A deep learning guide to MICCAI 2015

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Deep learning activities

- MICCAI 2015 Tutorial

- Deep learning for medical imaging https://sites.google.com/site/skevinzhou/teaching/tutorials/miccai2015

- MICCAI 2015 Main Conference (23 papers vs 4 papers MICCAI2014)

- MICCAI 2015 Workshops

- DLMIA: Deep learning in Medical Image Analysis: From Random Search to Optimization Heuristics
- MLMI: Machine Learning in Medical imaging
- MCV: Medical Computer Vision: Algorithms for Big Data

Tutorial Agenda: Deep learning for medical imaging

Introduction to Neural Network and Deep Learning

8:30 – 9:30am Theories & Practices

Prof. Heung-Il Suk, Korea University, Korea

Plenary Talk

9:30 – 10:30am Deep Learning History

Prof. Juergen Schmidhuber, IDSIA, Switzerland

Coffee Break

10:30 – 11:00am

Invited Talks on Deep Learning for Medical Imaging

11:00 – 11:30am Deep Learning Applications to Medical Image Analysis

Prof. Dinggang Shen, Univ. of North Carolina, USA

11:30 – 12:00pm Chest Radiograph Categorization with Deep Feature Selection

Prof. Hayit Greenspan, Tel Aviv University, Isreal

12:00 – 12:30pm From DBNs to Deep ConvNets: Pushing the State of the Art in Medical Image Analysis

Prof. Gustavo Carneiro, University Adelaide, Australia

Main conference

1. q-Space Deep Learning for Twelve-Fold Shorter and Model-Free Diffusion MRI Scans
2. Automatic Fetal Ultrasound Standard Plane Detection Using Knowledge Transferred Recurrent Neural Networks
3. Automatic Localization and Identification of Vertebrae in Spine CT via a Joint Learning Model with Deep Neural Networks
4. DeepOrgan: Multi-level Deep Convolutional Networks for Automated Pancreas Segmentation
5. 3D Deep Learning for Efficient and Robust Landmark Detection in Volumetric Data
6. A Hybrid of Deep Network and Hidden Markov Model for MCI Identification with Resting-State fMRI
7. Automatic Coronary Calcium Scoring in Cardiac CT Angiography Using Convolutional Neural Networks
8. Deep Learning and Structured Prediction for the Segmentation of Mass in Mammograms
9. Cross-Domain Synthesis of Medical Images Using Efficient Location-Sensitive Deep Network
10. Marginal Space Deep Learning: Efficient Architecture for Detection in Volumetric Image Data
11. Vito – A Generic Agent for Multi-physics Model Personalization: Application to Heart Modeling

Main conference

1. Detection of Glands and Villi by Collaboration of Domain Knowledge and Deep Learning
2. Ultrasound-Based Detection of Prostate Cancer Using Automatic Feature Selection with Deep Belief Networks
3. Computer-Aided Pulmonary Embolism Detection Using a Novel Vessel-Aligned Multi-planar Image Representation and Convolutional Neural Networks
4. Deep Convolutional Encoder Networks for Multiple Sclerosis Lesion Segmentation
5. Neutrophils Identification by Deep Learning and Voronoi Diagram of Clusters
6. U-Net: Convolutional Networks for Biomedical Image Segmentation
7. A Novel Cell Detection Method Using Deep Convolutional Neural Network and Maximum-Weight Independent Set
8. Beyond Classification: Structured Regression for Robust Cell Detection Using Convolutional Neural Network
9. Deep Voting: A Robust Approach Toward Nucleus Localization in Microscopy Images
10. Unregistered Multiview Mammogram Analysis with Pre-trained Deep Learning Models
11. Automatic Feature Learning for Glaucoma Detection Based on Deep Learning
12. Fast Automatic Vertebrae Detection and Localization in Pathological CT Scans - A Deep Learning Approach

Workshop: DLMIA

- [DLMIA-O-1] Multi-scale Structured CNN with Label Consistency for Brain MR Image Segmentation.
- [DLMIA-O-2] Convolutional Networks for Kidney Segmentation in Contrast-Enhanced CT Scans
- [DLMIA-O-3] Deep Similarity Learning for Multimodal Medical Images
- Keynote Talk: Deep Learning: State of the Art
- [DLMIA-O-4] Microscopy Cell Counting with Fully Convolutional Regression Networks
- [DLMIA-P-1] Computational Mammography using Deep Neural Networks.
- [DLMIA-P-2] Holistic Classification of CT Attenuation Patterns for Interstitial Lung Diseases via Deep Convolutional Neural Networks.
- [DLMIA-P-3] Convolutional Neural Networks for Real-Time Epileptic Seizure Detection.
- [DLMIA-P-4] Chest Pathology Identification using Deep feature selection with Non-Medical Training.
- [DLMIA-P-5] An Analysis of Robust Cost Functions for Deep CNN in Computer-Aided Diagnosis.
- [DLMIA-P-6] A Resolution Adaptive Hierarchical Deep Learning Scheme Applied to Nuclear Segmentation in Histology Images.

