Abstract: 3D reconstruction from 2D image dataset is a fundamental task in image based computational biomechanics. 3D reconstruction of femur from its DICOM dataset is primarily a manual process, which is a setback in computational modeling such as Finite Element Analysis (FEA). Furthermore, it requires expensive biomedical image processing software, skill set and considerable time. Hence, we are introducing a coupled automated 3D reconstruction and mesh generation process to resolve these issues. Currently, available works are too generic and scattered while our proposed process represents a specific solution to this problem. To execute this task, we have designed a pixel-based clustering method to dig out the femur profile that eventually propagates point cloud.

Here, pixel clustering method was employed to collect femur features to generate 3D bone geometry (in Figure 1(a)). A cluster can be stated as a disjoint set of pixels where two sets are disconnected. The clusters were created horizontally and vertically across the CT slices to keep the proximity of the neighbors as close as possible. Concurrently, it ensured cluster size is smaller, which prevented the influence of outliers. Each cluster had a particular measure of central tendency. However, due to the intersection of this measure found in regions like femoral head, acetabulum socket, it failed to provide optimal clustering for those regions. Hence, the shapes of the slices were configured to make femoral head clusters larger. Thus, a complex shape like the femoral head was distinguished from its neighboring pelvis and acetabulum. This procedure was applied to the distal part of the femur to remove the patella. Furthermore, the pixel clustering method can efficiently eradicate isolated pixels. The method is further beneficial as it is able to preserve the actual pixel value while extracting femur profile, and thereby facilitating proper mesh generation, which was later accomplished by mesh generation algorithm [1, 2].

With our proposed method, we can generate the perfect 3D shape of femur (in Figure 1(b)). Obtaining the femoral head shape was a challenging task because of its position. Nevertheless, our approach can identify non-femoral pixel positions and turn them into “don’t care”. Moreover, its noise removal rate is approximately 100%. Yet, some expected pixels are found missing which are needed to be populated.

We have developed a CT-based image processing framework for 3D reconstruction and subsequent mesh generation of a femur. We find the preliminary results promising. We are exploring further to use this technique efficiently for patient specific FE modeling for predicting femoral fracture.

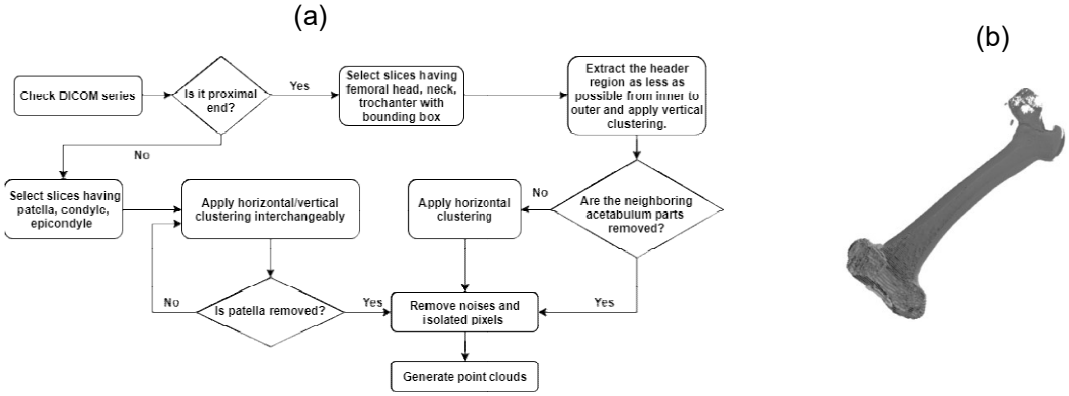

Figure 1: (a) The flow diagram of pixel clustering method and (b) reconstructed femur from DICOM images

References:

1. Stéfan van der Walt et al., scikit-image: Image processing in Python (2014).

2. Dawson-Haggerty et al., “trimesh”, version-3.2.0 (2019).