Deep Learning- Automatic Malignancy Detection

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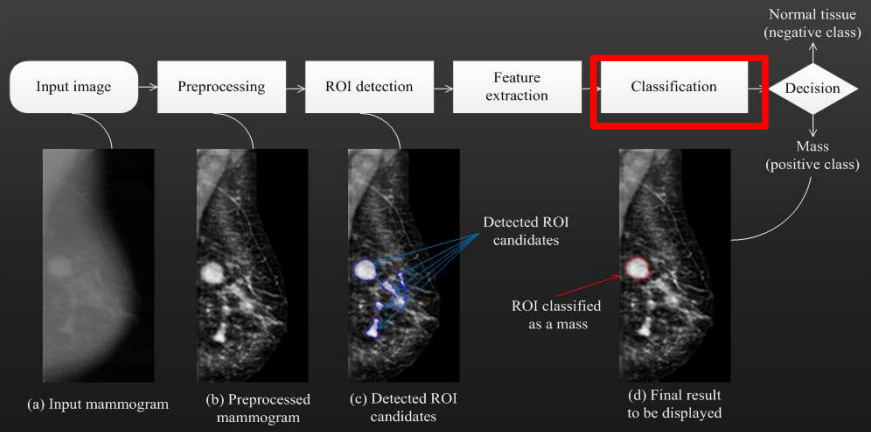
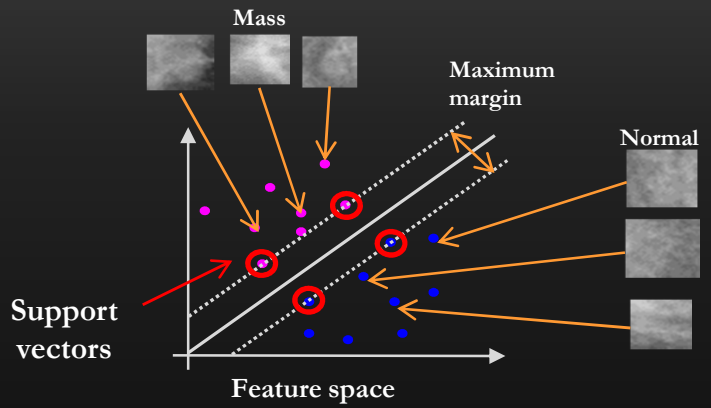
- **Deep learning based breast mass classification**
  - Latent feature representation with depth directional long-term recurrent learning for single-view analysis
  - Latent feature representation with 3D multi-view deep CNN for bilateral analysis

- **Recent publications related to medical deep learning in Prof. Ro Lab.**

  - Latent feature representation with depth directional long-term recurrent learning for breast masses in digital breast tomosynthesis, Medical Physics, vol.62, no.3, pp.1009–1031 , 2017
  - Latent feature representation with 3-D Multi-view Convolutional Neural Network for Bilateral Analysis in Digital Breast Tomosynthesis ,", IEEE ICASSP, 2016
  - Region matching based on local structure information in ipsilateral digital breast tomosynthesis views,",IEEE ICIP 2015
  - Detection of masses in digital breast tomosynthesis using complementary information of simulated projection," Medical Physics, vol. 42, pp. 7043 2015
  - Breast mass detection using slice conspicuity in 3D reconstructed digital breast volumes," Physics in Medicine and Biology, vol. 59, pp. 5003 2014

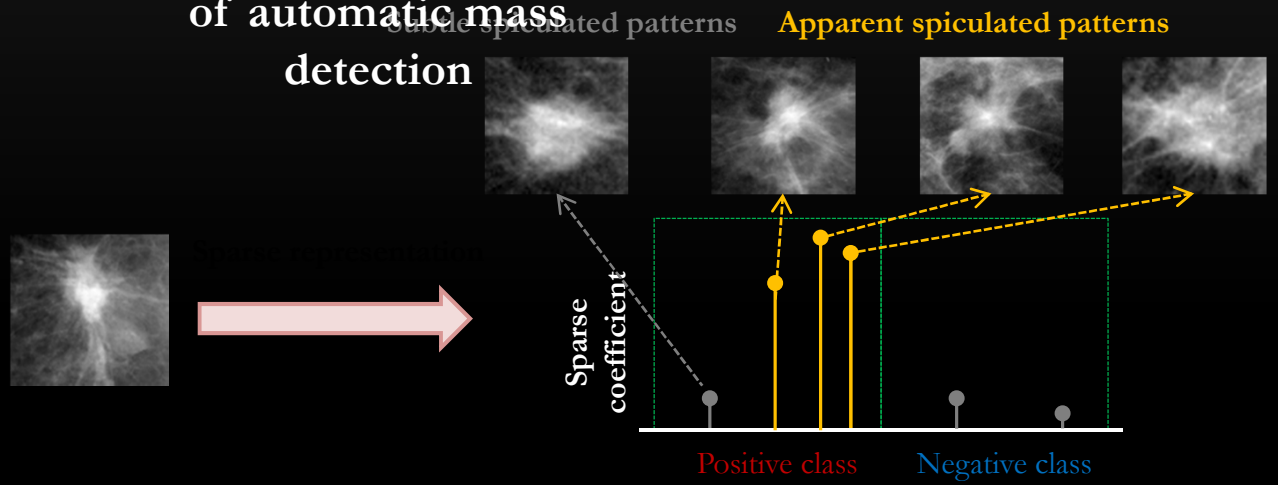
Automatic mass detection via visual recognition





