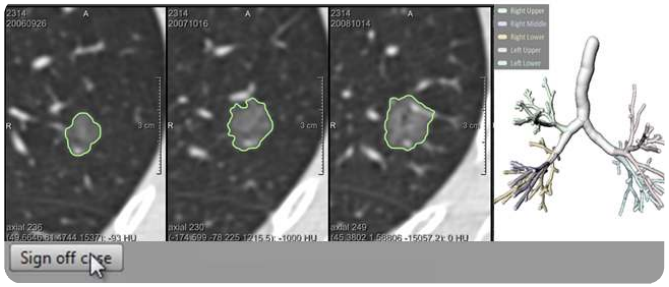
Long CT Screening

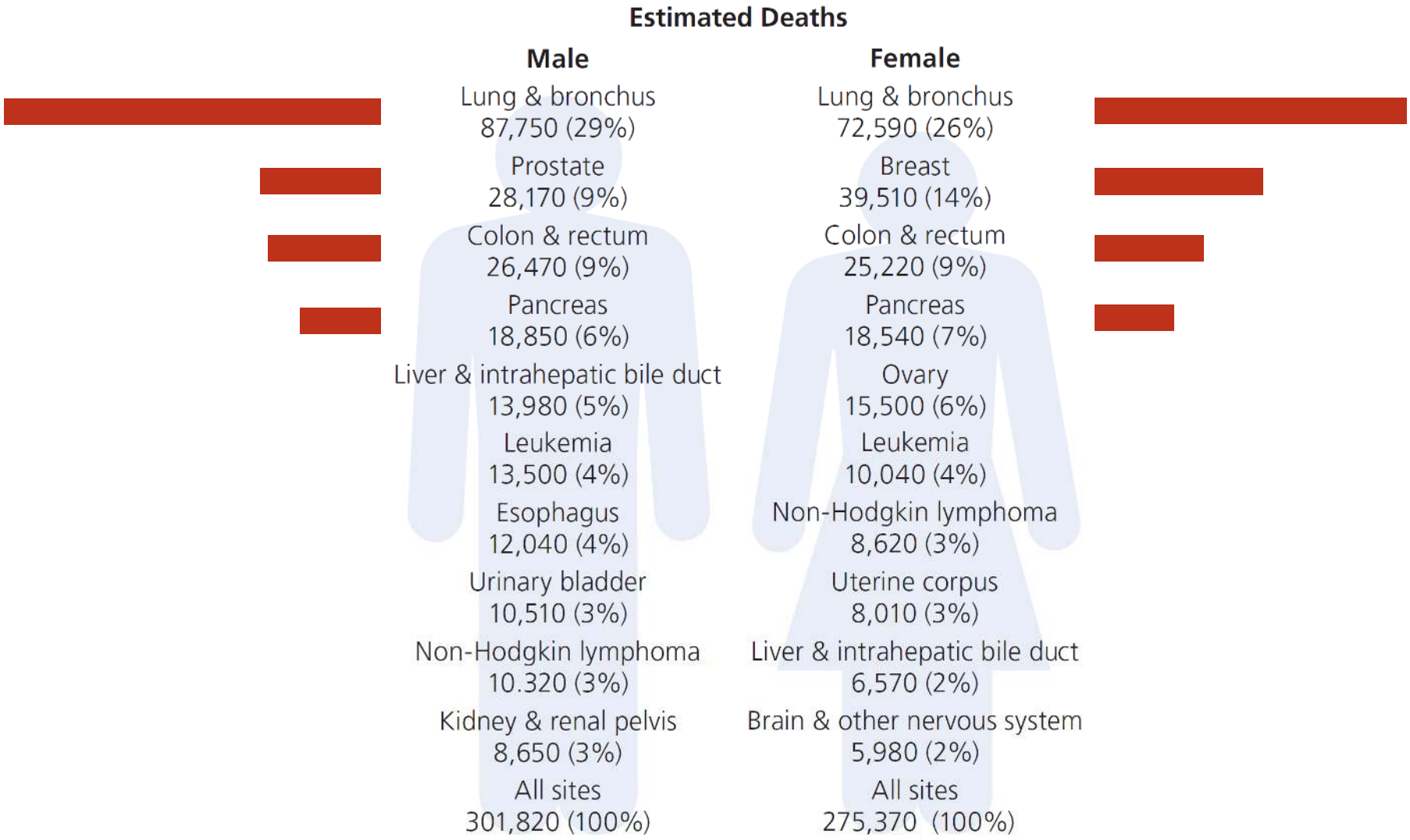


Bram van Ginneken
Diagnostic Image Analysis Group
Department of Radiology
Radboud University Medical Center
Nijmegen, The Netherlands

