Lung nodule detection in chest CT with Convolutional Neural Networks

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Lung cancer screening

- Lung cancer is the most deadly cancer worldwide
  - Five-year survival rate: 16%
  - Lung cancers detected at an early stage: 15%

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20% mortality reduction in the cohort scanned with low-dose chest CT

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Reduced Lung-Cancer Mortality with Low-Dose Computed Tomographic Screening

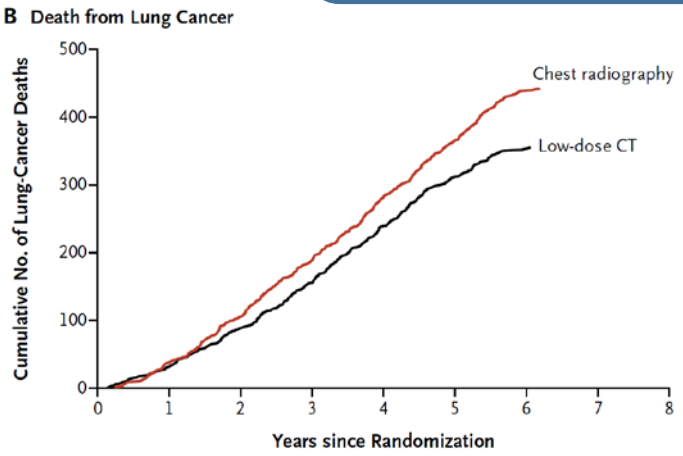
The National Lung Screening Trial Research Team*

ABSTRACT

BACKGROUND

The aggressive and heterogeneous nature of lung cancer has thwarted efforts to reduce mortality from this cancer through the use of screening. The advent of low-dose helical computed tomography (CT) altered the landscape of lung-cancer screening, with studies indicating that low-dose CT detects many tumors at early stages. The National Lung Screening Trial (NLST) was conducted to determine whether screening with low-dose CT could reduce mortality from lung cancer.

The members of the writing team (who are listed in the Appendix) assume responsibility for the integrity of the article. Address reprint requests to Dr. Christine D. Berg at the Early Detection Research Group, Division of Cancer Prevention, National Cancer Institute, 6130 Executive Blvd., Suite 3112, Bethesda, MD 20892-7346, or at bergc@mail.nih.gov.



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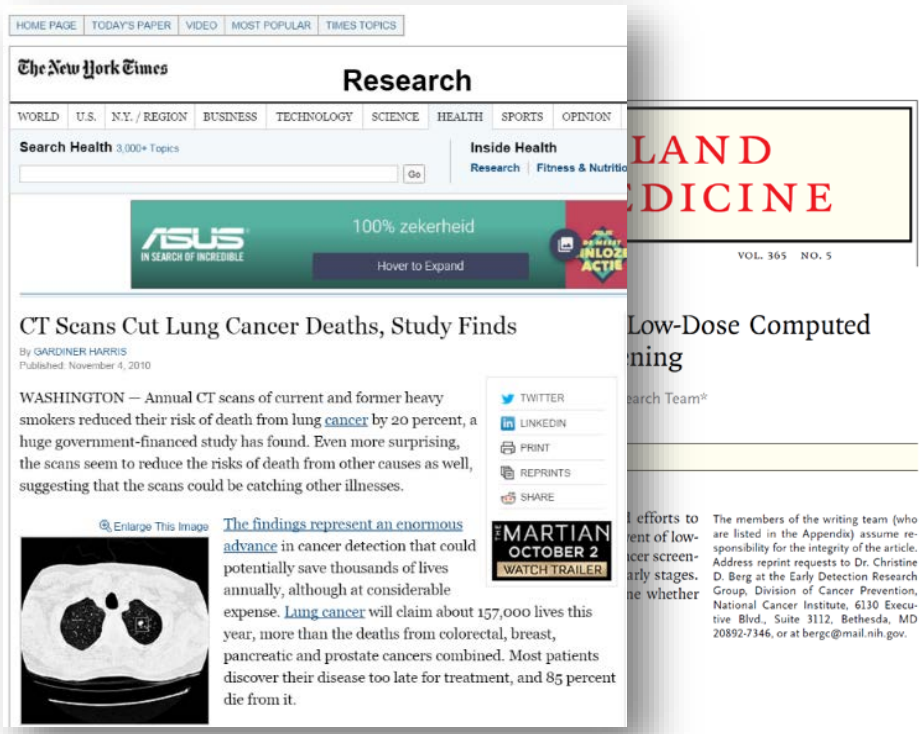

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CT Scans Cut Lung Cancer Deaths, Study Finds

By GARDINER HARRIS
Published: November 4, 2010

WASHINGTON — Annual CT scans of current and former heavy smokers reduced their risk of death from lung cancer by 20 percent, a huge government-financed study has found. Even more surprising, the scans seem to reduce the risks of death from other causes as well, suggesting that the scans could be catching other illnesses.

