. There are different medical imaging techniques used like [2], General Medical X-ray Imaging, Pediatric X-ray Imaging, Fluoroscopy, Mammography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), Radiography, Dental Cone-beam Computed Tomography, Nuclear imaging, Ultrasound Imaging. Currently, a dentist prefers 3D imaging technique for clinical diagnosis purpose. CBCT is used to detect various teeth related disease. In dentistry, computer aided process such as dental implant, orthodontics planning, face and jaw cosmetic surgeries are being developed [3]. CBCT imaging provides several advantages like accurate measurements, improves localization of impacted teeth etc.

A. Anatomy of human tooth:

Figure 1 shows the human tooth anatomy. Teeth are an important substance in the body. It is like a crusher for hard food. The structure is dividing in three sections Root, Crown and Neck includes hardest past Enamel and Pulp softer part. Dentine is layer in between contains microscopic tubes. Tooth decay is the common disease now days. Bacteria damage hard tissues of tooth it results dental caries. X-ray play important role to detect and diagnose disease.

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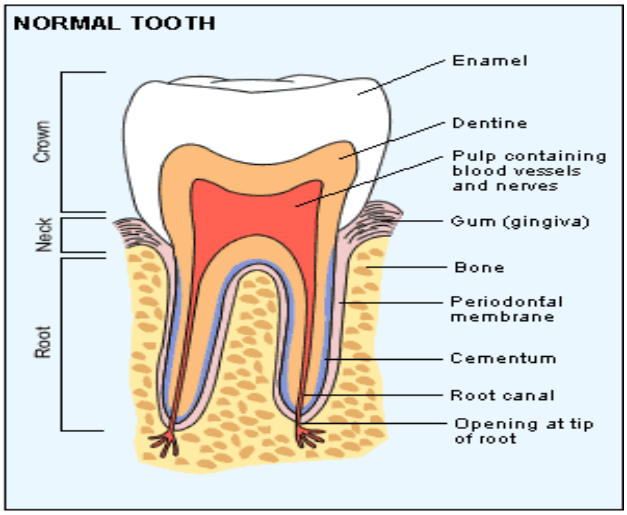

Figure 1: Human tooth anatomy

B. Teeth diseases

Dental x-ray imaging is help full for dentists for finding minute disorder and changes in human teeth. With reference to World Health Organization record 60-90% of school children and nearly 100% of adults have or have had caries [4, 5]. There are some diseases which can be detected by x-rays such as, caries, moderate and severe occlusal lesion, proximal caries, advanced proximal lesion, root surface caries, evaluation of trauma, third molars, tooth development etc.

II. DENTAL IMAGING

Dental imaging starts with x-rays as conventional radiographs. As dentists are more relying on x-rays and researchers consistently working for giving better and ultimate accuracy results with technology updates in dentistry. The time line in dental imaging starts with conventional film-based radiographs and recently 3D cone beam computed tomography is using by dentist in clinical practice. After conventional film-based approach immediately digital imaging came in picture as Radio-visio-graphy (RVG) which is 2D technique. In this RVG system a sensor is directly connected to computer, it captures and sends to computer system. A computer with supportive software processed the captured image and stores in digital form to hard disc. Dental imaging can broadly classify in two categories, conventional (film based) and Digital imaging. Film based technique is used in general practices by dentist but currently preferring digital one because of low radiation doses (X-ray exposure) and quality of X-ray images (dental radiographs). Conventional imaging technique consists of three major types of dental x-ray film used for most procedures: Bitewing, Periapical and Panoramic film.

A. Conventional imaging system

Figure 2 shows the conventional dental film-based x-ray processing mechanism also different imaging units used in dentistry. Operators are more rely on digital technology but conventional imaging technique is used as common practices in clinics and educational institutes.

i) Conventional X-ray unit

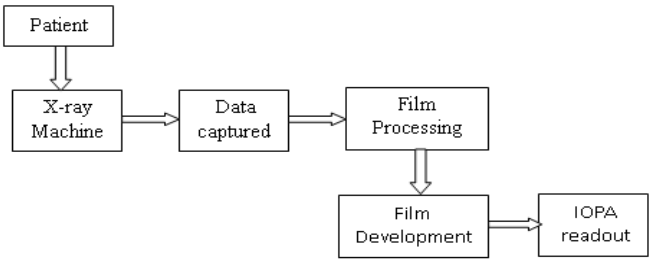

Figure 2: Conventional x-ray system

ii) Digital Imaging system: Digital imaging system consists of sensor, computer and software associated with hardware system. Figure 3 shows the 2D and 3D digital machines used in dentistry. The quality of image varies according to the hardware and software associated with machine.

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Figure 3:- RVG (RadioVisio Graphy) with sensor, 2D OPG Carestream 8000C Digital Panoramic machine

B. DIACOM

Digital Imaging and Communications in Medicine standard is used for transferring medical data (images) one place to another also it can be store in computer hard disc for a long time. DICOM is a standard that specifies a nonproprietary data exchange protocol, which was developed by the American College of Radiology and the National Electrical Manufacturers Association [6, 7]. It is an international standard for transmitting and receiving DIACOM images without information loss. These images can be display and or print for clinical records also for patient reference.
Following are some DIACOM viewers for dentist compatibly with different operating systems [8].

