Machine Learning in Radiology

Amir Tahmasebi, PhD
Senior Scientist
Philips Research North America

Artificial Intelligence for Radiology

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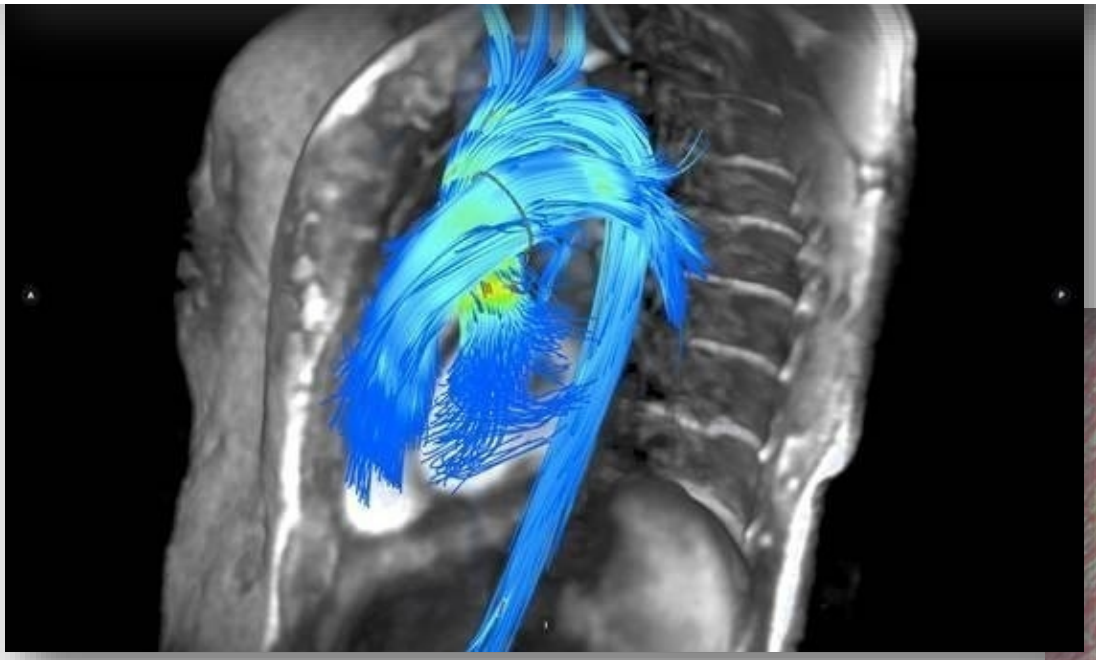
First Comprehensive Visualization and Quantification of Cardiac 4D Flow and cardiac Function Available to Physicians in clinical settings



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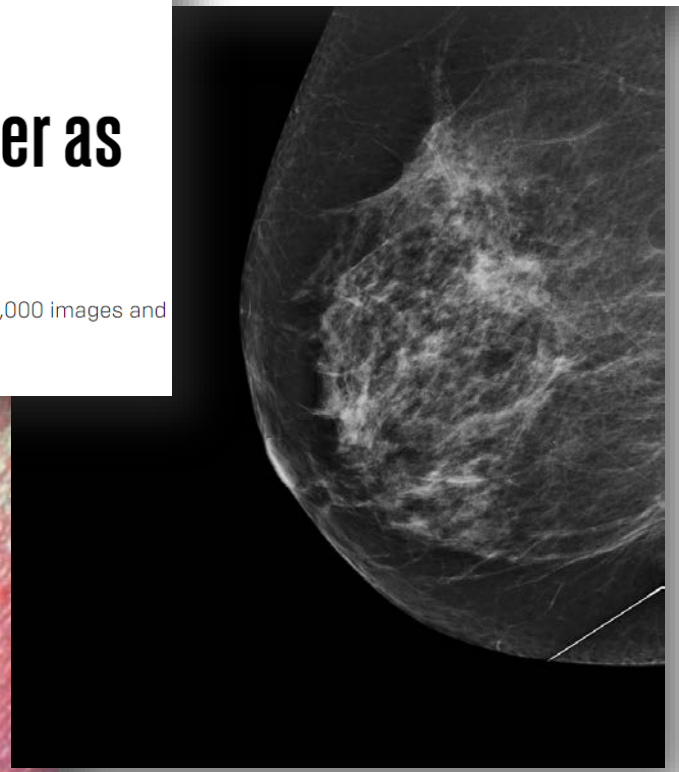
Artificial Intelligence

Radiology by robots: this is what breast cancer looks like to tumour-hunting AI

age-scanning algorithms to identify a range of health
ant accuracy



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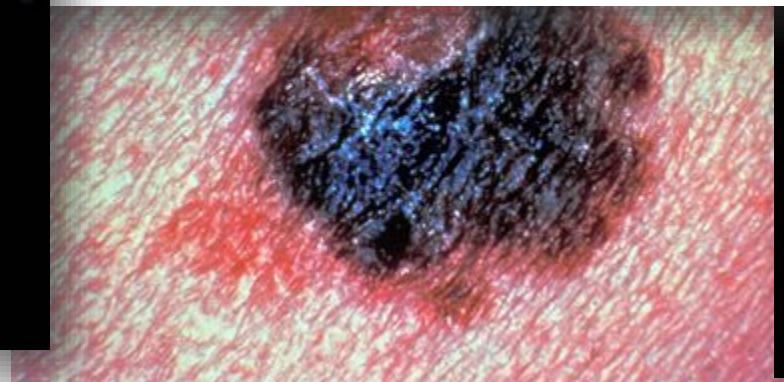
Cancer

This AI can spot skin cancer as accurately as a doctor

The artificial intelligence was trained on an image database of 129,000 images and performed as well as trained medical professionals



Artificial Intelligence for Radiology

human versus machine learning

MedCityNews

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Will the rise of the machines imperil radiologists?

By ARUNDHATI PARMAR

Post a comment / Jan 16, 2017 at 11:09 PM

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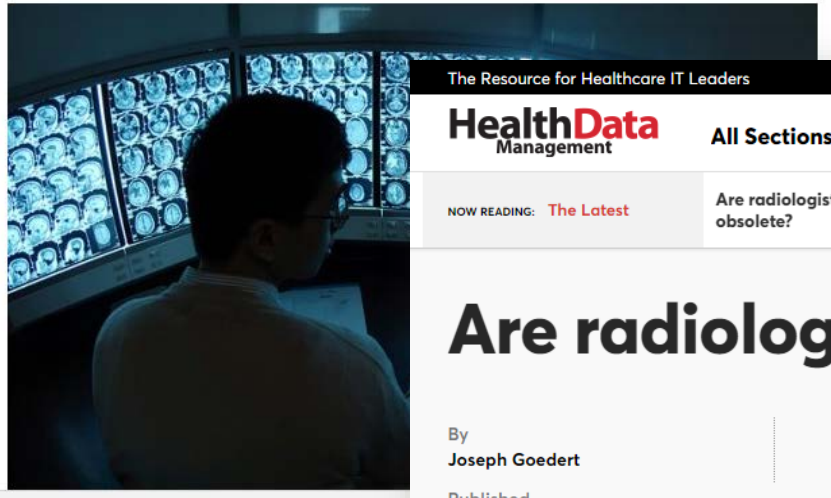

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Are radiologists becoming obsolete?

By
Joseph Goedert

Published
November 09 2016, 3:14pm EST

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Artificial intelligence
Medical imaging

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With the evolution of IBM's Watson supercomputer and other advancements in artificial intelligence, could machines replace radiologists? That's a topic to be explored during a session at RSNA 2016, Nov. 27-Dec. 2 at McCormick Place in Chicago.

BUSINESS INSIDER | DIGITAL INDUSTRY INSIDER

Digital disruption in radiology – will it put doctors out of work?

