Emphysema

- A chronic disease of lung that described as decrease in the amount of oxygen transferred to the blood and therefore causes shortness of breath.
- Mostly caused by smoking
- It is characterized by elasticity loss of the tissue surrounding the alveoli limiting the expanding and shrinking of airspaces.

About 4.7 million Americans had emphysema in 2011

- Emphysema with chronic bronchitis is referred to as Chronic Obstructive Lung Disease (COPD) which is the fourth leading cause of death in the United States and affects 5% of the population.

Dataset Descriptions

HRCT scans are from 39 people.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT</td>
<td>Never smokers (9 People)</td>
<td>9</td>
</tr>
<tr>
<td>CLE</td>
<td>Healthy smokers and smokers with COPD (10 People)</td>
<td>10</td>
</tr>
<tr>
<td>PSE</td>
<td>Healthy smokers and smokers with COPD (20 People)</td>
<td>20</td>
</tr>
</tbody>
</table>

The aim of the study

- This study aims to investigate the deep learning solution for discriminating emphysema subtypes by using raw pixels of input HRCT images of lung.
- Convolutional Neural Network (CNN) is used as the deep learning method for experiments carried out in the Caffe deep learning framework.
- As a result, promising percentage of accuracy is obtained besides low processing time without any preprocessing of the input images.
Deep Learning

- Deep learning is a new area in machine learning to solve problems of artificial intelligence with a special emphasis on artificial neural networks.
- Deep learning presents a new way of imitating the human brain functionality in representing information.
- It is an innovative area in the artificial intelligence research which aims to decipher complex data representation method adopted by the human brain for decades.
- Deep learning approaches such as:
  - deep neural networks (DNN),
  - convolutional deep neural networks (CDNN),
  - stacked auto encoders (SA),
  - deep belief networks (DBN) take their roots from neural networks.
- 'Deep' refers to several layers stacked on top of each other.
- A deep learning architecture is constructed by stacking layers each of which is supposed to extract higher level representations, i.e. features.

Deep Belief Network (DBN) Structure

Convolutional Neural Networks (CNN)

Convolutional Neural Networks (CNN)

HRCT images for the study

The dataset is provided by Sørensen (2010)

Patches

6x61 patches from HRCT (a) NT (b) CLE (c) PSE
Caffe Deep Learning Framework

- Caffe is a fast open-source framework to implement the fastest CNNs and developed by the Berkeley Vision group in 2012.
- It supports a wide variety of architectures and efficient implementations vital machine learning tasks such as prediction and learning.
- It provides state-of-the-art deep learning models for research projects.
- It is designed to be a C++ library but it has bindings for other programming languages such as Python and Matlab.
- Caffe provides means to use both GPU and CPU processing in a parallel fashion.
- High speed is achieved by Compute Unified Device Architecture (CUDA) which is capable of processing over 40 million images in a day with a single K40 or Titan GPU (approximately 2 ms per image).

Parallel computing styles of CPU and GPU

GPU computing puts emphasis on parallel computing rather than higher processing unit performance.

CPU has low number of parallel units that are powerful in processing. However, parallelism outperforms powerful unit performance.

Experimental Results

- In these experiments, a computer with a CPU of 8 cores each at 2.3 GHz is utilized. Also CUDA GPU acceleration is enabled by use of the graphic processor (GeForce 840M with 384 CUDA cores at 1029 MHz clock speed). Ubuntu Linux is the host operating system on which the experiments are conducted.
- Since 61x61 pixel images are used, the network has 3721 (=61x61) input neurons.
  - The dataset is split into two parts for training and testing.
  - Training is achieved via 138 out of 168 patches and the remaining 30 patches are for testing purposes.
  - The network parameters used in model are such that; learning rate is 0.0001, momentum 0.9, weight decay 0.0005, and solver mode is a flag that can be switched to CPU or GPU.
  - Training is achieved via 138 out of 168 patches and the remaining 30 patches are for testing purposes.
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CPU vs. GPU computing time

<table>
<thead>
<tr>
<th>Iterations</th>
<th>CPU</th>
<th>GPU</th>
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<tbody>
<tr>
<td>100</td>
<td>2.09</td>
<td>0.00</td>
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<tr>
<td>200</td>
<td>6.63</td>
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<tr>
<td>300</td>
<td>10.9</td>
<td>0.00</td>
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<tr>
<td>400</td>
<td>15.5</td>
<td>0.00</td>
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<tr>
<td>500</td>
<td>20.3</td>
<td>0.00</td>
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<tr>
<td>600</td>
<td>25.0</td>
<td>0.00</td>
</tr>
<tr>
<td>700</td>
<td>30.0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Conclusions

- Emphysema recognition from HRCT scans requires high level anatomical knowledge of a physician that must be supported by automated computer recognition.
- In literature emphysema is researched in detail and many computer based solutions are presented.
- But the result of direct classification results don’t take place in most of them. The model are used together with texture analysis preprocessing.
- Differently, we directly processed raw HRCT images in order to emphasize the classification performance of CNN. To our knowledge we gained the best comparing in this kind of studies.
References