Workshop

- [MCV] Structured Prediction with Convolutional Neural Networks for Multimodal Brain Tumor Segmentation

- [MLMI] HEp-2 Staining Pattern Recognition Using Stacked Fisher Network for Encoding Weber Local Descriptor
- [MLMI] Tumor Classification by Deep Polynomial Network and Multiple Kernel Learning on Small Ultrasound Image Dataset
- [MLMI] Deep Learning, Sparse Coding, and SVM for Melanoma Recognition in Dermoscopy Images
- [MLMI] Hierarchical Multi-modal Image Registration by Learning Common Feature Representations

Research Directions

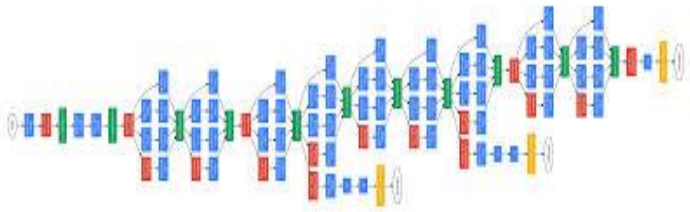
- **Network**
- Deeper with more layers, convolution 3x3
- Better initialization
- Speed
- Data augmentation

- **Joint learning , end-to-end formulation**
- Embed CNN as a part of the overall formulation (e.g., CRF, SSVM)
- Solving segmentation, registration, etc.

- **Recurrent Neural Network / LSTM for image**
- Parallel Multi-Dimensional LSTM

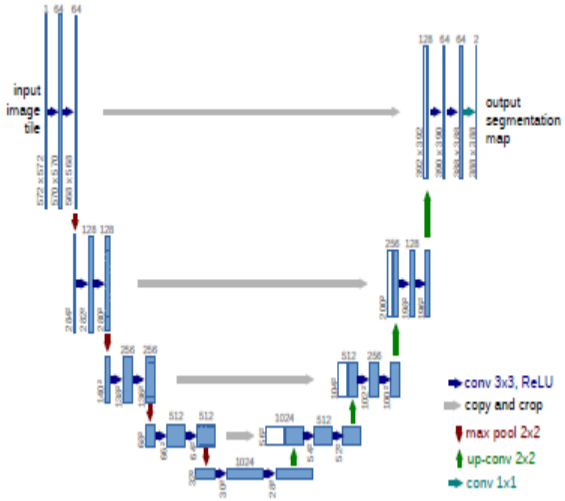
- **Reinforcement learning for search/control**
- - VITO

Deeper network



GoogleNet: Christian Szegedy et al, Going deeper with convolutions, CVPR 2015

ConvNet Configuration					
A	A-LRN	B	C	D	E
11 weight layers	11 weight layers	13 weight layers	16 weight layers	16 weight layers	19 weight layers
input (224 × 224 RGB image)					
conv3-64	conv3-64 LRN	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64
maxpool					
conv3-128	conv3-128	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128
maxpool					
conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256 conv1-256	conv3-256 conv3-256 conv3-256	conv3-256 conv3-256 conv3-256
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 conv1-512	conv3-512 conv3-512 conv3-512	conv3-512 conv3-512 conv3-512
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 conv1-512	conv3-512 conv3-512 conv3-512	conv3-512 conv3-512 conv3-512
maxpool					
FC-4096					
FC-4096					
FC-1000					
soft-max					

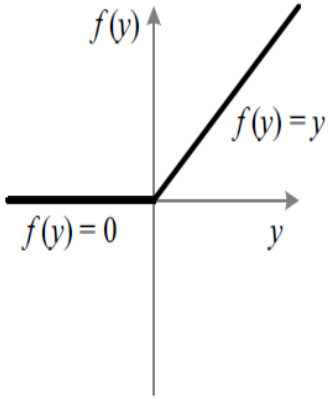


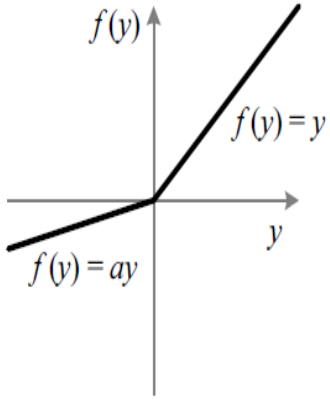
U-net (23 conv layers)

VGG (19 conv layer +3 fc layers)
Karen Simonyan and Andrew Zisserman, VERY DEEP CONVOLUTIONAL NETWORKS FOR LARGE-SCALE IMAGE RECOGNITION, ICLR 2015

Weight initialization

X. Glorot and Y. Bengio. Understanding the difficulty of training deep feedforward neural networks. In International Conference on Artificial Intelligence and Statistics, pages 249–256, 2010.





zero-mean Gaussian distribution with std $\sqrt{(1/n_l)}$

zero-mean Gaussian distribution with std $\sqrt{(2/((1+a^2)n_l))}$

Kaiming He Xiangyu Zhang Shaoqing Ren Jian Sun. Delving Deep into Rectifiers: Surpassing Human-Level Performance on ImageNet Classification, arXiv 2015.

