Material differentiation using DECT simulation

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Resume

Spectral tomography is one of the most interesting fields in actual medical imaging physics. Nowadays, its clinical implementation uses dual energy computed tomography (DECT). In this modality, the patient´s body is irradiated with two different X-ray spectra.

The main goal of this MSc project is to model and simulate the acquisition process of a dual energy CT equipment available in the Clinical Hospital of the Medicine School of the University of São Paulo. Preliminary studies regarding material differentiation using dual energy radiography and simulations with PENELOPE Monte Carlo code for radiation transport were done.

Introduction

In DECT two different X-ray spectra are used to irradiate the patient´s body. Using the known attenuation radiation expression(equation (1)), It is possible to decompose the attenuation coefficient in two components(equation (2)) [Alvarez et. Al. 1976, *Phys.Med.Biol* **21**].

$$I = I_0 \int S(E) e^{-\int \mu(x,y,z,E)ds} dE \qquad (1)$$

$$\mu(x,y,E) = a_1(x,y) f_1(E) + a_2(x,y) f_2(E) \qquad (2)$$

If there are two sets obtained with different spectra, and knowing the functions f_1 and f_2 it is possible to estimate the coefficients a_1 and a_2. It allows image enhacing or characterizing specific materials related to the functions f_1 and f_2 . An schematic representation of the process is presented in Figure 1.