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The findings represent an enormous advance in cancer detection that could potentially save thousands of lives annually, although at considerable expense. Lung cancer will claim about 157,000 lives this year, more than the deaths from colorectal, breast, pancreatic and prostate cancers combined. Most patients discover their disease too late for treatment, and 85 percent die from it.

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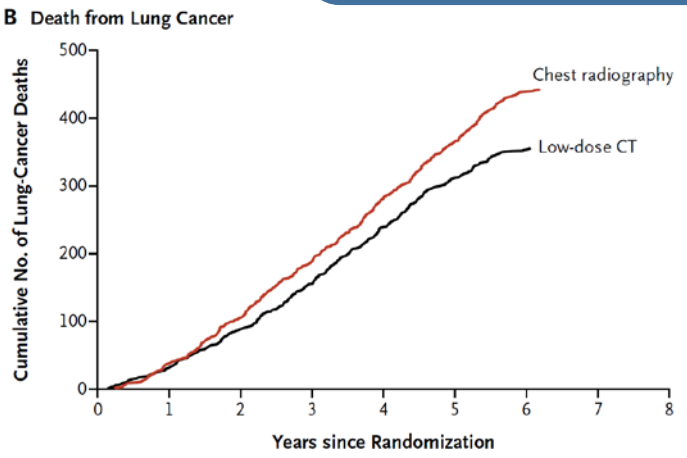
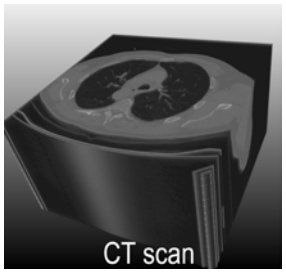
20% mortality reduction in the cohort scanned with low-dose chest CT



