Published online: 2019-09-27

Image Post-Processing in Dental Practice

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ABSTRACT

Image post-processing of dental digital radiographs, a function which used commonly in dental practice is presented in this article. Digital radiography has been available in dentistry for more than 25 years and its use by dental practitioners is steadily increasing. Digital acquisition of radiographs enables computer-based image post-processing to enhance image quality and increase the accuracy of interpretation. Image post-processing applications can easily be practiced in dental office by a computer and image processing programs. In this article, image post-processing operations such as image restoration, image enhancement, image analysis, image synthesis, and image compression, and their diagnostic efficacy is described. In addition this article provides general dental practitioners with a broad overview of the benefits of the different image post-processing operations to help them understand the role of that the technology can play in their practices. (Eur J Dent 2009;3:343-347)

Key words: Dentistry; Digital radiography; Image processing.

INTRODUCTION

Wilhelm Conrad Roentgen discovered the x ray in 1895. After this discovery film was used as an image receptor for many years. In recent years as a result of innovations in computer technology and their implementation in radiology, digital sensors have replaced film.[1]

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An important-maybe the most important- advantage of digital radiography is its ability to process the image data so that the information content of the image is more accessible to the human visual system.[2,3]

In this article image post-processing functions for dental digital radiographs commonly used in dental practice are presented and their diagnostic effects are described.

DIGITAL IMAGE

For a better understanding of the mechanism of image processing, it is good to know what a digital image actually is.[3] A digital image seen on the screen as a collection of brighter and darker areas is composed of a set of cells that are ordered in rows and columns. Individual cells are called "picture elements," which has been shortened to "pixels".[3,4] Each of these pixels has a number or digit assigned to it, based upon the amount of exposure the sensor received for the corresponding area.

Because there are numbers assigned to each pixel, and because these numbers are used by the computer program to assign a different gray scale value to that area, which results in what is seen as an image. Mathematical formulas can be applied to these numerical representations of the digital image to alter these values in specific way, which results in a new set of pixel values. The resulting set of numbers is used to display the processed (altered) image on the monitor screen.[3]

IMAGE POST-PROCESSING

Image processing is a computer-based procedure which changes recorded electronic (digital) image.[3,4] Any operation that acts to improve, restore, analyze or in some way change a digital image is a form of image post-processing.[5]

There are five groups of digital image processing:[6]

1. Image restoration 2. Image enhancement 3. Image analysis 4. Image synthesis 5. Image compression.

1. Image restoration

When the raw image data enter the computer, they are usually not yet ready for storage or display. A number of preprocessing steps need to be performed to correct the image for known defects and to adjust the image intensities so that they are suitable for viewing. Most of the preprocessing operations are set by the manufacturer and cannot be changed.[5]

2. Image enhancement

Most image enhancement operations are applied to make the image visually more appealing. This can be accomplished by increasing contrast, optimizing brightness and reducing unsharpness and noise.[5]

Brightness and contrast

Brightness and contrast setting can be used to correct overexposure or underexposure of an image.[4] Because correct exposure settings will result in an image with good contrast and density.[3] Exposure conditions can be corrected to some extent: an overexposed image can be made lighter and, similarly, the density of an underexposed image can be made darker.[3] Although it is no excuse to pay less attention to the correct exposure settings. But it can help to rescue an image in which exposure conditions were not optimal and thus prevent the need for a remake, saving the patient from an extra dose of radiation.[4]

It is reasonable to assume that in the near future, software for digital radiography will include tools to optimize contrast and brightness automatically for specific diagnostic tasks. Thus, the practitioner could use a single image, and thus a single exposure, to assess more than one diagnostic issue.[4]

Zoom in

Another simple but effective tool is the zoom function, which permits enlargement of the image. By using a twofold or threefold magnification, the user can recognize details more easily. To perform this action, the computer duplicates or interpolates rows and columns of the digital image, thus increasing the size of the image on the screen.[4]

For example, if the original image extends partly outside the screen because of the large number of pixels vertically and horizontally resolution is reduced to fit the image within the size of the screen. In these cases, magnification of the image is required to show the original pixel resolution. If magnification is increased beyond the original pixel resolution, it results in pixelation.[5]

Sharpening and smoothing

The purpose of sharpening and smoothing filters is to improve image quality by removing noise. Noise is irrelevant components of an image that hamper recognition and interpretation of the data of interest and it is often categorized as low-frequency noise (gradual intensity changes) or high-frequency noise (speckling).[5-7] Filters that sharpen an image remove low-frequency noise and intended to enhance the detail in an image. Filters that smooth an image, remove high-frequency noise and intended to reduce the amplitude of small detail in an image. For the correct application of filters, it is important to know what type of noise they reduce and how that affects radiographic features of interest. Without this knowledge, important radiographic features may degrade or disappear as noise is removed.[5]

Color

Color application of radiographs is controversial issue in dental digital radiography. Most digital systems currently on the market provide opportunities for color application of radiographic images.[5,6] All of the image data are stored as digital data. Look up tables (LUTs) are assigned to these data. Usually a gray scale LUT is used, but color LUTs can be used. The result gives false-color images, in that the colors of the image are not those of the object.

