Breast Journal Club

L'importanza della Ricerca in Oncologia

Machine learning per la diagnosi precoce

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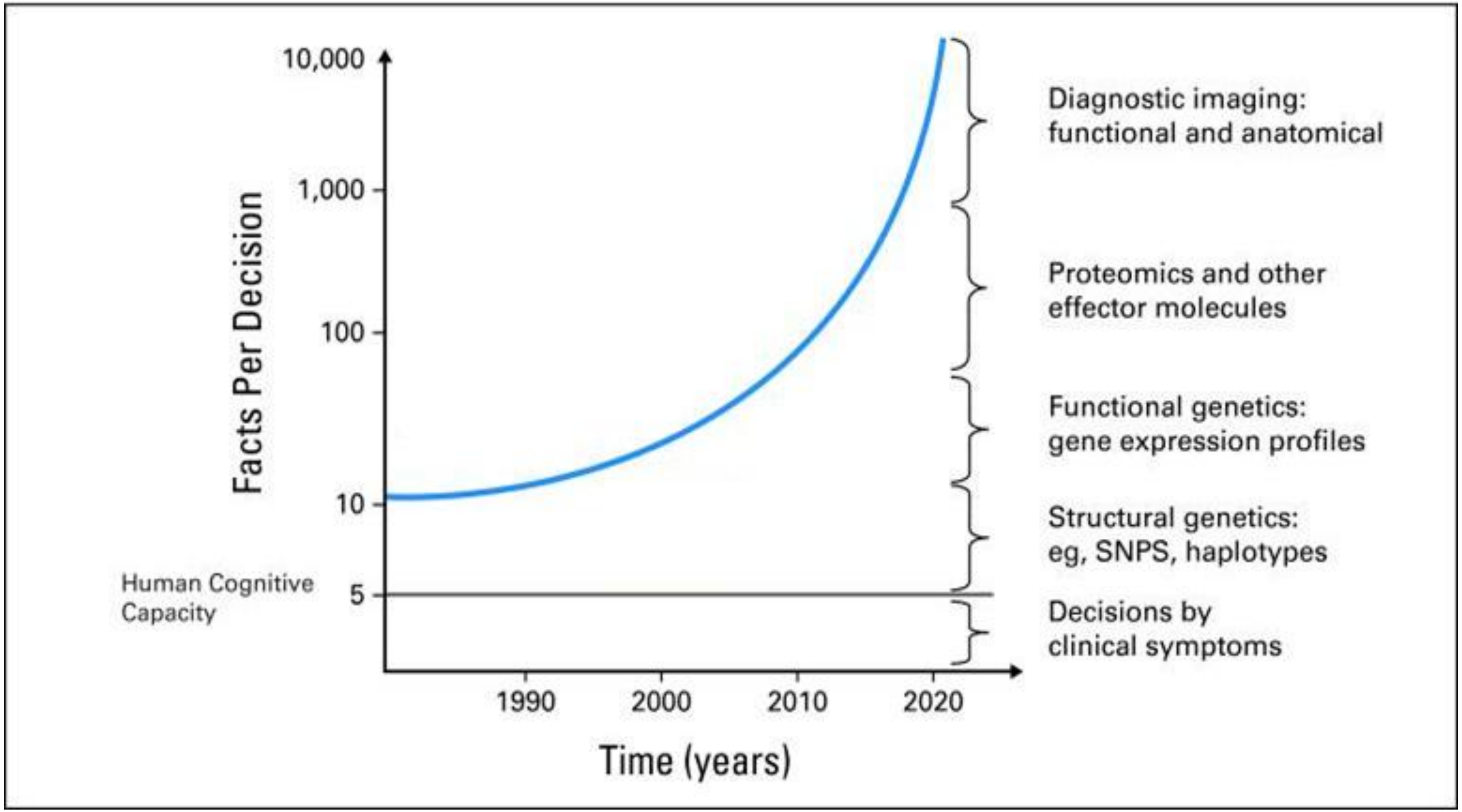
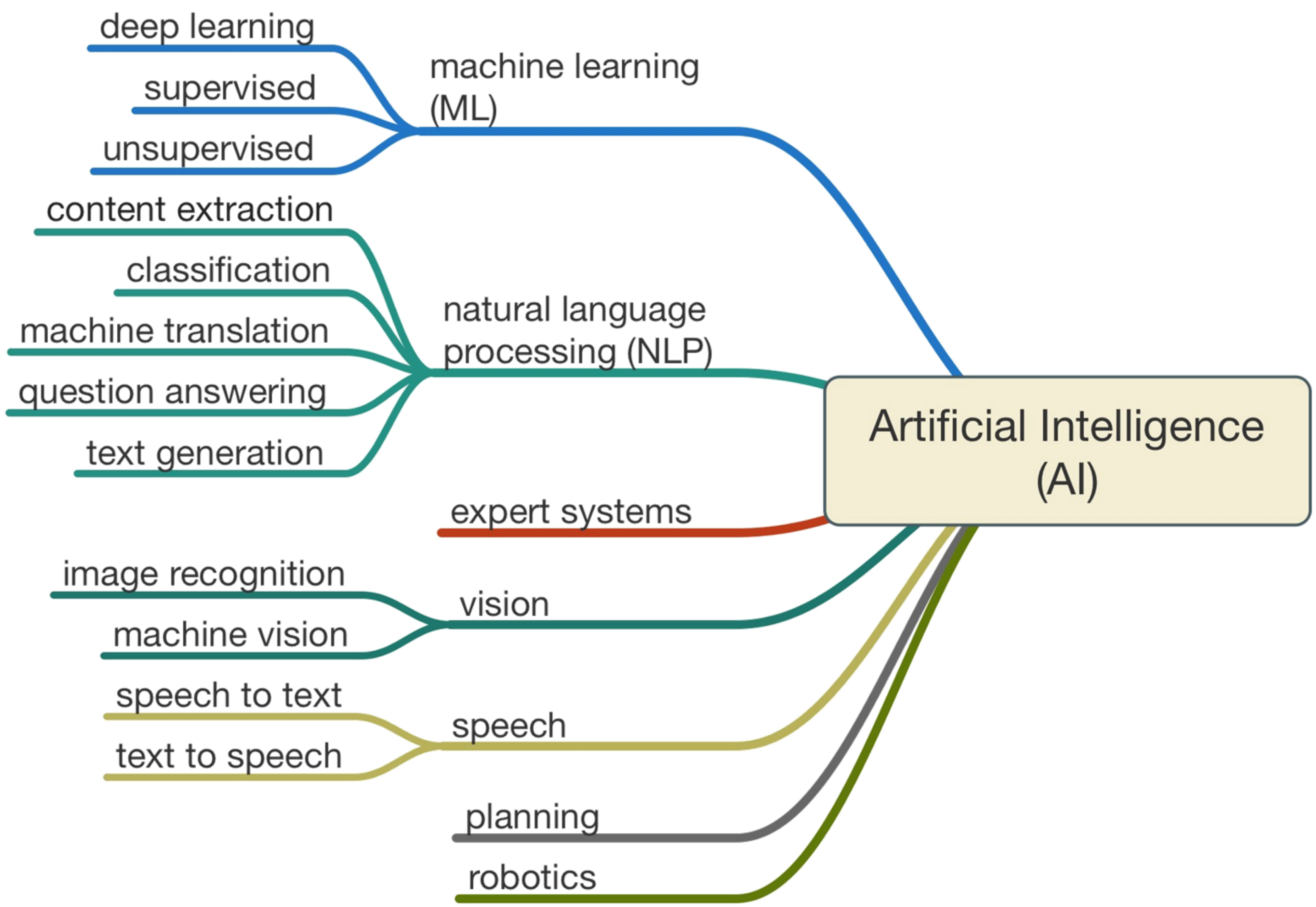
Conflicts of interest

- Member of the IBA Victoria Advisory Committee
- Scientific consultant for Varian Medical Systems
- Scientific consultant for KBMS.com & KBO Labs
- Scientific consultant for Medipass srl
- Scientific consultant for Roche
- Scientific consultant for Radius srl
- Sponsored researcher for InnovationSprint
- Sponsored researcher for Nanovi
- Sponsored researcher for Sophia genetics
- Sponsored researcher for View Ray Inc.
- Inventor patent #202020000005950