Radboud University Nijmegen

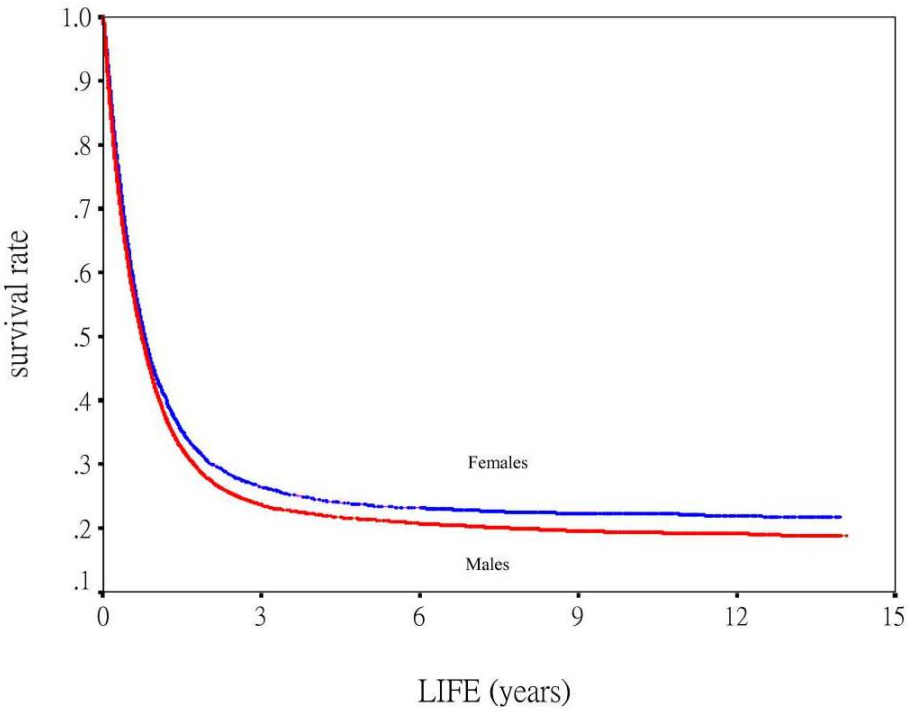
IN·DEI·NOMINE·FELICITER

Lung cancer

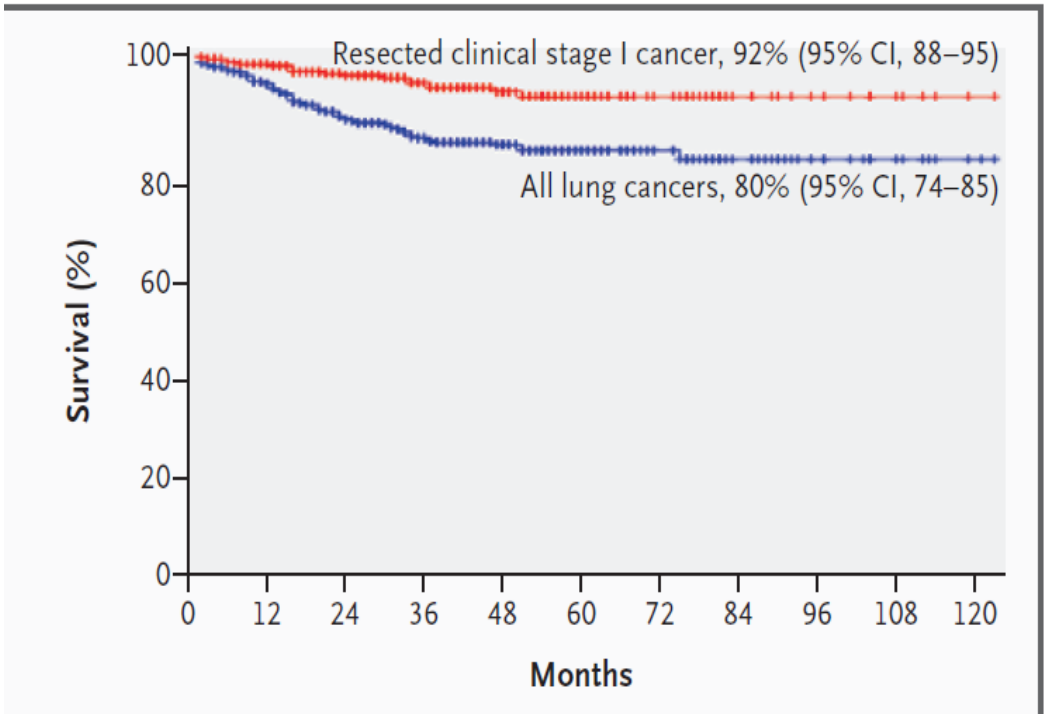


Lung cancer survival

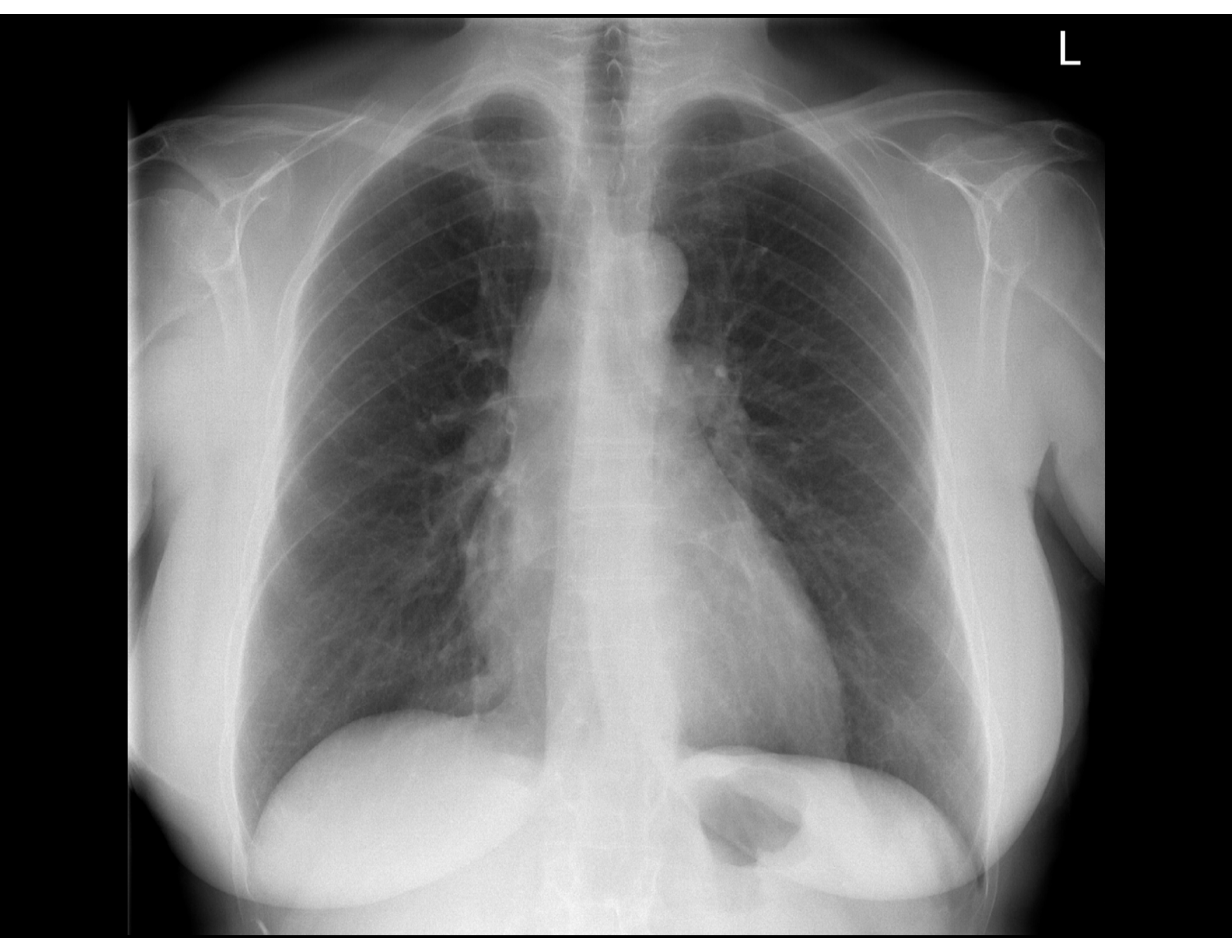
Symptoms

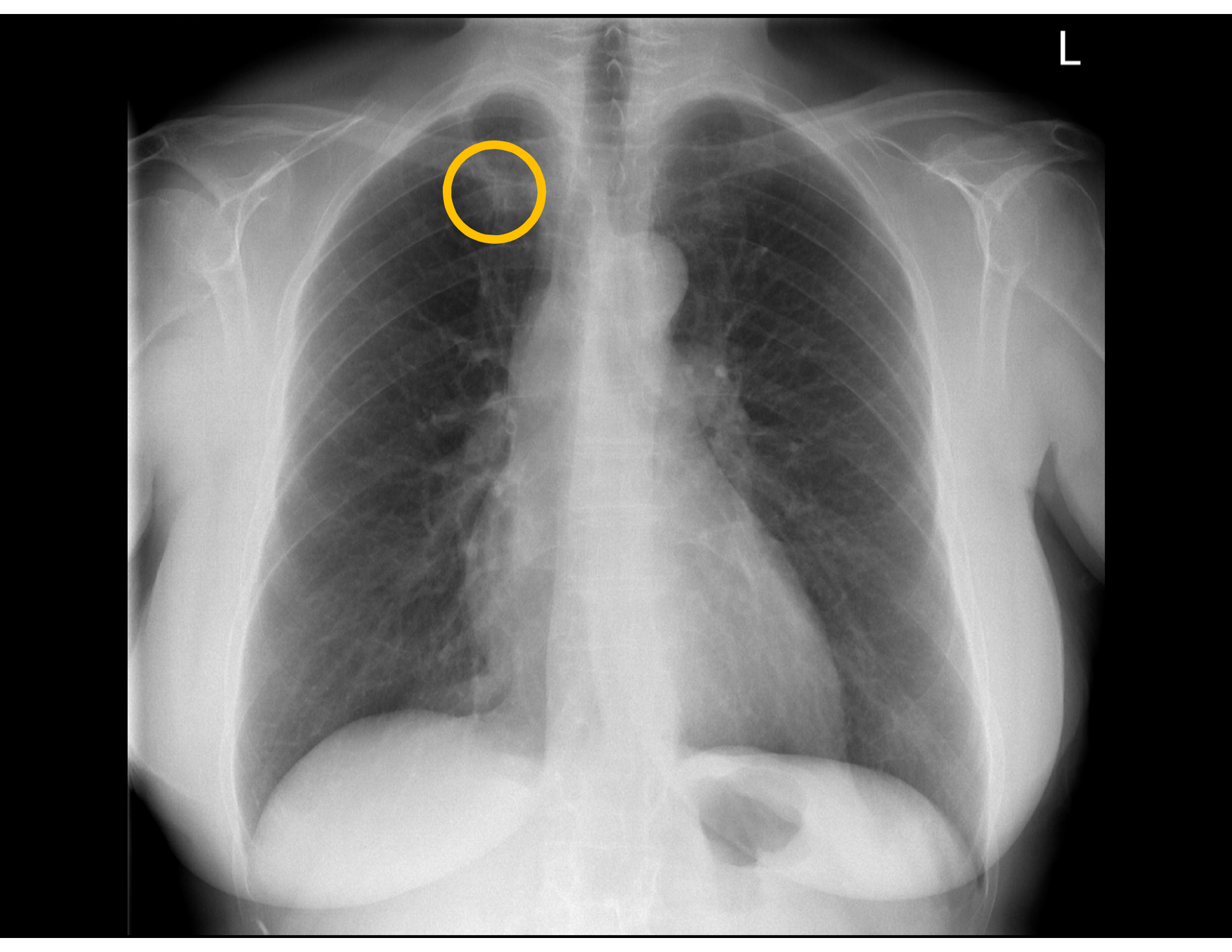


Early detection



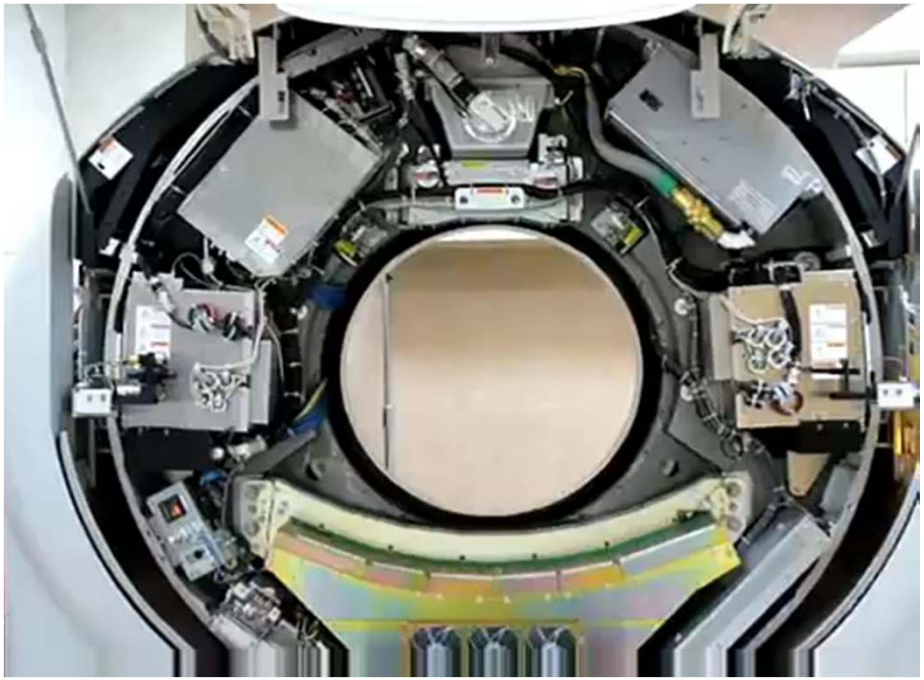
Screening with chest radiography


L


L

Radboud University Nijmegen

