Evolutions in Digital Pathology

And future perspectives

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Disclosures

AstraZeneca: congress support, paid consultancies, research sponsoring

IBEX: research sponsoring, congress support

Imagene: congress support

Johnson and Johnson: paid consultancies, research sponsoring

Merck Sharp & Dome (MSD): speaker's fees, paid consultancies, advisory boards

Novartis: paid consultancies, speaker's fees

Owkin: research sponsoring

Roche (Dx and Phx): congress support, advisory boards, paid consultancies

Alumnus Howest Bioinformatics@Home

No AI tools have been used for the creation of this presentation

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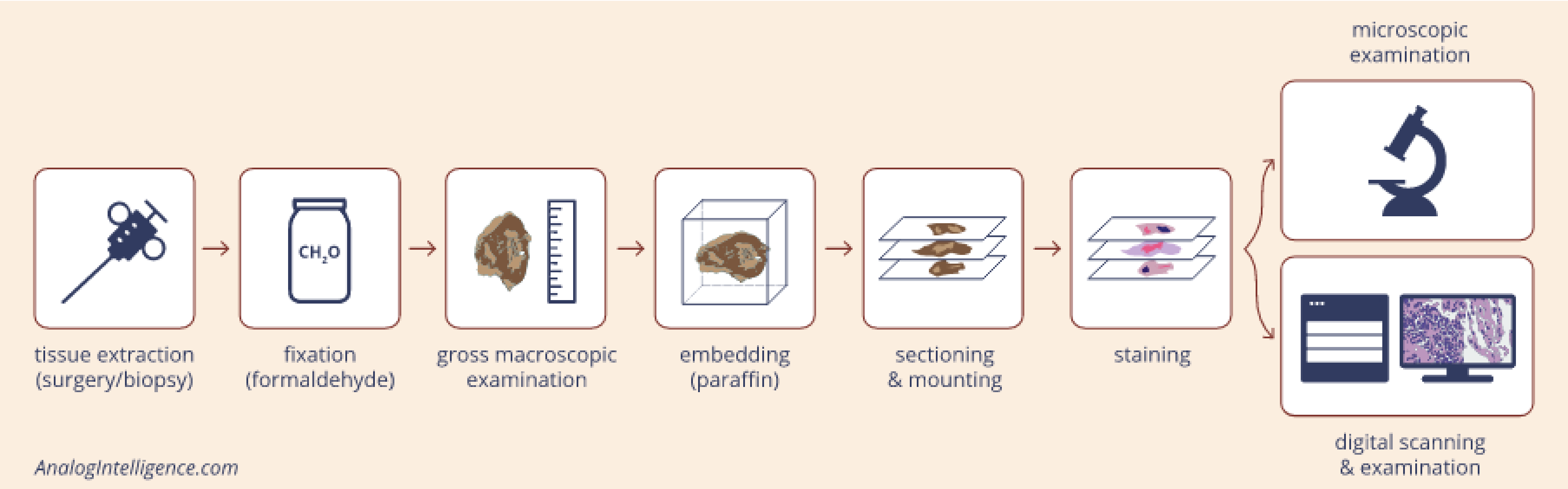
Workflow Pathology Lab



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References:

1. Picture from analogintelligence.com

Revolutions in pathology

Pathology
1900

1ste Revolutie: Immunohistochemistry
1980

3th revolution: Digitalisation
2017

1900 | 1917 | 1934 | 1951 | 1968 | 1985 | 2002

2017
Artificial intelligence

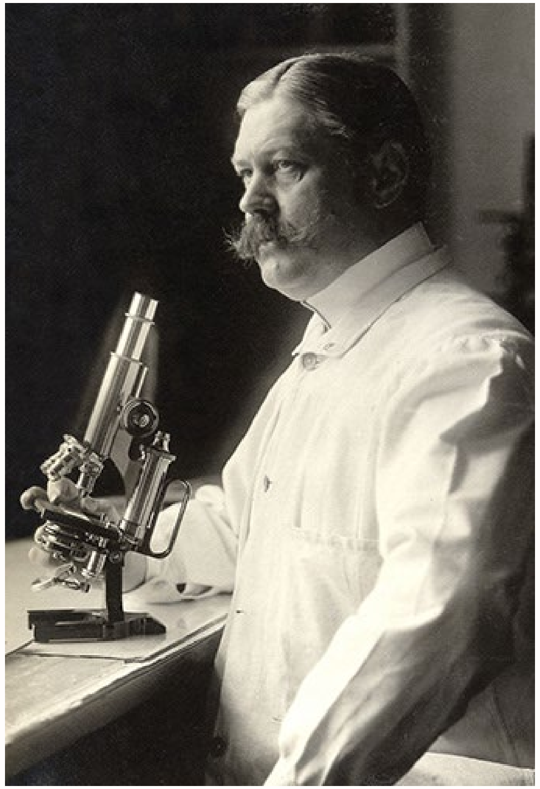
2007
Molecular pathology

2nd revolution: Molecular pathology
2004

References:

1. https://www.leica-microsystems.com/products/light-microscopes/p/leica-dm4000-m/
2. https://www.thermofisher.com/be/en/home/brands/ion-torrent.html
3. https://www.pacb.com/auto_tags/pacbio-rs-ii/
4. https://www.illumina.com/systems/sequencing-platforms/hiseq-3000-4000.html

