AI: a revolution in healthcare?

Science Meets Business
NovioTech Campus, Nijmegen
30 januari 2020

Bram van Ginneken

Diagnostic Image Analysis Group, Radboud University Medical Center; Fraunhofer MEVIS, Bremen; Thirona, Nijmegen

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Diagnostic Image Analysis Group

The Diagnostic Image Analysis Group is part of the Departments of Radiology, Nuclear Medicine and Anatomy, Pathology, Ophthalmology, and Radiation Oncology of Radboud University Medical Center. We develop computer algorithms to aid clinicians in the interpretation of medical images and improve the diagnostic process.

The group has its roots in computer-aided detection of breast cancer in mammograms, and we have expanded to automated detection and diagnosis in breast MRI, ultrasound and tomosynthesis, chest radiographs and chest CT, prostate MRI, neuro-imaging, retinal imaging, pathology and radiotherapy. The technology we primarily use is deep learning.

It is our goal to have a significant impact on healthcare by bringing our technology to the clinic. We are therefore fully certified to develop, maintain, and distribute software for analysis of medical images in a quality controlled environment (MDD Annex II and ISO 13485) and we closely collaborate with many companies that use our technology in their products.

On this site you find information about the history of the group and our collaborations, an overview of people in DIAG, current projects, publications and theses, contact information, and info for those interested to join our team.

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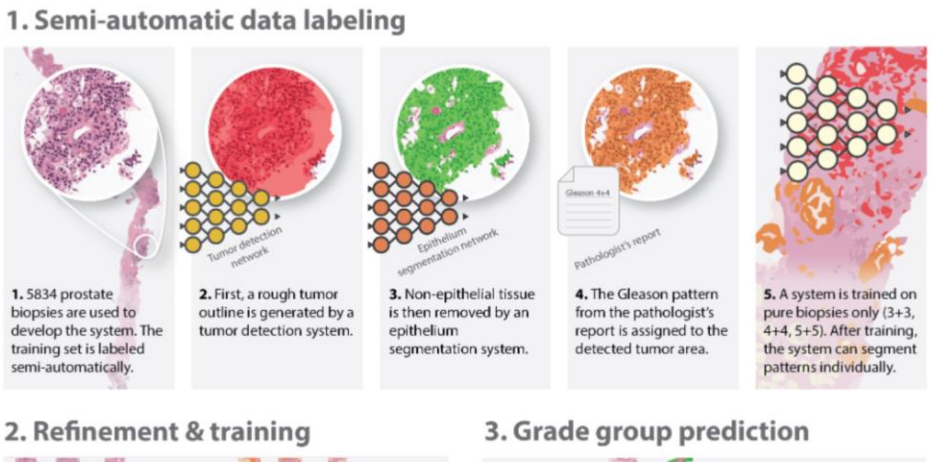
Highlights

January, 2020



Disclosures

- Developer CAD4TB (Delft Imaging Systems): royalties & funding
- Co-founder and CSO Thirona: stock, royalties & funding
- Developer Veolity (MeVis Medical Solutions) & DynaCAD Lung (InVivo): royalties & funding
- ScreenPoint is a spin-off from DIAG; DIAG receives royalties & funding
- DIAG funding: Canon, Siemens Healthineers, Philips Medical, Elekta, Sectra, Novartis

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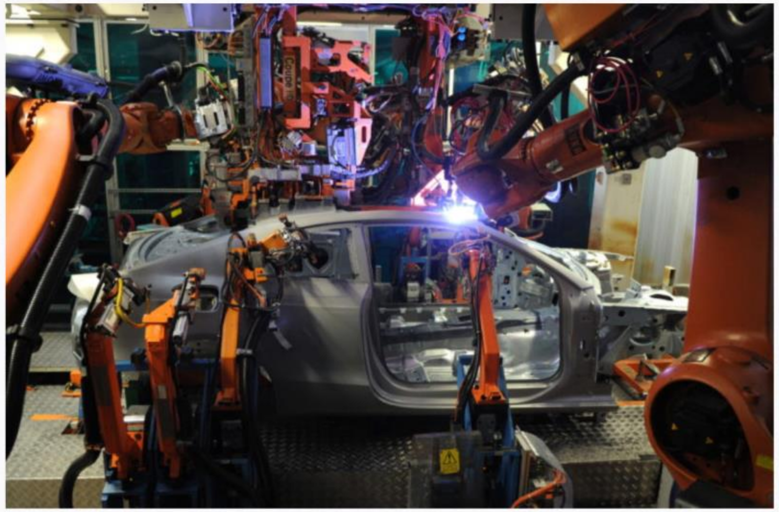

Robots on an assembly line at the Audi plant in Ingolstadt, Germany | Oliver Lang/AFP via Getty Images

Germany's €3B plan to become an AI powerhouse

Here's what's in Merkel's strategy for how to conquer the second wave of artificial intelligence.

By **JANOSCH DELCKER** | 11/14/18, 7:00 AM CET | Updated 4/19/19, 1:29 AM CET

BERLIN — In the global race to dominate artificial intelligence, Europe's industrial powerhouse is taking the gloves off.

On Thursday, Chancellor Angela Merkel will present her strategy on how Germany aims to beat the United States, China and other nations in the emerging second wave of artificial intelligence (AI) that uses industrial rather than consumer data to boost factories and supply chains around the world.

At the heart of the document — which has seen last-minute updates — is a plan to make vast troves of data available to German researchers and developers, improve conditions for entrepreneurs, stop a brain drain of AI experts and loosen regulation in certain areas, according to several government officials involved in drafting the strategy.

The officials, who spoke on the condition of anonymity because the strategy has not yet been officially approved by Cabinet, said that Merkel's experts believe the car industry, manufacturing as well as the health care sector are the three areas most immediately affected by recent developments in artificial intelligence.

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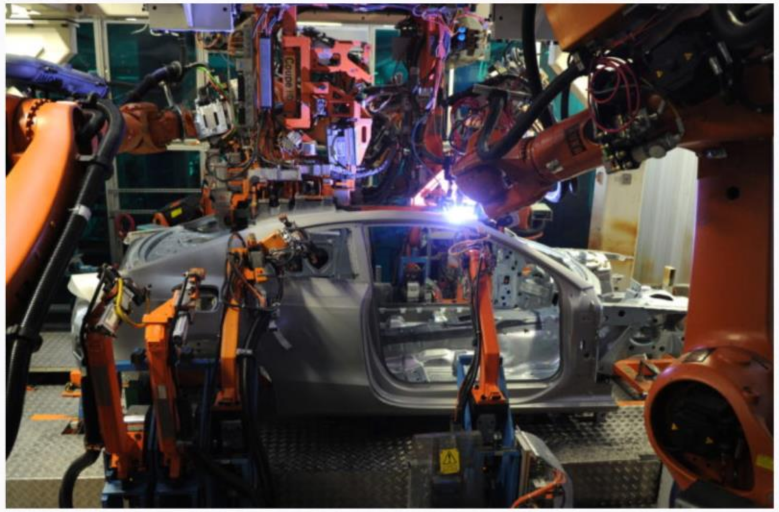

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To take on Big Tech, US can learn antitrust lessons from Europe

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Voorstel focussectoren voor sectorale hubs

	Gezondheidszorg	Agricultuur	Mobiliteit & Logistiek	Veiligheid
Toegevoegde waarde AI:	Zeer grote maatschappelijke waarde en financieel potentieel - geschatte besparingen door AI ~170 mld € in Europa (PwC)	Mogelijk grote maatschappelijke waarde door bijdrage aan voedselvoorziening wereldwijd en vermindering van vervuiling van de aarde.	Economisch één van de meest waardevolle sectoren voor AI (McK). Grote potentie voor duurzaamheid en veiligheid	Veiligheid belangrijk voor maatschappij. Defensie moet op internationaal niveau kunnen acteren, wat nu vooral op digitaal niveau is (waaronder AI).
	Nederland voorloper op het gebied van Value Based Healthcare, waarvoor recent 70 miljoen euro is gecommitteerd vanuit Ministerie van VWS.	Smart Diary Farming en Farm Data Train zijn twee initiatieven die bouwen aan veilige en transparante dataplatformen voor de Nederlandse agrarische sector.	Rijkswaterstaat zeer actief in toepassen AI voor wegverkeer. Ook op lokaal niveau zoals StadsDashboard van gemeente Rotterdam. Smart Data Factory (TNO) om real-time data te delen tussen logistieke bedrijven.	Defensie gebruikt AI actief; gemeente Den Haag bezig met het opzetten van een AI hub gefocust op o.a. security; UN plannen om centrum AI voor veiligheid op te zetten in NL

TU Eindhoven investeert 100 miljoen in kunstmatige intelligentie

EINDHOVEN - De Technische Universiteit Eindhoven investeert de komende jaren 100 miljoen euro in een nieuw instituut voor kunstmatige intelligentie. Per 2 september gaat het nieuwe instituut van start, onder leiding van Carlo van de Weijer, hoofd slimme mobiliteit bij de TU/e.

Merlijn van Dijk 04-07-19, 08:00 **Bron:** ED

Van die 100 miljoen wil de universiteit onder meer 50 nieuwe hoogleraren aantrekken voor het instituut dat Eindhoven Artificial Intelligence Systems Institute (EAISI) gaat heten. Daarbovenop wil de TU/e de komende vijf jaar gemiddeld 30 miljoen euro per jaar ophalen buiten de universiteit. ,,Dat kunnen bijvoorbeeld Brusselse gelden zijn", zegt Van de Weijer.

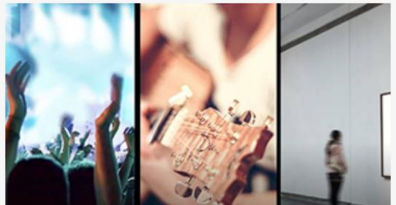
Naast het werven van nieuw personeel investeert de universiteit ook in een nieuw lab, op de tweede verdieping van het Laplace gebouw. Van de Weijer: ,,Dat moet een grote speeltuin worden voor studenten en onderzoekers die al met artificial intelligence bezig zijn."

Met behulp van kunstmatige intelligentie kunnen machines en software zelfstandig problemen oplossen. Van de Weijer ziet dat kunstmatige intelligentie een steeds grotere rol gaat spelen bij fysieke machines, waar het tot dusver veel gebruikt wordt bij software. ,,Het landt in de echte wereld", zegt hij. ,,Dan kom je op de specialisatie van deze regio."

Manifesteren

EAISI gaat zich onder meer richten op gezondheidszorg en mobiliteit. Zo moeten autonoom rijdende auto's in de toekomst zelf beslissingen nemen. Daar is kunstmatige intelligentie voor nodig. ,,Als iemand een fout advies krijgt van Google, is er geen man overboord", illustreert Van de Weijer. ,,Als een auto beslist gas te geven wanneer hij moet remmen, is er natuurlijk meer aan de hand."

Binnen het instituut komt ook ruimte voor onderwijs en mensen die willen promoveren, stelt Van de Weijer. Twee maanden geleden werd hij benaderd om leiding te geven aan het nieuwe instituut. De details van het plan moeten volgens hem nog worden ingevuld. ,,We gaan tijdens de vakantieperiode doorwerken om alle plannen te specificeren."



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26 | 2

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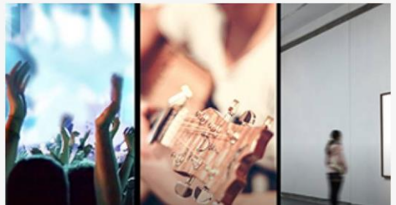

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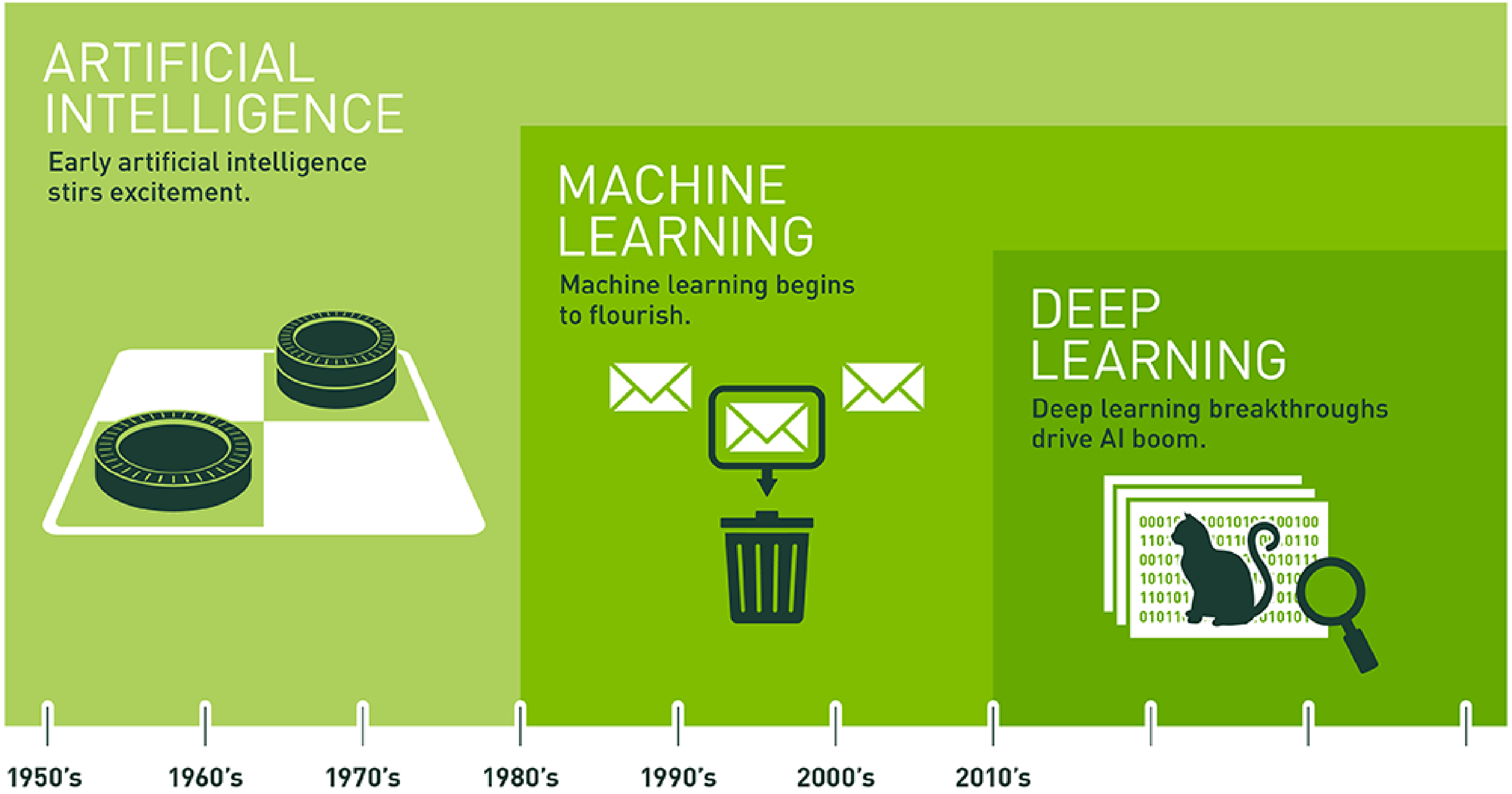
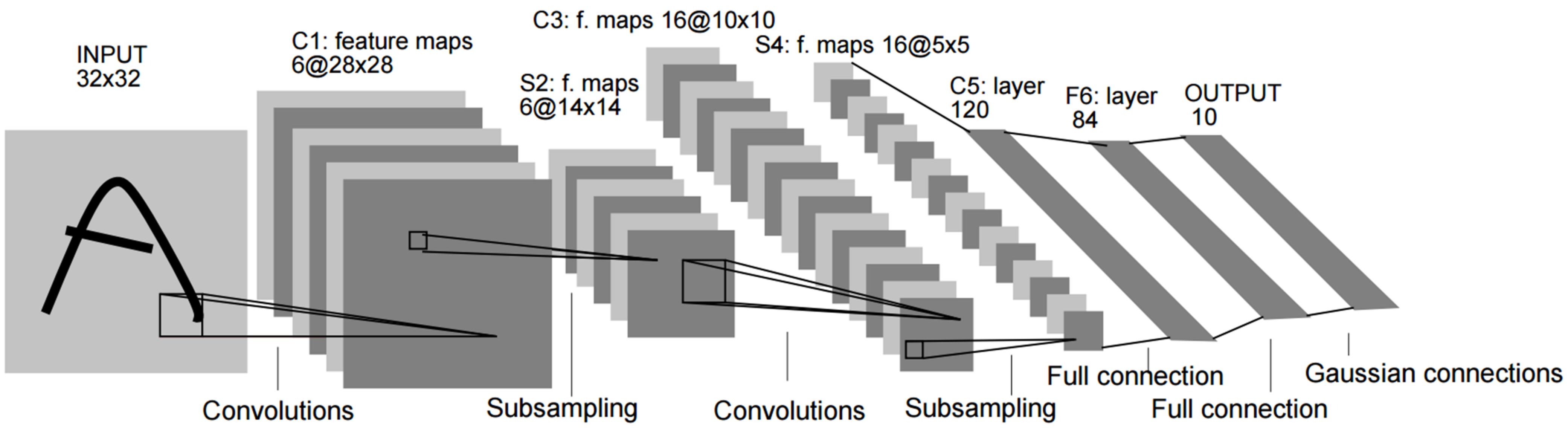
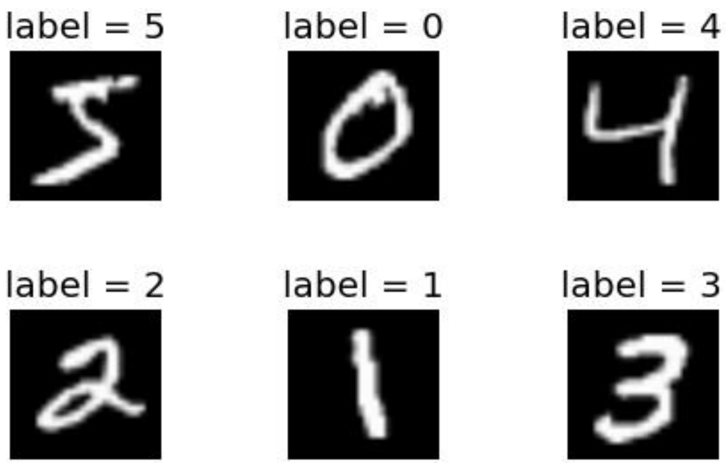


Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

LeNet: Yann LeCun, 1998

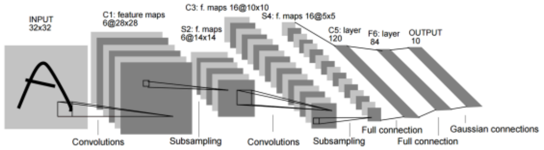


60,000 free parameters in the complete network
Trained with backpropagation using 60,000 images of handwritten digits
In 1998, Yann LeCun was the only person on earth who could get this to work

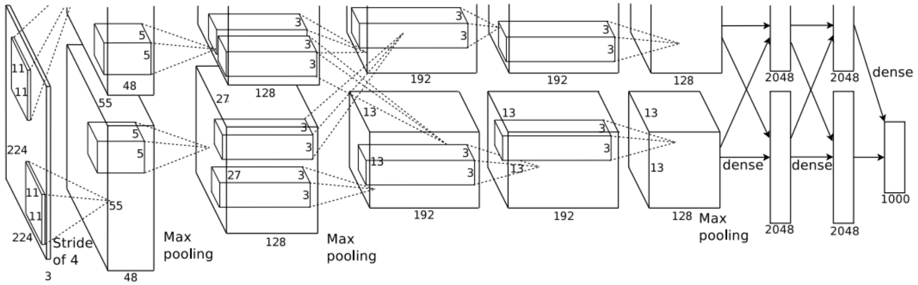


Input: image. Output: number(s). Classifier/discriminator

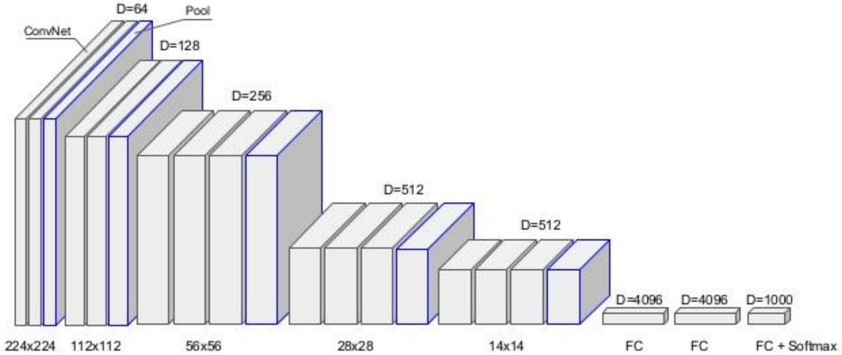
LeNet (1998)



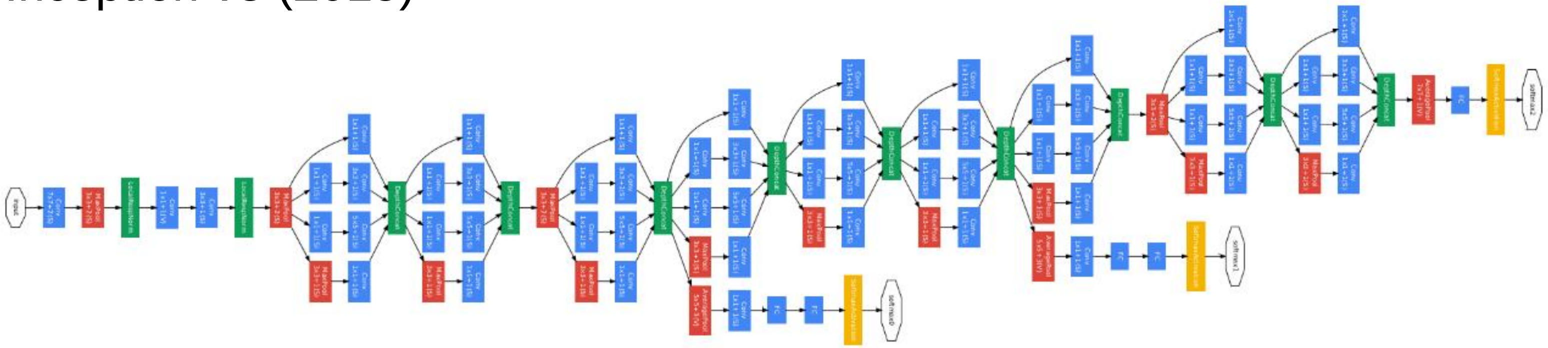
AlexNet (2012)



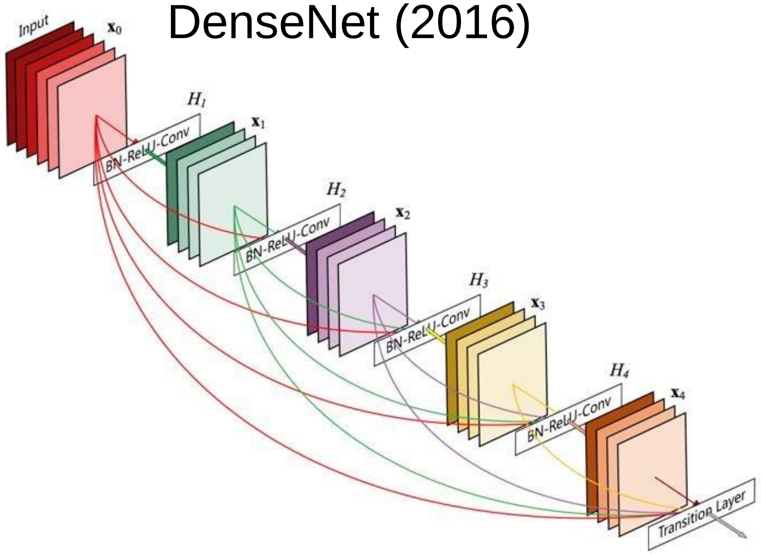
VGGNet (2013)



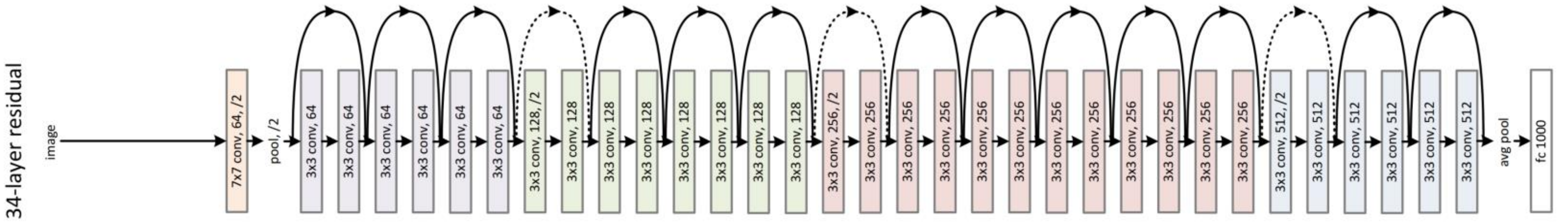
Inception v3 (2015)



DenseNet (2016)



ResNet (2015)



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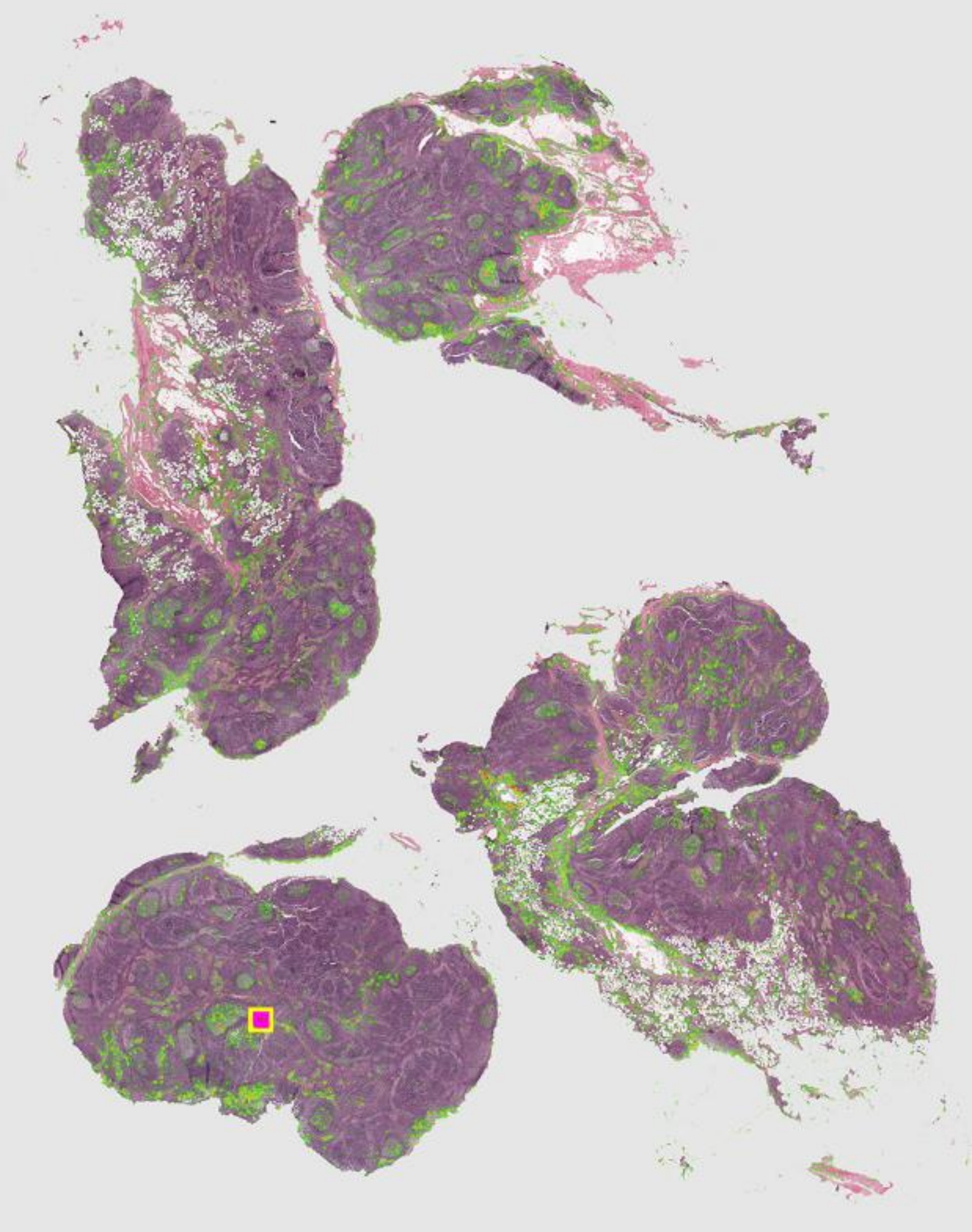
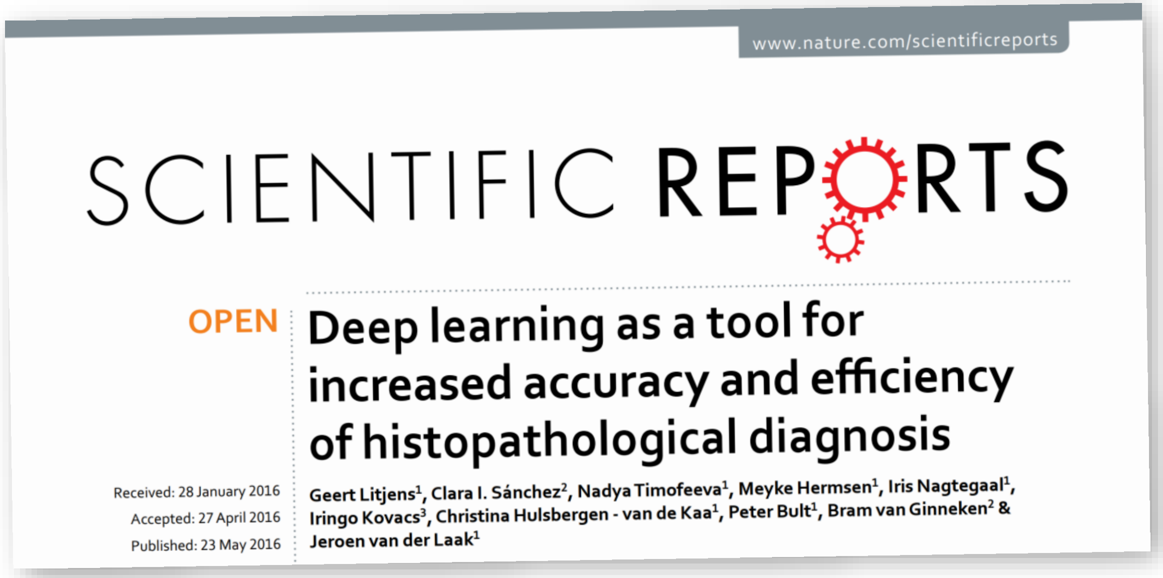
Example 1:
Lymph node metastases and prostate cancer in pathology

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Deep learning as a tool for increased accuracy and efficiency of histopathological diagnosis

Received: 28 January 2016
Accepted: 27 April 2016
Published: 23 May 2016

Geert Litjens[1], Clara I. Sánchez[2], Nadya Timofeeva[1], Meyke Hermsen[1], Iris Nagtegaal[1], Iringo Kovacs[3], Christina Hulsbergen - van de Kaa[1], Peter Bult[1], Bram van Ginneken[2] & Jeroen van der Laak[1]

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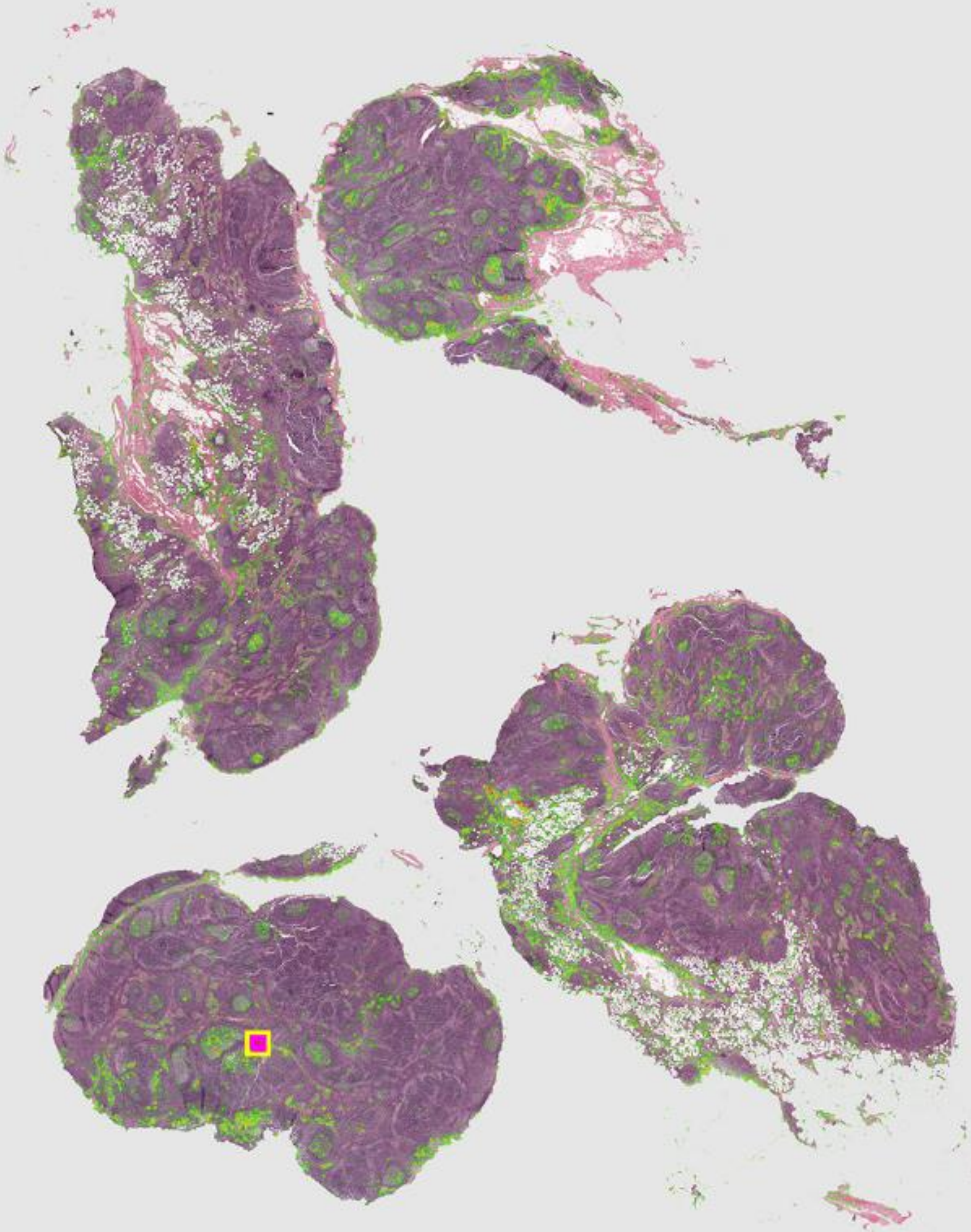