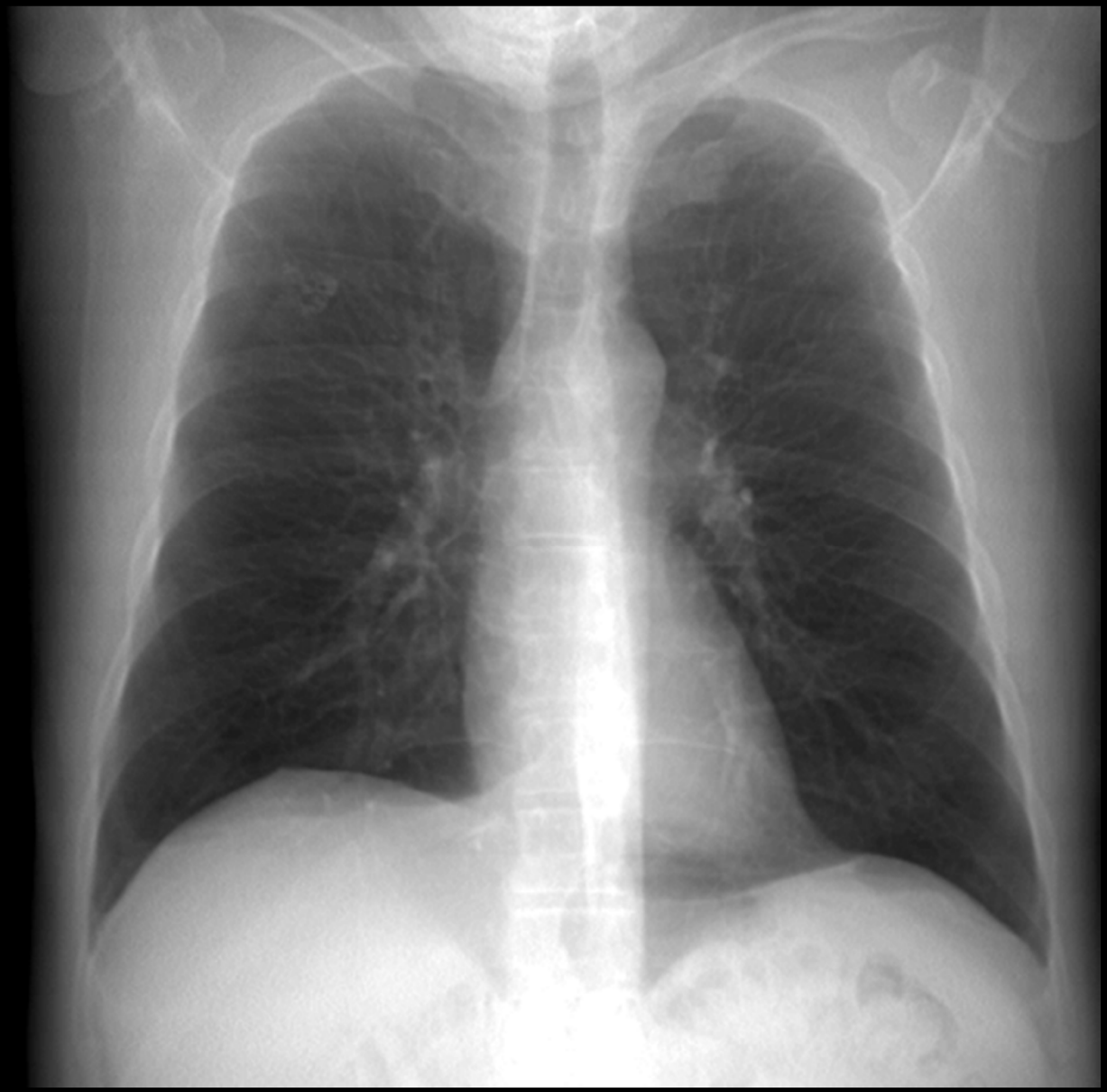
IN·DEI·NOMINE·FELICITER



Radboud University Nijmegen

IN·DEI·NOMINE·FELICITER

CT versus CXR

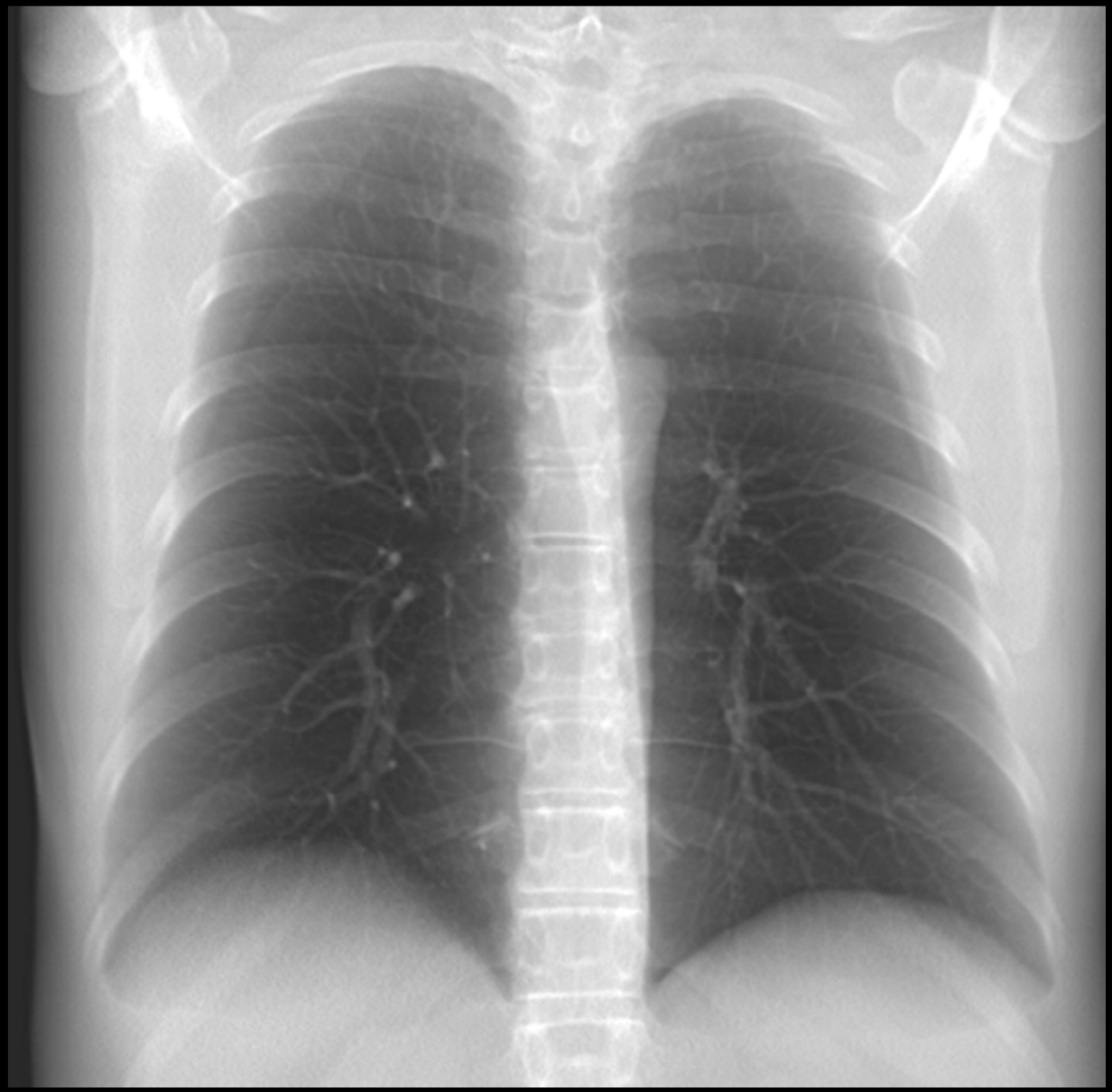


Simulated
X-ray

CT versus CXR

105 mm

CT versus CXR



70 mm

CT versus CXR

35 mm

CT versus CXR

Key points thoracic CT acquisition and viewing

- CT is an isotropic modality: similar resolution in all directions (this was not always the case; many hospitals use outdated strategies for acquisition and data storage)
- You can view the images in any direction (tradition: axial only)
- Adjust the window level depending on what you are looking for (Q: Why not a more effective color lookup table? A: tradition)
- Adjust the section width (slice thickness, slab thickness) to reduce noise or help yourself for your detection task
- Use slab MIP, MinIP, averaging

