

Deep Neural Networks

Dr. Debdoot Sheet

Assistant Professor, Department of Electrical Engineering
Principal Investigator, Kharagpur Learning, Imaging and Visualization Group
Indian Institute of Technology Kharagpur

www.facweb.iitkgp.ernet.in/~debdoot/



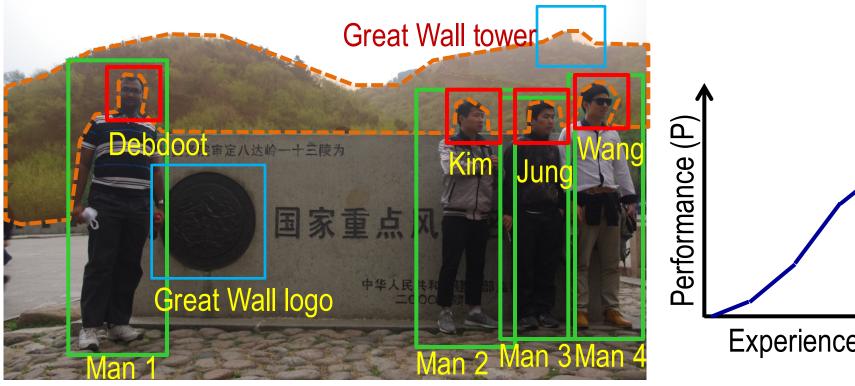
Learning?

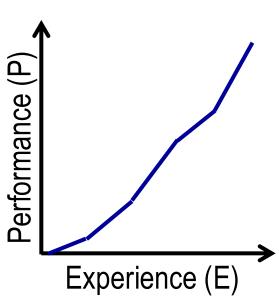
A computer program is said to **learn** from **experience E** with respect to some class of **tasks T** and performance **measure P**, if its performance at tasks in **T**, as measured by **P**, improves with experience **E**

-Tom Mitchell



Demystifying Learning

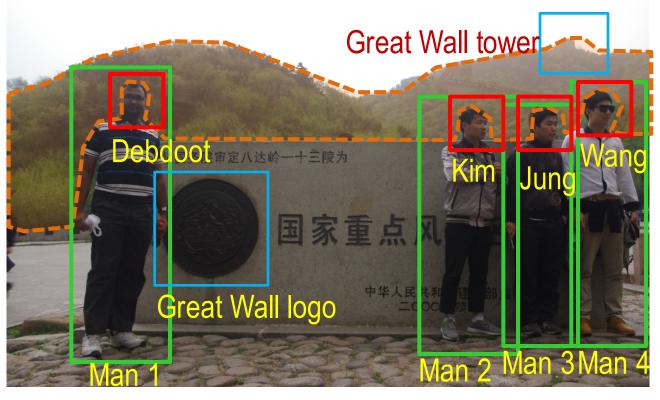




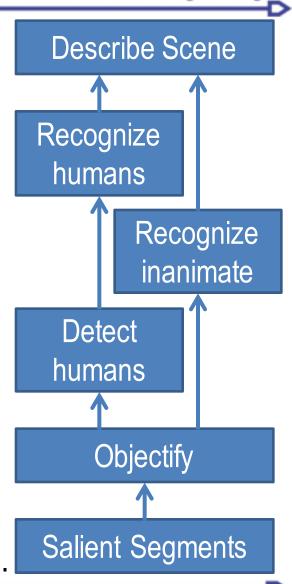
Debdoot, Kim, Jung and Wang are standing near the Great Wall logo and the Great Wall tower is behind them.



How was it Learning?

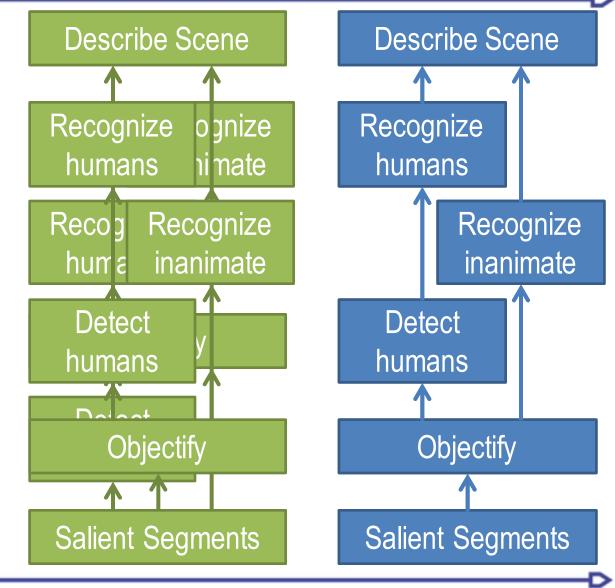


Debdoot, Kim, Jung and Wang are standing near the Great Wall logo and the Great Wall tower is behind them.