4.94% top-5 error

Speed

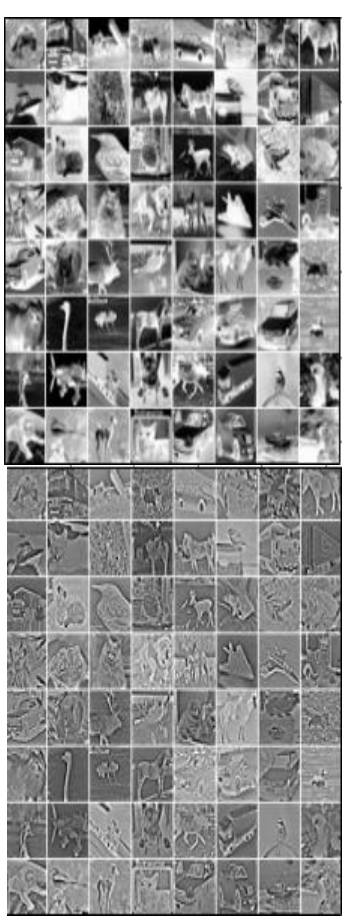
- **Sparse approximation**
- Tensor
- DropConnect
- Sparse image pattern

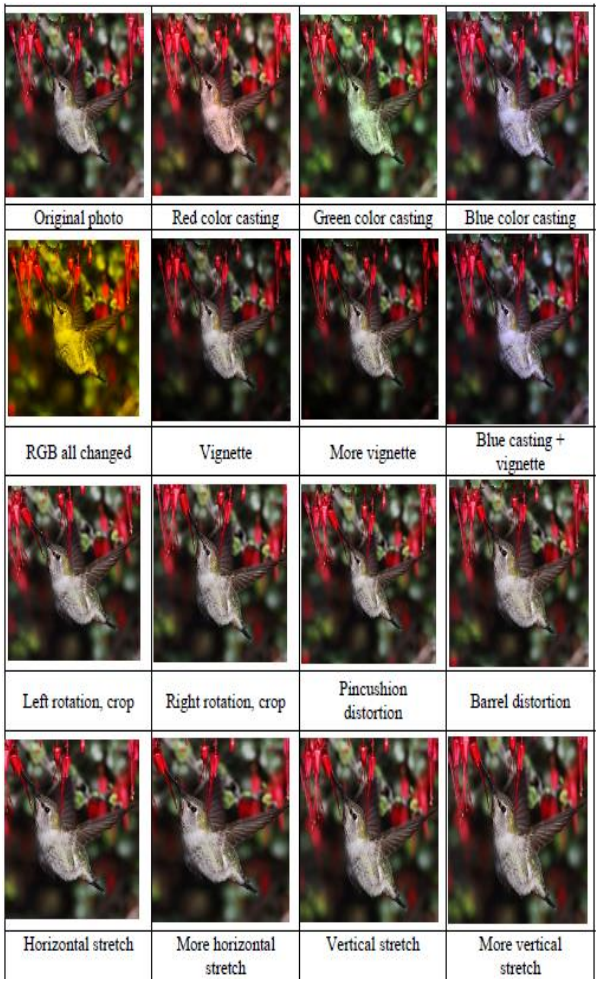
- 3D Deep Learning for Efficient and Robust Landmark Detection in Volumetric Data
- Cross-Domain Synthesis of Medical Images Using Efficient Location-Sensitive Deep Network
- Marginal Space Deep Learning: Efficient Architecture for Detection in Volumetric Image Data

Data augmentation

- **Geometric transformation**
- Affine: random cropping, scaling
- Deformation
- Graphics algorithms (lens distortion)

- **Photometric transformation**
- Zero mean unit variance
- ZCA whitening
- Graphics algorithms (color casting, vignetting)



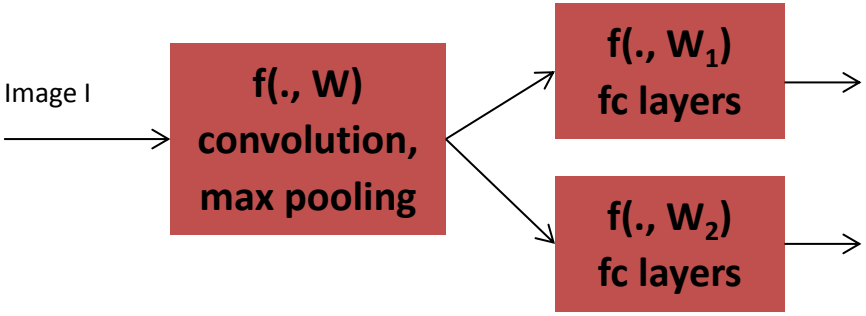


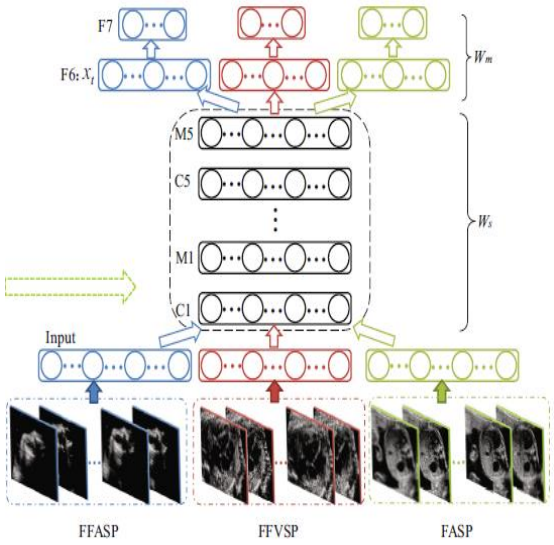
Deep Image: Scaling up Image Recognition
Ren Wu et al. Baidu Research, arXiv, 2015