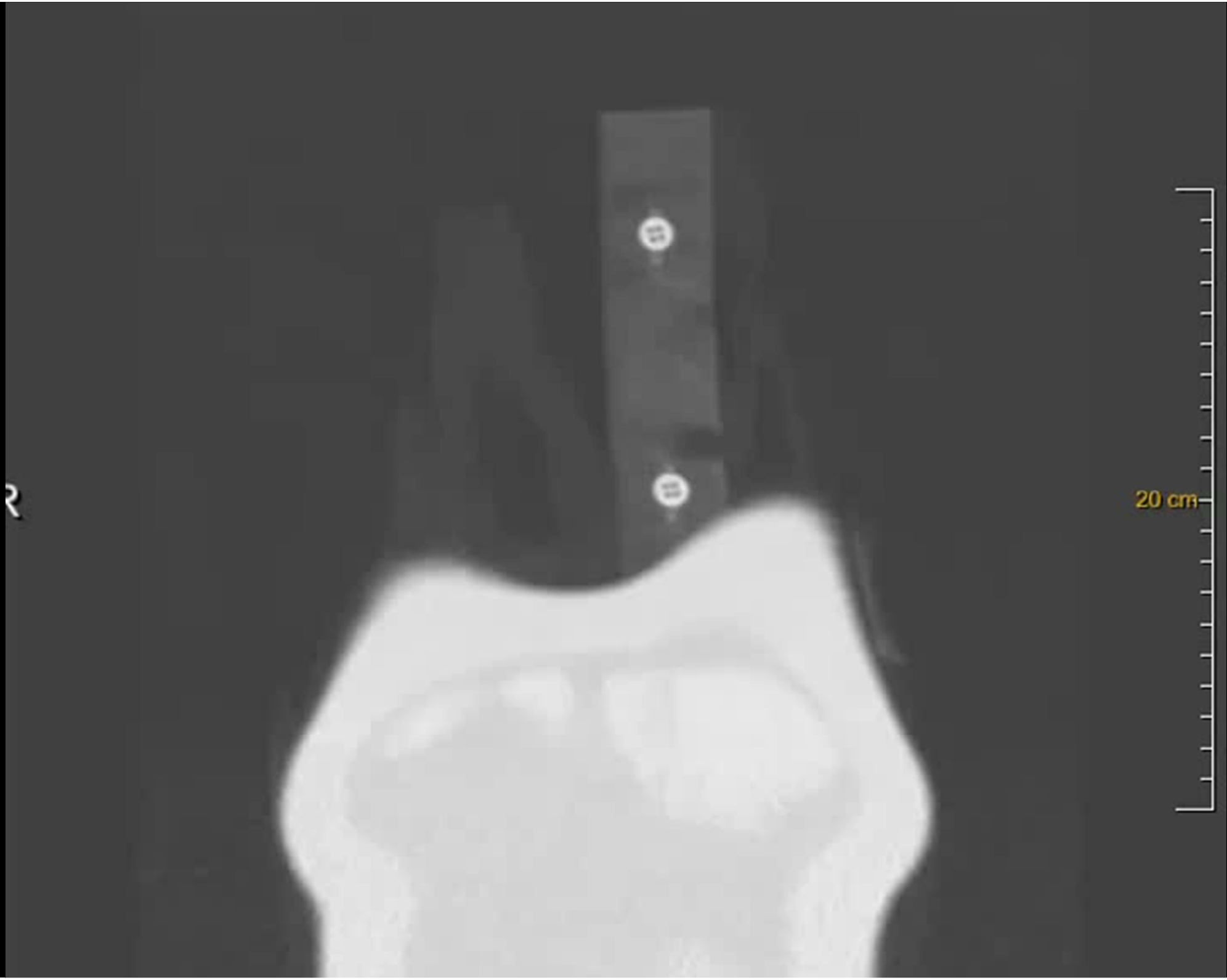
Demo 370, lidc606

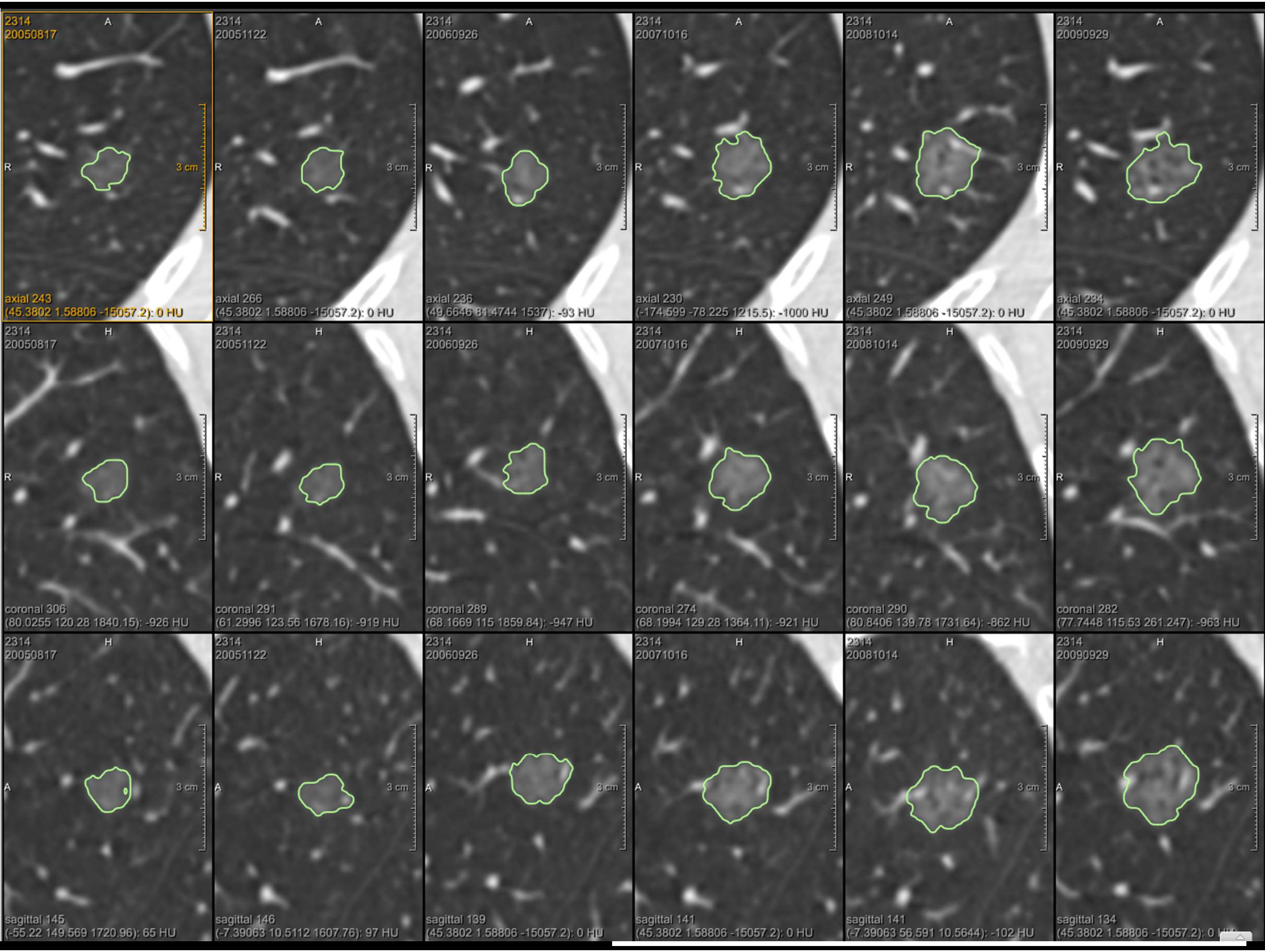
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 4, 2011 VOL. 365 NO. 5

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

The National Lung Screening Trial Research Team*


R
20 cm


2314
20050817
A
R
3 cm
axial 243
(45.3802 1.58806 -15057.2): 0 HU
2314
20051122
A
R
3 cm
axial 266
(45.3802 1.58806 -15057.2): 0 HU
2314
20060926
A
R
3 cm
axial 236
(49.6646 81.4744 1537): -93 HU
2314
20071016
A
R
3 cm
axial 230
(-174.599 -78.225 1215.5): -1000 HU
2314
20081014
A
R
3 cm
axial 249
(45.3802 1.58806 -15057.2): 0 HU
2314
20090929
A
R
3 cm
axial 234
(45.3802 1.58806 -15057.2): 0 HU
2314
20050817
H
R
3 cm
coronal 306
(80.0255 120.28 1840.15): -926 HU
2314
20051122
H
R
3 cm
coronal 291
(61.2996 123.56 1678.16): -919 HU
2314
20060926
H
R
3 cm
coronal 289
(68.1669 115 1859.84): -947 HU
2314
20071016
H
R
3 cm
coronal 274
(68.1994 129.28 1364.11): -921 HU
2314
20081014
H
R
3 cm
coronal 290
(80.8406 139.78 1731.64): -862 HU
2314
20090929
H
R
3 cm
coronal 282
(77.7448 115.53 261.247): -963 HU
2314
20050817
H
A
3 cm
sagittal 145
(-55.22 149.569 1720.96): 65 HU
2314
20051122
H
A
3 cm
sagittal 146
(-7.39063 10.5112 1607.76): 97 HU
2314
20060926
H
A
3 cm
sagittal 139
(45.3802 1.58806 -15057.2): 0 HU
2314
20071016
H
A
3 cm
sagittal 141
(45.3802 1.58806 -15057.2): 0 HU
2314
20081014
H
A
3 cm
sagittal 141
(-7.39063 56.591 10.5644): -102 HU
2314
20090929
H
A
3 cm
sagittal 134
(45.3802 1.58806 -15057.2): 0 HU