Background| Oncology: multiomics medicine by design



Background | Artificial intelligence



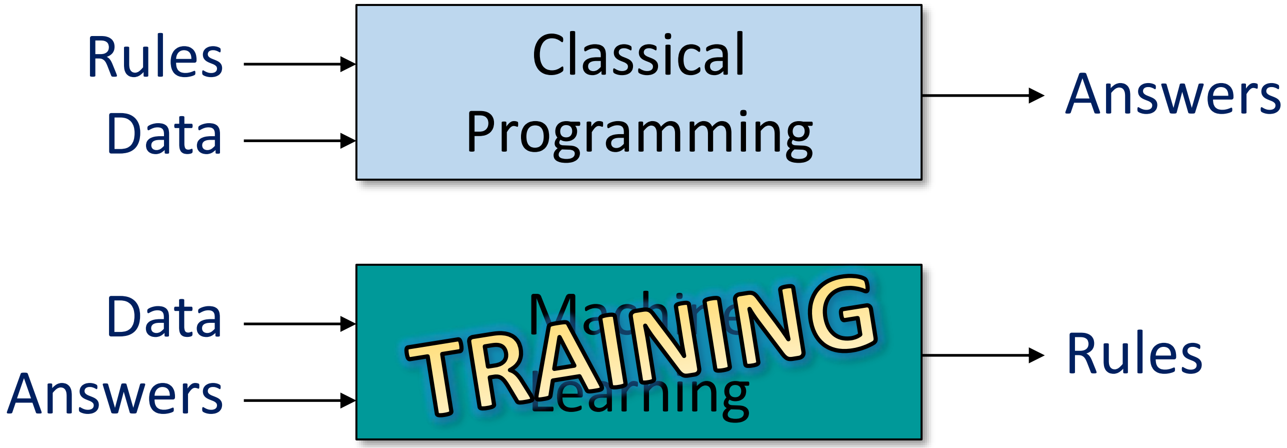
Rationale for using AI

To do quicker (and better?) what humans can already do and to do what humans can not do

Machine learning

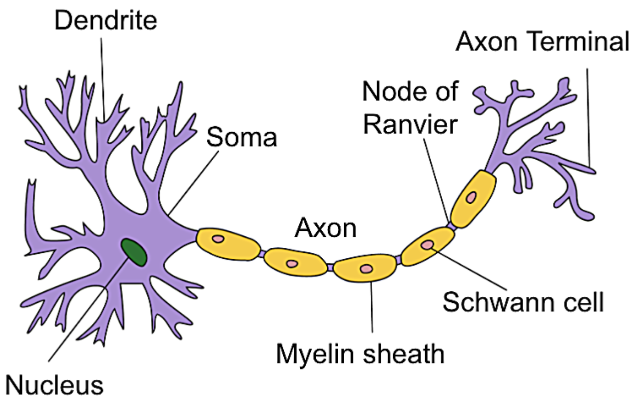
It is a method where the ***target*** (goal) is defined and the ***steps to reach*** that target is learned by the machine itself by ***training*** (gaining experience)

Background | Artificial intelligence

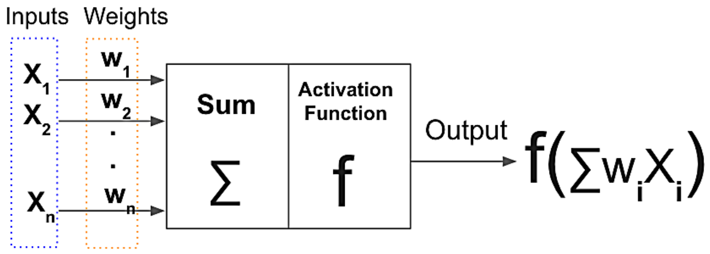


Deep learning

- It is a specific **subfield** of ML
- It puts **emphasis** on **learning successive layers** of increasingly meaningful representations