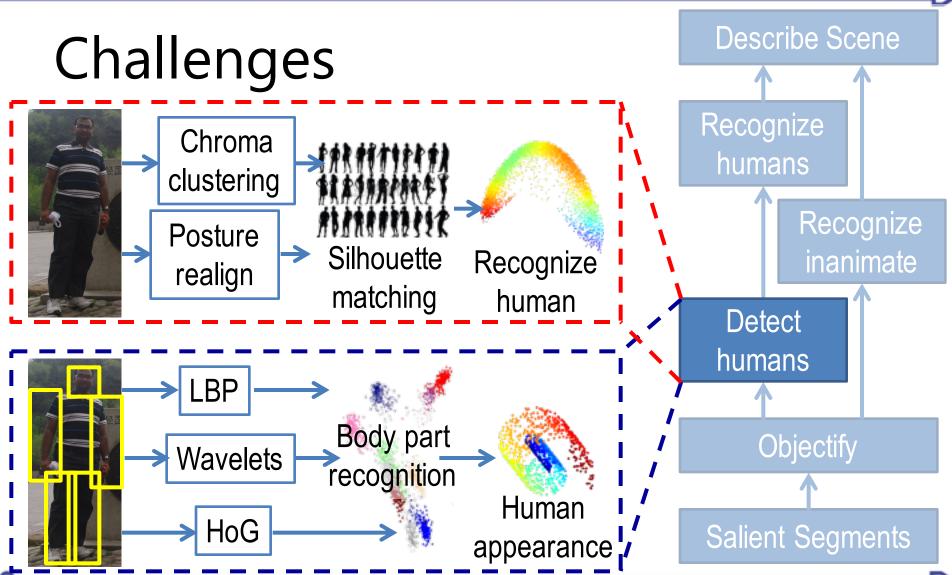




Challenges



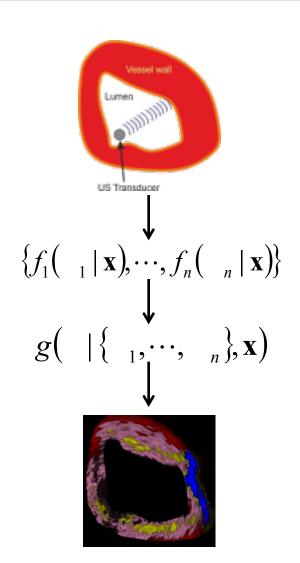






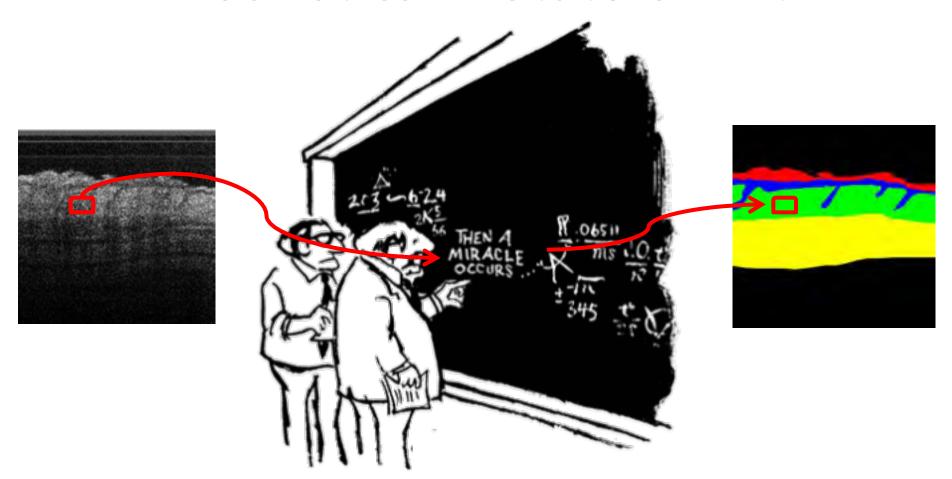
Sheet, Debdoot, et al. "Deep learning of tissue specific speckle representations in optical coherence tomography and deeper exploration for in situ histology." *IEEE 12th International Symposium on Biomedical Imaging (ISBI)*, 2015.

