Continuative Deep Learning Network (CD-NET) Model for Multidimensional Image Segmentation in Ultrasound Systems

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Background, Motivation, and Objective

Ultrasound imaging and analysis has been utilized to diagnose various diseases in medicine. Deep learning-based object segmentation algorithms have recently developed with multidimensional ultrasound images. In these methods, deep-learning training was performed in 2D and 3D, separately. The 3D images were converted into individual 2D images, and even video images where continuous frames of 2D images exist were divided into the separate 2D images for the deep-learning training. However, the conversion of a multidimensional image into 2D images degrades continuous information across dimensions during the deep-learning training process, thus reducing the accuracy in the multidimensional segmentation of diseased regions such as tumors or rotator cuff tears of ultrasound images. Thus, a novel continuative deep-learning method considering the continuity of images, denoted as CD-NET., has been developed for better analysis of multidimensional images obtained using ultrasound systems.

Statement of Contribution/Methods

In the CD-NET, a novel type of layers similar to LSTM was placed between the connected U-Net structures to maintain continuative information between dimensions. The CD-NET was then employed to do multidimensional segmentation of images, including 3D ultrasound images of a rotator cuff and time-lapse images of acoustically trapped cells. The 3D images of rotator cuff tears were obtained using our developed 3D ultrasound imaging system. On the other hands, the time-lapse images of cells before and after acoustic trapping were obtained using a single-beam acoustic trapping system. For evaluation of CD-NET, mean Intersection over Union (mIoU) values of the segmented 3D and time-lapse images and similarities between continuous images were compared to the outcomes obtained using other models.

Results/Discussion

For evaluation of our model, the mIoU values and similarity were obtained. In particular, the image similarity was utilized for the quantification of continuity between frames. The results showed that the mIoU value of outcomes was more than 80.5%, which is superior to U-Net and its similarity was ~ 85%. Here it was found the CD-NET offered better outcomes for the segmentation of multidimensional images obtained using ultrasound systems, suggesting its potential as a new intelligent tool for biomedical ultrasound imaging and analysis.

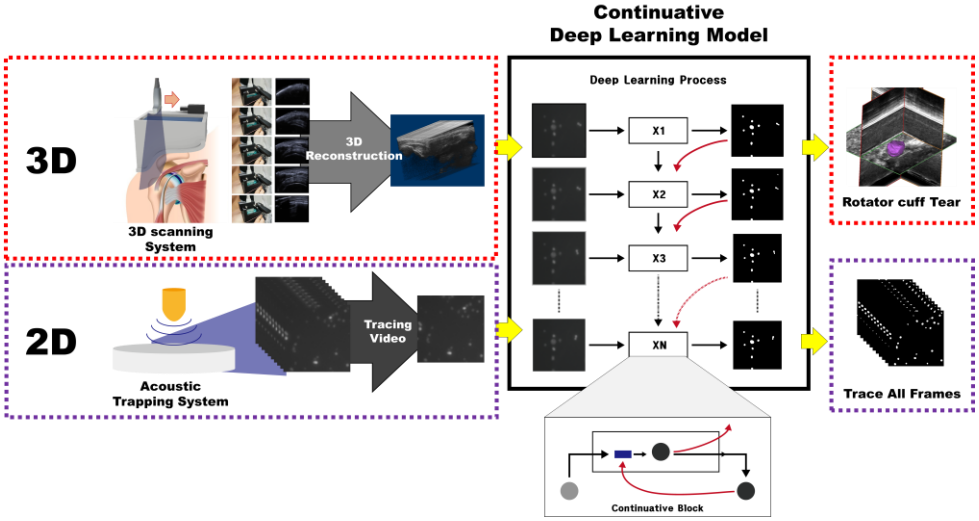

Figure 1. Conceptual image of the CD-NET architecture and the predicted outcomes