3D OCT image compression using shearlet transform

B. Haydar, B. Tamadazte, N. Andreff, and A. Bartoli

I. Introduction

Optical Coherence Tomography (OCT) is an established medical imaging technique which allows the acquisition of cross-sections in a non-destructive and contactless manner. The use of OCT is recently expanded in numerous medical applications such as ophthalmology and dermatology. OCT is also called *optical biopsy*, in opposition to the conventional *surgical biopsy* which requires tissue removal, transport and storage for histopathological examination. Existing OCT imaging systems offer three types of acquisition modes: A-Scan (1D optical core), B-Scan (2D slice image) and C-Scan (volume image). However, in addition to the high axial and spatial resolutions which characterize OCT images, the acquisition time remains an issue, especially 3D images as is the case of the rest of 3D medical imaging systems MRI, CT-SCan. Therefore, reducing the OCT acquisition time is an ongoing scientific challenge. Recently, few researches [2] have tried to reduce the OCT acquisition time using Compressed Sensing (CS) [1].

II. 3D Compressed Sensing using Shearlet Transform

Signal and image compression have motivated an intensive research, especially since the 1980s. Different image decomposition methods based on anisotropic (i.e. directionally sensitive) basis functions have emerged such as wavelets, curvelets, contourlets, and more recently shearlet. Shearlet transform are probably the most adapted and efficient method for image decomposition due to the introduction of an additional operator called *shear*. It can be shown that for a certain type of images, so-called cartoon-like images, the shearlet transform yields an optimally sparse image representation [3] which is the basis of CS. The general CS problem is defined as an l_1-optimization problem:

$$\min_x \|x\| \quad \text{subject to} \quad \|y - \mathbf{A}x\|_2 \leq \epsilon \tag{1}$$

where $\mathbf{A}$ is the encoding matrix that gives rise to the measured data y with an accuracy ϵ and x is the vector of interest representing the number of non-zero elements of the considered image (respectively, volume). More precisely, $y = \mathbf{A}x$ which means the acquired data y are transformed (here, using the shearlet transform) to the new image data x using matrix $\mathbf{A}$.

B. Haydar, B. Tamadazte, and N. Andreff are with FEMTO-ST Institute, Univ. Bourgogne Franche-Comté, CNRS, F-25000 Besançon, France. brahim.tamadazte@femto-st.fr

B. Haydar, and A. Bartoli are with EnCoV, IP, CNRS/UCA/SIGMA, Clermont-Ferrand, France. adrien.bartoli@gmail.com

Shearlet transform allow decomposing the OCT volume data to a sparsifying multiscale approximation coefficients using a generating function [4]. These multiscale coefficients are obtained as the convolution of the time-domain directional shearlet filters with the input image (respectively, volume). While, the inverse shearlet transform allows one to reconstruct the initial image (respectively, volume) by computing the sum of all the dual convolutions of the shearlet filters with their corresponding shearlet coefficients. Note that the compression rate is directly related to the number of shearlet coefficients used to reconstruct the image (respectively, volume) which are function of the scale and the shearing parameters.

III. Preliminary Results

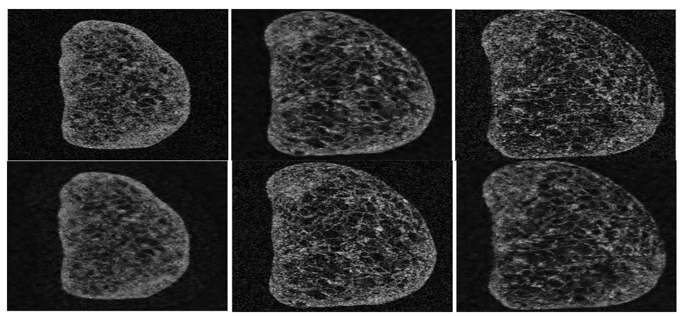

Fig. 1: First line: original (top) and (bottom) reconstructed images.

Figure 1 shows our preliminary results for 3D OCT images reconstruction using the shearlet transform [4]. In this example, we considered a volume OCT image of size of 281×281×199 pixels (only slices 1, 100 and 150 are shown). The reconstruction is performed using only 50% of the initial data demonstrating high similarity between initial and reconstructed images.

References

[1] Candes, Romberg and Tao, *Robust uncertainty principles: exact signal reconstruction from highly incomplete frequency information*, IEEE Trans. on Information Theory, vol. 52, p. 489-509, 2006.

[2] L.-A. Duflot, A. Krupa, B. Tamadazte, A. Andreff, *Shearlet transform: a good candidate for compressed sensing in optical coherence tomography*, in IEEE EMBC, pp. 435-438, 2016.

[3] E. Candés and D. Donoho, *New tight frames of curvelets and optimal representations of objects with piecewise c2 singularities*. Communications on pure and applied mathematics, 57(2):219266, 2004.

[4] W.-Q. Lim, "Nonseparable Shearlet Transform," in IEEE Trans. on Image Processing, vol. 22, 5, pp. 2056-2065, 2013.