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A QUANTITATIVE METHOD FOR THE THREE-DIMENSIONAL ASSESSMENT OF HUMAN CORTICAL LONG-BONE ARCHITECTURE BASED ON µ-CT IMAGES

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Summary: Long human bones are mostly divided in two distinct portions: a highly porous portion called trabecular bone located at each ends of the bone (epiphyses), and a fewer porous portion called cortical bone located in the central part (diaphysis) which mainly provides the general stiffness of the bone. In spite of the mechanical functions, the cortical bone has also a highly connected porous architecture which ensures the blood vessel supply inside the bone. For several decades, it is widely admitted that a cellular activity, called BMU activity, which ensures the dynamic bone remodeling, is closely related to mechanical stimulus. The BMUs structure can be interpreted as a 3D oriented canal which presents a closing cone on one side and connectivity on the other side. Thus, the investigation of the bone architecture would permit bone remodeling quantification.

The aim of this study is to provide a method which is able to identify the 3D features of the canals network and its connectivities using µ-CT images in order to quantify the remodeling activity and to supply cortical bone architectural datas. An original algorithm, based on Python, is developed. It extracts the contours from the thresholded images and identifies 3D link between consecutives images in order to reconstruct the canals and computes the geometrical characteristics. Particular attention was paid to the threshold method by using an adaptive Otsu thresholding coupled with bilateral and morphological filters in order to reduce image noise. Furthermore, the algorithm is able to detect connectivities and thereby defines the beginning or the end of canals. Hence, each canal can be described by the length, the equivalent diameter, the volume (and then the ductal volume porosity), aspect ratio, and orientation. Likewise, some connectivities features are computed as the opening angle, and the diameters ratio of the connected canals. Therefore, this study is the first one to propose an automated method for the connectivity detection and thus a clear definition of cortical canals which may quantifies the remodeling activity of bone sample.