A Deep Siamese-based Plantar Fasciitis Classification Method Using Shear Wave Elastography

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Background, Motivation and Objective

Thickening and hypoechogenicity of plantar-fascia shown in B-mode ultrasound are among the most effective criteria for assessment of plantar fasciitis (PF). For that, shear wave elastography (SWE) is strongly recommended for PF diagnosis since the stiffness measurement provides better sensitivity. We hypothesize here that computer-aided diagnosis (CAD) based on deep learning will further improve the sensitivity as it can automatically extract effective features in an "end-to-end" way. To improve the discriminative ability of traditional deep learning methods (e.g. CNNs), we propose a novel Deep Siamese framework via Multi-task Learning and Transfer Learning (DS-MLTL) using SWE.

Statement of Contribution/Methods

The proposed model contains two identical branches with shared weights. Each branch includes 16 convolutional layers (transferred from VGG-16 Conv layers) for feature extraction and 3 fully connected layers for feature fine-tuning (Fig. 1A). In the training phase, a pair of SWE images is used as input for the Siamese network. This network then outputs both classification results and the similarity score of the two images. In the test phase, only classification results were used. The key idea behind a Siamese network is to learn a matching function which constrains similar pairs to be close to each other while dissimilar pairs to be separated by a predefined margin. In this DS-MLTL model, the classification task and the similarity learning task are learned jointly to benefit each other. For performance evaluation, we collected an SWE dataset of plantar-fascia of 282 images of disease pattern and 60 images of normal pattern using Mindray R7 US scanner with an L14-6MHz transducer.

Results/Discussion

Experimental results show that our method achieves favorable accuracy of 84%. Fig. 1B shows the comparison of ROC curves of the 4 models. The AUC of DS-MLTL is 90%, hence performing better than CNN, TL, and DS-ML models. Moreover, compared with various features of sono and elastograms (thickness, hypoechogenicity, elasticity value, and etc.), the DS-MLTL model achieves the highest accuracy (Fig 1C). To the best of our knowledge, this is the first prospective study that used a DL model for an intelligent diagnosis of PF based on 2D-SWE.

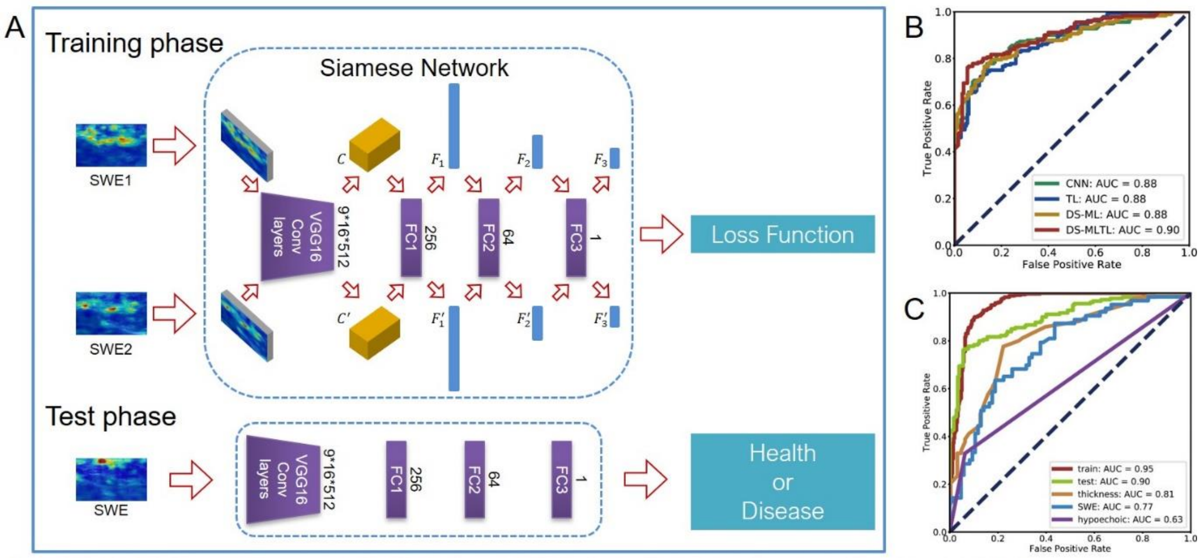

Fig 1. (A) Architecture of the proposed DS-MLTL model. (B) Comparison of receiver operating characteristic (ROC) curves among the 4 models. (C) Comparison of ROC curves among DS-MLTL and sonographic characteristics.