

Artificial Intelligence in Medicine

Wei-Hung Weng, MD, MMSc

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

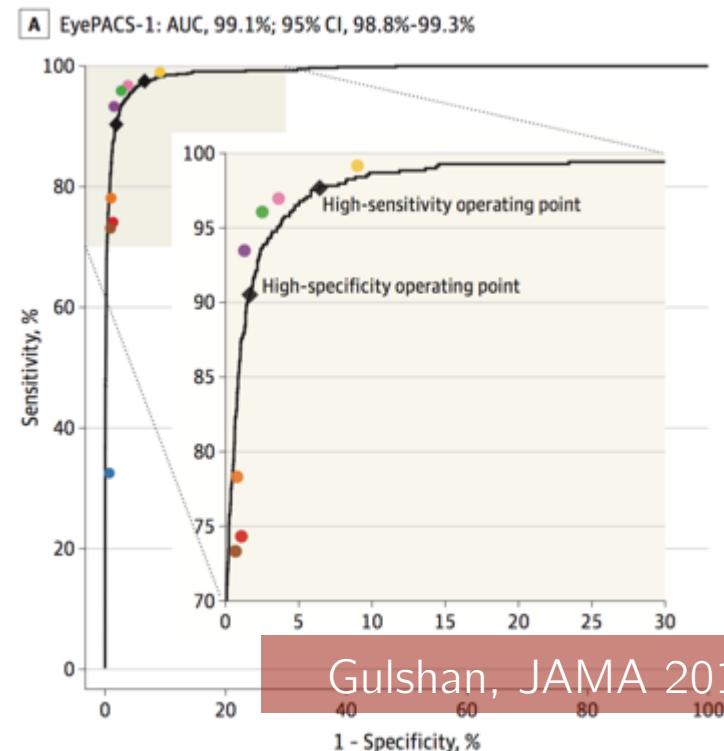
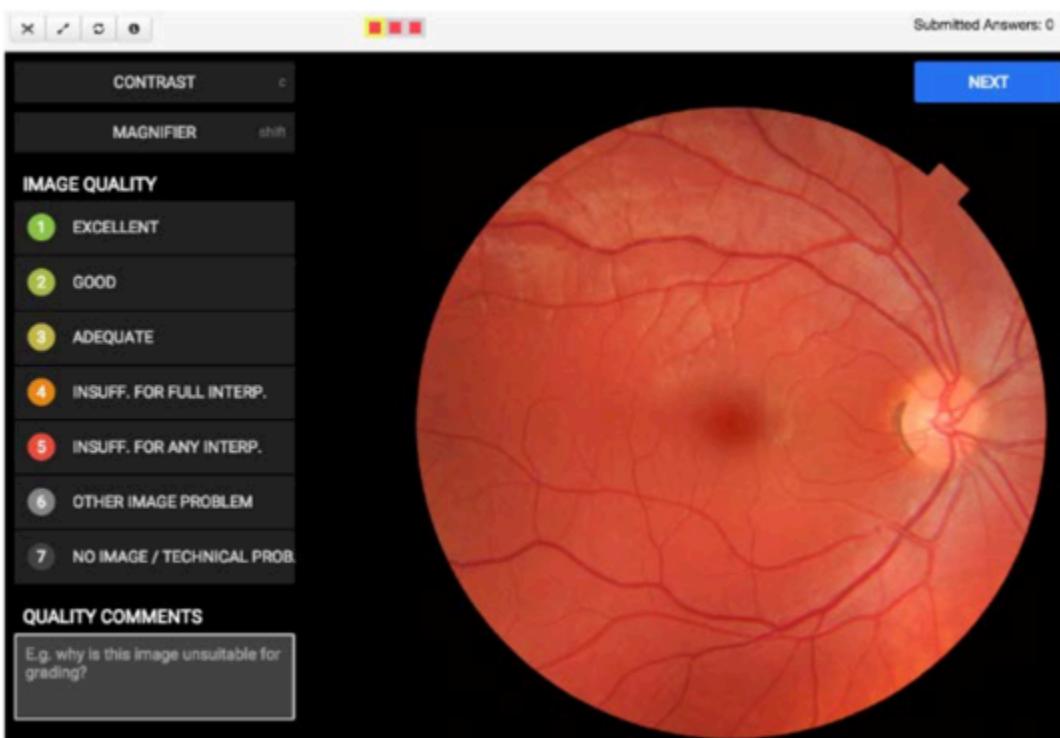
 SAVE  SHARE  COMMENT 26  TEXT SIZE  PRINT \$8.95 BUY COPIES