Tools of the pathologist



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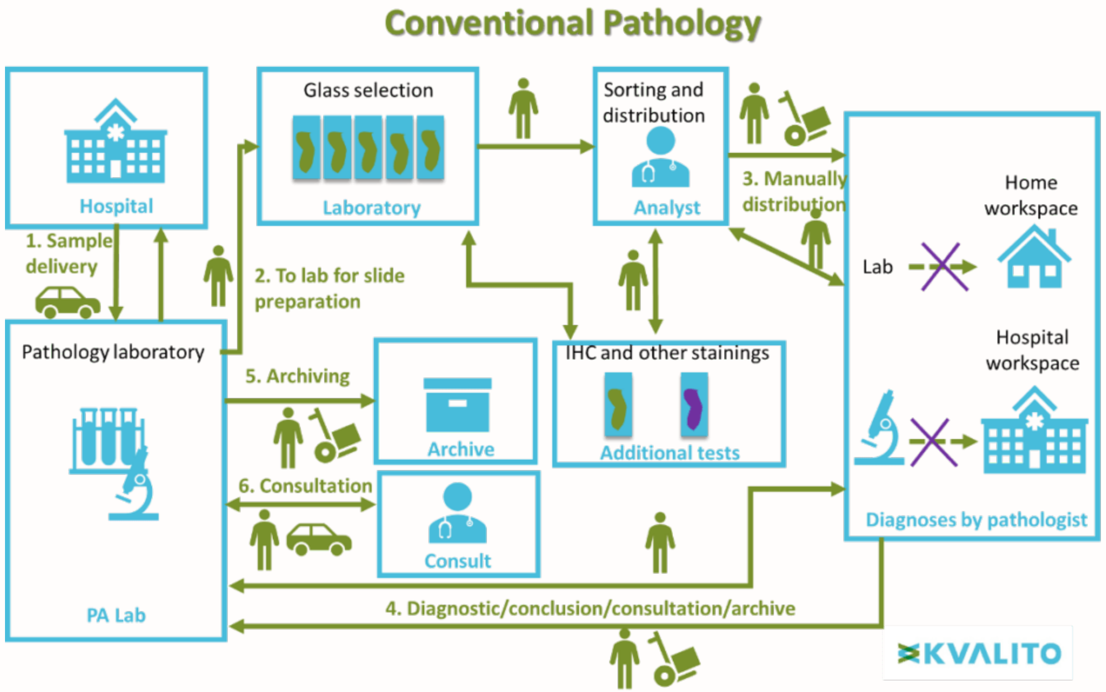
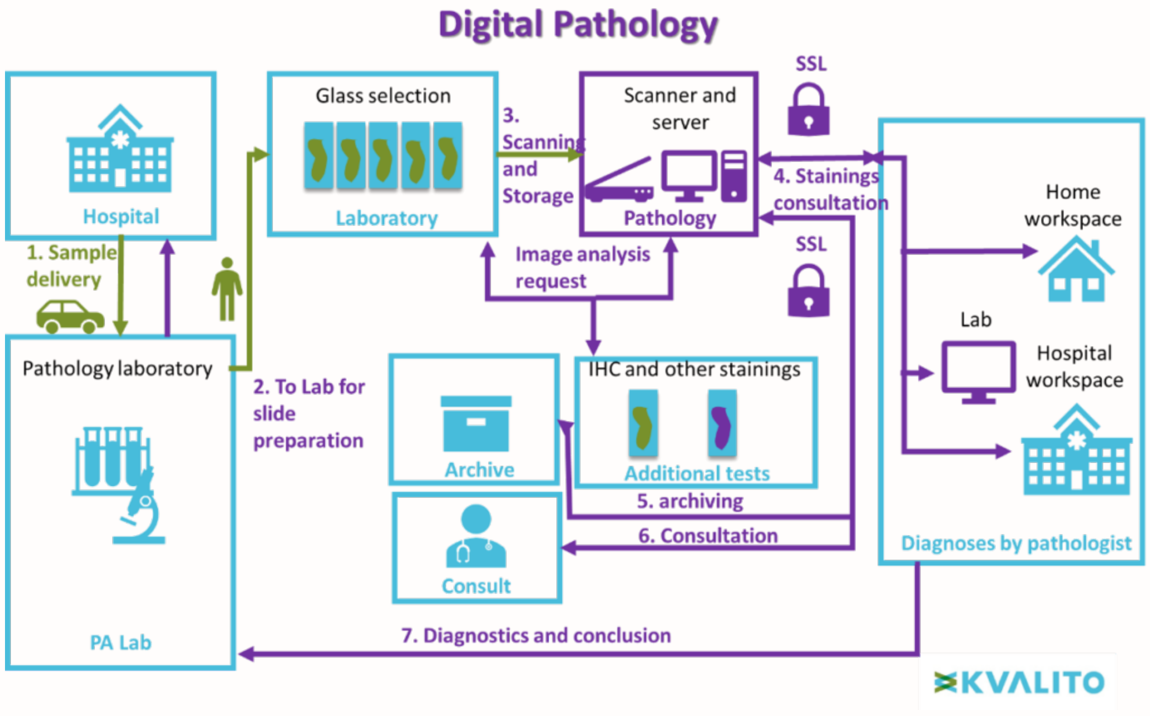
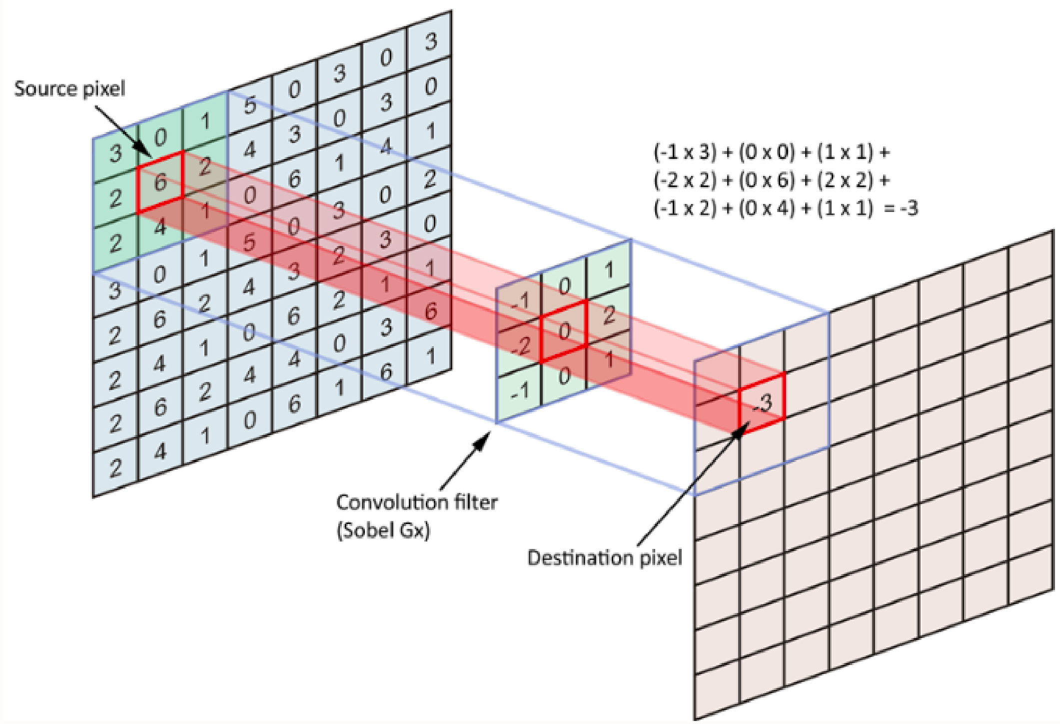
Impact of digital pathology on workflow

