

# Artificial Intelligence in Medicine

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UP-MIT-Stanford-AeHIN Big Data for Health Conference and  
Workshops for Asia-Pacific

July 4, 2017



Massachusetts  
Institute of  
Technology

# Disclosure

- No conflict of interest

TRUE?

# Technology Will Replace Many Doctors, Lawyers, and Other Professionals

by Richard Susskind and Daniel Susskind

OCTOBER 11, 2016

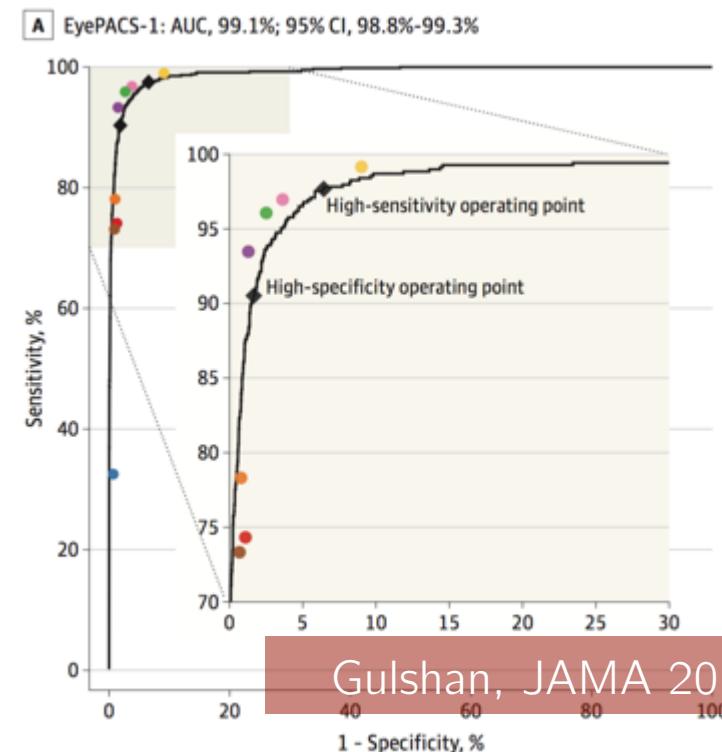
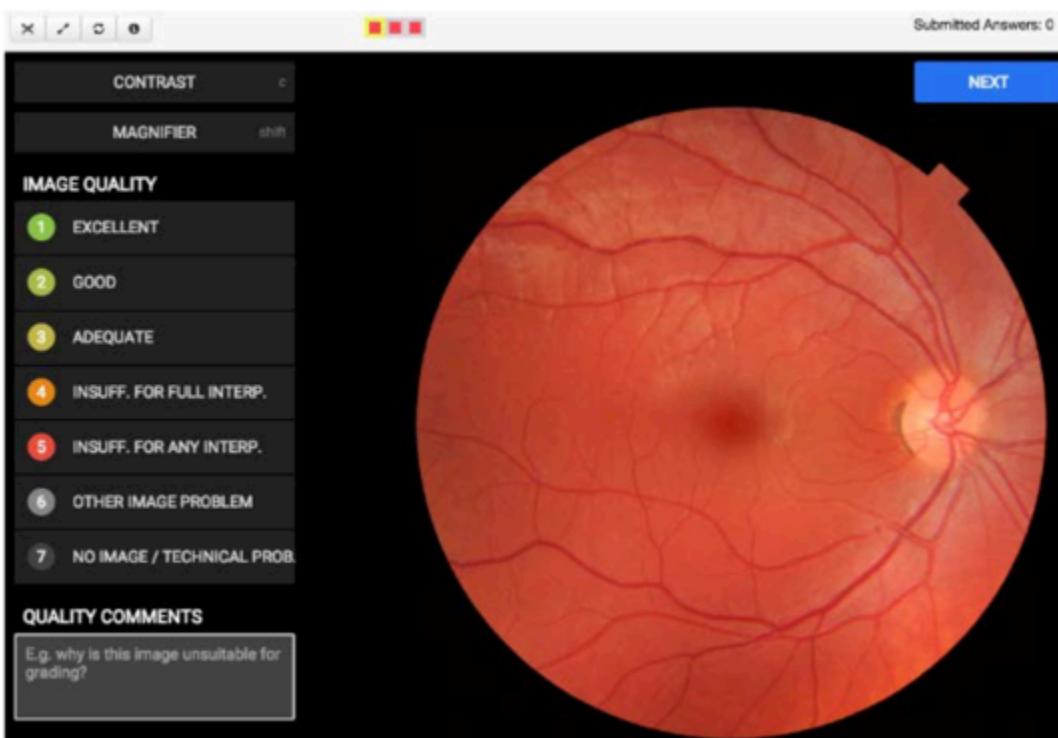
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<https://hbr.org/2016/10/robots-will-replace-doctors-lawyers-and-other-professionals>

# Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

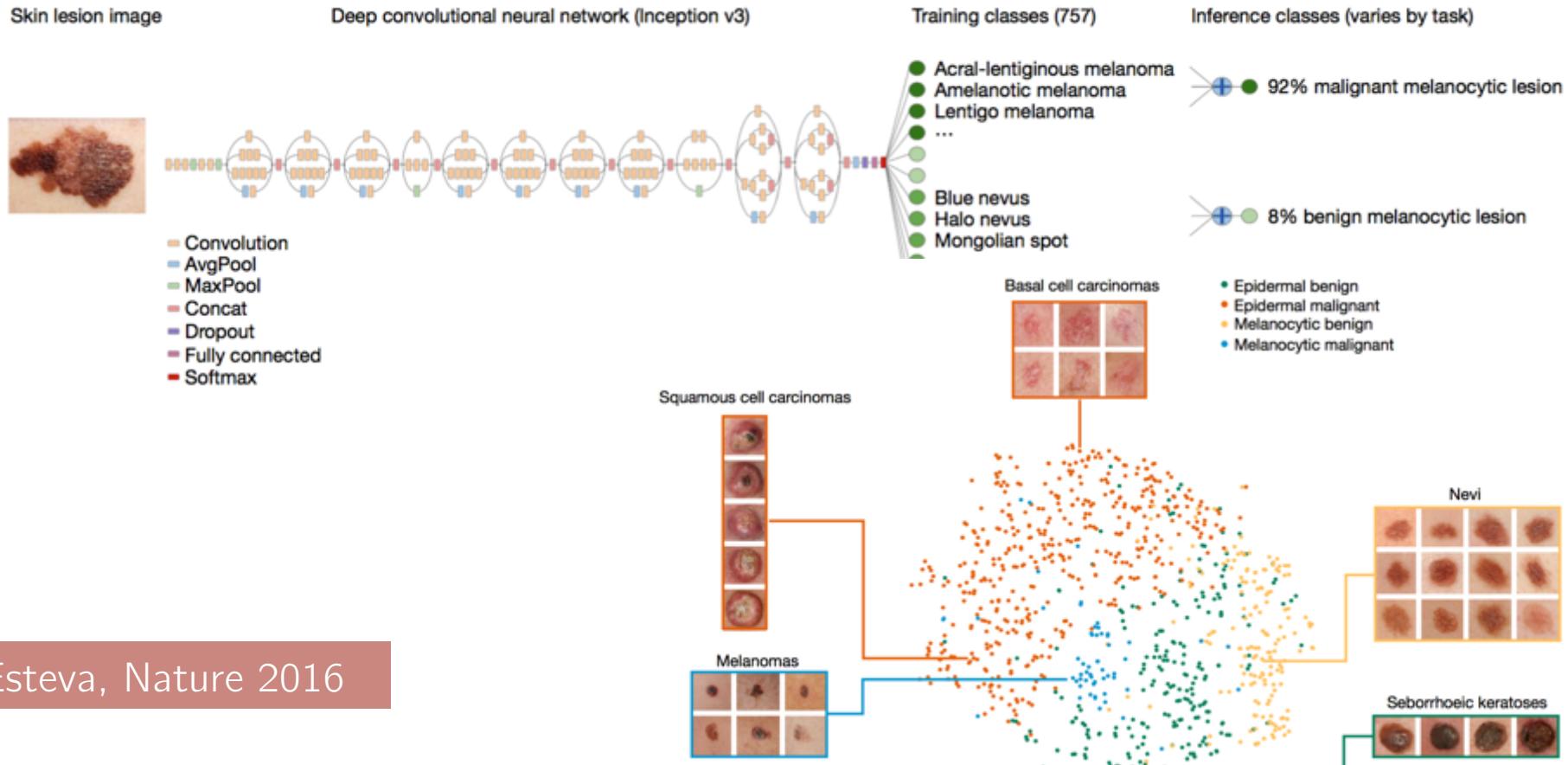
Varun Gulshan, PhD; Lily Peng, MD, PhD; Marc Coram, PhD; Martin C. Stumpe, PhD; Derek Wu, BS; Arunachalam Narayanaswamy, PhD; Subhashini Venugopalan, MS; Kasumi Widner, MS; Tom Madams, MEng; Jorge Cuadros, OD, PhD; Ramasamy Kim, OD, DNB; Rajiv Raman, MS, DNB; Philip C. Nelson, BS; Jessica L. Mega, MD, MPH; Dale R. Webster, PhD