Deep Learning for COMPUTATIONAL MEDICAL IMAGING



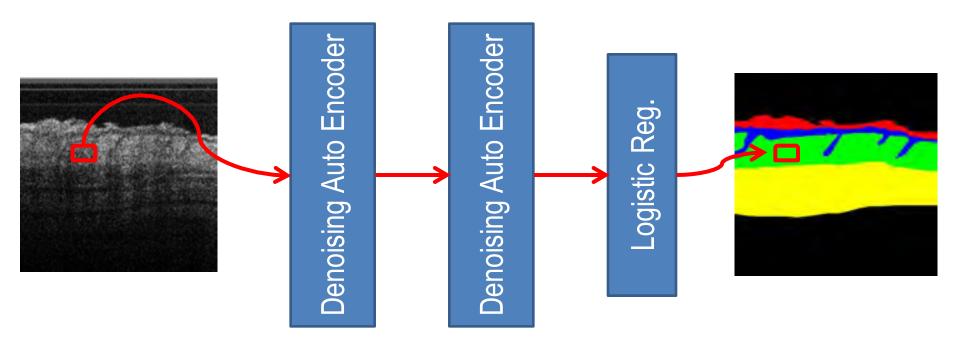


Heuristics in State of Art



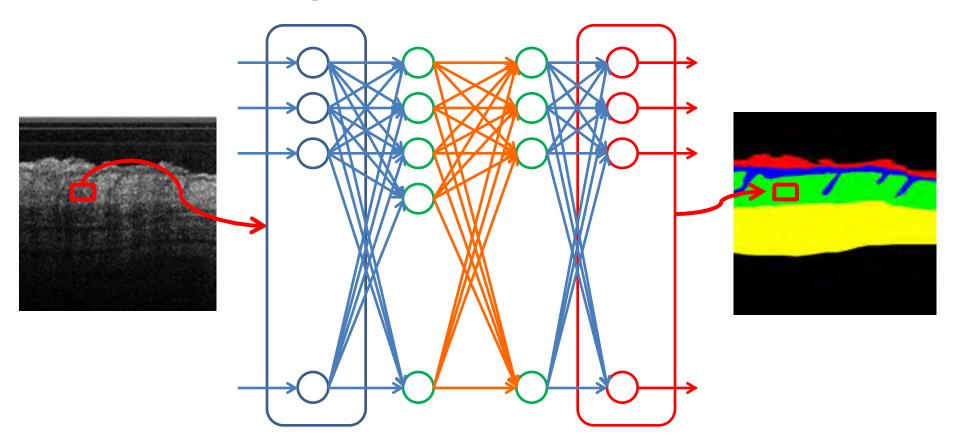


The Solution



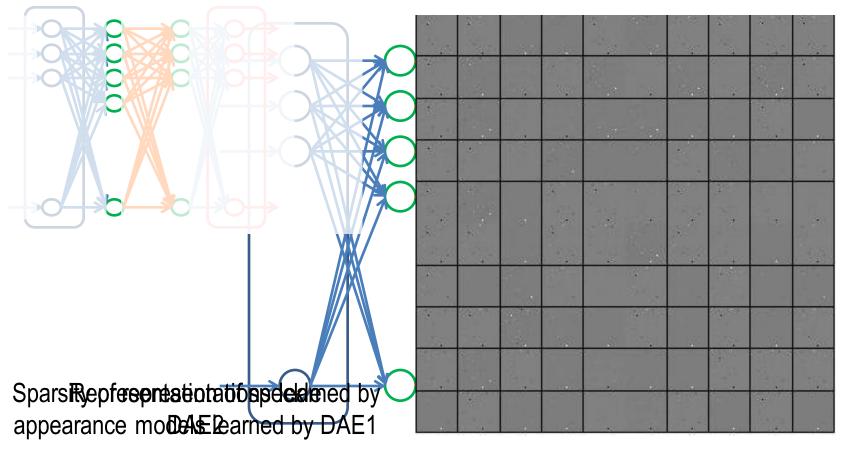


Using a Deep Network



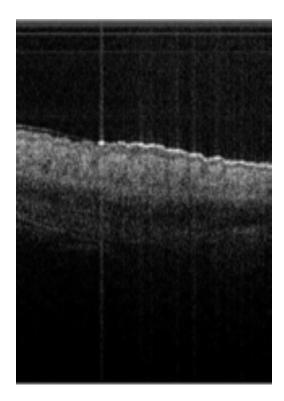


Learning of Representations

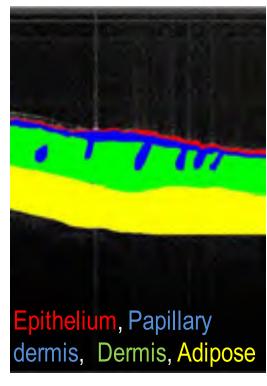




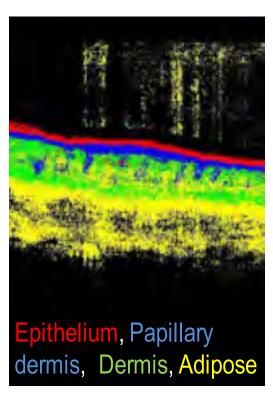
Results in Wounds



(a) OCT image of wound



(b) Ground truth



(c) In situ histology

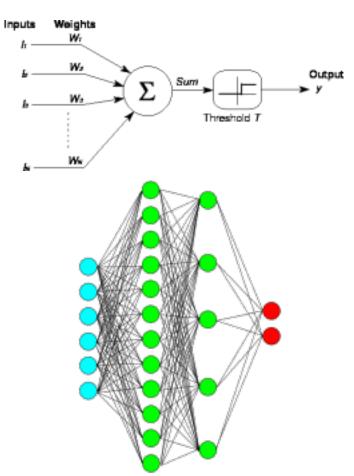


FAMILY HISTORY OF DEEP LEARNING



Deep Learning, origin and growth

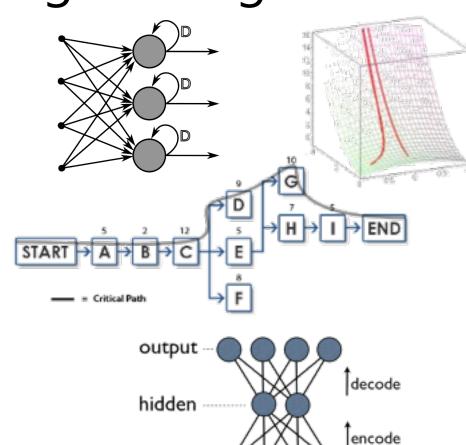
- Around 1950 NN age
 - Neural Nets (McCulloch and Pitts, 1943)
 - Unsupervised Learn. (Hebb, 1949)
 - Supervised Learn. (Rosenblatt, 1958)
 - Associative Memory (Palm, 1980; Hopfield, 1982)
- 1960
 - Discovery of visual sensory cells that respond to Edges (Hubel and Wiesel, 1962)
 - Feed Forward Multi Layer Perceptron (FF-MLP) (Ivakhnenko, 1968)
- 1980 Neocognition
 - Convolution + WeightReplication + Subsampling (Fukushima, 1980)
 - Max Pooling
 - Back-propagation (Werbos, 1981; LeCunn, 1985, 1988)





Deep Learning, origin and growth

- 1980-2000 Search for simple, low-complexity, problem-solvers
 - Recurrent Neural Network (RNN) (Hochreiter and Schmidhuber, 1996)
 - Local learning Feed forward NN (Dayan and Hinton, 1996)
 - Advanced gradient descent (Schaback and Werner, 1992)
 - Sequential Network Construction (Honavar and Uhr, 1988)
 - Unsupervised Pre-training (Ritter and Kohonen, 1989)
 - Auto-Encoder (Hinton et al., 1989)
 - Back Propagating Convolutional Neural Networks (LeCun et al., 1989, 1990a, 1998)