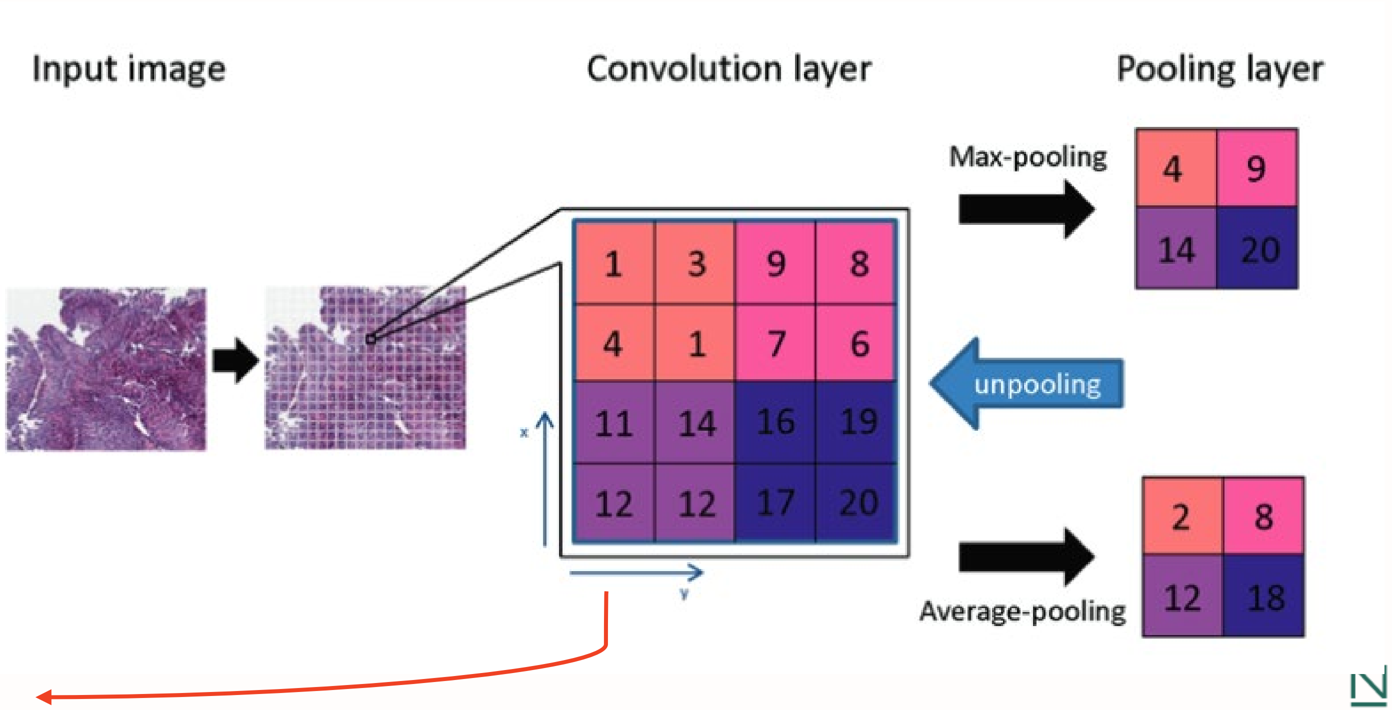


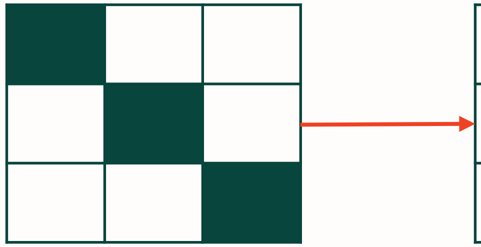
- Additional scanning step
- Less physical steps
- Faster and easier access to stored slides



Convolution and pooling (nD)







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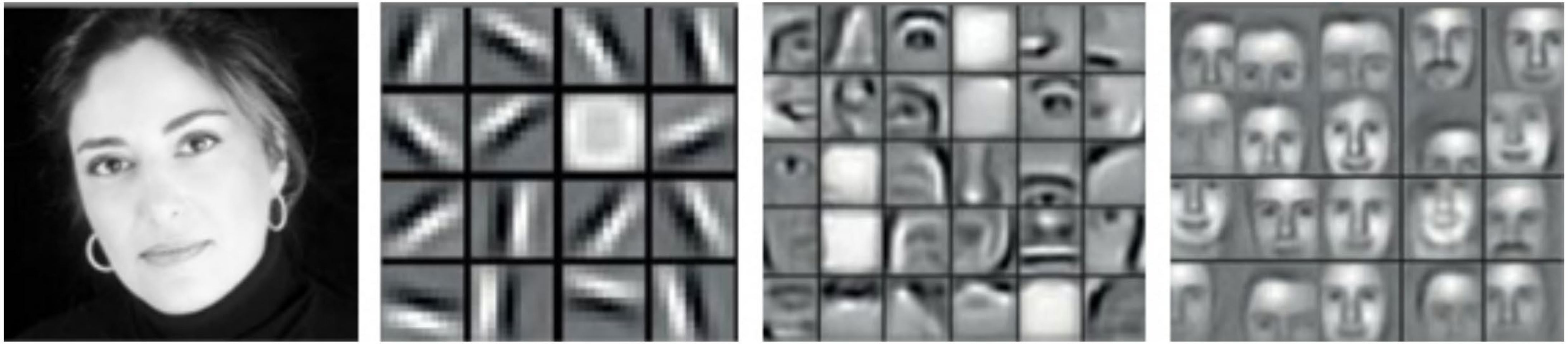
References:

