AI in Medical Imaging: Rise of the Machines

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Disclosures

I have no relevant financial relationships to disclose.

My work at UW–Madison/UW Health informs my expertise, but I do not represent the views of the university or UW Health. I am providing this information as a private citizen and subject matter expert only.

AI IN MEDICAL IMAGING

- BRIEF HISTORY OF MEDICAL IMAGING AND AI
- RISE OF THE MACHINES
- AI IN MEDICAL IMAGING
- FORCASTING THE FUTURE

BRIEF HISTORY OF MEDICAL IMAGING AND AI

THE STORY OF RADIOLOGY

1895 – Roentgen

1928 – Bronchography, iodinated contrast

1936 – First radionuclide treatment

1940's – Angiography

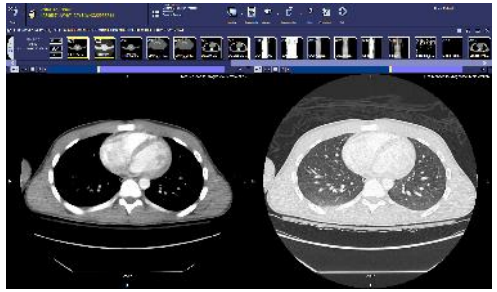
1956 – First clinical ultrasound

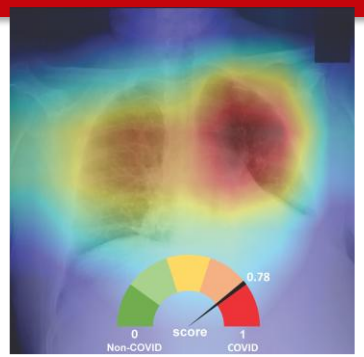
1960's – Television used in radiology

1971 – First Digital Modality: CT

1980's – Dawn of NMR

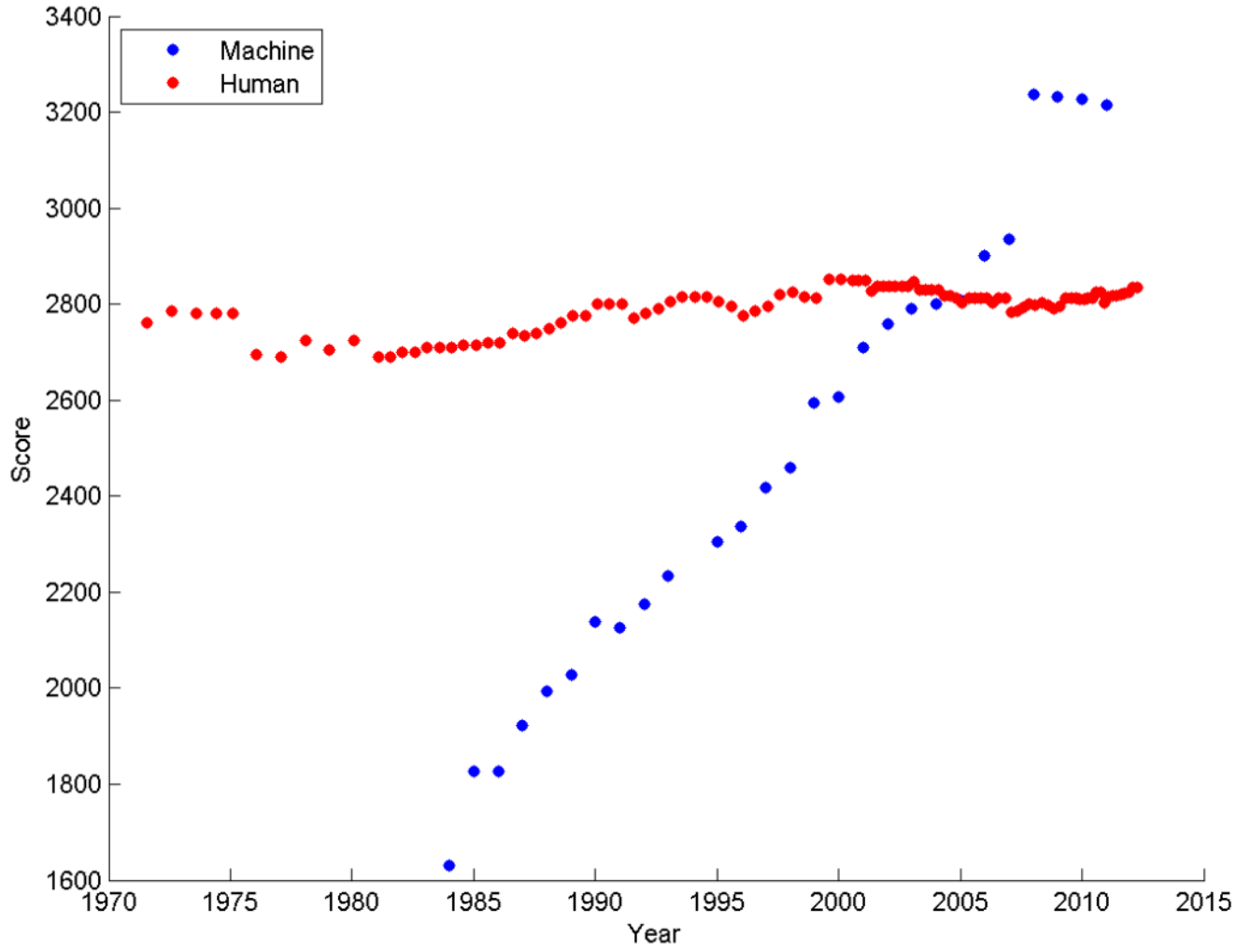
1990's – PACS





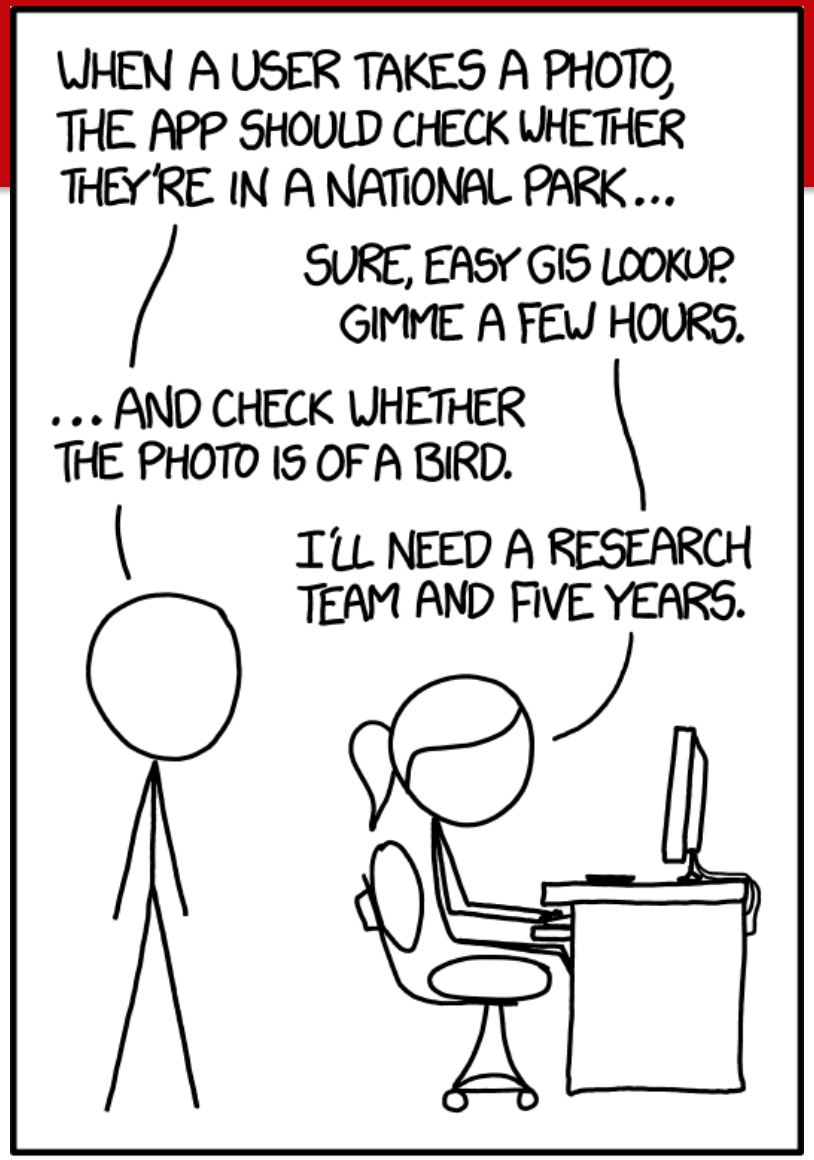
2020's – Rise of AI in medicine

MACHINE VS. HUMAN PERFORMANCE IN CHESS

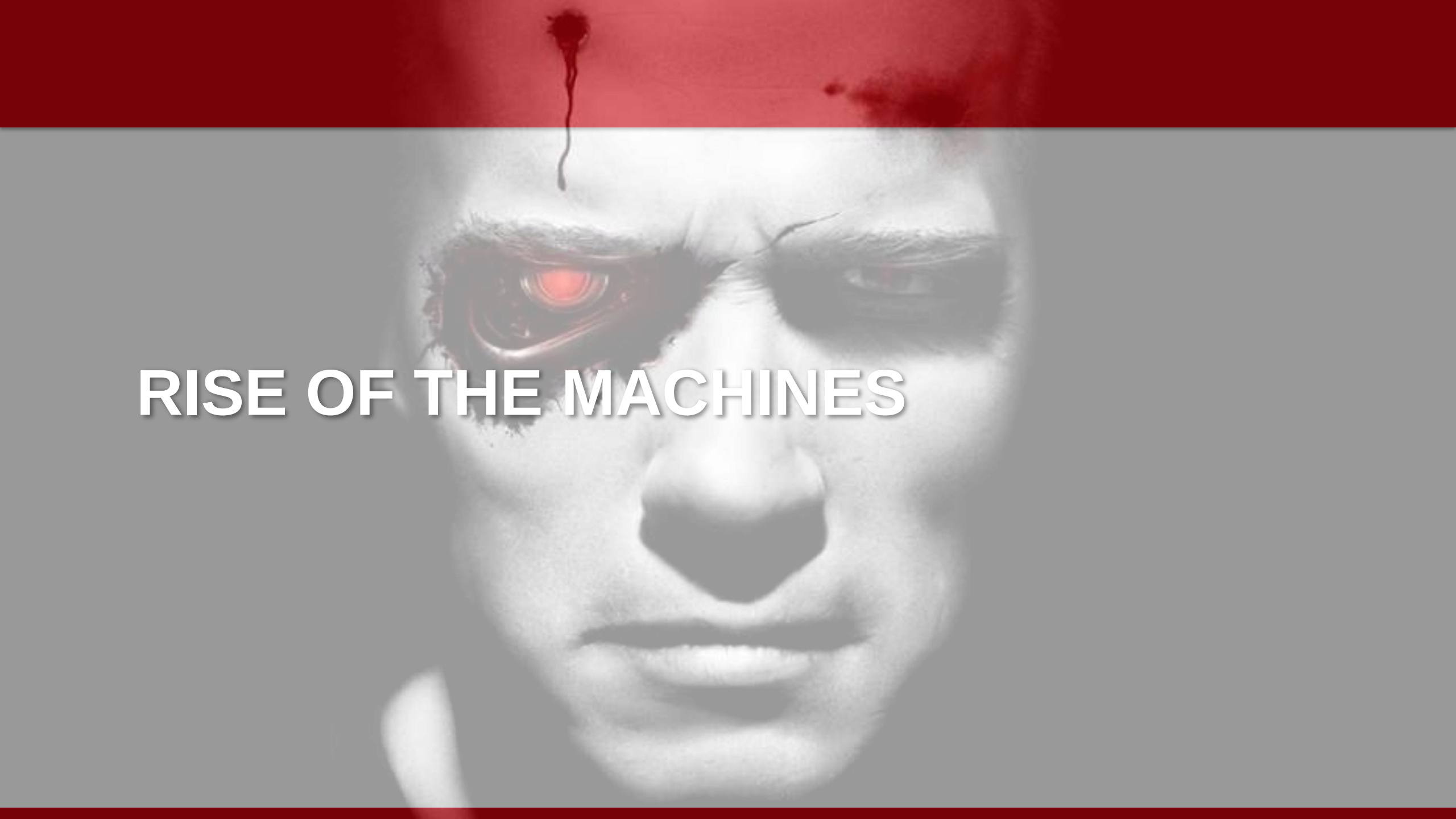


https://srconstantin.wordpress.com/2017/01/28/performance-trends-in-ai/

