基于深度学习的医学影像配准算法研究

中期检查

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Motivation

ISA	Independent Subspace Analysis
Motivation	Maximize independence of features, while allowing dependence inside subspaces with predefined structures.
Pre-requirement	whitened data

Interpretation 1

Maximizing likelihood

$$
\begin{aligned}
\boldsymbol{s} &= \boldsymbol{W}\boldsymbol{x} \\
u_i &= \sqrt{\sum_{j \in S_i} s_j^2} \\
p(\boldsymbol{s}) &= \prod_i \frac{1}{Z_i} \exp\left(-\frac{u_i}{b}\right) \\
\arg\min_{\boldsymbol{W}} & \quad \mathrm{E}_{\boldsymbol{x}}\left[\sum_i u_i\right] \\
\text{subject to} & \quad \boldsymbol{W}\boldsymbol{W}^{\mathsf{T}} = \boldsymbol{I}
\end{aligned}
$$

Interpretation 2

As a 2-layer neural network

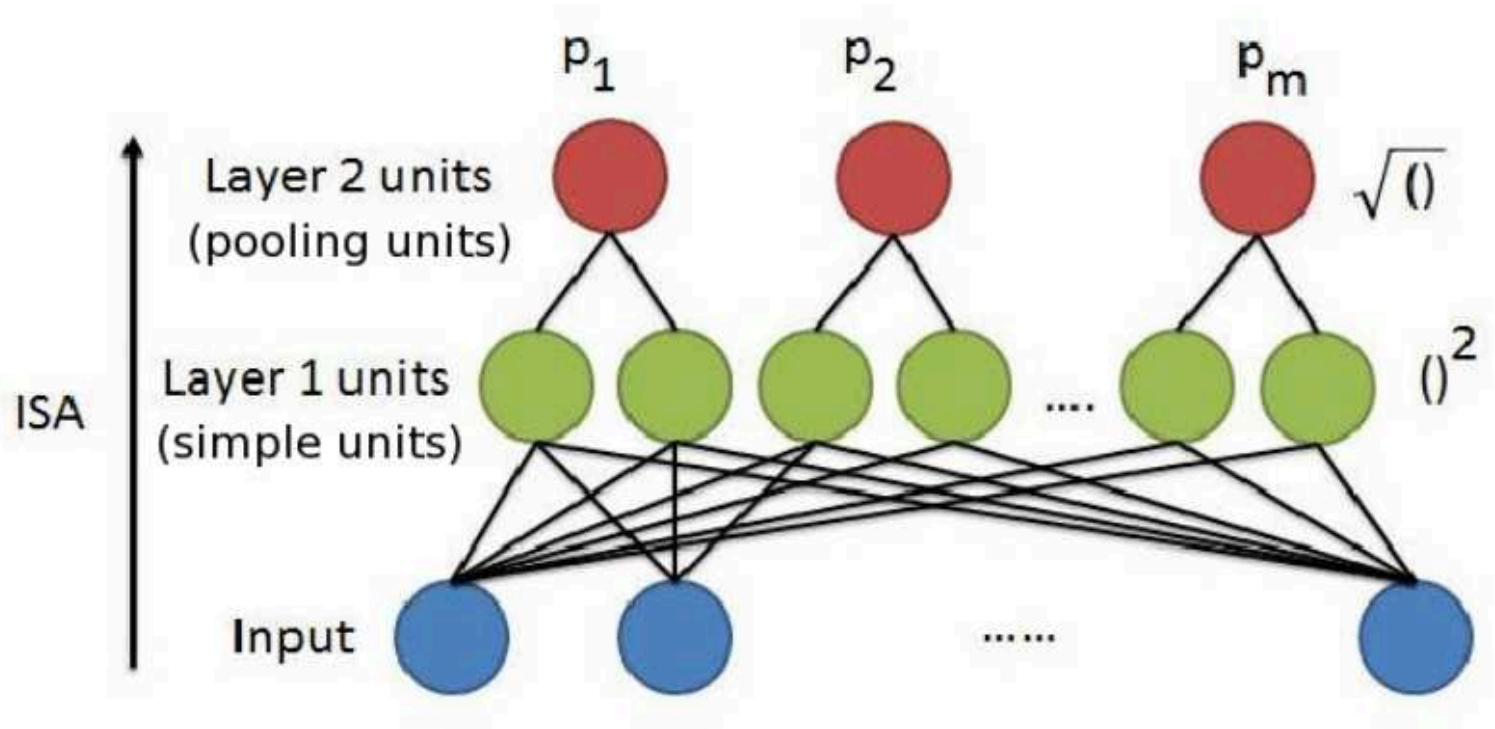


image from [1]