- Benchmarks on various fine-grained classification tasks
- 4.58% ImageNet top-5

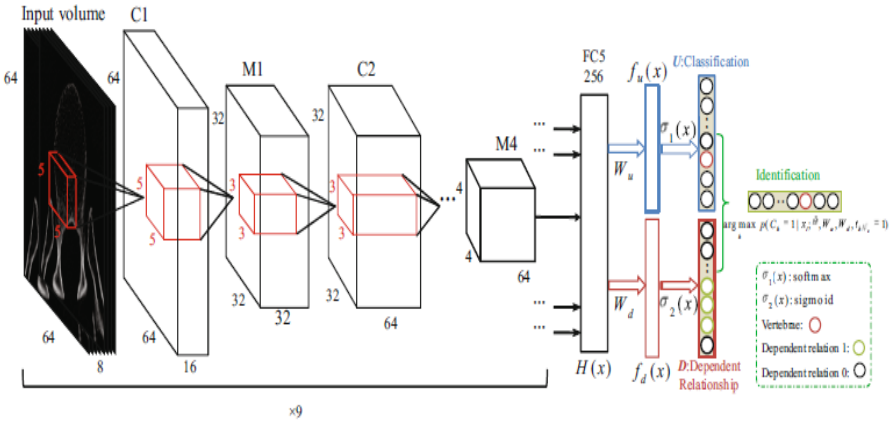
http://stats.stackexchange.com/questions/117427/what-is-the-difference-between-zca-whitening-and-pca-whitening

Joint learning, end-to-end formulation



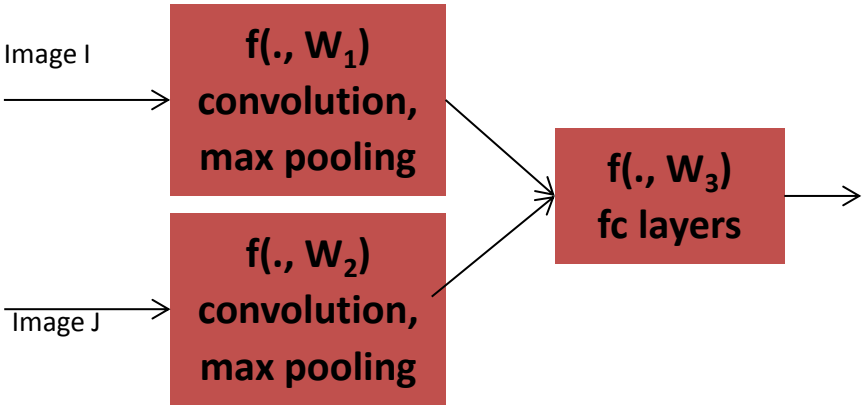


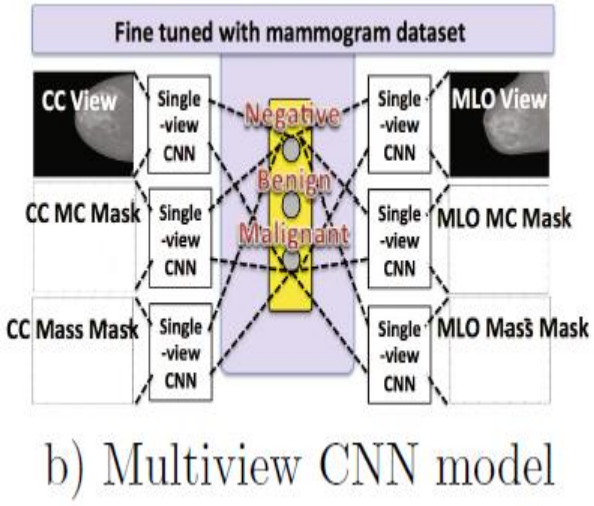
Automatic Fetal Ultrasound Standard Plane Detection Using Knowledge Transferred Recurrent Neural Networks



Automatic Localization and Identification of Vertebrae in Spine CT via a Joint Learning Model with Deep Neural Networks

