

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

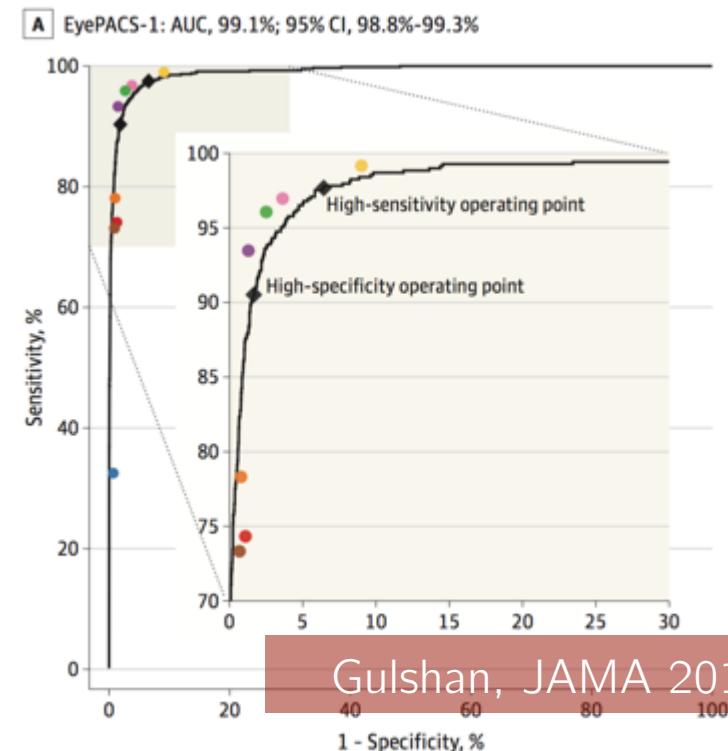
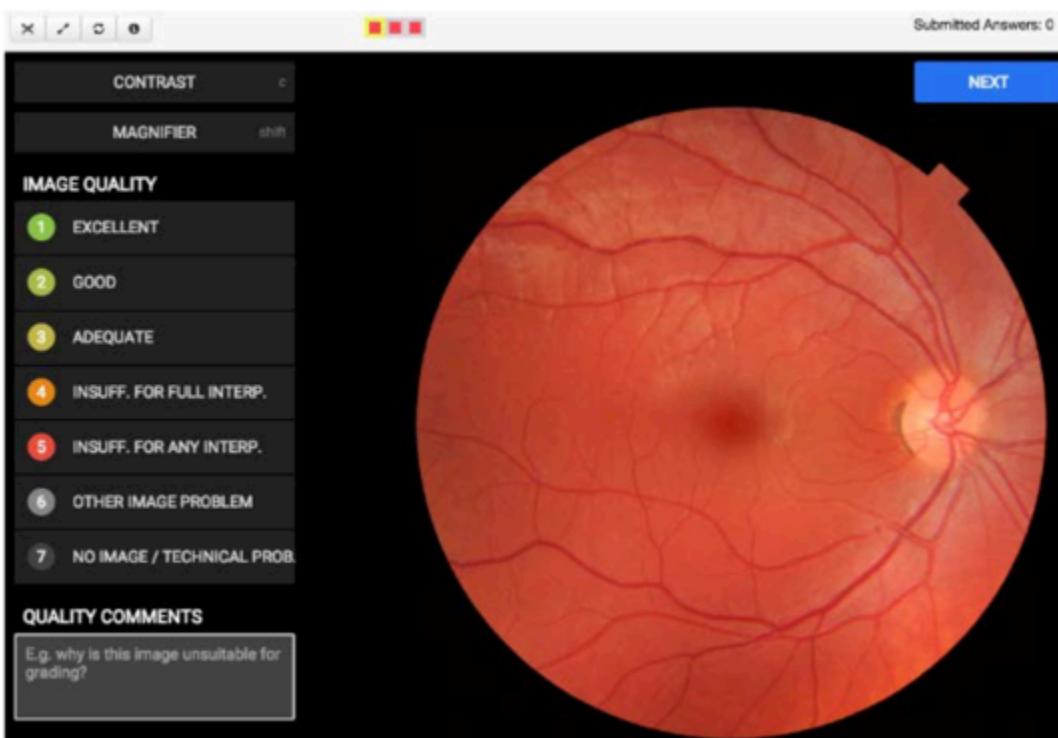
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<https://hbr.org/2016/10/robots-will-replace-doctors-lawyers-and-other-professionals>