Interpretation 3

Sparse coding with orthonormal regularizer.

$$\begin{aligned} \arg\min_{\boldsymbol{W}} \quad & \mathrm{E}_{\boldsymbol{x}}\left[\sum_i u_i\right] \\ \text{subject to} \quad & \boldsymbol{W}\boldsymbol{W}^{\mathsf{T}} = \boldsymbol{I} \end{aligned}$$

Stacked ISA

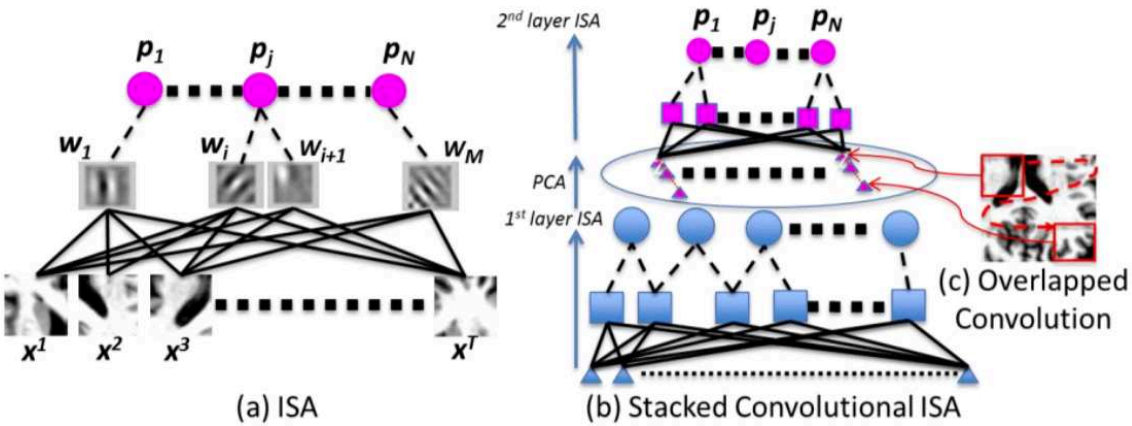


Fig. 2. Graphical depiction of ISA and the stacked convolutional ISA network

image from [2]

Optimization Method

Batched gradient decent:

$$\boldsymbol{W} \leftarrow \boldsymbol{W} - \alpha \frac{1}{N} \sum_{i=1}^{N} \frac{\partial T(\boldsymbol{x_i}; \boldsymbol{W})}{\partial \boldsymbol{W}}$$

Implementation Details

Utilities python2 + theano

Parallel Computing Data parallel on GPUs, both PCA and batched gradient computing/update are parallelized.