Challenge of Images



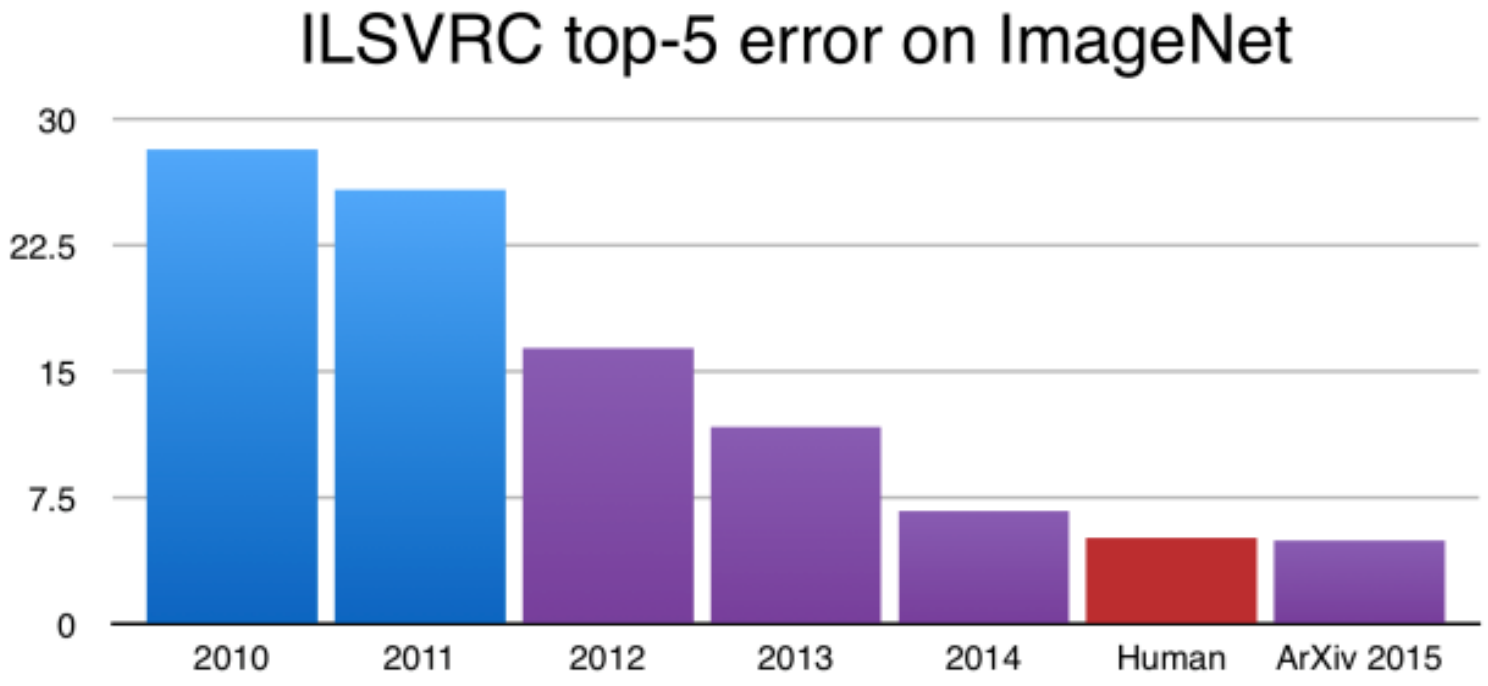
https://xkcd.com/1425/


RISE OF THE MACHINES

MACHINE LEARNING IN IMAGING

ImageNet Performance

- Dramatic performance improvement from adoption of deep vs. shallow learning (neural net layers)



https://medium.com/athelas/a-brief-history-of-cnns-in-image-segmentation-from-r-cnn-to-mask-r-cnn-34ea83205de4

THE FUTURE OF RADIOLOGY?

https://youtu.be/2HMPRXstSvQ

THE FUTURE OF RADIOLOGY?

I think if you work as a radiologist, you are like the coyote that is already over the edge of the cliff but hasn't yet looked down so doesn't realize that there is no ground underneath him. People should stop training radiologists now. It's just completely obvious that within five years deep learning is going to do better than radiologists because it is going to be able to get a lot more experience. It might be ten years, but we've got plenty of radiologists already.

Geoff Hinton - 2016

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THE FUTURE OF RADIOLOGY?

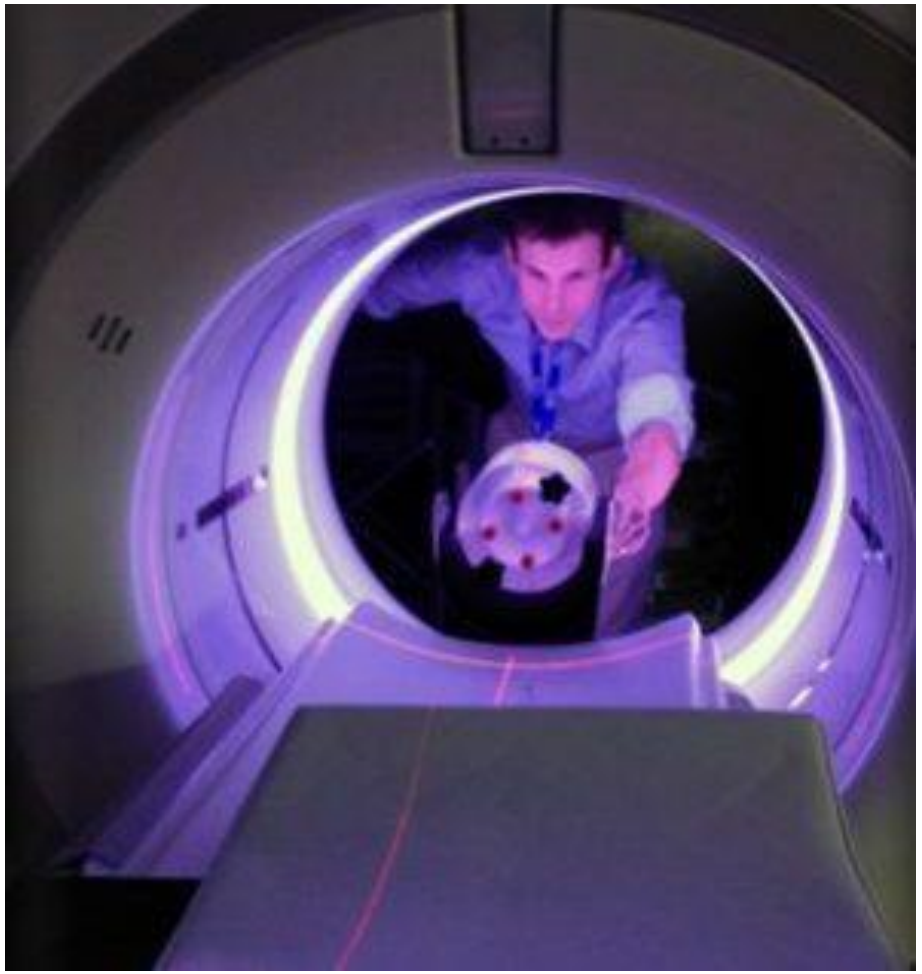
https://longstreet.typepad.com/thesciencebookstore/2014/10/addition-to-the-psych-warfaresurrender-leaflet-colelction.html