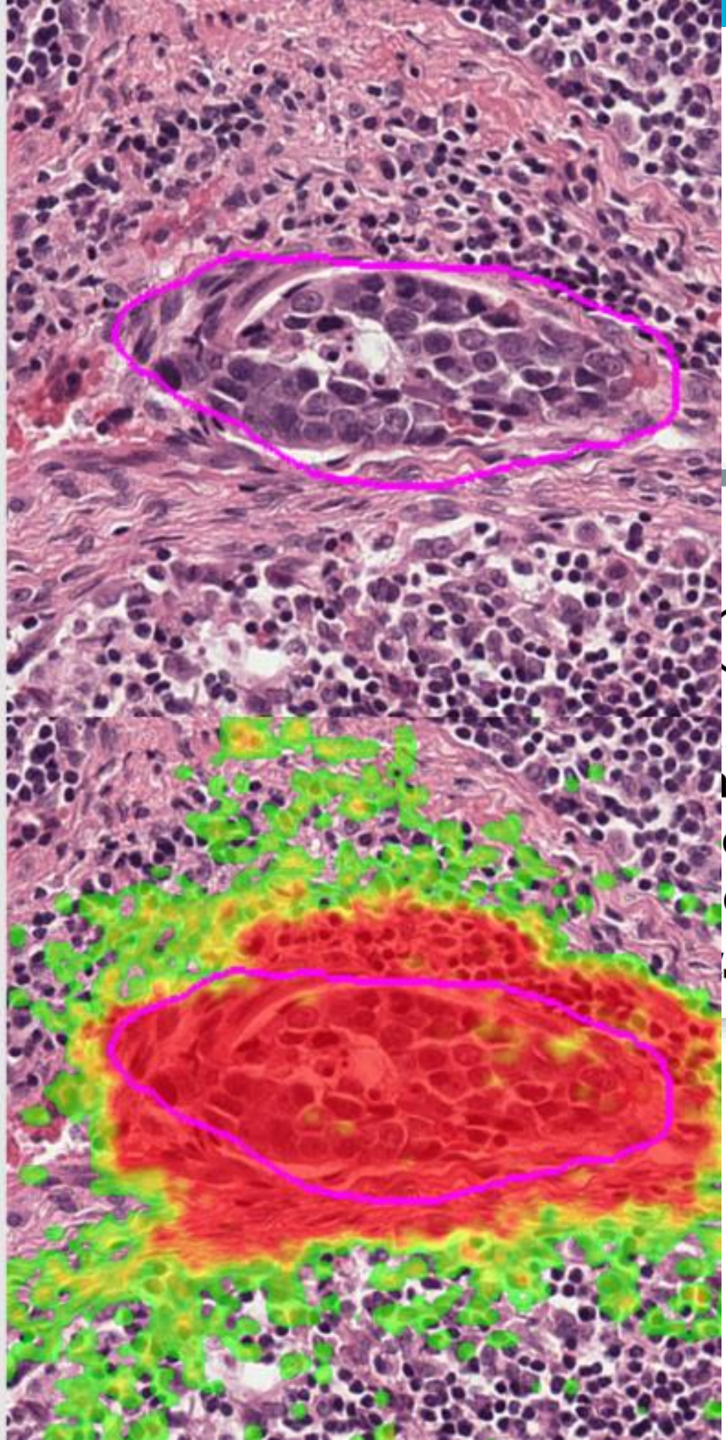

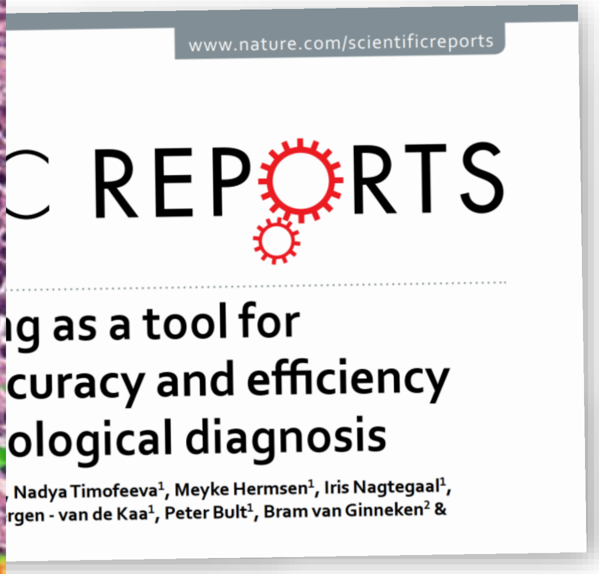
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npo

CAMELYON16

ISBI Challenge on cancer metastases detection in lymph node

Babak Ehteshami Bejnordi

Prague

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IEEE Signal Processing Society

JAMA | Original Investigation

Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women With Breast Cancer

Babak Ehteshami Bejnordi, MS; Mitko Veta, PhD; Paul Johannes van Diest, MD, PhD; Bram van Ginneken, PhD; Nico Karssemeijer, PhD; Geert Litjens, PhD; Jeroen A. W. M. van der Laak, PhD; and the CAMELYON16 Consortium

IMPORTANCE Application of deep learning algorithms to whole-slide pathology images can potentially improve diagnostic accuracy and efficiency.

OBJECTIVE Assess the performance of automated deep learning algorithms at detecting metastases in hematoxylin and eosin–stained tissue sections of lymph nodes of women with breast cancer and compare it with pathologists' diagnoses in a diagnostic setting.

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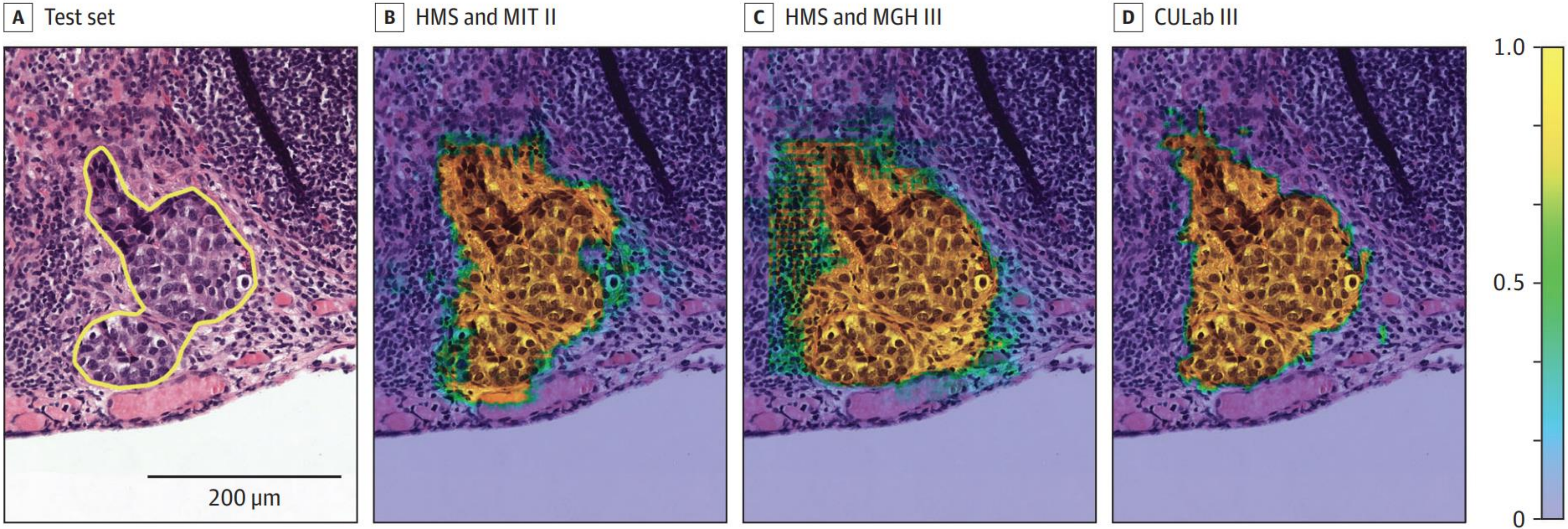
Related articles page 2211 and page 2250

Supplemental content

CME Quiz at jamanetwork.com/learning and **CME Questions** page 2252

CONCLUSIONS AND RELEVANCE In the setting of a challenge competition, some deep learning algorithms achieved better diagnostic performance than a panel of 11 pathologists participating in a simulation exercise designed to mimic routine pathology workflow; algorithm performance was comparable with an expert pathologist interpreting whole-slide images without time constraints. Whether this approach has clinical utility will require evaluation in a clinical setting.



Articles

Automated deep-learning system for Gleason grading of prostate cancer using biopsies: a diagnostic study

Wouter Bulten, Hans Pinckaers, Hester van Boven, Robert Vink, Thomas de Bel, Bram van Ginneken, Jeroen van der Laak, Christina Hulsbergen-van de Kaa, Geert Litjens

Summary

Background The Gleason score is the strongest correlating predictor of recurrence for prostate cancer, but has substantial inter-observer variability, limiting its usefulness for individual patients. Specialised urological pathologists have greater concordance; however, such expertise is not widely available. Prostate cancer diagnostics could thus benefit from robust, reproducible Gleason grading. We aimed to investigate the potential of deep learning to perform automated Gleason grading of prostate biopsies.

Lancet Oncol 2020

Published Online January 8, 2020 https://doi.org/10.1016/S1470-2045(19)30739-9

See Online/Comment https://doi.org/10.1016/

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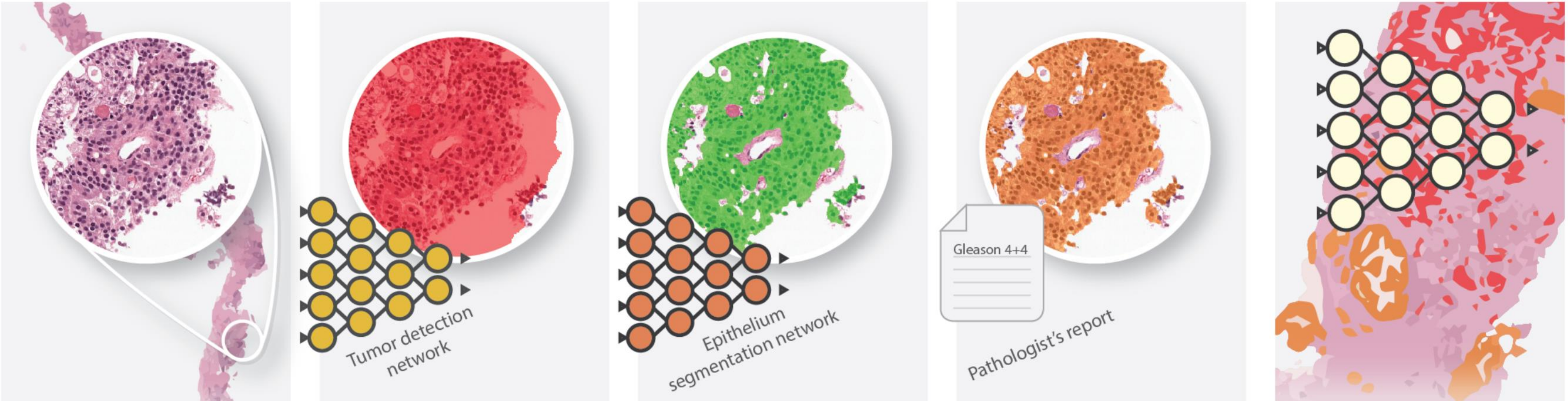


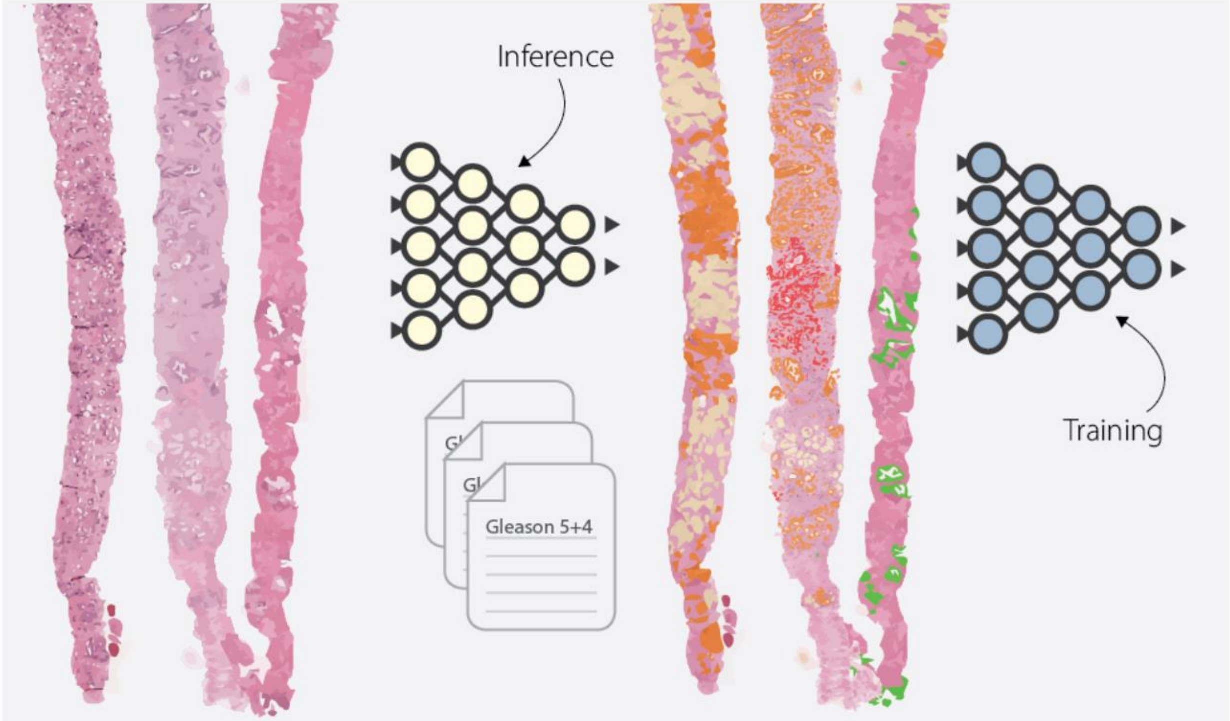
1. 5834 prostate biopsies are used to develop the system. The training set is labeled semi-automatically.

2. First, a rough tumor outline is generated by a tumor detection system.

3. Non-epithelial tissue is then removed by an epithelium segmentation system.

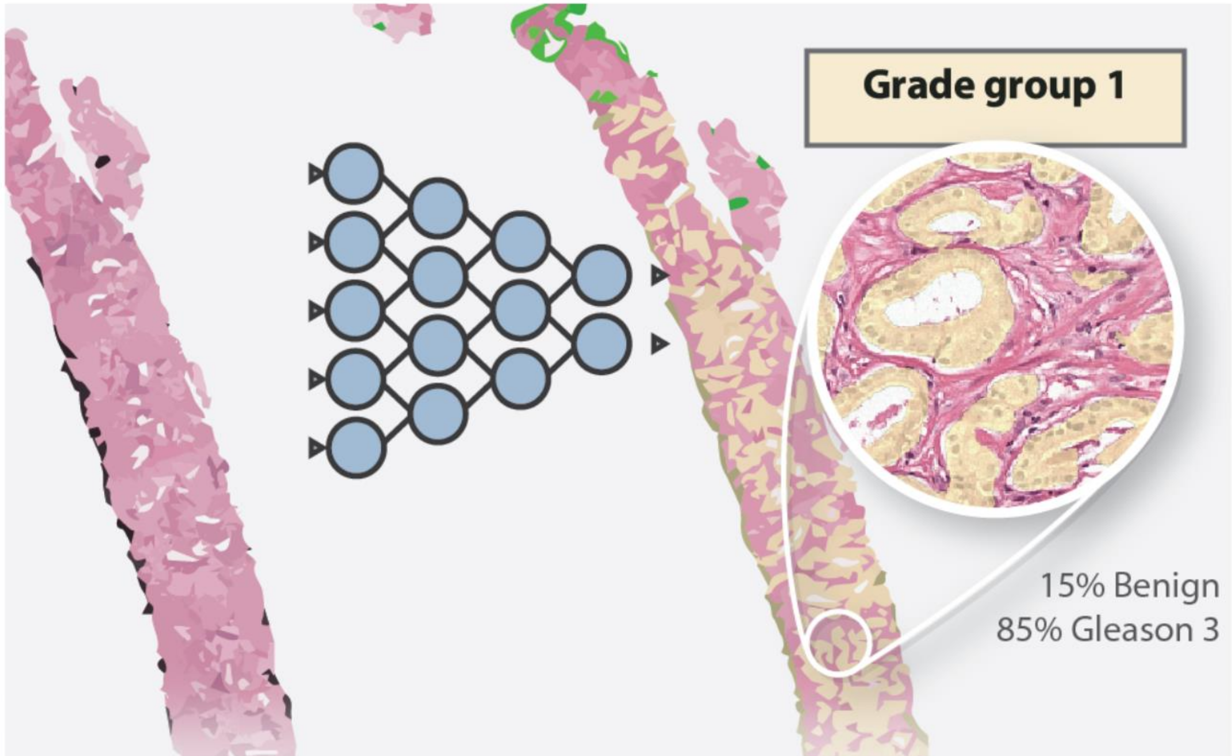
4. The Gleason pattern from the pathologist's report is assigned to the detected tumor area.

5. A system is trained on pure biopsies only (3+3, 4+4, 5+5). After training, the system can segment patterns individually.

