Myotendinous Junction Region Segmentation in 2D Ultrasound Images with Fully Convolutional Neural Networks: A preliminary study

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***Abstract*— The displacement of the myotendinous junction (MTJ) obtained by ultrasound imaging is essential to understand the mechanics and pathological conditions of the muscle-tendon unit during motion. This paper presents an automatic method to measure the MTJ through segmenting an effective MTJ region. The ultrasound images were first preprocessed with level-set-based method. Followed by the application of a proposed fully convolutional neural networks (FCNN), the MTJ regions were successfully predicted and thus the MTJ displacement among consecutive ultrasound images was achieved. Preliminary tests were conducted on a normal subject, and the feasibility was demonstrated.**

I. Introduction

Muscle-tendon unit (MTU) that consists of muscle and tendon plays an important role in force generation and energetics during human movement. In recent decades, ultrasound imaging has shown its great importance in comprehending the adaptation of muscle and tendon as well as evaluating their function and pathological status by monitoring the architectural changes among muscle and tendon. The variation of fascicle length and tendon length are both frequently-used architectural parameters in ultrasound images to quantify the pattern of interaction between tendon and muscle. Myotendinous junction(MTJ) (Fig. 1(a)), as the intersection of tendon and aponeuroses, which's displacement can be tracked for the estimation of tendon length changes [1]. However, the lack of a robust automatic MTJ localization method limits the application of MTJ in human movement studies. This research presents a semantic segmentation method to gain an efficacious MTJ region, through which the MTJ displacement among consecutive images was gained.

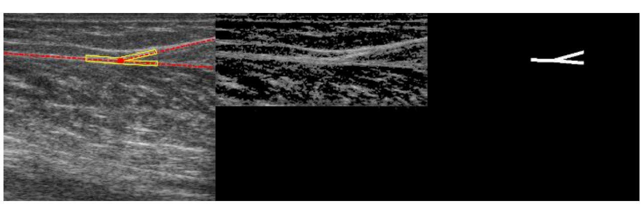

Figure 1. Typical ultrasound image of gastrocnemius tendinous features. (a) labelled effective region on the original ultrasound image. (b) image preprocessed with lavel-set-based method. (c) the mask of the effective MTJ region used for the supervision of FCNN traning.

II. Methods

In musculoskeletal ultrasound images, the tendinous tissues, including aponeuroses and tendon, depict ridge-like hyper echoic bands (Fig. 1(a)). Therefore, the image was first preprocessed with level-set-based method, a well-known segmentation method for changing curves, to enhance the tendinous tissue structure (Fig. 1(b)). Then the effective MTJ region (Fig. 1(a)) was defined and made to be the corresponding mask (Fig. 1(c)). Followed by the transferring of the convolutional layers (with pretrained weights) from the VGG-16 model, depends on which the fully convolutional neural networks were finally designed in a U Net up-sampling as well as concatenating manner (Fig. 2).

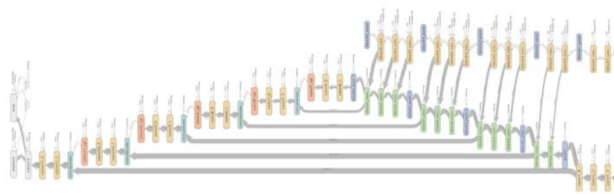

Figure 2. The proposed fully convolutional neural networks.

III. Results and Discussion

The model was trained with 300 pieces of preprocessed ultrasound images from 7 healthy subjects, also was tested with 30 images from another normal subject. The training accuracy represented by the dice coefficient between labeled masks and predicted masks is 0.88, while the testing one is 0.65. Furthermore, the MTJ tracking accuracy among consecutive images from the testing subject was evaluated by computing the coefficient of multiple correlation (CMC) between automatic method and manual one. The preliminary results were shown in Fig .3. It shows the predicted MTJ region was in accordance with the labeled one. This study suggests that the proposed MTJ segmentation method can predict the MTJ region well even with confined training dataset, also gaining a competitive MTJ tracking result (CMC = 0.99) when compared with other automatic methods [1].

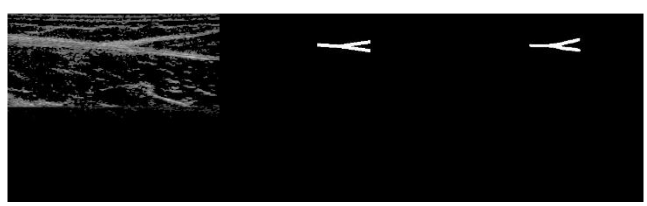

Figure 3. (a)the preprocessed image from the testing dataset. (b) the labeled MTJ region. (c) the predicted MTJ region.

ACKNOWLEDGMENT

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REFERENCES

[1] Zhou G Q, Zhang Y, Wang R L, et al. Automatic Myotendinous Junction Tracking In Ultrasound Images With Phase Based Segmentation[J]. 2018.