C. Limitations

- 2D imaging
  - 2D Radiographs do not reveal the soft-tissue issues related to hard-tissue.
  - The tooth to the surrounding structures relation cannot be assessed perfectly.
  - Replication accuracy in 2-D radiographic images is poor.
  - Anatomical or background noise, leading to difficulty in interpreting radiographs.
  - 2-D radiographs show less severe bone destruction than is actually present.
- 3D imaging
  - CBCT image shows poor soft tissue contras and image affected by noise.
  - Detector sensitivity, resolution affect the clarity of CBCT images
  - CBCT image lag to show skull site distances [9]

TABLE I. SUBJECTIVE COMPARATIVE ANALYSIS

Technique	Analog	Digital techniques		
	Conventional	RVG	2D Digital	3D Digital
View	Limited	IOPA, OPG	IOPA, OPG, Cep.	360
Radiation	More	80% less	26–35 µSv	10 to 36 µSv.
Cost	Low	Moderate	High	Very high
Software	N	Y	Y	Y
Hardware	Y	Y	Y	Y
Retake	Y	Y	Y	N
Limits	Small view	2D only	No 3D	Soft tissue
Digital Image processing	N	Y	Y	Y
Processing speed	Poor	Fast	Fast	Very Fast

Table 3 shows findings and comparative analysis of conventional and digital imaging systems. No doubt radiation dose is reduced in digital one compared to conventional film based system. In CBCT somewhat radiation exposure increases because it covers maximum area for scanning. The magnetic field rotates around the object and produces number of slices of each section. As far as concerned with accuracy 3D imaging technique provides high accuracy and quality of images which can be transmitted over a channel to another end for telemedicine purpose.

III. SIGNIFICANCE OF IMAGE PROCESSING IN DENTISTRY

In dentistry most of the diseases find and diagnosed by imaging techniques. It may be either conventionally and or digitally. Scope of image processing is to enhance the quality of radiographs by applying pre and post processing techniques, machine learning techniques (classifications). There are may image analyzing and detecting techniques (feature extraction), algorithms and methods are available also machine learning technique using Feed Forward Neural networks

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and K-Nearest Neighbour Classifier [10]. Changing hardware is not at all solution always; limitations can overcome by updating new software for the same. It reduces extra hardware cost and complexity.

- Necessity of software in dental imaging:

The softwares which are used in dentistry can be of two types, type-1 for image manipulation (technical side) and type-2 for clinic scheduling and managing. Following are the some requirements associated with type-1 software like, Contrast enhancement, negative replica, colour contrast, zooming (in/out) with clearity, image cropping, lesion measurement, sharpness and resolution, store (DIACOM), transmission (Telemedicine).

IV. METHODOLOGY

A novel approach towards quality enhancement of dental film-based x-ray radiographs by digital image processing in MATLAB environment. The proposed work is to reproduce the images on computer screen by quality enhancement process for proper and accurate diagnosis of dental related disease. In this IOPA (Intraoral Periapical) radigraphs are considered for experimentation. For experimentation purpose collected different IOPA films from various dental clinics and institutes. The proposed system development:

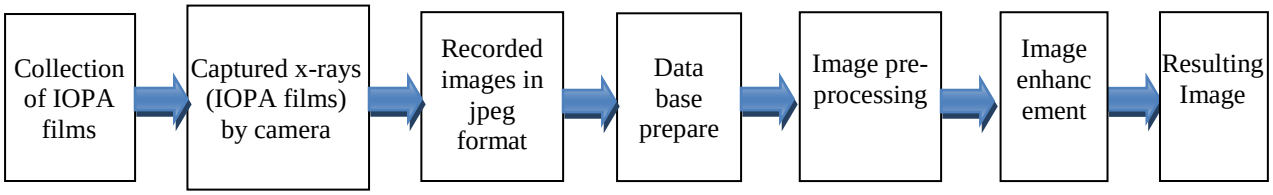

Figure: Proposed system work flow diagram

V. EXPERIMENTATION ANALYSIS

Experimentation is done on Matlab environment. Results are obtained on IOPA film. First image is converted in to gray scale then calculated histogram to find frequency distribution in image then processed histogram equalization.

