

Advances in Imaging Technologies and Artificial Intelligence for Early Detection of Breast Cancer

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Disclosures

- Funding from NIH
 - R01 CA145601, R21 CA216495, R01 CA207490
- Research funding from
 - Hologic, Inc., GE Healthcare, Koios Medical
- Consultant
 - iCAD, Inc.

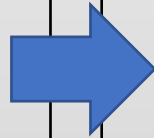
Overview

- What is deep learning?
- Examples of current state-of-the-art
- The future of breast imaging with deep learning

Definitions

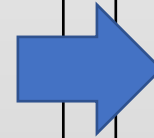
Artificial Intelligence (AI)

- Branch of computer science creating systems to perform tasks that require human intelligence



Machine learning (ML)

- Computer algorithms that can perform specific tasks without using explicit instructions



Deep learning (DL)

- Branch of ML that uses artificial neural networks

Artificial Neural Networks

- Deep learning typically use convolutional neural network (CNN)
- Learn a task by training
 - Humans 1000's of images
 - CNN 100,000's of images
- CNN learns more slowly than a human, but remembers every image that it sees

CNN First Used to Analyze Mammograms in 1994

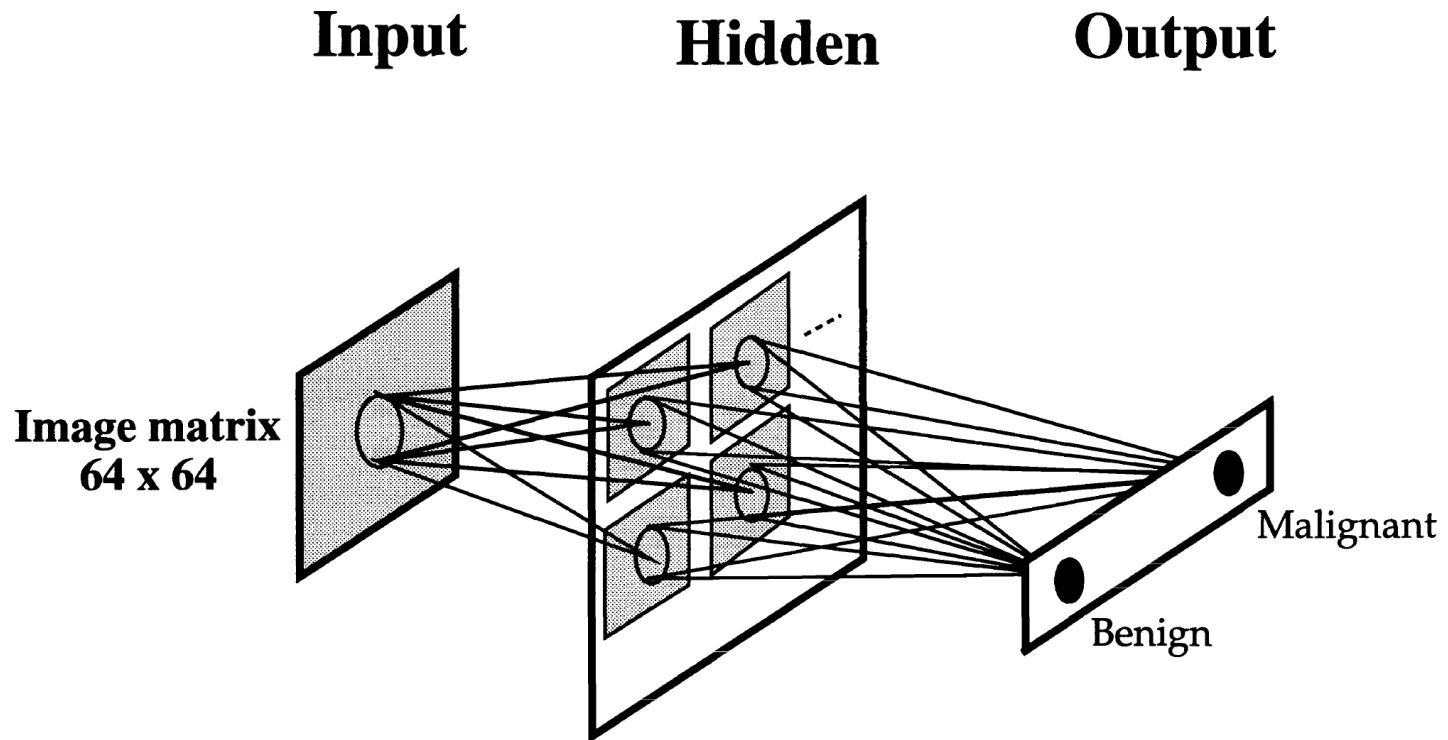


Figure 3. Structure of a convolution neural network.

