

Implications of Digital Image Processing in the Paraclinical Assessment of the Partially Edentated Patient

MAGDA ECATERINA ANTOHE¹, DORIANA AGOP FORNA¹, CRISTINA GENA DASCALU^{2*}, NORINA CONSUELA FORNA¹

¹Grigore T. Popa University of Medicine and Pharmacy, Faculty of Dental Medicine, 16 University Str., 700115, Iasi, Romania

²Grigore T. Popa University of Medicine and Pharmacy, Faculty of Medicine, 16 University Str., 700115, Iasi, Romania

The application of certain digital processing techniques offers the possibility of extra accuracy in the interpretation of paraclinical examinations of this type, with profound implications in the diagnosis as well as in the hierarchy of the treatment plan. The purpose of this study is to identify the type of imaging processing for the identification of pathological elements from orthopantomographies and articular tomographies. A number of 20 orthopantomographies and 15 temporomandibular joint tomography have undergone through various image enhancement techniques. Various methods of image enhancement (enhancement) have been used for those procedures whereby it becomes more useful in the following aspects: specific details are highlighted; noise is eliminated; the image becomes more visually attractive. The workings were done in Corel PhotoPaint 7.0, using the automatic procedures available. The choice of a particular type of image enhancement technique has been selected for each type of pathology found in orthopantomographies or articular tomography, providing the best accuracy for an optimal imaging interpretation that underpins a precision diagnosis. Of the most useful imaging processing in the optimization of the orthopantomographic image accuracy the point-to-point transformations are to be noted. The image processing proposed in this article focused primarily on improving the radiological image attributes to highlight specific anatomical structures, and secondly, the contour detection, where it was necessary for the diagnostic purposes as well.

Key words: digital image processing, orthopantomography, TMJ tomography, image enhancement, oral pathology

Paraclinic examinations have a particularly important role in detecting the defining elements for a complete diagnosis in the area of partial edentation [1,2]. From the wide range of paraclinical examinations used in the diagnosis of partial edentation, orthopantomography has the widest utility, being used in a first stage to produce an overall picture, then requiring specific examinations for the accuracy of identifying that pathology, or for objectification the details required by a certain therapeutic algorithm [3-5]. The closed mouth-open mouth temporomandibular articulation tomography is a first form of assessment of the temporomandibular joint, which is prevalently affected in algo-dysfunctional syndromes, consequent to the various types of edema complications, with its various forms [6-8]. The application of certain digital processing techniques offers the possibility of extra accuracy in the interpretation of paraclinical examinations of this type, with profound implications in the diagnosis as well as in the hierarchy of the treatment plan [6,9,10].

Digital image processing can be defined in a broad sense as the technology of using computerized algorithms to transform images stored electronically to highlight or blur some of their. This is a true field of study that has been developing lately and has many applications in robotics and intelligent systems, medical imaging, photography and visual arts, etc. [7]. The main object of this field is the electronic image, which is, in fact a representation / approximation of a real object or real scenes, made by combining a very large set of fundamental elements, called pixels (Picture Elements) [11,12]. Pixels are characterized by a number of attributes that contain numeric information useful for computerized image interpretation and implicitly processing: spatial coordinates that define the precise position of each pixel in the image adding colour (expressed by gray levels or basic colour

palettes), size and possibly opacity. It follows that a digital image will have a better quality as more pixels are used to define it.

Digital imaging techniques are generally geared towards reaching two major objectives:

- Improving the quality of the information contained in an image, for a better human interpretation (initial stage);
- The numerical quantization of the information contained in an image as precisely as possible for its automated interpretation (the ultimate goal of achieving the so-called *smart visualization* - Computer Vision, useful in robotics and expert systems, which not only manages images, but also *understands* their content, recognizing specific elements - objects, colour shades, scenes, etc.).

Therefore, three levels of approach can be differentiated in this area:

Basic procedures: the main objective of which is to improve the image quality by means of noise abatement, accentuation of colour palette or contours, etc.; Advanced procedures: which aim is to extract attributes that characterize the image, allowing mainly the recognition of objects within it - by segmentation techniques; Intelligent procedures: aiming at interpreting the image and extracting its meaning, which can be further used for so-called *intelligent visualization* - used for example in stand-alone navigation programmes [5,13,14].