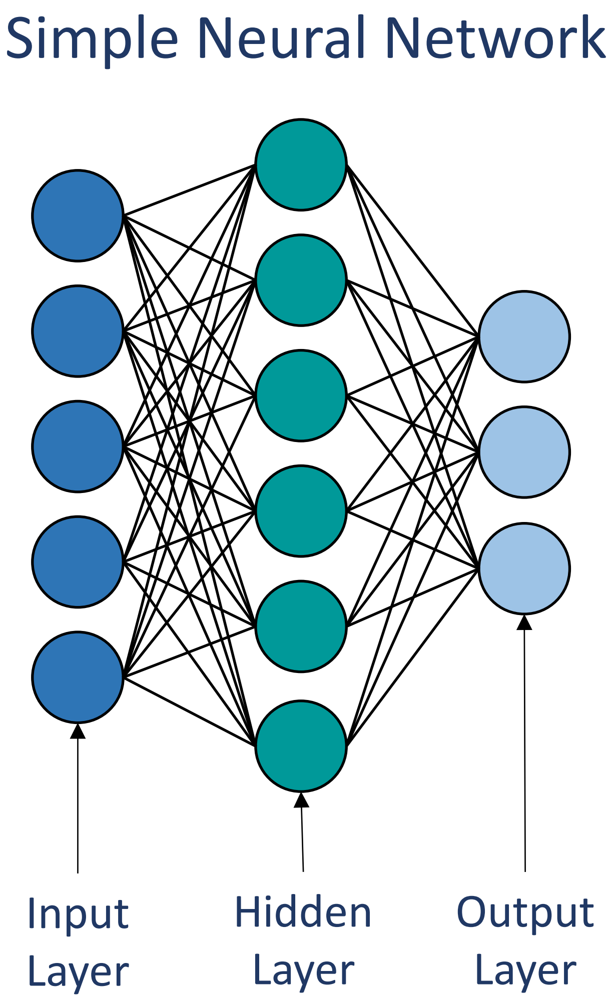


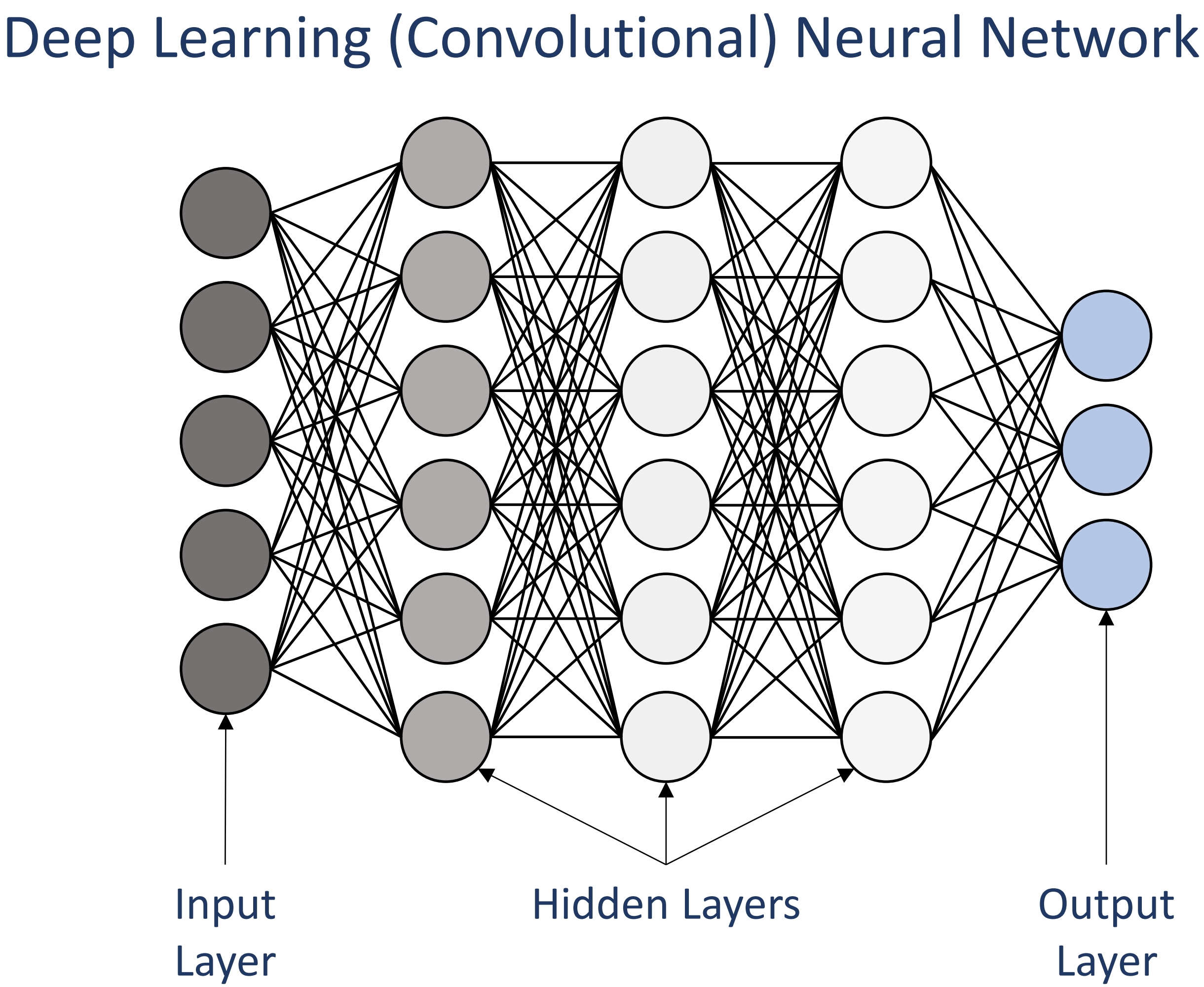
Structure of a typical neuron



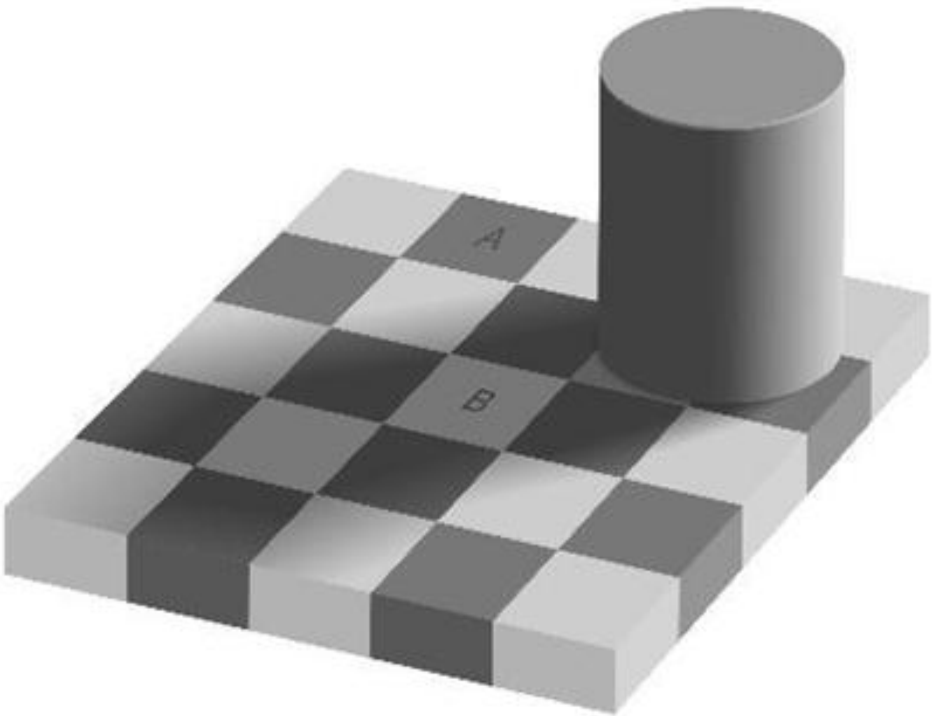
Structure of artificial neuron

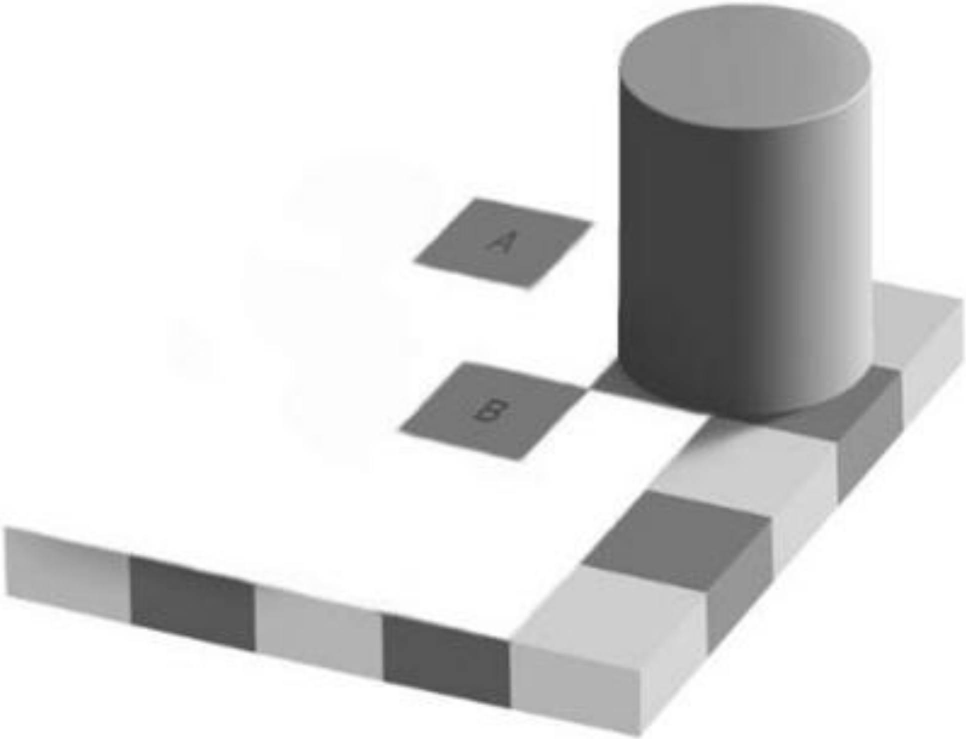
Background | Artificial intelligence



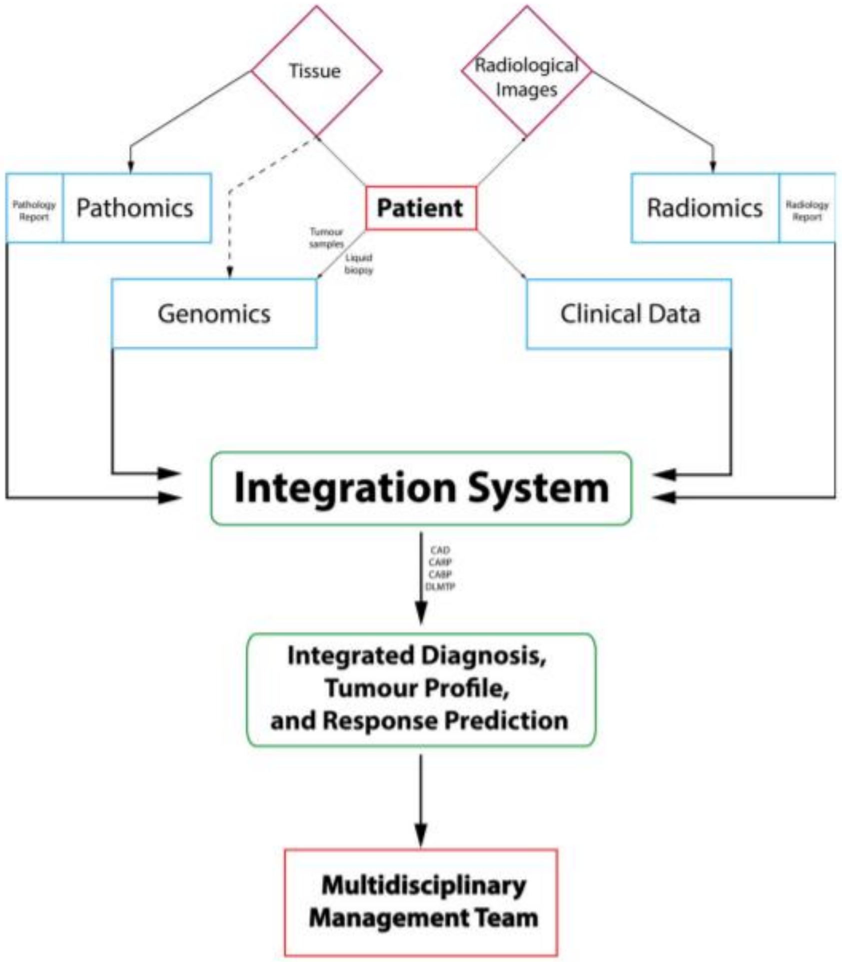


Background | Is radiology an optical illusion?