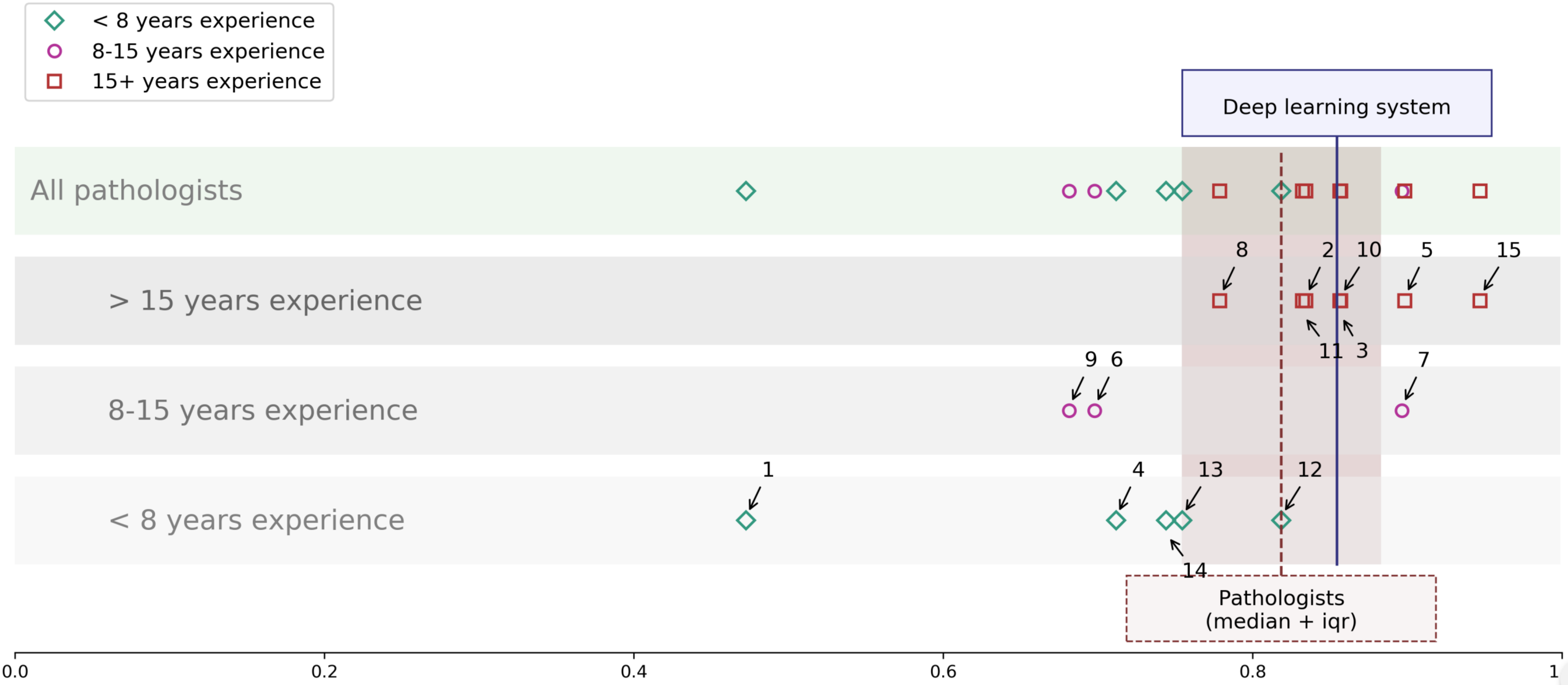


6. The full training set is labeled using the network trained on pure biopsies. Reports are used to further refine the labels.

7. Using the new labels the final system is trained.



8. To evaluate, the final system is applied to the test set. Each gland is labeled with Gleason 3, 4, 5 or benign. The normalized percentag-es are used to compute the Gleason grade group.



< 8 years experience
8-15 years experience
15+ years experience
Deep learning system
All pathologists
> 15 years experience
8-15 years experience
< 8 years experience
8
2
10
5
15
11
3
9
6
7
1
4
13
12
14
Pathologists
(median + iqr)
0.0
0.2
0.4
0.6
0.8
1

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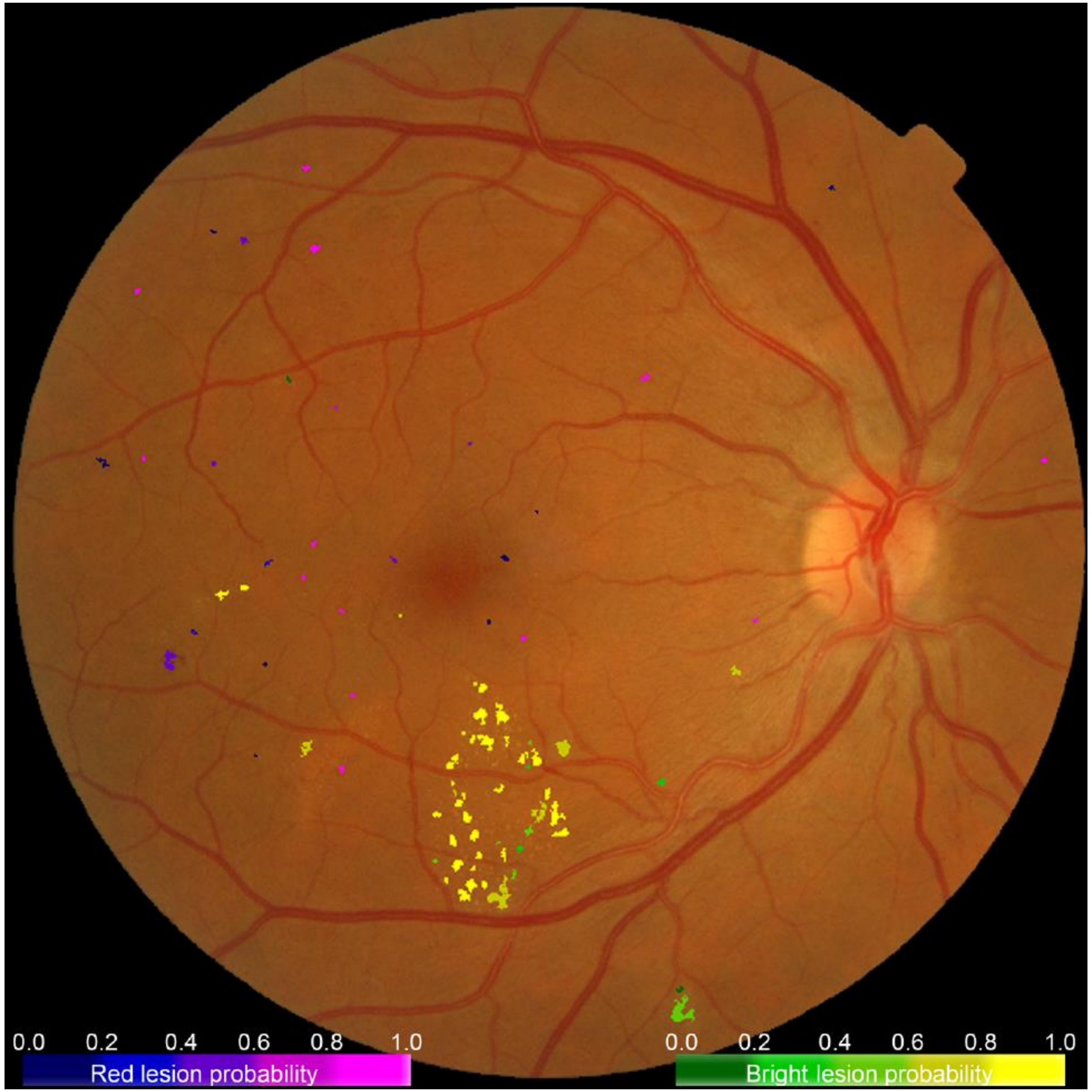
Example 2: Ophthalmology



Niemeijer et al. IEEE Trans Med Imag (2009) 28:775-85
Sánchez et al. Invest Ophthalmol Vis Sci (2011) 52:4866-71

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Automated Analysis of Retinal Images for Detection of Referable Diabetic Retinopathy

Michael D. Abràmoff, MD, PhD; James C. Folk, MD; Dennis P. Han, MD; Jonathan D. Walker, MD; David F. Williams, MD, MBA; Stephen R. Russell, MD; Pascale Massin, MD, PhD; Beatrice Cochener, MD, PhD; Philippe Gain, MD, PhD; Li Tang, PhD; Mathieu Lamard, PhD; Daniela C. Moga, MD, PhD; Gwénolé Quellec, PhD; Meindert Niemeijer, PhD

Importance: The diagnostic accuracy of computer detection programs has been reported to be comparable to that of specialists and expert readers, but no computer detection programs have been validated in an independent cohort using an internationally recognized diabetic retinopathy (DR) standard.

Objective: To determine the sensitivity and specificity of the Iowa Detection Program (IDP) to detect referable diabetic retinopathy (RDR).

Design and Setting: In primary care DR clinics in France, from January 1, 2005, through December 31, 2010, patients were photographed consecutively, and retinal color images were graded for retinopathy severity according to the International Clinical Diabetic Retinopathy scale and macular edema by 3 masked independent retinal specialists and regraded with adjudication until consensus. The IDP analyzed the same images at a predetermined and fixed set point. We defined RDR as more than mild nonproliferative retinopathy and/or macular edema.

Participants: A total of 874 people with diabetes at risk for DR.

Main Outcome Measures: Sensitivity and specificity of the IDP to detect RDR, area under the receiver operating characteristic curve, sensitivity and specificity of the retinal specialists' readings, and mean interobserver difference (κ).

Results: The RDR prevalence was 21.7% (95% CI, 19.0%-24.5%). The IDP sensitivity was 96.8% (95% CI, 94.4%-99.3%) and specificity was 59.4% (95% CI, 55.7%-63.0%), corresponding to 6 of 874 false-negative results (none met treatment criteria). The area under the receiver operating characteristic curve was 0.937 (95% CI, 0.916-0.959). Before adjudication and consensus, the sensitivity/specificity of the retinal specialists were 0.80/0.98, 0.71/1.00, and 0.91/0.95, and the mean intergrader κ was 0.822.

Conclusions: The IDP has high sensitivity and specificity to detect RDR. Computer analysis of retinal photographs for DR and automated detection of RDR can be implemented safely into the DR screening pipeline, potentially improving access to screening and health care productivity and reducing visual loss through early treatment.

JAMA Ophthalmol. 2013;131(3):351-357

DR DETECTION PROGRAM

The IDP consists of previously published components for image quality assessment,[19] microaneurysm and hemorrhage detection,[20,21] detection of exudates and cotton wool spots,[22] and a new component for detection of irregular lesions, including large hemorrhages and neovascularization.[6,23] Generally, IDP examines each pixel in each image, analyzes it and its surrounding pixels, and combines the analysis of multiple neighboring pixels into multiple lesions or retinal structures, with their likelihood, size, shape, location, type, and other properties, as well as the quality of each image. The algorithms have all been published previously. A separate fusion algorithm, also previously published,[24] combines these analyses of individual lesions and structures, as well as the image quality. The final

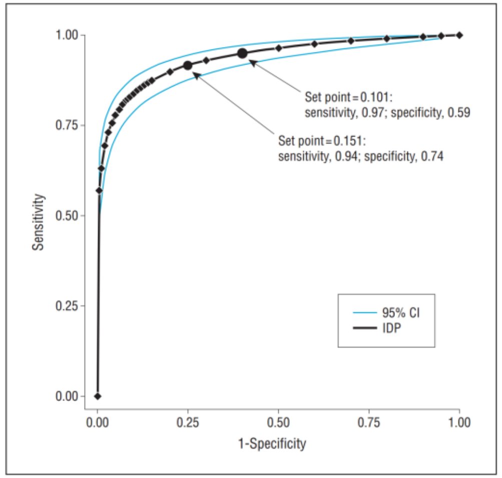


Figure 3. Receiver operator characteristics curve of the Iowa Detection Program (IDP) to detect referable diabetic retinopathy, defined as more than mild nonproliferative retinopathy and/or macular edema according to International Clinical Diabetic Retinopathy criteria by an adjudicated consensus of 4 retinal specialists and 2 selected set points. The area under the curve is 0.9373.

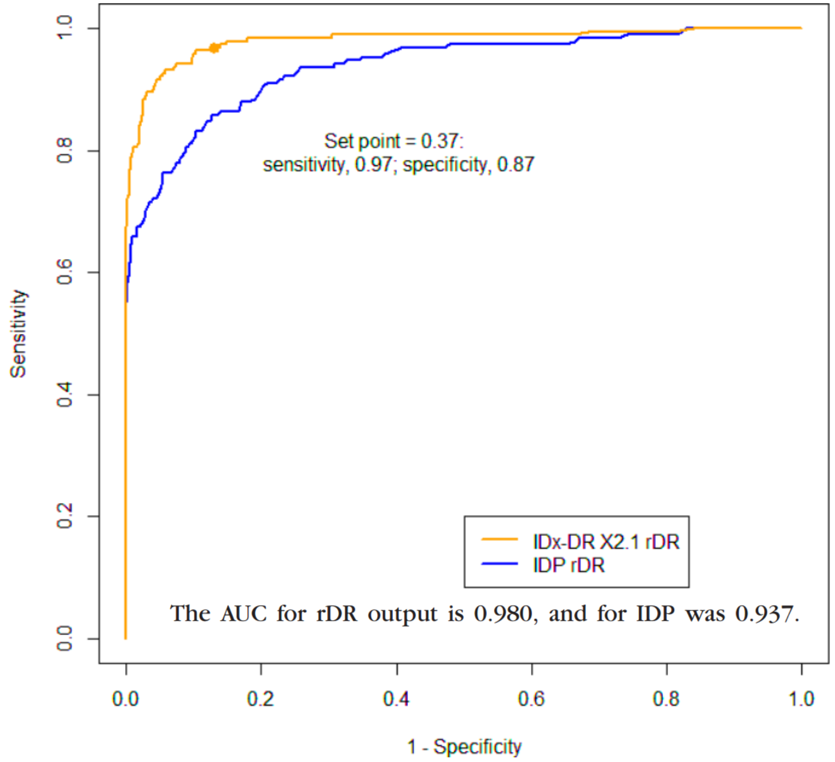
IOVS | October 2016 | Vol. 57 | No. 13 | 5201

Retina

Improved Automated Detection of Diabetic Retinopathy on a Publicly Available Dataset Through Integration of Deep Learning

Michael David Abràmoff,[1–3] Yiyue Lou,[4] Ali Erginay,[5] Warren Clarida,[3] Ryan Amelon,[3] James C. Folk,[1,3] and Meindert Niemeijer[3]

The device applies a set of CNN-based detectors to each of the images in the exam. These detectors are trained and optimized to detect normal anatomy, such as optic disc and fovea, as well as the lesions characteristic for DR, such as hemorrhages, exudates, and neovascularization. Though the CNNs are particular to each type of lesion and parameters vary slightly between them, they are inspired by Alexnet[23] (for more limited training sets) and the Oxford Visual Geometry Group[26] (for more extensive training sets) network architectures. They were trained on 10,000 to 1,250,000 unique samples, depending on the lesion to be detected, extracted from images from patients with DR, and manually annotated by one or more experts, as well as positive and negative confounders.[27] The unique samples underwent a variety of augmentations to increase spatial, rotational, and scale variance.



The AUC for rDR output is 0.980, and for IDP was 0.937.

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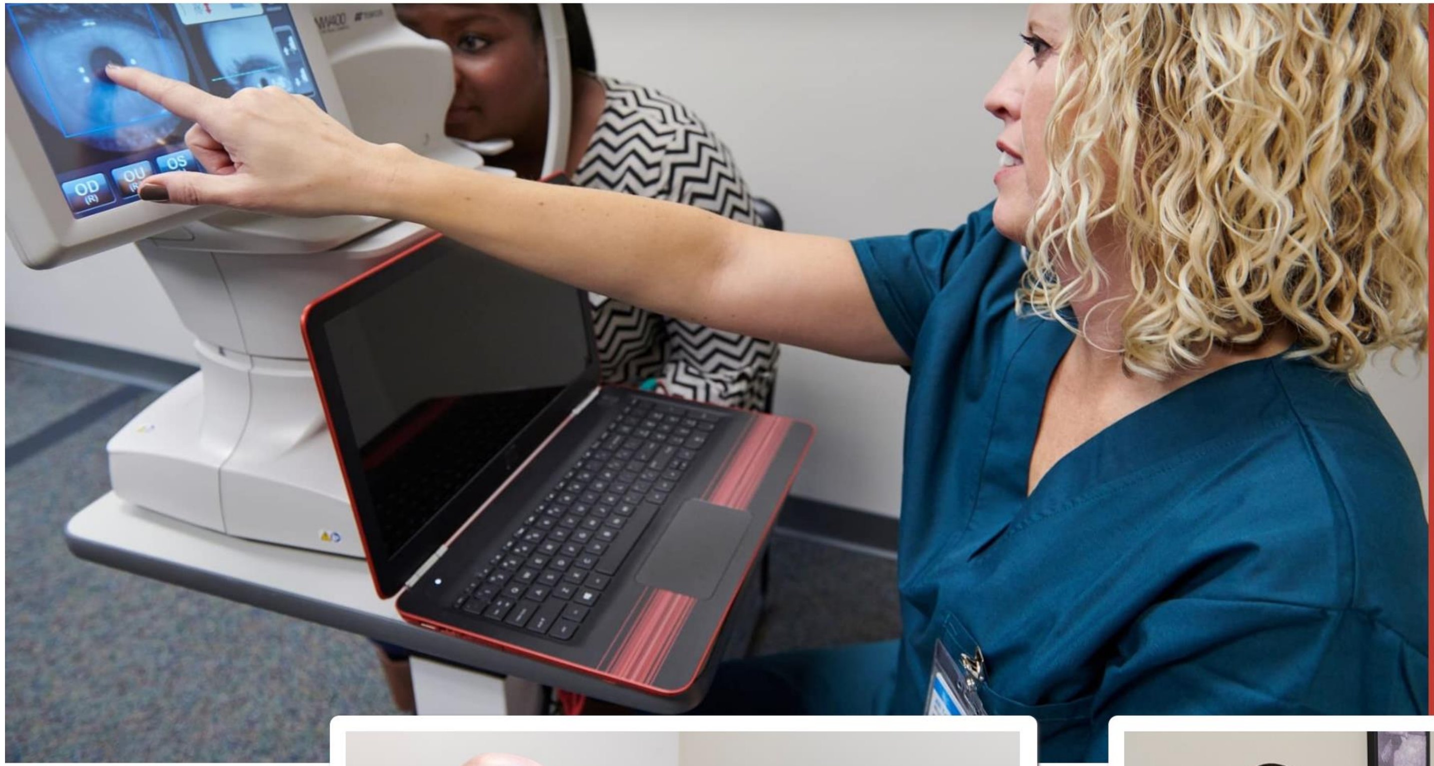


Autonomous AI that instantly detects disease

Increase patient access to early disease detection.

