Chaotic-based Deep Learning Approach for Identifying Nonalcoholic Fatty Livers with Ultrasound Images

Yi-Ju Lee

Institute of Statistical Science, Academia Sinica

Abstract

Background

The nonalcoholic fatty liver (NAFL) is a common liver abnormality that is often overlooked in the early stages because there are no symptoms. Ultrasound is the most commonly used tool for screening fatty liver; however, it could be easily inferred by anisotropy, bone or air blocking, or other abnormal morphology of the tissues. In addition, the ultrasonic scattering signal is random and tissue-specific, which feature may be bypassed by adopting linear analysis methods. Thus, in this research, we propose a chaotic-based model by using the concepts of information theory to extract and represent the image feature dynamics in NAFL.

Method

In this research, we use Shannon Entropy, which has shown robustness in imaging preprocessing in previous studies, to quantify the complexity of B-mode ultrasound image sequences. We use ChaosNet, a model which layers that simulates the dynamic system of human neuronal firing patterns, for classification. The DenseNet 121 is conducted for comparison. Four hundred B-mode ultrasound image series (half are NAFL) were acquired from MedPix and Kaggle. The images were cropped and preprocessed. The ChaosNet and DenseNet are established using Pytorch with cross-entropy loss as loss function. The batch size is 256, and the models are trained for 500 epochs with 2 DGX A100 (40G) GPU.

Result

The area under the receiver operating characteristics curve obtained using the proposed approach was equal to 0.936 with entropy-preprocessing, being higher than the one obtained with the DenseNet model, 0.911. The testing accuracy was equal to 0.83 and 0.87, and the computation time is 2.06 hours and 3.23 hours, respectively.

Conclusions

The proposed entropy method may help extracted the image-based features and does not require pre-selected ROIs in ultrasounds before model training. The approach represents the properties of chaotic neuron induced complex behavior, which is more efficient in comparison with other models. The chaotic-based deep learning model

improves the automatic identification of NAFL.

Keywords: chaotic dynamics, deep learning, non-alcoholic fatty liver (NAFL), ultrasound