Lydia Ramsey

Nov. 30, 2016, 4:48 PM 3,654

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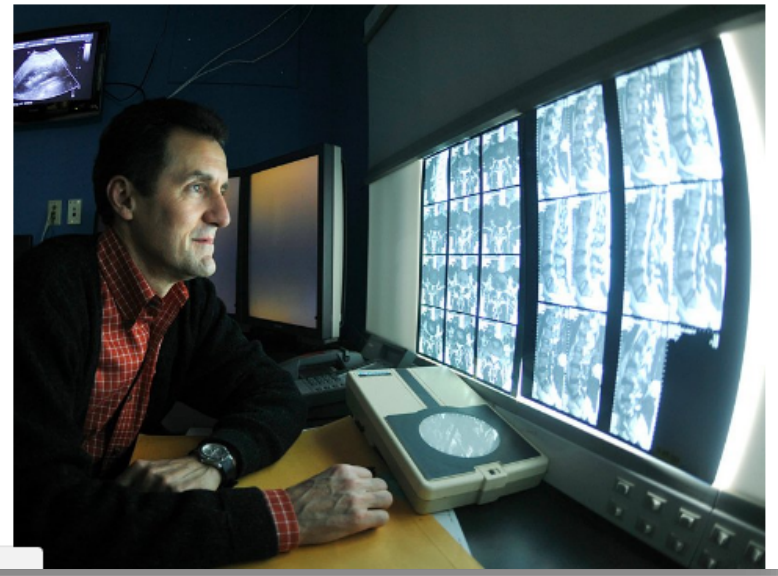
CHICAGO — Medical imaging has



Artificial Intelligence for Radiology

human + machine learning

Keith Dreyer, DO, PhD,
vicechairman, radiology,
computing and information
sciences,
Massachusetts General Hospital

DiagnosticImaging

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Securing Radiology's Future Through the Digital Revolution

News | November 28, 2016
By Julie Kaufield, MA, RT(R)

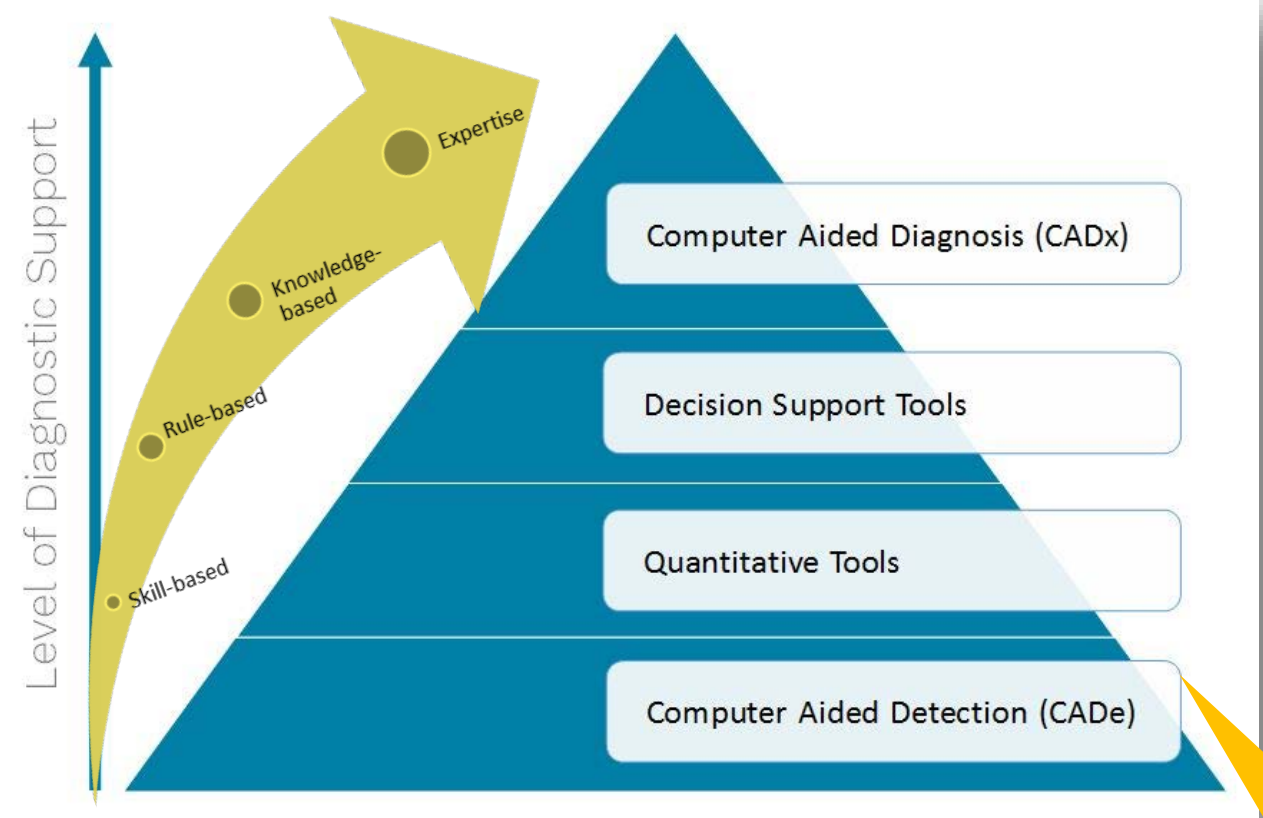
The most effective use for AI is one using a Centaur approach where computers and humans work together, Dreyer said.

"To make new radiology, you have to understand our domain, have access to our environments, and have a vision of what radiology is going to look like tomorrow," Dreyer said, regarding the value radiologists bring to machine learning.

Radiology of the future will be about using machines to make us smarter, do more, and give us more value by giving us more time to communicate, he said.

Artificial Intelligence for Radiology

How/Where can it be useful?



http://signifyresearch.net/analyst-insights/

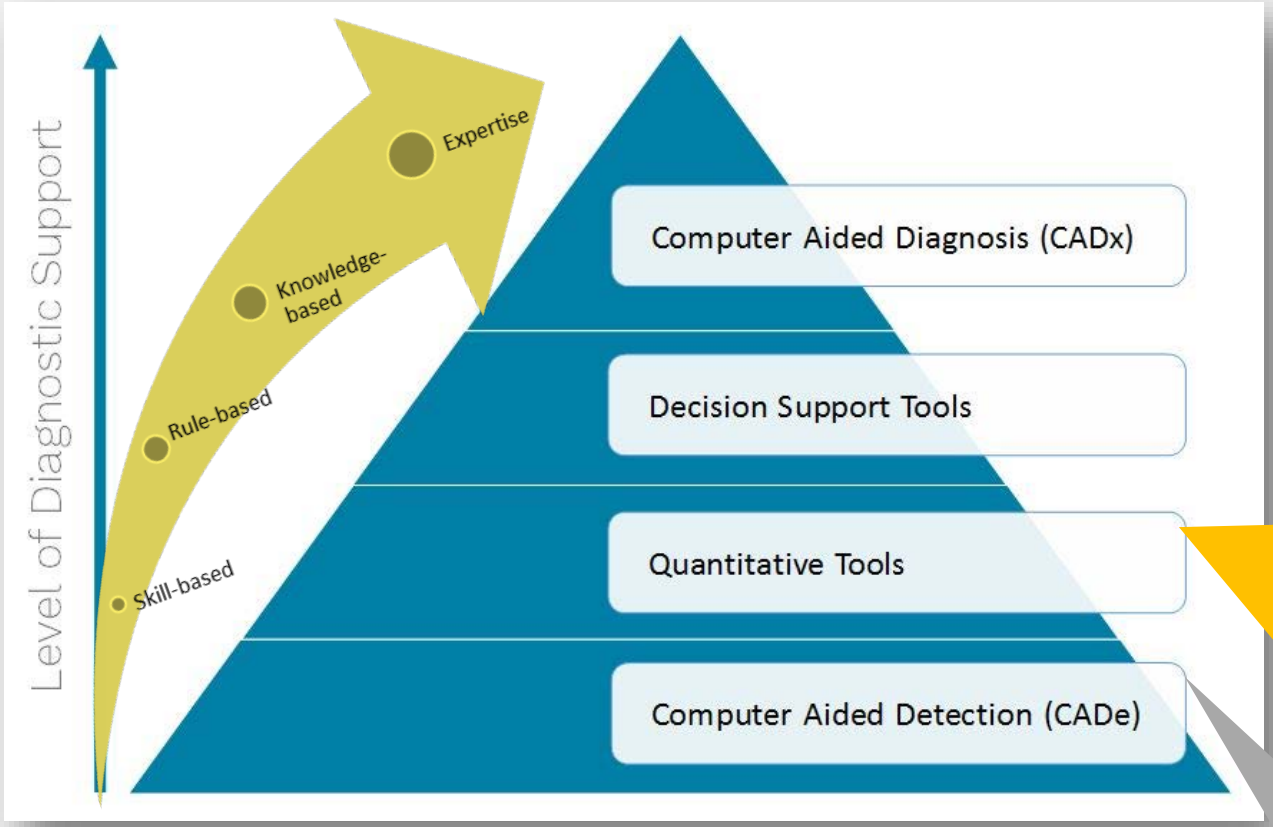
- **Automation**
- **Accuracy**
- **Consistency**

Identify a variety of cancers such as breast cancer, prostate cancer, and lung lesions

iCAD

Artificial Intelligence for Radiology

How/Where can it be useful?