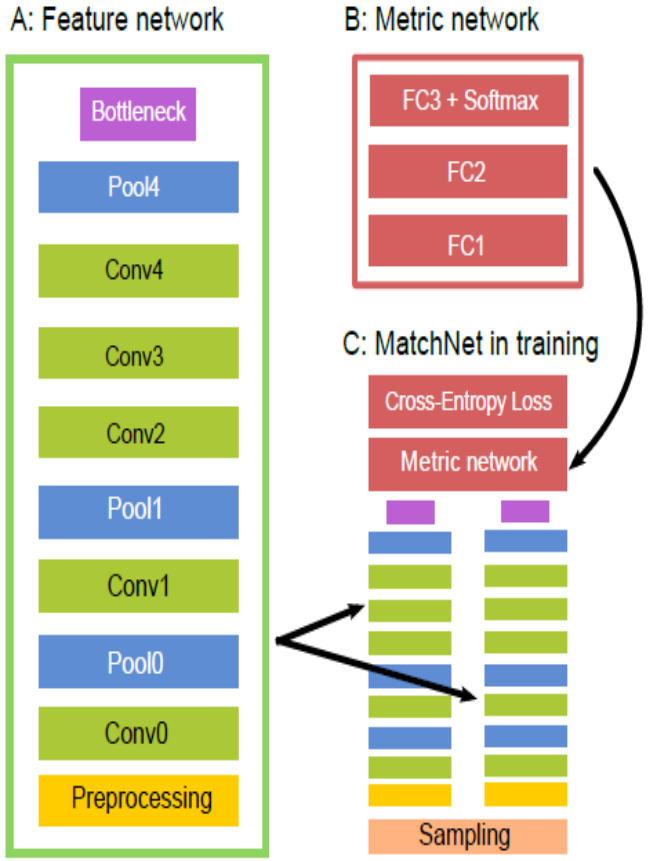
Joint learning, end-to-end formulation





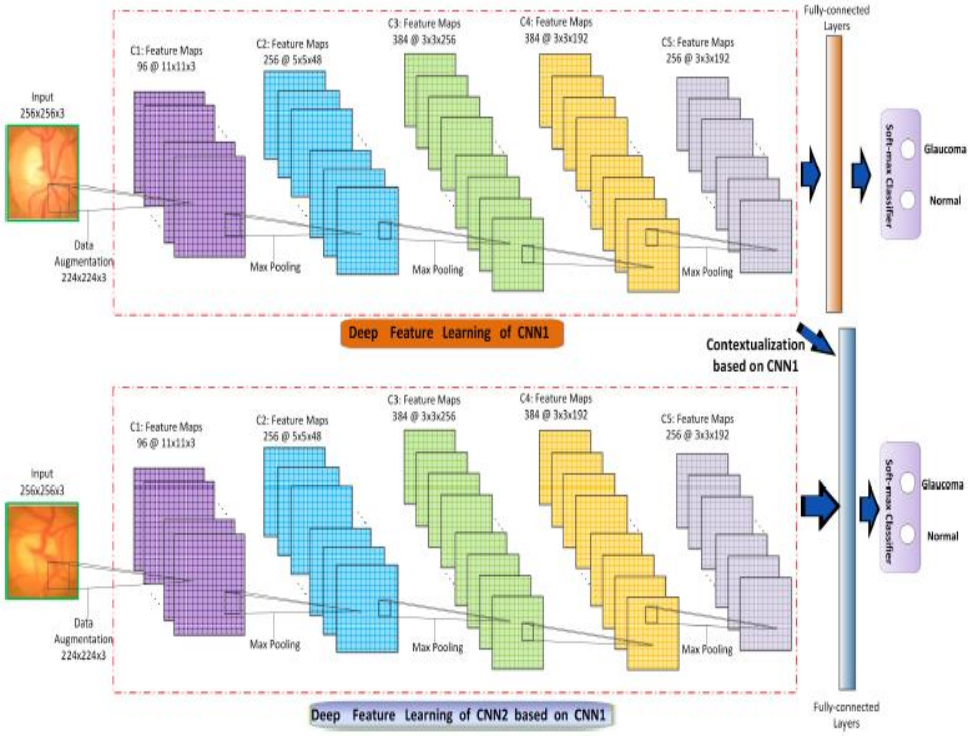
b) Multiview CNN model

Unregistered Multiview Mammogram Analysis with Pre-trained Deep Learning Models

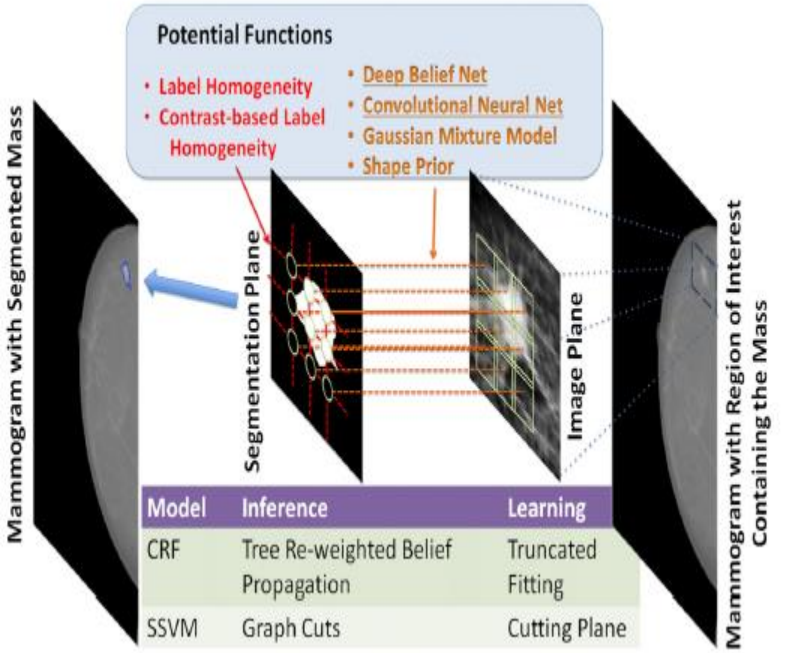


MatchNet: Unifying Feature and Metric Learning for Patch-Based Matching

Joint learning, end-to-end formulation

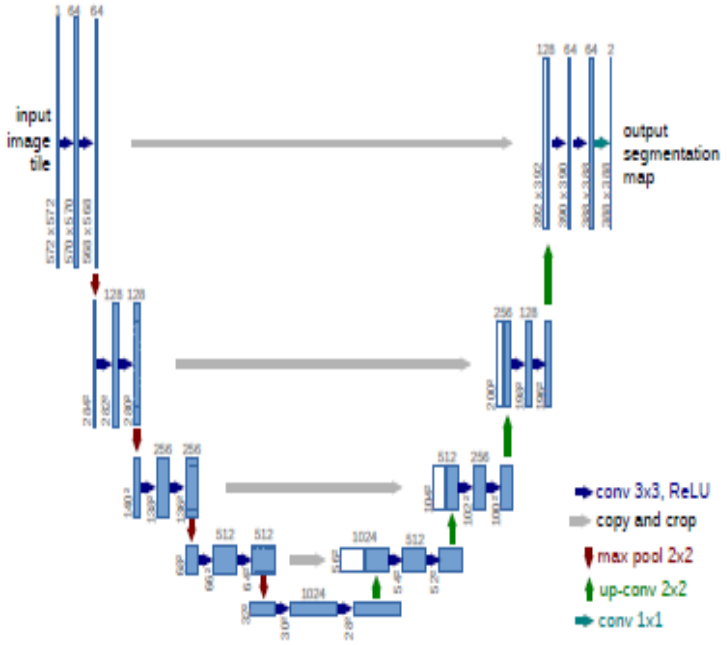