EARLY REALITIES OF MEDICAL IMAGING AI

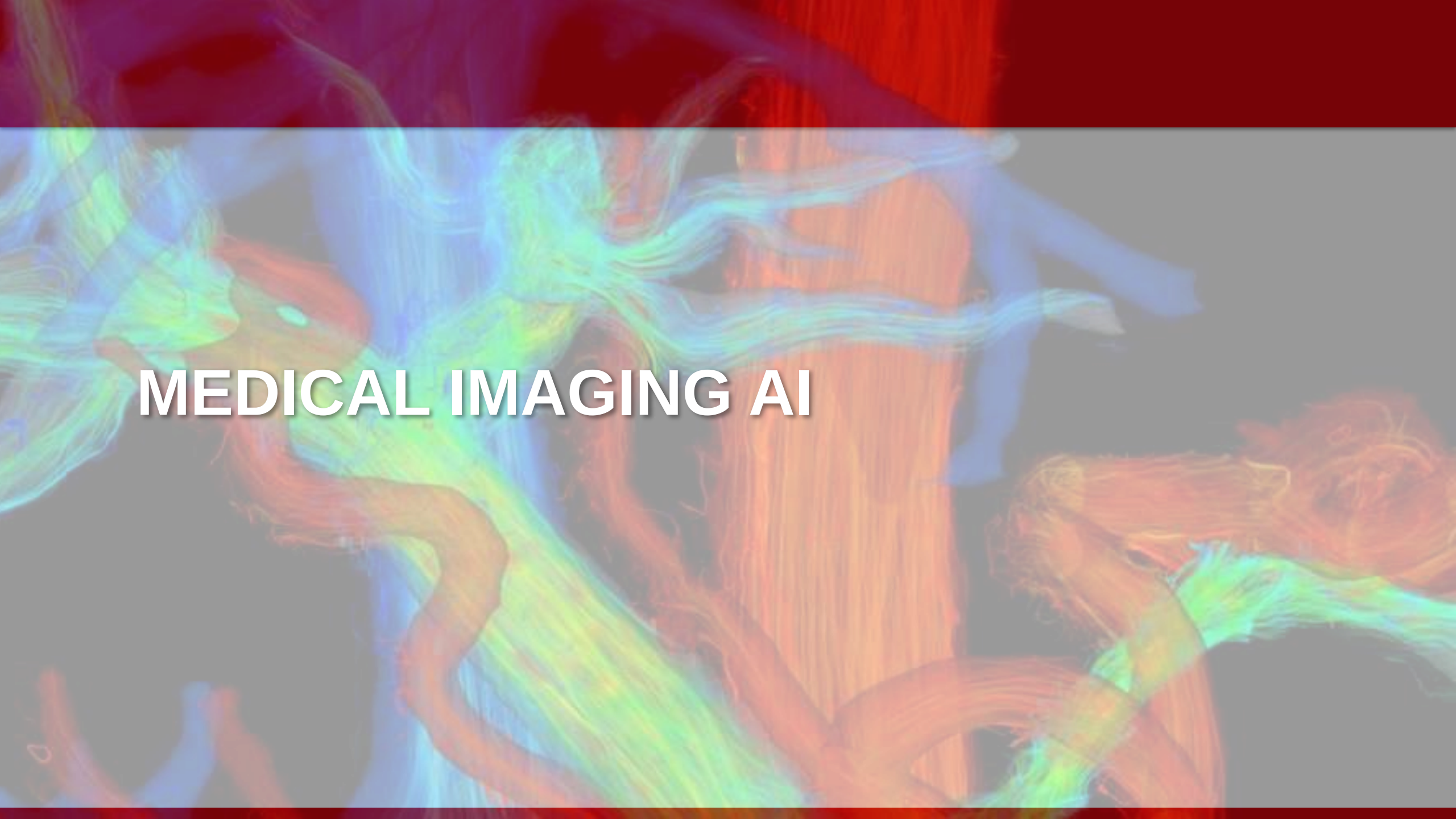
"When we collect data from Stanford Hospital, then we train and test on data from the same hospital, we can publish papers showing [the algorithms] are comparable to human radiologists in spotting certain conditions…

[When] you take that same model, that same AI system, to an older hospital down the street, with an older machine, and the technician uses a slightly different imaging protocol, that data drifts to cause the performance of AI system to degrade significantly.

In contrast, any human radiologist can walk down the street to the older hospital and do just fine…"



Andrew Ng, "Healthcare's AI Future", 4/29/2021
https://hai.stanford.edu/events/healthcares-ai-future-conversation-fei-fei-li-andrew-ng


MEDICAL IMAGING AI

IMPACT OF AI ON HEALTHCARE

AI is going to profoundly change healthcare. It just won't change it in the ways that we think that it will.

Unknown

OPPORTUNITIES FOR AI IN IMAGING

Predict need for imaging

Appropriateness Criteria

Right Exam Right Patient

EMR

Protocoling

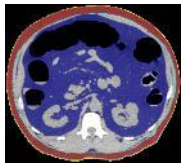
Scheduling

No Show Prediction

Electronic Prior Auth

Image Generation

Modalities



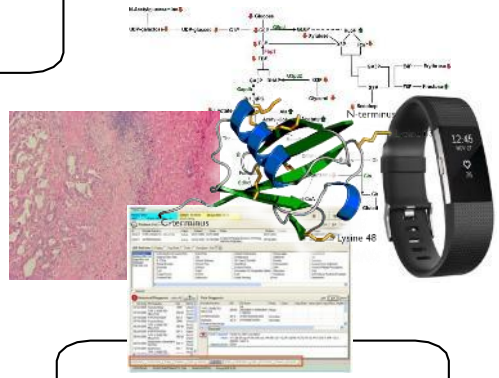
Analysis/ Segmentation

Triage/Dx

Opportunistic Screening

Interpretation Reporting

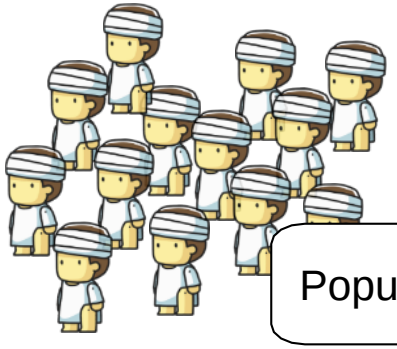
Radiologist Workflow



Data Integration

Care Integration/ Coordination

Follow up



Population Health

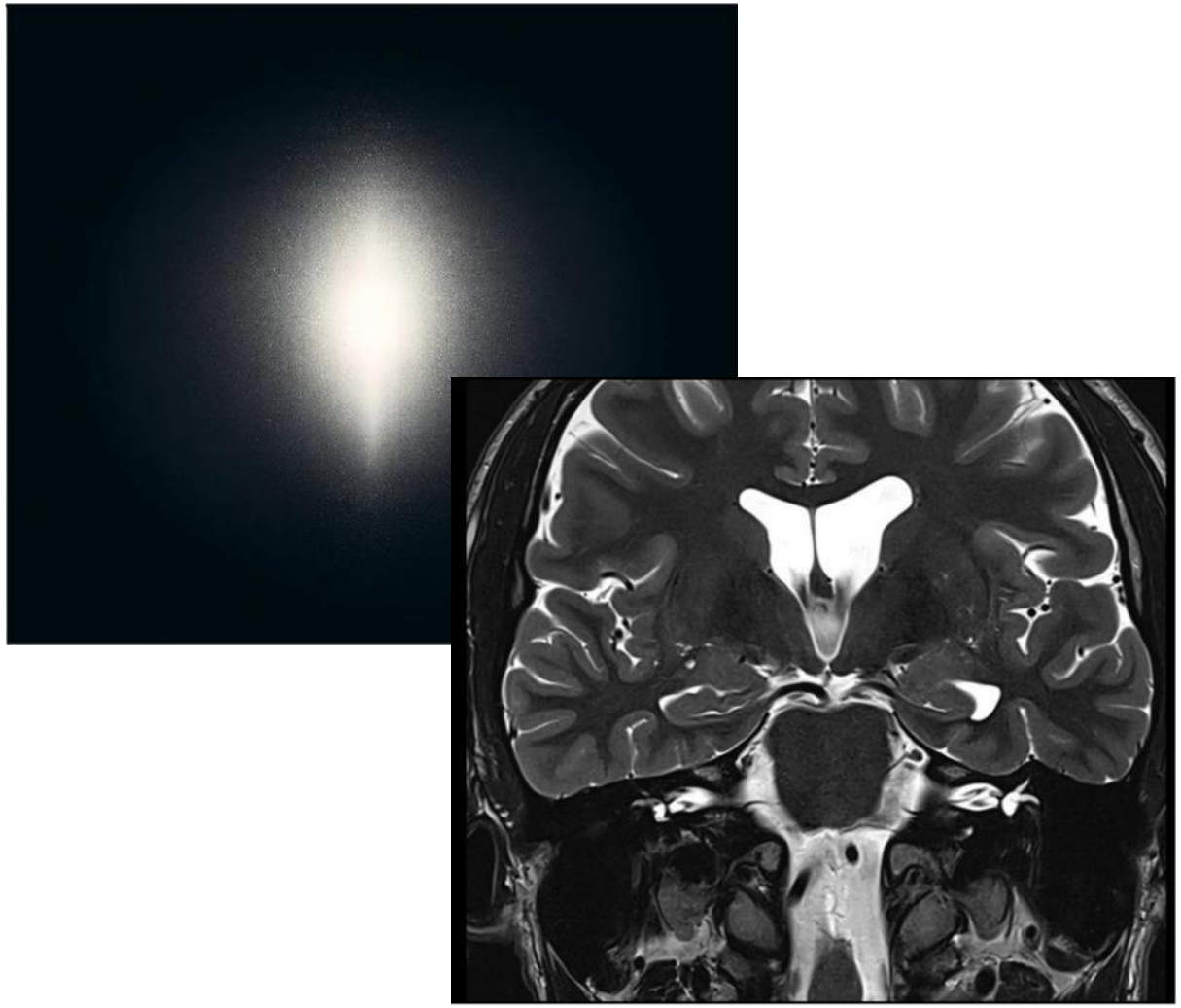
MEDICAL IMAGING AND THE FDA

- >80% of all FDA approved devices that contain AI are in Radiology, why?