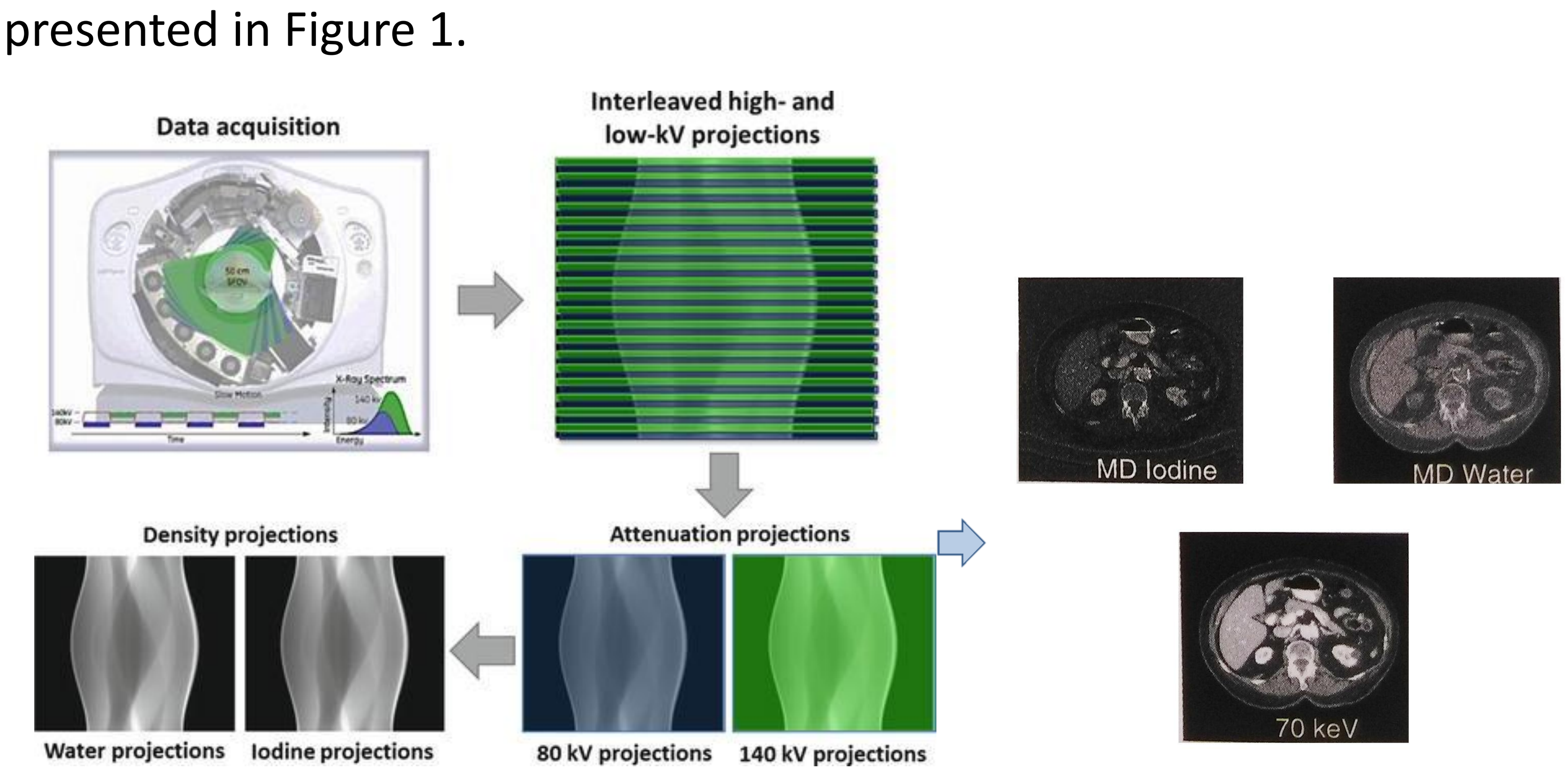

Figure 1: Echematic representation of DECT decomposition(GE, healthcare)

Materials and methods

Material Ordering

It were taken radiographic images of some materials (nylon, polyethilene, polystirene, acrylic and polycarbonate) of known attenuation coefficient and simple geometry (cylinders with known dimensions). These materials were used to testing the detection capability of the method described in (1) and (2**).**

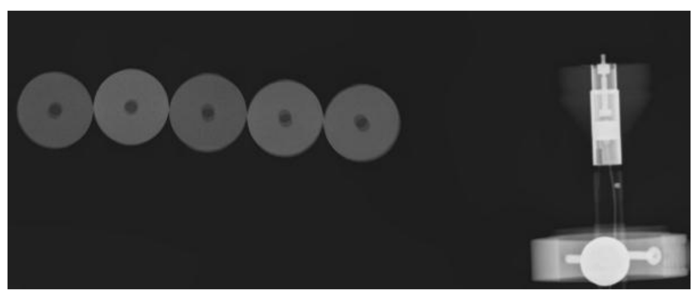

Figure 2: Example of images used for the material ordering

The intensities were measured as the mean gray value on a region inside each material using ImageJ. The expression (2) simplies and allows to solve (1) using f_1 and f_2 as the attenuattion coefficients of two of the materials.

The solutions were obtained ussing Matlab. It was simulated the same arrangement using PENELOPE MC code in order to perform a comparative analysis.

CT simulation

The constructed the geometry for simulating a DECT acquisition system is shown on Figure 3. There were chosen five materials to fill the inner cylinders,(Acrylic, Polystyrene, Polypropylene, Polycarbonate and cortical bone). The outer cylinder is filled with water. The deposited energy were estimated in each detector for each angle (5° spacing) . For this simulation, it were used a tungsten X-ray spectra of 120 kVp.