<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

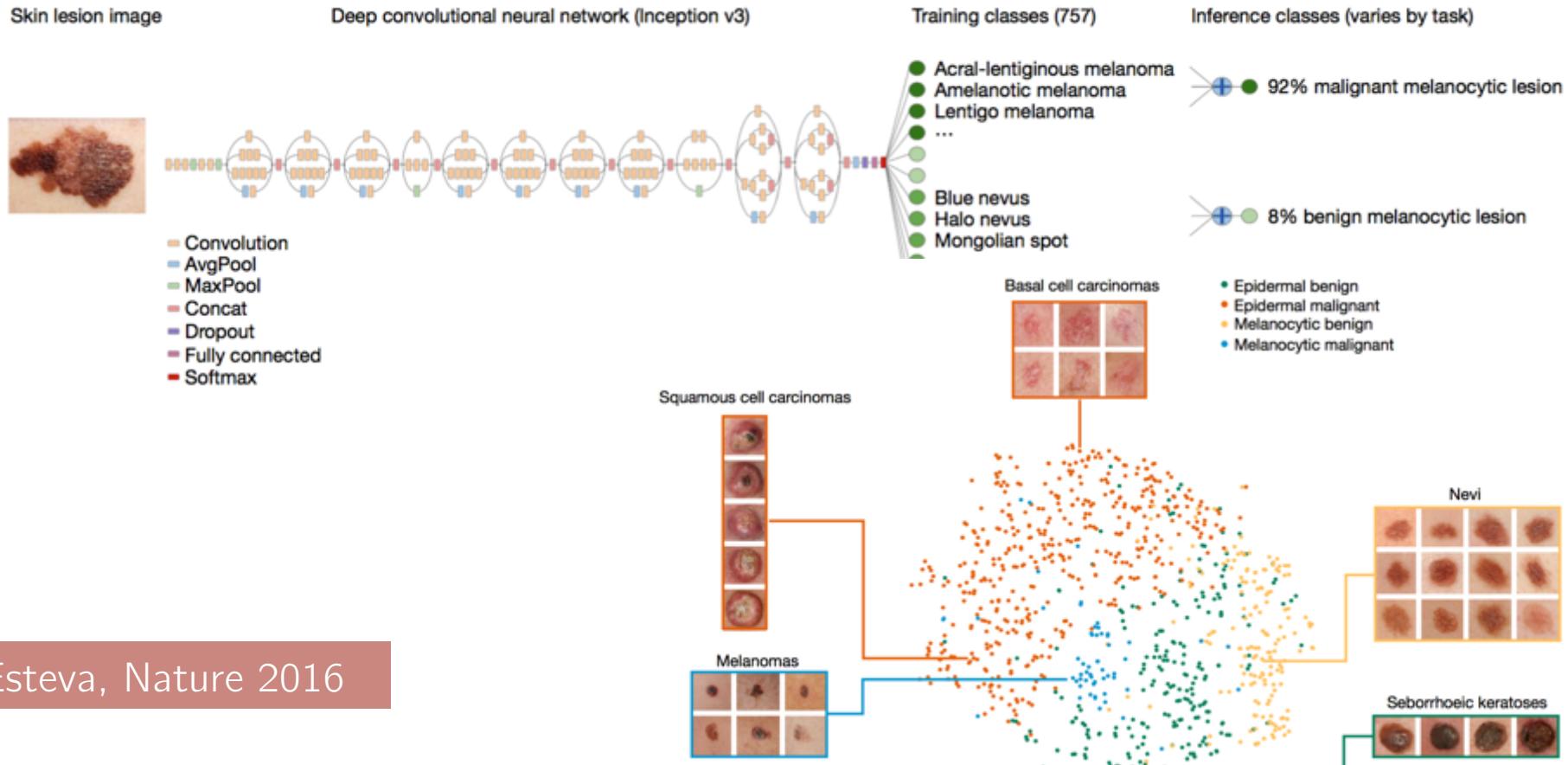
Varun Gulshan, PhD; Lily Peng, MD, PhD; Marc Coram, PhD; Martin C. Stumpe, PhD; Derek Wu, BS; Arunachalam Narayanaswamy, PhD; Subhashini Venugopalan, MS; Kasumi Widner, MS; Tom Madams, MEng; Jorge Cuadros, OD, PhD; Ramasamy Kim, OD, DNB; Rajiv Raman, MS, DNB; Philip C. Nelson, BS; Jessica L. Mega, MD,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