Pulmonary nodule detection CAD

- CAD architecture

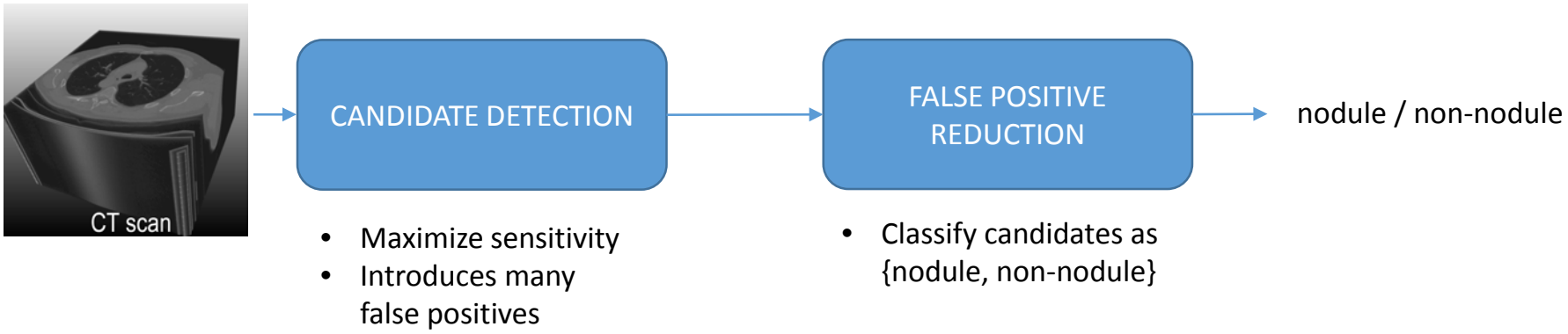


CANDIDATE DETECTION

- Maximize sensitivity
- Introduces many false positives

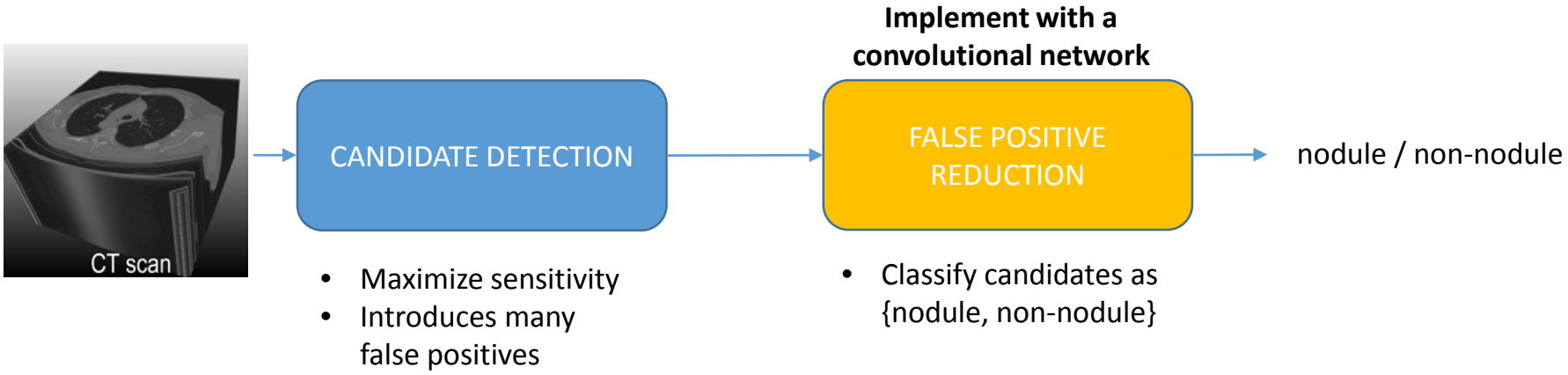
Pulmonary nodule detection CAD

- CAD architecture



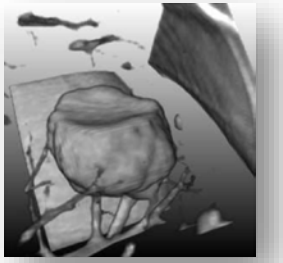
Pulmonary nodule detection CAD

- CAD architecture



Pulmonary nodule

- CT scans are 3D images
  - Lung nodules are objects to classify in a 3D domain



- Convolutional networks with 3D data
  - 3D convolutions, 3D filters
  - Complexity increase
  - Training procedure very long
  - Big memory usage
  - Only limited performance gain

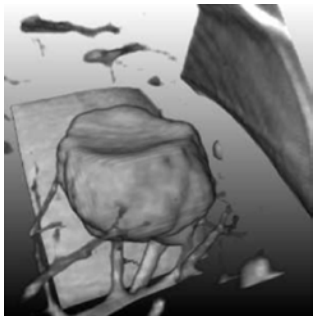
Table 2: Results of the models on the test set. The accuracy refers to the proportion of correct predictions. 3-way means that we are trying to classify a scan as AD, MCI or HC, and the other three lines (AD vs. HC, AD vs. MCI and HC vs. MCI), refer to binary classifications. The second column corresponds to results with 2D convolutions, and the third column corresponds to results with 3D convolutions.

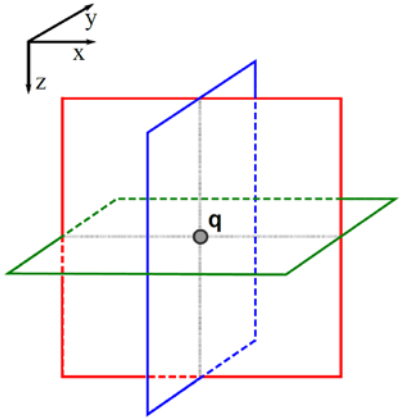
Classification	Accuracy (2D)	Accuracy (3D)
3-way	85.5[illegible]%	89.4[illegible]%
AD vs. HC	[illegible]%	[illegible]%
AD vs. MCI	82.24%	86.84%
HC vs. MCI	90.13%	92.11%