What has Changed Since 1994

- Computers are more powerful
- Large databases of digital mammograms

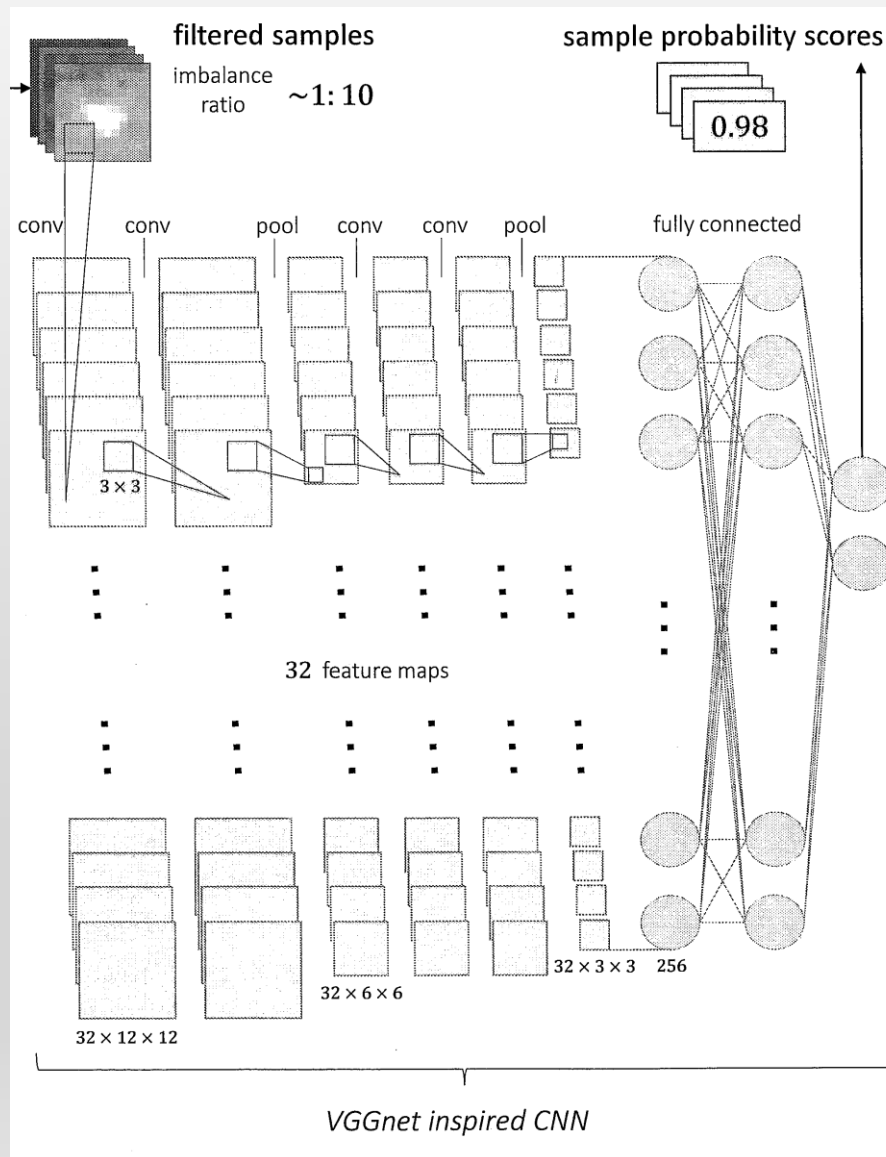


Circa 1997

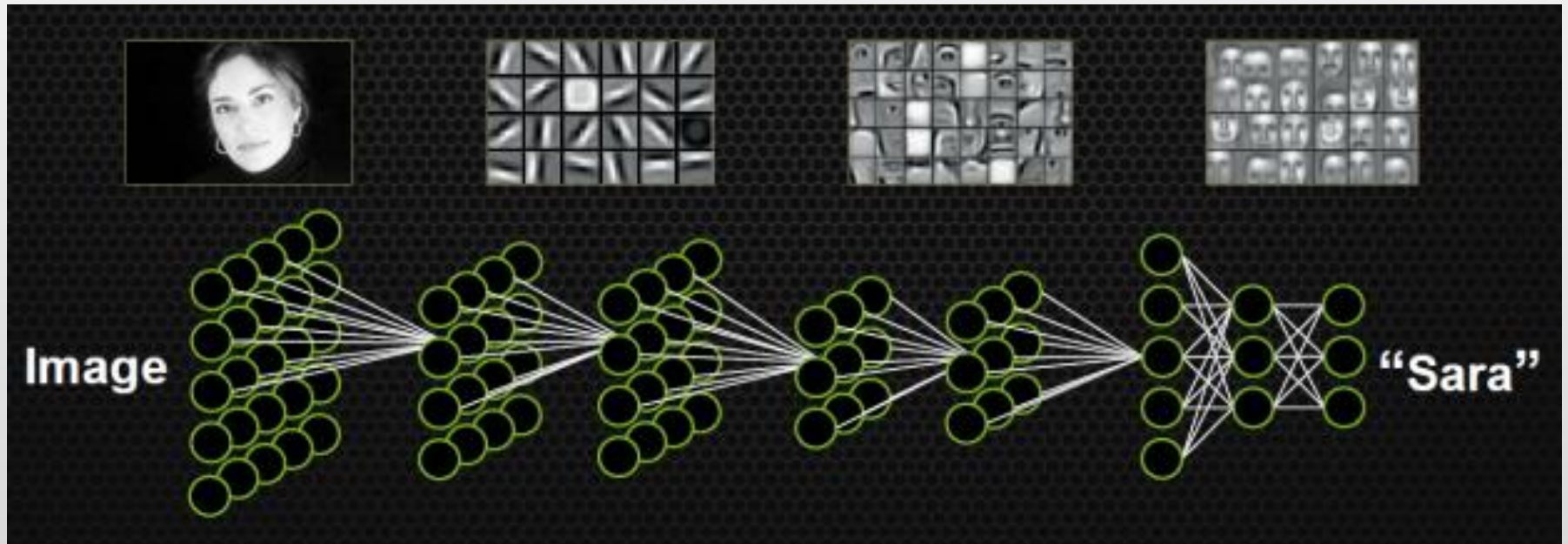
Deep CNN

More difficult tasks →
more complex network

More complex network
→ more training data



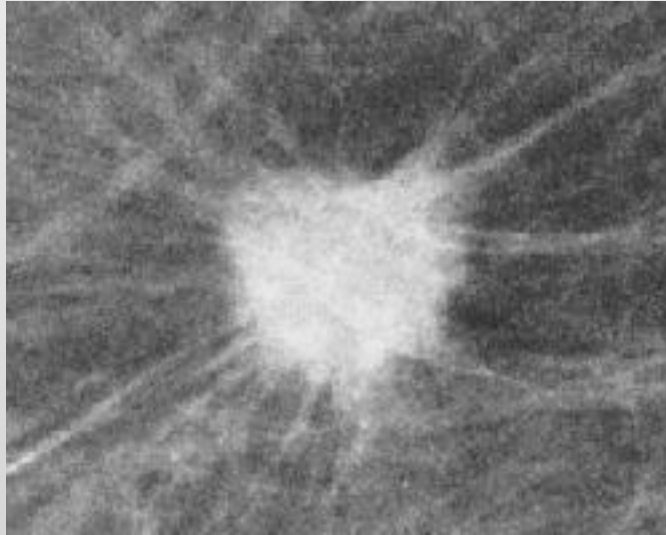
A Deep CNN



Taken from NVIDIA dev blog

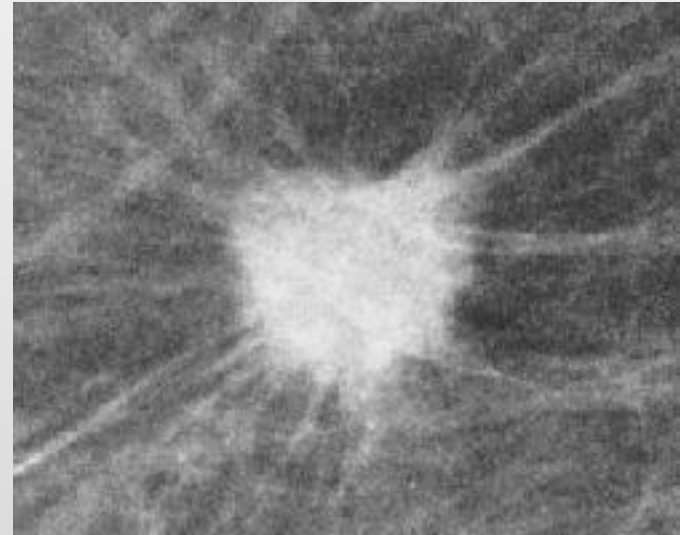
Why is Deep Learning a Significant Advance

Is this mass malignant or benign?



Traditional Approach

1. Ask radiologists how they do it