Medical Imaging

Dermatologist-level classification of skin cancer with deep neural networks

Andre Esteva^{1*}, Brett Kuprel^{1*}, Roberto A. Novoa^{2,3}, Justin Ko², Susan M. Swetter^{2,4}, Helen M. Blau⁵ & Sebastian Thrun⁶



Esteva, Nature 2016

Medical Text

Using Machine Learning to Parse Breast Pathology Reports

Adam Yala,¹ Regina Barzilay,¹ Laura Salama,³ Molly Griffin,² Grace Sollender,⁸ Aditya Bardia,¹⁰ Constance Lehman,⁵ Julliette M. Buckley,² Suzanne B. Coopey,² Fernanda Polubriaginof,⁹ Judy E. Garber,⁶ Barbara L. Smith,² Michele A. Gadd,² Michelle C. Specht,² Thomas M. Gudewicz,⁴ Anthony Guidi,⁷ Alphonse Taghian,³ and Kevin S. Hughes²

Pathology Report: REMOVED_ACCESSION_ID
ACCESSIONED ON: REMOVED_DATE
CLINICAL DATA: Carcinoma **right breast**.
*** FINAL DIAGNOSIS ***
LYMPH NODE (SENTINEL), EXCISION
(REMOVED_CASE_ID): METASTATIC CARCINOMA IN 1 OF 1 LYMPH NODE.
NOTE: The metastatic deposit spans 0.19cm and is identified on H&E and cytokeratin immunostains. A second cytokeratin-positive but cauterized focus likely also represents metastatic tumor (<0.1cm). There is **no evidence of extranodal extension**. BREAST (RIGHT), EXCISIONAL BIOPSY
(REMOVED_ACCESSION_ID : REMOVED_CASE_ID -B):
INVASIVE DUCTAL CARCINOMA (SEE TABLE #1). DUCTAL CARCINOMA IN-SITU, GRADE 1. ATYPICAL DUCTAL HYPERPLASIA. LOBULAR NEOPLASIA (ATYPICAL LOBULAR HYPERPLASIA).
TABLE OF PATHOLOGICAL FINDINGS #1 INVASIVE CARCINOMA
Tumor size: Cannot evaluate. Grade: 1.
Lymphatic vessel invasion: Not identified.
Blood vessel invasion: Not identified.
Margin of invasive carcinoma: Invasive carcinoma extends to less than 0.2cm from the inferior margin of the specimen.
Stains for receptors: Outside immunohistochemical stains demonstrate that the tumor cells express estrogen and progesterone receptors.



| Name | Extraction |
|--|------------|
| Breast Side | Right |
| Ductal Carcinoma in Situ | Present |
| Invasive Lobular Carcinoma | Absent |
| Invasive Ductal Carcinoma | Present |
| Cancer | Present |
| Lobular Carcinoma in Situ | Absent |
| Atypical Ductal Hyperplasia | Present |
| Atypical Lobular Hyperplasia | Present |
| Lobular Neoplasia | Present |
| Flat Epithelial Atypia | Absent |
| Blunt Adenosis | Absent |
| Atypia | Present |
| Positive Lymph Nodes | Present |
| Extracapsular Axillary Nodal Extension | Absent |
| Isolated Cancer Cells in Lymph Nodes | Absent |
| Lymphovascular Invasion | Absent |
| Blood Vessel Invasion | Absent |
| Estrogen Receptor Status | Positive |
| Progesterone Receptor Status | Positive |
| HER 2 (FISH) Status | Unknown |