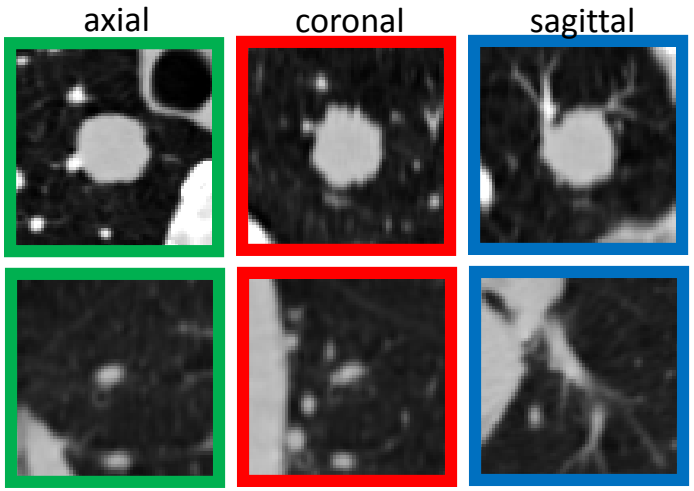
(arxiv:1502.02506)

Pulmonary nodule

- Our approach: multi-planar views
  - We extract 2D views of nodules in 3D

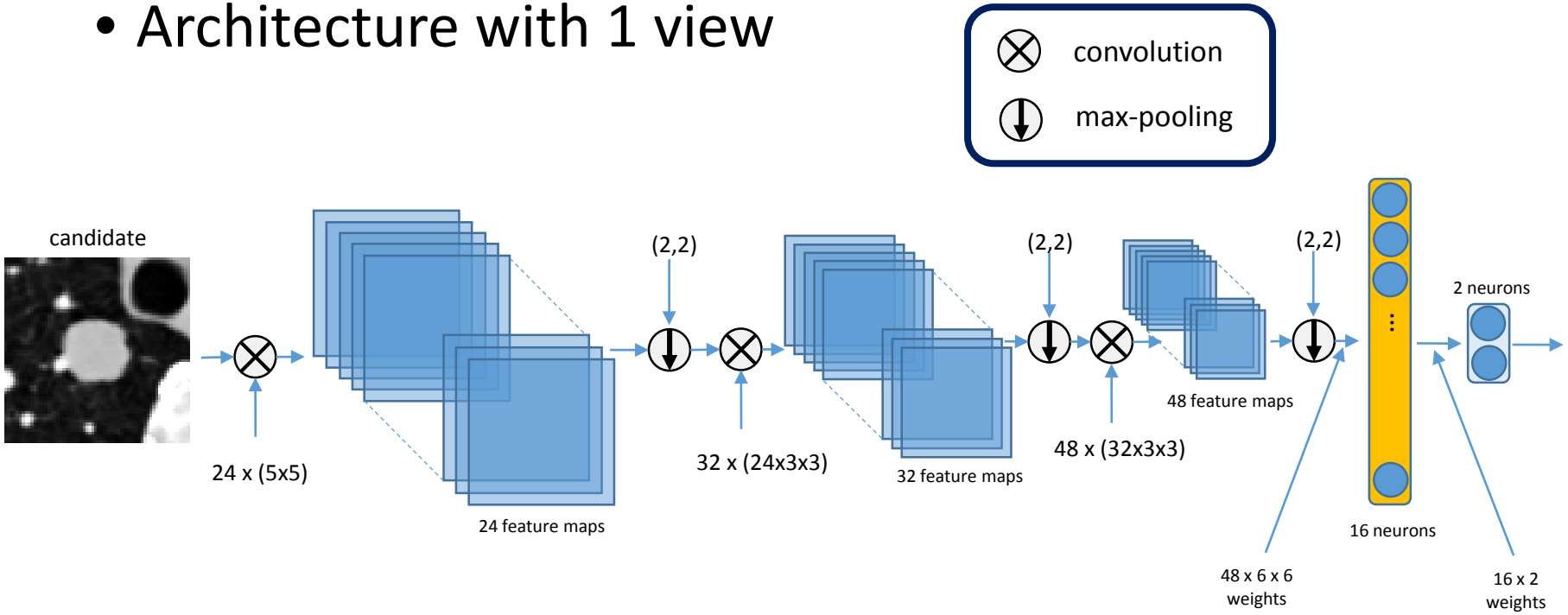






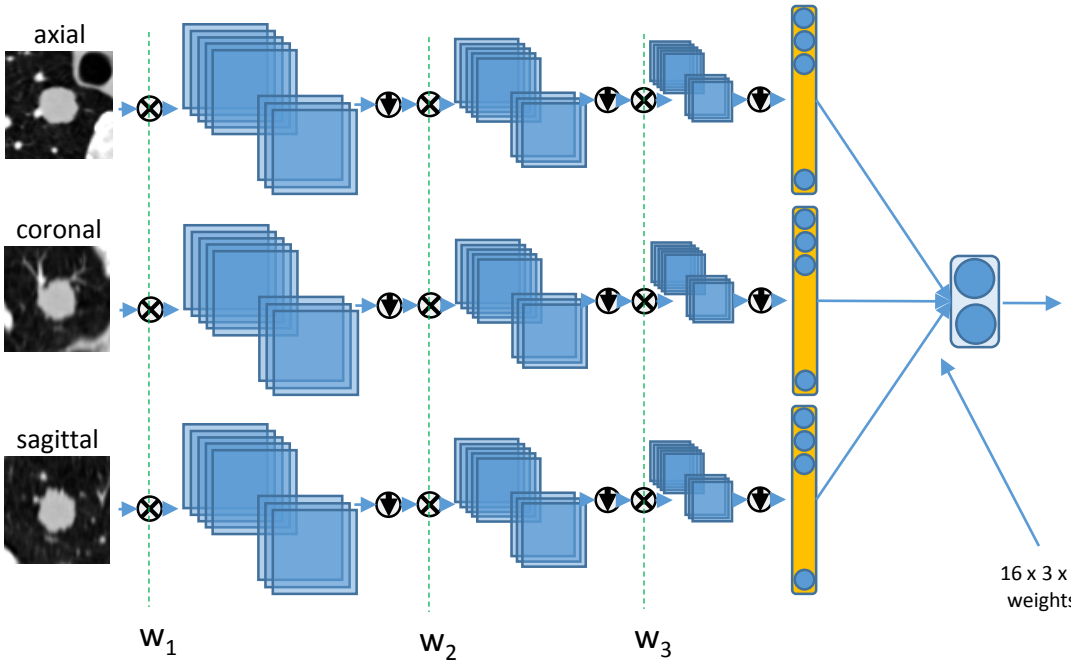
Convolutional Network as FP reduction