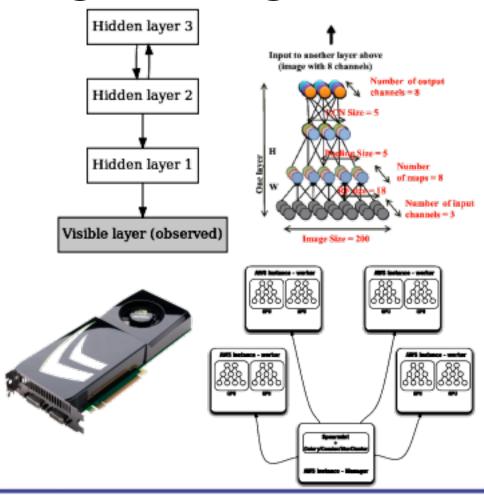


input



Deep Learning, origin and growth

- 2000 Era of Deep Learning
 - NIPS 2003 Feature Selection Challenge (Neal and Zhang, 2006)
 - MNIST digit recognition (LeCun et al., 1989)
 - Deep Belief Network (DBN) / Restricted Boltzmann Machines (Hinton et al., 2006)
 - Auto Encoders (Bengio, 2009)
- 2006
 - GPU based CNN (Chellapilla et al., 2006)
- 2009
 - GPU DBN (Raina et al., 2009)
- 2011
 - Max-Pooling CNN on the GPU (Ciresan et al., 2011)
- 2012
 - Image Net (Krizhevsky et al., 2012)





Families of Deep Learning

- Fully connected networks
 - Autoencoders
 - Autoencoders
 - Stacked Autoencoder
 - Sparse Autoencoder
 - Denoising Autoencoder
 - Convolutional Autoencoder
 - Belief Networks
 - Restricted Boltzmann Machines
 - Deep Belief Networks

- Convolutional Networks
 - Conv-Nets
 - LeNet, GoogLeNet, AlexNet
 - U-Nets
 - Res-Nets
- Recurrent Neural Networks
 - Long short-term memory (LSTM)

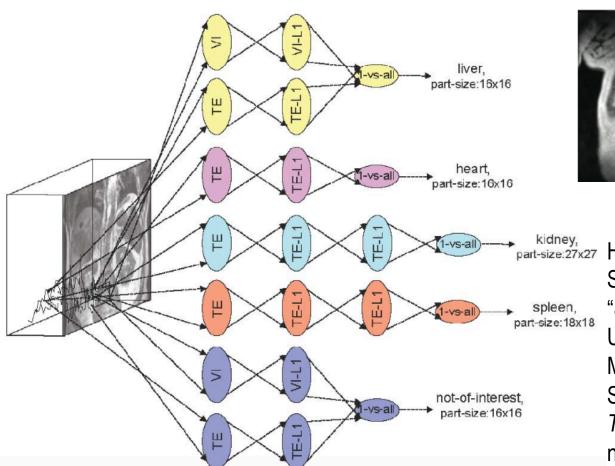


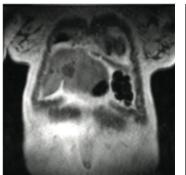
Medical Image Analysis with

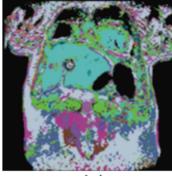
DEEP LEARNING TODAY



Organ Detection in MRI







H.-C. Shin, M. R. Orton, D. J. Collins, S. J. Doran, and M. O. Leach, "Stacked Autoencoders for Unsupervised Feature Learning and Multiple Organ Detection in a Pilot St., Study Using 4D Patient Data," *IEEE Trans. Pat. Anal. Mach. Intell.*, vol. 35, no. 8, pp. 1930-1943, Aug. 2013.

(Contents Continued from Front Cover)

Call for Papers: IEEE International Symposium on Biomedical Imaging . .

Call for Papers: IEEE-NIH 2016

Call for Papers: Wireless Health 2016 ...



IEEE Trans. Med. Imaging Spl. Issue

IEEE TRANSACTIONS ON

MEDICAL IMAGING

A PUBLICATION OF

THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY

THE IEEE NUCLEAR AND PLASMA SCIENCES SOCIETY

THE IEEE SIGNAL PROCESSING SOCIETY
THE IEEE ULTRASONICS, FERROELECTRICS, AND FREQUENCY CONTROL SOCIETY









Indexed in the National Library of Medicine, PubMed®, and MEDLINE



IIIMEDLINE

MAY 2016

VOLUME 35

NUMBER 5

ITMID4

(ISSN 0278-0062)

