Intra-observer variability of CT image segmentation of the knee joint

R.Asadirad[1], D.Kahani[1], P.Riches[1]

[1] University of Strathclyde, Wolfson centre, Glasgow, G4 0NW, UK

Introduction: Computer-Assisted Orthopedic Surgery (CAOS), developed to improve the alignment of the arthroplasty components, has increased in number significantly during the last decade [1]. Some CAOS procedures rely on pre-operative imaging, raising the possibility of and inter- and intra-observer variability affecting segmentations [2] previously studied in a variety of other tissues and locations [3]. However, despite the high prevalence of knee models and applications of knee joint models, the variability and repeatability of segmentation of knee not been previously investigated. Therefore, this study investigates the intra-observer influence on semi-automatic segmentation of the knee joint.

Methodology: A CT image of the knee joint acquired from a single, prone participant, imported to ITK-Snap and segmented semi-automatically using the active contour (snake) and threshold method. This procedure repeated five times by the same operator and named as S1-S5. After each segmentation the observer, edited the model manually to improve the segmentation. All the automatic and semi-automatic segmentation parameters kept the same. Differences in model outcome solely dependent on the manual edit performed after the automatic segmentation. Segmentations were imported to CloudCompare®, and the absolute distance between point clouds determined.

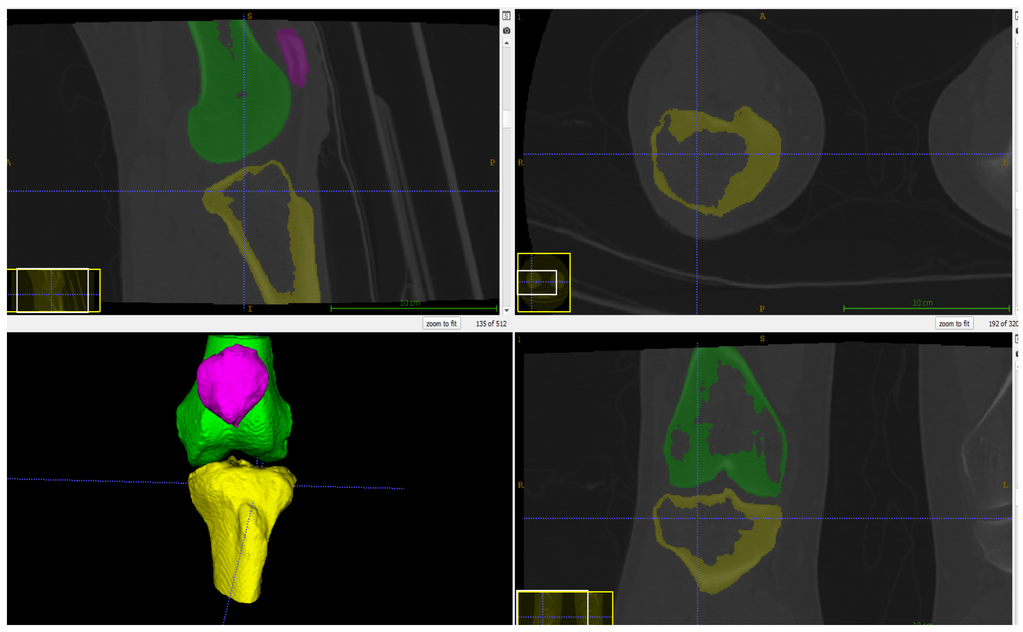

Figure 1. Segmentation of knee joint by ITK-Snap software

Results: An example cloud comparison is shown (Figure 2). The mode unsigned difference between these point clouds is under 0.5mm (Figure 3). Typically, the data were heavily skewed (Figure 3) with occasional differences of up to 2.5 mm at on internal structures resulting from the manual editing of the scan. However, 99.5% of point cloud comparisons had less than 1.21mm difference, which is less than a voxel diagonal (Table 1).