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4D Flow from Arterys

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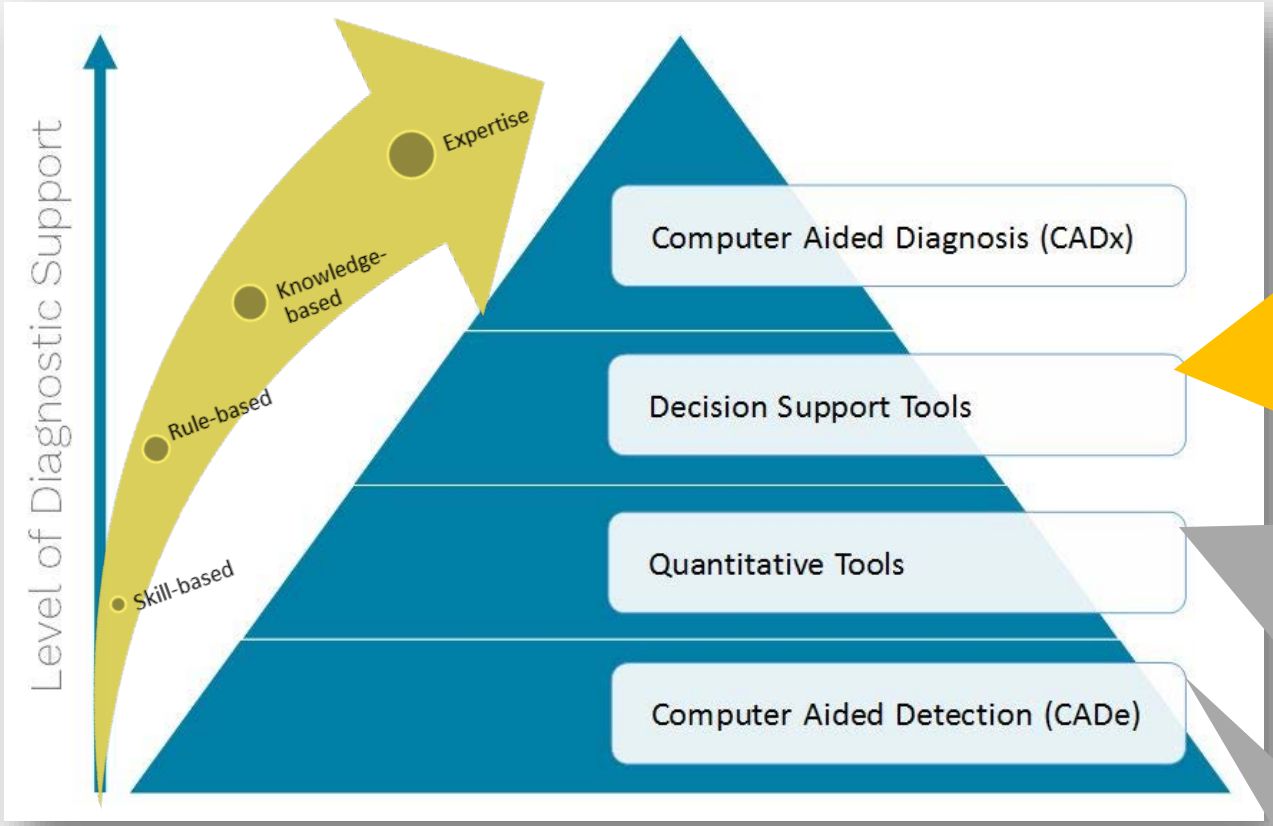

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- **Integration**
- **X-collaboration**

detection and quantification, alongside supporting information extracted from an EHR, pathology reports and other patient records, to assist with diagnosis

IBM Watson Health

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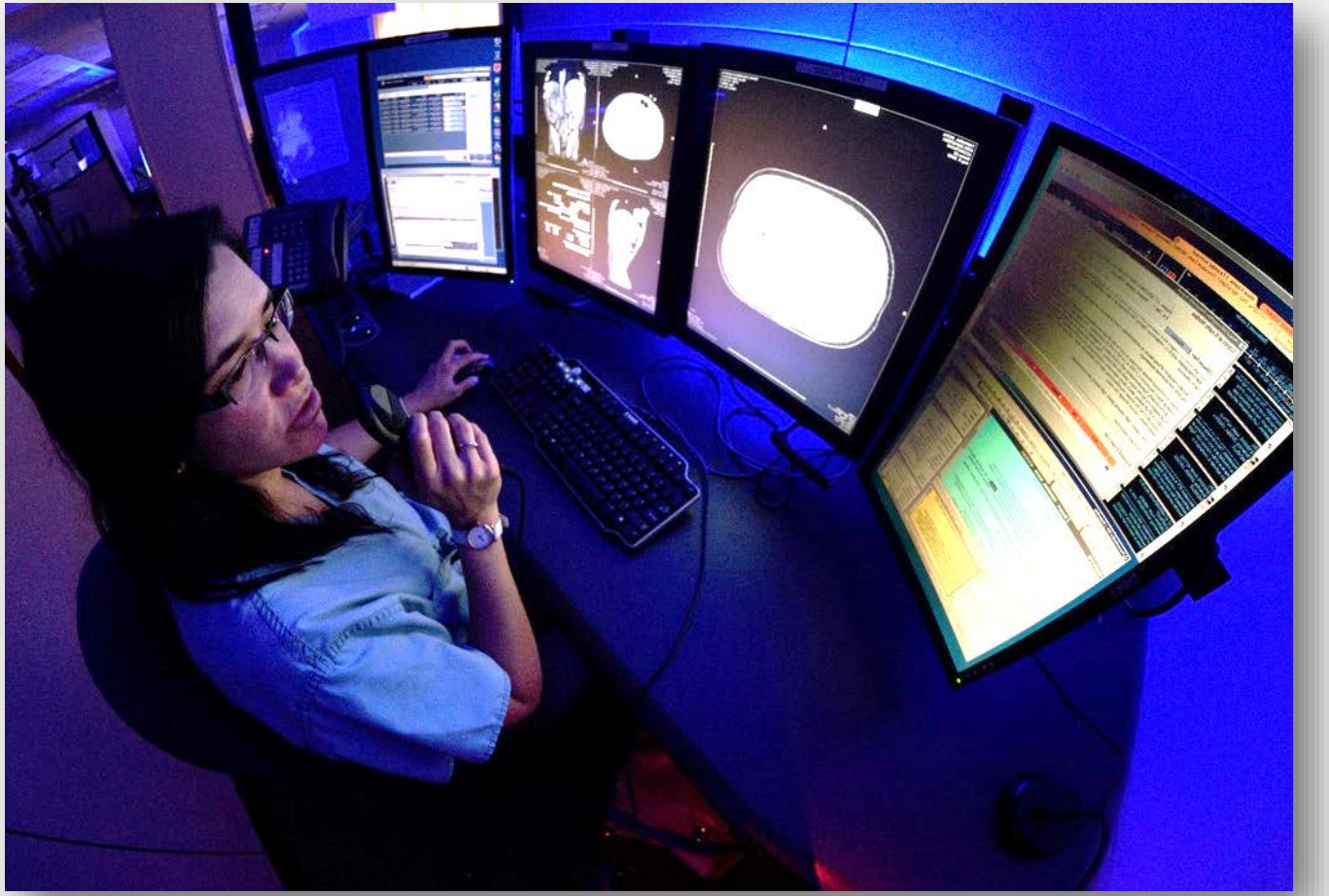
iCAD

Artificial Intelligence for Radiology

How/Where can it be useful?