2. Create mathematical formulae to quantify the features
3. Do this for many features and use a statistical classifier to give the likelihood that the mass is malignant



Deep Learning Approach

- Take 1000's to 100,000's lesions and input the image of the mass with truth to a deep convolution neural network (DCNN)
- The DCNN learns what is important to distinguish benign from malignant masses
 - With enough cases, finds the best set of features

Advantages of Deep Learning

- Don't need to do any special programming
- Can find optimal feature set
- Can be very accurate
- Scales well with the number of images
- Once you have the images, there is a short time to develop technique

Disadvantages of Deep Learning

- Requires large amounts of computer power and computer memory
- Don't know what the features that are selected
- Needs a lot of cases; at least an order of magnitude more

What are the Immediate Implications? (What Can DL Do Now)

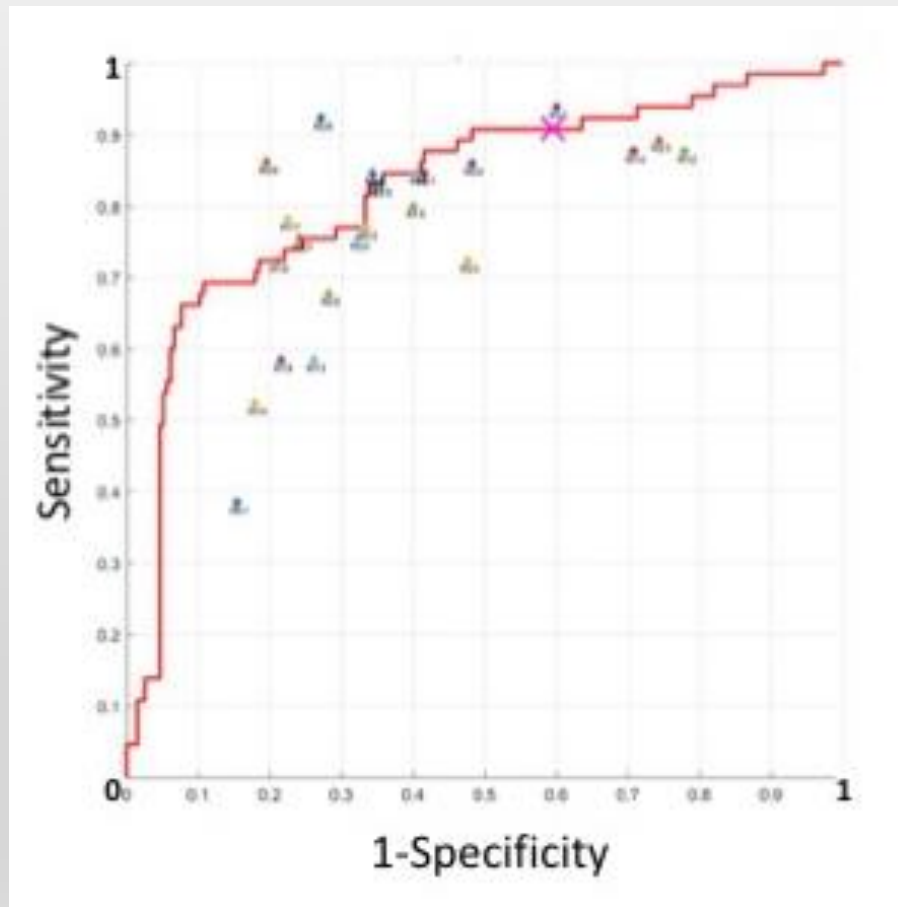
1. State-of-the-art in lesion detection
2. Breast cancer risk estimation