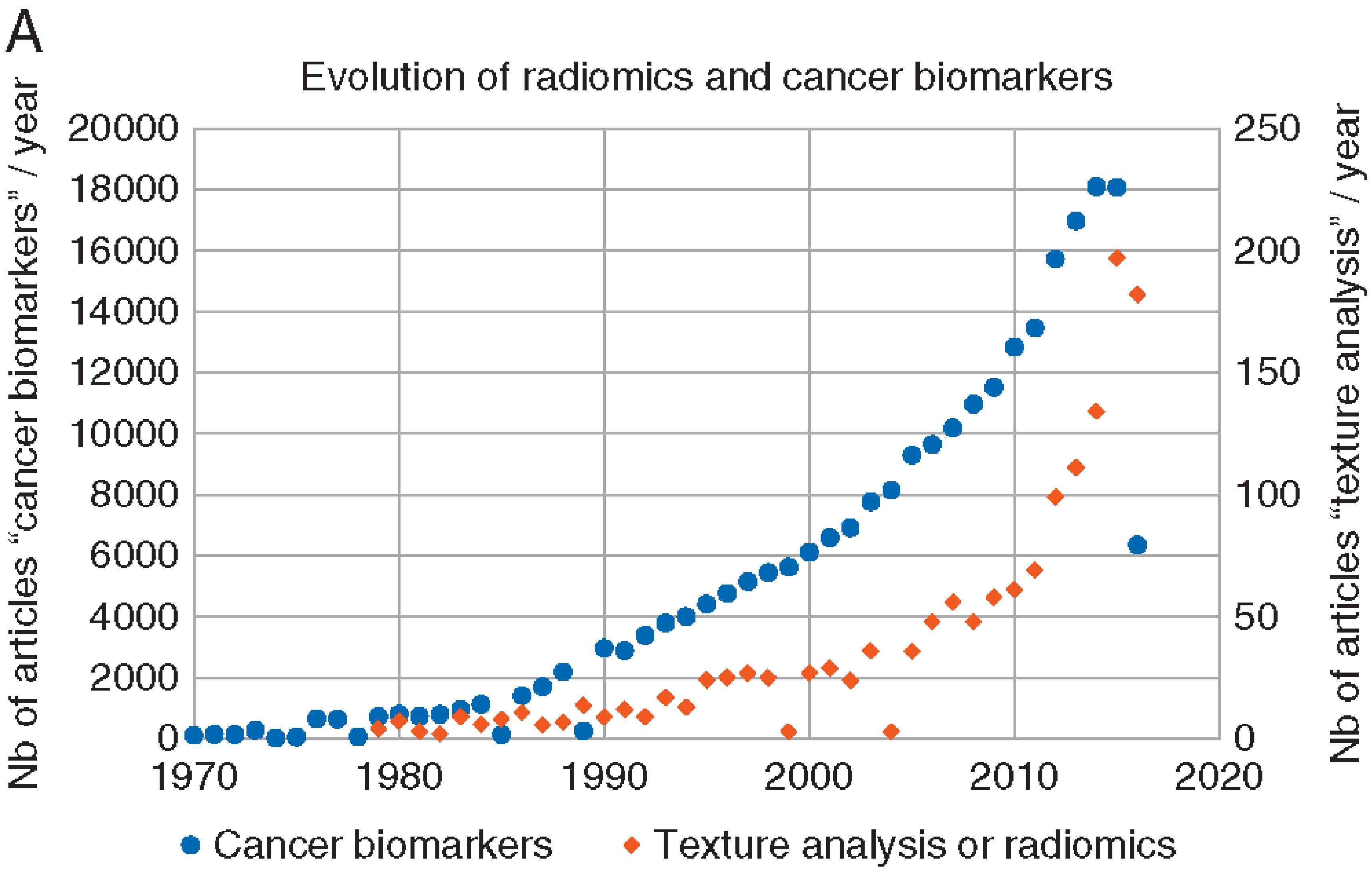
Background| Imaging biomarkers



Practical objectives of imaging analysis

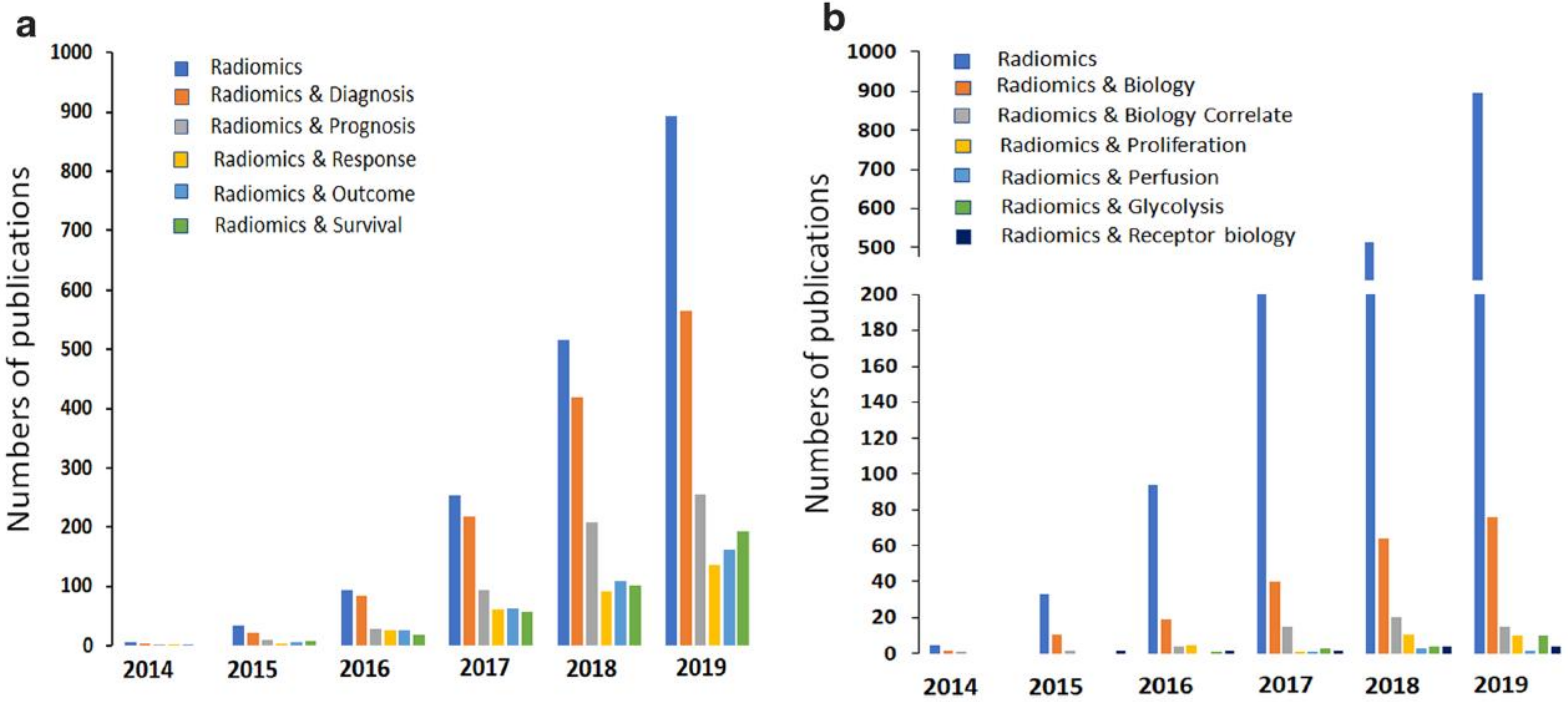
- **Characterization** of tumour through quantitative features
- Therapeutic response **prediction**
- Patient **stratification** for therapy **choice**
- Radiotherapy treatment **optimiziation**