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

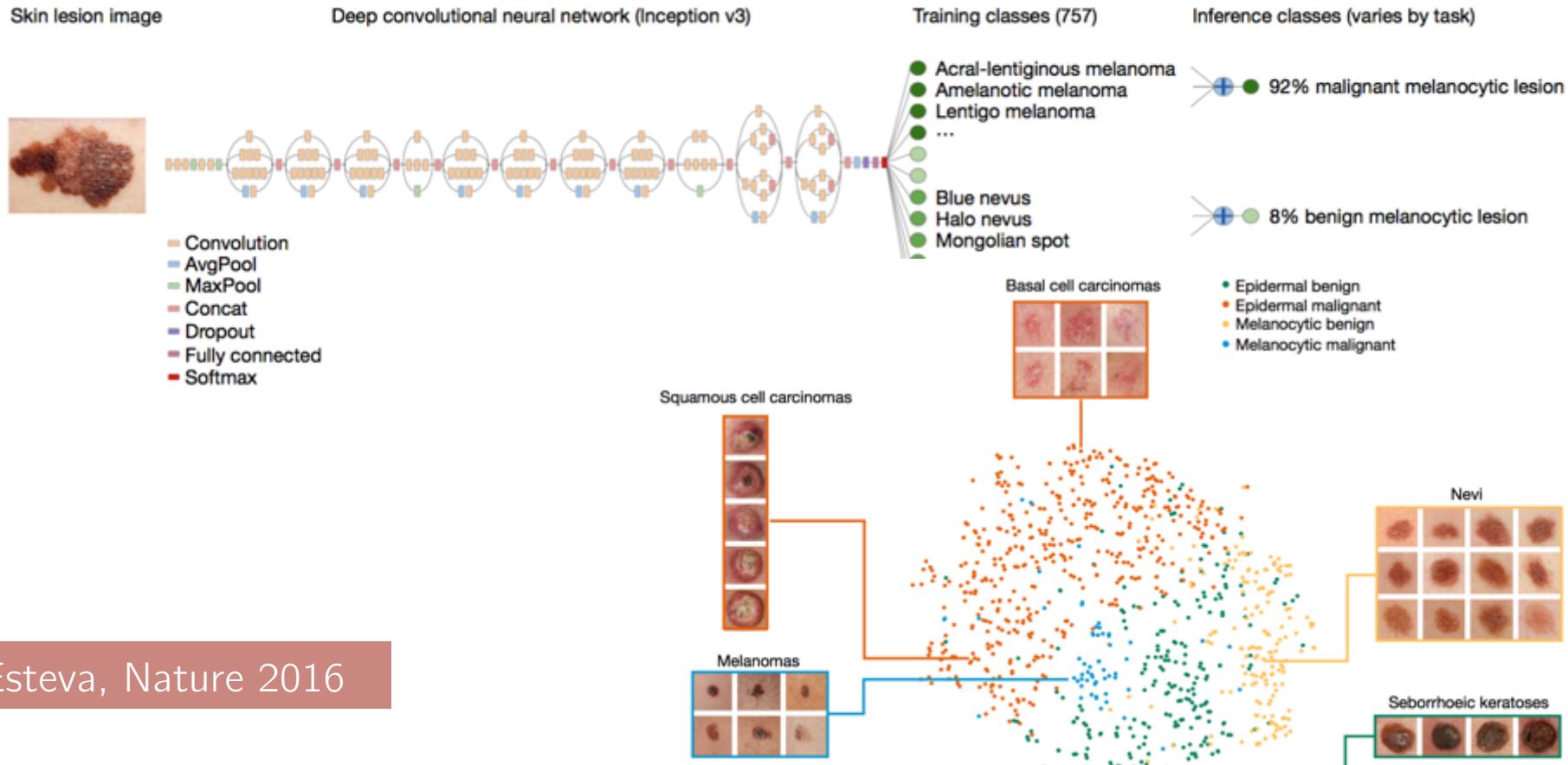


Gulshan, JAMA 2016

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



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

Startups

MEDICAL IMAGING & DIAGNOSTICS

Multimodal Data

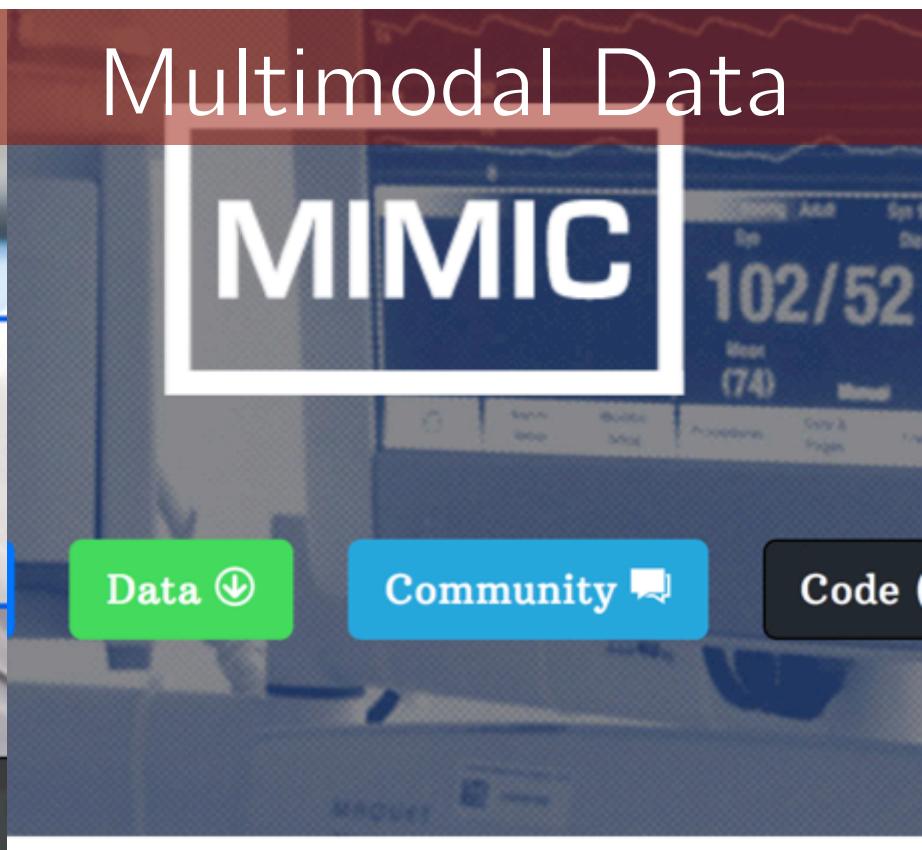
eICU Collaborative Research Database



Data ↴

Community 💬

Code

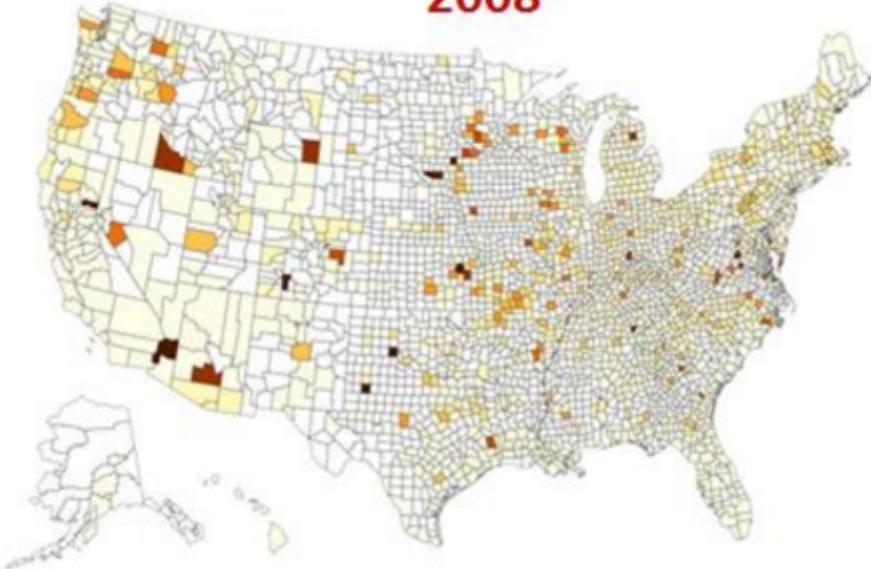


If you use MIMIC data or code in your work, please cite the following publication:

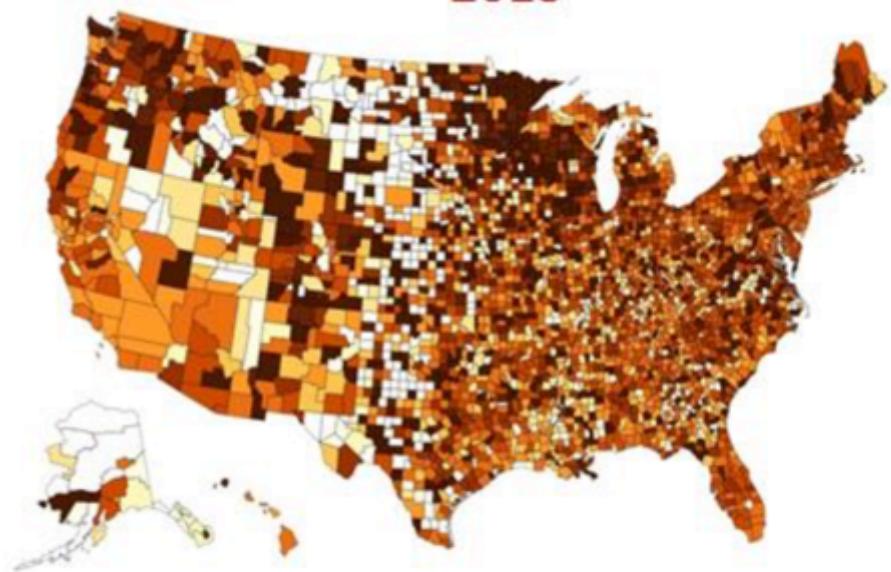
III, a freely accessible critical care database. Johnson AE, Shen L, Lehman L, Feng M, Ghassemi M, Moody B, Szolc D, Mark RG. *Scientific Data* (2016). DOI: 10.1038/sdata.2016.35. Available from: <https://www.nature.com/articles/sdata201635>
<http://mimic.physionet.org/>
<http://eicu-crd.mit.edu/>

Adoption of EHR

2008



2013



Courtesy by Owen Hsu (Wistron)



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™

Why Now?

