A model based method for recognizing psoas major muscles in torso CT images

Naoki Kamiya*[a], Xiangrong Zhou[a], Huayue Chen[b], Takeshi Hara[a], Ryujiro Yokoyama[c], Masayuki Kanematsu[d], Hiroaki Hoshi[e], Hiroshi Fujita[a]

[a]Department of Intelligent Image Information, Division of Regeneration and Advanced Medical Sciences, Graduate School of Medicine, Gifu University, Yanagido 1-1, Gifu 501-1194, Japan
[b]Department of Anatomy, Graduate School of Medicine, Gifu University, Gifu 501-1194, Japan.
[c]Department of Radiology Services, Gifu University Hospital, Gifu 501-1194, Japan.
[d]Department of Radiology, Gifu University School of Medicine and Gifu University Hospital, Gifu 501-1194, Japan.
[e]Department of Radiology, Division of Tumor Control, Graduate School of Medicine, Gifu University, Gifu 501-1194, Japan.

ABSTRACT

In aging societies, it is important to analyze age-related hypokinesia. A psoas major muscle has many important functional capabilities such as capacity of balance and posture control. These functions can be measured by its cross sectional area (CSA), volume, and thickness. However, these values are calculated manually in the clinical situation. The purpose of our study is to propose an automated recognition method of psoas major muscles in X-ray torso CT images. The proposed recognition process involves three steps: 1) determination of anatomical points such as the origin and insertion of the psoas major muscle, 2) generation of a shape model for the psoas major muscle, and 3) recognition of the psoas major muscles by use of the shape model. The model was built using quadratic function, and was fit to the anatomical center line of psoas major muscle. The shape model was generated using 20 CT cases and tested by 20 other CT cases. The applied database consisted of 12 male and 8 female cases from the ages of 40's to 80's. The average value of Jaccard similarity coefficient (JSC) values employed in the evaluation was 0.7. Our experimental results indicated that the proposed method was effective for a volumetric analysis and could be possible to be used for a quantitative measurement of psoas major muscles in CT images.

Keywords: Muscle segmentation, X-ray CT images, Psoas major muscle, CAD, Shape model

1. INTRODUCTION

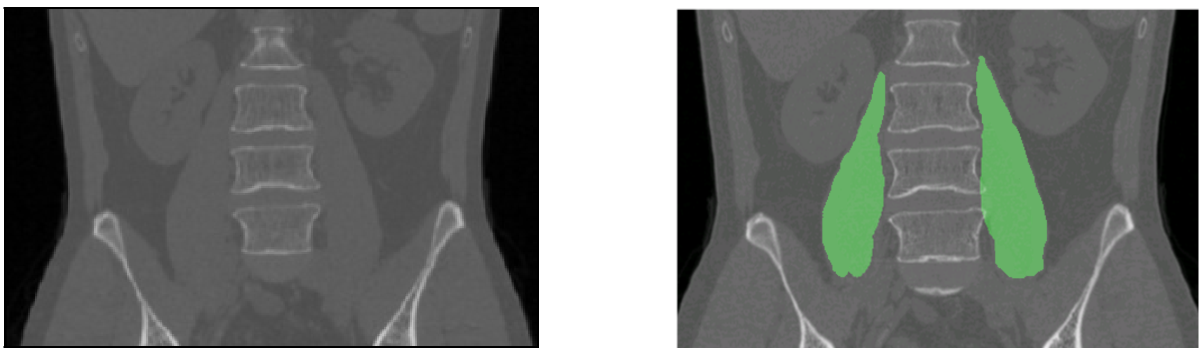
Information on the position, volume, and thickness of abdominal muscle structures is essential when planning surgeries and for visualization of abdominal organs. In computer-assisted radiology and surgery and computer-aided detection/diagnosis (CAD), visualization of abdominal skeletal muscles from CT images is a mandatory pre-processing step. In addition, abdominal skeletal muscles have a complex structure and cannot be distinguished from other organs only based on CT number alone; hence, automated recognition of these muscles remains a challenge till date. The muscle of human body is distinguished by surface muscle and deep muscle [1]. In particular, the psoas major muscle plays an important role in walking, and hence, visualization of this muscle is important in the detection of atrophy. Thus, the recognition of skeletal muscle structures in CT images is gaining attention and is expected to be the target feature in future CAD systems. In this study, we propose a method for recognition of the psoas major muscle (so called "a deep muscle"). In a part of our previous study [2], the test database was very small, so we could not conclude the usability of our method in wider range of ages. In this study, we proposed an improved new method for recognizing psoas major muscles with an increased dataset including variety of ages and genders.