Multi-modal Data

- Image
  - Pixel/voxel
- Non-image
  - EMR
  - Genomics
  - …



http://www.axisimagingnews.com/healthcare-it/pacs-ris/

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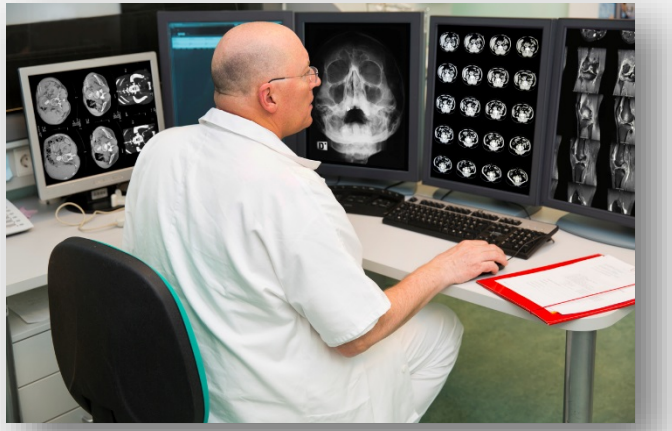
How/Where can it be useful?

Collaboration

- One radiologist vs. multiple radiologists
- Radiologist + Pathologist
- Radiologist + Oncologist
- …



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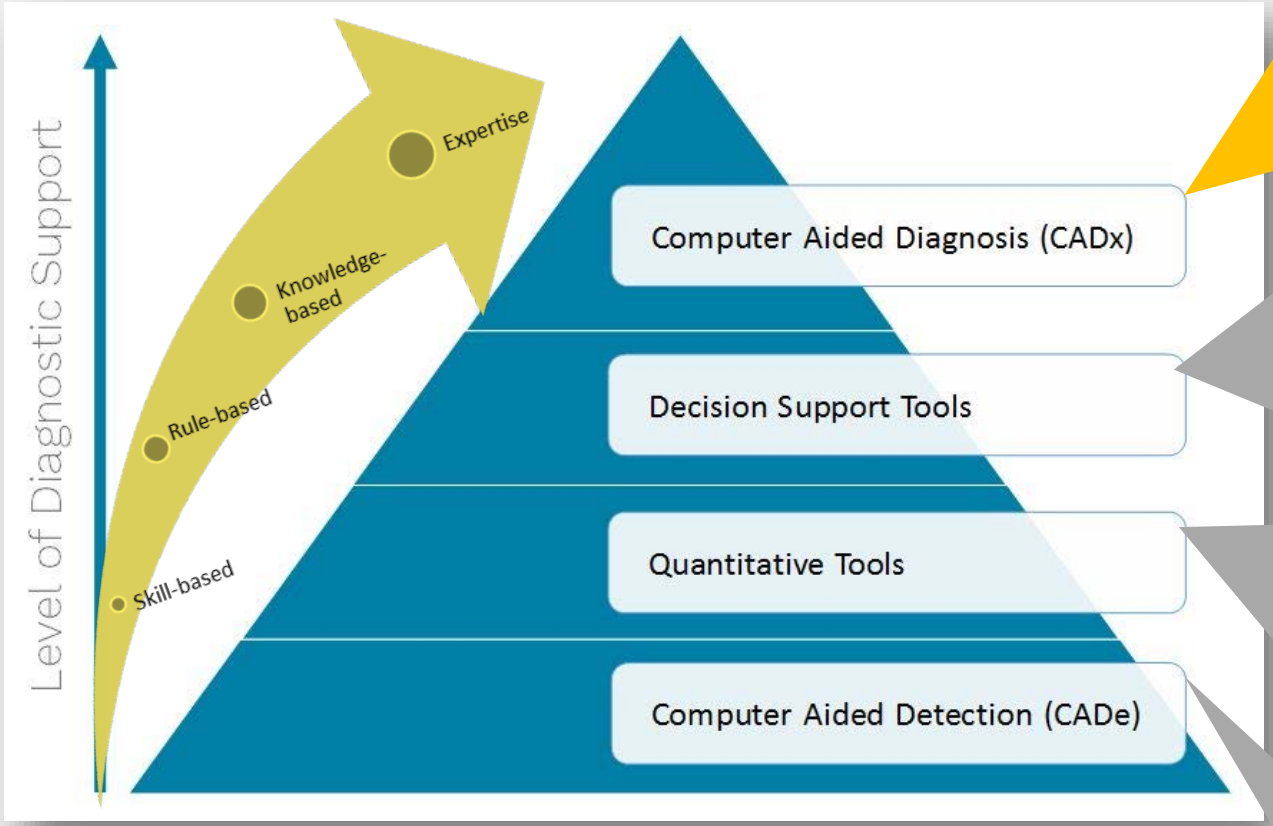

http://signifyresearch.net/analyst-insights/

provide information beyond detection and quantification by also providing interpretation of the scan, for example by providing a probability score for the presence of cancer

Aidence, Enlitic and CureMetrix

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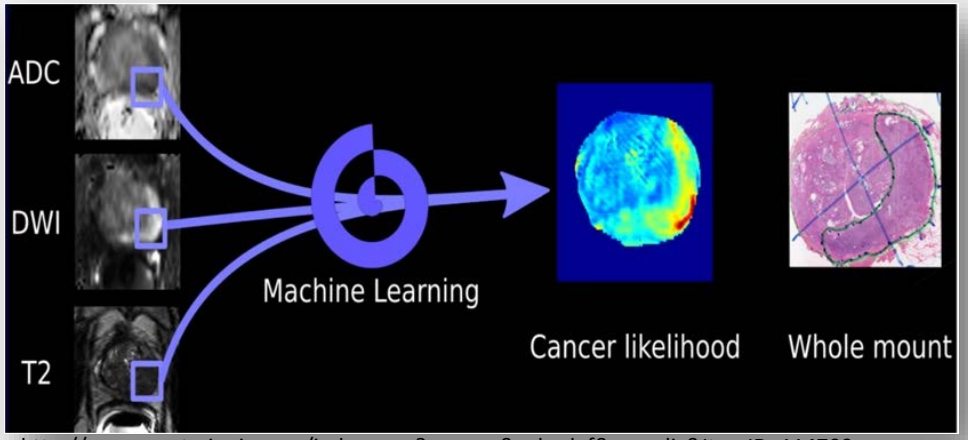
Artificial Intelligence for Radiology

How/Where can it be useful?