How Good are Deep Learning Algorithms?

1. State-of-the-art in lesion detection
2. Breast cancer risk estimation

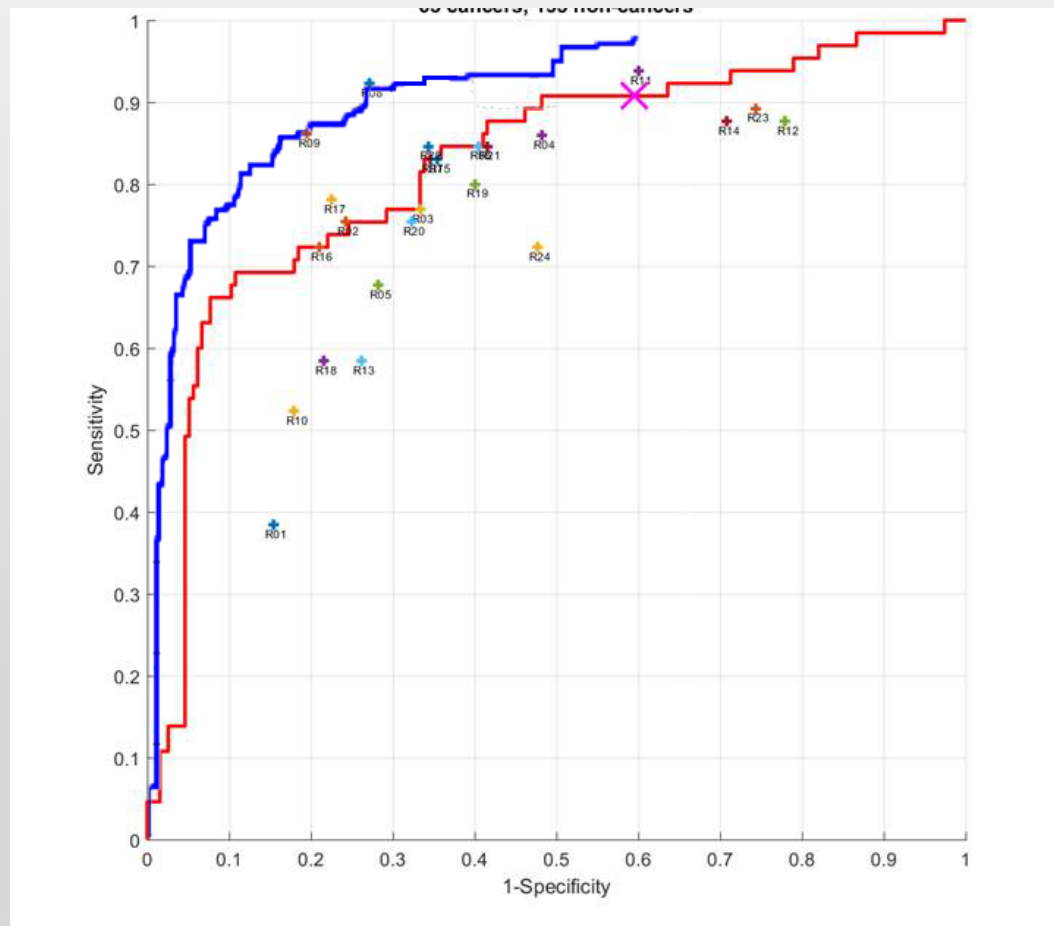
Deep Learning vs Radiologists

- iCAD system for Hologic tomosynthesis images



Courtesy
S. Periaswamy,
iCAD, inc.

Deep Learning vs Radiologists



What are the Immediate Implications? (What Can AI Do Now)

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2. Breast cancer risk estimation

Breast Cancer Risk Prediction

ORIGINAL RESEARCH • BREAST IMAGING

Radiology

A Deep Learning Mammography-based Model for Improved Breast Cancer Risk Prediction

Adam Yala, MEng • Constance Lehman, MD, PhD • Tal Schuster, MS • Tally Portnoi, BS • Regina Barzilay, PhD

