A comparative study of deep learning based methods for MRI image processing

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Deep Learning for Computer Vision and Natural Language Processing
EECS 6894

Introduction
Articles
Motivation
Medical background
Neurological Diseases
MRI
Image processing pipeline
Datasets
Preprocessing
Random Forest for Classification
Results

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Articles

Deep Learning for Cerebellar Ataxia Classification and Functional Score Regression
Zhen Yang, Shenghua Zhong, Aaron Carass, Sarah H. Ying, and Jerry L. Prince
Johns Hopkins University

Deep Learning of Image Features from Unlabeled Data for Multiple Sclerosis Lesion Segmentation
Youngjin Yoo, Tom Brosch, Anthony Traboulsee, David K.B. Li, and Roger Tam
University of British Columbia

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Motivation

- MRI data
- Deep Learning + Machine Learning
- Different goals and barriers while same data type, hence a comparative study
  - Data description
  - Preprocessing
  - Methods and Algorithms used
  - Results
- Project: Diabetic Retinopathy Detection
- Personal reasons

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Ataxia

Overview *A neuro-degenerative disease*
- Affects the cerebellum
- Symptoms: lack of muscular coordination

https://www.youtube.com/watch?v=5eBwn22Bnio

Goals:
Classify different types of Ataxia: HC, SCA2, SCA6, AT
Quantify functional loss based on structural change

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Multiple sclerosis

Overview *A inflammatory disease*
- Brain cells damaged: Demyelination
- Symptoms: Mental, Physical, Psychatric troubles
- Cause: Genetic? Environmental factors?

https://www.youtube.com/watch?v=qgySDmRRzxY

Goals:
Automatic segmentation of lesionned areas

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MRI imaging

- Human body composed of small magnets
- Magnets aligned then excited by pulses
- Magnets go back to their lowest energy state, electromagnetic waves emitted
- Processing of these waves enable to reconstruct 3D structure, differentiate muscles tissues from fat, white matter from grey matter in the brain

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MRI imaging

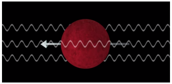

Figure: Initial state

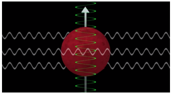

Figure: Excitation

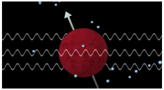

Figure: Energy emission

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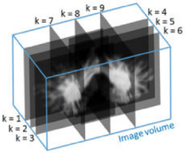
Datasets

Ataxia

- 168 scans
- 3D Images projected on 9 plans (Resulting in 32 * 32 images)



Not enough labelled data ⇒ Interest of generating synthetic data

Multiple Sclerosis

- 1450 scans
- Resolution 256 * 256 * 50
- Only 100 scans segmented

Lot of unlabelled data ⇒ Interest of unsupervised methods

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Preprocessing

Ataxia

- 3D Images projected on 9 plans (Resulting in 32 * 32 images)
- Generate translated and rotated images
- Reduce dimensions using a Stacked Auto-Encoder for each plan

Multiple Sclerosis

- Images of resolution 256 * 256 * 50
- Patches 9 * 9 * 3 (low-scale features)
  $\Rightarrow$ Train Restricted Boltzmann Machines for feature extraction
- Patches 15 * 15 * 5 (high-scale features)
  $\Rightarrow$ Train Deep Belief Network for feature extraction

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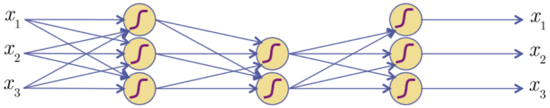
Stacked Auto-Encoder



- Target vector is the output
- Along the way, compression of the data
- Trained layer after layer (greedy)

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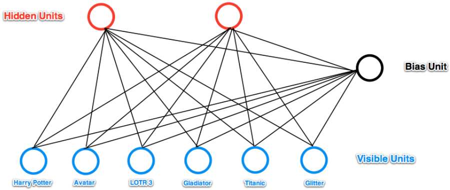
Restricted Boltzman Machines