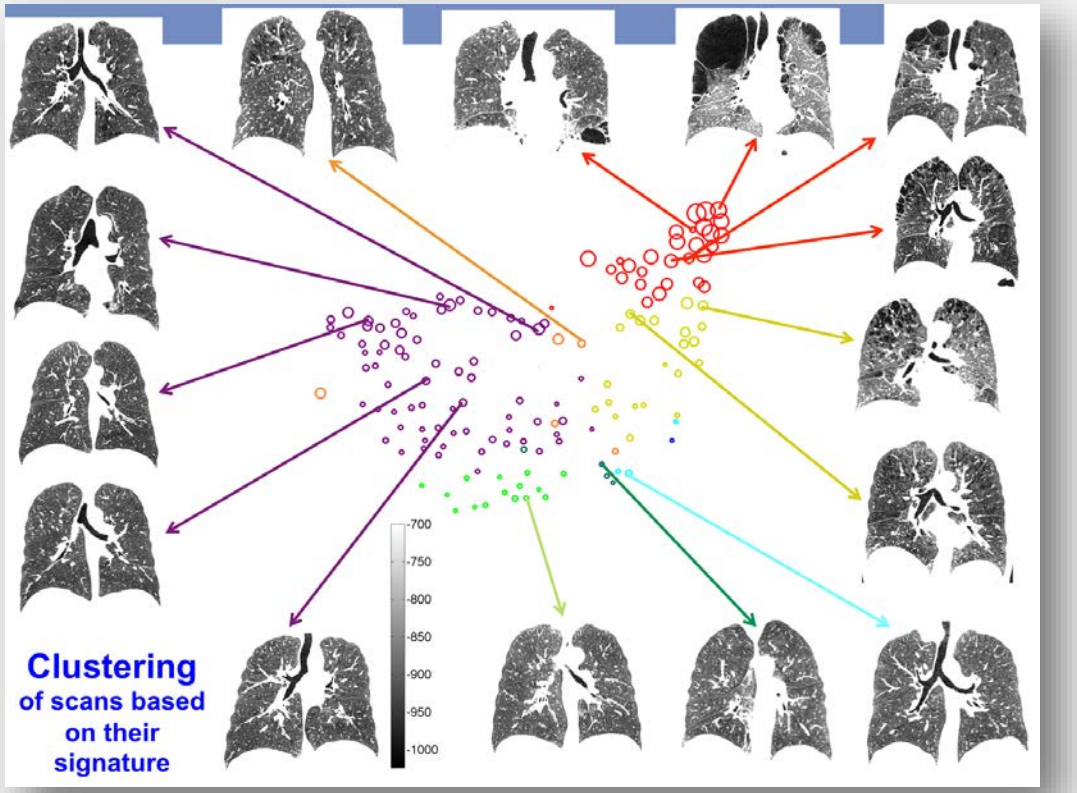
- **Supervised**
  - Learning from [human] expert



http://www.auntminnie.com/index.aspx?sec=ser&sub=def&pag=dis&ItemID=114700

- PIRADS
- BIRADS
- LUNGRADS
- …

- **Unsupervised**
  - Discover new knowledge

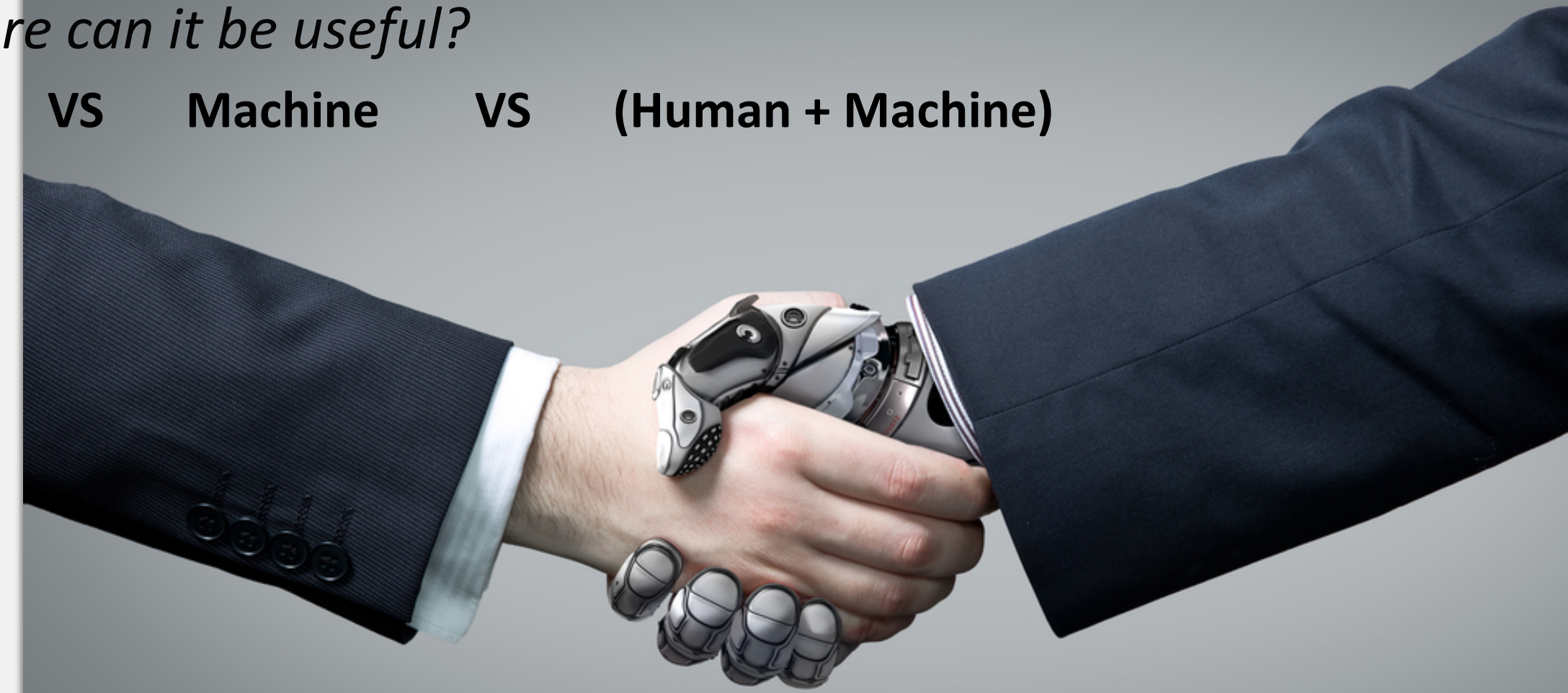


http://hbil.bme.columbia.edu/content/adaptive-quantification-and-subtyping-pulmonary-emphysema-ct-images

Artificial Intelligence for Radiology

How/Where can it be useful?

- **Human VS Machine VS (Human + Machine)**

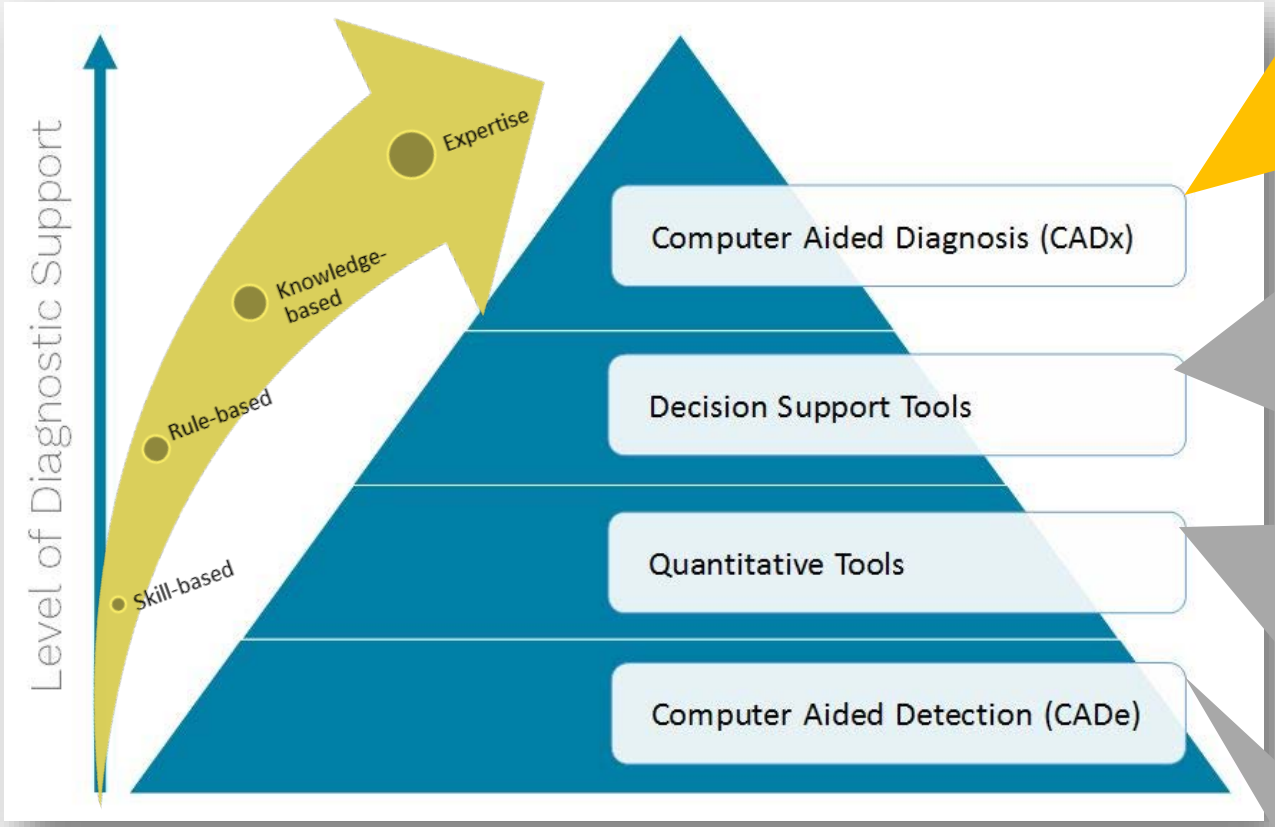


Human + Machine > Human/Machine

https://www.datanami.com/2015/10/16/avoiding-the-pitfalls-of-bigger-data-at-the-human-machine-interface/

Artificial Intelligence for Radiology

How/Where can it be useful?