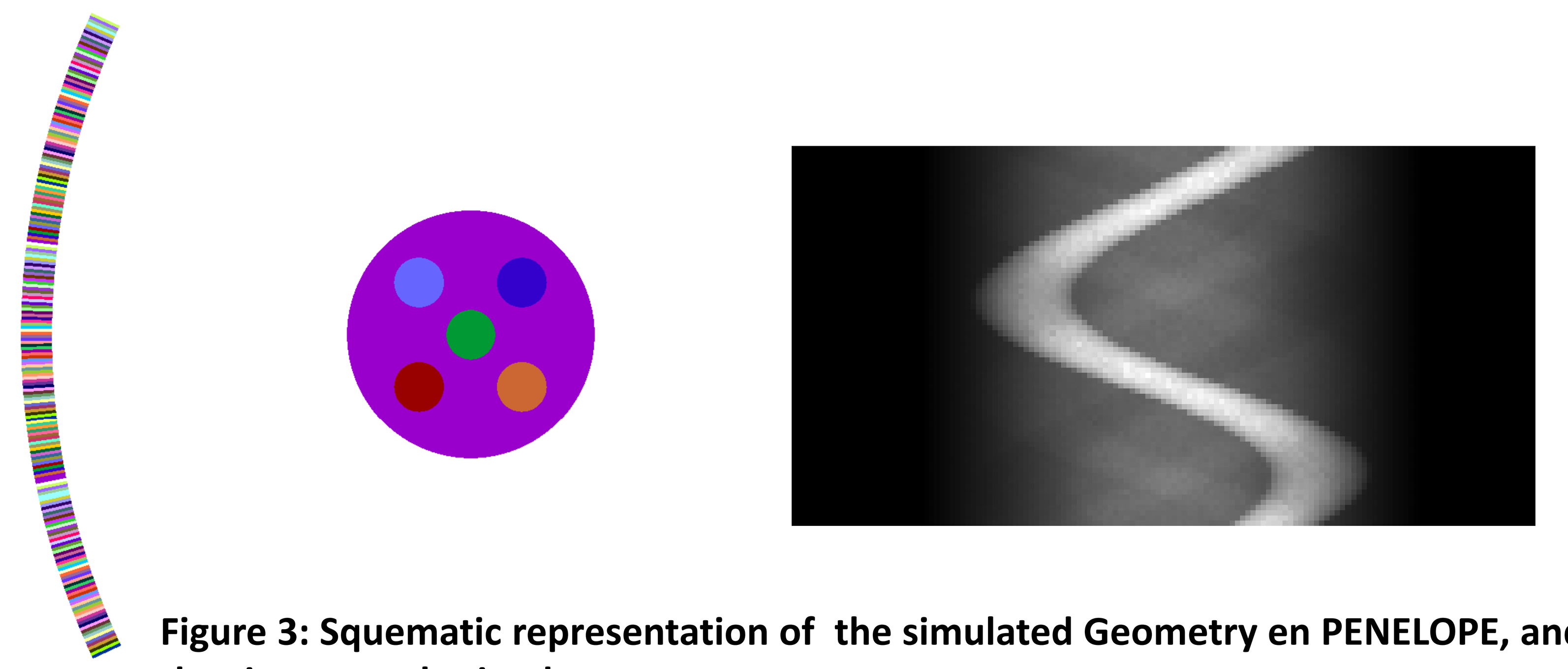

Figure 3: Squematic representation of the simulated Geometry en PENELOPE, and the sinogram obteined.

Preliminary results

Figure 4 shows the attenuation coefficients obtained in both methods. This preliminary comparative result shows that the calculated values are underestimated. This was caused because of the absence of collimation on the simulated radiation beam. However, it is possible to identify that the order of the attenuation coefficients are preserved.