Medical Image Analysis 13 (2009) 757–770

Contents lists available at ScienceDirect

Medical Image Analysis

journal homepage: www.elsevier.com/locate/media

A large-scale evaluation of automatic pulmonary nodule detection in chest CT using local image features and k-nearest-neighbour classification

K. Murphy [a,*], B. van Ginneken [a], A.M.R. Schilham [a], B.J. de Hoop [b], H.A. Gietema [b], M. Prokop [b]

[a] *Image Sciences Institute, University Medical Center, Utrecht, The Netherlands*
[b] *Department of Radiology, University Medical Center, Utrecht, The Netherlands*

ARTICLE INFO

Article history:
Received 1 July 2008
Received in revised form 26 June 2009
Accepted 2 July 2009
Available online 30 July 2009

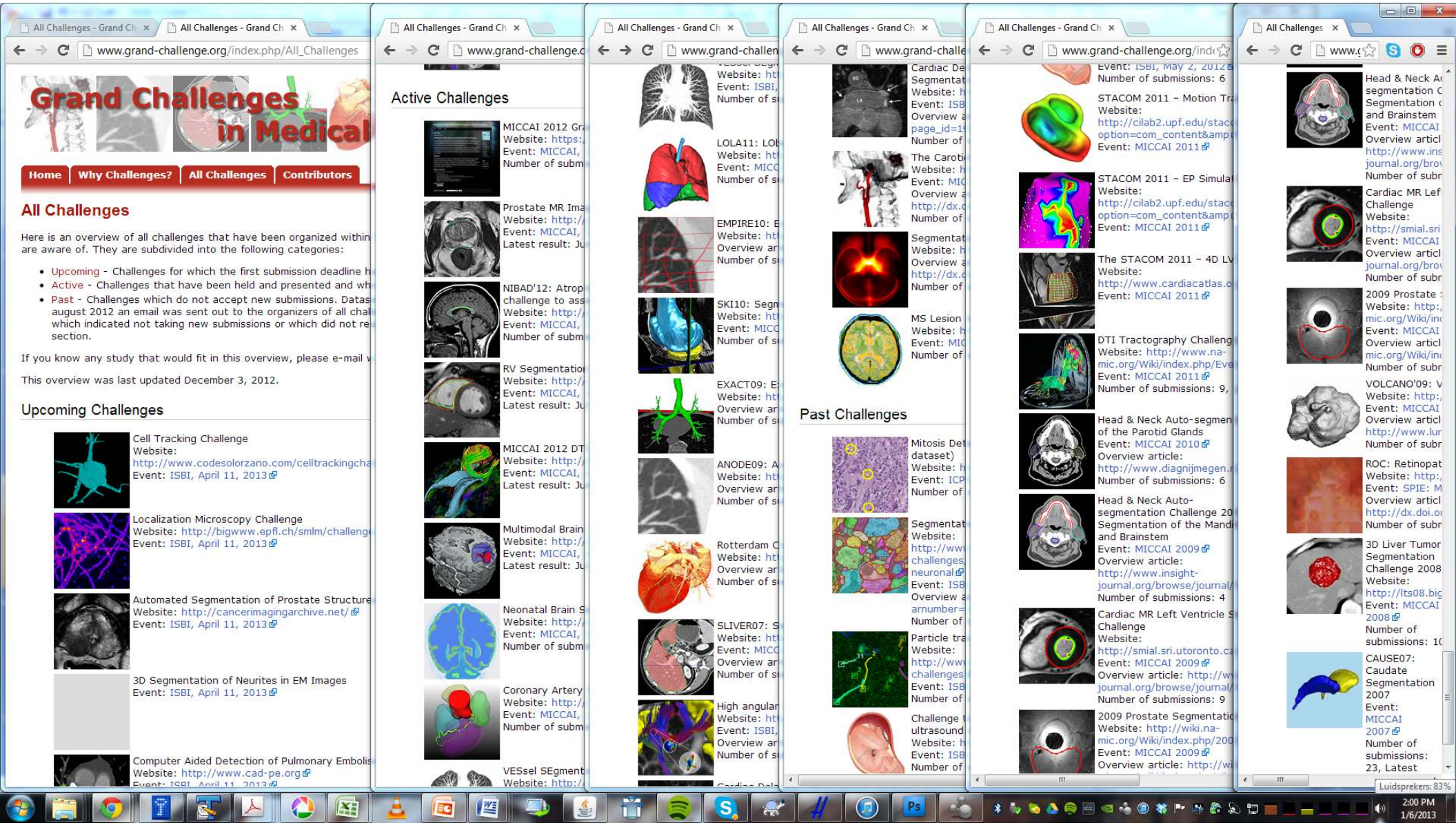
Keywords:
Nodule detection
Lung nodule
CT
Automatic detection
kNN
Shape index