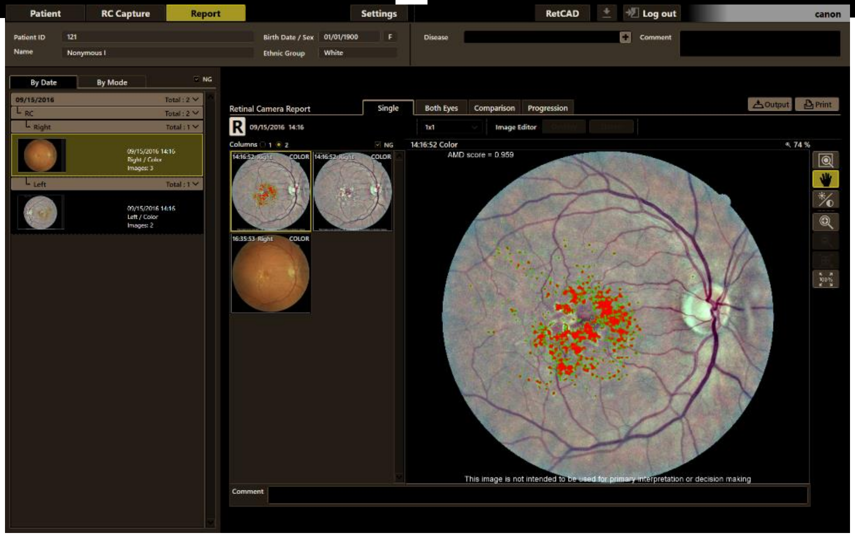
Learn More

IDx-DR

The first ever autonomous AI system cleared by the FDA to provide a diagnostic decision

How to test for DR in primary care

Download our white paper on the pros and cons of telmedicine and AI solutions thirona



Radboudumc

Acta Ophthalmologica

Acta Ophthalmologica 2019

Evaluation of a deep learning system for the joint automated detection of diabetic retinopathy and age-related macular degeneration

Cristina González-Gonzalo,[1,2,3,4] Verónica Sánchez-Gutiérrez,[5] Paula Hernández-Martínez,[5] Inés Contreras,[5,6] Yara T. Lechanteur,[4] Artin Domanian,[4] Bram van Ginneken[2] and Clara I. Sánchez[1,2,3,4]

[1]A-eye Research Group, Radboud University Medical Center, Nijmegen, The Netherlands
[2]Diagnostic Image Analysis Group, Radboud University Medical Center, Nijmegen, The Netherlands
[3]Donders Institute for Brain, Cognition and Behaviour, Radboud University Medical Center, Nijmegen, The Netherlands
[4]Department of Ophthalmology, Radboud University Medical Center, Nijmegen, The Netherlands
[5]Department of Ophthalmology, University Hospital Ramón y Cajal, Ramón y Cajal Health Research Institute (IRYCIS), Madrid, Spain
[6]Clínica Rementería, Madrid, Spain

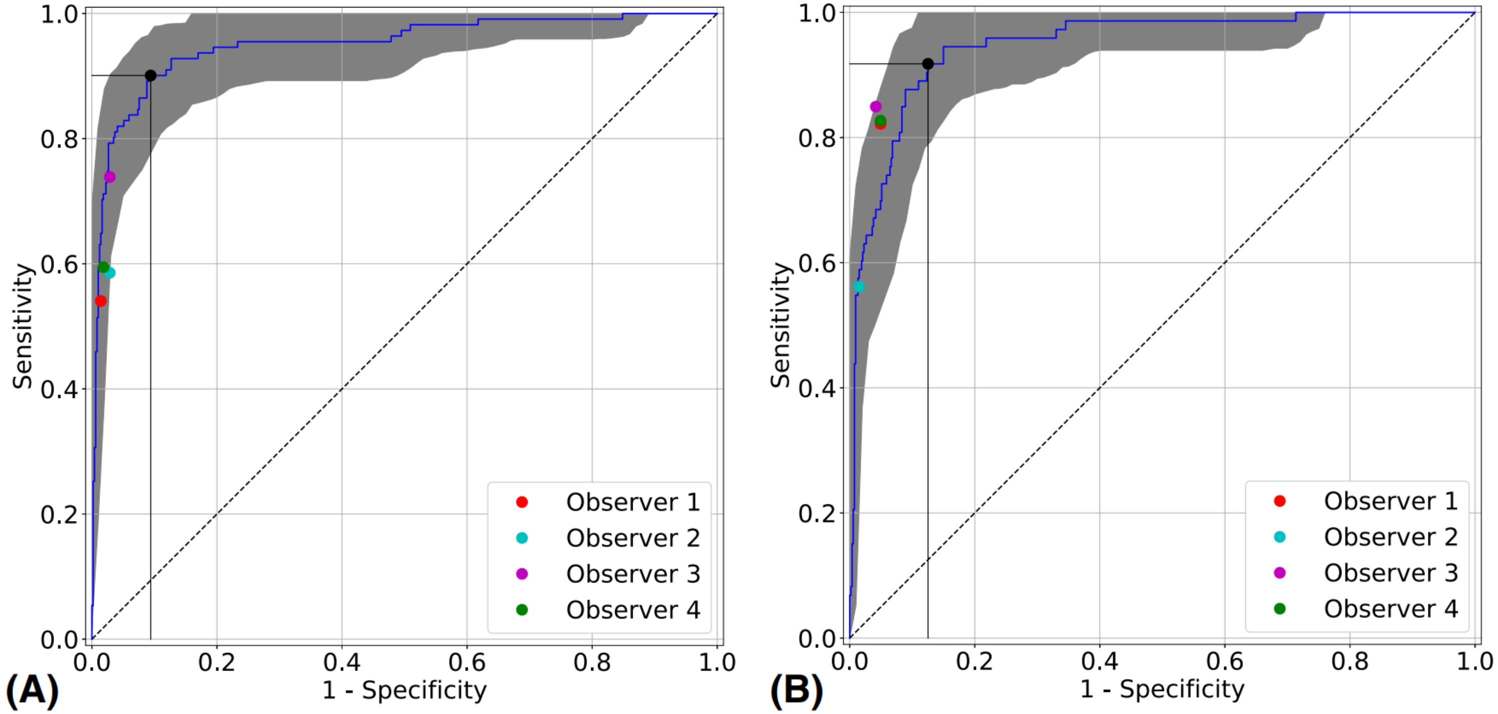
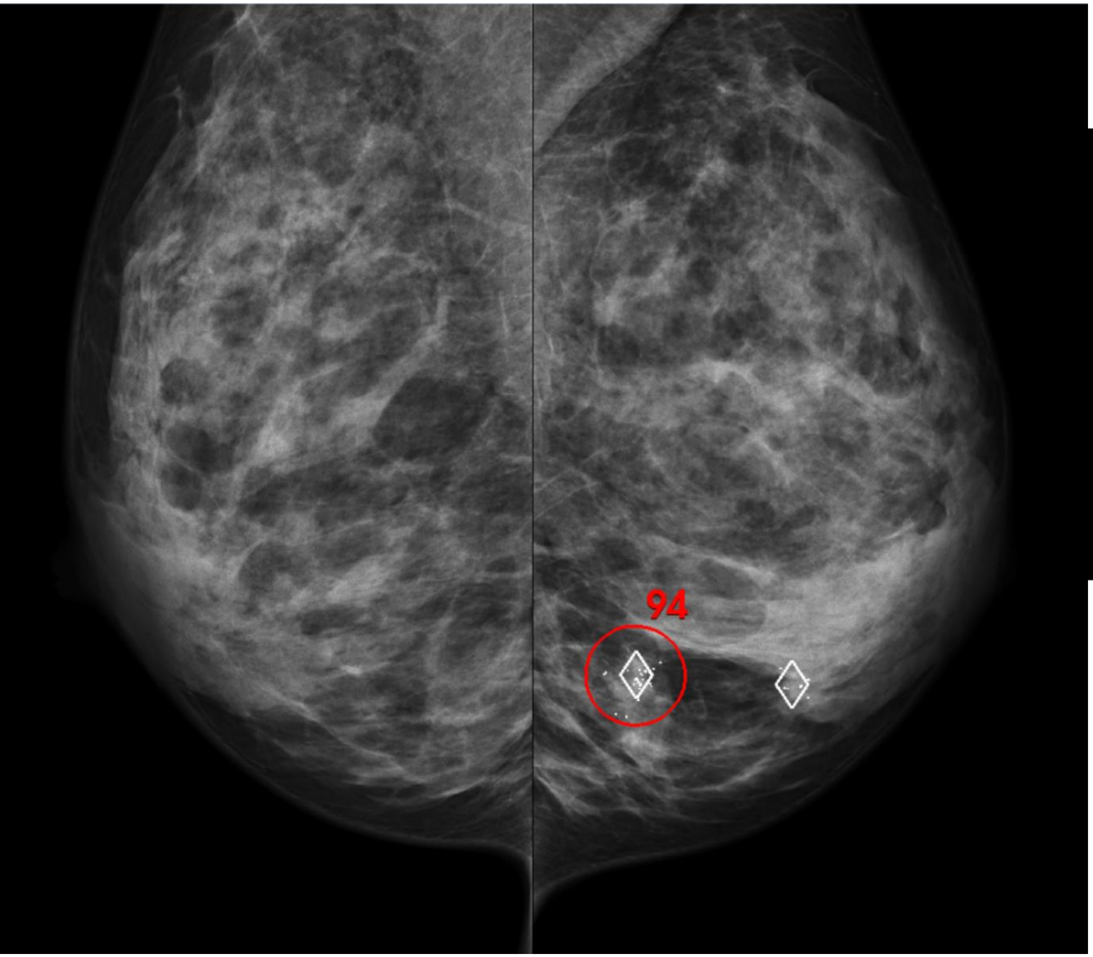


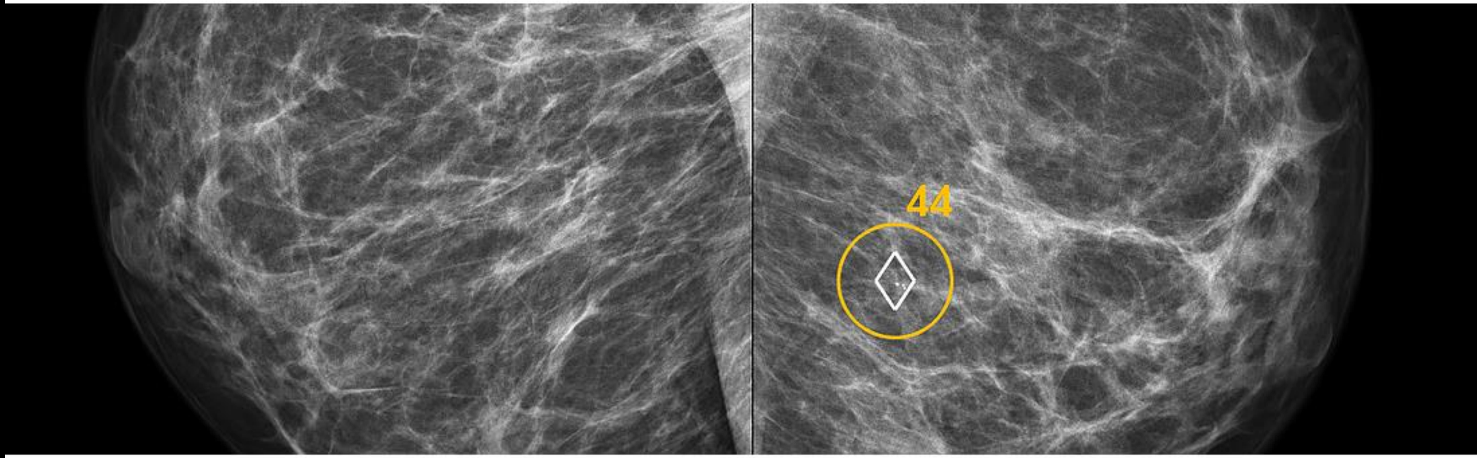
Fig. 2. Receiver operating characteristic curves for joint detection of referable DR (A) and AMD (B) in the DR-AMD dataset (600 images). Performance of RetCAD v.1.3.0 corresponds to the blue curves (95% CI within grey area); the coloured circles, to the human observers. The black circle indicates the SE and SP of RetCAD v.1.3.0 at its optimal operating point. For DR vs. AMD + controls (A), AUC was 95.1% (95% CI, 90.8%–98.2%), SE was 90.1% (95% CI, 85.2%–96.8%) and SP was 90.6% (95% CI, 85.5%–96.7%). For AMD vs. DR + controls (B), AUC was 94.9% (95% CI, 90.9%–97.9%), SE was 91.8% (95% CI, 84.6%–97.8%) and SP was 87.5% (95% CI, 83.5%–93.9%). AMD, age-related macular degeneration; AUC, area under the receiver operating characteristic curve; CI, confidence interval; DR, diabetic retinopathy; SE, sensitivity; SP, specificity.

Example 3: Mammography

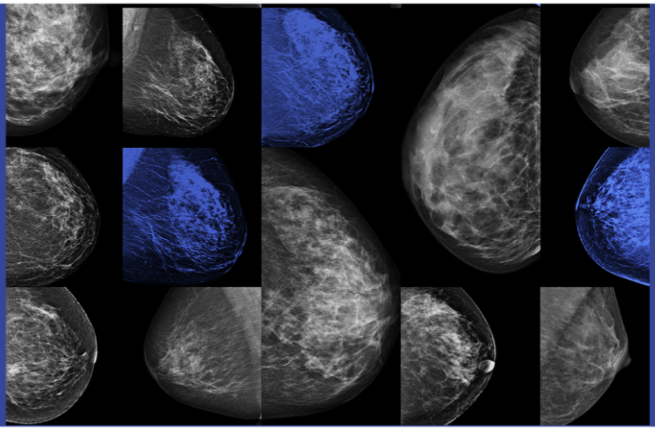
Radboudumc

Transpara





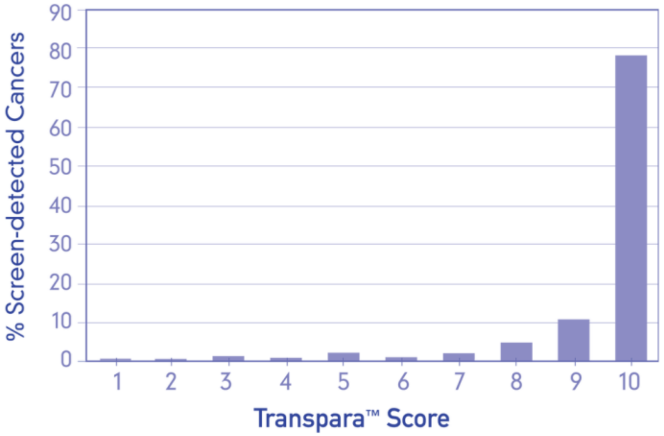
AUTOMATICALLY CATEGORIZES MAMMOGRAMS



Transpara Score

Categorizes your exams

Transpara categorizes mammograms in ten equally sized groups, to present an increasing proportion of those with cancer. Most mammograms with cancer fall into the highest category (Transpara Score 10), while very few exams with cancerous lesions have a low score. The score's display alerts you to mammograms with a higher likelihood of cancer, and also provides you with increased confidence for reporting normal exams. Integrated with RIS/PACS applications, you can even use Transpara Score to create worklists.



OXFORD

JNCI J Natl Cancer Inst (2019) 111(9): djy222

doi: 10.1093/jnci/djy222
Article

ARTICLE

Stand-Alone Artificial Intelligence for Breast Cancer Detection in Mammography: Comparison With 101 Radiologists

Alejandro Rodriguez-Ruiz, Kristina Lång, Albert Gubern-Merida, Mireille Broeders, Gisella Gennaro, Paola Clauser, Thomas H. Helbich, Margarita Chevalier, Tao Tan, Thomas Mertelmeier, Matthew G. Wallis, Ingvar Andersson, Sophia Zackrisson, Ritse M. Mann, Ioannis Sechopoulos

See the Notes section for the author's affiliations.
Correspondence to: Ioannis Sechopoulos, PhD, Department of Radiology and Nuclear Medicine, Radboud University Medical Centre, Geert Grooteplein 10, 6525 GA, Post 766, Nijmegen, the Netherlands (e-mail: Ioannis.sechopoulos@radboudumc.nl).