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Artificial Intelligence for Radiology

Challenges

- **Supervised**
  - [Annotated] data as Ground Truth
  - Domain dependent
    - Scalability

- **Unsupervised**
  - Lucky-guess
  - Scalability

Artificial Intelligence for Radiology

The danger

- Can a machine think by itself and come up with new rules?
  - intuit unexpected insights,
  - conjure alternative scenarios
  - understand emotion

Trained machines are exquisitely well suited to their environment—and ill-adapted to any other.

- University of Pittsburgh Medical Center
- **Goal:** using machine learning to predict whether pneumonia patients might develop severe complications
  - to send patients at low risk for complications to outpatient treatment, preserving hospital beds and the attention of medical staff
  - **The model did what it was told to do: Discover a true pattern in the data.**
    - One of the rules instructed doctors to send home pneumonia patients who already had asthma, despite the fact that asthma sufferers are known to be extremely vulnerable to complications.
      - hospital policy to send asthma sufferers with pneumonia to intensive care

http://nautil.us/issue/40/learning/is-artificial-intelligence-permanently-inscrutable

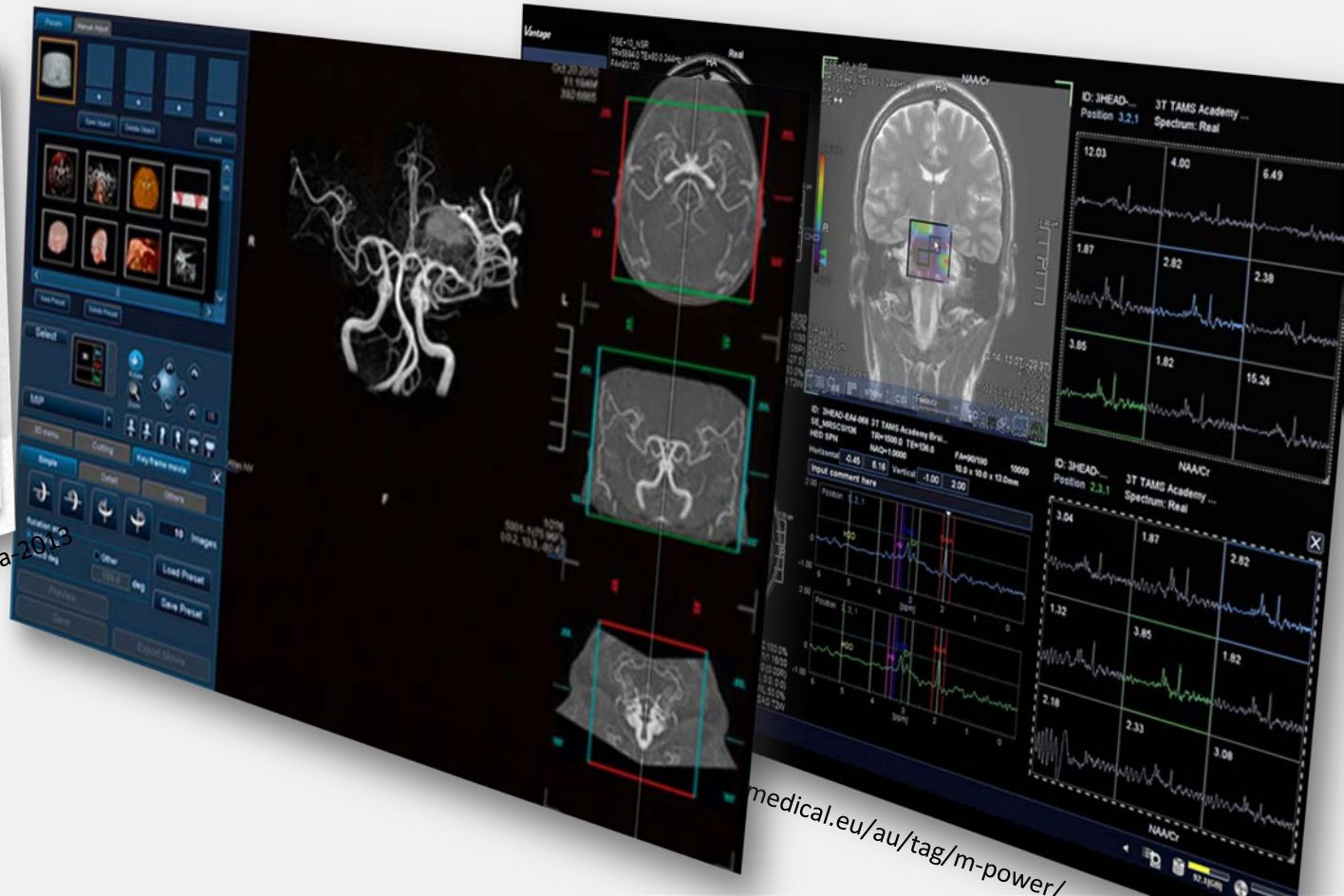
Artificial Intelligence for Radiology

Role of Industry

- Facilitate integration to workflow

Right information at the right time

https://www.itnonline.com/content/primordial-announces-new-customers-solutions-rsna-2013



medical.eu/au/tag/m-power/

Artificial Intelligence for Radiology

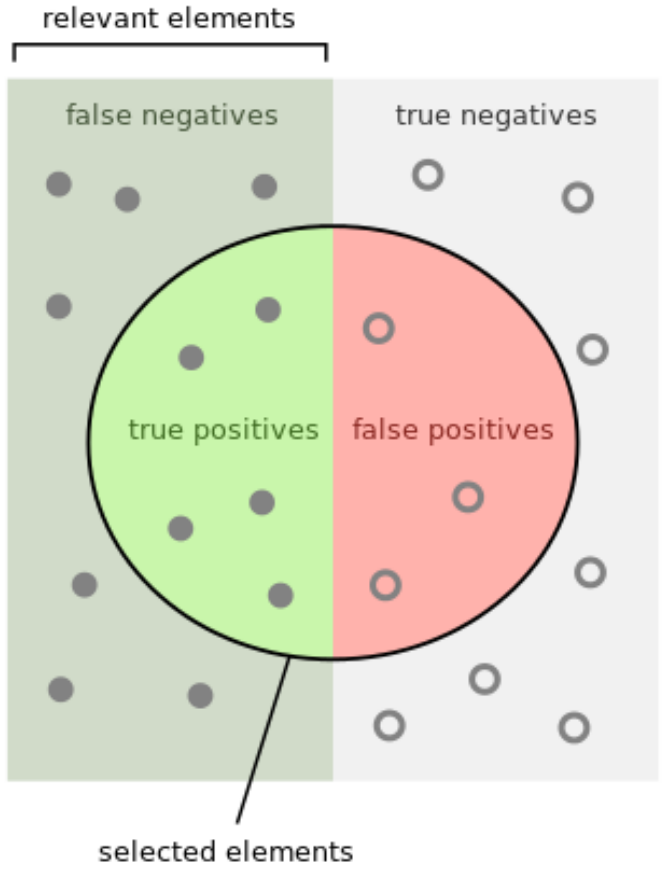
What matters from clinician's point of view