- Software intended for ***diagnosis***, prevention, ***monitoring***, treatment, or mitigation of a disease or other medical condition = **Software as a Medical Device (SaMD)**

WHERE HAS AI BEEN SUCCESSFUL?

- Image reconstruction:
  - 40+ years of algorithmic math replaced in 5 years by machine learning based computational methods
  - Better image quality
  - Lower dose (CT)
  - Fewer artifacts
  - Faster acquisition (less motion degradation)



MRI K-space to Image reconstruction example

WHERE HAS AI BEEN SUCCESSFUL?

- Real-time device embedded feedback (ultrasound and radiography):
  - Real-time quality checks during image acquisition
  - Automated image plane prescription
  - Real-time anatomy labeling
  - Automated image capture
  - ***Improved technologist efficiency and exam quality***

Real-time ultrasound technique coaching example

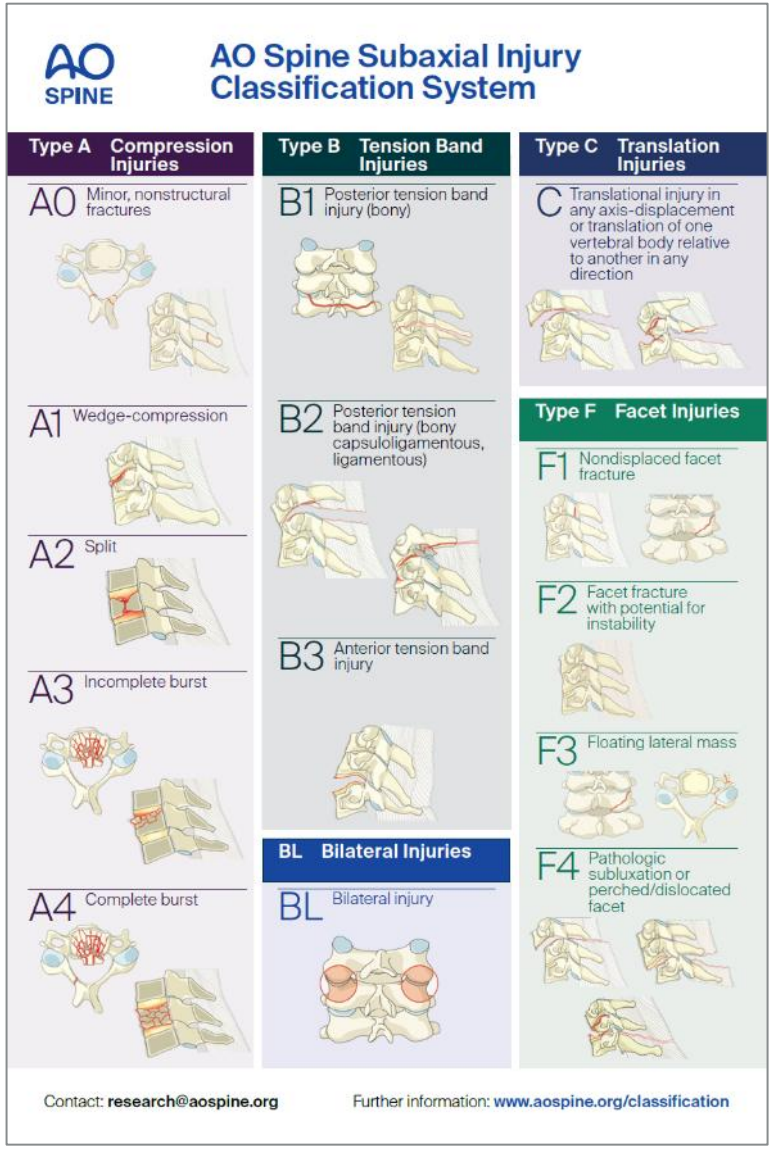
WHERE HAS AI BEEN SUCCESSFUL?

- AI-driven operations optimizations:
  - AI allows markedly faster data driven operational improvements
  - Access improved by >17,000 patient days
  - Allows procedures to be safely enabled at remote locations
  - Allows for expanded self-service scheduling

Data and AI-driven operational optimization

WHERE HAS AI BEEN SUCCESSFUL?

- Workflow embedded information surfacing:
  - Summarization of patient's relevant history
  - Findings tracking
  - Surfacing guidelines and staging references



AI IN MEDICAL IMAGING AT UW HEALTH

GE HealthCare

aidoc

CHANGE HEALTHCARE
Part of Optum®

Epic

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

RAPIDAI

Combinostics

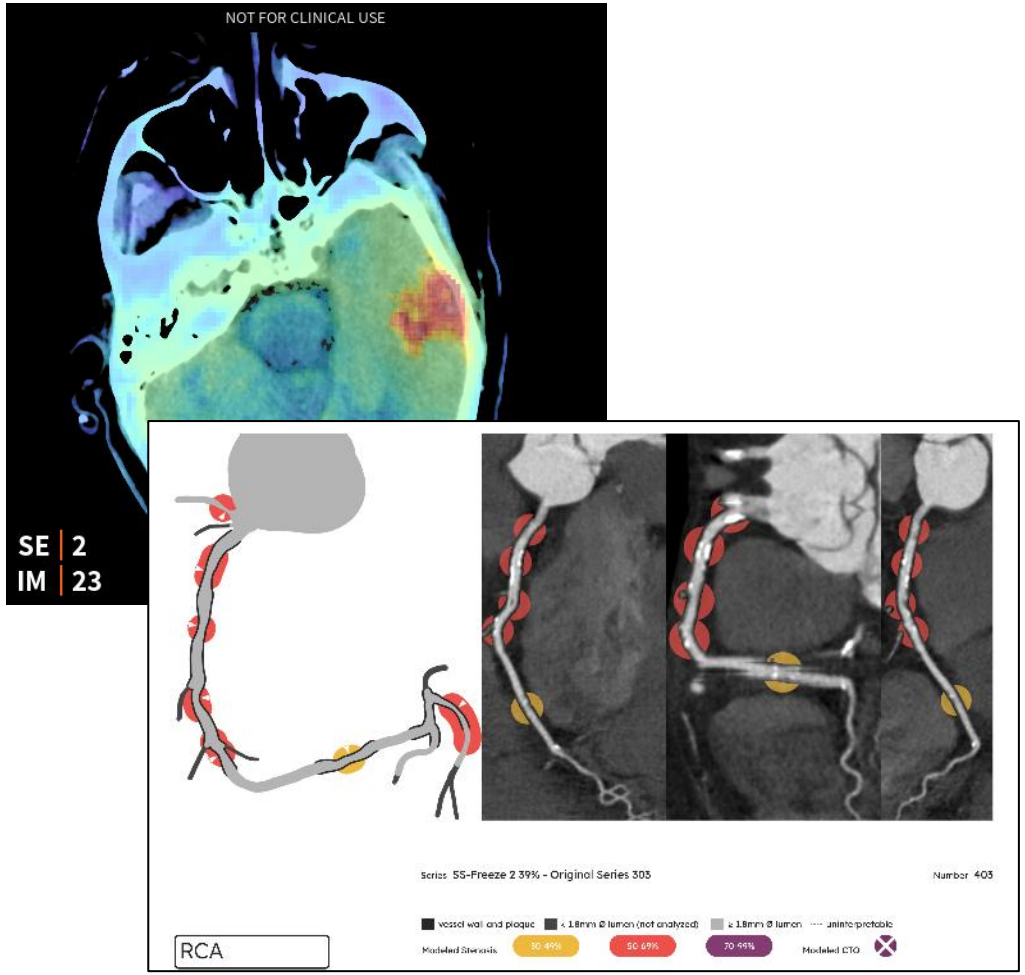
Heartflow

Microsoft + NUANCE

AI IN IMAGING INTERPRETATION

- FDA approved for detecting and alerting radiologists to abnormal cases
  - Triage of urgent cases
  - Second “set of eyes” (cautiously w/ clearance)
- Radiologist + AI better than Radiologist or AI alone (multiple studies)

- Risk: AI without QA



Example AI output from Aidoc and Heartflow

IMAGING TIMELINE: REAL PATIENT AT UW

13:45
Patient Arrives at Radiology (ER CT) (Stroke)

13:53
First images acquired

14:18
Last images acquired

14:34
Aidoc results available

14:56
First prelim complete and findings communicated

15:02
Final report

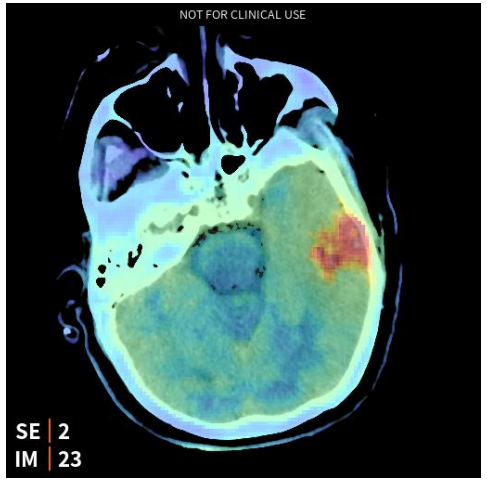
20 minutes

Timely results:

- Aidoc finding available 20 minutes before first prelim complete

Format:

- Heat map of flagged area (Red)
- Series and image number



THE FUTURE OF RADIOLOGY?