Automatic Feature Learning for Glaucoma Detection

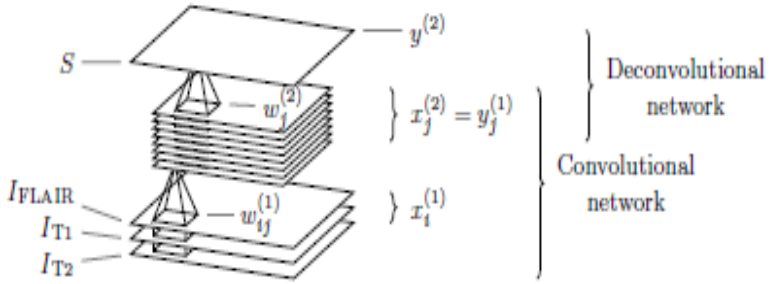


Deep Learning and Structured Prediction for the Segmentation of Mass in Mammograms

End-to-end for segmentation

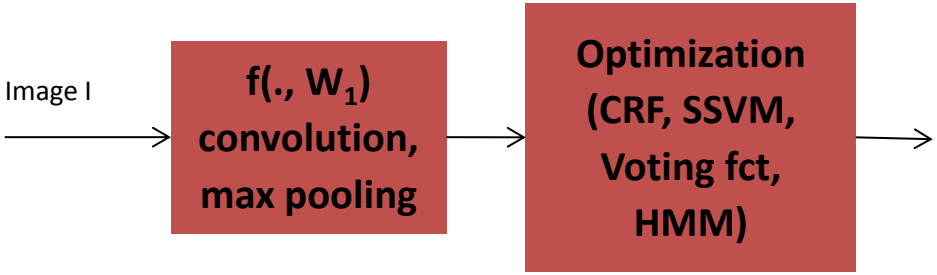


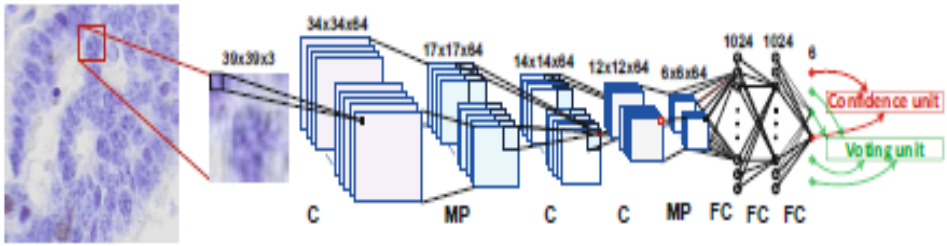
U-net (23 conv layers)



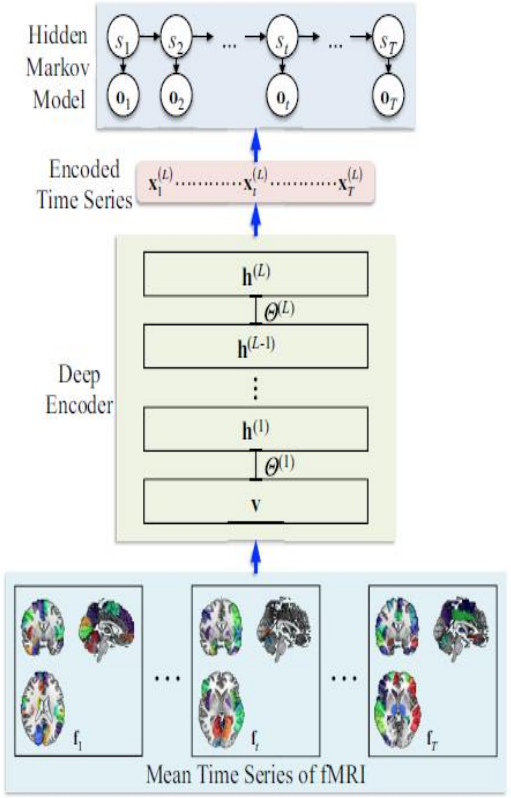
Deep Convolutional Encoder Networks for Multiple Sclerosis Lesion Segmentation