Background | Imaging biomarkers



Limkin EJ et al. *Ann Oncol.* (2017)

Background| Imaging biomarkers



Radiomics | Definitions

Radiomics

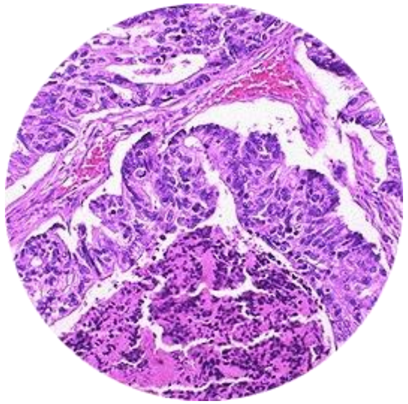
- Converts medical **images** into **quantitative data** using mathematical algorithms
- Extracts **features** such as texture, shape, and intensity to assess **tissue characteristics** and **heterogeneity**

Radiogenomics

- Integrates **radiomic features** with **genomic data** to uncover the biological basis of imaging phenotypes
- Facilitates **non-invasive prediction** of tumor **molecular characteristics** and **resposnse** to **therapy**

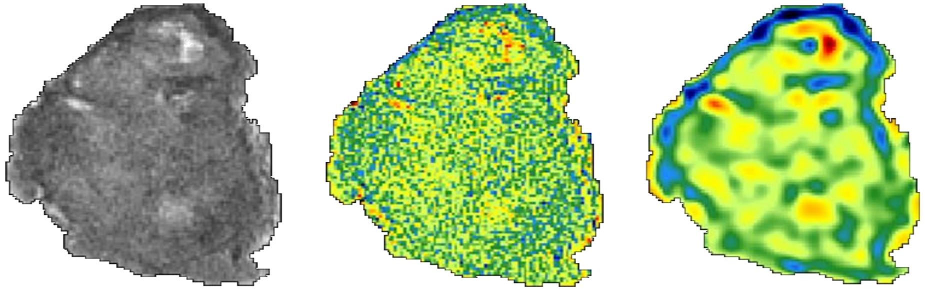
Radiomics| Definitions

Histological evaluation



- Invasive
- Difficult to repeat
- Tumor heterogeneity
- General risks
- Expensive

Radio(geno)mics evaluation



- Not invasive
- Repeatable
- Analyzes entire tumor volume : genomics
- Uses already available diagnostic exams
- Cheap

AI applications| Early diagnosis in breast cancer

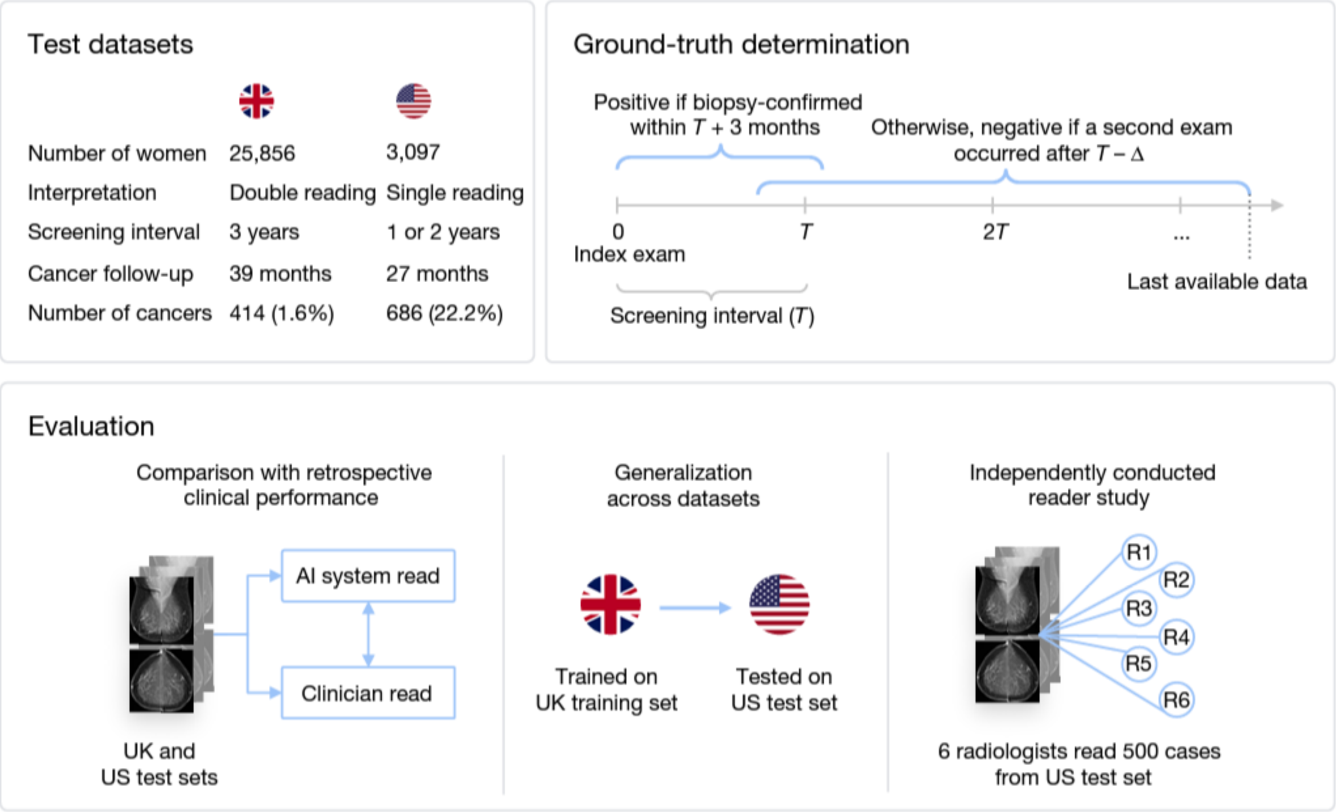
1998

R2 Technology's ImageChecker M1000 system

- Risk prediction
- Screening
- Diagnosis and characterization

AI applications| Early diagnosis in breast cancer

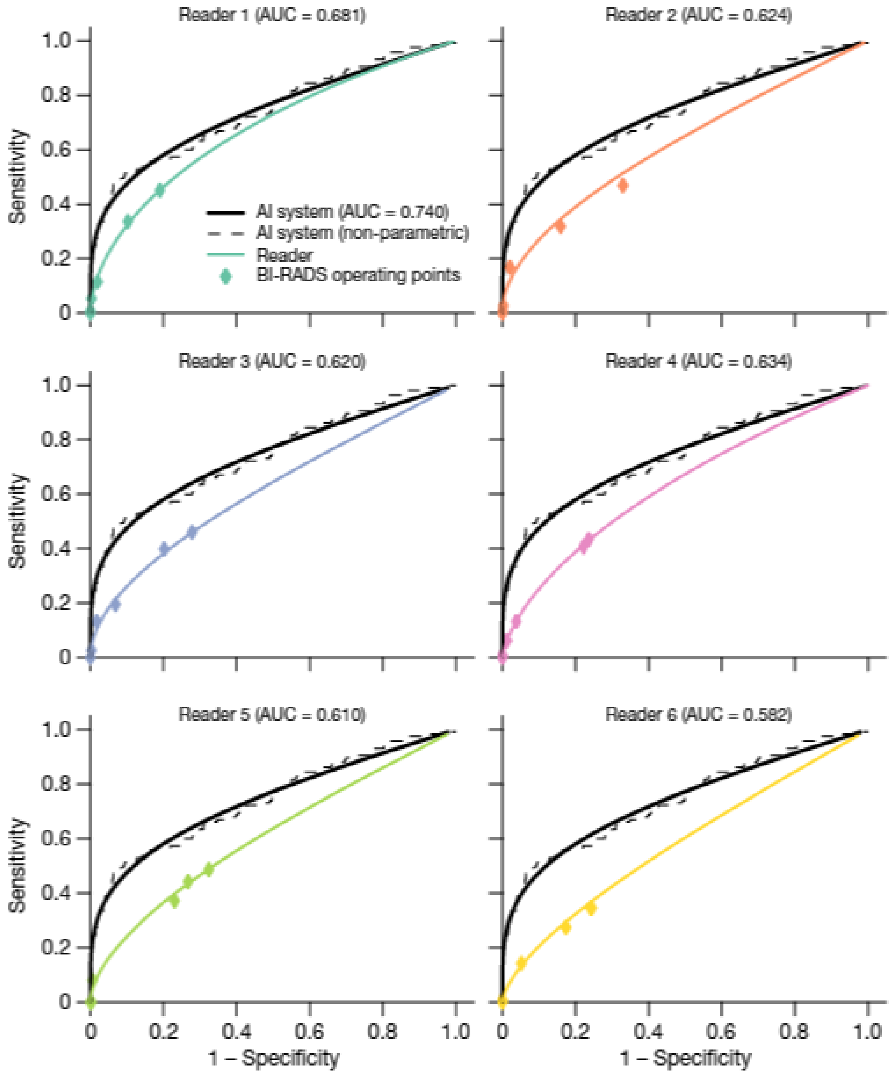
International evaluation of an AI system for breast cancer screening