Combinostics

Imaging biomarkers

Export .CSV

Summary

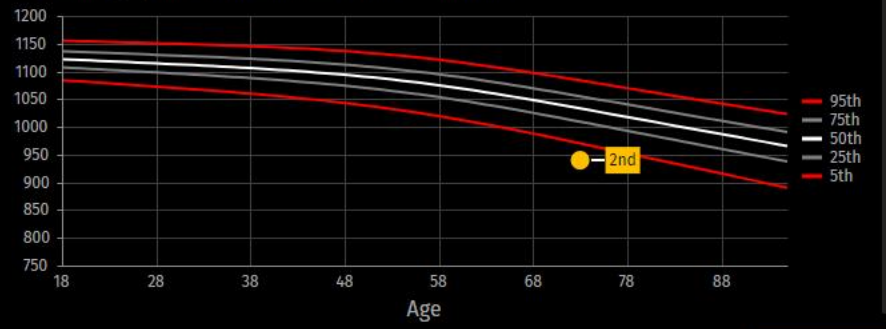
Volume/score	Total	
Cerebral gray and white matter	940 ml	2nd
Cerebral gray matter	564 ml	6th
Cerebral white matter	376 ml	4th
Cerebrospinal fluid	94.2 ml	≥99th
Cerebral cortex	524 ml	7th
Anterior vs. Posterior score	-1.1	27th
Computed callosal angle	76.8 °	≤1st

Volume/score	Right		Left	
Amygdala	0.9 ml	≤1st	0.7 ml	≤1st
Entorhinal area	1.8 ml	≤1st	1.3 ml	≤1st
Hippocampus	2.4 ml	≤1st	1.8 ml	≤1st
Inferior lateral ventricle	2.2 ml	≥99th	3.7 ml	≥99th
Lateral ventricle	31.9 ml	94th	49.6 ml	≥99th
Thalamus	7.2 ml	30th	7.0 ml	21st
Hippocampal atrophy score	5.9	≥99th	9.5	≥99th

Cortical atrophy score	Total		Right		Left	
Cerebral cortex	2.5	98th	2.4	98th	2.6	98th
Frontal lobe	1.9	97th	1.7	95th	2.1	98th

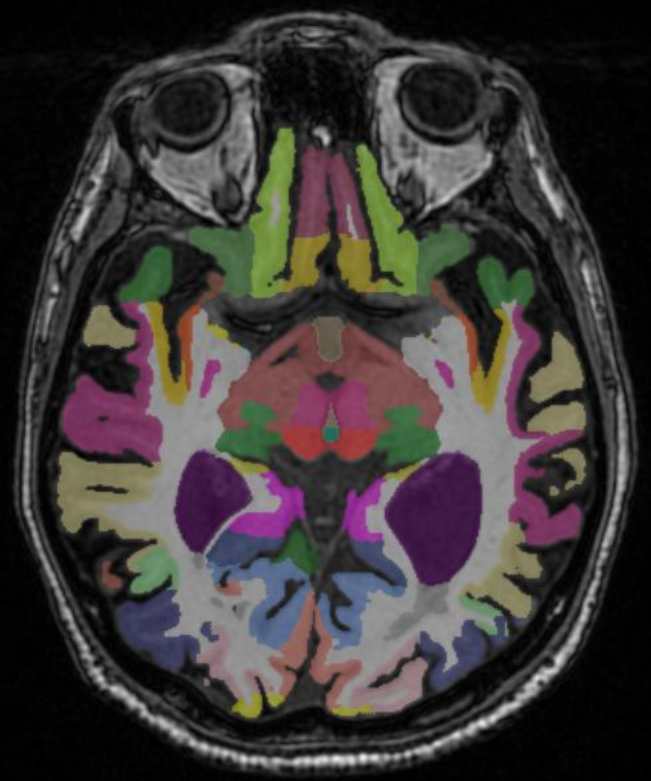
Percentiles

Cerebral gray and white matter volume (total) [ml]

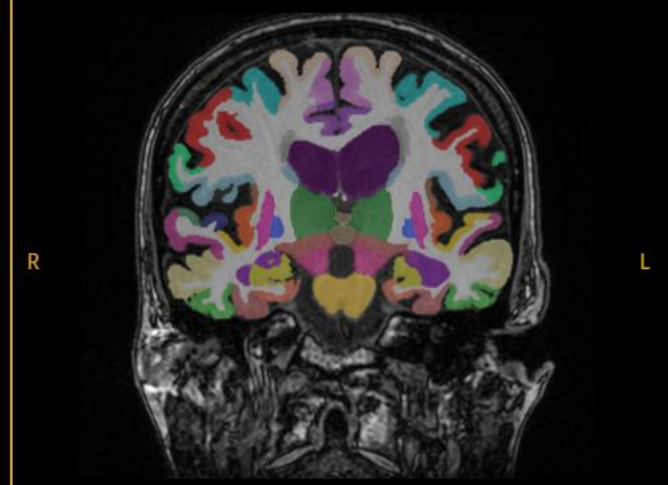


T1 FLAIR Whole brain segmentation Axial 1|2

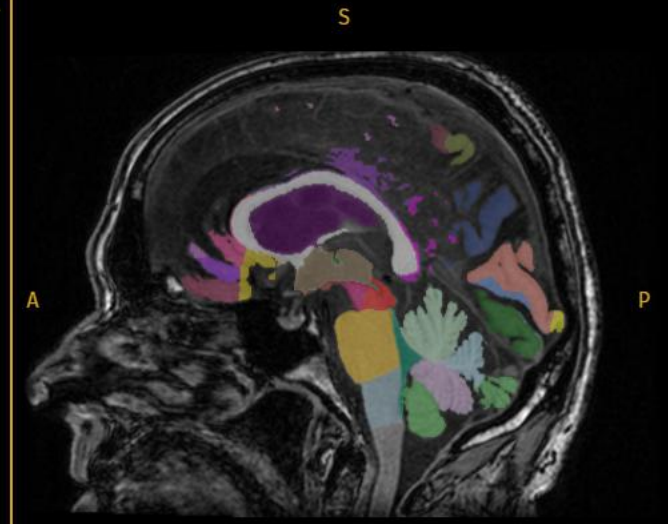
, M, 19500701 A Anonymized
Pre Ax T1 Stealth, 20240511 GE MEDICAL SYSTEMS, DISCOVERY MR750