- Architecture with 1 view



Convolutional Network as FP reduction

- Architecture with 3 views

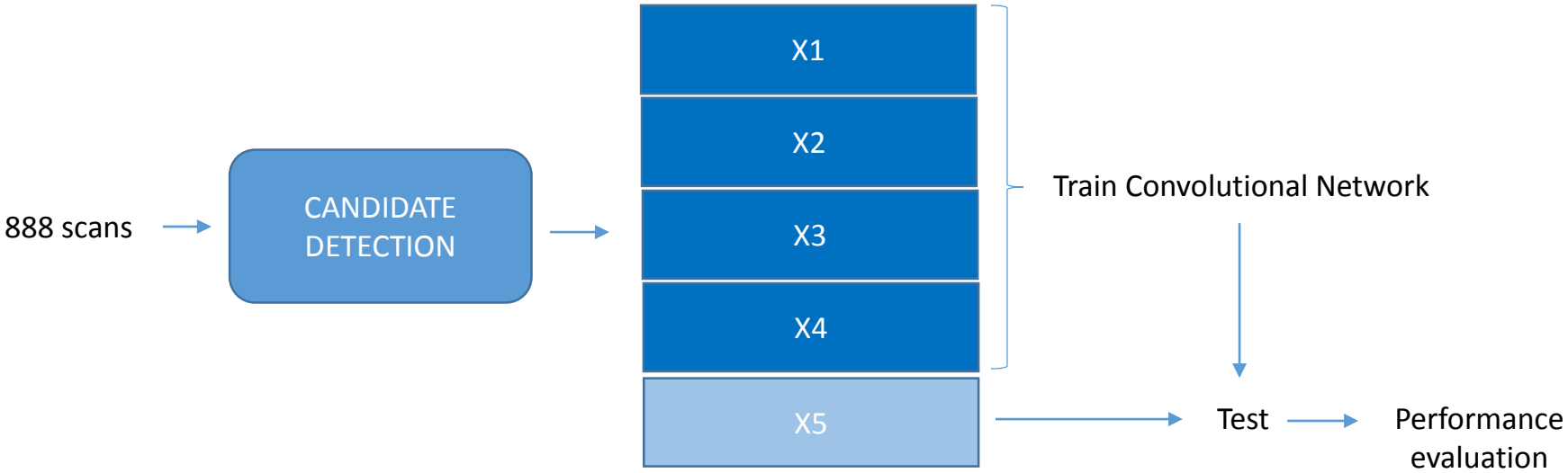


- The weights are shared across the three streams
- The fully-connected layers are merged in the final **soft-max** layer