1. Yousif M, Van Diest PJ, Laurinavicius A, Rimm D, Van Der Laak J, Madabhushi A, et al.. Artificial intelligence applied to breast pathology. Virchows Archiv 2022;480(1):191–209.
2. Cui M, Zhang DY. Artificial intelligence and computational pathology. Laboratory Investigation 2021;101(4):412–22.
3. Du S. Understanding Deep Self-attention Mechanism in Convolutional Neural Networks. Published in AI salon on Medium 2020; https://medium.com/ai-salon/understanding-deep-self-attention-mechanism-in-convolution-neural-networks-e8f9c01cb251

Deep learning feature extraction



References:
1. Prayuda AJD. The evolution of computer vision techniques on face detection, part 2. Published in Nodeflux on Medium 2018; https://medium.com/nodeflux/the-evolution-of-computer-vision-techniques-on-face-detection-part-2-4af3b22df7c2

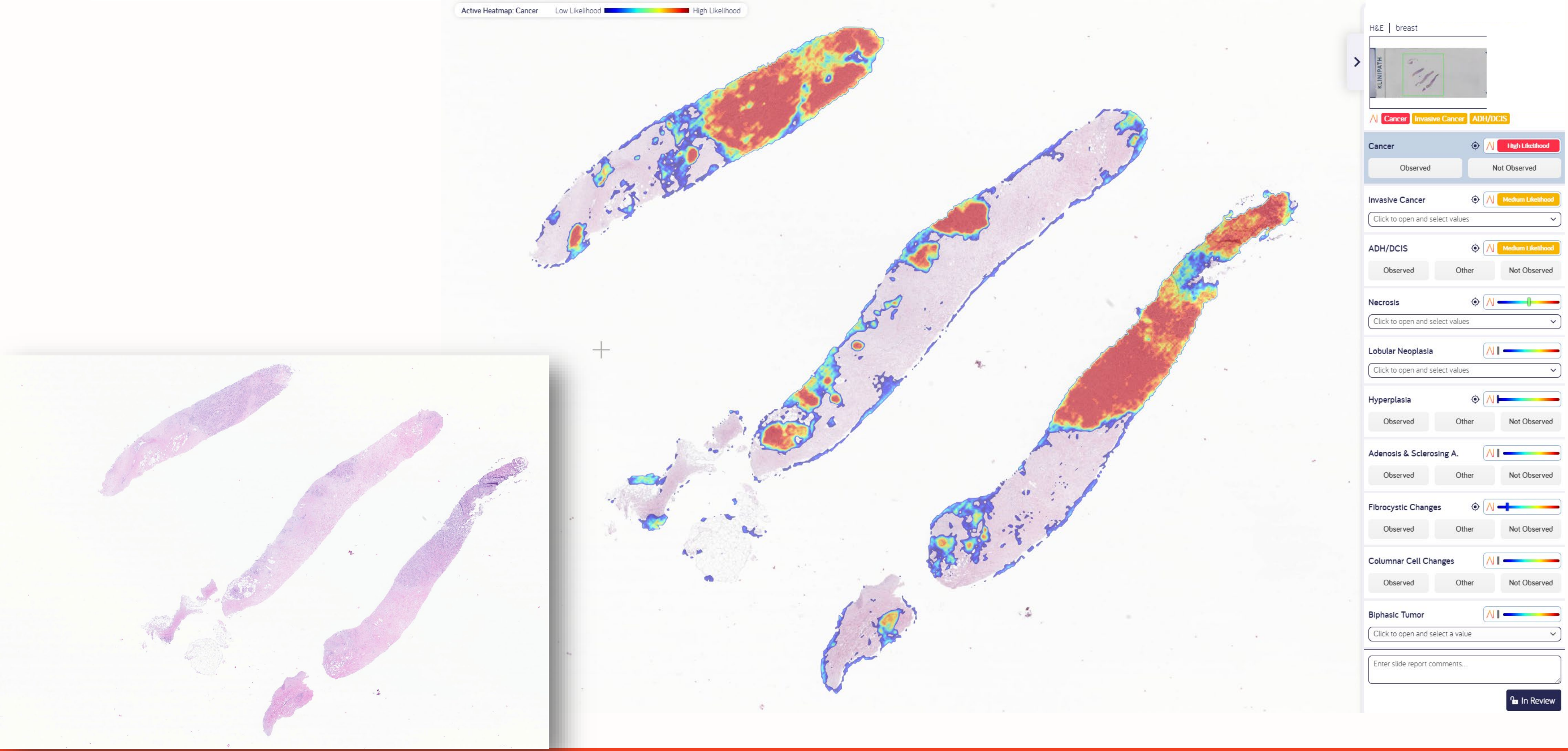
AI optic illusions

References:

1. Prayuda AJD. The evolution of computer vision techniques on face detection, part 2. Published in Nodeflux on Medium 2018; https://medium.com/nodeflux/the-evolution-of-computer-vision-techniques-on-face-detection-part-2-4af3b22df7c2

More commercial software

IBEX Galen™ breast



Methods

Sample retrieval

- 248 breast excisions ~ 2-3 H&E slides
- Retrospectively
- Pathology archives PA² Antwerp

