Multi-function Convolutional Neural Networks for More Accurate Alzheimer’s Disease Diagnosis Using Brain MRI Images than Current Convolutional Neural Networks

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Abstract: In recent years, Convolutional Neural Networks (CNNs) have been successful in various important real-world applications such as medical imaging for disease diagnosis. Current CNNs typically use the same activation function for all neurons. However, they may not always guarantee the most optimal performance for diverse complex big data applications. ReLU is a popular activation function since it has many good properties, such as being simple and having a non-vanishing gradient. However, there are many other activation functions (i.e. unipolar sigmoid, bipolar sigmoid, hyperbolic tangent, etc.) that may also be used in addition to ReLU. Not every neuron has to use the same activation function. Activation functions are important since they transform the input space to a different space in the output, and effective activation function selections for different neurons can be optimized to achieve better training and testing performance. Defining the ideal neural network structure with suitable mathematical functionality for a particular dataset for a biomedical imaging application is just as important as tuning the hyper-parameters of a CNN. For this research, Multi-function Convolutional Neural Networks (MCNNs) are newly developed to improve the training and testing performance for more accurate Alzheimer’s Disease (AD) diagnosis by allowing great flexibility in using different activation functions for different neurons. This research work uses brain MRI images for a 4-class classification problem; the output is one of the following four AD stages: non-demented, very mild dementia, mild dementia, and moderate dementia. For simulations, Inception-v4 is used as the architecture of a current CNN model, and MCNNs are created using revised Inception-v4 with newly added random activation function selection for neurons in different convolutional blocks. Six activation functions (Softplus, ReLU, Sigmoid, Softsign, Linear, Tanh) are used for simulations. 3-fold cross validation is used for comparison between current CNNs and MCNNs by calculating comprehensive metrics (i.e. accuracy, f1-score, and specificity). Overall, simulations show that MCNNs can detect AD more accurately than current CNNs.

References: