Automatic Estimation of Muscle Fiber Orientation in Ultrasound Images Using Artificial Neural Network

Sheng Wang[1], Yang Xiao[2], [1]Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

Background, Motivation and Objective

Ultrasound image of muscle fascicles has been established as a very effective tool to provide valuable information for clinical diagnosis on muscle injuries and disorders. However, it is time-consuming and laborious to manually label the fascicles image, especially under dynamic condition. Although there are encouraging work using traditional image processing approach like Hough Transform and Local Radon Transform, a flexible, general, robust solution is not available, yet. The reasons for this are manifold. First and foremost, current solution are based on edge detection so they are not robust enough against low-contrast images from atrophy patients. Second, existing methods often require certain parameter tuning for different ultrasound equipment. To solve the problems mentioned above, an automatic muscle fascicle tracking method based on ANN (artificial neural network) is proposed.

Statement of Contribution/Methods

In this study, B-mode ultrasound images of gastrocnemius muscle (Fig.a). were collected in 10 subject (5 healthy, 5 atrophy). For each image, an auxiliary line is generated to predict the orientation of the muscle fascicle (Fig.b). Then a discriminator (Fig.c) based on a 50-layers ResNet neural network is trained to judge whether the auxiliary line is parallel to the muscle fascicle. If it is not parallel, a new auxiliary line with different orientation will be generated and judged again. If it is parallel, the orientation of the auxiliary line will be output as the orientation of muscle fascicle.

Results/Discussion

The root mean square errors (RMSE) of tracking results is 2.25 degrees in the low image quality subjects (Fig.e), and 1.48 degrees in high image quality subjects (Fig.f). And the backbone ANN (ResNet-50v2) was able to run 300 frames per second in single GPU (Nvidia Titan V). The proposed approach not only significantly reduces the manual parameter tuning process for different ultrasound equipment, but also makes the muscle fiber tracking more robust to the patients affected by muscular atrophy.

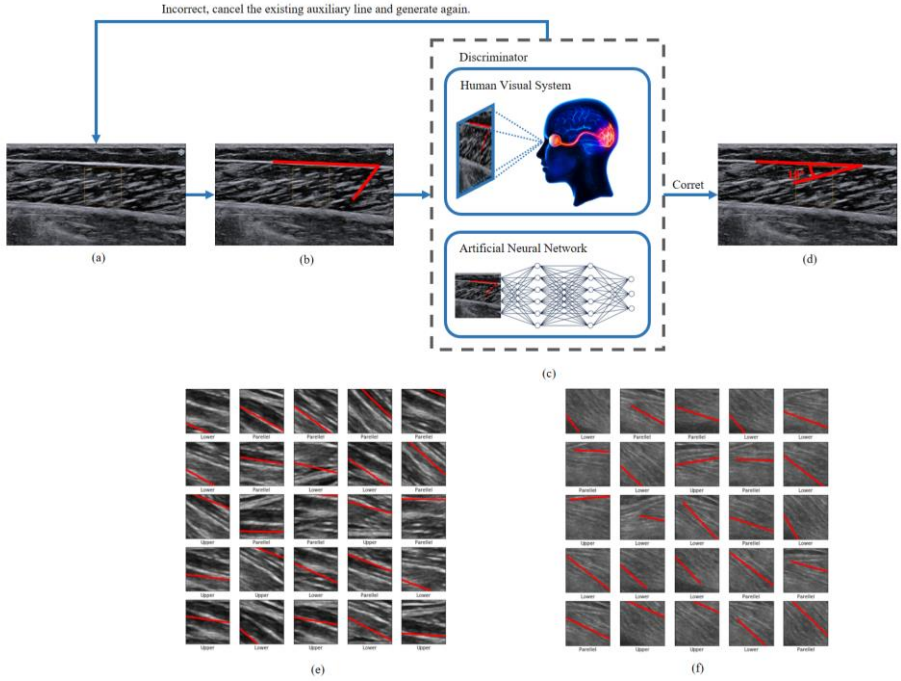

Fig. 1. (a) A B-mode image for GM passive stretching. (b) An auxiliary line is generated to predict the orientation of the muscle fascicles. (c) Discriminator models which are able to judge whether the generated auxiliary line is parallel to the actual muscle fascicles. (d) If the discriminator claims the auxiliary is correctly placed, the iteration terminates and the system outputs the orientation of the muscle fiber. (e) Result in high quality muscle fascicles B-mode images. (f) Result in low quality muscle fascicles B-mode images.