Using pre-trained convolutional neural networks to classify interstitial lung diseases in chest computed tomography scans

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Chest computed tomography (CT) scans are widely used for automatic detection and classification of Interstitial lung disease (ILD) using computer-aided diagnostic (CAD) systems. The goal of these CAD systems is to reduce the time taken for and to optimize the diagnostic decisions made by radiologists. Convolutional neural networks (CNN) have been shown to be extremely effective at visual classification tasks. However, CNNs require large, labeled datasets in order to tune millions of parameters. Medical datasets large enough to train a CNN from scratch are not readily available. In this work, we explore the feasibility of using CNNs that have been fully trained with a non-medical dataset to classify ILDs in CT scan patches using “transfer learning”; a technique where features identified by the pre-trained CNN are then used to train a new CAD system.

**Data Sets**

- ImageNet Data Set (used to pre-train the CNN)
  - 1.2 Million Images
  - 1000 Categories
  - Sample Images:

- Talisman Test Suite Data Set
  - 14,904 images from 85 Patients
  - 5 Categories (disease types)
  - Sample Images:

**Methodology**

**HLS to RGB**

CT scans are saved in Hounsfield units (HU) but the CNNs work using expect RGB images. RGB images consist of 3 color channels that have values between 0 and 255.

**Oversampling**

When class sizes are imbalanced, take random samples with replacement to make training class sizes equal. This way all classes are represented equally during training.

**Transfer Learning**

1) Start with InceptionV3 CNN fully trained on ImageNet data set. InceptionV3 is a high performing CNN designed by Google.

2) Input CT-scan images that have been converted to RGB

   - Extract features generated from CT-scan images

   - Use Features to train a Neural Network with a single hidden layer that predicts ILD

**Best Leave One Patient Out Results**

Using features extracted from an intermediate layer of the ImageNet trained InceptionV3 CNN.

- Average F1 Score = 0.8308
- Standard deviation = 0.0594

**Normalized Confusion Matrix**

- CAD Prediction Examples:

**Conclusions**

- Transfer learning is feasible for classifying ILD patches
- Extracting features from an intermediate layer of the InceptionV3 model gave the best results, indicating that information learned by later layers is not applicable to ILD classification
- Emphysema has an average recall of 0.59 but it is underrepresented in this dataset (only 407 images)
- Our future work involves looking at data augmentation (a method of generating artificial data) and fine-tuning to improve results

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