- Visible and Hidden Units

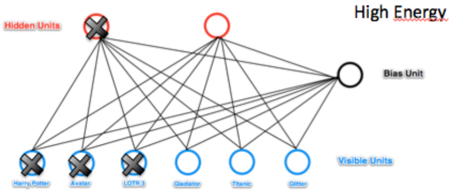


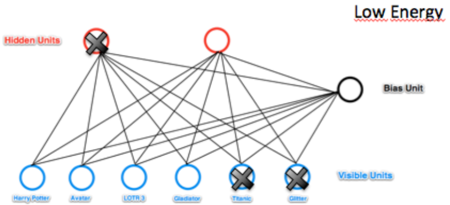
- Energy Based Method

$$E(v, h) = -v^T Wh - a^T v - b^T h$$

$$P(v, h) = \frac{1}{Z} e^{-E(v,h)}$$

Restricted Boltzman Machines





Restricted Boltzman Machines

How to train RBM ? [Hinton 2002]

- Generate hidden units from visible units
- Generate visible units from these very hidden units
- Update weight:

$$\Delta W_{i,j} = \alpha(< v_j, h_i >_{input} - < v_j, h_i >_{generateddata})$$

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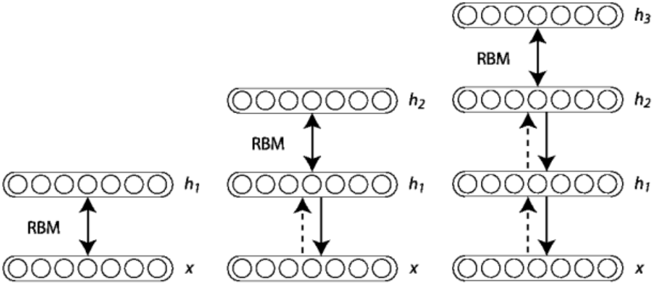
Deep Belief Networks [Hinton 2009]



- Stacked RBMs
- Greedy training

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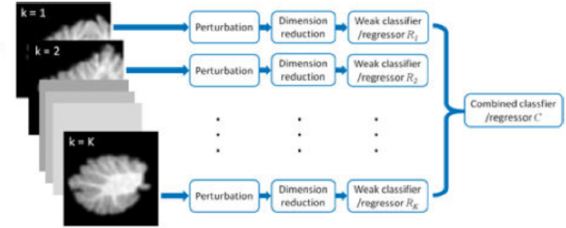
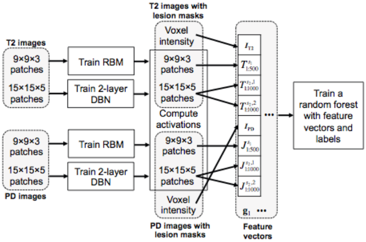
Classification

Ataxia

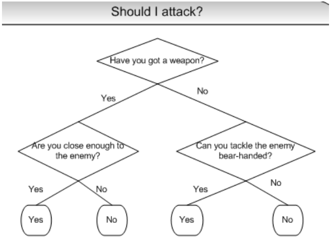


Multiple Sclerosis



Random Forests

- Bagging Data
- Selecting Features
- Generate Decision Tree



Averaging all the decision trees $\Rightarrow$ Classifier

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Results

Ataxia

Method	Error rate (%)
ROI volume PCA	16.25 ± 8.44
Image PCA	16.25 ± 11.86
Log-Jacobian PCA	22.50 ± 15.37
Proposed method with PCA	15.00 ± 11.49
Proposed method with SAE	13.75 ± 12.43

Multiple Sclerosis

Dice Similarity Measure:

Q : Lesionned voxels (manually segmented)

P : Lesionned voxels (automatically segmented)

$$d = \frac{2|Q \cap P|}{|Q| + |P|}$$

Weiss (state of the art) : mean 29, std 13

Method: mean 38, std 19

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Thank you for your attention !

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