Joint learning, end-to-end formulation





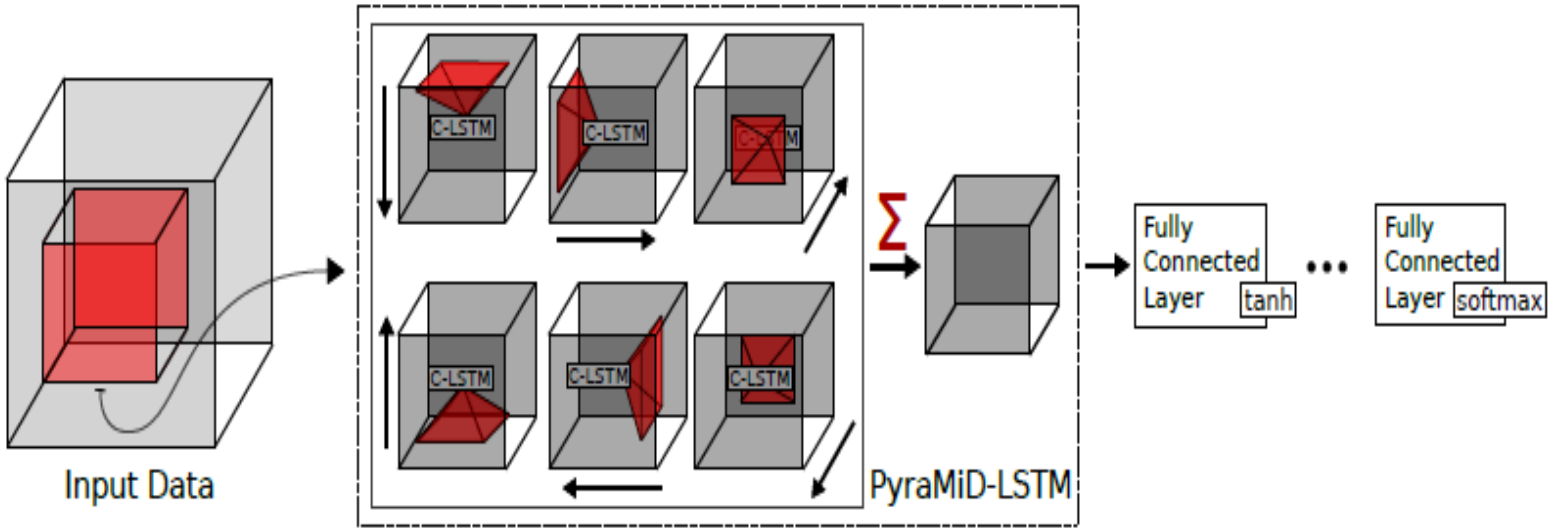
Deep Voting: A Robust Approach Toward Nucleus Localization in Microscopy Images



A Hybrid of Deep Network and Hidden Markov Model

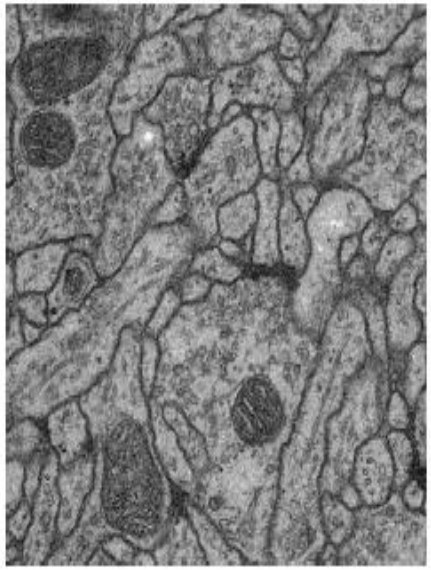
Parallel Recurrent Neural Network / LSTM for image analysis

- Perceive the entire spatial context.



M. Stollenga, W. Beyon, M. Liwicki, J. Schmidhuber. Parallel Multi-Dimensional LSTM, With Application to Fast Biomedical Volumetric Image Segmentation. Advances in Neural Information Processing Systems (NIPS), 2015

Neuronal Membrane Segmentation (ISBI Challenge)