# Medical Imaging

## Dermatologist-level classification of skin cancer with deep neural networks

Andre Esteva<sup>1\*</sup>, Brett Kuprel<sup>1\*</sup>, Roberto A. Novoa<sup>2,3</sup>, Justin Ko<sup>2</sup>, Susan M. Swetter<sup>2,4</sup>, Helen M. Blau<sup>5</sup> & Sebastian Thrun<sup>6</sup>



Esteva, Nature 2016

# Discovering Shifts to Suicidal Ideation from Mental Health Content in Social Media

Medical Text

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## MHs (Mental Health subreddits)

I have been considering going for some formal therapy. Any suggestions?

Everyday I feel sad and lonely

Since past sometime I think I am having panic attacks. I really need help from you guys.

It has been so many years, I feel I still can't move on. I am noticing behavior what could be considered "triggers" now.

## SW (SuicideWatch)

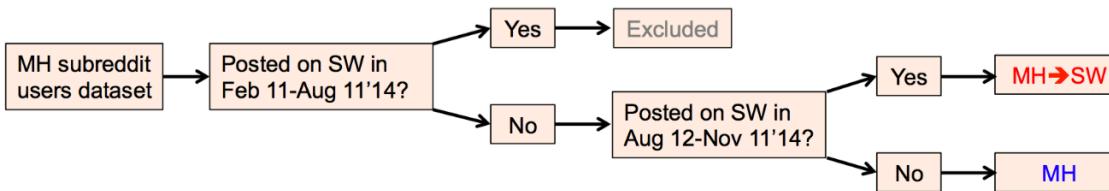
I know I was never meant to lead this life.

Don't want to hurt the people I care but I can't take this anymore.

Today I felt I have nothing left, why am I even living... I don't see a point.

I'd kill myself, but the other part of me tells me not to waste all the money my parents invested on me..

**Table 1:** Example titles of posts in the MHs and SW datasets; content has been carefully paraphrased to protect the privacy of the individuals.



**Figure 1:** Schematic diagram of obtaining MH → SW and MH classes of users.

	MH	MH → SW	z	p
<b>Linguistic Structure</b>				
nouns	0.294	0.125	6.51	***
verbs	0.045	0.107	2.19	**
abverbs	0.048	0.099	4.87	***
readability index	0.609	0.232	5.51	***
accommodation	0.857	0.487	5.46	**
<b>Interpersonal Awareness</b>				
1st person singular	0.018	0.086	-10.6	***
1st person plural	0.093	0.078	4.53	*
2nd person	0.058	0.031	8.01	*
3rd person	0.087	0.042	6.32	***
<b>Interaction</b>				
posts authored	18.97	10.31	2.53	*
post length	215.62	443.73	-15.4	***
comments authored	122.42	106.22	0.95	-
comments received	19.862	13.414	1.05	*
comment length authored	63.417	87.116	-1.88	*
comment length received	42.323	26.362	5.44	**
response velocity (mins)	7.746	6.966	0.84	-
vote difference	28.788	7.681	7.18	***