Evaluation on LIDC-IDRI data set

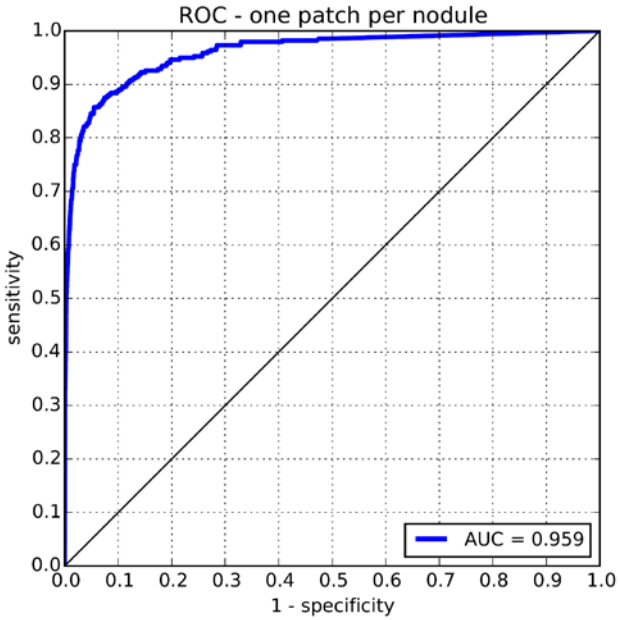
https://wiki.cancerimagingarchive.net/display/Public/LIDC-IDRI

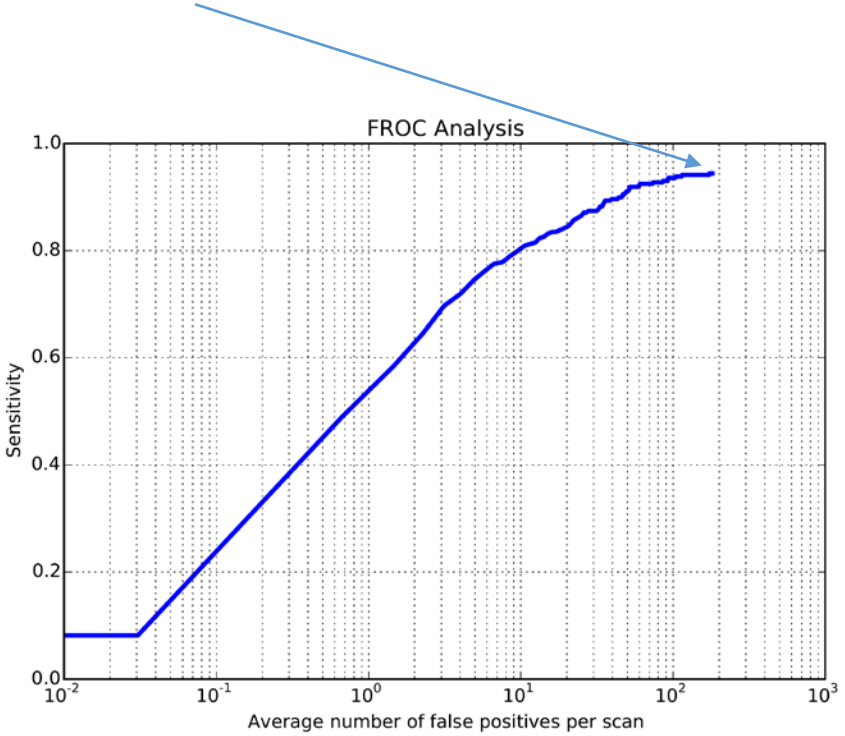
- Experiments



Performance using 1 view

- Candidate detector sensitivity = 0.944





Performance using 3 views?

- Run the code yourself!

Theano implementation

- Pre-trained networks
  - `1View.pkl`
  - `3Viewz.pkl`

```
> THEANO_FLAGS='floatX=float32,device=cpu,nvcc.fastmath=True' ipython notebook
> example/lungnodules/CNNLungNoduleCADTest.ipynb
```

- Data
  - ~~`1ViewTestset.npz`: one fold of LIDC-IDRI with 1 patch per nodule, >700MB~~
  - ~~`3ViewsTestset.npz` one fold of LIDC-IDRI with 3 patches per nodule, >2GB~~
  - `1ViewTestset_small.npz` (one fold of LIDC-IDRI with 1 patch per nodule)

- Pre-computed classification results
  - `output_1_view.csv`
  - `output_3_views.csv`