Intensity: 33
Slice: 151/300 P WW/WC: 7003/3501

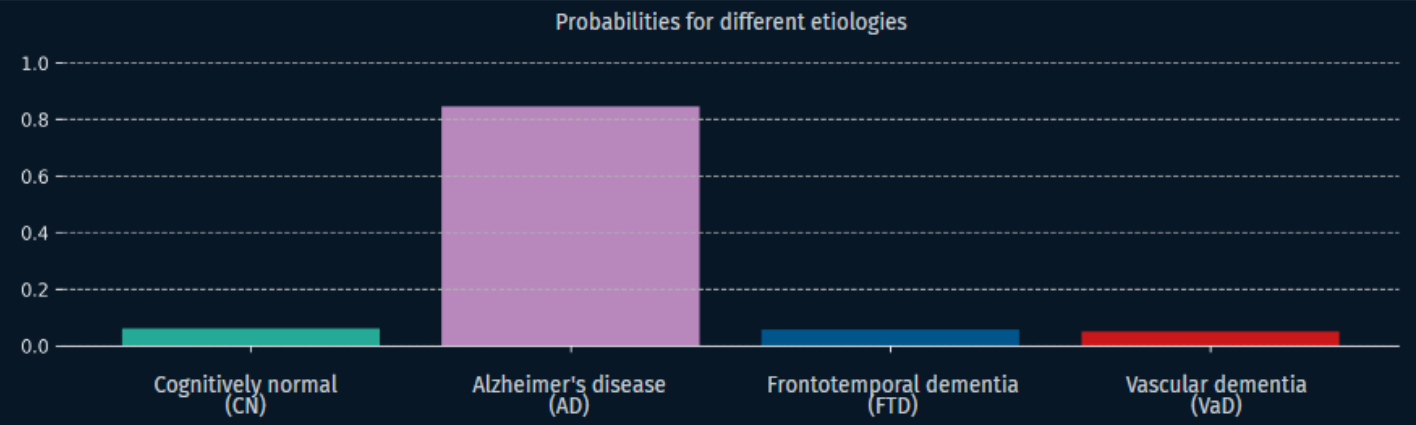


Slice: 257/512 I WW/WC: 7003/3501



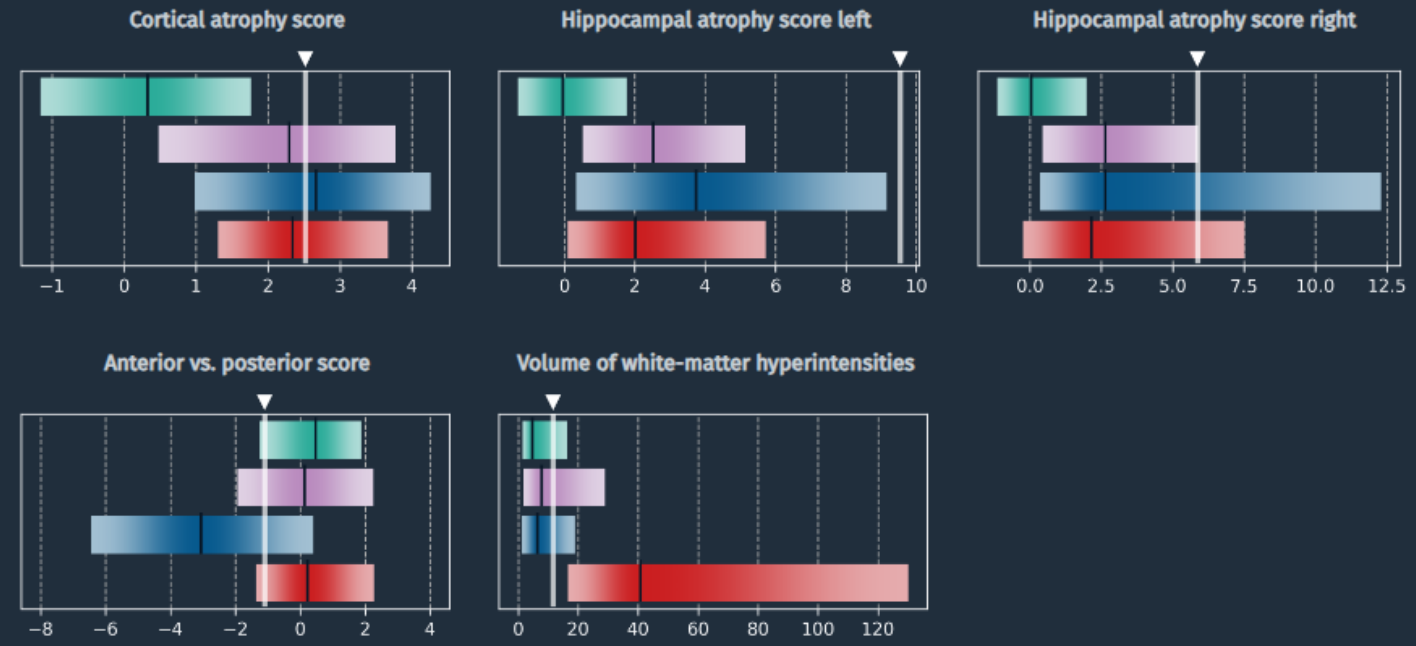
Slice: 257/512 I WW/WC: 7003/3501

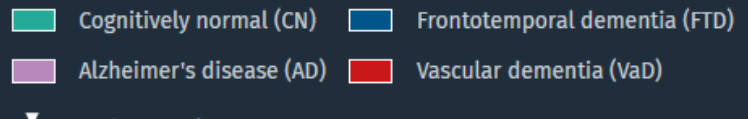
Summary

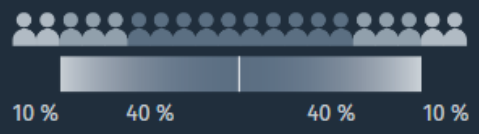


Comparison to diagnostic groups

Cortical atrophy score	Hippocampal atrophy score left	Hippocampal atrophy score right	Anterior vs. posterior score	Volume of white-matter hyperintensities
2.52 (96th)	9.54 (≥99th)	5.86 (≥99th)	-1.10 (12th)	11.72 (82nd)

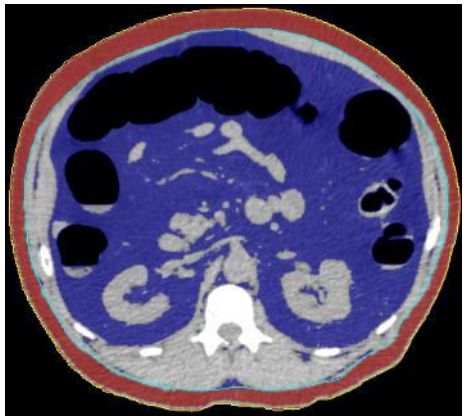




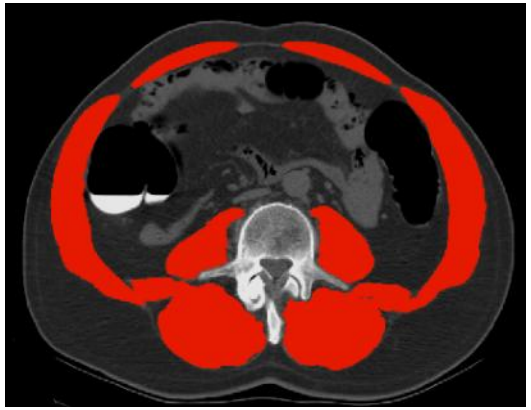


Opportunistic Screening AI – Population Health Impact

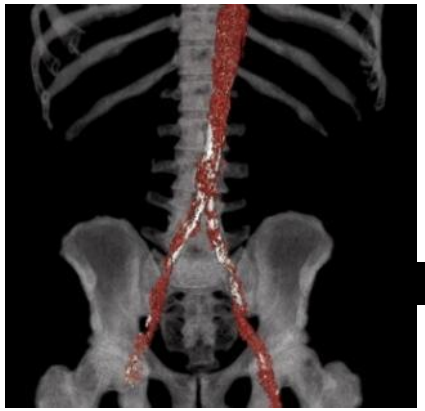
- **Opportunistic CT Biomarkers**
  - **A single automated CT parameter from each of the five abdominal components for predicting future events**



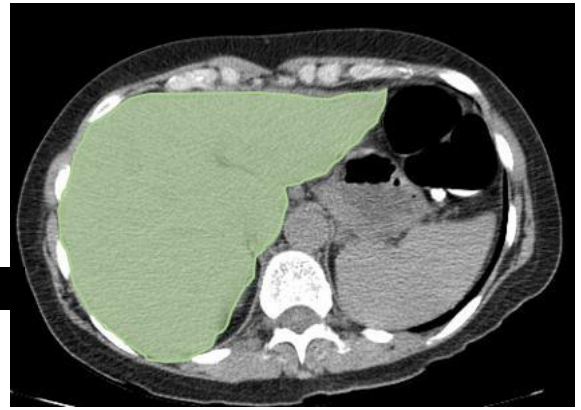
V/S Fat Ratio at L1 level



Mean Muscle HU at L3 level



Agatston Ca++ score for L1-L4



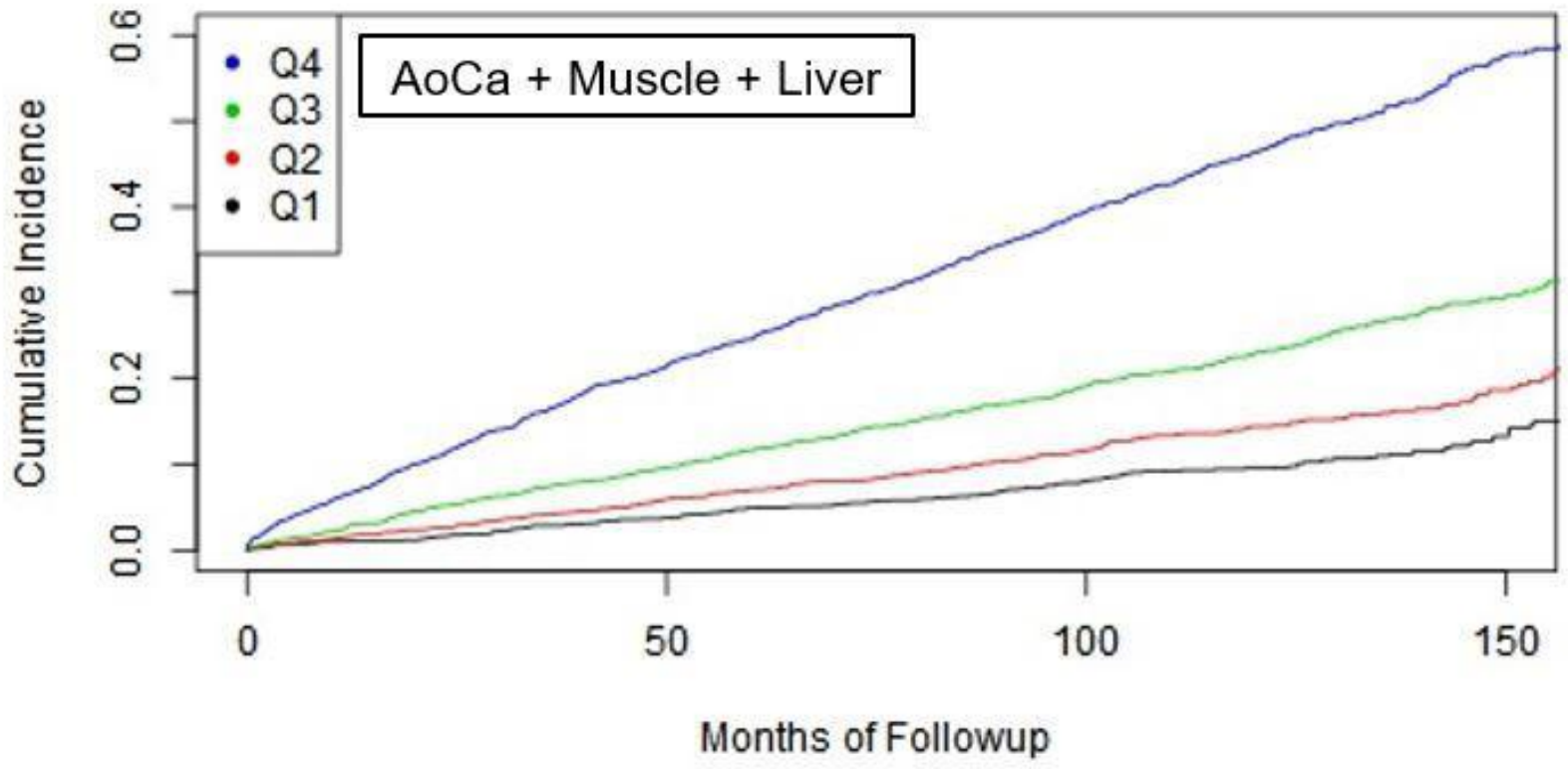
Mean Volumetric Liver HU

Trabecular HU at L1 level

Opportunistic Screening AI – Population Health Impact

- Time-to-Event Plots for Predicting Cardiovascular Events:

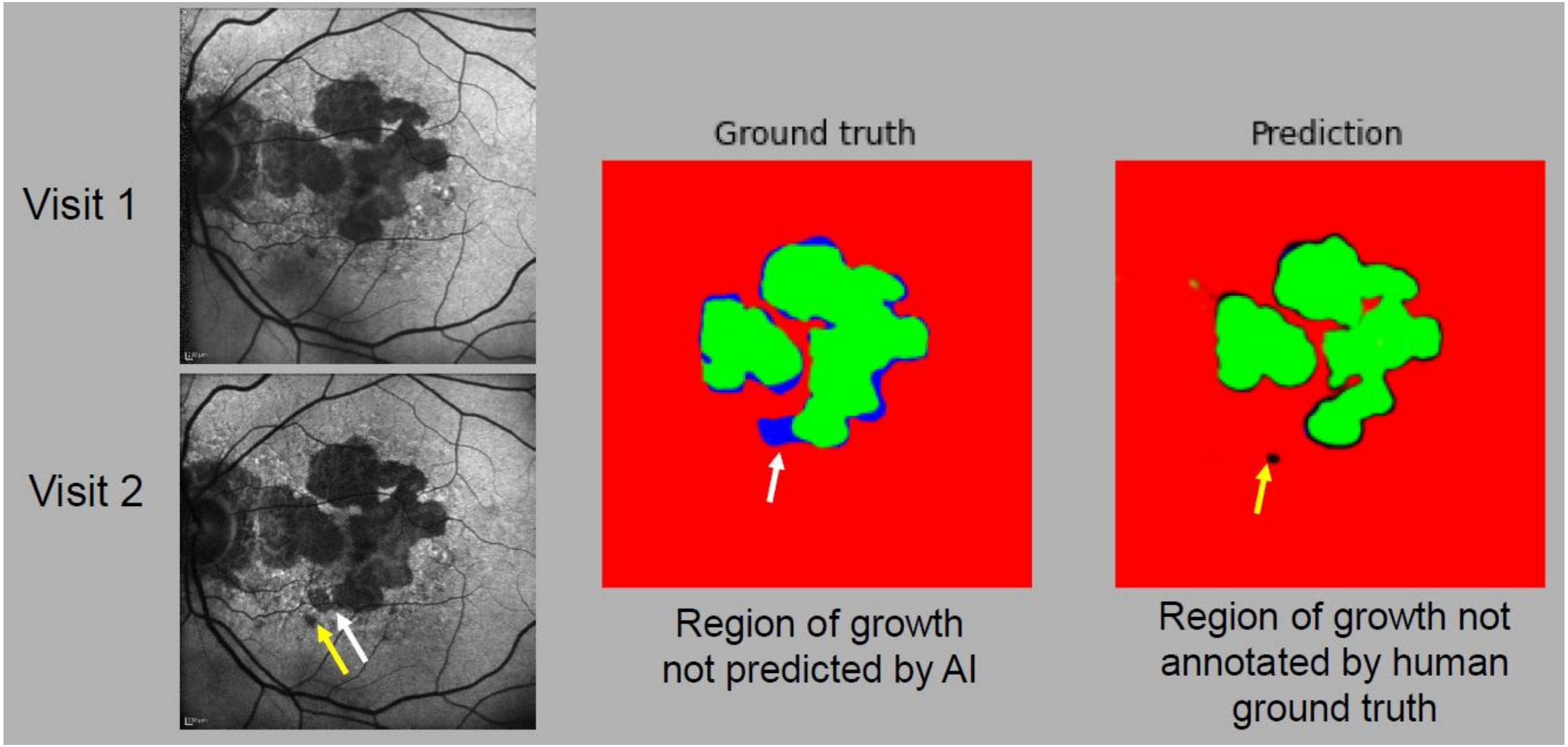
Multivariate Cox Proportional Hazards Model



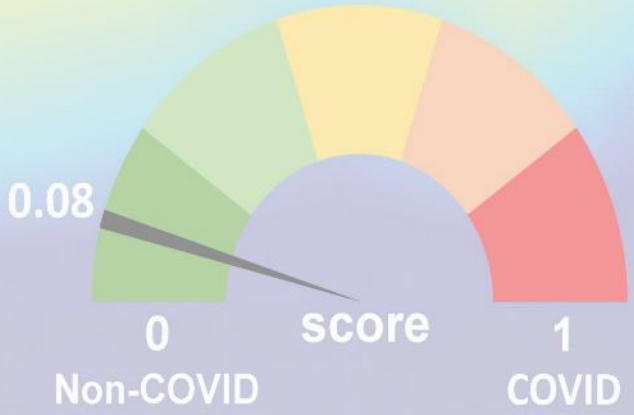
OPHTHALMOLOGY AI AT UW HEALTH

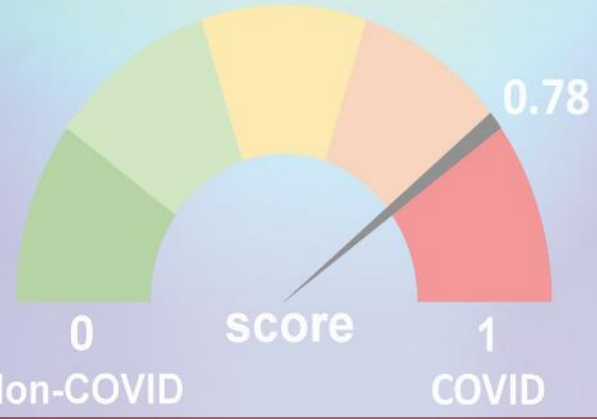
Department of Ophthalmology and Visual Sciences
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

Prediction of Geographic Atrophy Enlargement using Various Deep Learning Approaches



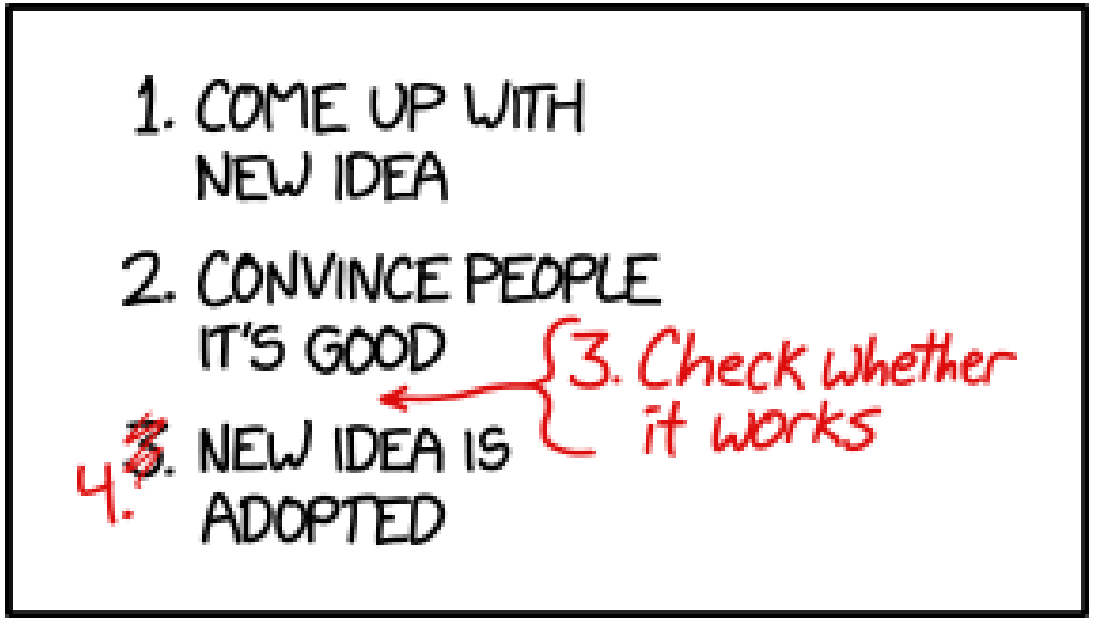
FORCASTING THE FUTURE





Generative AI Use Case – “10X”

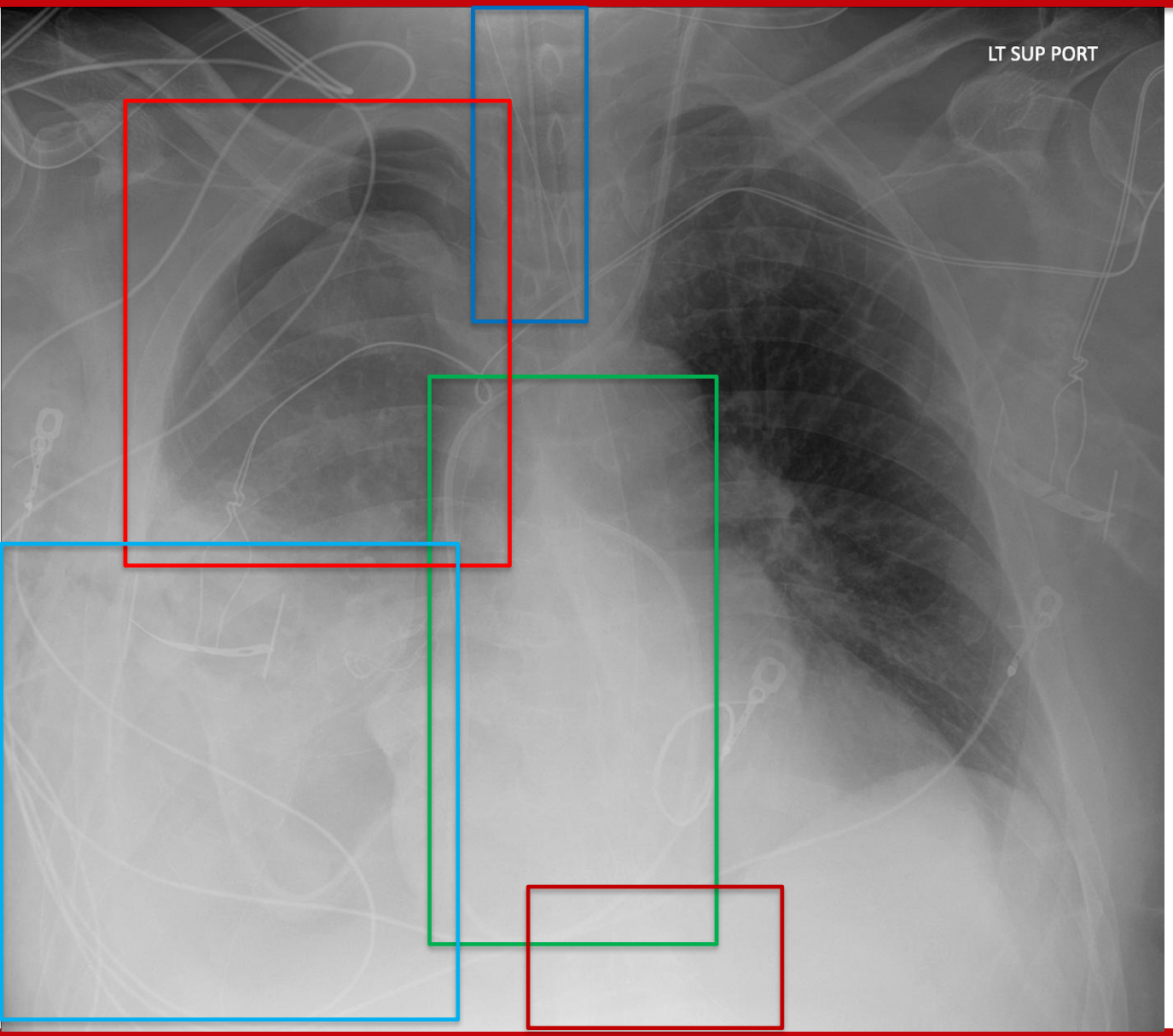
- Chest X-rays
  - Most common radiology procedure
  - ~238/1000 population per year
- Not enough radiologists
- Can generative AI allow for a 10X increase in volume?



