3D analysis of bone ultra structure from phase nano-CT imaging

This work is proposed in team 4 "Tomographic Imaging and Radiotherapy" of the CREATIS laboratory (UMR CNRS 5220, Inserm U1044) of INSA de Lyon and University Lyon I. CREATIS is a research unit specialized in medical imaging and gathering both specialists in signal and image processing, image acquisition as well as medical doctors (180 researchers).

Team 4 is working on tomographic methods for the characterization of bone tissue. This application is motivated by the research on bone fragility disease such as osteoporosis since the risk of fracture is not fully understood and remains difficult to predict. In particular, the team has a long collaboration with the ESRF in Grenoble (European Synchrotron Radiation Facility) in synchrotron micro-tomography imaging. The team has done extensive work on the micro-CT characterization of bone micro architecture and has a high notoriety in this field. Our team recently obtained unique 3D images bone tissue at the cellular scale by using micro-Ct at 300nm or nano-CT at 60nm (cf Figure 1). Our aim is to pursue this work by using the new capabilities of a synchrotron phase nano-CT setup currently developed at ESRF (beamline ID16A). This system is expected to produce large 3D images with an isotropic voxel size up to 20nm.

The purpose of this work will be to develop efficient image processing methods to quantify bone ultra structure from the new 3D images acquired on this state of the art, synchrotron phase nano-CT.

Different image analysis methods will be investigated to extract relevant information from the various structures found at the nano scale, showing the pore lacunar-canaliculi network (LCN) and features in the bone matrix (collagen fibers). First segmentation methods will be developed to extract the porous lacunar-canaliculi network (LCN). The physical characteristics of the phase nano CT image in terms of contrast (for instance varying background) and signal to noise ratio will have to take into account. After segmentation, quantitative parameters have to be computed from the binary image. Parameters suitable to quantify the complexity of the network will be proposed. Finally, 3D texture analysis methods will also be considered to quantify the orientation in 3D of the collagen fibers that are visible on these images. Advanced methods and tools will be used to evaluate and visualize the 3D orientation fields.

The method will have to be tested and applied to series of samples acquired in collaborations with various teams at the European level. Since the nano-CT images are of big size (from 8 to 64 Gb), efficient algorithms will have to be implemented. In particular, we will be interested in algorithms parallelizable on clusters of computers.

This field of research is totally new and is at the cutting edge of research. The phase nano-CT setup developed at the ESRF is a quasi unique instrument. This it is expected that this work would lead to high level publications.

Supervision :
F. Peyrin, CREATIS, INSA Lyon, UMR CNRS 5220, Inserm U630, UCB Lyon
Directeur de Recherche INSERM
Figure 1: 3D display of the bone lacuno-canalicular network (LCN) imaged synchrotron micro-CT (voxel 280 nm). Osteocytes lacunae have a circular arrangement around the Haversian canals and communicate through thin channels called canaliculi. Top left: zoom on an osteocyte lacunae obtained by nano-CT at 60nm.

Scientific competence:

Françoise Peyrin received her doctorate degree in Computer Sciences in 1982 from INSA-Lyon, France. Since 1981, she has been a researcher in the CREATIS Laboratory at INSA-Lyon. Her research interests include 3D imaging techniques particularly in x-ray tomography, 3D image analysis and wavelet based methods. The research is particularly applied to bone tissue imaging. She leads a group in the laboratory and is a scientific collaborator at the ESRF, Grenoble, France. She is the author of more than 160 papers in peer reviewed journals and 300 international conferences among which more than 120 in IEEE ICASSP, ICIP or ISBI conferences.

II-7 Ingénierie biomédicale, Biomedical engineering

The student should have knowledge in signal and image processing, computing and should know C++. He should be interested in the whole imaging chain, from image acquisition to image reconstruction. He or she should have interest in biomedical research and should be ready to collaborate with various multidisciplinary teams.

Publications