*kamiya@fjt.info.gifu-u.ac.jp; phone 81 58 230-6515; fax 81 58 230-6514; www.fjt.info.gifu-u.ac.jp

Medical Imaging 2010: Computer-Aided Diagnosis, edited by Nico Karssemeijer, Ronald M. Summers,
Proc. of SPIE Vol. 7624, 76241X · © 2010 SPIE · CCC code: 1605-7422/10/$18 · doi: 10.1117/12.843758

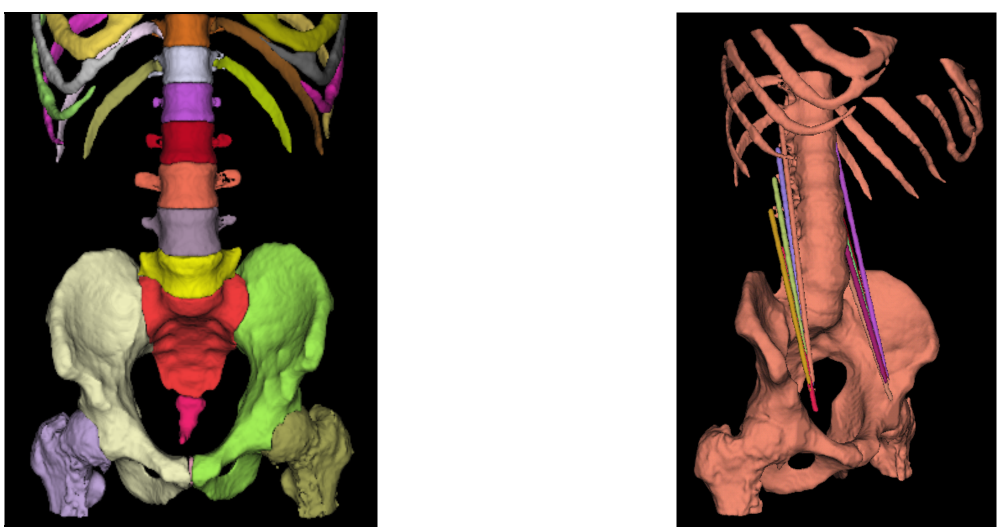
2. METHODS

We first carried out pre-processing based on CT numbers for basic recognition of the human body parts such as fat tissues, muscles, organs, and bones from the CT images [3]. Then, we carried out automatic identification of the anatomical feature points on the skeleton and called them landmarks (LMs) and each LM pair selected on centrum and pelvis was composed of anatomical origin and insertion of the psoas major muscle. After these LM identifications, the centre line of the skeletal muscles was determined by connecting each LM pair with a straight line. There existed ten anatomical centre lines in total on right and left sides in the abdominal body. Then, we created an outer shape model of the psoas major muscle using a set of pre-extracted muscle regions (Fig. 1). Each psoas major muscle is composed of five muscle fivers. Then, we used the quadratic function to describe the shape. Figure 2 shows the skeleton labeled image and the skeleton with ten anatomical center lines. Figure 3 shows the model building process. Finally, we used this model to recognize the muscle regions with region growing of CT numbers.



(a) (b)

Figure 1. Manually extraction of psoas major muscles. (a) Original CT image (axial view), and (b) CT image with extracted regions (green).



(a) (b)

Figure 2. Recognized skeletons and anatomical center lines determined. (a) Skeleton labeled image (each color describes different skeletons), and (b) ten anatomical center lines with skeleton.