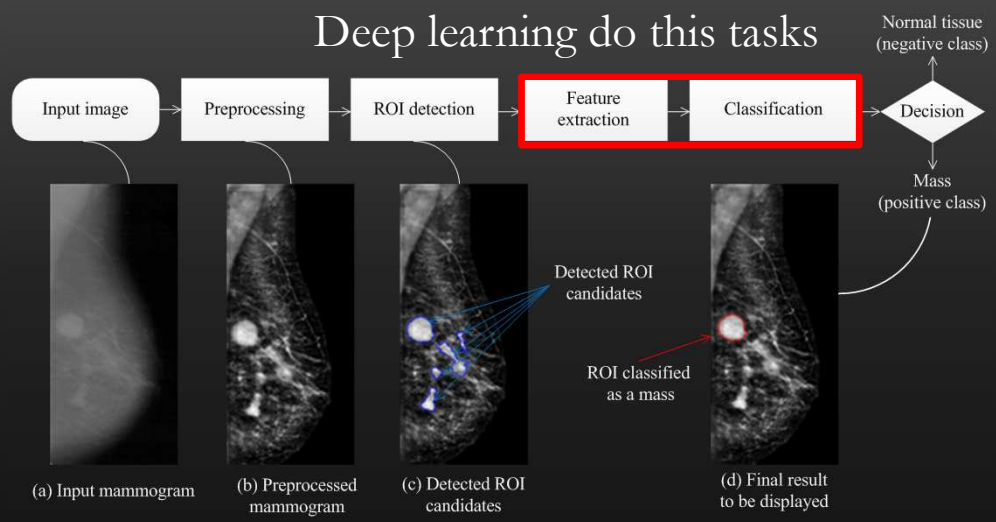
Example of SVM classification

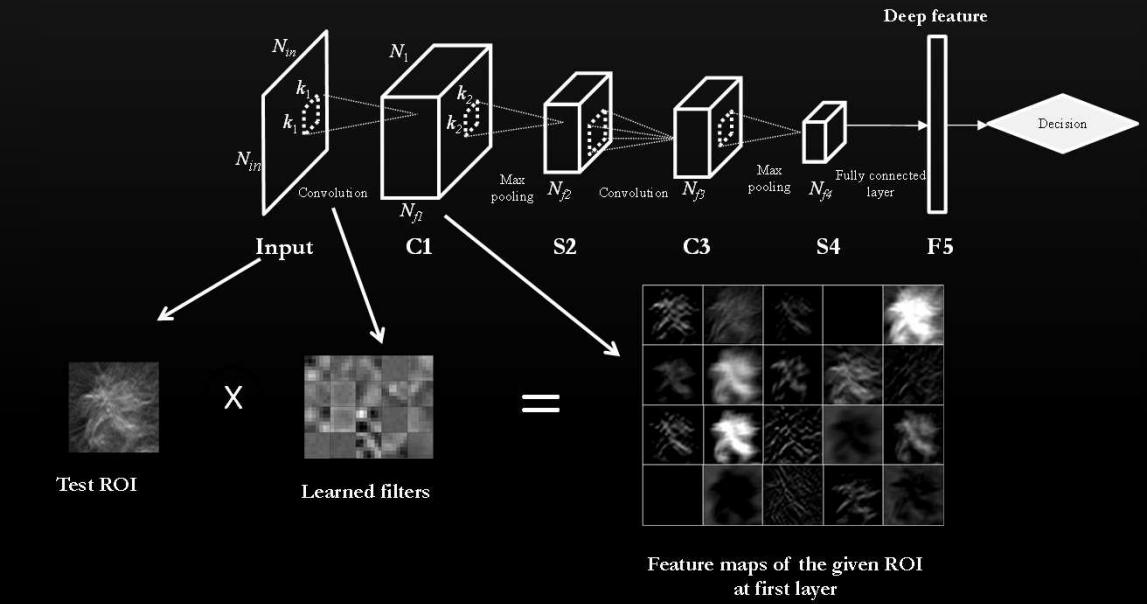
A general framework of automatic mass detection