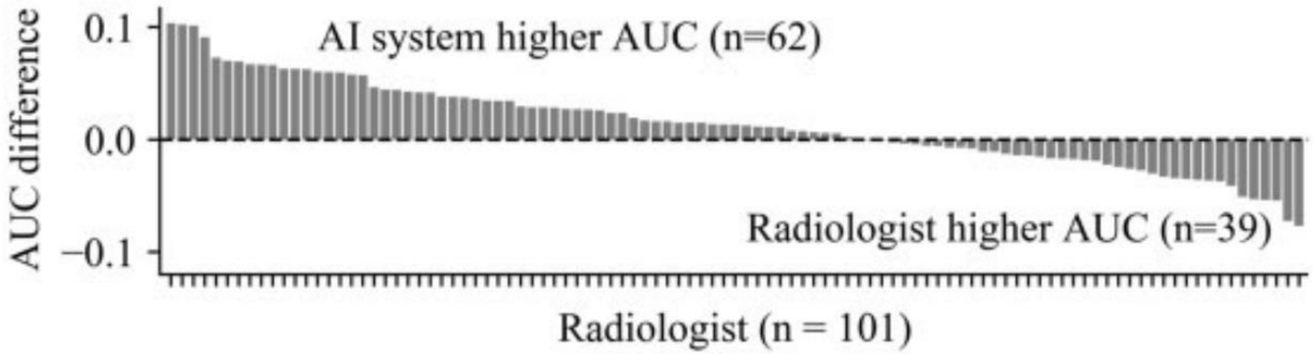
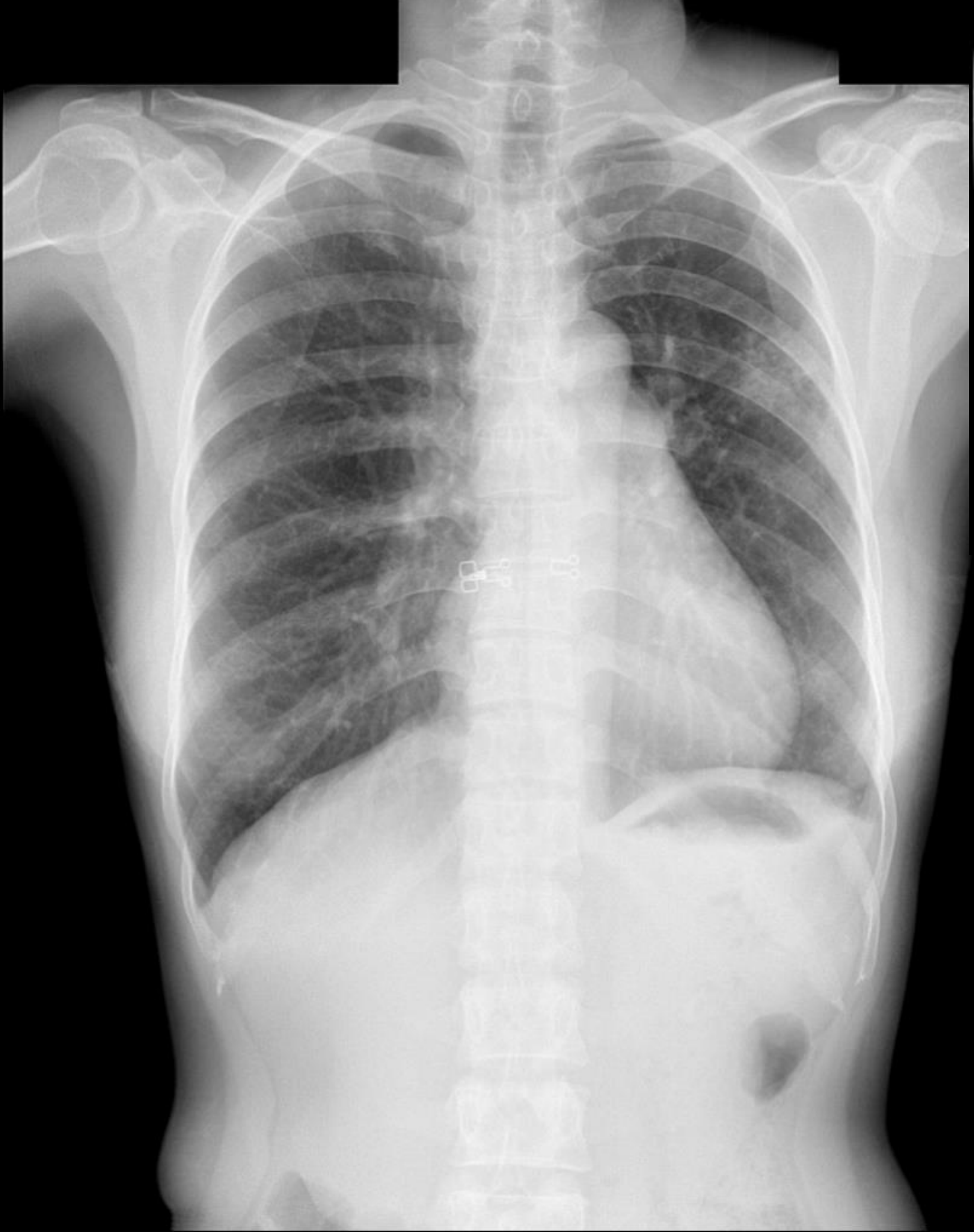
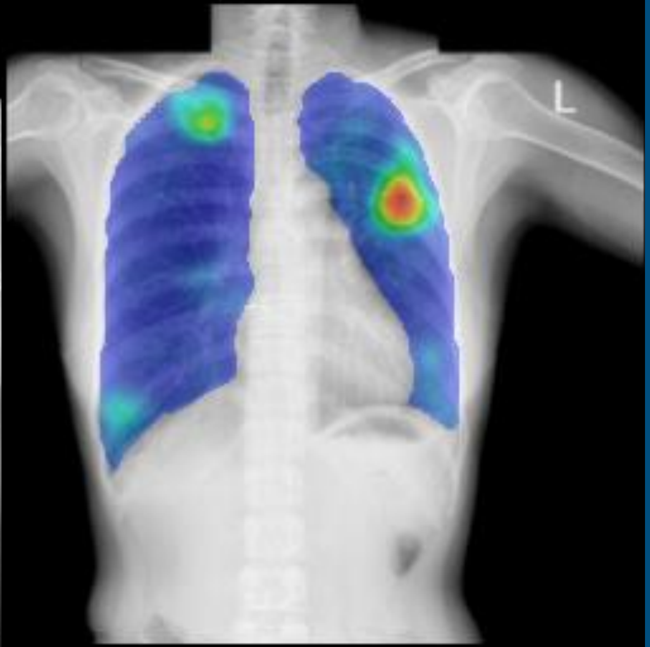


Figure 2. Differences in area under the receiver operating characteristic curve (AUC) between the artificial intelligence (AI) system and each radiologist.

Example 4:
Screening for tuberculosis





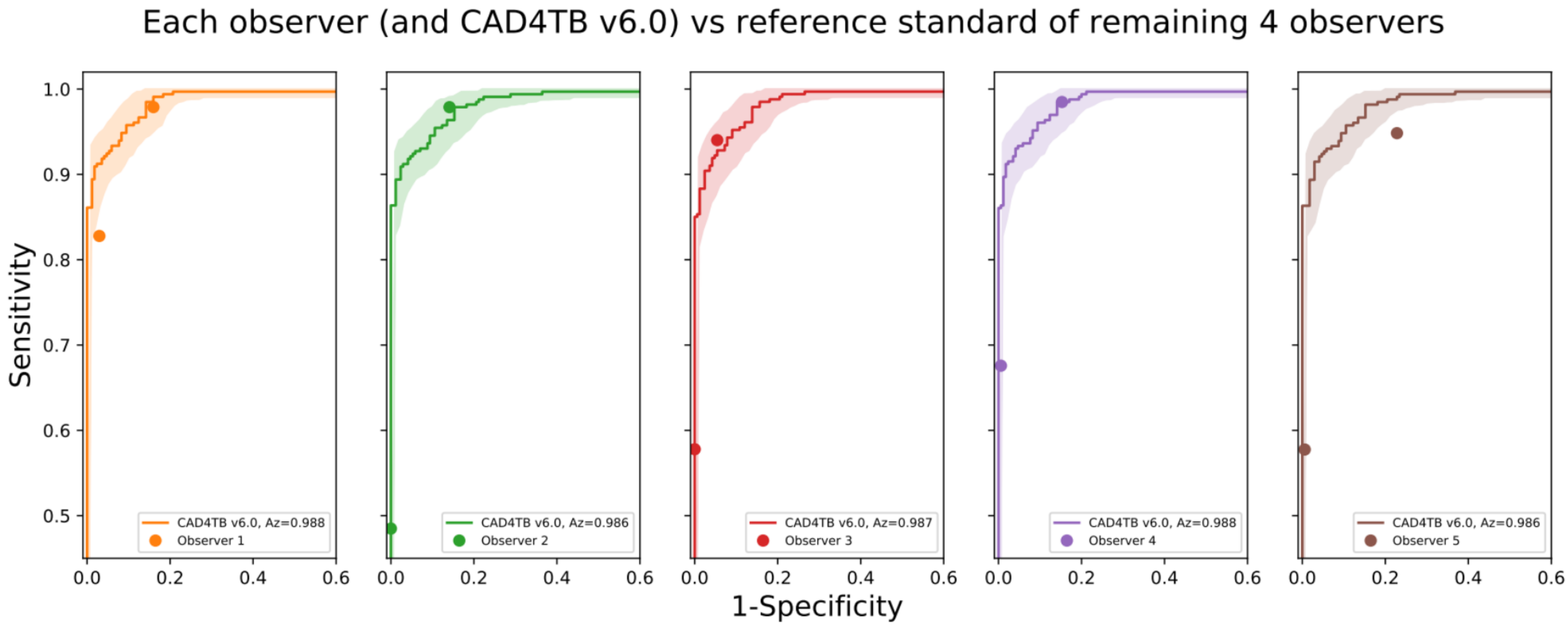
CAD4TB

Artificial intelligence for the detection of tuberculosis

- CE certified
- 40+ publications
- Activated in 30+ countries
- Screening 5,000+ people per day

Computer aided detection of tuberculosis on chest radiographs: An evaluation of the CAD4TB v6 system

Keelin Murphy[1,*], Shifa Salman Habib[2], Syed Mohammad Asad Zaidi[2], Saira Khowaja[3,4], Aamir Khan[3,4], Jaime Melendez[5], Ernst T. Scholten[1], Farhan Amad[2], Steven Schalekamp[1], Maurits Verhagen[6], Rick H. H. M. Philipsen[5], Annet Meijers[5], and Bram van Ginneken[1]




مفت
TB


TB

Florent Geerts replied to Panggih R. Sudarsono's comment on this

Florent Geerts • 1st
Business Unit Manager at Delft Imaging Systems & Business Development Manager...
1w

Very proud to say that at Delft Imaging Systems we've hit a new important milestone: more than 5 million people have been screened for tuberculosis with our CAD4TB artificial intelligence software, all around the world.

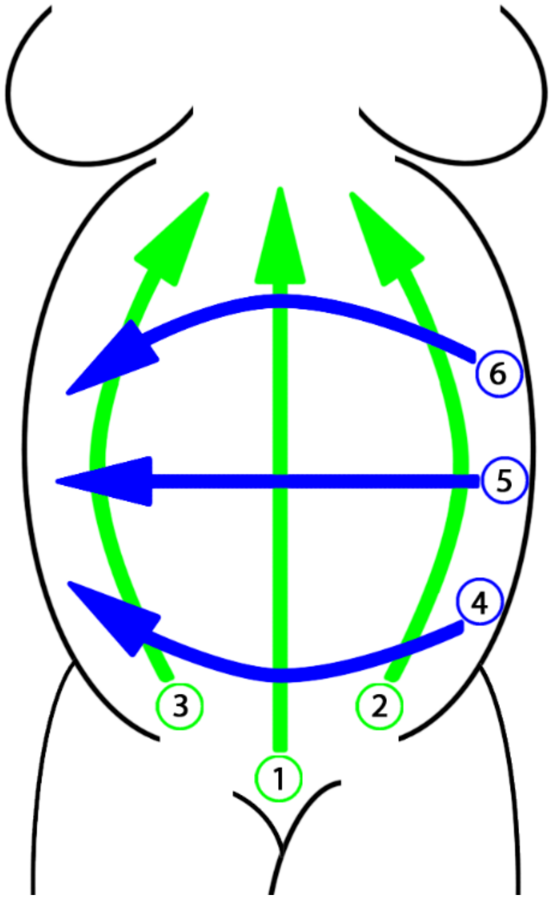
From here, we look forward to further expanding the performance of the software and its features, and look to implement it in even more countries to support the detection of tuberculosis and help fight this disease that still costs the lives of 1.6 million people every year.

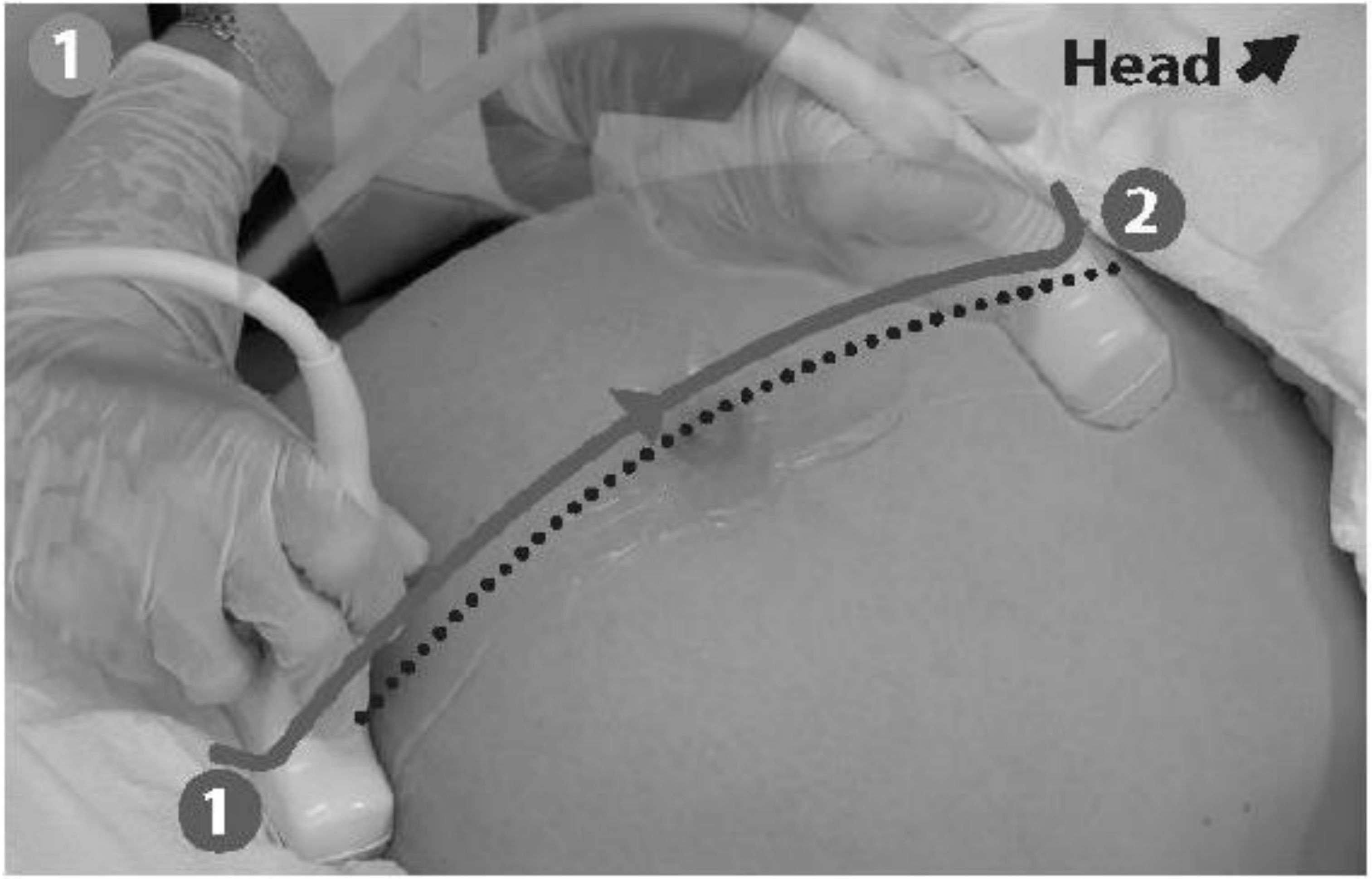
A big thanks to our partners, our customers and our sister-company Thirona that supports in the development of CAD4TB.

