Bones segmentation from lower extremity MRI for patientspecific modeling

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BONES SEGMENTATION FROM LOWER EXTREMITY MRI FOR PATIENT-SPECIFIC MODELING

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INTRODUCTION

Medical imaging is widely used in the field of biomechanics to construct patient-specific musculoskeletal models [1]. In particular, magnetic resonance imaging (MRI) provides the most comprehensive evaluation of geometries, joint damage, and osteoarthritis and is a good multi-plane image for soft tissue contrast [2]. However, manual segmentation of human structures is a time-consuming and labor-intensive task and a bottleneck for future advancements in the field. This study presents a method to extract bones from lower extremity MRI images automatically.

METHODS

The total number of segmentation target bones is 10 (pelvis, femur, tibia, patella, and tarsal). Lower extremity MRI images (field strength 1.5T, sequence: T1-fl2d) stitched into three or four scans were used. A multi-atlas-based method was used to segment bones, and a total of 27 atlas data sets were created through manual segmentation. Among these, 9 atlas data were finally selected considering image quality and registration performance. All atlas data include information on manually marked bone regions and the original MRI images.

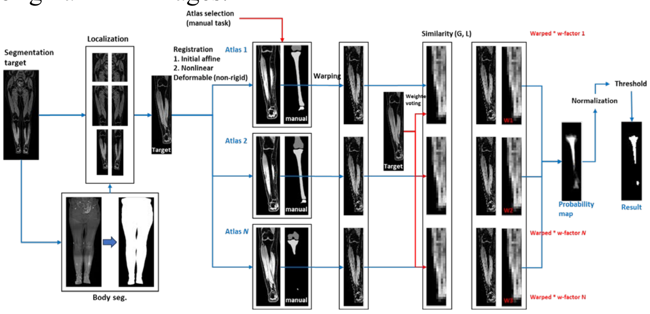

Fig. 1 Schematic diagram of the segmentation algorithm

Segmentation proceeded in the following steps: atlas selection, segmentation of body surface, localization, image registration using a pyramid model, similarity computation between target and atlas image, and weighted voting (Fig. 1). Body surface information was used to reduce the amount of computation when computing the registration and similarity. In addition, the number of iterations of the pyramid model was determined by considering the segmentation results and computation time. The 10 bones finally segmented have different label values in the image, and the segmentation results for each bone were quantitatively compared with manual segmentations. Four metrics (sensitivity, specificity, accuracy, and precision) were used for quantitative comparison.

RESULTS AND DISCUSSION

Table 1 shows the segmentation results according to the similarity criterion. The two similarity criterion methods showed similar results but different performances depending on the bone segmented. It is known that the pelvis shapes in males and females are different. Atlas-based segmentation is based on the morphological information of the target object. However, our atlas data did not distinguish between male and female pelvis. In the future, we plan to improve this through additional research.

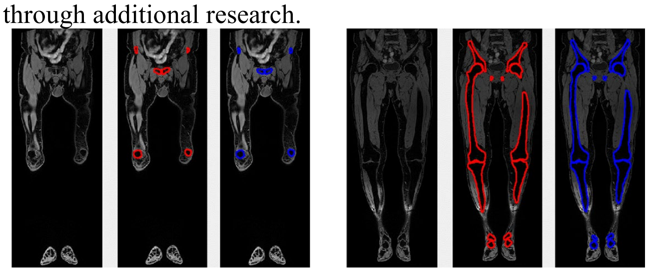

Fig. 1 Segmentation results: original image (left), manual marking (middle), segmented result (right)

CONCLUSIONS

Atlas-based methods have shown good overall performance for bone segmentation, but expansion of the atlas set is required for the pelvis.

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Table 1 Experimental results

SC*	Metric	Left					Right				
		Tibia	Femur	Pelvis	Patella	Tarsal	Tibia	Femur	Pelvis	Patella	Tarsal
NMI	Sensitivity	0.771	0.526	0.279	0.696	0.360	0.714	0.631	0.258	0.715	0.564
	Specificity	0.997	0.988	0.999	0.999	0.994	0.997	0.994	0.999	0.998	0.994
	Accuracy	0.991	0.966	0.986	0.991	0.964	0.990	0.977	0.985	0.991	0.974
	Precision	0.866	0.703	0.771	0.925	0.757	0.849	0.853	0.782	0.896	0.837
NCC	Sensitivity	0.772	0.526	0.281	0.692	0.351	0.714	0.631	0.262	0.717	0.561
	Specificity	0.997	0.988	0.999	0.999	0.994	0.997	0.994	0.999	0.998	0.994
	Accuracy	0.991	0.966	0.986	0.991	0.964	0.990	0.977	0.985	0.991	0.973
	Precision	0.867	0.703	0.771	0.925	0.756	0.851	0.852	0.784	0.899	0.835

Note.-NMI = normalized mutual information, NCC = normalized cross correlation

*Similarity criterion