Experimental part

The purpose of this study is to identify the type of imaging processing for the identification of pathological elements from orthopantomographies and articular tomographies. A number of 20 orthopantomographies and 15 temporomandibular joint tomographies have undergone through various image enhancement techniques. These processing techniques have focused on the accuracy of diffuse or

*email: cdascalu_info@yahoo.com; Phone: 0766456205

All authors have equal contributed to this work

encapsulated osteotomic processes, as well as the accurate identification of cavity reports sinus or mandibular canal, particularly important aspects of the variation of the imaging palette through additional elective data at a later stage, data necessary for choosing the best therapeutic option in the long run. Various methods of image enhancement (*enhancement*) have been used for those procedures whereby it becomes more useful in the following aspects: specific details are highlighted; noise is eliminated; the image becomes more visually attractive.

Two ways to address this goal were used:

- spatial techniques - which refer to the direct manipulation of the pixels that make up the image;
- frequency techniques - which refer to manipulation of a Fourier transform or Wavelet transform of an image; The workings were done in Corel PhotoPaint 7.0, using the automatic procedures available.

Results and discussions

The choice of a particular type of image enhancement technique has been selected for each type of pathology found in orthopantomographies or articular tomography, providing the best accuracy for an optimal imaging interpretation that underpins a precision diagnosis.

Of the most useful imaging processing in the optimization of the orthopantomographic image accuracy the point-to-point transformations are to be noted.

We used the equation, $g(x, y) = T[f(x, y)]$, in which the vicinity of a point coincides with the point itself, and T is usually a gradient transformation function. Examples of this category are:

Making an image negative: it is useful for improving white or gray details in the dark areas of an image (fig.1)

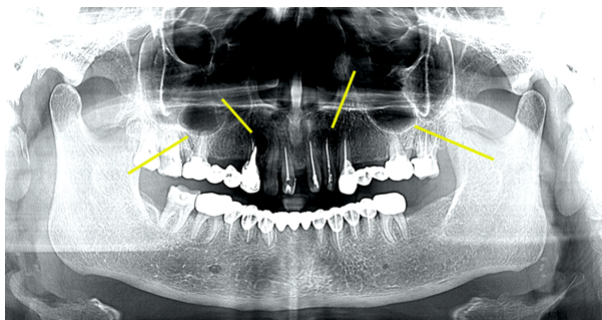


Fig. 1. Negative an image

This type of transformation provides particularly useful information for evaluating reports with the maxillary sinuses, while providing data on cavity contours, root contours, aspects underlying therapeutic choice decisions.

Thresholding: is useful as a precursor to segmentation because it helps to highlight an object of interest from a background by eliminating the insignificant details of an image (fig. 2,3)

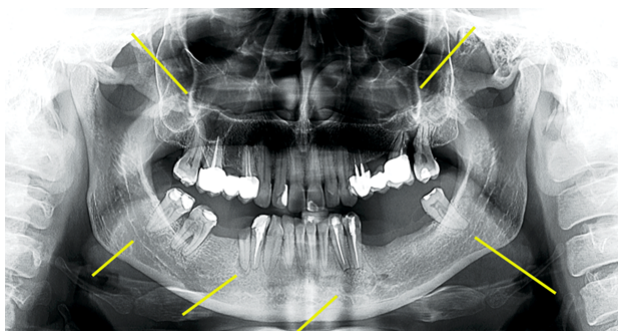


Fig.2 Thresholding transformation of orthopantomography

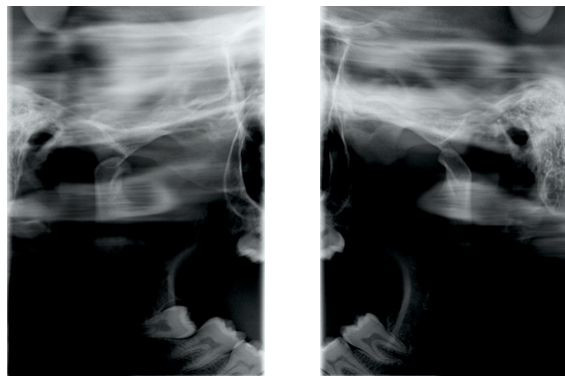


Fig. 3. Thresholding transformation of TMJ tomography

This type of analysis is particularly useful in identifying osteitis processes encapsulated, (granuloma, cyst, with exact determination of its size and reports with old roots or other formations of interest).