Example of sparse representation based classification

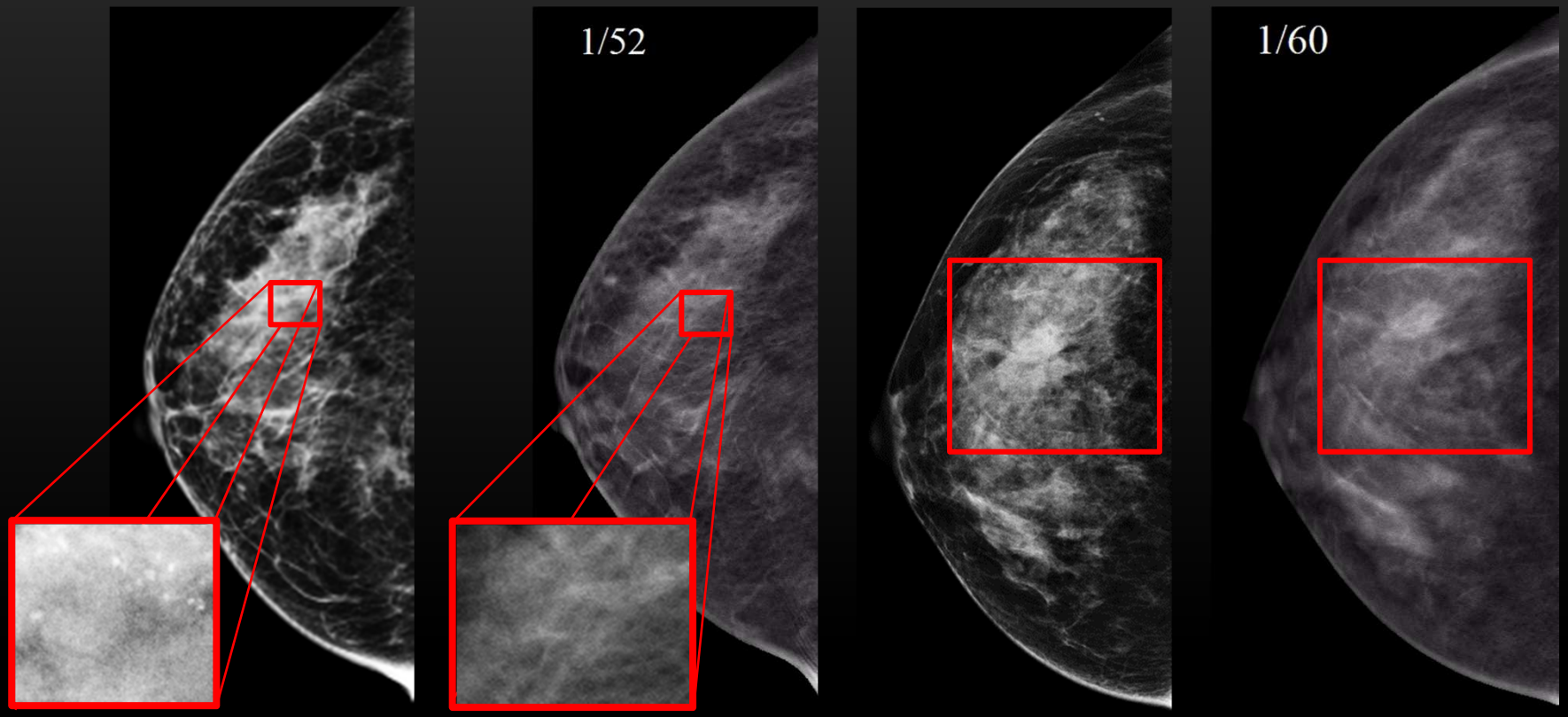
Mass detection via deep learning





Breast cancer screening : 2D DM and 3D DBT

- 3D DBT clearly shows breast cancers



Latent feature representation with depth directional long-term recurrent learning

Related publication:

Latent feature representation with depth directional long-term recurrent learning for breast masses in digital breast tomosynthesis, Yong Man Ro etal. Medical Physics, revising, 2016