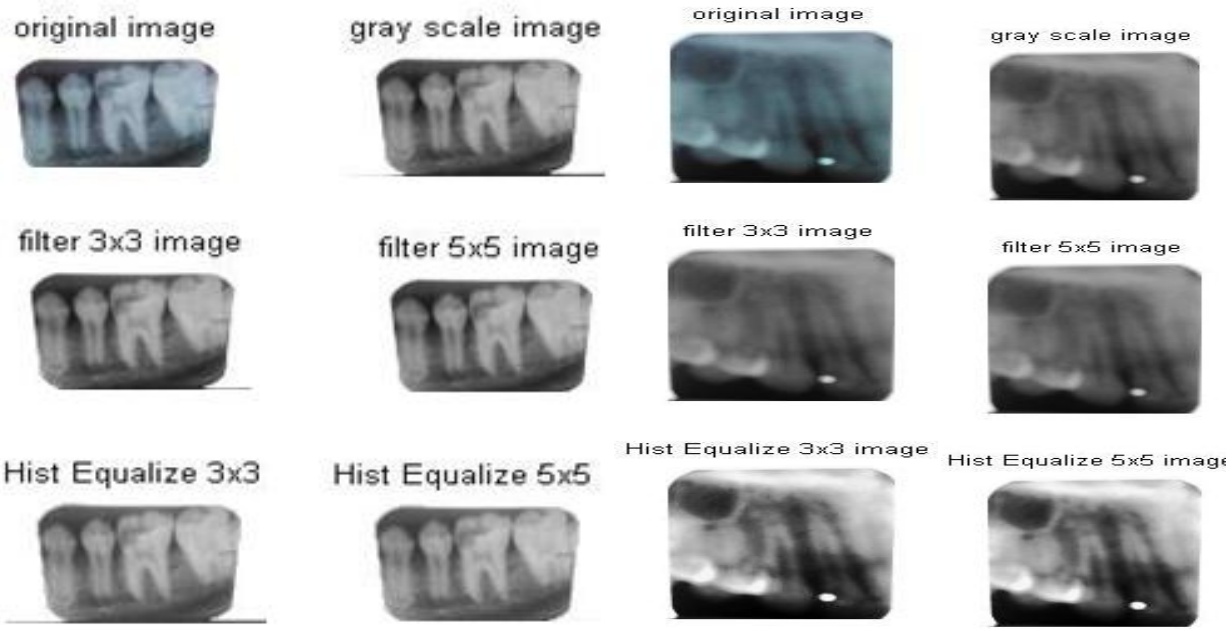

Figure: 4- 3x3 & 5x5 Filtering and histogram operation on image

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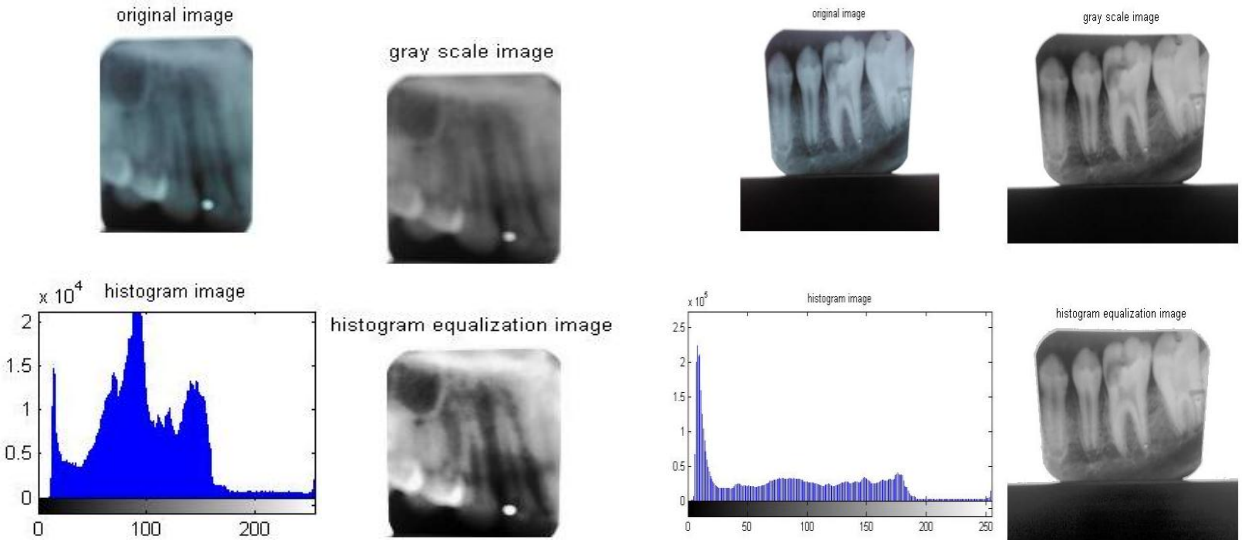

Figure 5:- Histogram and histogram equalized image

VI. CONCLUSION

Dental imaging is fast growing filed. As technology is updating quality of radiographs are also improving. The imaging methodology is varying operator to operator. Conventional film based method has sharp clarity but due to high radiation dose, retake and processing time required more dentists are switching to 2D and 3D digital imaging techniques. Here proposed work is to improve the quality of conventional films by digital image processing and the results are shown by calculating histogram of image and applying filtering for sharpening and smoothening image. Result shows improvement in image quality which will be beneficial for dentist at remote places to diagnose without retake.

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