The Compact 3D Convolutional Neural Network for Medical Images

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■ Background

1. The Images for medical diagnosis
   - too big and many 2D slices.
   - very sparse matrix.
   - too hard to find lesions, even though specialists

2. Lung cancer
   - lung cancer strikes 225,000 per 1 year in the U.S.
   - health care costs over $12 billion
   - the early detection from CT is the most important.

3. Previous works
   - Lung nodule classification by 2D CNN, 3D CNN
   - lung classification by multi view 2D CNN
   - multi scale CNN for lung nodule
   - etc.

■ Problem Statements

1. The limitation of 2D slices
   - too many 2D slices / 1 patient. (~ 300 slices)
   - too hard to find cancer from dissection images
   - no volumetric intuition.

* 3D CNNs are required, instead of 2D CNN.

2. The problem of previous 3D CNNs
   - high computation costs
   - small patch (64x64x64) to find patterns
     or interpolation to (50x50x20)
   - too slow at fully connected layers

3. Evaluation methods and work
   - evaluated by accuracy and confusion matrix
   - the compact implementation of 3D CNN

■ Datasets

1. Lung scans (CT)
   - provided by the National Cancer Institutes
   - stage1 (~240GB) from Kaggle competition
     (Data Science Bowl 2017)

Data	Patients
Cancer	362
No Cancer	1035

2. Luna2016 datasets
   - Evaluation datasets for nodules in the lung CT.
   - merely used.
   - ~120GB

3. CT sizes are variable
   - (# of slices, 512, 512) 3D structure. Channel is 1.

■ Methods / Algorithms / Model

1. SqueezeNet [Iandola et al. 2017)
   - Alexnet-level accuracy with 50x Fewer Parameter
   - 2D image application

2. My suggestion for this work
   - SqueezeNet3D for 3D structures
   - it is basically the same to architecture 2D squeezeNet, but 3D conversion.
   - no fully connected layers (input independent)
   - benefits : low computation costs,
     high performance, small memory size

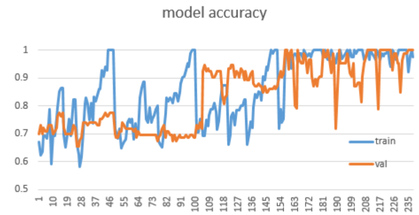
3. Padded CT volume : size of (128, 128, 128)
   - resize by ¼ size

4. K-fold cross validation

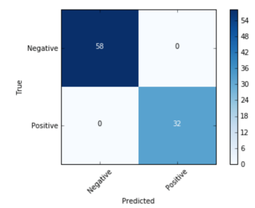
5. Pseudo-label [DH Lee. 2013]

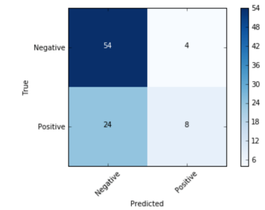
■ Experimental Evaluation and Findings

1. Model accuracy ((TP + TN) / total) : > 0.99



2. val. set : 100%, but test set : 70% accuracy





■ Conclusion / Future Directions

1. SqueezeNet3D is more powerful than other 3D CNNs
   - faster minimizing the training loss
   - small sizes (1,861,186 parameters, ~8MB)
   - speed~4x up than other 3D CNN with GPU

2. The state of the art result for validation
   - but, test scores are not satisfied

3. Future work
   - Data preprocessing : no padding, variable size
   - Implementation of SqueezeNet3D architecture
     not dependent on variable stacked sizes of CT
   - 3D Data augmentation for unbalanced data