Overview of the proposed method

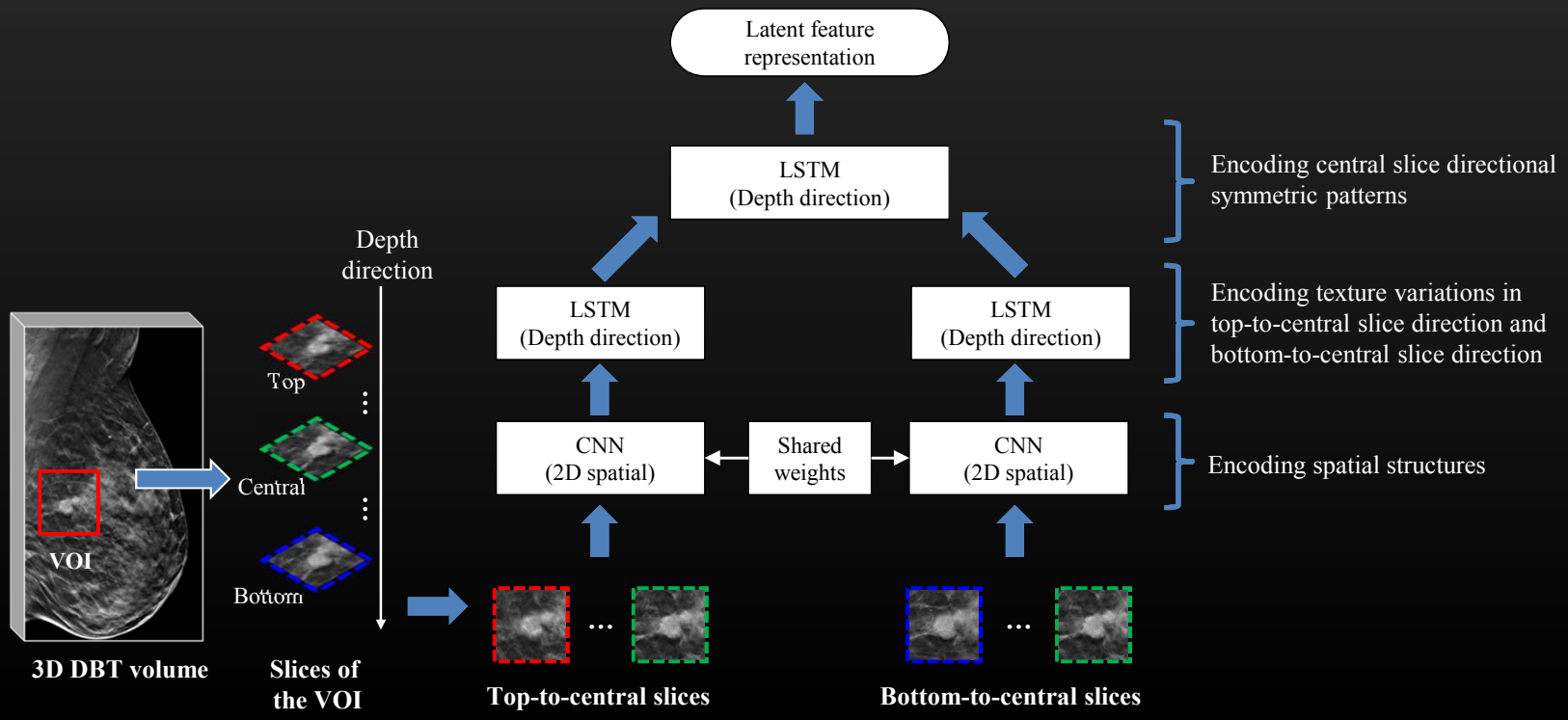
❖ Variation of depth directional texture patterns

- Slices of masses show similar texture patterns, while FPs show different texture patterns among slices (as a medical doctor's diagnosis)
  - ✓ Because FPs are occurred when tissues in different depth are overlapped

Mass

Example of breast cancer screening using DBT [2]

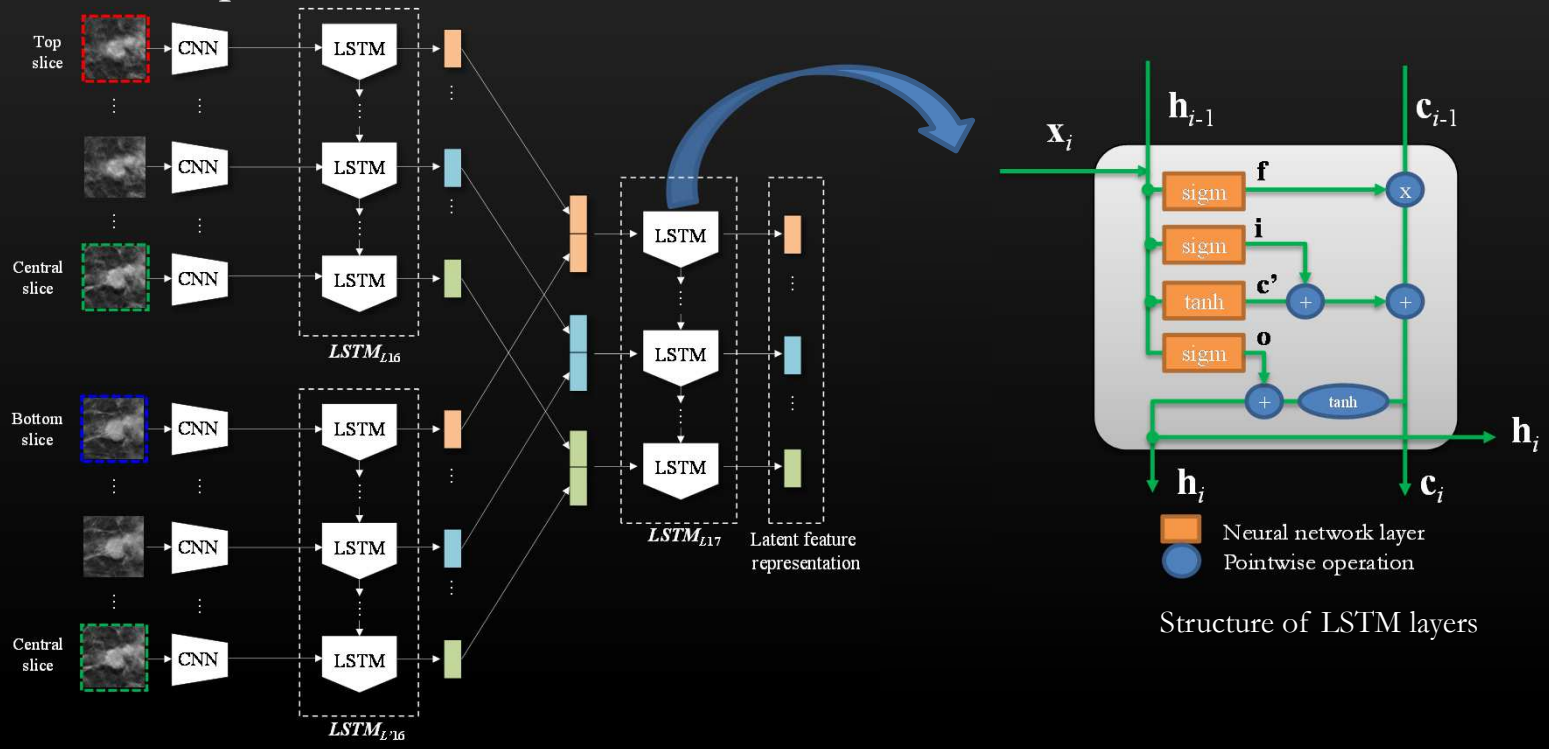
❖ Encoding scheme for masses via the proposed latent feature representation