Network Structure

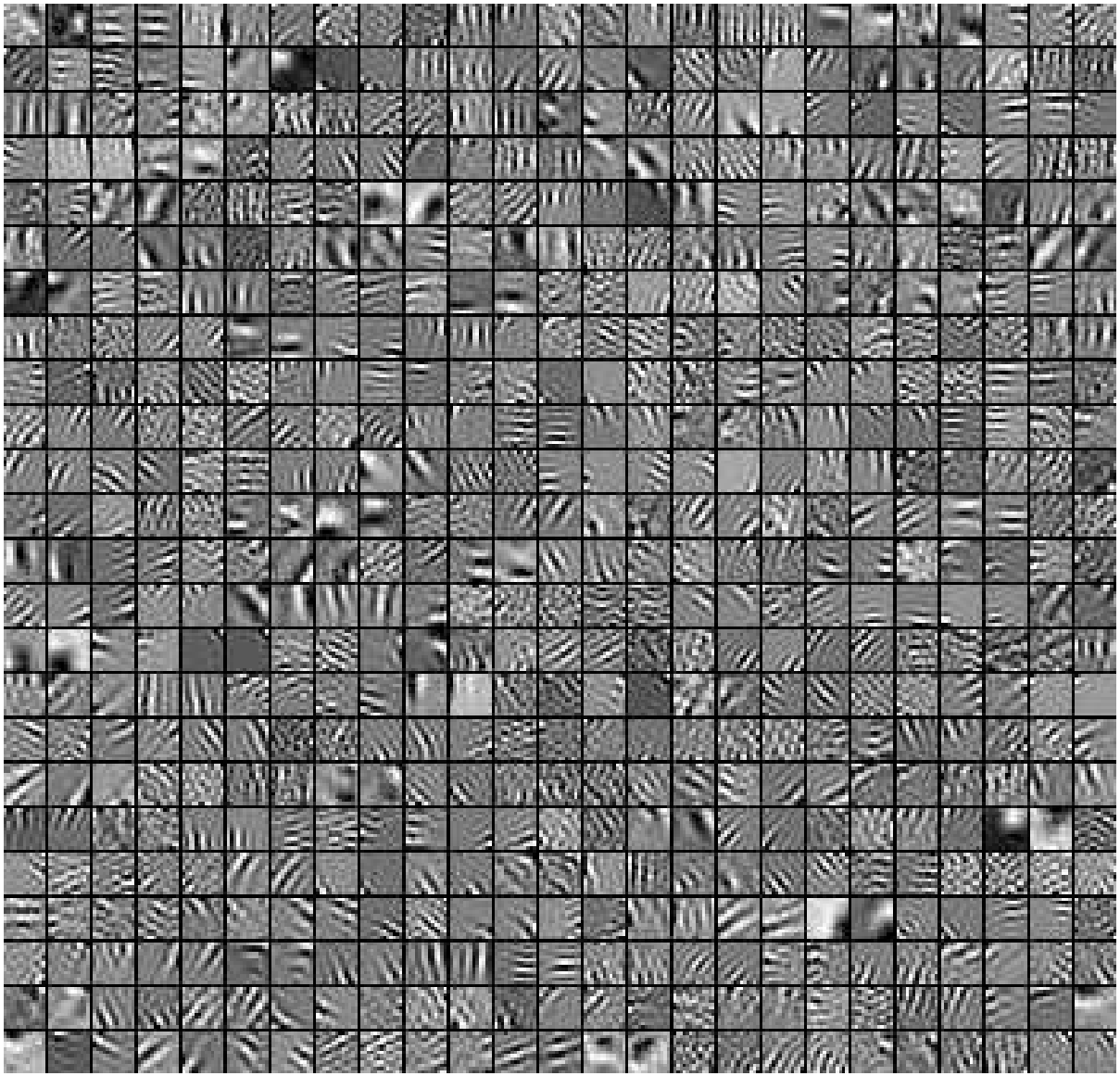
Layer	Input Patch Size	Hidden Ftr	Output Ftr
1	$13 \times 13 \times 13$	300	150
2	$21 \times 21 \times 21$	200	50

Note: layer 1 convolution stride is 8, so actual layer 2 input size is $150 \times 2 \times 2 \times 2$.