SPECIAL ISSUE ON DEEP LEARNING IN MEDICAL IMAGING

GUEST EDITORIAL	
Deep Learning in Medical Imaging: Overview and Future Promise of an Exciting New Technique	1153
SPECIAL ISSUE PAPERS	
Pulmonary Nodule Detection in CT Images: False Positive Reduction Using Multi-View Convolutional Networks A. A. A. Setio, F. Ciompi,	
G. Litjens, P. Gerke, C. Jacobs, S. J. van Riel, M. M. W. Wille, M. Naqibullah, C. I. Sánchez, and B. van Ginneken Improving Computer-Aided Detection Using Convolutional Neural Networks and Random View Aggregation	1160
H. R. Roth, L. Lu, J. Liu, J. Yao, A. Seff, K. Cherry, L. Kim, and R. M. Summers Automatic Detection of Cerebral Microbleeds From MR Images via 3D Convolutional Neural Networks	1170
Q. Dou, H. Chen, L. Yu, L. Zhao, J. Qin, D. Wang, V. C. Mok, L. Shi, and PA. Heng Locality Sensitive Deep Learning for Detection and Classification of Nuclei in Routine Colon Cancer Histology Images.	1182
K. Sirinukunwattana, S. E. A. Raza, YW. Tsang, D. R. J. Snead, I. A. Cree, and N. M. Rajpoot	1196
Lung Pattern Classification for Interstitial Lung Diseases Using a Deep Convolutional Neural Network	1207
Marginal Space Deep Learning: Efficient Architecture for Volumetric Image Parsing	1217
Deep 3D Convolutional Encoder Networks With Shortcuts for Multiscale Feature Integration Applied to Multiple Sclerosis Lesion Segmentation	1229

(Contents Continued on Back Cover)

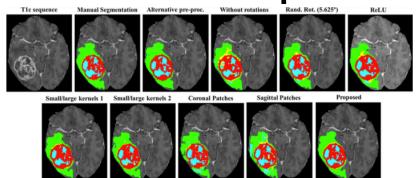
Brain Tumor Segmentation Using Convolutional Neural Networks in MRI Images S. Pereira, A. Pinto, V. Alves, and C. A. Silva Automatic Segmentation of MR Brain Images With a Convolutional Neural Network P. Moeskops, M. A. Viergever, A. M. Mendrik, L. S. de Vries, M. J. N. L. Benders, and I. Išgum Combining Generative and Discriminative Representation Learning for Lung CT Analysis With Convolutional Restricted Boltzmann Machines G. van Tulder and M. de Bruijne Fast Convolutional Neural Network Training Using Selective Data Sampling: Application to Hemorrhage Detection in Color Fundus Images M. J. J. P. van Grinsven, B. van Ginneken, C. B. Hoyng, T. Theelen, and C. I. Sánchez Deep Convolutional Neural Networks for Computer-Aided Detection: CNN Architectures, Dataset Characteristics and Transfer Learning ... H.-C. Shin, H. R. Roth, M. Gao, L. Lu, Z. Xu, I. Nogues, J. Yao, D. Mollura, and R. M. Summers Convolutional Neural Networks for Medical Image Analysis: Full Training or Fine Tuning? .. N. Tajbakhsh, J. Y. Shin, S. R. Gurudu, R. T. Hurst, C. B. Kendall, M. B. Gotway, and J. Liang AggNet: Deep Learning From Crowds for Mitosis Detection in Breast Cancer Histology Images .. S. Albarqouni, C. Baur, F. Achilles, V. Belagiannis, S. Demirci, and N. Navab Unsupervised Deep Learning Applied to Breast Density Segmentation and Mammographic Risk Scoring M. Kallenberg, K. Petersen, M. Nielsen, A. Y. Ng, P. Diao, C. Igel, C. M. Vachon, K. Holland, R. R. Winkel, N. Karssemeijer, and M. Lillholm Multi-Instance Deep Learning: Discover Discriminative Local Anatomies for Bodypart Recognition Z. Yan, Y. Zhan, Z. Peng, S. Liao, Y. Shinagawa, S. Zhang, D. N. Metaxas, and X. S. Zhou q-Space Deep Learning: Twelve-Fold Shorter and Model-Free Diffusion MRI Scans V. Golkov, A. Dosovitskiy, J. I. Sperl, M. I. Menzel, M. Czisch, P. Sämann, T. Brox, and D. Cremers A CNN Regression Approach for Real-Time 2D/3D Registration S. Miao, Z. J. Wang, and R. Liao ANNOUNCEMENTS