#CAD4TB #EndTB #UnionConf2019 #TB

Example 5:
Low-cost, automated ultrasound

Automating maternal ultrasound





K.K. DeStigter *et al.*, Low-cost teleradiology for rural ultrasound, GHTC (2011)

Head

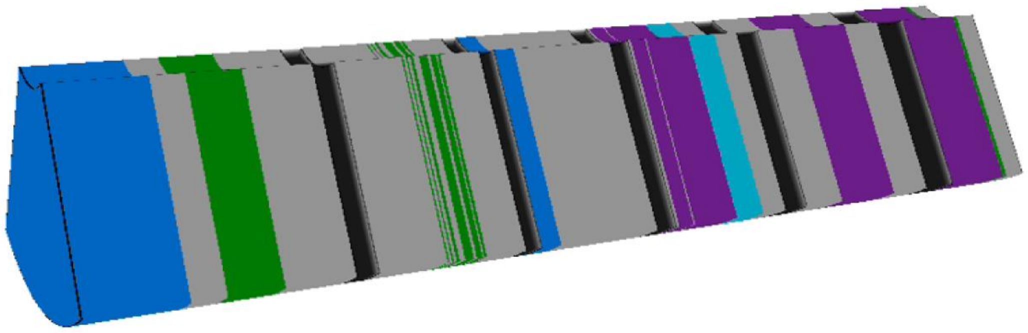
Head partly

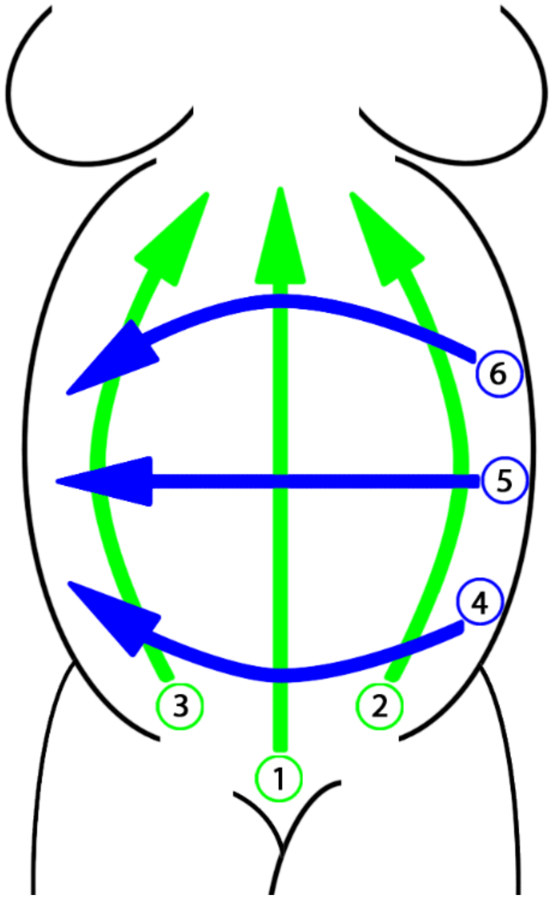
Body

Side view

Transducer detached

Other





Radboudumc

Head

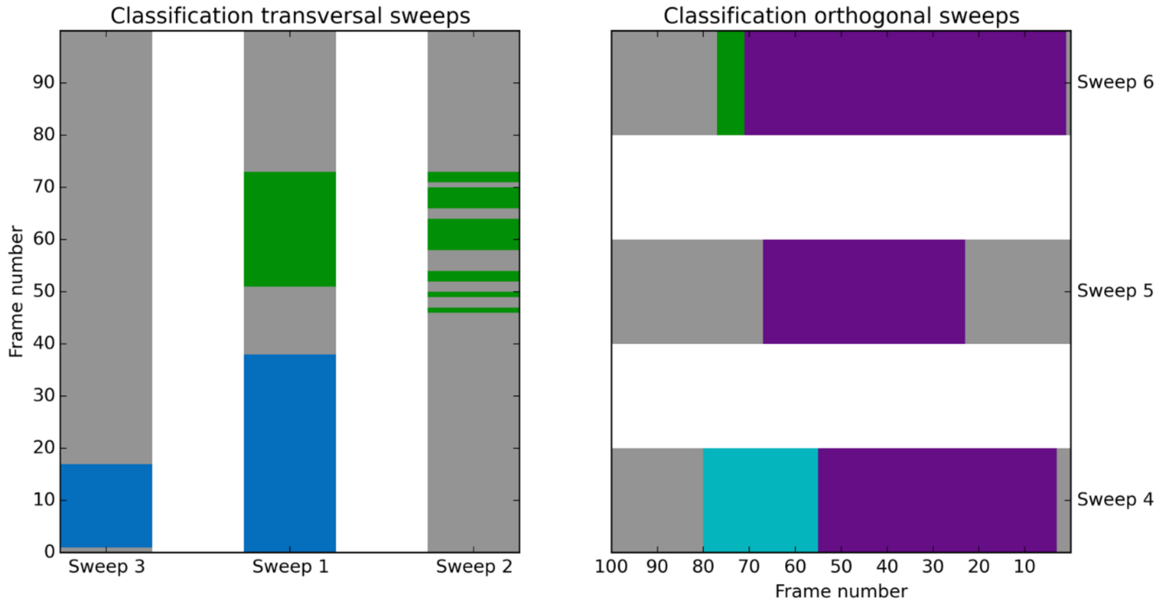
Head partly

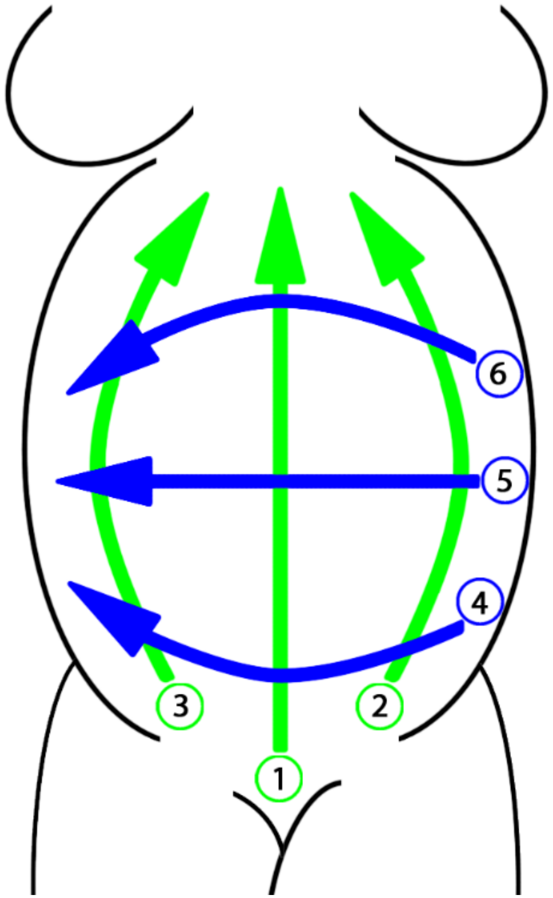
Body

Side view

Transducer detached

Other





Head

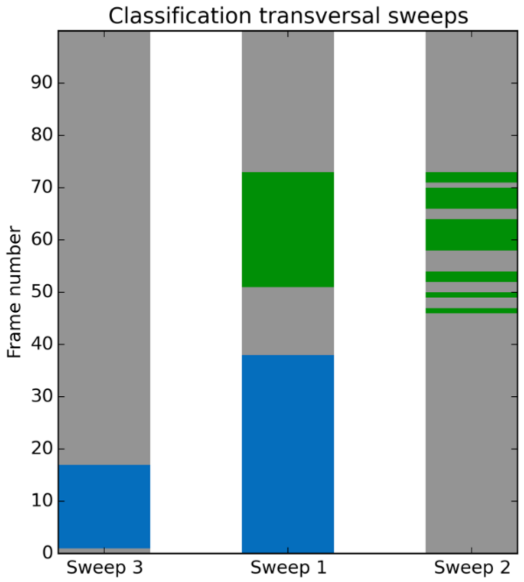
Head partly

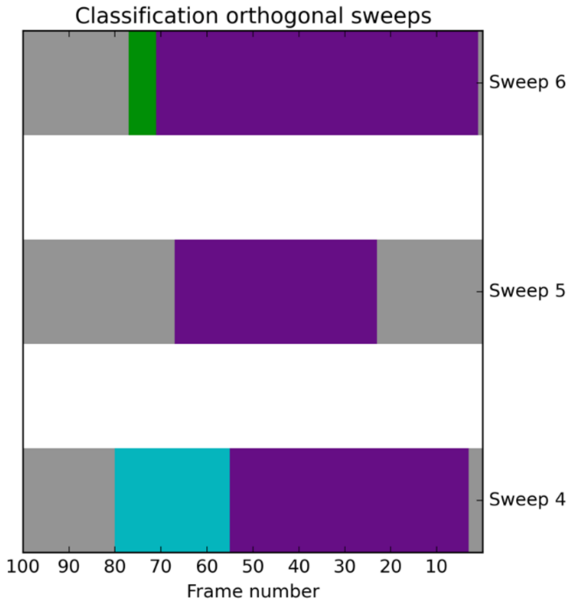
Body

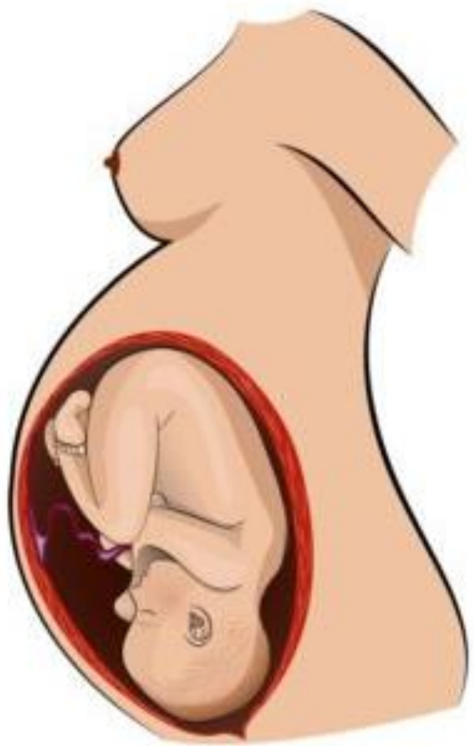
Side view

Transducer detached

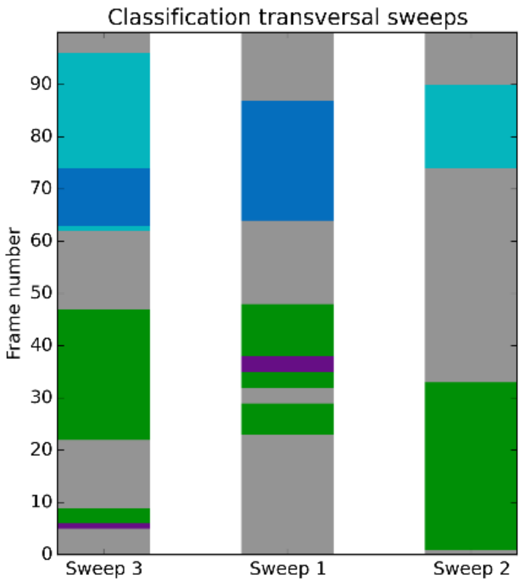
Other

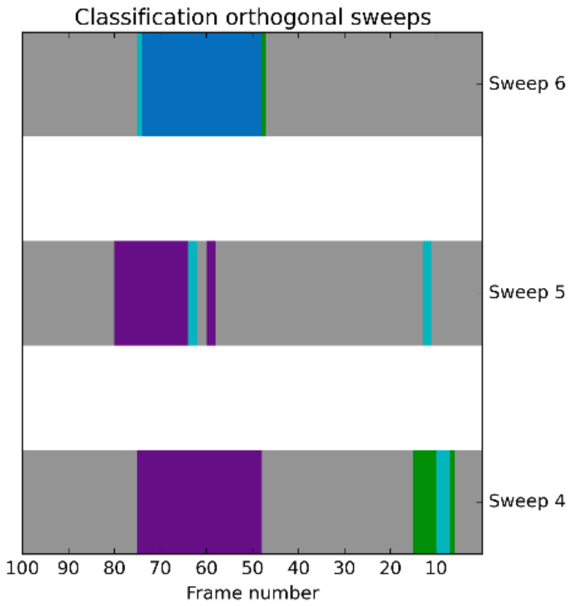






- Head
- Head partly
- Body
- Side view
- Transducer detached
- Other





Head

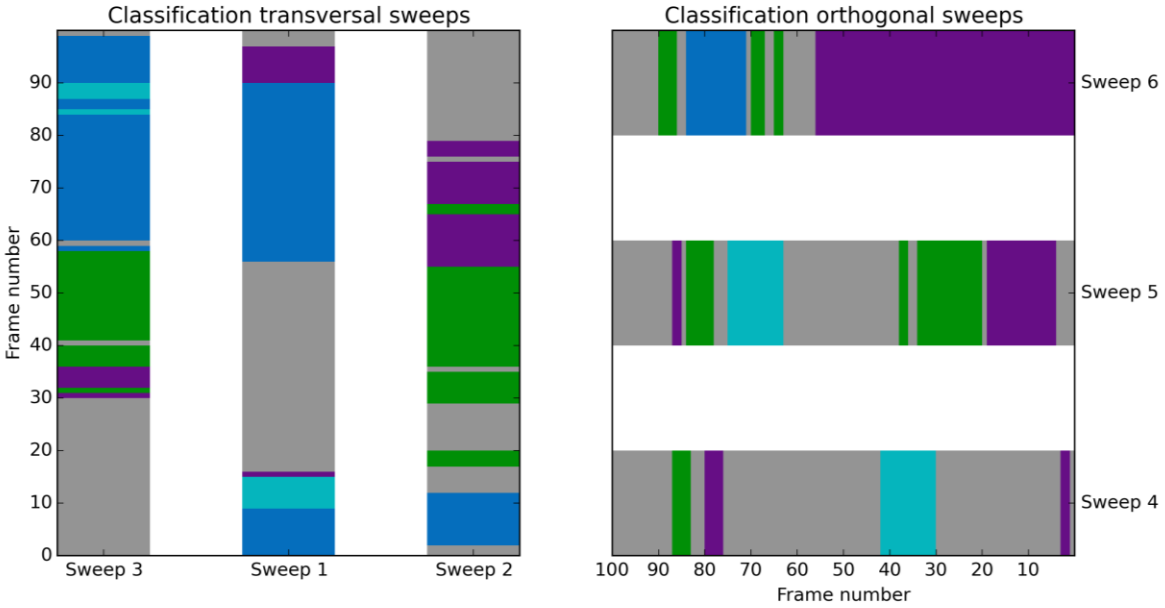
Head partly

Body

Side view

Transducer detached

Other

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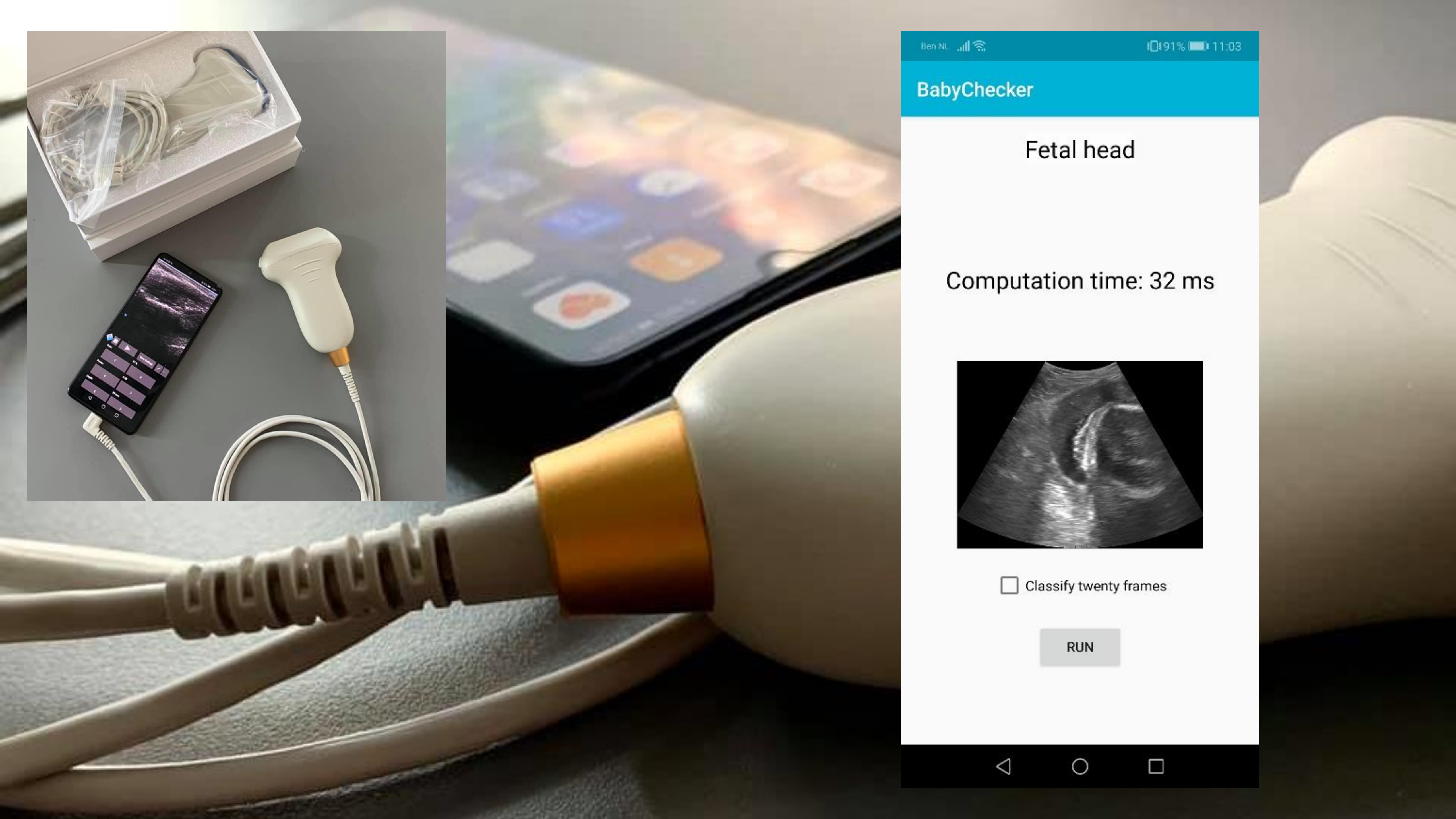
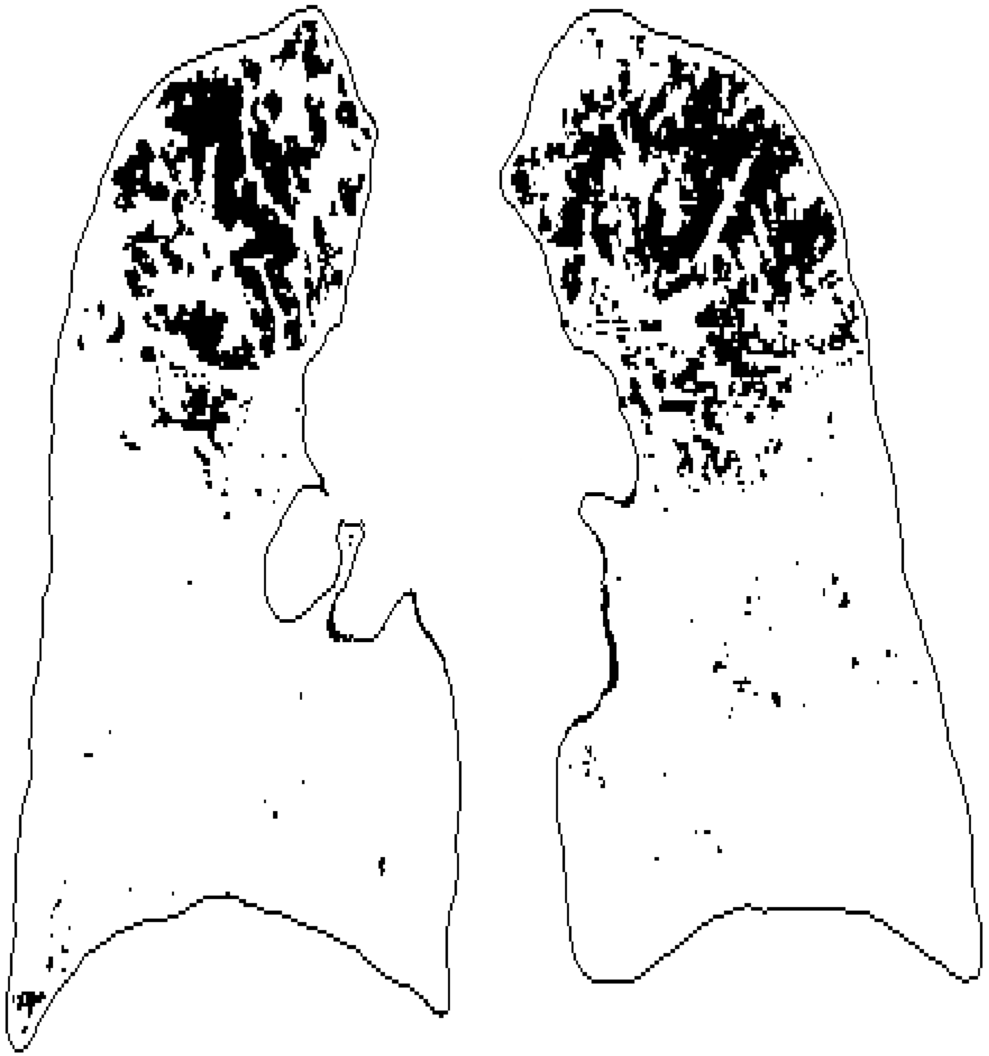