THE INVENTION OF CLINICAL TRIALS

https://xkcd.com/2530/

Generative AI Use Case – “10X”



FINDINGS:

Endotracheal tube in expected position. The left internal jugular approach pulmonary artery catheter has been advanced with tip at the level of the right main pulmonary artery. Enteric tube has been repositioned and now courses below the diaphragm and terminates below the field-of-view of this study.

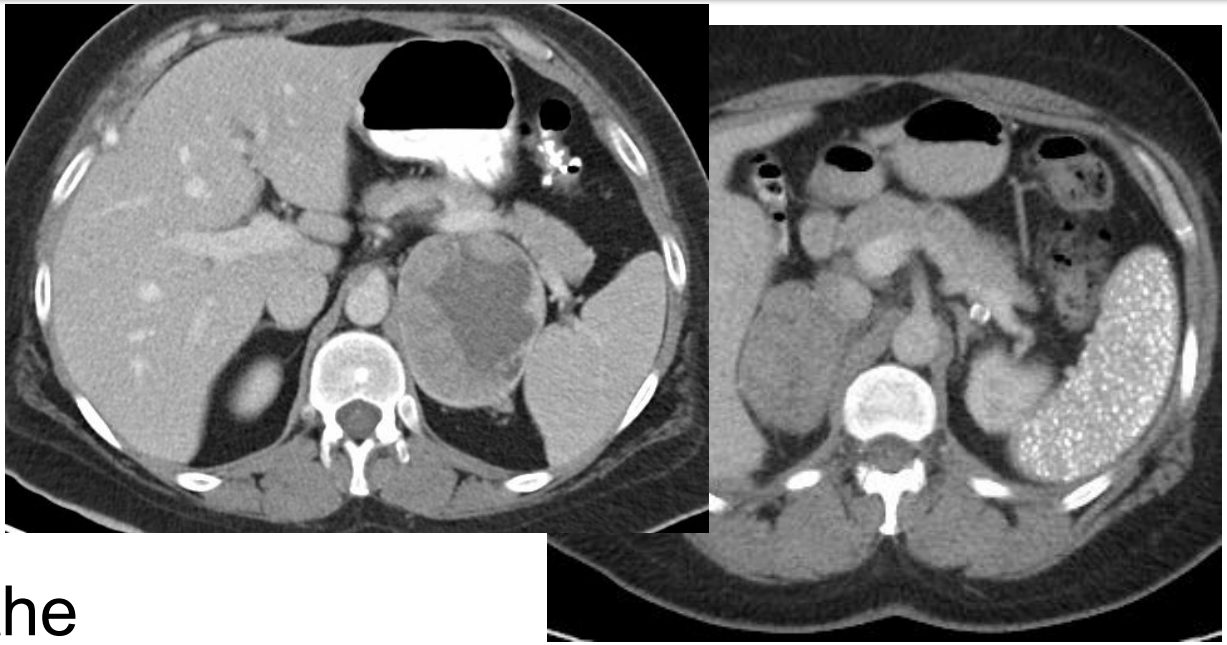
Interval development of moderate size right pneumothorax. Chest tube terminates near the right lung base. There is subcutaneous emphysema along the right lateral chest wall at the chest tube insertion site.

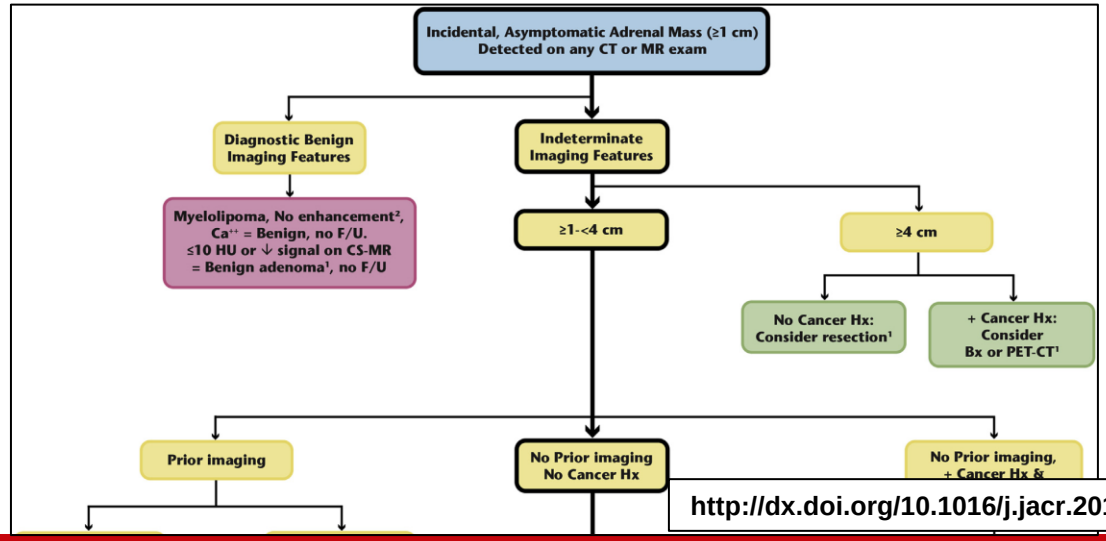
Generative AI Use Case – Conversing with an Image

- PROMPTS:

  “Show me 20 cases with similar imaging features and show the distribution of pathologies”

  “Based on my findings, suggest the most appropriate classification system, provide the staging for this case, and provide the clinical management recommendations”

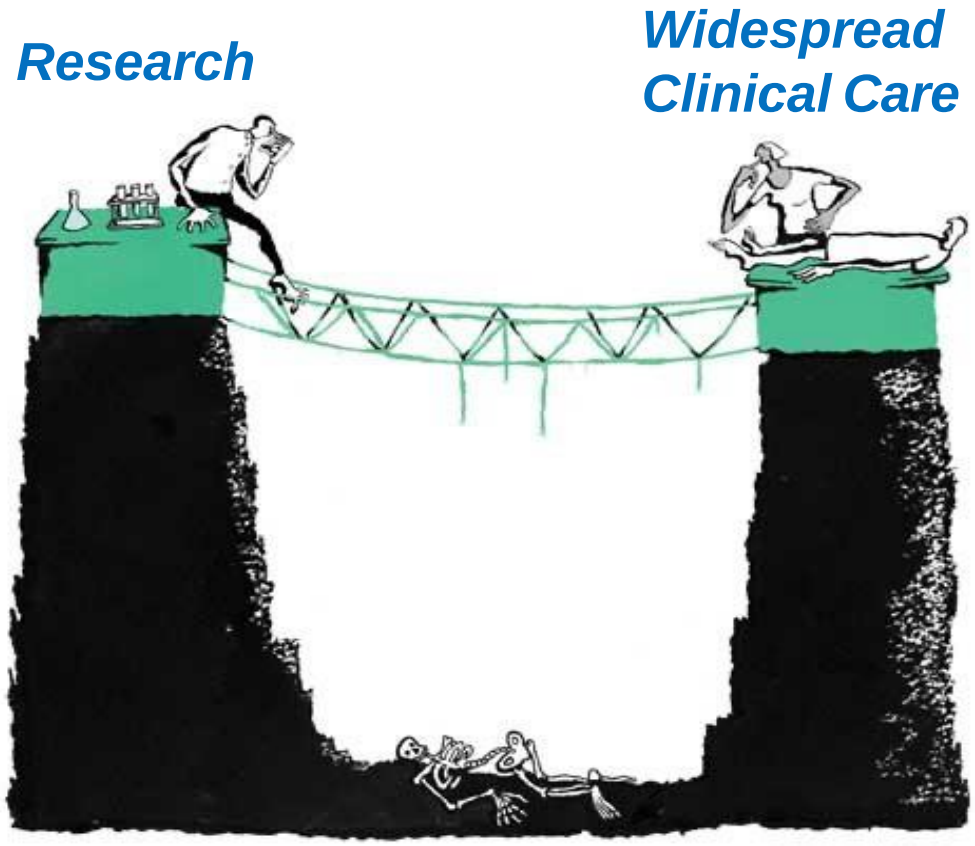




http://dx.doi.org/10.1016/j.jacr.2017.05.001

A WORD OF CAUTION

- How do we translate discovery into practice?
  - Clinical and workflow integration is often harder than the AI itself
- How do we impact the world around us?



INTEGRATION IS HARD

ELON MUSK : DESIGN IS OVERRATED MANUFACTURING IS UNDERRATED

https://youtu.be/2dBKA-S9L4A

CONCLUSION

- AI offers incredible potential to improving clinical care
- There has never been a better time for clinical innovation
- There is tremendous work yet to be done


Thank You!