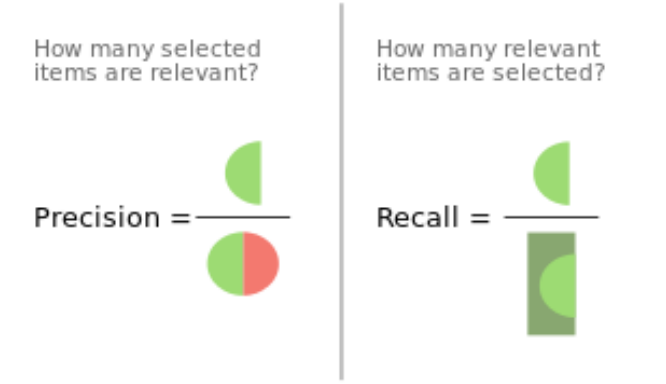
- Precision / Recall – trade-off
  - *Predict cancer with high confidence*
  - *Avoid missing too many cancer cases*

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F = 2 \times \frac{Precision \times Recall}{Precision + Recall}$$





Wiki

Artificial Intelligence for Radiology

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$$Recall = \frac{TP}{TP + FN}$$

$$Specificity = \frac{TN}{TN + FP}$$

$$Sensitivty = \frac{TP}{TP + FN}$$

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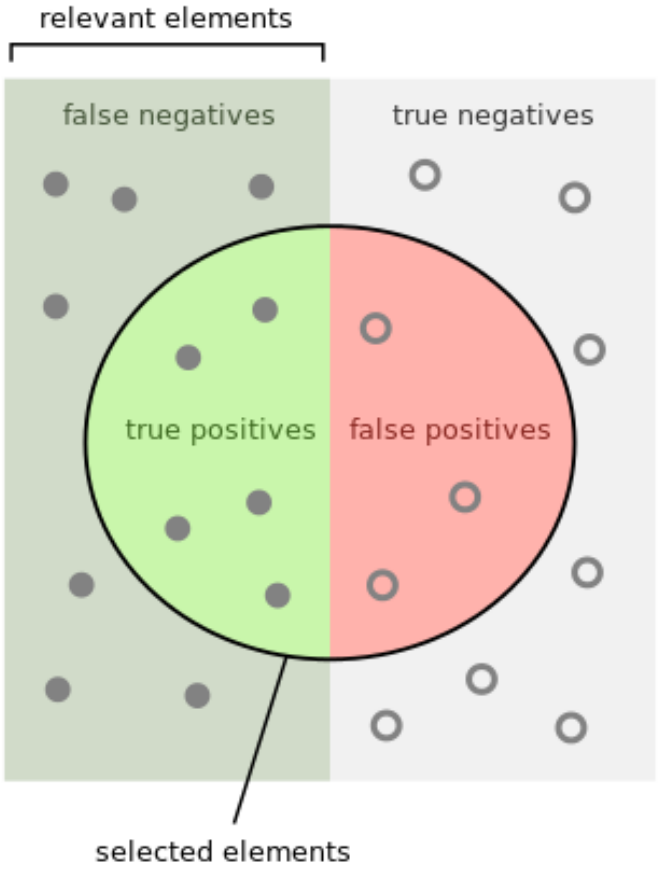
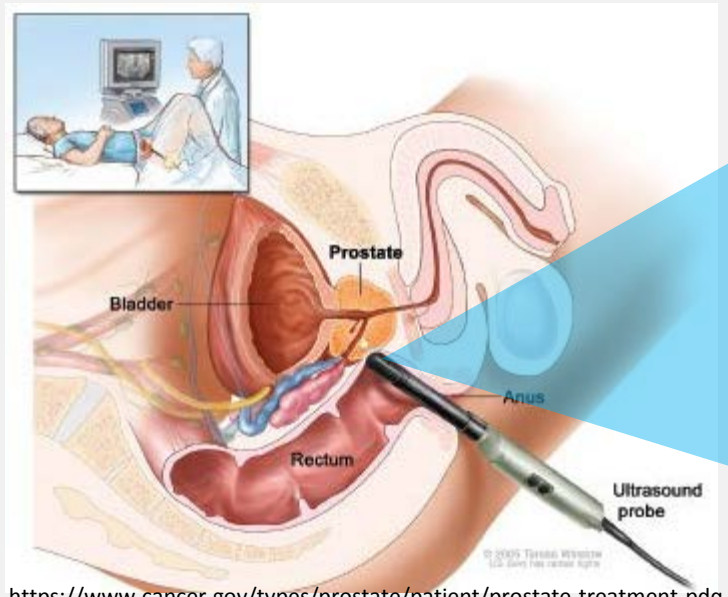


Wiki

Artificial Intelligence for Radiology

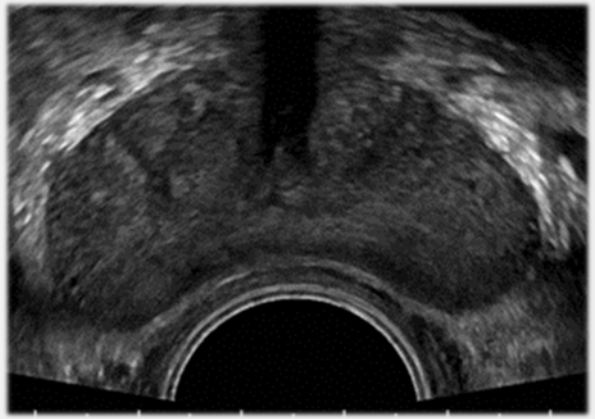
Use Case: *Tumor Tissue Characterization using Ultrasound*

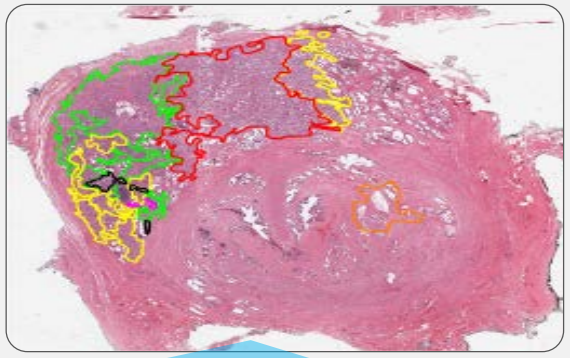
Problem Definition:



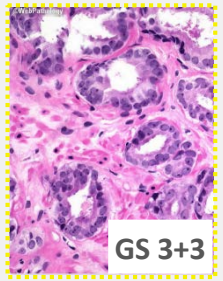
https://www.cancer.gov/types/prostate/patient/prostate-treatment-pdq

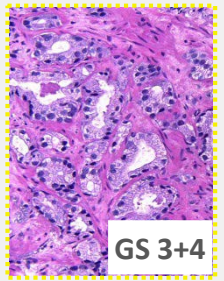
Prostate under Ultrasound

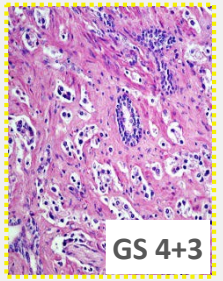


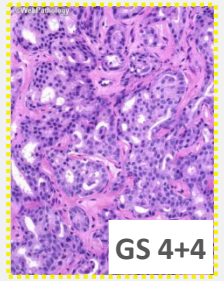


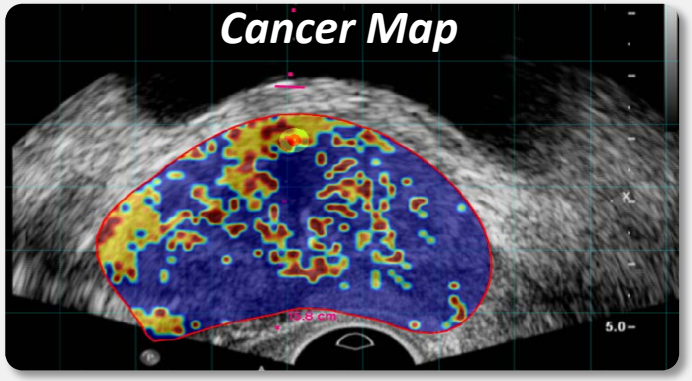
Prostate under microscope











Courtesy of Dr. Abolmaesumi

Artificial Intelligence for Radiology

Use Case: *Tumor Tissue Characterization using Ultrasound*

Steps:

1. *Understand the problem*
2. *Define input(s) and output(s)*
3. *Investigate limitations and boundary conditions*
4. *Collect representative data*
    1. *[Labels]*
5. *[Calculate features/engineer features]*
6. *Define ML framework*
7. *Define Metric for evaluation*

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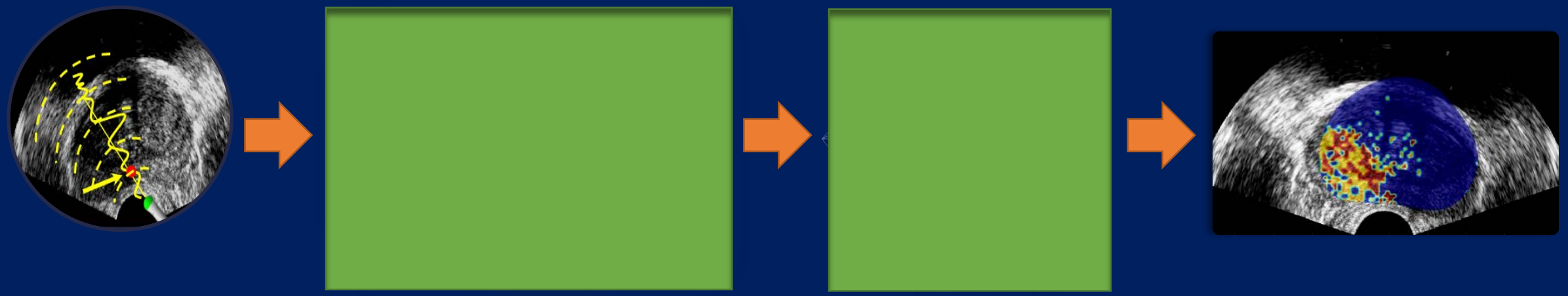

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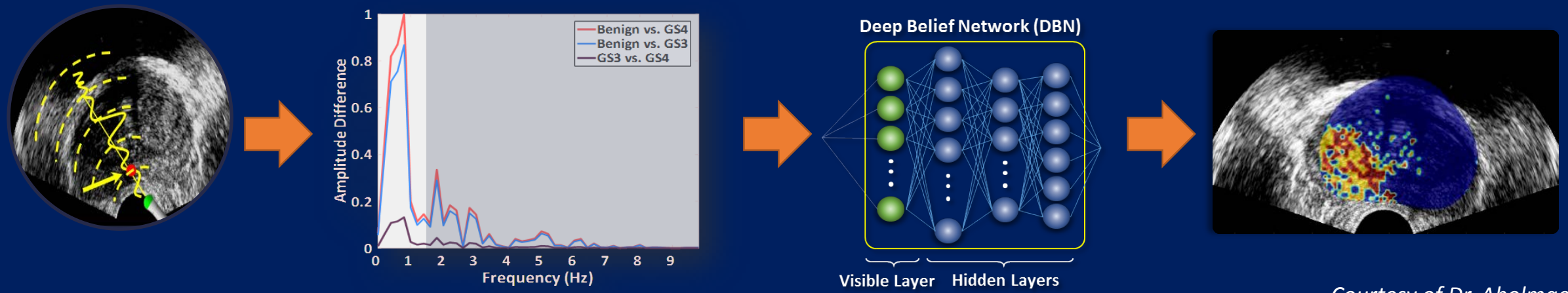

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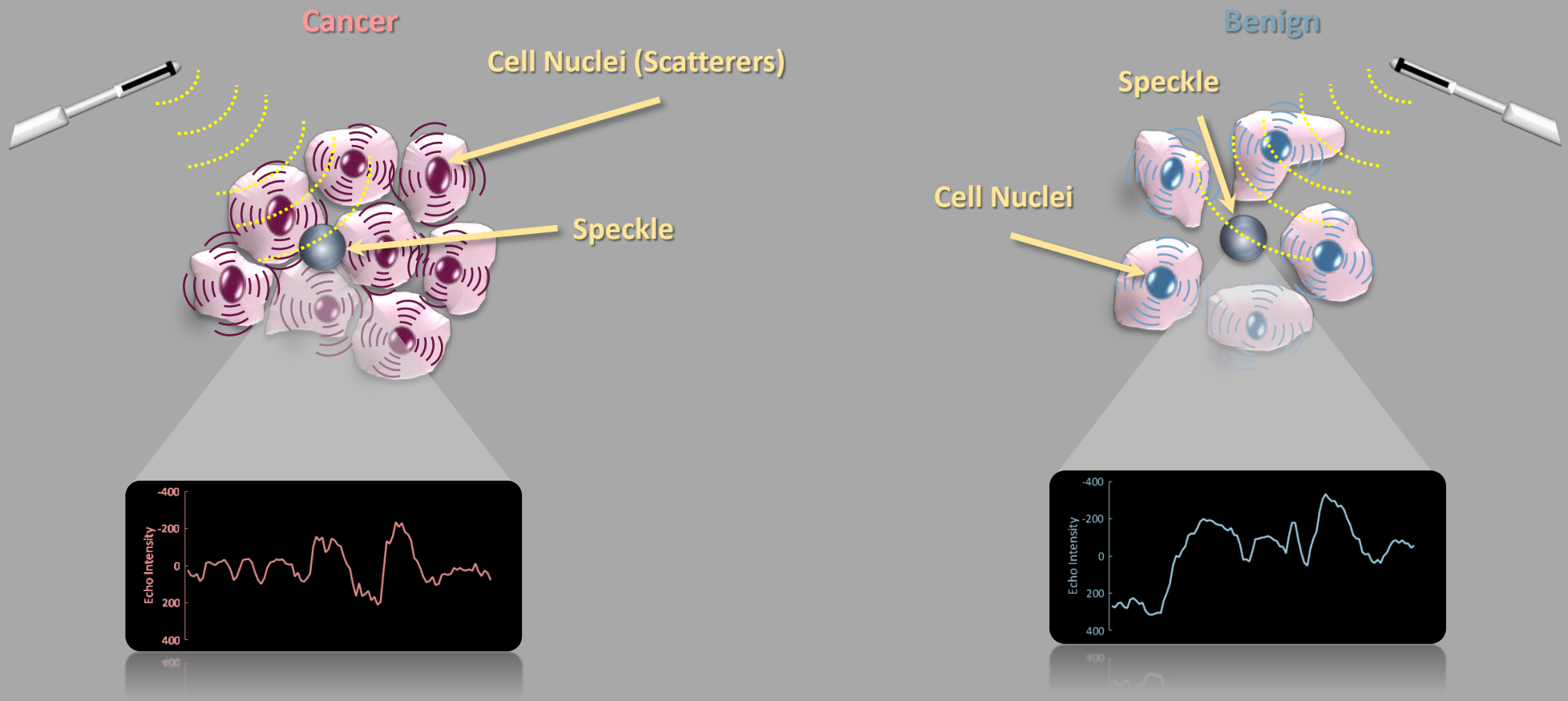
Interpretability

Artificial Intelligence for Radiology

Use Case: *Tumor Tissue Characterization using Ultrasound*



Courtesy of Dr. Abolmaesumi

References

[1] Classifying cancer grades using temporal ultrasound for transrectal prostate biopsy, International Conference on Medical Image Computing and Computer-Assisted Intervention (MICCAI), 653-661, 2016

[2] Ultrasound-based detection of prostate cancer using automatic feature selection with deep belief networks, International Conference on Medical Image Computing and Computer-Assisted Intervention (MICCAI), 70-77, 2015

[3] Ultrasound-based predication of prostate cancer in MRI-guided biopsy, Workshop on Clinical Image-Based Procedures, 142-150, 2014

Questions and Comments?

Amir.Tahmasebi@Philips.com