Ben NL
91% 11:03
BabyChecker
Fetal head
Computation time: 32 ms
Classify twenty frames
RUN

Radboudumc

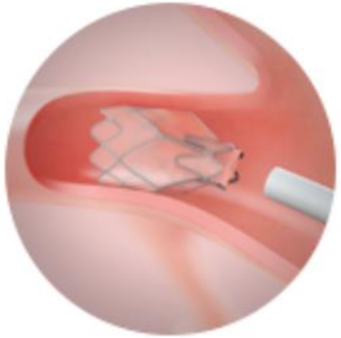
Example 6:
COPD treatment response prediction



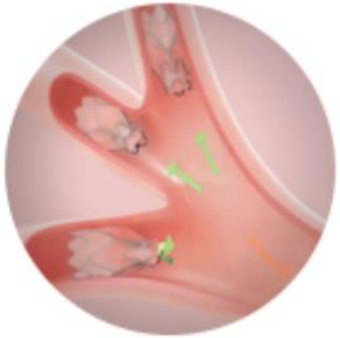
StratX

thirona

pulmonX

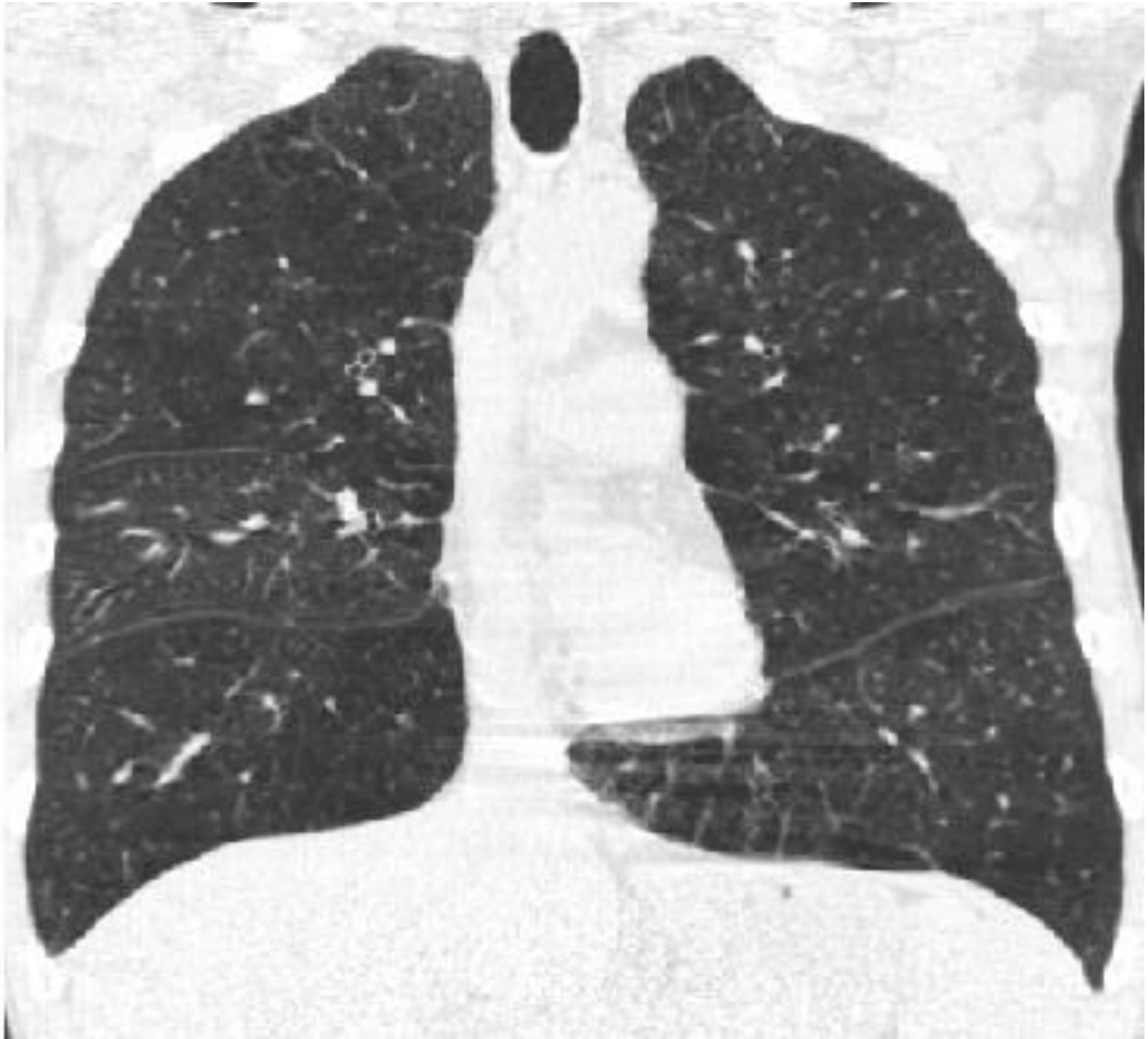


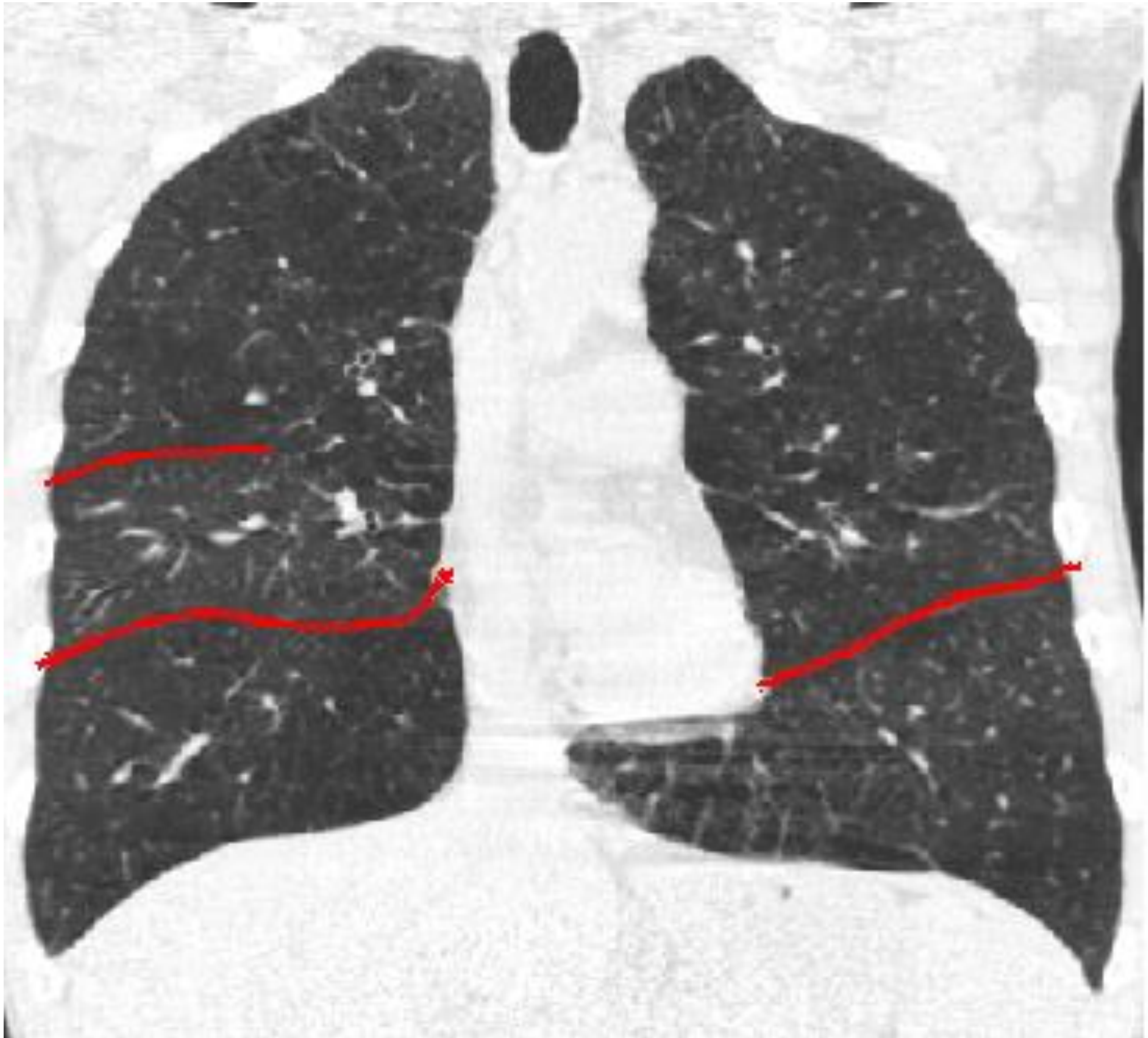
Using a standard bronchoscope, Zephyr valves are delivered to target airways using a flexible delivery catheter



Once implanted, the one-way valve prevents airflow into the diseased region, while allowing trapped air and fluids to escape

Reducing the volume of the diseased region may allow healthier regions to expand and function more efficiently





StratX

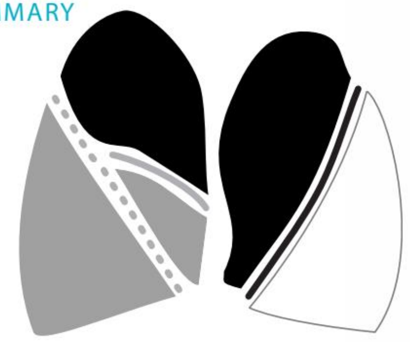
thirona

StratX™ Lung Report

pulmonX

Patient ID	35-127-AJJ	Upload Date	27 July 2016
Scan ID	0026671	Report Date	27 July 2016
CT Scan Date	16 February 2011	Scan Comments	

SUMMARY



KEY

- ≥70% Voxel Density Less Than -910 HU
- 60-70% Voxel Density Less Than -910 HU
- 50-60% Voxel Density Less Than -910 HU
- <50% Voxel Density Less Than -910 HU
- >95% Fissure Completeness
- 80-95% Fissure Completeness
- <80% Fissure Completeness

RESULTS

	RIGHT LUNG				LEFT LUNG	
	RUL	RUL+RML	RML	RLL	LUL	LLL
% Fissure Completeness	64.2	65.0	84.9	65.0	100	100
% Voxel Density Less Than -910 HU	84	79	63	66	83	43
% Voxel Density Less Than -950 HU	67	59	36	40	69	16
Inspiratory Volume(ml)	1120	1492	372	1901	1717	1520

Disclaimer: Report contains quantitative assessment only and should not be construed as a complete radiological analysis.

CE XXXXX. Powered by Thirona LungQ v1.0.0

Page 1 of 3

SUMMARY

Illustration summarizes key information

RESULTS

Table lists validated measurements by lobe:

- Fissure completeness
- Emphysema density (based on voxel density less than -910 HU)
- Inspiratory volume

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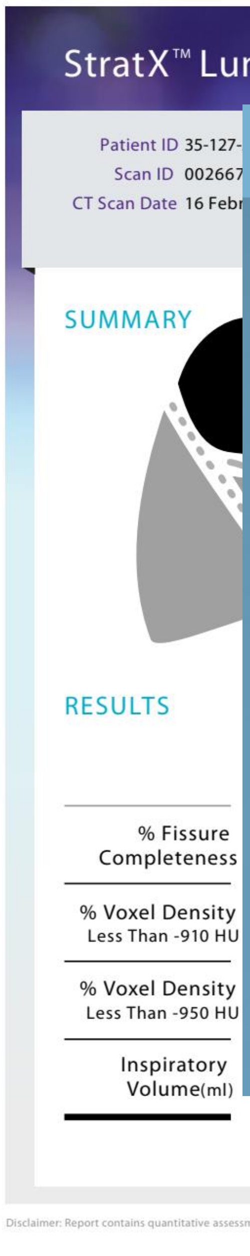
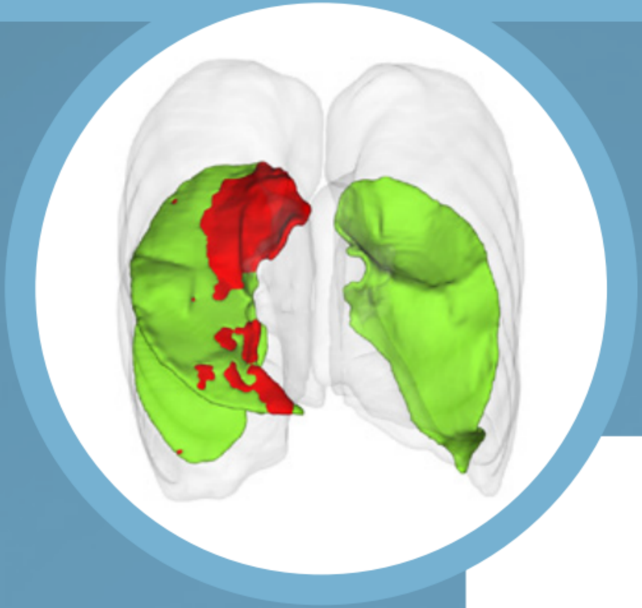
StratX





The StratX analysis quantifies the completeness of each fissure using an algorithm that has been validated in a retrospective study of over 200 EBV patients, the largest such analysis performed to date.[2] Fissure completeness is a proven predictor for volume reduction resulting from EBV therapy.[3]

	RIGHT LUNG			
	RUL	RUL+RML	RML	RLL
% Fissure Completeness	64.2	65.0	84.9	65.0

thirona

Radboudumc

thirona

WORKFLOW WITH RAPID TURNAROUND TIME

Capture CT Scan

Capture a high resolution chest CT scan according to the StratX CT parameters.

Upload CT Scan

Use web browser to upload CT scan to the secure, cloud-based StratX platform.

- Automatically anonymized data with no patient health information transfer
- Secure 256 bit SSL socket level encryption

Analyze Data + Generate Report

Data is analyzed by validated algorithms and the StratX report is uploaded to the StratX platform within 2-3 working days.

Review Report

Access pulmonxstratx.com to review the report in a .pdf (2D) or .html (3D) format from any clinical setting.

Confidently Determine Treatment Options

Determine the most suitable treatment option for your patient using the quantitative StratX information and clinical judgment.

AI in healthcare

- Broadly applicable: most applications currently in image analysis, will grow in other areas
- Can perform dedicated tasks, as well as, or maybe even better, than human experts

- Developing these AI systems is a lot of work.
  It involves careful collection and annotation of large amounts of data
  → Scalability is the big bottleneck: there are too many tasks

- Areas with a lack of human doctors will be early adopters of AI
- Companies will offer cost-effective healthcare solutions that combine AI with human expertise