**Table 2:** Differences between MH → SW and MH user classes based on linguistic structure, interpersonal awareness and interaction measures. Statistical significance is reported based on Wilcoxon signed rank tests at levels  $p = .05/N; .01/N; .001/N$ , ( $N = 17$ ), following Bonferroni correction.

De Choudhury, HCI 2016



# 106 STARTUPS TRANSFORMING HEALTHCARE WITH AI

# Startups



[https://cbi-blog.s3.amazonaws.com/blog/wp-content/uploads/2017/01/healthcare\\_AI\\_map\\_2016\\_1.png](https://cbi-blog.s3.amazonaws.com/blog/wp-content/uploads/2017/01/healthcare_AI_map_2016_1.png)

# Multimodal Data

## eICU Collaborative Research Database



Data ↴

Community 💬

Code



Data ↴

Community 💬

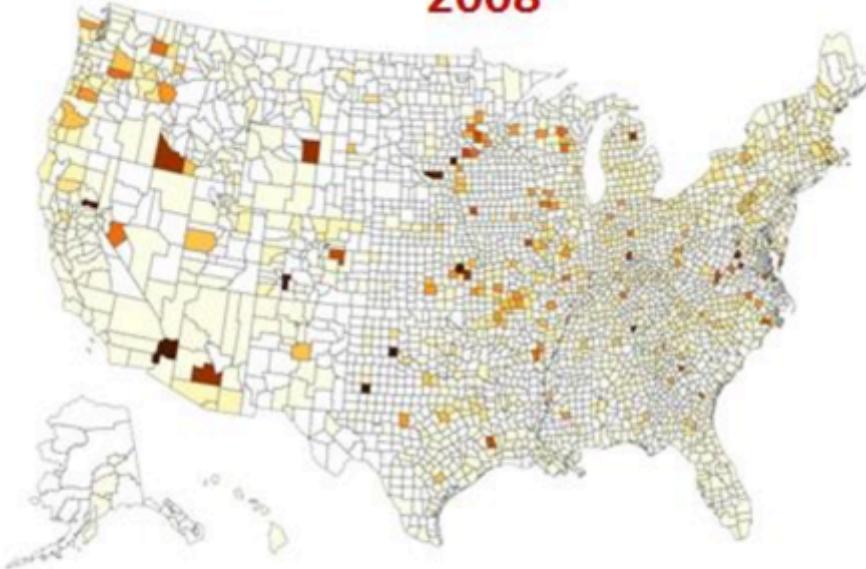
Code

If you use MIMIC data or code in your work, please cite the following publication:

*III, a freely accessible critical care database.* Johnson AE, Shen L, Lehman L, Feng M, Ghassemi M, Moody B, Szolc D, Mark RG. *Scientific Data* (2016). DOI: 10.1038/sdata.2016.35. Available from: <https://www.nature.com/articles/sdata201635>  
<http://mimic.physionet.org/>  
<http://eicu-crd.mit.edu/>

# Adoption of EHR

2008



2013



Courtesy by Owen Hsu (Wistron)

# THE 7 TYPES OF PHYSICIAN HANDWRITING

5 YEAR OLD HANDWRITING:

Patient seen and examined

No More

IMMACULATE, ILLEGIBLE SCRIPT:

Alone, yet rather, unlistened

SANSKRIT:

st' / x at + t + v + x

EVERY 4TH WORD LEGIBLE:

More critical in & un STAT!

