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INFLUENCE OF DIGITAL FILTERS USED TO OBTAIN CEREBRAL IMAGE IN NUCLEAR MEDICINE

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ABSTRACT

In the last decade, several studies about quality assurance in nuclear medicine instrumentation have been carried out in Brazil. In nuclear medicine, a radiopharmaceutical is administered to patients with the intention to perform a study in a gamma camera to obtain a contrast image. Such images show the real situation – a nuclear image can cause an erroneous diagnosis and, in extreme cases, the death of a patient. In image reconstruction, digital filters are used in order to obtain the best possible image. There are filters of different kind, each on for a special type of image, such as increased or decreased matrix, for example. This paper intent to discuss how filters affect the cerebral image quality, by showing that their adjustment may modify an image for the best or for the worst, and therefore modify a diagnosis.

1. INTRODUCTION

Nuclear Medicine is a medical speciality that uses safe techniques to viewing anatomical structures of the body [1]. Nuclear medicine produces similar 2D “projections” of the 3D radionuclide distribution inside the body.

Some examples of tomographic images modalities are: Computed X-ray Tomography (CT), Magnetic Resonance Imaging (MRI), Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET). This work only comprises the SPECT technique.

To realize the study, a radiopharmaceutical is administered to a patient in order to perform a study in a gamma camera to obtain a contrast image. In SPECT is allowed to recover the third dimension back through of image reconstruction (Figure 1) [2].

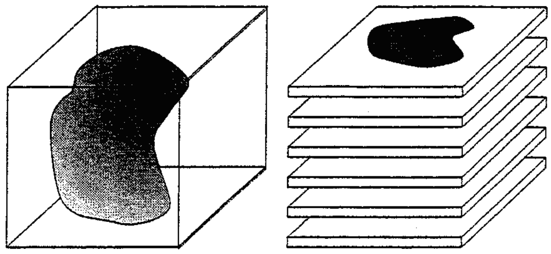

Figure 1. A 3D object is represented by a set of 2D slices.

2. IMAGE RECONSTRUCTION

Image reconstruction is the process of transforming a set of 2D projections into a 3D image. Some of the more common algorithms for image reconstruction are:

1. Simple Backprojection
2. Filtered Backprojection
3. Fourier Transform Reconstruction

Backprojection is the simplest image reconstruction method. It makes no assumptions about the form of the image before reconstruction. The major problem with simple backprojection reconstruction is that it leaves “extra” counts on the image in the wrong places.

Filtered backprojection is used to remove the extra counting from the simple backprojection reconstructed images. This procedure can be done before backprojection (pre-filtering) or after backprojection (post-filtering). It is usually done in the frequency space domain, which is mentioned in this paper [2][3].

The Fourier Transform (FT) will be discussing in the next section.

We will discuss how digital filters affect the cerebral image quality, by showing that their adjustment may modify an image. Besides, we intent to attract attention to the serious problem that can occur in image reconstruction and to prove that bad use of digital filters can injury the diagnosis of an examination of SPECT.

2.1. Digital Filtering

Medical equipments like gamma camera allow manipulating of the image. One of the parameters of imaging process is the digital filter. Digital filtering is a set of techniques that make the correction and enhance an image, i.e., filtering is used to decrease statistical noise and/or enhance edges. The correction is the removal of undesirable features and enhance is emphasize the features [3].

In frequency domain filtering, one must convert a spatial image into a frequency domain image; this conversion is made by the Fourier Transform. The Fourier Transform is a mathematical operation that changes a projection's data from being a function of counts per pixel to a completely equivalent function of amplitude versus cycles/pixel. This transformed projection is called the “spatial frequency domain” [2].

The basis of Fourier Transformation is that any curve or function can be represented as a series of sinus and cosines with different amplitudes and frequencies (v), as the square wave function showed in Figure 2, where the square function is composed for a lot of different frequencies (v) until the spectrum to be similar to the square wave function. . High frequency components are responsible for simulating the rapid changes in intensity and are responsible for edges and noise. Low frequency components are responsible for simulating amplitude of waveform and responsible for contrast and intensity.

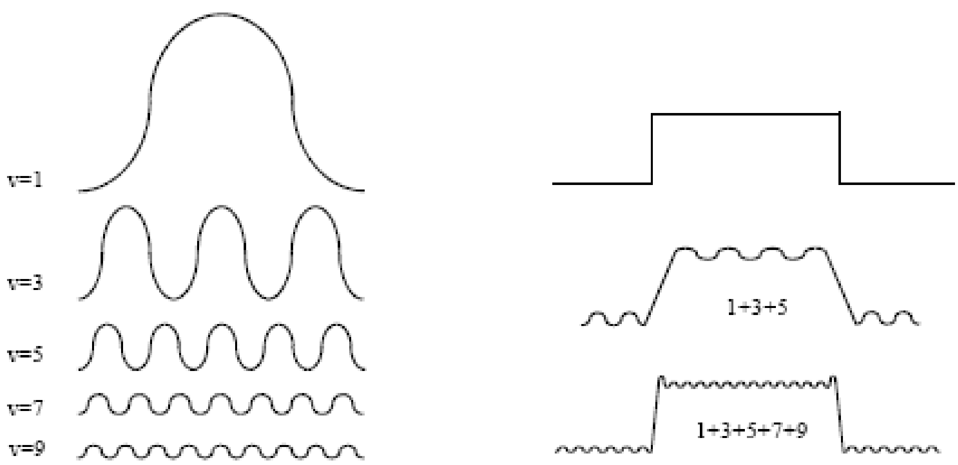

Figure 2. A square wave function.