ABSTRACT

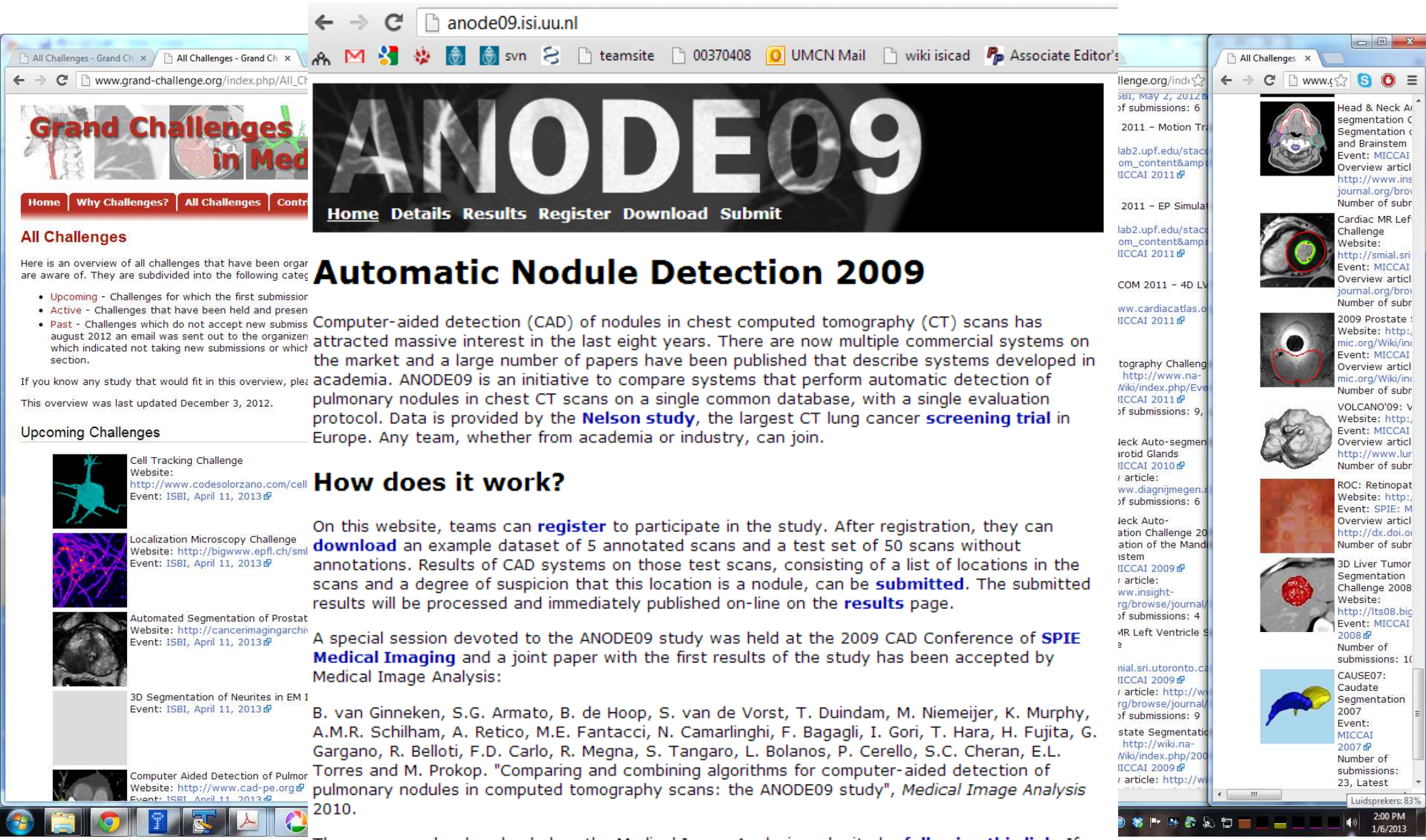
A scheme for the automatic detection of nodules in thoracic computed tomography scans is presented and extensively evaluated. The algorithm uses the local image features of shape index and curvedness in order to detect candidate structures in the lung volume and applies two successive k-nearest-neighbour classifiers in the reduction of false-positives.

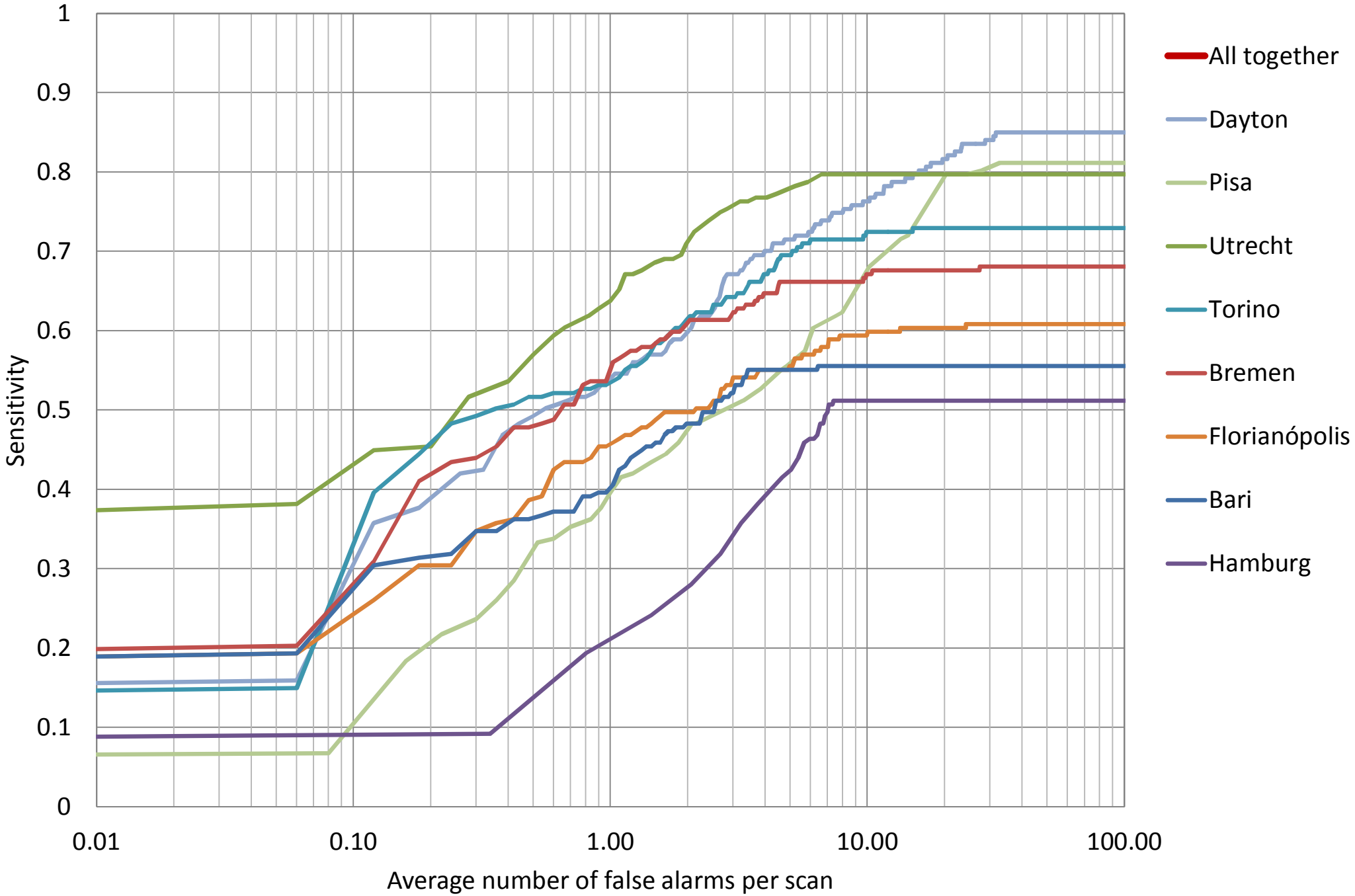
The nodule detection system is trained and tested on three databases extracted from a large-scale experimental screening study. The databases are constructed in order to evaluate the algorithm on both randomly chosen screening data as well as data containing higher proportions of nodules requiring follow-up. The system results are extensively evaluated including performance measurements on specific nodule types and sizes within the databases and on lesions which later proved to be malignant. In a random selection of 813 scans from the screening study a sensitivity of 80% with an average 4.2 false-positives per scan is achieved. The detection results presented are a realistic measure of a CAD system performance in a low-dose screening study which includes a diverse array of nodules of many varying sizes, types and textures.

