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BONE SEGMENTATION USING STATISTICAL SHAPE MODEL AND LOCAL TEMPLATE MATCHING

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Summary: Objective
Accurate bone segmentation is necessary to develop patient-specific models for in-silico clinical trials or personalized surgical implants. Various automatic segmentation techniques have been proposed to streamline the process (e.g. graph-cut or deep-learning), but these techniques do not provide any anatomical correspondences during the segmentation step, which makes exploitation of segmentation more difficult for subsequent biomedical purposes.
Bone segmentation using active shape model (ASM) would provide anatomical correspondences. However, this technique is error prone for thin structures, such as the scapular blade or orbital walls.
Method
We developed a new method relying on shape model fitting and local correction using image similarities. In the first step, statistical shape model (SSM) fitting was used to approximate the overall shape of the patient's bone. Then, at each node of the shape model, a 3D image patch was retrieved and compared with three corresponding templates extracted from a pre-segmented database. These patches were locally registered to the patient's scan, providing a local correction of the initial segmentation; the position of the nodes was corrected by majority voting between the three templates based on normalized correlation coefficient metric. The size of the patch was determined by the quality of the SSM fitting.
Results
The method was tested on three anatomical locations: i) scapula (80 CTs) ii) orbital bone (95 CBCTs) and iii) mandible (160 CTs). On average, results were accurate with surface distance smaller or equal to 0.5mm (0.32 (0.03) mm for scapulae, 0.51 (0.08) mm for orbits and 0.47 (0.18) mm for mandibles). The average Dice coefficient (DSC) was also high (94.2% (0.9%) and 93.2% (1.9%) respectively for scapular and mandibular bones). Since only inner surfaces of the orbits were segmented, it was not possible to compute DSCs.
Discussion
This approach results in accurately segmented bones while maintaining anatomical correspondence. It is able to separate joint surfaces, even in challenging pathological situations that include osteoarthritis. However, the initial SSM fitting needs to be sufficiently close to the target, otherwise, the image-based correction is not able to correct the segmentation. Therefore, the SSM must include a sufficient number of representative samples.