Human can distinguish many more colors than shades of gray. Transforming the gray values of a digital image into various colors could theoretically enhance the detection of objects within the image.[5,8,9]

Digital subtraction radiography

Digital subtraction radiography allows practitioners to distinguish small differences between subsequent radiographs that otherwise would have remained unnoticed because of superimposition of anatomical structures or differences in density that are too small to be recognized by the human eye.[4,5,10]

Mathematically, subtraction radiography is quite simple. Digital subtraction radiography software subtracts the value of the corresponding pixels of two images obtained within an interval of a few weeks or a few months, and it uses the outcome to calculate a new image.[4,5] When the gray levels of the corresponding pixels are the same, the output pixel is zero. If there is a change in the radiographic attenuation between the first and follow-up examination, this change shows up as a brighter area when the change represents repair and as a darker area when the change represents loss.[4,5]

Applications of digital subtraction radiography in general practice include the diagnosis and follow-up of periodontal bone resorption and caries, assessment of bone levels around implants, the progression of healing of periapical lesions and the investigation of small differences in mandibular condyle positions.[1,4,11]

3. Image analysis

It is difficult to define the difference between image post-processing and image analysis. When the user adjusts the whole image to make it more suitable for diagnostic purposes, the term "image post-processing" usually is applied. When the user performs certain calculations extracting specific information from the image, it is considered "image analysis".[4] This information can range from simple linear measurements to fully automated diagnosis.[5]

Measurement

Digital imaging software programs offer many tools for image analysis.[12] Digital rulers, densitometers and a variety of other tools are readily available. These tools are usually digital equivalents of existing tools used in endodontics, orthodontics, periodontics, implant dentistry and other areas of Dentistry.[5] With these tools measurements of length, angle and area can be made on a digital image.[3,13] The easiest way is to express the measurement as the number of pixels; however, a more convenient method is to use millimeters or inches as the unit of measurement.[3] Calibration of the magnification factor of a particular sensor is needed to convert pixel measurements in real length measurements.[3] Dental examples of measurement include caries detection, classification of periodontal disease, detection and quantification of periapical bone lesions.[5,6]

Segmentation

An important image post-processing technique used for medical image analysis and computer-assisted medical diagnosis is image segmentation.[14] The purpose of the image segmentation is to simplify and reduce basic components of the image. This process requires subdividing the image and separating objects from the background. Objects of interest are defined by diagnostic task (for example a tooth, caries lesion, bone level or an implant).[6]

Proporties finding

After segmentation of objects from image, several features are found that help to determine which classes belong to each object. For example some operations are performed to determine caries automatically on bitewing radiographs. Similar applications are applied such process as scanning of the face, fingerprint or pupil of the eye for security.[6,15,16]

Object classification

Intraobserver and interobserver consistence is quite variable in radiographic interpretation.

Therefore diagnostic classifications are made especially in dental radiography. For example periodontal disease is classified automatically in certain regions based on specific features on bitewing radiographs. This type of automatic diagnosis process is quick and easy, but not yet a definitive opinion on the reliability could not be reached.[6]

4. Image synthesis

Image data from many projections are synthesized and new image is created by this operation. The main purpose of this application is to develop three dimensional display of the interested object which is normally lost in conventional radiographic projections.[6,10] In this way the buccal and lingual sites of the alveolar crest can be inspected separately.[10]

5. Image compression

Proposed by White et al,[5] "The purpose of image compression is to reduce the size of digital image files for archiving or transmission. Image compression methods are generally classified as lossless or lossy. Lossless methods do not discard any image data and an exact copy of the image is reproduced after decompression. Lossy compression methods achieve higher levels of compression by discarding image data. Empirical evidence suggests that this does not necessarily affect the diagnostic quality of an image. Version 3.0 of the DICOM (Digital Imaging and Communications in Medicine) standard adopted JPEG (Joint Photographic Experts Group) as the compression method which provides a range of compression levels. Other types of image compression methods are being investigated for their use in medical imaging."

CONCLUSIONS

Digital imaging in dentistry is not expected in the future, it is here. Clinics tended to digital imaging techniques so it is required to develop appropriate modules that analysis digital radiographic images as described above. These operations are applied to digital radiographs in many patients for diagnostic purpose in this way it is possible to identify variety of diseases. All or only a few of these techniques are used for in image post-processing. It is hoped that computers will be able, some day, to solve diagnostic problems without intervention by the clinician. But the clinician is still very important in carrying out the diagnostic task. Image post-processing programs leave the initiative with the clinician and only support him or her in performing the diagnostic task.

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