| Category | Accuracy | F-score |
|------------------------|----------|---------|
| Breast side | 1.0 | 1.0 |
| DCIS | .99 | .99 |
| ILC | .99 | .99 |
| IDC | 1.0 | 1.0 |
| Carcinoma | .94 | .94 |
| LCIS | 1.0 | .98 |
| ADH | .90 | .90 |
| ALH | .98 | .98 |
| Lobular Neoplasia | .97 | .97 |
| Flat Epithelial Atypia | 1.0 | 1.0 |
| Blunt Adenosis | 1.0 | 1.0 |
| Atypia | .91 | .91 |
| Positive LN | .98 | .98 |
| ECE | .97 | .97 |
| ITC in LN | .96 | .96 |
| LVI | .92 | .88 |
| BVI | .93 | .90 |
| ER Status | .97 | .97 |
| PR Status | .97 | .95 |
| HER 2 Status | .96 | .94 |
| Report-Level | .90 | N/A |
| Average | .97 | .96 |

Yala, arXiv 2016

Achievement in Industry

- Watson
 - Identify pulmonary embolism on CT
 - Detect abnormal wall motion on echocardiography
 - Watson Oncology in Japan, India, ...
- Enlitic
 - Fracture detection on radiographs
- DeepMind Health
 - NHS Streams
- Lumiata
- ...



106 STARTUPS TRANSFORMING HEALTHCARE WITH AI

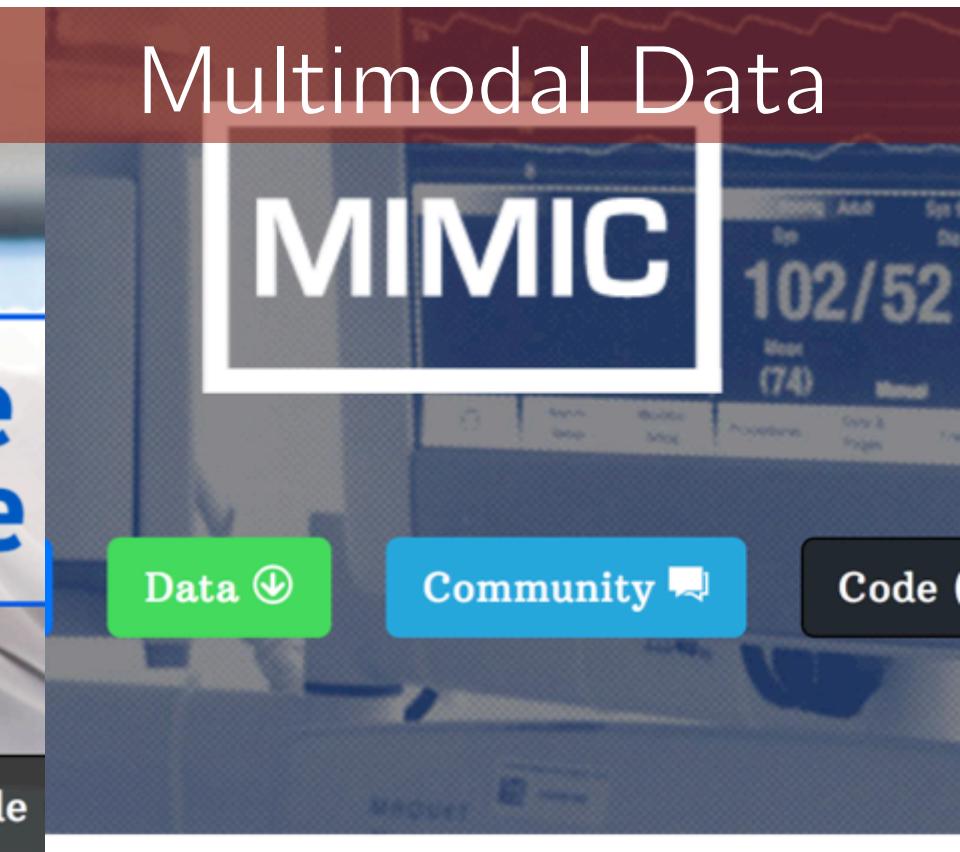
Startups



https://cbi-blog.s3.amazonaws.com/blog/wp-content/uploads/2017/01/healthcare_AI_map_2016_1.png