EVERY WORD MUST TOUCH LINE MARGINS:

Patient is often  
and oriented

TEENY TINY:

Patient has history of hypertension and diabetes

HAD 30 SECONDS TO WRITE NOTE:

me

<http://doccartoon.blogspot.sg/2011/09/7-types-of-physician-bad-handwriting.html>



# Standardization



1

Bitten by a turtle

W5921XS

2

Bitten by sea lion

W5611XD



3

Struck by macaw

W6112XA

## Water Sports category

**1st:** Hit or struck by falling object due to accident to canoe or kayak – V9135XA

**2nd:** Civilian watercraft involved in water transport accident with military watercraft – V94810

**3rd:** Burn due to water-skis on fire – V9107XA

## Strange Places category

 O1 → Hurt at the library Y92241

 O2 → Hurt at swimming pool of prison as the place of occurrence Y92146

 O3 → <https://www.linkedin.com/pulse/most-bizarre-icd-10-codes-infographic-nina-keller> Y92253

# Democratization of Knowledge and Resources



**coursera**



**TensorFlow**



**python™**

# Clinical Perspective

- Cost / Risk assessment and adjustment
  - Insurance
  - Resource reallocation
- Precision / Personalized medicine
  - Oncology / rare diseases / mental disorders / ...
  - Applications
    - Clinical decision support
    - Drug discovery
    - Outcome prediction
      - Lifespan prediction / Disease progression
    - Chronic disease management
      - Early prediction of blood glucose for self-management

# CS/AI/ML Perspective

- Risk stratification
- Causal inference
- Bias
- Time-series
- Unstructured data
- Interpretability
- Disease progression modeling
- Reasoning and decision making

Data Security

News

# Security breach fears over 26 million NHS patients



[http://www.telegraph.co.uk/news/2017/03/17/  
security-breach-fears-26-million-nhs-patients/](http://www.telegraph.co.uk/news/2017/03/17/security-breach-fears-26-million-nhs-patients/)

# Transparency

THIS IS YOUR MACHINE LEARNING SYSTEM?

YUP! YOU POUR THE DATA INTO THIS BIG  
PILE OF LINEAR ALGEBRA, THEN COLLECT  
THE ANSWERS ON THE OTHER SIDE.

WHAT IF THE ANSWERS ARE WRONG?

JUST STIR THE PILE UNTIL  
THEY START LOOKING RIGHT.



<https://xkcd.com/1838/>

# Replacing Your Job?

## The world's first artificially intelligent lawyer was just hired at a law firm



Chris Weller

© May 16, 2016, 10:26 AM 44,723

FACEBOOK

LINKEDIN

TWITTER

EMAIL

PRINT

Lawyers can get a bad reputation for being slimy and conniving, but ROSS has neither of those qualities.

Ask ROSS to look up an obscure court ruling from 13 years ago, and ROSS will not only search for



<http://www.businessinsider.com/the-worlds-first-artificially-intelligent-lawyer-gets-hired-2016-5>

# Limitations of AI

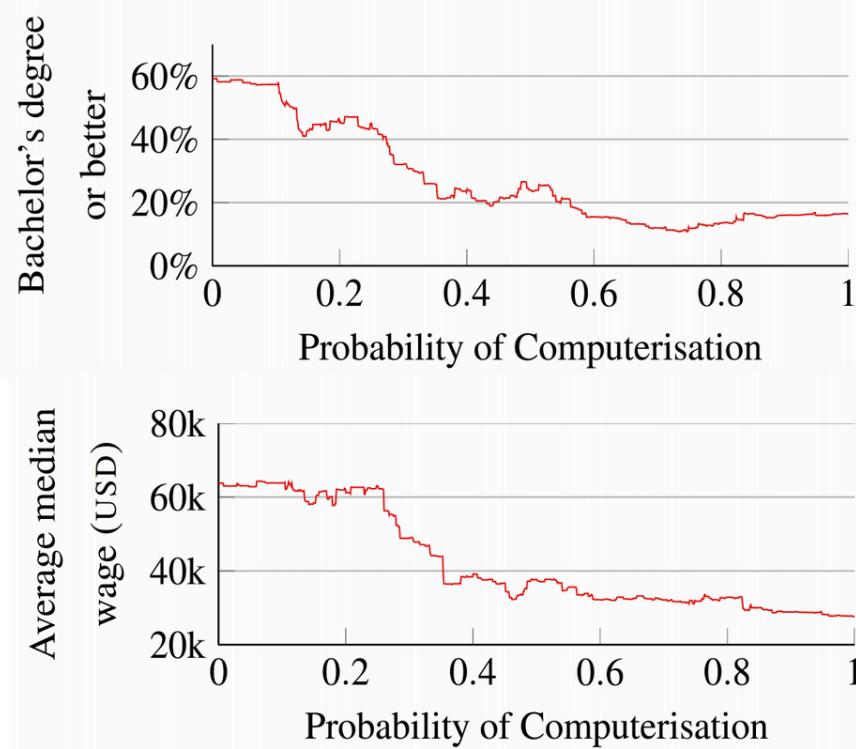
- Autonomous manipulation in unstructured environment
- Emotion
- Thinking, reasoning and decision making
  - Inference
  - Abstraction
  - Cognition
  - Commonsense knowledge
  - Insight
- Creativity
- Social intelligence