IEEE Trans. Med. Imaging, vol. 35, no. 9, May 2016

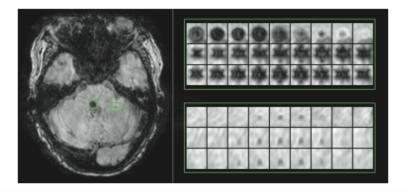


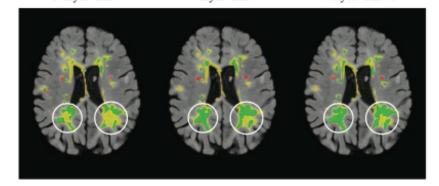


Some Snapshots from the Issue



S. Pereira, A. Pinto, V. Alves, and C. A. Silva, "Brain Tumor Segmentation Using Convolutional Neural Networks in MRI Images", *IEEE TMI*, vol. 35, no. 5, May 2016.





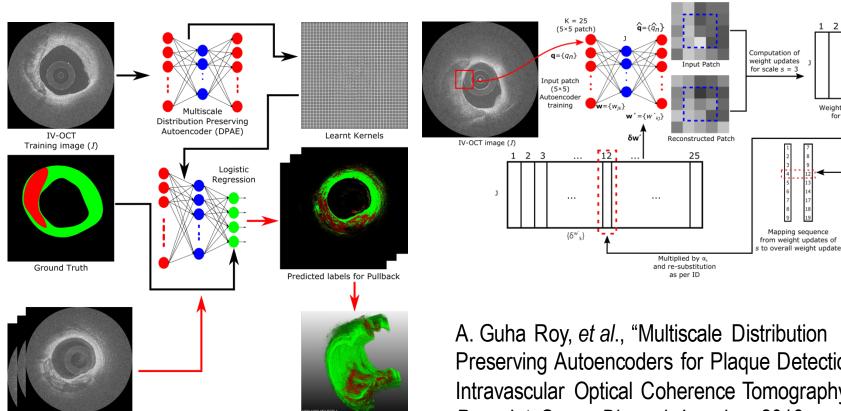
T. Brosch, et al., "Deep 3D Convolutional Encoder Networks With Shortcuts for Multiscale Feature Integration Applied to Multiple Sclerosis Lesion Segmentation", *IEEE TMI*, vol. 35, no. 5, May 2016.

Q. Dou, et al., "Automatic Detection of Cerebral Microbleeds From MR Images via 3D Convolutional Neural Networks", *IEEE TMI*, vol. 35, no. 5, May 2016.



Test IV-OCT Pullback

Distribution Preserving Autoencoders



Volumetric Visualisation of IV-OCT Pullback

A. Guha Roy, et al., "Multiscale Distribution Preserving Autoencoders for Plague Detection in Intravascular Optical Coherence Tomography", Proc. Int. Symp. Biomed. Imaging, 2016

1 2 3 4

Weight updates for the nodes for the specific scale s

matrix (ID)



Endnote (almost there)

"It's like in quantum physics at the beginning of the 20th century" *Trishul Chilimbi* (MSR, DNN, Adam)

"The experimentalists and practitioners were ahead of the theoreticians. They couldn't explain the results. We appear to be at a similar stage with DNNs. We're realizing the power and the capabilities, but we still don't understand the fundamentals of exactly how they work."



Take home message

- Hardware Resources
 - Custom workstations
 - GTX TITAN X / Tesla K40
 - GTX 1080 / GTX 1060
 - Deep Learning Box
 - NVIDIA DGX-1
- Toolboxes
 - Theano + Pylearn2 (Python)
 - Torch (Lua)
 - CUDA + DIGITS + cuDNN (NVIDIA)
 - Matlab DeepLearningToolbox (GitHub)
 - Matlab 2016 NN Toolbox
 - Autoencoders
 - Convolutional Neural Network

- More information
 - www.deeplearningbook.org
 - www.deeplearning.net
 - Schmidhuber (2014). Deep Learning in Neural Networks: An Overview (arXiv:1404.7828)
 - Deng and Yu (2013). Deep Learning: Methods and Applications.
- Conferences
 - Int. Conf. Learning Representations (ICLR)
 - Neural Inf. Process. Sys. (NIPS)