Transformation in intensity: it is also a contrast modification of the image, (which gives the accuracy of evaluation of a certain type of endodontic obturation, as a conclusive example) usually in the sense of uniformity and diminution of major contrast differences (fig.4);

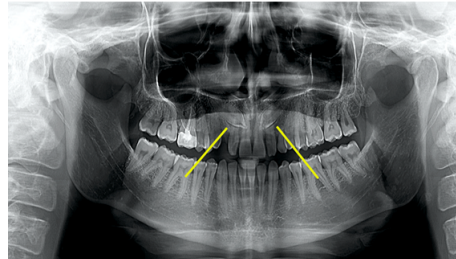


Fig. 4.
Transformation in
intensity at the
orthopantomography
level

Transforming grayscale: can be achieved by using three major types of functions: linear functions, logarithmic functions and exponential functions. Logarithmic and exponential transformations are intended to add additional shade to the image as it associates a narrow range of reduced gray input levels, a widened range of output gray levels, thus possibly revealing additional details (fig.5).

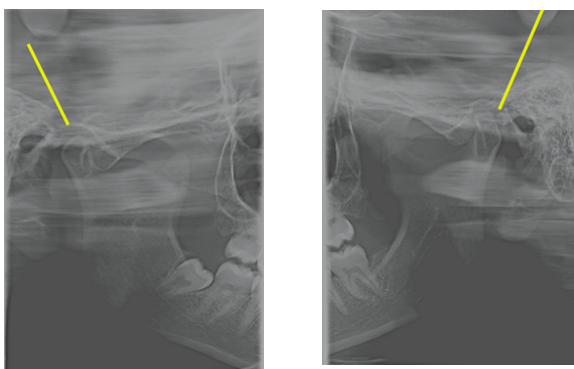


Fig. 5. Logarithmic transformation of orthopantomography

Separation of gray levels: is similar to thresholding transformation, highlights a specific range of gray levels and suppresses others, also to highlight certain elements in an image (fig.6).

BitPlane type separation: isolates private bits in an image with certain pixel values, also to highlight some of its details, using the principle that bits with high values contain significant visual information and bits with low values contain subtle details. Particularly useful in optimizing the accuracy of orthopantomography are neighborhood transformations - spatial filters. This type of transformation operates on a plurality of pixels located in the immediate vicinity of a central pixel, usually on a rectangular shape around it, and generally results in the

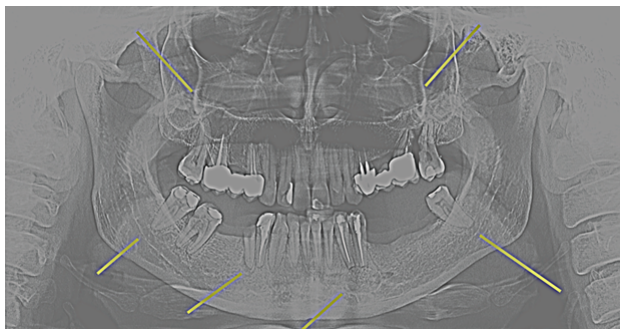


Fig. 6 Separation of gray levels

elimination or reduction of noise in an image. The main examples in this category are (12). Sharpening filters: to highlight the fine details of an image and its outlines, and to eliminate the blurring areas, using for this purpose spatial differentiation, i.e. the rate of change of a function, which is based on its I and II derivatives. From the category of accent filters, one of the simplest and most efficient is the Laplacian filter, which uses the transformed Laplace of a function, and highlights contours and any other image discontinuities.