A golden retriever dog is sitting at a desk in a laboratory setting. The dog is wearing black safety goggles and a white lab coat over its brown fur. It has a small "DANGER! HOT SURFACE" tag around its neck. In front of the dog is a blue mug with the words "PICK ONE" and "NATURE'S RA..." visible. To the right of the dog is a round-bottom flask containing a brown liquid, connected to a glass apparatus. The background is a purple wall.

I HAVE NO  
IDEA WHAT  
I'M DOING

[http://knowyourmeme.com/photos/  
234739-i-have-no-idea-what-i-m-doing](http://knowyourmeme.com/photos/234739-i-have-no-idea-what-i-m-doing)

We predict that **high-skilled jobs are relatively resistant to computerisation.**





## VIEWPOINT

### INNOVATIONS IN HEALTH CARE DELIVERY

# Adapting to Artificial Intelligence Radiologists and Pathologists as Information Specialists

**Artificial intelligence**—the mimicking of human cognition by computers—was once a fable in science fiction but is becoming reality in medicine. The combination of big data and artificial intelligence, referred to by some as the fourth industrial revolution,<sup>1</sup> will change radiology and pathology along with other medical specialties. Although reports of radiologists and pathologists being replaced by computers seem exaggerated,<sup>2</sup> these specialties must plan strategically for a future in which artificial intelligence is part of the health care workforce.

Radiologists have always revered machines and tech-

This progress in radiologists. Radiology ages, such as chest radi complex and data rich. Cr and magnetic reson greater clarity, has m stances; for example, a chest radiograph but Jha, JAMA 2016 has come at a price— markedly. For example, 4000 images in a CT

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Radiology, University  
of Pennsylvania,  
Philadelphia.