2.2. Filters

Filters are mathematical functions that are multiplied into the frequency domain data sets to change the frequency distribution of the power spectrum. A filter is a magnitude versus a frequency function [3].

One can apply various filters to remove or alter the magnitude of selected frequencies in our frequency domain data set. There are three types of filters: low pass, high pass and band pass. Low pass filters are used to allow low frequencies through the filter and to reduce or attenuate high frequencies. High pass filters are used to allow high frequencies through the filter and to reduce or attenuate low frequencies and band pass filters are used to allow a certain band or range of frequencies through the filter.

You can also combine two or more filters into a single filter function (combination filters are Band-Pass filters). However, once a frequency is removed by a filter, further processing will not restore it. The only way to get that information back is to go back to the raw image data and reconstruct it from scratch.

3. METHODOLOGY AND EXPERIMENTAL PROCEDURES

This work was carried out on Nuclear Medicine Service of São Vicente de Paulo Hospital (HSVP), in Rio de Janeiro, Brazil, between November/2006 and April/2007, with the collaboration of doctors and technicians responsible for the achievement of studies in that period.

The HSVP equipment is a gamma camera SPECT Picker, model PRISME TECL 1000, which has available the following filters: Metz, Butterworth low pass, Band pass and Wiener, to known:

- Metz filter: provides limited resolution enhancement combined with noise suppression and contrast enhancement;
- Butterworth low pass: is used for noise suppression and provides no contrast enhancement;
- Band pass: is used for resolution enhancements as well as for noise suppression;
- Wiener: provides a restorative filter similar to the Metz filter that is not count dependent. This filter is the device default.

We followed a total of ten brain studies performed with the radiopharmaceutical Tc-99m-ECD. The data of five healthy patients were processed with the Wiener filter. When this filter was modified, we noted the images showed some inexistent lesions.

In the same manner, we analyze five patients with diagnostic known and purposely, we applied some inappropriate filters; doing this, the images omitted the real pathology. For instance, in the patient “A”, the utilization of filter Band Pass show clearly the area with a severe brain hypo perfusion (signalized in Figure 3). The filter used in this exam emphasizes the edges and the resolution. In Figure 4, to the same patient, this hypo perfusion is less emphasized by the filter Wiener, appearing to be a not very serious problem. Now, the filter used produces an aspect more homogeneous, the edges are not enhanced.

The intensity of this hypo radioactivity that manifest the hypo perfusion, severe or soft, can denote grave or discrete disturbance of the cognizance capacity of patient.

4. CONCLUSIONS

This work proves that there is no perfect filter, but when the adequate filter is used, we can perceive an improvement in the image and in the diagnosis.

The images processed must show the real situation of the patient, because an unclear image can cause an erroneous diagnosis and, in extreme cases, the death of a patient.

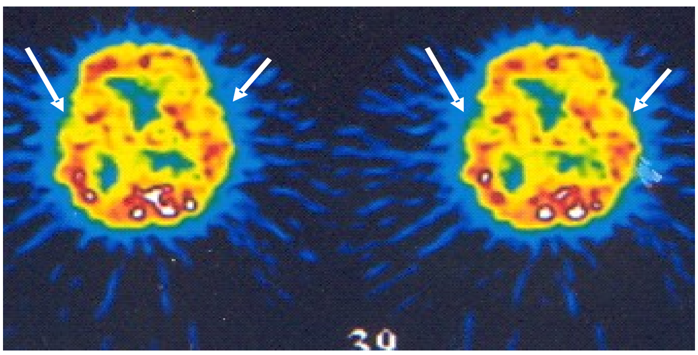

Figure 3. When we use the filter "Band pass" the image shows a severe hypo perfusion (real) at signalized area.

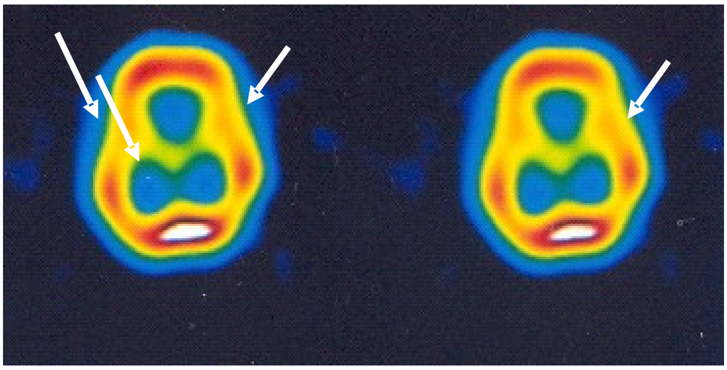

Figure 4. To the same exam, when we modify the filter to the filter Wiener, the image shows a soft hypo perfusion at signalized area.

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REFERENCES

1. N. J. Couto e S. V. Barros, "Alinhamento de Imagens de Medicina Nuclear", *Monograph in Electrotechnique and of Computers Engineering of University of Port*, Biomedical Engineering Institute, 2000/2001.
2. "Basic SPECT Image Acquisition, Reconstruction, and Frequency Domain Filtering", http://www.uab.edu/radiography/Nmt422/.
3. "Fundamentos de Radiodiagnóstico por imagem", http://www.if.ufrgs.br/ast/med/imagens/index.htm