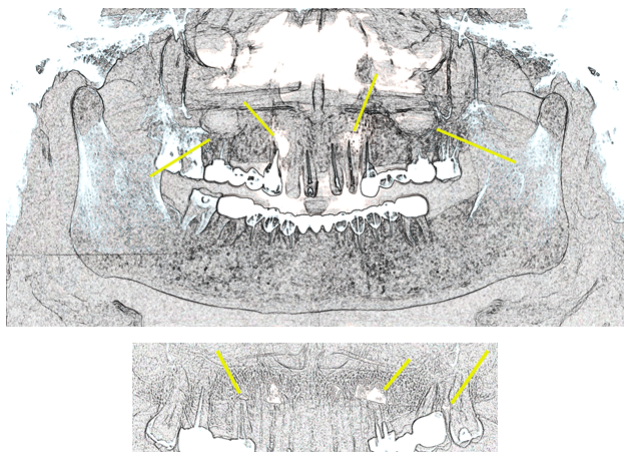


Fig. 7 Sharpening function

For optimal results, the Laplace filtered image is then subtracted from the original image, the result obtained having a significantly better level of detail rendering (fig.7). In practice, in order to achieve optimum results, a number of accentuation filters are combined, the choice of which depends on a case-by-case basis, starting from the observation that: the 1st order derivatives generally produce thicker edges but have a better response when changing gray levels, and order 2 derivatives are more sensitive to thin lines and details. This method of digital processing is particularly useful in shaping prosthetic restorations, evaluating their reports with neighborhood structures. This technique can provide a series of correlations with the structure of prosthetic restorations, respectively with the structure of the biomaterials involved [15-17].

This function has found utility in assessing extensive osteitis processes, contributing to a correct therapeutic decision, which may remain in the conservative registry, or need surgical methods [18-19].

Equally, in the Frequency Techniques area, we used imaging of orthopantomographies and Fourier Transformation Joints. The Fourier Transform [20] is a way of modifying the periodic functions, which will be expressed by a sum of sines and cosines of different frequencies, multiplied by different coefficients - Fourier series. The discrete Fourier transform of a two-dimensional image acts on the spectrum of the component's

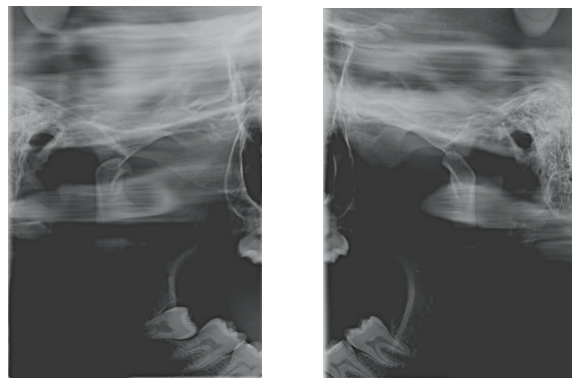


Fig. 8 Low Pass Smoothing Filter

frequencies, also having the effect of smoothing or accentuating it.

Frequency filtering has similar results to spatial filtering, but its big advantage is that it is faster, especially for large images - which makes it more commonly used in professional image processing software. The most frequently used frequency filters will be: Low Pass Smoothing Filters: remove all components of the high-frequency image (fig.8);

This technique has proven to be particularly useful for the analysis of articular tomographs, making it easy to detect contours of the glenoid cavity or articular tuber, which is the basis for specific analyzes that are absolutely necessary for oral reabsorption.

Conclusions

The methods of digital image processing cover a particularly widespread plague. At present, these methods are applicable in all life sciences and in almost all technical disciplines (Jahne, 2002), transforming them from specialized applications used by only a few researchers, in a standardized scientific instrument.

Applying these imaging methods to dental practice is particularly important, providing an accurate addition to the assessment of orthopantomography and temporomandibular joint tomography, common paraclinical examinations, aspects underpinning the formulation of a precise diagnoses, and the development of a therapeutic plan choice.

The image processing proposed in this article focused primarily on improving the radiological image attributes to highlight specific anatomical structures, and secondly, the contour detection, where it was necessary for the diagnostic purposes as well.

To identify diffuse osteotic processes, transformations separation of the gray level provide a clear improvement of acuity at this level, for incurable infectious processes, type analysis sharpening function offers optimized image enhancement data and evaluation of the extent of the processes in relation to the affected dental structure, neighbouring dental structures or other formations and cavities particularly important in the therapeutic approaches.

In order to improve the interpretation of articular tomography, for varied clinical situations, the imaging processes Low Pass Smoothing Filter confer with the identification of the contours of the glenoid cavity, the articular tubercle, the articular condyloma, leading to a precise diagnosis, while creating the premise of elaboration plan to rehabilitate these particularly complex pathologies.

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