Latent feature representation with depth directional long-term recurrent learning for breast masses in digital breast tomosynthesis, Yong Man Ro etal. Medical Physics, revising, 2016

❖ Central slice directional learning using depth directional long-term recurrent learning

- Modelling the symmetric pattern of slice feature representations of masses with respect to the central slice



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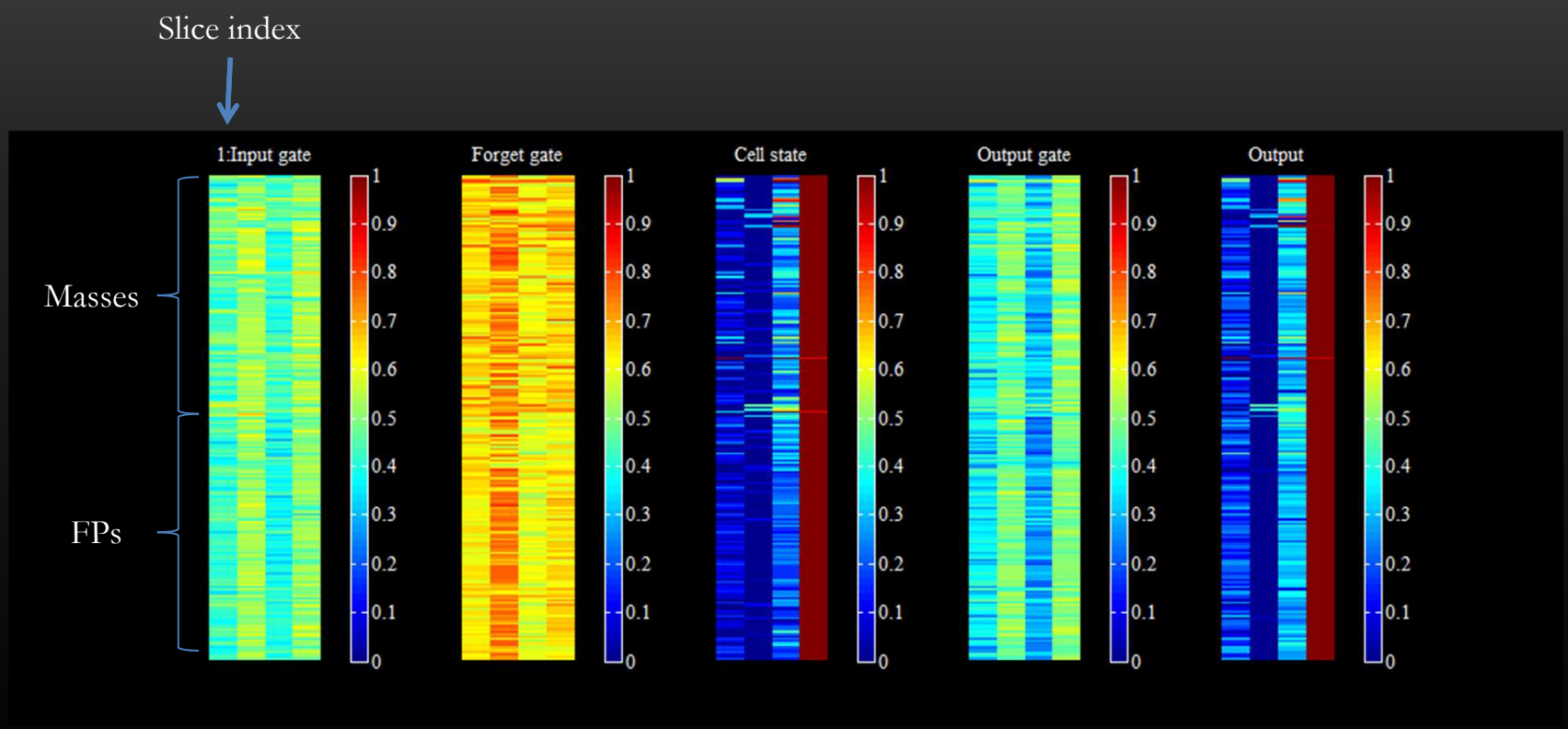
Visualization of activations on the learned LSTM layer