5-year risk model

Deep-Learning 0.70

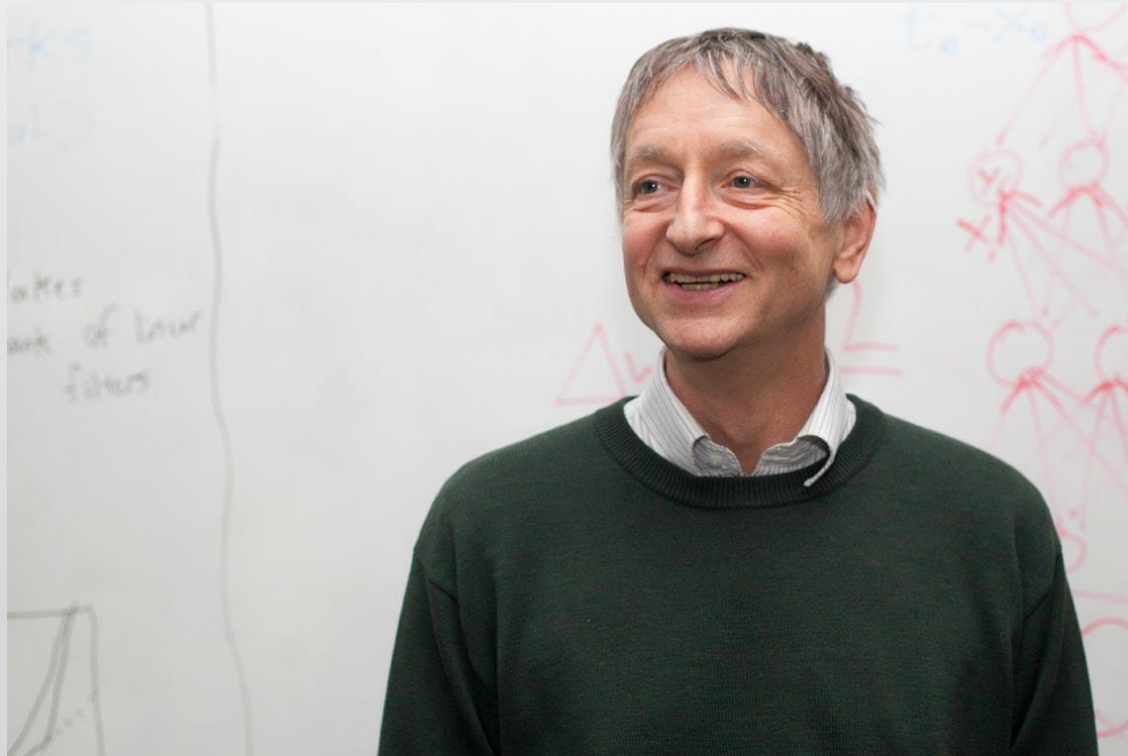
Tyrer-Cuzick 0.62

$p < 0.001$

Deep Learning

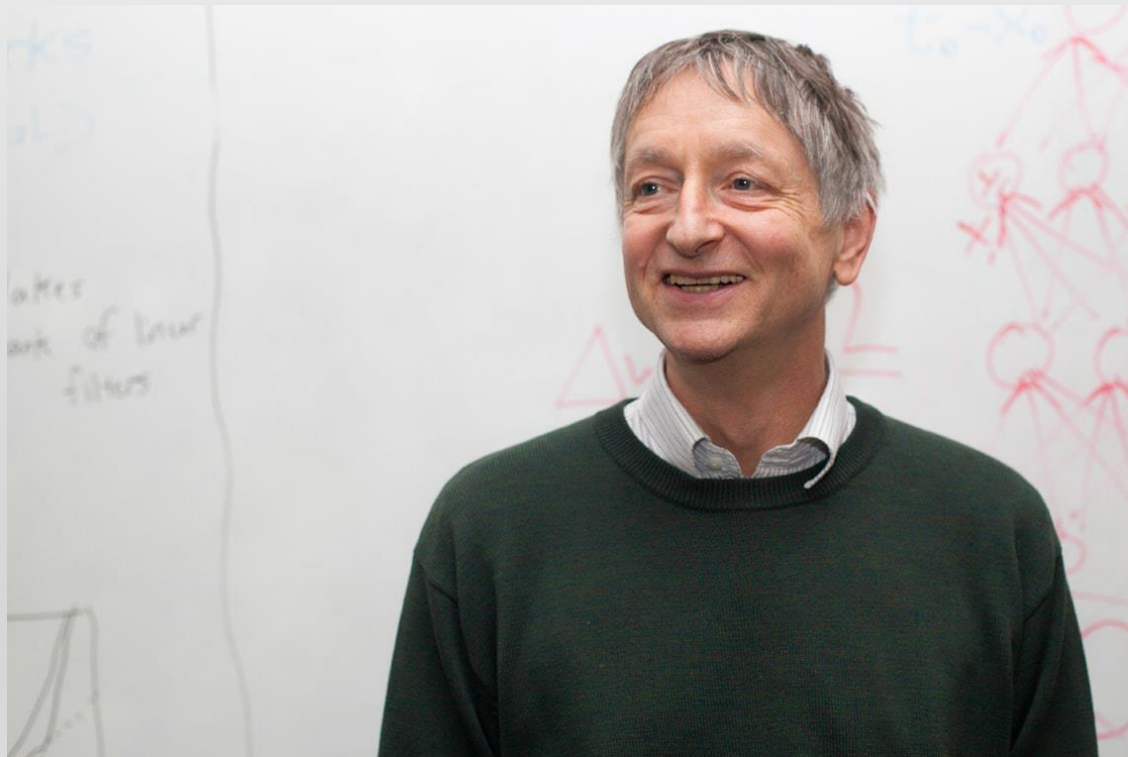
- Deep learning is competitive with expert radiologists in image interpretation

Geoff Hinton (inventor of deep learning)



Geoff Hinton, 2016 (inventor of deep learning)

“Stop training radiologists now”





The NEW ENGLAND
JOURNAL of MEDICINE

Sept. 29, 2016

Predicting the Future — Big Data, Machine Learning, and Clinical Medicine

Ziad Obermeyer, M.D., and Ezekiel J. Emanuel, M.D., Ph.D.

Machine learning will displace much of the work of radiologists.