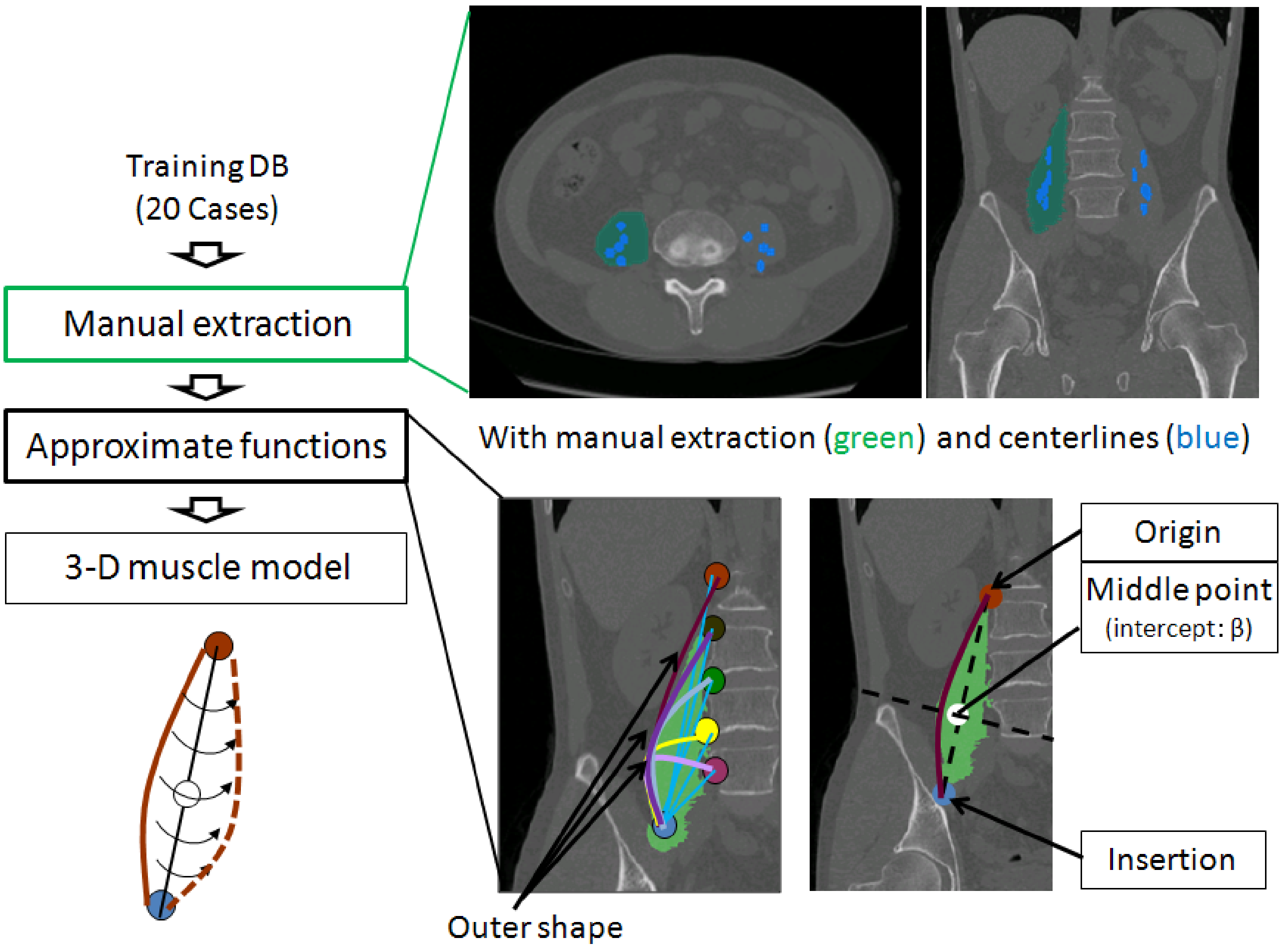
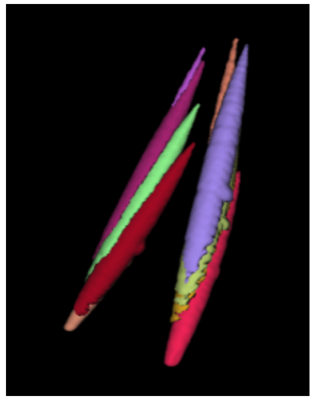


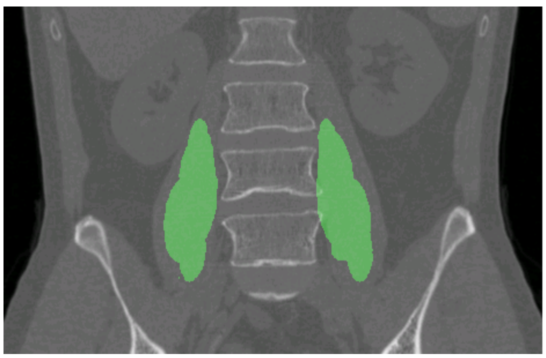
Figure 3. Model building process. The shape of psoas major muscle is presented by a set of quadratic functions.