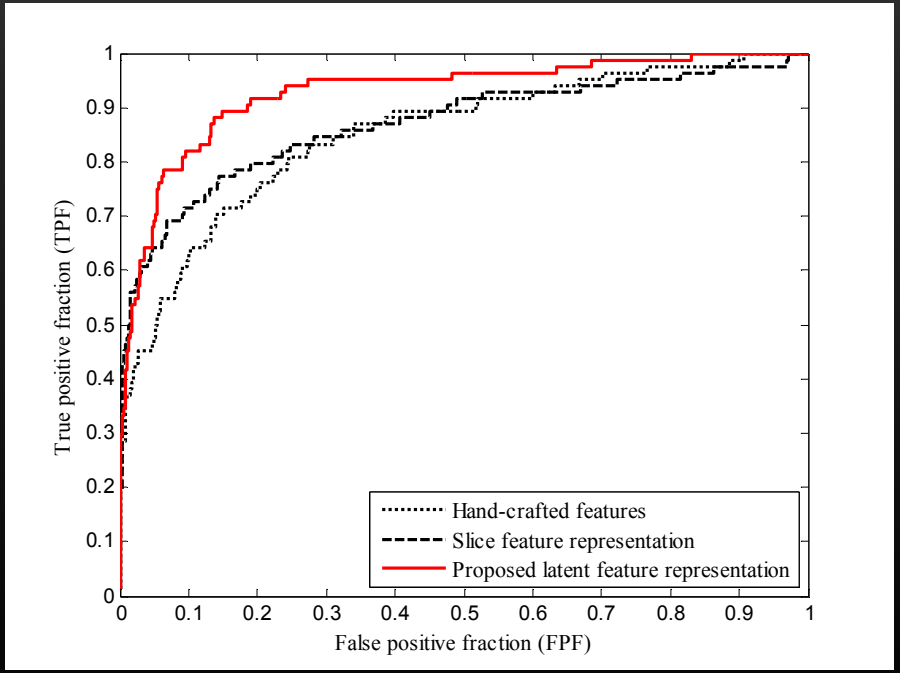


Evolution of states of three gates and a memory cell and an output (i.e., latent feature representation) for 4 LSTM cells at last LSTM layer

Experiment 1

❖ Classification performance comparisons with existing methods

ROC curve



Feature group	AUC
Hand-crafted features [1]	0.847
Slice feature representation	0.871
Proposed latent feature representation	**0.919**

[1] Kim D H, Kim S T and Ro Y M 2015 Improving mass detection using combined feature representations from projection views and reconstructed volume of DBT and boosting based classification with feature selection Phys. Med. Biol. 60 8809

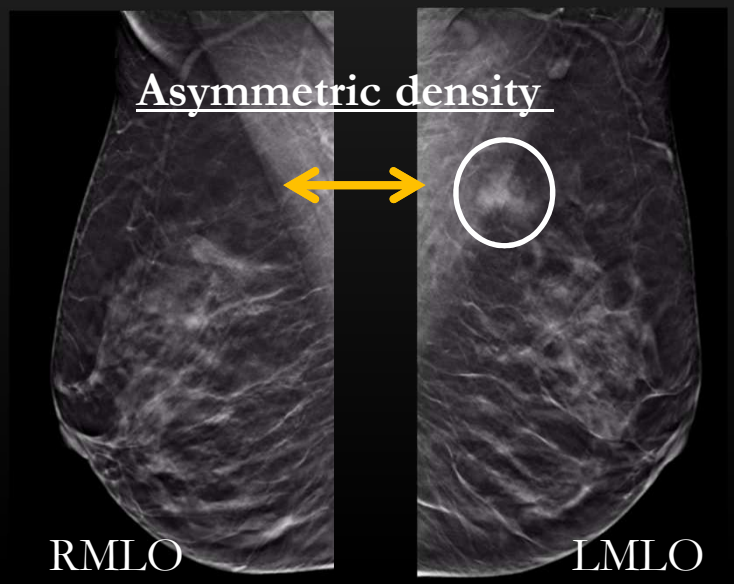
Bilateral analysis:
Latent feature representation with 3D multi-view CNN

Related publication:

Latent feature representation with 3-D Multi-view Convolutional Neural Network for Bilateral Analysis in Digital Breast Tomosynthesis ,", Yong Man Ro IEEE ICASSP, 2016