**Emanuel suggested that computers may replace
radiologists in the next 4-5 years (ACR 2016 keynote)**

What the Radiology Experts Say

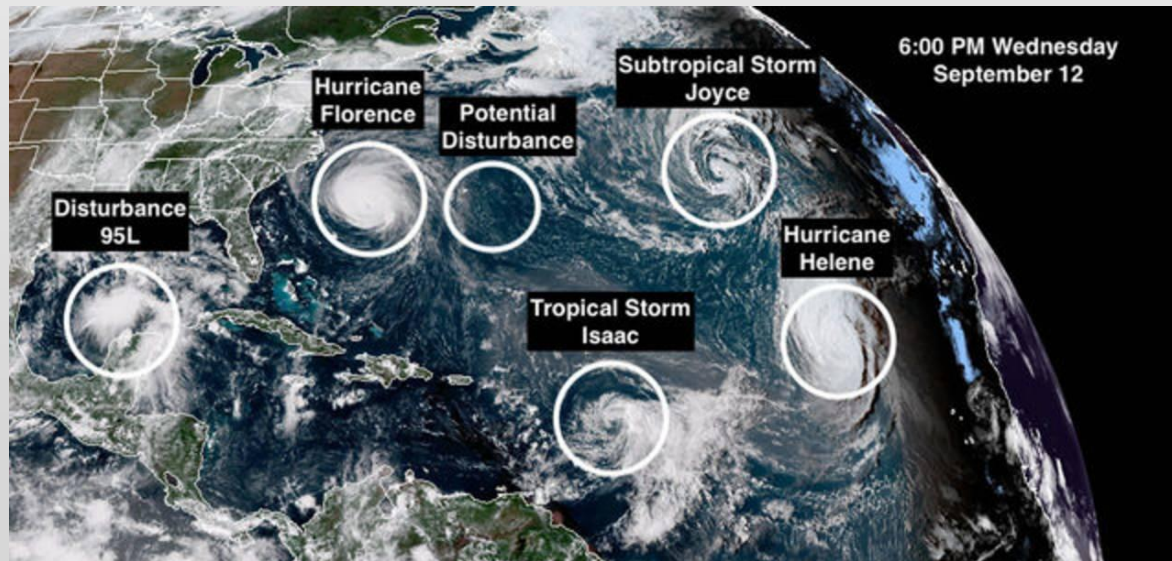


What the Radiology Experts Say

- Artificial intelligence (AI) will be our friend
- AI will help us be better radiologists

Incoming Storm

- A storm is approaching
- There will be wind and rain (true)
 - Hurricane or a simple rain shower?





Harness the Power or Risk being Swept Away



Deep Learning Will be a Disruptive Technology

- Breast imagers need to embrace it and direct its development and application to improve patient care

Leverage the Development of Deep Learning for Breast Imaging

- Ask the right questions
 - Define relevant clinical questions

Naïve Plumber



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Fukushima No. 1 Reactor



Ask the Right Question

- Can DL find breast cancer in a screening mammogram?
 - Naïve question from the last century
- Can DL determine BI-RADS breast density categories?
 - Naïve question from the last decade
- Can DL determine the molecular sub-type?
 - Naïve question from this decade

Ask the Right Question

- Can DL find triple negative breast cancer earlier than a radiologist?
- Can DL determine the invasive potential of DCIS?
- Can DL more accurately assess risk and thereby develop personalized screening regimes?
- Can DL be used to discover if there are more than four molecular sub-types?

Radiologists and Deep Learning

- Don't be a passive observer
- Don't be just the source of images
- Don't be just on the medical advisory board
- Breast imagers need to be leading the research
 - Address the important clinical questions
 - Scrutinize the performance of DL tools
 - Ensure the DL tools are usable and well integrated into your workflow

In the Future

- Breast imagers will move away from being primarily image interpreters
- Breast imagers will provide image-based information to improve patient care
 - Oncologists
 - Surgeons
 - Pathologists
- Through radiomics, radiogenomics, and image-guided therapies
 - Deep learning will speed these developments

Summary

- Deep learning is here and it's a disruptive technology
- Opportunity for breast imagers to expand their clinical impact
 - provide more value to their clinical colleagues
 - leading to better patient care
- Breast imagers need to direct what it does and how it should be implemented