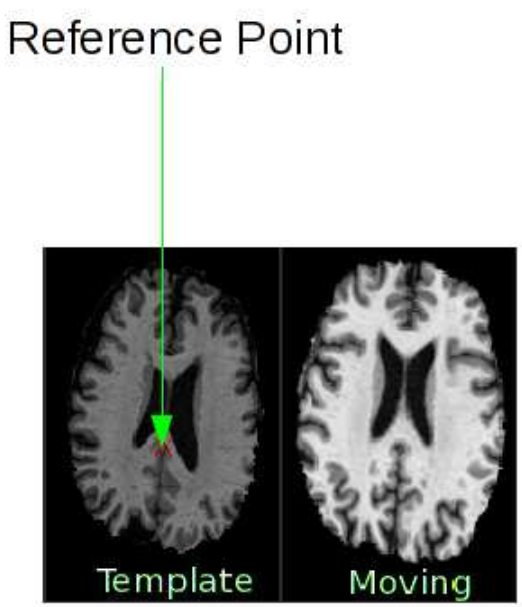
Hardware Intel(R) Core(TM) i7-4930K CPU @ 3.40GHz, 55GiB RAM, 4 Nvidia Titan GPUs

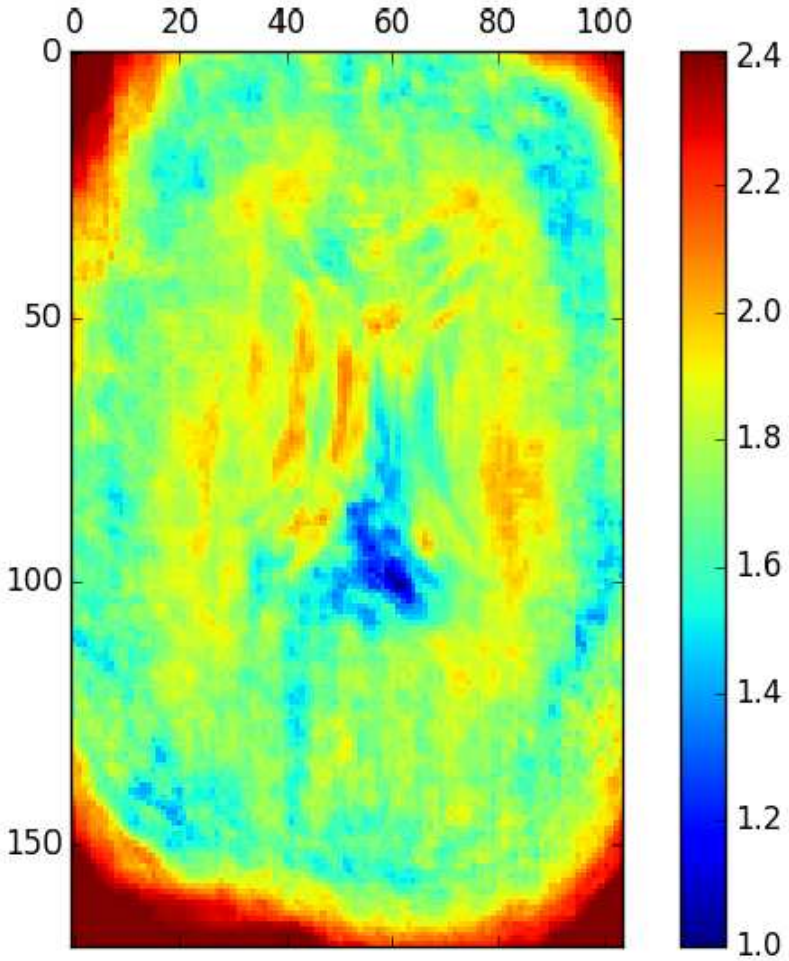
Efficiency For layer 2: 5.5GiB training data, 15secs for PCA, 0.15secs for each iteration.

Filters of Layer 1



Feature Discriminability and Robustness





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Problems and Future Work

Major Problem No handy tool for non-rigid registration with custom features

Future Work

2 weeks	Test feature performance by rigid registration
5 weeks	Try other feature learning methods

Thanks!

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References I

[1] Quoc V Le et al. "Learning hierarchical invariant spatio-temporal features for action recognition with independent subspace analysis". In: *Computer Vision and Pattern Recognition (CVPR), 2011 IEEE Conference on*. IEEE. 2011, pp. 3361–3368.

[2] Guorong Wu et al. "Unsupervised deep feature learning for deformable registration of MR brain images". In: *Medical Image Computing and Computer-Assisted Intervention–MICCAI 2013*. Springer, 2013, pp. 649–656.