Objectives

- Develop and evaluate the **accuracy** of an AI system applied to nearly 29.000 **mammographic screening images**
- Compare it with **human performance** (6 radiologists)

AI applications| Early diagnosis in breast cancer



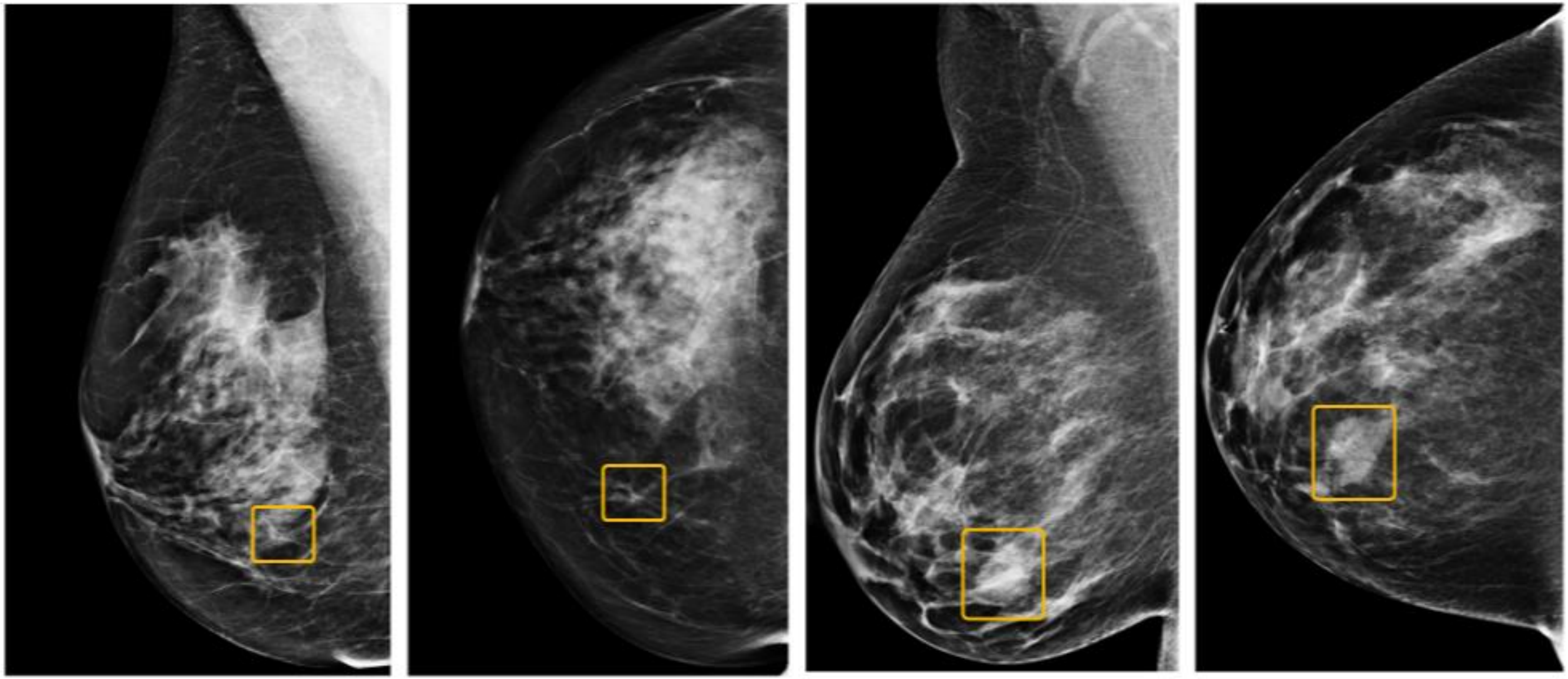
AUC 0.62

AUC 0.74

AI system **exceeded human performance**

(ΔAUC = +0.12 ; p = 0.0002)

AI applications| Early diagnosis in breast cancer



– 9,4% of FN and – 5,7% of FP

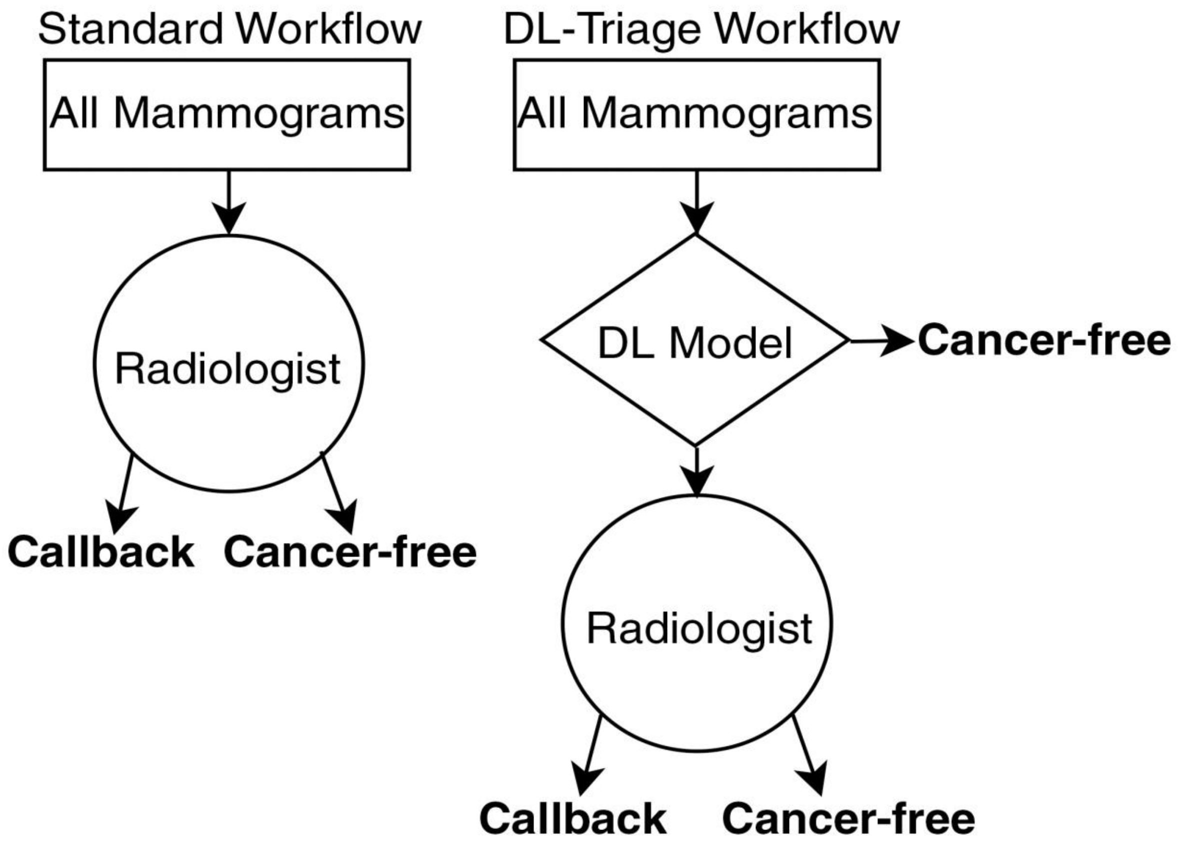
AI applications | Early diagnosis in breast cancer