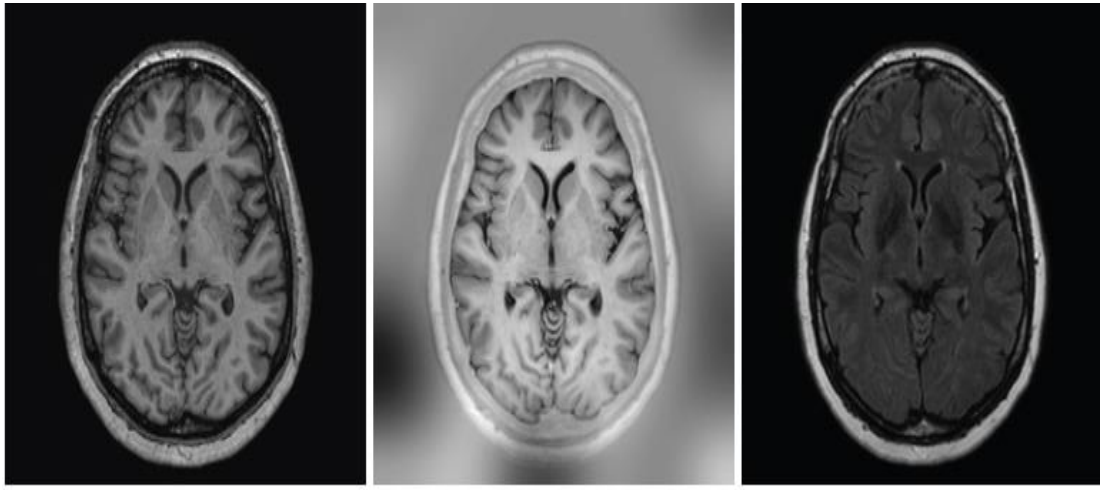
(a) Input

(b) PyraMiD-LSTM

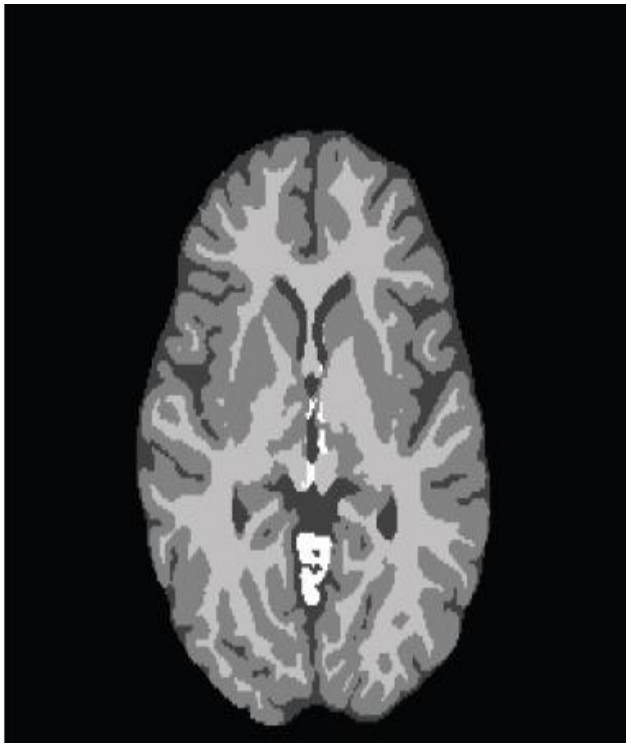
Leading Groups

Group name	Rand Error	Warping Error	Pixel Error
** human values **	0.002109173	0.000005341	0.001041591
CUMedVision	0.017334163	0.000000000	0.057953485
DIVE-SCI	0.017841947	0.000307083	0.058436986
IDSIA-SCI	0.018919792	0.000616837	0.102692786
optree-idsia	0.022777620	0.000807953	0.110460288
motif	0.026326384	0.000426483	0.062739851
SCI	0.028054308	0.000515747	0.063349324
Image Analysis Lab Freiburg	0.038225781	0.000352859	0.061141279
Connectome	0.045905709	0.000478999	0.062029263
PyraMiD-LSTM	0.046704591	0.000462341	0.061624006
DIVE	0.047680695	0.000374222	0.058205303
IDSIA	0.050399038	0.000420380	0.061338666
INI	0.060110507	0.000495529	0.068537199

MR Brain Segmentation (ISBI NEATBrain15 challenge)

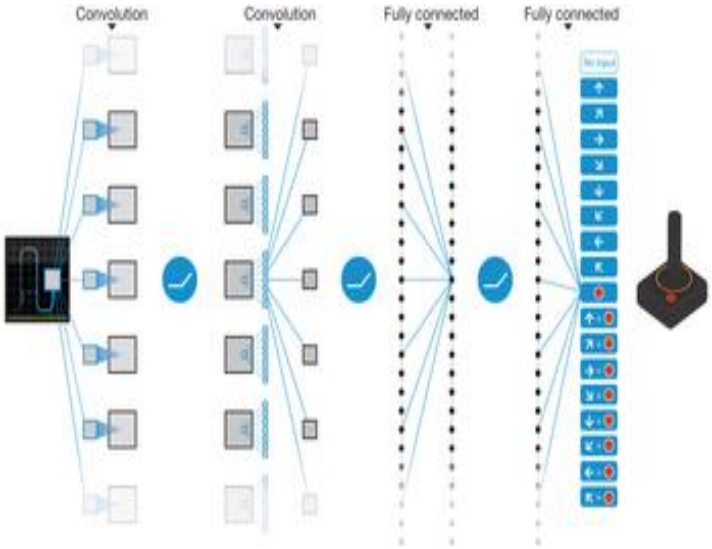


(a) T1 (b) IR (c) FLAIR



Reinforcement learning

Human-level control through deep reinforcement learning. Nature 518(7540), 529–533 (2015)



Vito – A Generic Agent for Multi-physics Model Personalization: Application to Heart Modeling