Multi-function Convolutional Neural Networks for More Accurate Alzheimer's Disease Diagnosis Using Brain MRI Images than Traditional 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. Traditional CNNs typically use the same activation function for all neurons[1]. 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. 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[2]. 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 436 brain MRI images[3] 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, traditional CNN models are made using Inception-v4 as the architecture, and MCNN models are created using a newly revised Inception-v4 with random activation function selection for neurons in different convolutional blocks. Three activation functions (ReLU, Sigmoid, Tanh) are used for simulations. Stratified 3-fold cross validation is used to compare traditional CNNs and MCNNs in terms of accuracy. Overall, simulations show that MCNNs can diagnose AD more accurately than traditional CNNs. Better and faster algorithms will be created to efficiently find the best set of different activation functions of a MCNN. Traditional CNN software using Inception-v4 or Inception-ResNet-v2 [4] can be modified by adding different activation functions to develop new MCNN software for more accurate image classification.

References:

1. A. Krizhevsky, I. Sutskeyer, and G. E. Hinton, "ImageNet classification with deep convolutional neural networks," *Advances in Neural Information Processing Systems 25*, pp. 1097-1105, Lake Tahoe, Dec. 3-6, 2012.
2. L. M. Zhang, "A new multifunctional neural network with high performance and low energy consumption," *15th IEEE Int. Conf. on Cognitive Informatics & Cognitive Computing*, pp. 101-109, Palo Alto, Aug. 22-23, 2016.
3. OASIS Brains Datasets. [Online]. Available: http://www.oasis-brains.org/#data.
4. C. Szegedy, S. Ioffe, V. Vanhoucke and A. Alemi, "Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning," *The Thirty-First AAAI Conference on Artificial Intelligence (AAAI-17)*, pp. 4278-4284, San Francisco, Feb. 4-9, 2017.