Ground truth

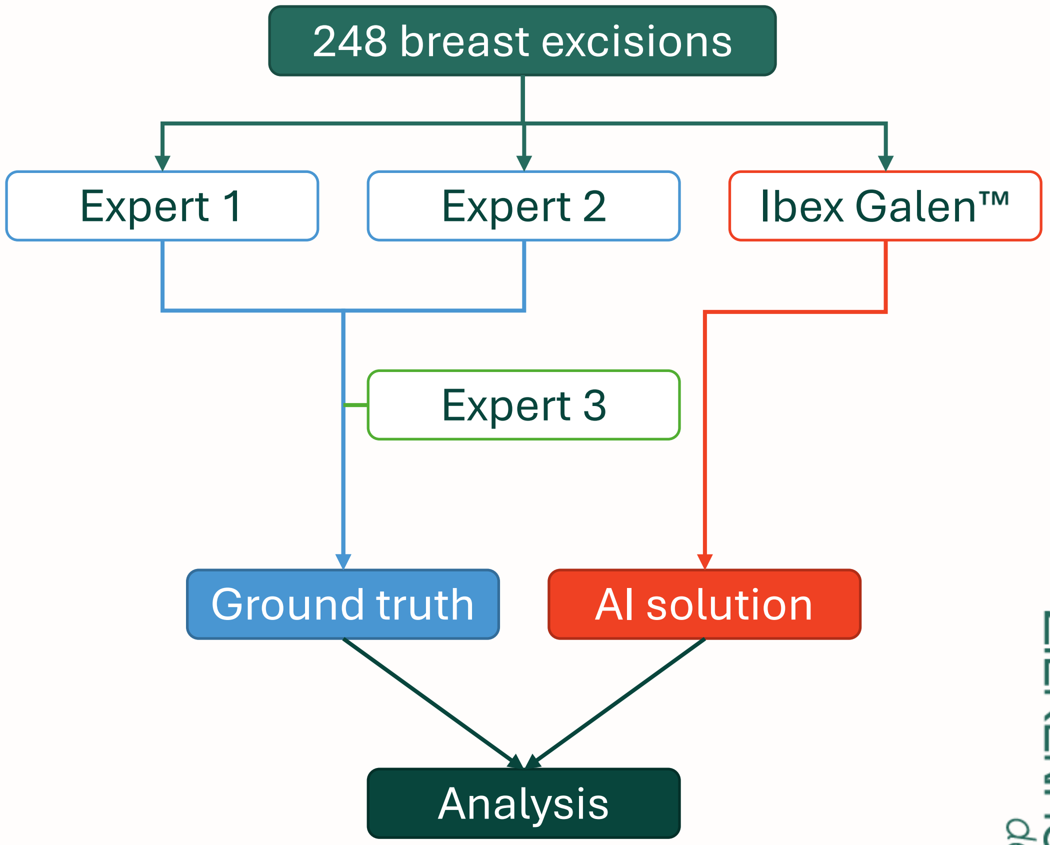
- Consensus 2 independent and blinded expert readers
- 3rd expert reader for discrepant cases

Artificial Intelligence

- Ibex Galen™ platform
- Detection of invasive carcinoma and ductal carcinoma in situ
- Differentiation between invasive carcinoma subtypes
- Differentiation between DCIS grade

Analysis

- Confusion matrices: accuracy, sensitivity, specificity
- Receiver of Operating Characteristics (ROC) curve: area under the curve (AUC)



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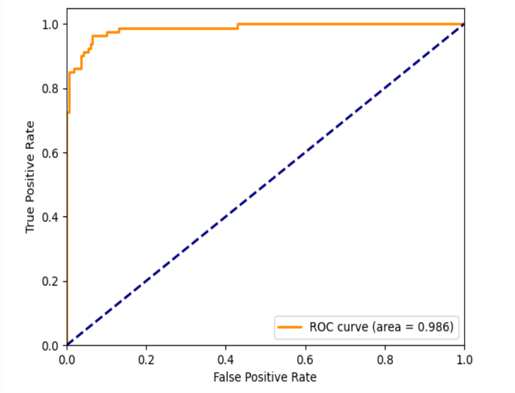
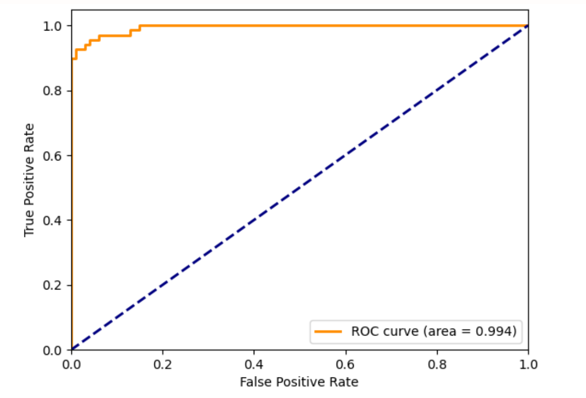
Results: primary endpoints

Analysis	AUC [95% CI]	Sensitivity	Specificity
Detection of invasive carcinoma	0.986 [0.973; 0.998]	89.9% [0.887; 0.996]	96.3% [0.840, 0.939]
Detection of DCIS	0.994 [0.987; 1.000]	95.6% [0.868, 0.995]	95.0% [0.882, 0.986]
Differentiation of subtypes	0.963 [0.922; 1.000]	85.3% [0.742, 0.927]	90.0% [0.541, 1]
Differentiation of DCIS grade	0.970 [0.931; 1.000]	90.2% [0.791, 0.964]	100.0% [0.561, 1]