Clinical practice: Bilateral analysis

- **Bilateral analysis for breast cancer screening and diagnosis**
  - Mass is an **asymmetric density** which is visible on two projections (CC and MLO)
  - Asymmetry between the left and right breast of a given subject is an important sign used by radiologists to diagnose breast cancer



Example of reconstructed slices including a mass (white circled)

Conventional: hand-crafted features in DBT

- **Measuring the bilateral dissimilarity between two VOIs in left breast and right breast [1]**
  - Texture dissimilarity (i.e., Sum of squared differences (SSD) measure)
  - Dissimilarity of intensity distribution (i.e., Histogram correlation)
  - Dissimilarity of mass characteristics between VOIs (i.e., Absolute difference of single features)

- **Limitation**
  - Bilateral characteristics are abstract
  - Due to the subtle characteristics of masses in bilateral analysis, it is hard to design effective hand-crafted features

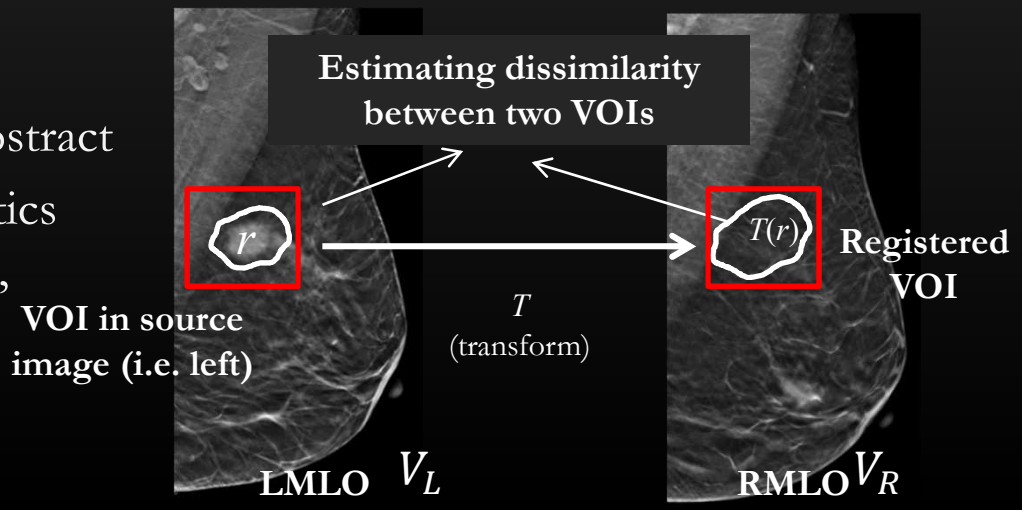
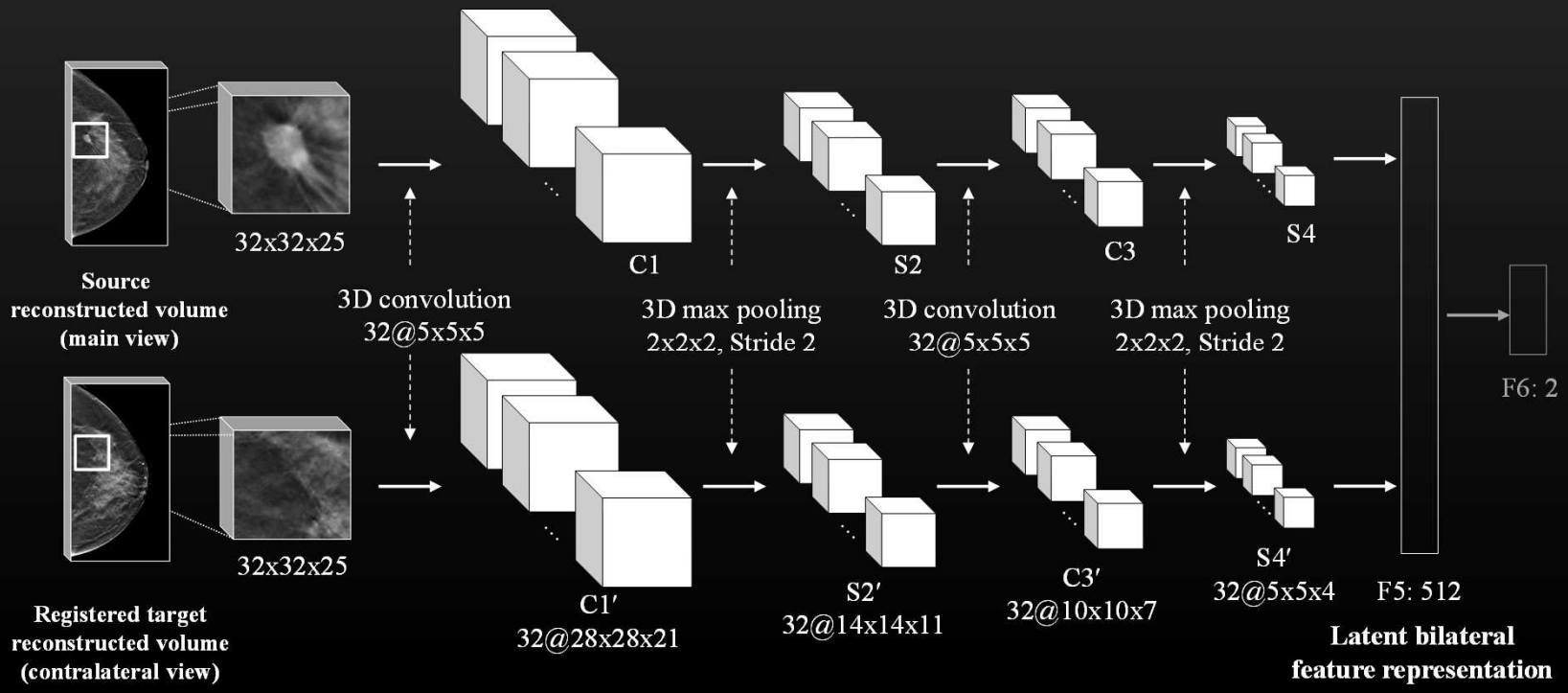