Multimodal Data

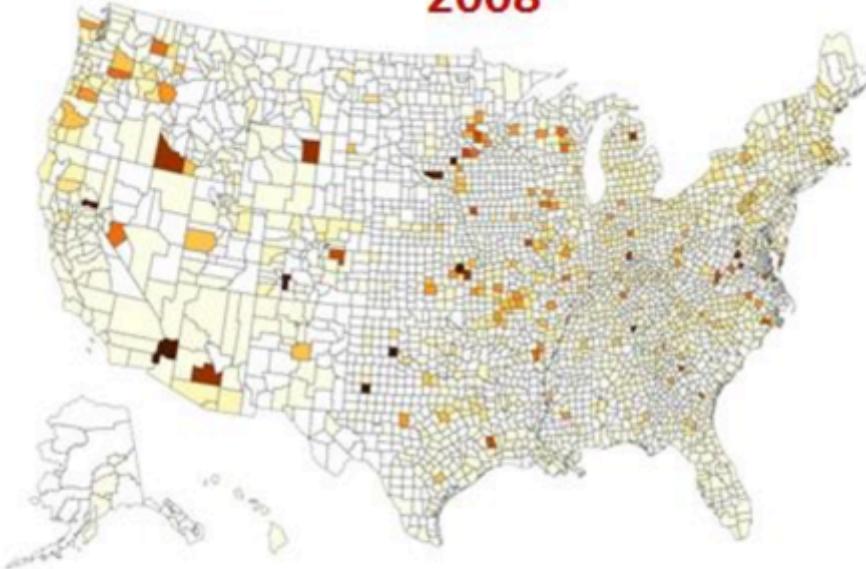


If you use MIMIC data or code in your work, please cite the following publication:

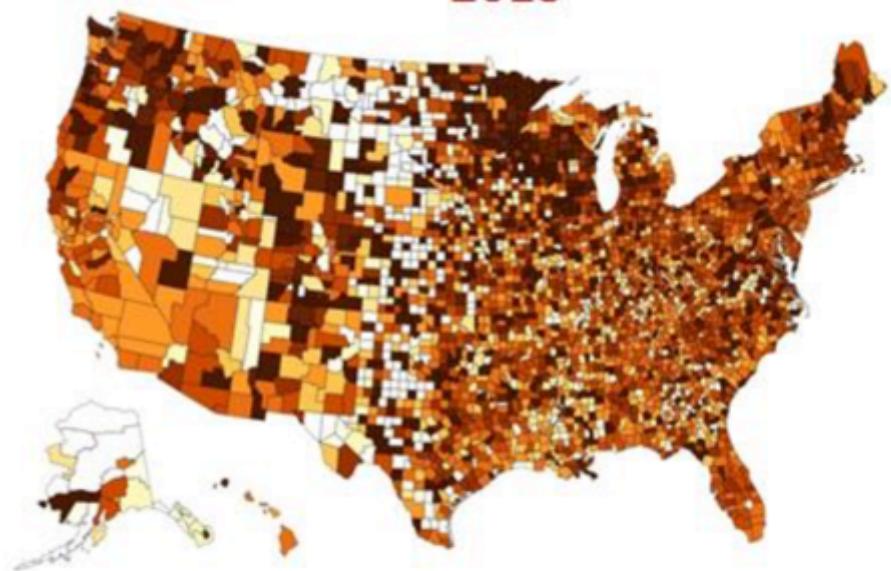
III, a freely accessible critical care database. Johnson AE, Shen L, Lehman L, Feng M, Ghassemi M, Moody B, Szoldad Mark RG. *Scientific Data* (2016). DOI: 10.1038/sdata.2016.35
available from: <https://mimic.physionet.org/>
<http://eicu-crd.mit.edu/>

Adoption of EHR

2008



2013



Courtesy by Owen Hsu (Wistron)



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



Why Now?

- High quality (?) multimodal data
 - Variety, volume, velocity
 - Social media, sensor, wearable, vital signs, lab data, notes, imaging, -omics
 - Adoption of EHR
- Standardization
 - UMLS, SNOMED, ICD, RxNorm, LOINC, ...
- Advances and democratization in ML
 - Open-source / algorithms & tools
 - Different approaches of knowledge representation

Clinical Perspective

- Cost / Risk assessment and adjustment
 - Insurance
 - Resource redistribution
- Precision / Personalized medicine
 - For
 - 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

Issues

- Domain specific vs. generalization
- Data quality
- Privacy / Data security
 - Open-source and ubiquitous
 - Innovation, ecosystem
- 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.