FDA approved AI tools

Product Name	Vendor	Country of Origin	Modality
		Cancer Detection	
cmAssist®	CureMetrix	United States	Mammography
Genius AI™ Detection	Hologic®, Inc.	United States	Mammography and Tomosynthesis
Lunit INSIGHT MMG	Lunit	South Korea	Mammography
MammoScreen® 2.0	Therapixel	France	Mammography and Tomosynthesis
ProFound AI®	iCAD, Inc.	United States	Mammography and Tomosynthesis
Saige-Dx™	DeepHealth, Inc.	United States	Mammography
Transpara®	ScreenPoint Medical B.V.	Netherlands	Mammography and Tomosynthesis

Taylor CR et al. *Diagnostics* (2023)

AI applications| Early diagnosis in breast cancer



AUC standalone **AI** compared with the mean **reader** (0.84 vs 0.81; *p*= 0.002)

5182 DBT examinations

5 radiologists performance

417 of 459 detected cancers [90.8%]
477 recalls in 5182 [9.2%]

AI performance

413 of 459 detected cancers [90.0%]
358 recalls in 5182 [6.9%]
p 0.002

Use of AI to automatically filter out cases results in 39.6% less workload

AI applications| Early diagnosis in breast cancer

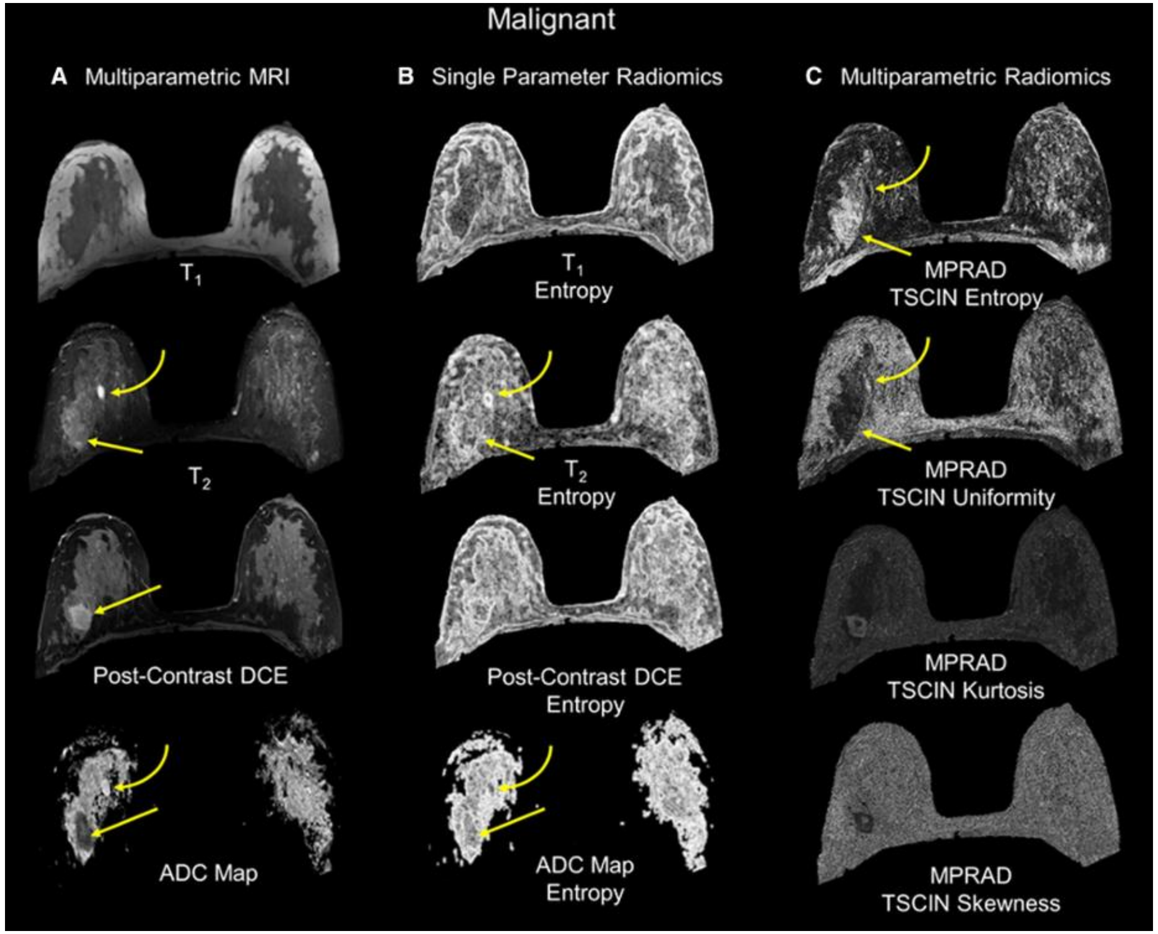
FDA approved AI tools

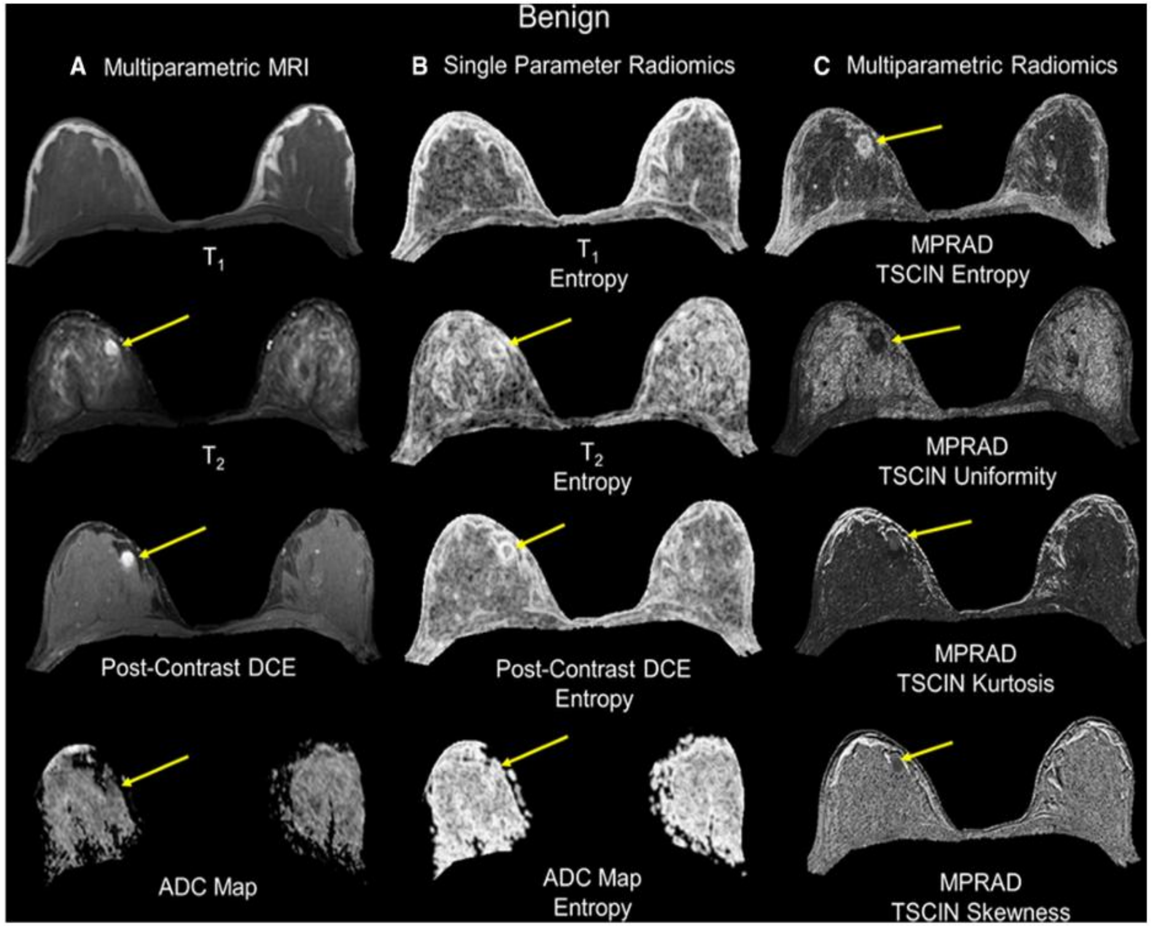
Triage

cmTriage®	CureMetrix, Inc.	United States	Mammography
HealthMammo	Zebra Medical Vision	Israel	Mammography
Saige-Q™	DeepHealth, Inc.	United States	Mammography and Tomosynthesis
Syngo.BreastCare	Siemens®	Germany	Mammography