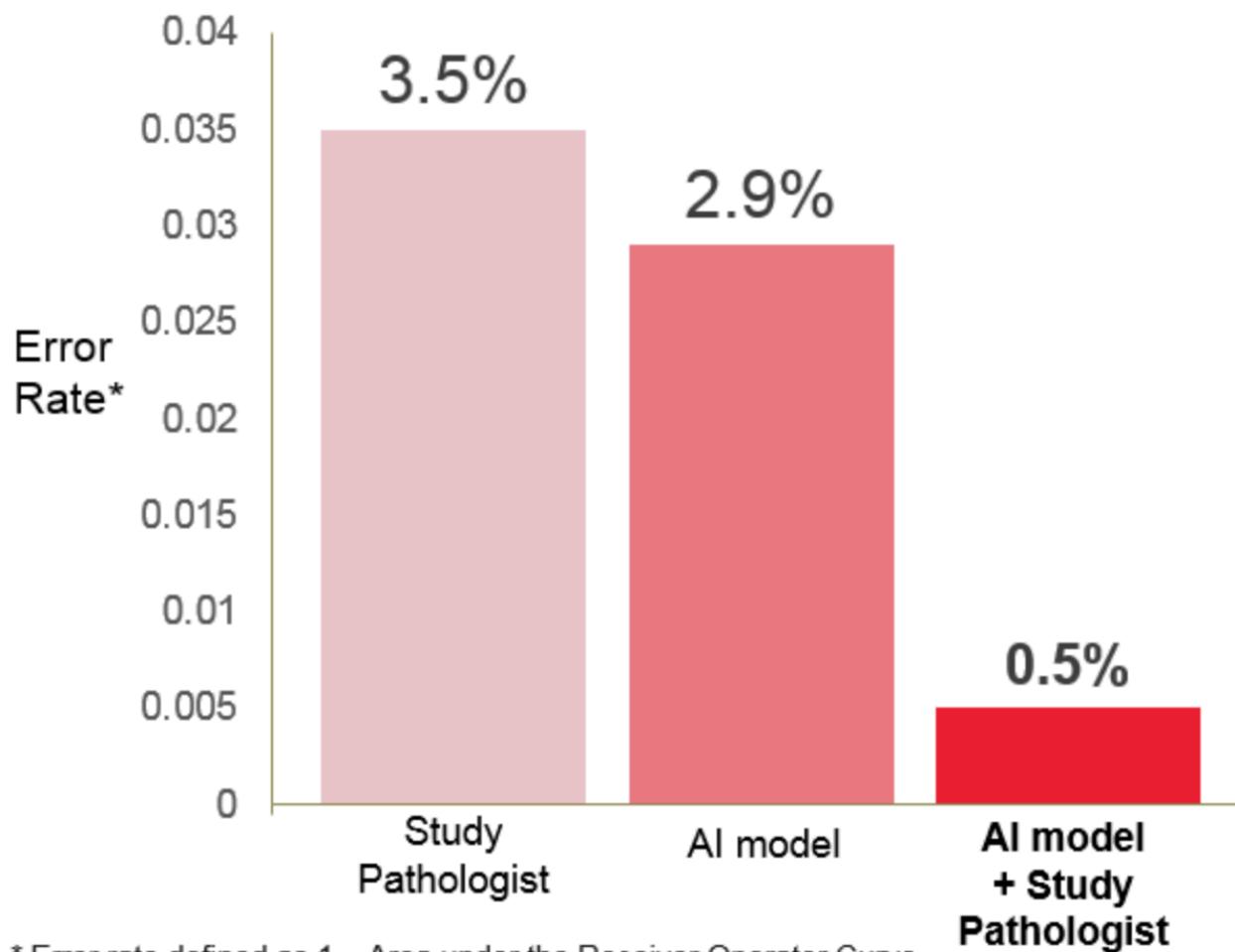
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Eric J. Topol, MD  
Scripps Research  
Institute, La Jolla,  
California.

# What We Can Do

- Find good problems, collect reliable data > Big data and algorithms
- Collaboration > Expert or AI only
  - AI: pattern recognition and massive repetitive tasks
  - Expert: high-level integration, interpretation and decision making
- Sharing
  - Engineers: open-source platforms and algorithms
  - Clinicians: open-source data and knowledge
- Experience
  - Learning how AI works
  - Communicating with machine (programming)

# (AI + Pathologist) > Pathologist



\* Error rate defined as  $1 - \text{Area under the Receiver Operator Curve}$

\*\* A study pathologist, blinded to the ground truth diagnoses,  
independently scored all evaluation slides.

Courtesy by Dr. Andrew Beck (PathAI)  
Wang, arXiv 2016

# Take Home Message

- Data-driven, ML-based approach, with standardized medical language
- Defining good problems + finding reliable data sources
  - Cost, risk, precision medicine
  - Causality, bias, unstructured data, interpretability, reasoning and decision making
- Collaborating with machine and human community (sharing)
- Experiencing, learning and communicating
- Acknowledgement
  - Leo Celi (MIT), Alvin Marcelo (UP-AeHIN), Mornin Feng (NUS)
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- ckbjimmy@mit.edu / Wei-Hung Weng (LinkedIn)
- [http://ckbjimmy.github.io/2017\\_cebu](http://ckbjimmy.github.io/2017_cebu)