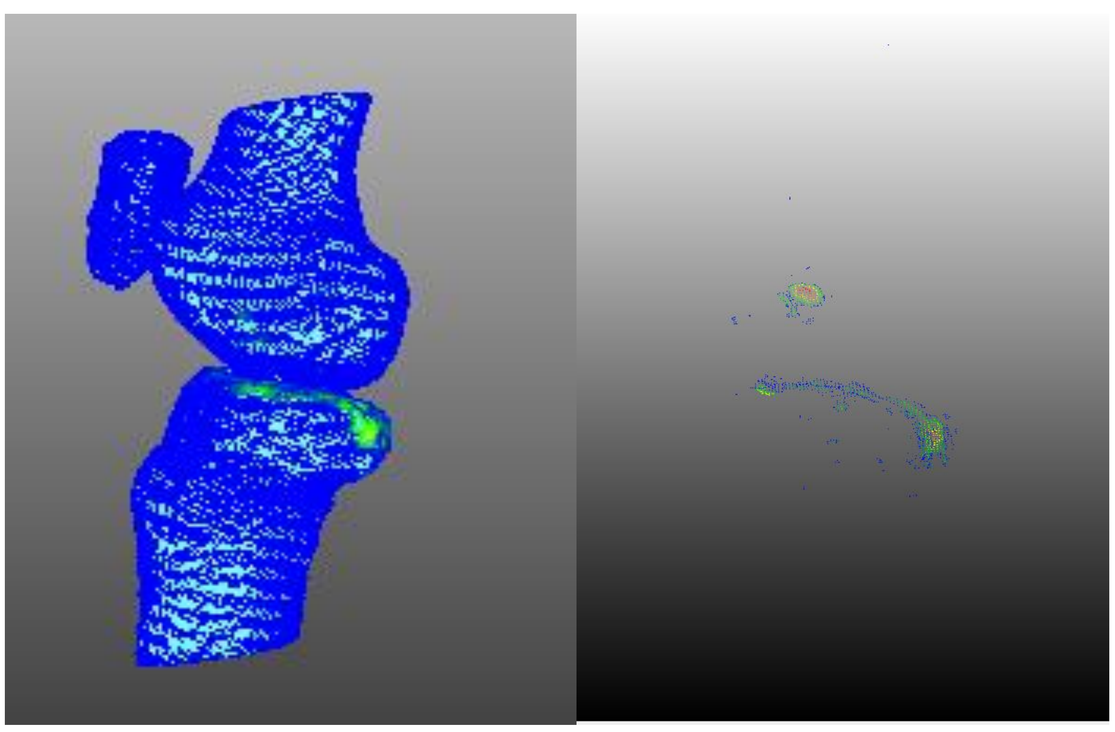

Figure2 . An example of cloud comparison and the difference

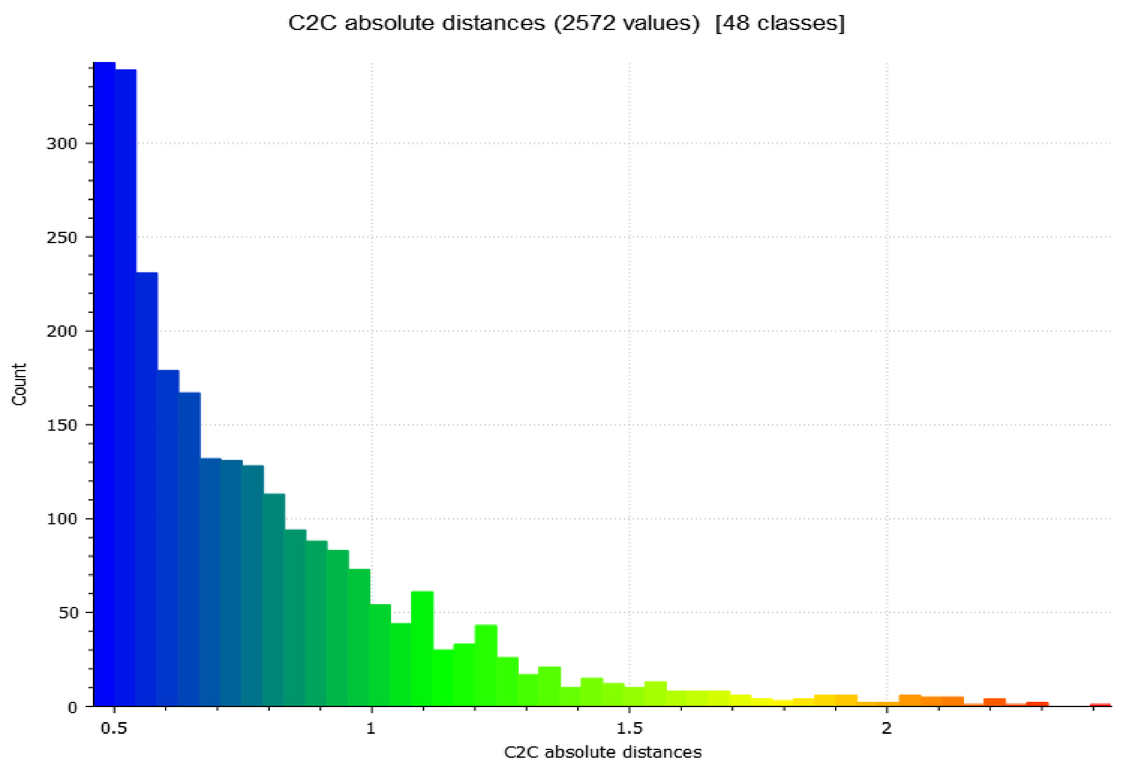

Figure3. Histogram of cloud comparison. Red is maximum difference and blue is the minimum

Discussion & conclusion: Semi-automatic segmentation has good intra-observer reliability. However, considerable localised differences in segmentation were observed and work should continue to determine whether such differences have implications for pre-operative planning or FEA analyses.

	S1	S2	S3	S4	S5
S1	100%				
S2	99.81%	100%			
S3	99.78%	99.89%	100%		
S4	99.68%	99.57%	99.70%	100%	
S5	99.80%	99.90%	99.91%	99.71%	100%

Table 1. Percentage of point comparisons < voxel diagonal length

References:

1. Picard, F., et al., Computer assisted orthopaedic surgery: Past, present and future. Med Eng Phys, 2019. 72: p. 55-65.
2. Luca Friedli, D.K., Georgios Kanavakis, Demetrios Halazonetis, Nikolaos Gkantidis, The effect of threshold level on bone segmentation of cranial base structures from CT and CBCT images. Scientific Reports, 2020. 10(7361).
3. Gitto, S., et al., Effects of Interobserver Variability on 2D and 3D CT- and MRI-Based Texture Feature Reproducibility of Cartilaginous Bone Tumors. J Digit Imaging, 2021. 34(4): p. 820-832.