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

- Computational intelligence \neq computational consciousness
- Procedure
- Emotion
- Thinking, reasoning and decision making
 - Inference
 - Abstraction
 - Cognition
 - Commonsense knowledge
 - Insight



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)



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,¹ will change radiology and pathology along with other medical specialties. Although reports of radiologists and pathologists being replaced by computers seem exaggerated,² 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

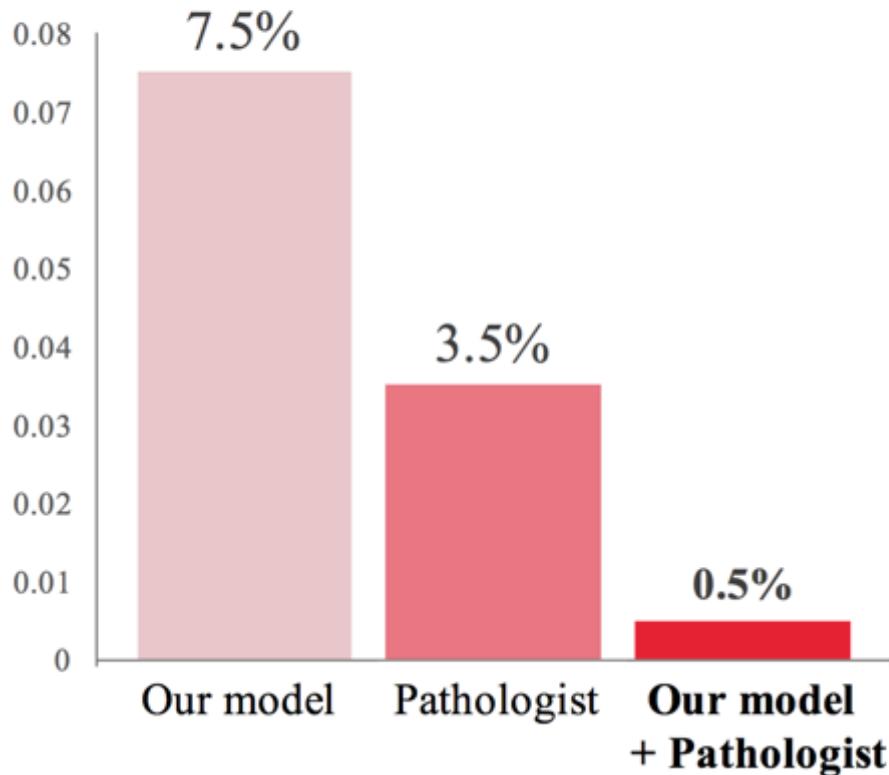
Saurabh Jha, MBBS,
MRCS, MS
Department of
Radiology, University
of Pennsylvania,
Philadelphia.

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
 - Expert: high-level integration, interpretation and decision making (learn Bayesian logic, statistics, and data science and be aware of other sources of information!)
 - AI: pattern recognition and massive repetitive tasks
- Sharing
 - AI researchers open-source platforms and algorithms
 - You can open-source data and knowledge
 - We can do nothing without sharing!
- Experience
 - Learning from AI
 - Communicating with AI

Deep Learning vs Pathologist



The **combination** of a pathologist and the Beck Lab deep learning system **reduces error rate by 85% to 0.5%.**

Courtesy by Dr. Andrew Beck (PathAI)

Take Home Message

- Data-driven, machine learning-based approach
- Define good problems and find reliable data sources
 - Cost, risk, precision medicine
 - Causality, bias, unstructured data, interpretability, reasoning and decision making
- Human-machine collaboration
- Share your data and knowledge
- Learn from / communicate with AI
- Acknowledgement
 - Leo Celi (MIT), Alvin Marcelo (UP-AeHIN), Mornin Feng (NUS)
 - Peter Szolovits (MIT), David Sontag (MIT)
- ckbjimmy@mit.edu / Wei-Hung Weng (LinkedIn)
- http://ckbjimmy.github.io/2017_cebu