Illustration of hand-crafted bilateral feature extraction

[1] "Feature extraction from bilateral dissimilarity in digital breast tomosynthesis reconstructed volume," *IEEE international conference on image processing*, 2015.

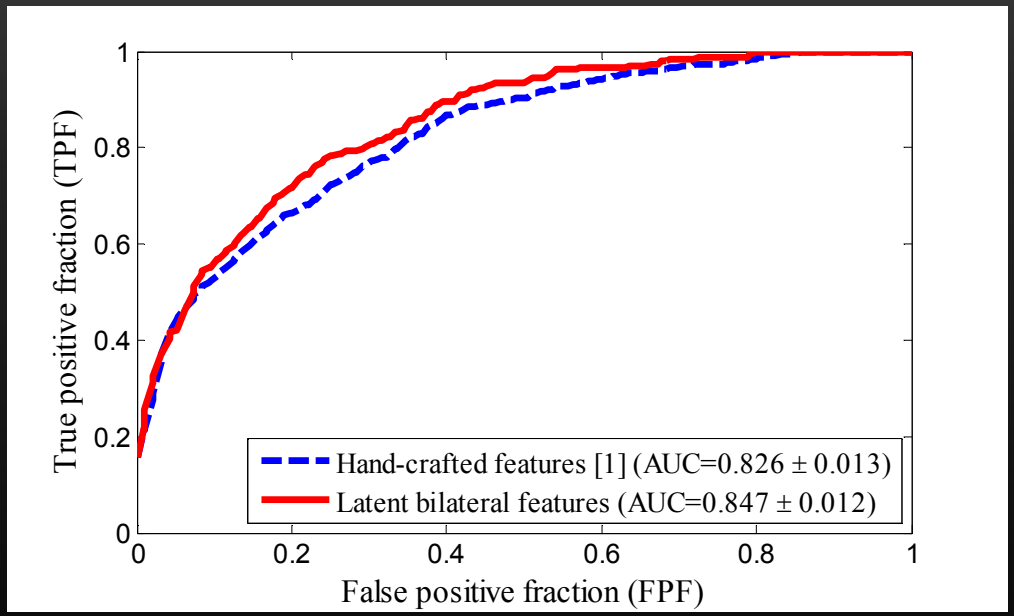
Bilateral analysis with multi-view 3D CNN

- 3D CNN learns tissue structure in volume
- Multi-view fusion network learns different representation of VOIs as input and learns features individually

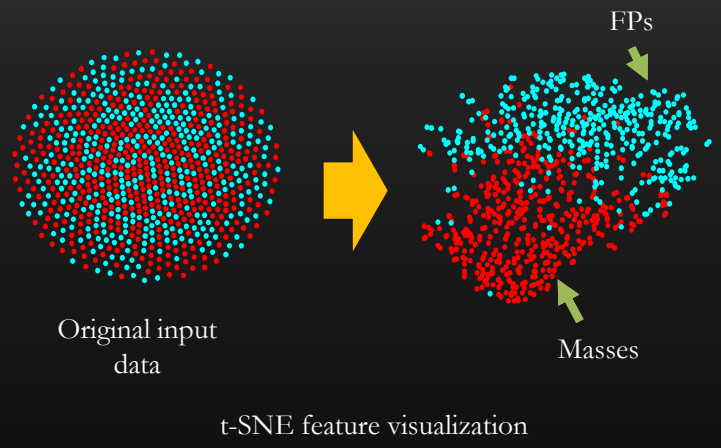


"Latent feature representation with 3-d multi-view deep convolutional neural network for bilateral analysis in digital breast tomosynthesis," *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 2016.

Experimental results



Comparisons of ROC curves of FP reduction using hand-crafted features and proposed latent bilateral feature representation



"Feature extraction from bilateral dissimilarity in digital breast tomosynthesis reconstructed volume," *IEEE international conference on image processing*, 2015.