3. EXPERIMENTS AND RESULTS

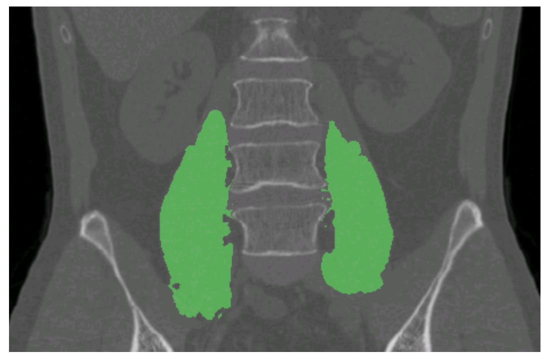
Our proposed method in the model building was applied to 20 cases of non-contrast X-ray CT images. Then, the accuracy of the recognition results was evaluated using the other 20 CT cases on the basis of the overlapping rate between the computer recognized regions and those extracted manually by one of the authors under the guidance of an anatomy specialist. In more concrete terms, the Jaccard similarity coefficient (JSC) was calculated to evaluate the proposed method. The averages of the JSC values obtained from 20 cases tested were 0.7. Figures 4 and 5 show the generated model [Fig. 4 (a)] and recognition results [Fig. 4(c) and Fig. 5]. These results show that the upper region remains consideration, but overall tendency is apprehensible for volumetric analysis of muscles. Other results are shown Figure 6 and Figure 7.



(a)



(b)



(c)

Figure 4. Recognition of muscles. (a) shape model of psoas major muscles, (b) overlapped region between shape model with CT images, and (c) extraction results using region growing from the overlapped region.

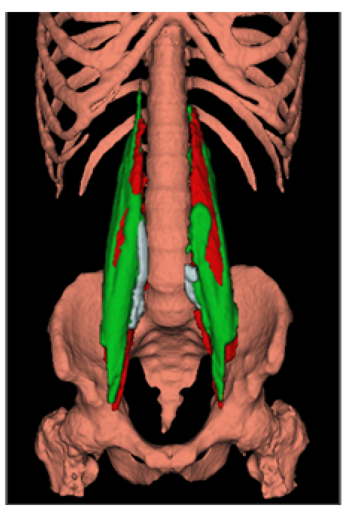
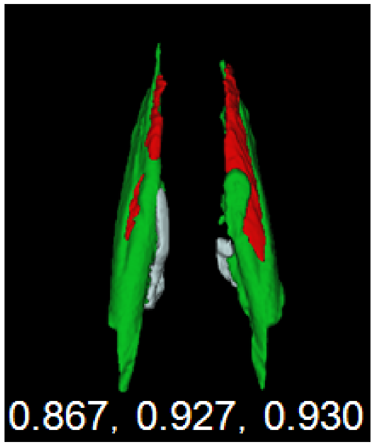
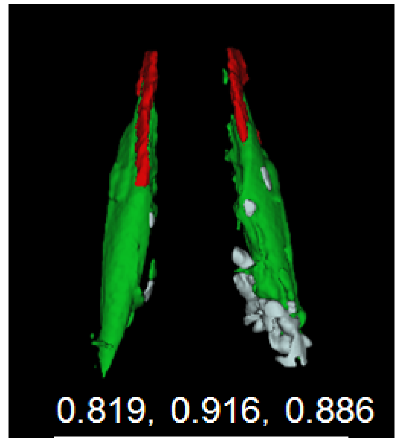


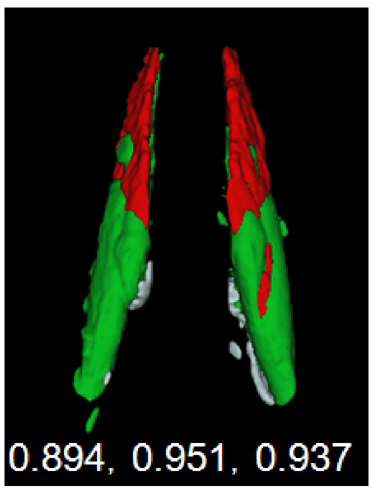
Figure 5. Experimental results with skeleton (green: concordance, red : under-recognition, blue : over-recognition).