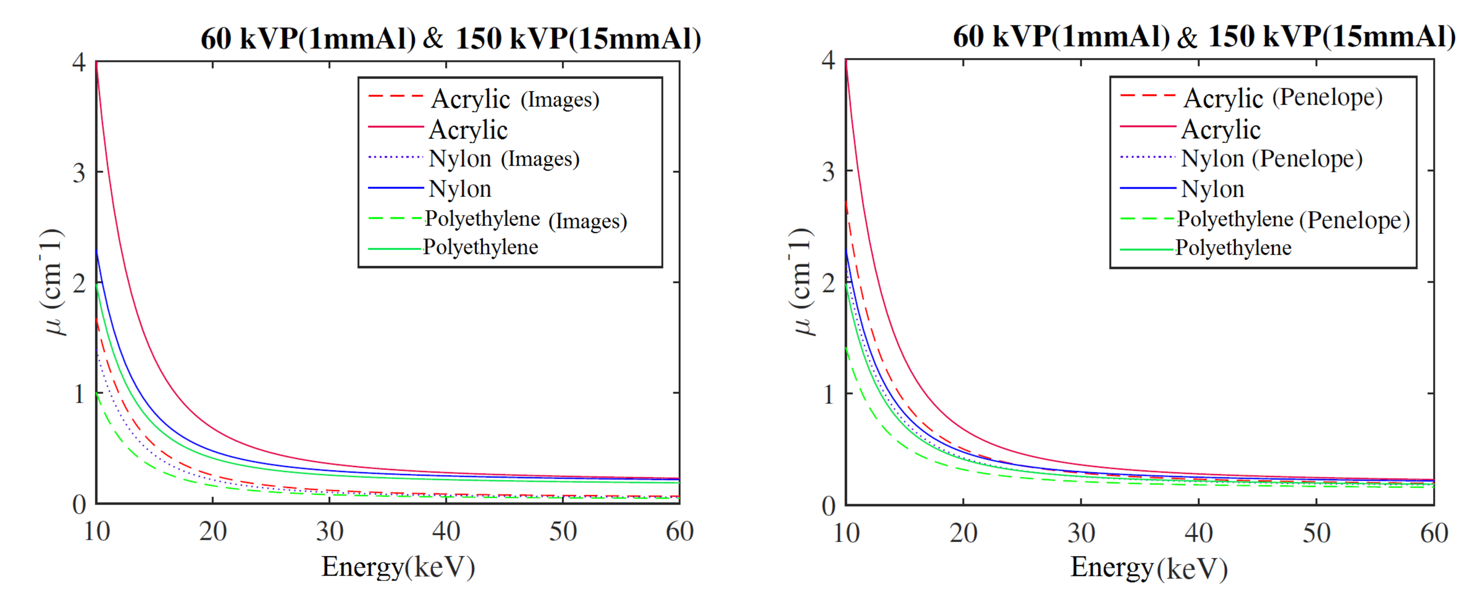

Figure 4: Results obtained using both images and simulations of the cylinders.

Figure 5 shows CT reconstructed images using the simulated acquisition setup. Although the reconstruction shows adequatedly the structures of the imaging object, the resulting images present artifacts due to the angular spacing and the beam hardening produced by bone. The optimization of these factores are in course. After corrected, new set of sinogram adquisitions and the implementation of dual energy acquisitions by switching kVp will be conducted.

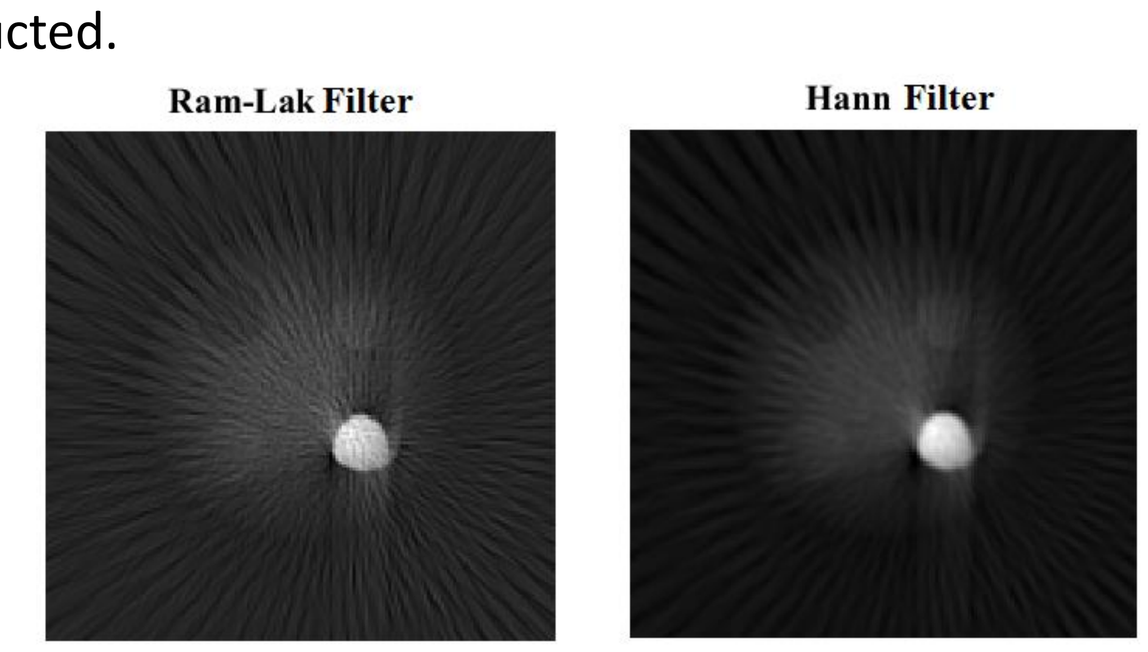

Figure 5: Reconstructed images show artifacts due to angle spacing and materials contrast.

Acknowledgment

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