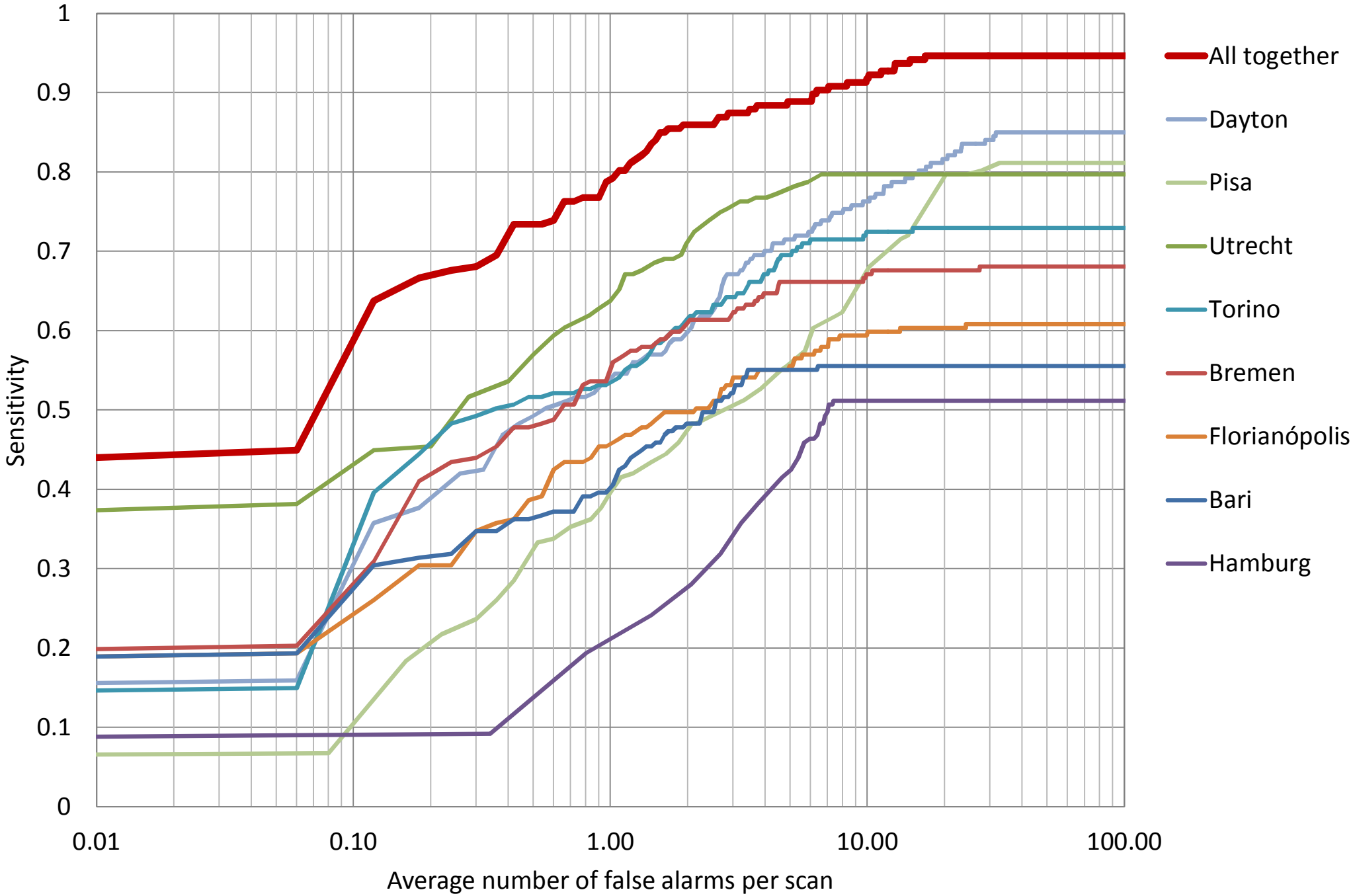
www.grand-challenge.org



www.grand-challenge.org




1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Sensitivity
0.01
0.10
1.00
10.00
100.00
Average number of false alarms per scan
All together
Dayton
Pisa
Utrecht
Torino
Bremen
Florianópolis
Bari
Hamburg


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Sensitivity
0.01
0.10
1.00
10.00
100.00
Average number of false alarms per scan
All together
Dayton
Pisa
Utrecht
Torino
Bremen
Florianópolis
Bari
Hamburg

Literature

- Messay, T.; Hardie, R. C. & Rogers, S. K. A New Computationally Efficient CAD System for Pulmonary Nodule Detection in CT Imagery, *Medical Image Analysis,* **2010***, 14*, 390-406
- Teramoto, A. & Fujita, H. Fast lung nodule detection in chest CT images using cylindrical nodule-enhancement filter, *International Journal of Computer Assisted Radiology and Surgery , Springer,* **2013**, 1-13
- Choi, W.-J. & Choi, T.-S. Automated Pulmonary Nodule Detection System in Computed Tomography Images: A Hierarchical Block Classification Approach, *Entropy, Multidisciplinary Digital Publishing Institute,* **2013***, 15*, 507-523
- Keshani, M.; Azimifar, Z.; Tajeripour, F. & Boostani, R. Lung nodule segmentation and recognition using SVM classifier and active contour modeling: a complete intelligent system, *Computers in Biology and Medicine ,* **2013***, 43*, 287-300
- Fotin, S. V.; Reeves, A. P.; Biancardi, A. M.; Yankelevitz, D. F. & Henschke, C. I. A multiscale Laplacian of Gaussian filtering approach to automated pulmonary nodule detection from whole-lung low-dose CT scans, *Proceedings of the SPIE ,* **2009***, 7260*, 72601Q1-72601Q8
- Guo, W. & Li, Q. High performance lung nodule detection schemes in CT using local and global information, *Medical Physics ,* **2012***, 39*, 5157-5168
- Riccardi, A.; Petkov, T. S.; Ferri, G.; Masotti, M. & Campanini, R. Computer-aided detection of lung nodules via 3D fast radial transform, scale space representation, and Zernike MIP classification, *Medical Physics,* **2011***, 38*, 1962-1971
- Cascio, D.; Magro, R.; Fauci, F.; Iacomi, M. & Raso, G. Automatic detection of lung nodules in CT datasets based on stable 3D mass-spring models, *Computers in Biology and Medicine ,* **2012**
- Camarlinghi, N. Automatic detection of lung nodules in computed tomography images: training and validation of algorithms using public research databases *The European Physical Journal Plus, Springer,* **2013***, 128*, 1-21
- van Ginneken, B.; Armato, S. G.; de Hoop, B.; van de Vorst, S.; Duindam, T.; Niemeijer, M.; Murphy, K.; Schilham, A. M. R.; Retico, A.; Fantacci, M. E.; Camarlinghi, N.; Bagagli, F.; Gori, I.; Hara, T.; Fujita, H.; Gargano, G.; Belloti, R.; Carlo, F. D.; Megna, R.; Tangaro, S.; Bolanos, L.; Cerello, P.; Cheran, S. C.; Torres, E. L. & Prokop, M. Comparing and combining algorithms for computer-aided detection of pulmonary nodules in computed tomography scans: the ANODE09 study, *Medical Image Analysis ,* **2010***, 14*, 707-722
- Jacobs, C.; van Rikxoort, E. M.; Twellmann, T.; Scholten, E. T.; de Jong, P. A.; Kuhnigk, J. M.; Oudkerk, M.; de Koning, H. J.; Prokop, M.; Schaefer-Prokop, C. & van Ginneken, B. Automatic Detection of Subsolid Pulmonary Nodules in Thoracic Computed Tomography Images, *Medical Image Analysis ,* **2014***, 18*, 374-384
- Murphy, K.; van Ginneken, B.; Schilham, A. M. R.; de Hoop, B. J.; Gietema, H. A. & Prokop, M. A Large Scale Evaluation of Automatic Pulmonary Nodule Detection in Chest CT using Local Image Features and k-Nearest-Neighbour Classification, *Medical Image Analysis ,* **2009***, 13*, 757-770