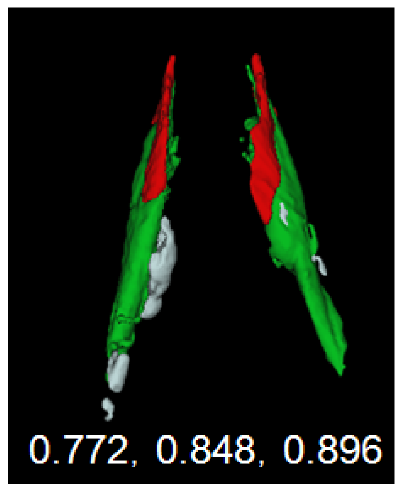
(a) 40 Male



(b) 50 Female



(c) 70 Male



(d) 80 Female

Figure 6. 3-D view of experimental results. The value under the each figure is concordance ratio, reproduction ratio and relevance ratio, respectively.

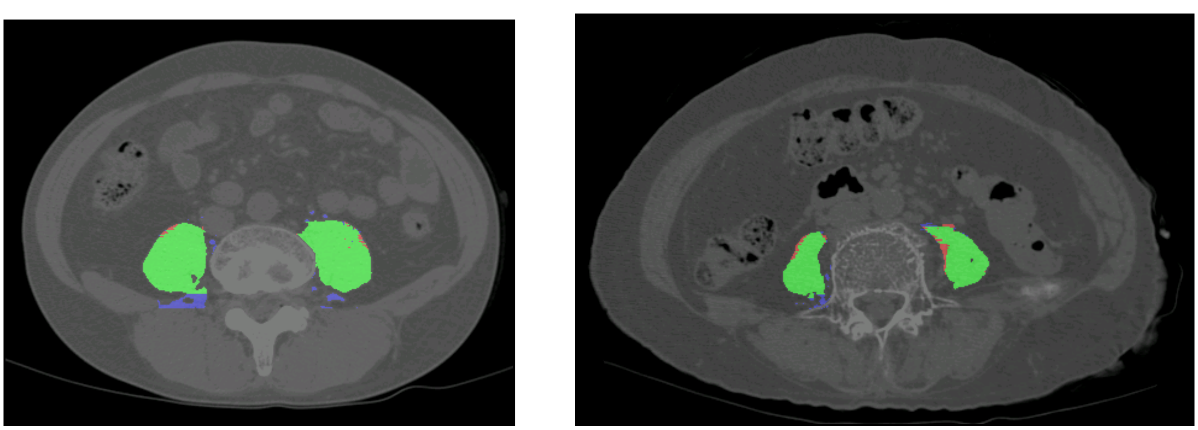


Figure.7 Example of experimental results. (green: concordance, red : under-recognition, blue : over-recognition).

4. CONCLUSION

We have proposed a new method for recognizing psoas major muscles by using the shape model. The experimental results showed that the proposed method can be used for effective recognition in the CT images and that it can be used for volumetric analysis. This method showed the possibility that the computerized analysis of the muscle volume and thickness can be useful in the diagnosis of muscle atrophy. We are still collecting the new image data and these data will be employed to evaluate the performance of our model based recognition approach.

ACKNOWLEDGEMENTS

The authors would like to thank all the members of Fujita Lab. of Gifu University for their valuable contribution to this work. This research work was supported by Grant-in-Aid for Scientific Research on Innovative Areas, MEXT, Japan.

REFERENCES

[1] R. Drake, W. Vogl, and A. W. M. Mitchell, "Gray's anatomy for students," Churchill Livingstone, 2005.

[2] N. Kamiya, X. Zhou, T. Hara, H. Fujita, R. Yokoyama, and H. Hoshi, "Fully automated extraction, classification and measurement of the skeletal muscles and fat regions in torso X-ray CT images", 94th Scientific Assembly and Annual Meeting of the Radiological Society of North America, p. 887, 2008.

[3] X. Zhou, T. Hara, H. Fujita, R. Yokoyama, T. Kiryu, M. Kanematsu, and H. Hoshi, "Preliminary study for automated recognition of anatomical structure from torso CT images," in Proc. 27th. Annu. Conf. Eng. Medicine Biol. (EMBC), Shanghai, China, Sep. 2005, #340, in CD-ROM.

[4] K. Takahashi, H. E. Takahashi, H. Nakadaira, and M. Yamamoto, "Different changes of quantity due to aging in the psoas major and quadriceps femoris muscles in women," J Musculoskelet Neuronal Interact., vol. 6, no. 2, pp. 201-5, 2006.

[5] M.R.Anderberg, *Cluster Analysis for Applications*, Academic Press, U.S.A., 1973.