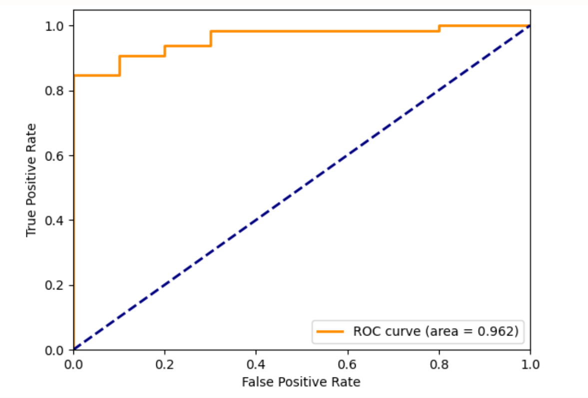
Invasive Cancer Detection



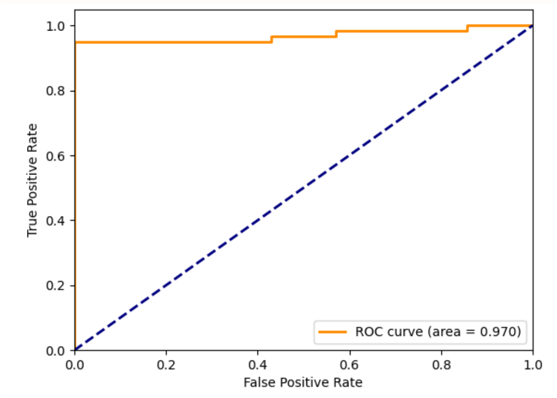
DCIS Detection



ILC vs IDC

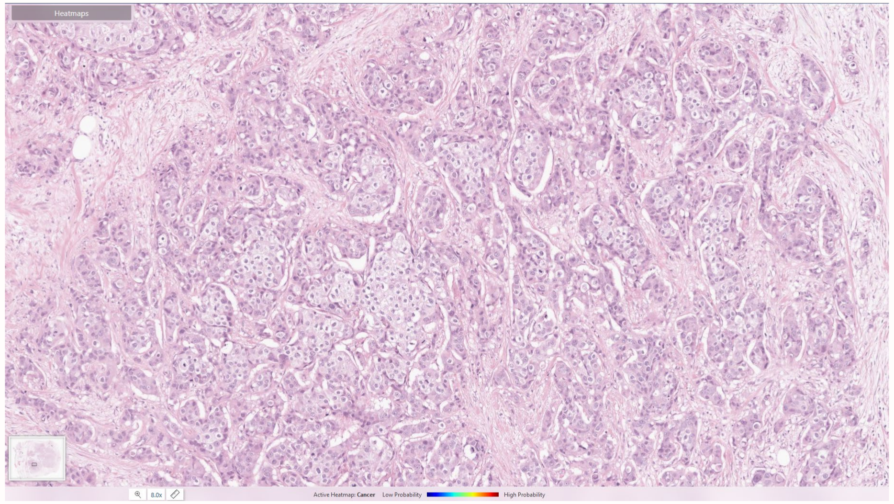


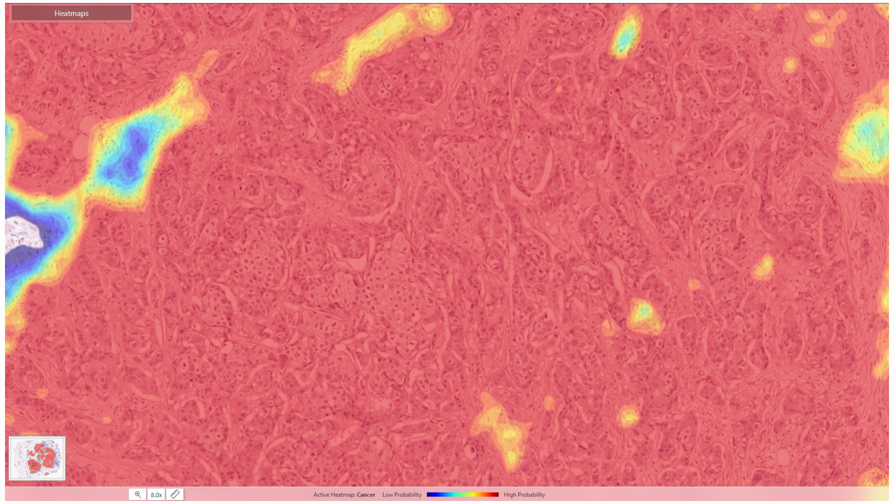
DCIS LG vs HG

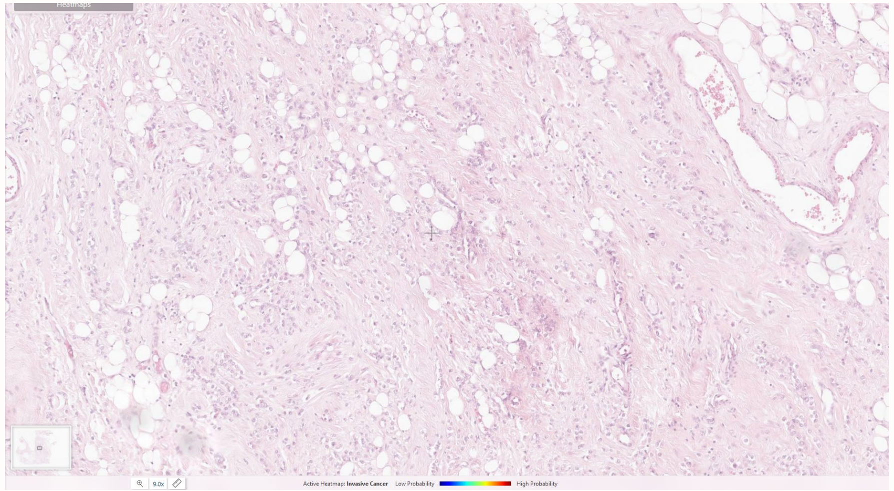


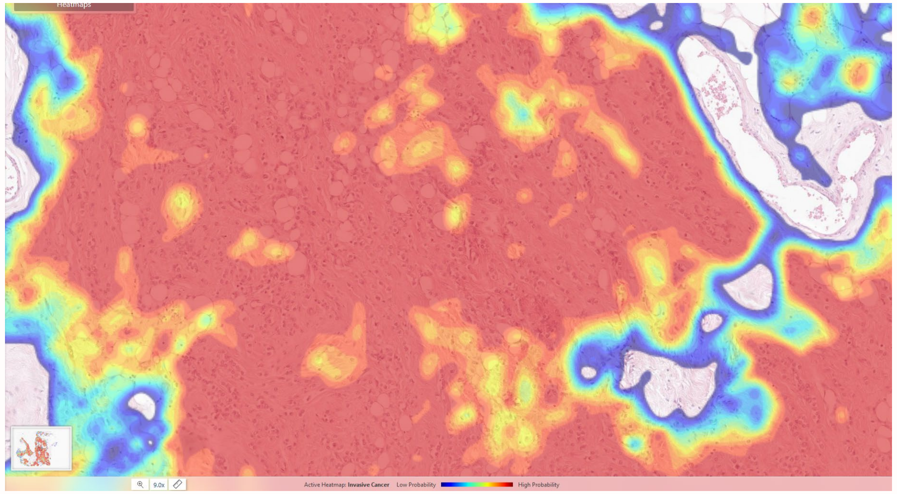
References:
1.