- Improve exam management
- Categorize cases by complexity
- Replace the second reader in double-reading sites

AI applications| Early diagnosis in breast cancer





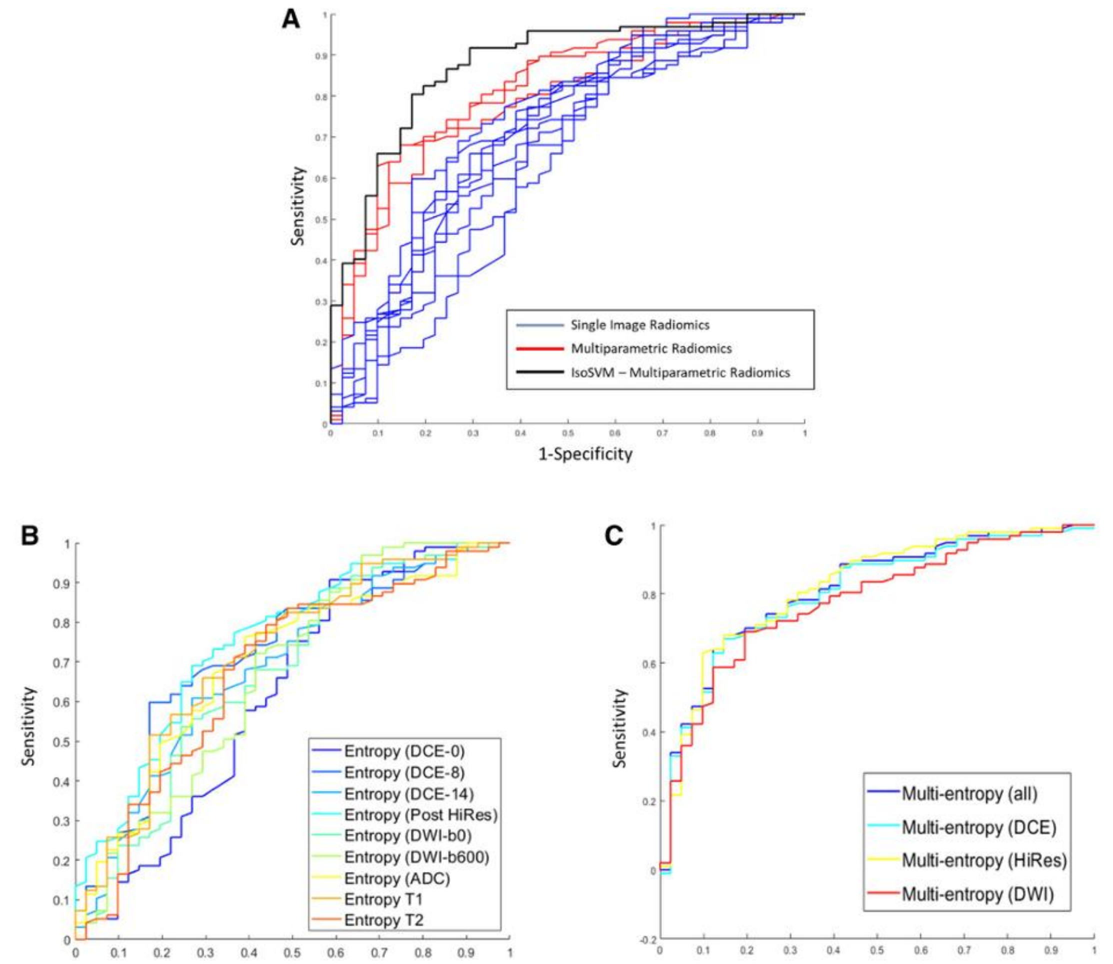
AI applications| Early diagnosis in breast cancer

Table 2 Single and multiparametric entropy values corresponding to benign and malignant breast tumors

	Benign tumor	Malignant tumor	*p* value	AUC
MRI metrics				
ADC map values ($\times 10^{-3}$ mm^2/s)	1.89 ± 0.10	1.15 ± 0.03	0.0001	
K^{trans} (1/sec)	0.27 ± 0.05	0.80 ± 0.32	0.005	
Single parameter entropy				
Entropy T1	4.14 ± 0.11	4.66 ± 0.06	0.00008	0.72 (0.64–0.79)
Entropy T2	4.98 ± 0.12	5.42 ± 0.06	0.002	0.68 (0.59–0.75)
Entropy b0	4.44 ± 0.17	5.06 ± 0.09	0.002	0.67 (0.59–0.75)
Entropy b600	3.00 ± 0.20	3.77 ± 0.09	0.0009	0.67 (0.59–0.75)
Entropy ADC	4.90 ± 0.12	5.40 ± 0.06	0.0004	0.70 (0.62–0.77)
Entropy post-contrast DCE (High spatial resolution)	5.00 ± 0.10	5.54 ± 0.05	0.00001	0.75 (0.67–0.82)
Entropy PK-DCE Pre	4.32 ± 0.12	4.65 ± 0.05	0.02	0.62 (0.54–0.70)
Entropy PK-DCE post (wash-in)	4.89 ± 0.08	5.30 ± 0.05	0.00006	0.72 (0.64–0.79)
Entropy PK-DCE post (wash-out)	4.90 ± 0.09	5.24 ± 0.04	0.00007	0.69 (0.60–0.76)
Multiparametric entropy				
TSPM entropy (all Parameters)	7.06 ± 0.27	8.93 ± 0.17	< 0.00001	0.82 (0.74–0.88)
TSPM entropy (PK-DCE)	7.06 ± 0.27	8.92 ± 0.17	< 0.00001	0.82 (0.74–0.88)
TSPM entropy (high spatial resolution DCE)	6.74 ± 0.19	8.28 ± 0.12	< 0.00001	0.82 (0.75–0.88)
TSPM entropy (DWI)	6.66 ± 0.22	8.20 ± 0.15	< 0.00001	0.78 (0.70–0.85)

DWI diffusion-weighted imaging, *ADC* apparent diffusion coefficient, *PK* pharmacokinetic, *DCE* dynamic contrast enhancement, *FOS* first order statistics, *TSPM* tissue signature probability matrix

The mpRad features successfully classified breast lesions with excellent sensitivity and specificity of 82.5% and 80.5%, respectively, with AUC of 0.87 (0.81–0.93).
mpRad provided a 9-28% increase in AUC metrics over single radiomic parameters.



Tumor boards | The role of AI

To the Editor: As I observed the tumor board, case after case of breast cancers were discussed and appropriate multidisciplinary management was planned for each individual patient. Then came one case that changed everything.

Case #9 was a patient with 2 sets of mammograms pulled up to the big screen for all to see. The radiologist explained that the first set of images taken 3 months ago appeared completely normal and no suspect pathology could be found. The radiologist went on further to point out the evident pathology on the second set of images taken this week, thereby raising suspicion for cancer. Everyone's eyes darted back and forth between the images, struggling to find some sort of hint of cancer in the first set of images. The radiologist continued, "This miss would be entirely acceptable if not for a recent advancement in our practice." She mentioned that a few days before having our patient's first images taken, we had implemented a new artificial intelligence (AI) software in our system. Although that software predicted a 35% chance of malignancy in the first images, we did not see it and waved it off. The radiologist pulled up an image with the AI prediction overlay, outlining the area of suspicious malignancy of which to the people in the board room could not appreciate. She said, "We dismissed AI's prediction because we did not see what it saw."

The surgeons, pathologists, oncologists, and fellow radiologists all looked visibly disturbed by this case and the new decision landscape they faced. A look of confusion at facing a new complicated ethical world could be seen on the

When another AI dilemma arises, will we be equipped to address the elephant in the board room?

Thank you for your kind attention

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