Development of Synthetic Chest Image Network for Implementing Dual Energy Chest X-ray Image with Single X-ray Exposure

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Introduction
In this study, we developed an algorithm with a novel network for translating single energy chest images into material decomposed images, which would be useful for improving diagnostic accuracy. We applied various recent network structures to design the network. The presented network is different from conventional deep-learning-based image processing, which has been demonstrated to improve image characteristics such as noise and resolution. The proposed network can translate the domain of images so that they are useful for clinical diagnostic accuracy. It is expected that they will significantly assist in the diagnosis of pathologies of the chest region.

Hypothesis
Deep learning based non-linear mapping can translate single energy image to dual energy image without double X-ray exposures.

Methods
The training data used in this study were 300 cases of DE chest images obtained from Yonsei University Severance Hospital in South Korea. These data consisted of pairs of single chest images and their corresponding dual energy chest images. In addition, we used publicly accessible pneumonia chest images data for confirming how proposed network can be affect to classification performance of pneumonia. The proposed network was developed using convolutional neural networks (CNN). Our model consisted of eight convolution layers (encoder) and eight deconvolution layers (decoder). The overall model structure was developed based on the fully convolution network (FCN) usually used for semantic segmentation. The model was trained to learn meaningful features while generating the output image from the input image. In addition, we used various techniques to improve the quality of the prediction images effectively. For instance, we utilized batch normalization, and residual building block. SCI-Net was inspired by a convolutional autoencoder, which consisted of an encoding path (upper half of the network, from 512×512 to 4×4) to retrieve the features of interest, and a symmetric decoding path (lower half of the network, from 4×4 to 512×512), which enables the prediction of the synthetic image. To classify pneumonia patient, we constructed CNN model which has 6 hidden layers and 2 output class.

Results
As shown in figure 1, proposed network effectively removed bone or soft tissue component without any distortion of necessary material components. Average structure similarity index measure between synthetic chest image and dual energy chest image is approximately 0.85. The motion artifact, which is one of main concerns in dual energy image was partially resolved in prediction images of the proposed network, and there was no distortion of the image information of the lesions. In addition, as described in figure 2 accuracy of prediction of pneumonia classification was improved approximately 10 % when using proposed network as preprocessing of classifying task of pneumonia classification.
Conclusion
The proposed method could generate bone or soft tissue decomposed chest images with single X-ray rather than dual X-ray exposure, which is necessary for DE X-ray imaging. In addition, the image predicted using the proposed method provides high quality images with less contamination owing to image noise and motion artifact than conventional DE X-ray.
imaging. Finally, it is expected that the proposed network can contribute to the improvement of diagnostic accuracy for both chest X-ray and computer aided diagnosis.

**Statement of Impact**

We proposed a technique to generate material selective images with single X-ray exposure which was limited in the conventional technology.

**Keywords**

chest image, convolution neural network, synthetic image