Example detection invasive carcinoma NST









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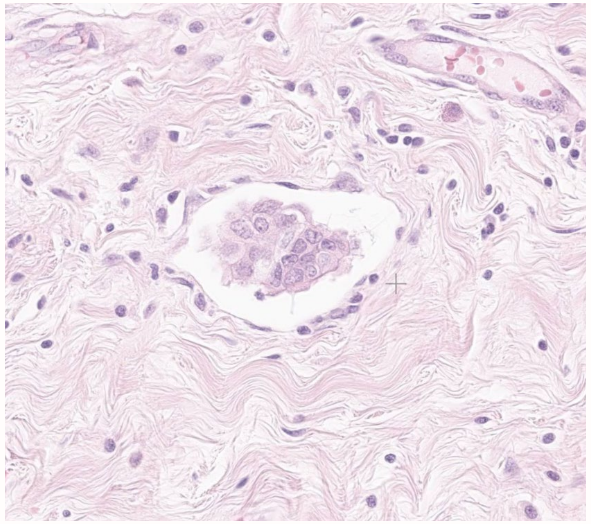
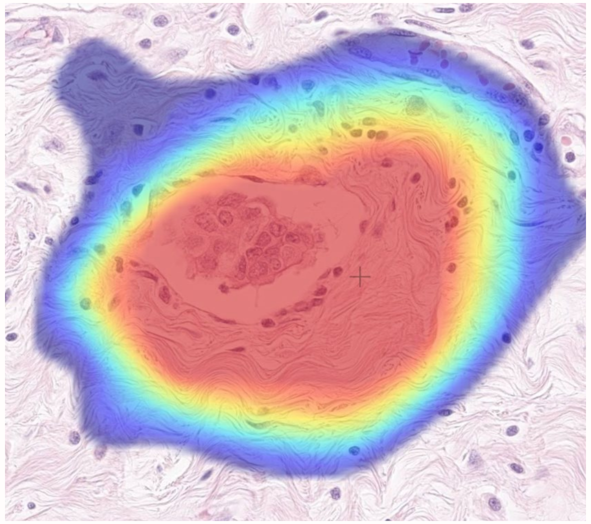
References:
1. IBEX

Results: exploratory endpoints

Analysis	AUC [95% CI]	Sensitivity	Specificity
Stromal tumor infiltrating lymphocytes (sTILs)	0,958 [0,919; 0,998]	91,4% [0,814; 0,963]	100% [0,851; 1,000]
Detection of lymphatic invasion	0,896 [0,825; 0,968]	72,2% [0,560; 0,841]	86,4% [0,732; 0,936]
Detection of benign lesions	Statistical analysis ongoing		
Detection of biopsy site effects	Statistical analysis ongoing		





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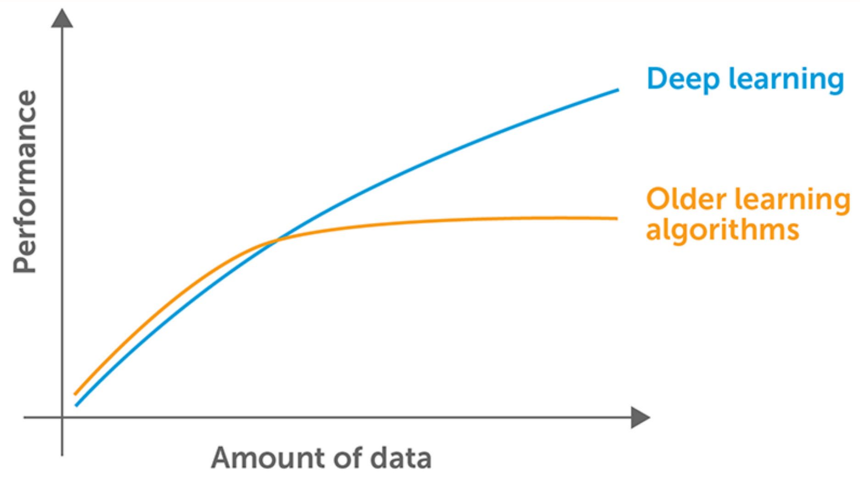
Why now AI?

- Task automatisation
- More data (and more complex)
- Need for standardized evaluation

} More complex algorithms & no human bias

- Reduction in hardware cost

- Opportunities
  - Use of more data(sources) in decision making
  - Integration in clinical trials



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2. Cui M, Zhang DY. Artificial intelligence and computational pathology. Laboratory Investigation 2021;101(4):412–22.

Impact AI on pathology

Workflow optimalisation

- Time consuming tasks: screening for lymph node metastasis, scoring IHC(PD-L1)
- Pre-order technicques
- Automated (structured) reporting
- Standardisation
- Literature: 20-40% efficiency gain (less reporting time) and 1-1.5 days TAT gain
- Aid in diagnostics: clear cut cases, “hints” for difficult cases

Change in thinking

- Collaboration: MLT, bioinformaticians, engineers, DPO’s
- Diagnostics: know the strengths and weaknesses of AI and models

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2. Cui M, Zhang DY. Artificial intelligence and computational pathology. Laboratory Investigation 2021;101(4):412–22.

AI challenges and remarks

Implementation

- Market = immature and scattered
- High cost of commercial platforms
- No integration in the reimbursement system of the Belgian health care system
- Workflow improvements only possible when closely integrated with LIS/IMS/EPD

Ethics

- Fairness of data
- Collaboration with non-(para)medici
- What to do if model fails?

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References:

1. Yousif M, Van Diest PJ, Laurinavicius A, Rimm D, Van Der Laak J, Madabhushi A, et al.. Artificial intelligence applied to breast pathology. Virchows Archiv 2022;480(1):191–209.
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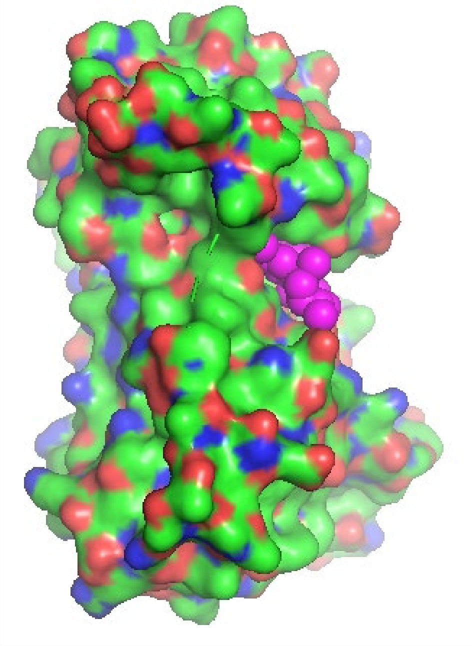
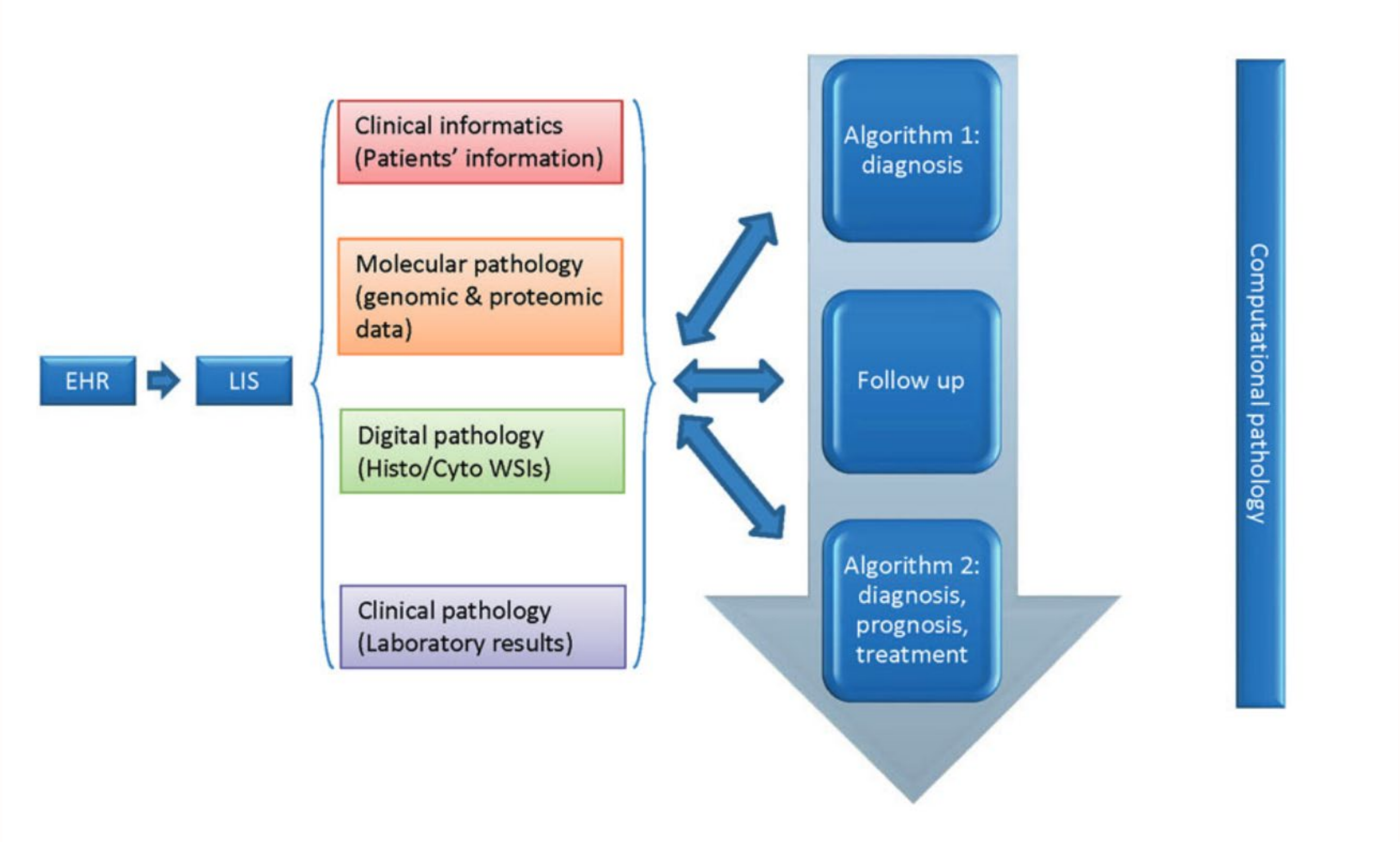
AI future perspectives





References:
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Take home messages

Digitization in pathology

- Workflow improvements
- Source for AI

Artificial intelligence: it's there/coming (due to more (complex) data)

- Need for AI: improved workflow, standardization
- Scattered landscape of AI platforms (+high cost)
- Know strengths and weaknesses of AI and models → Trust! (➔ **Education!**)

Opportunities

- Multimodel learning (other sources e.g. molecular biology)
- Collaborations

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Thank you!

Glenn Broeckx

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Roberto Salgado, PhD

Sabine Declercq, PhD

Questions?

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Ziekenhuis aan de Stroom [ZAS] is het netwerk van ZNA en GZA Ziekenhuizen

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