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

Clinical Perspective

- Precision / Personalized medicine
 - For
 - Oncology
 - Rare diseases
 - Mental disorders
 - Applications
 - 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

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

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

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 attached to its collar. 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.

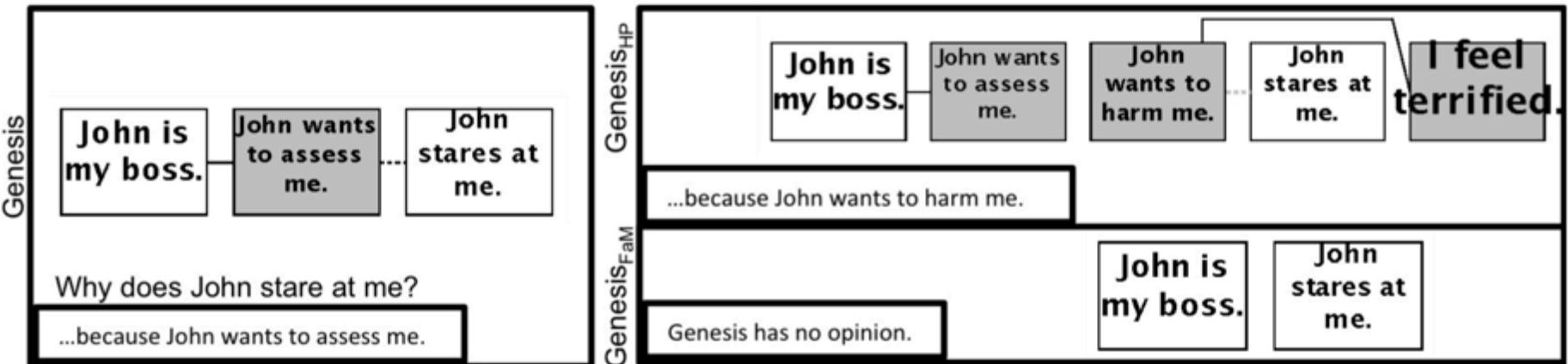
I HAVE NO
IDEA WHAT
I'M DOING

[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)

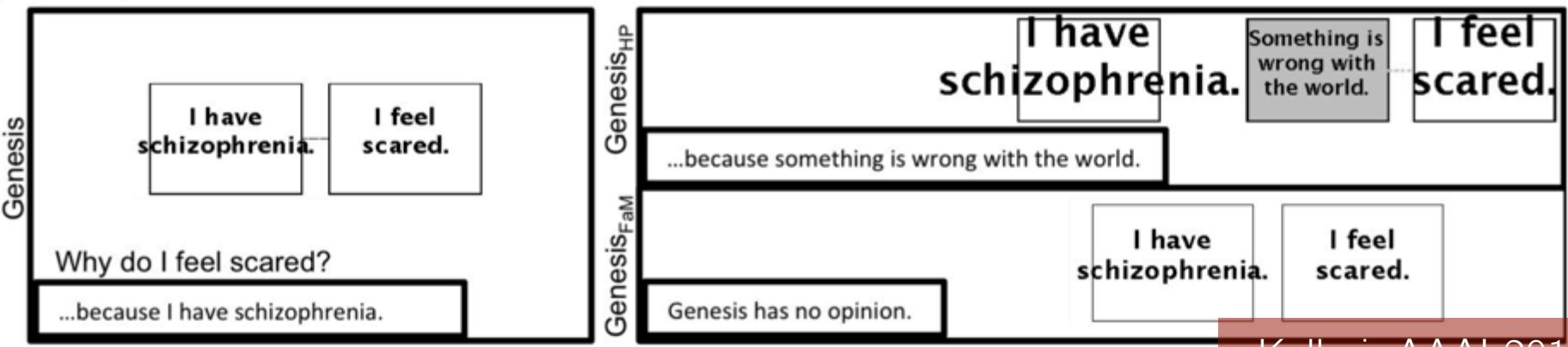
Inducing Schizophrenia in an Artificially Intelligent Story-Understanding System

Pratyusha Kalluri and Patrick Henry Winston

(B) System performance on the Paranoid Delusion Task



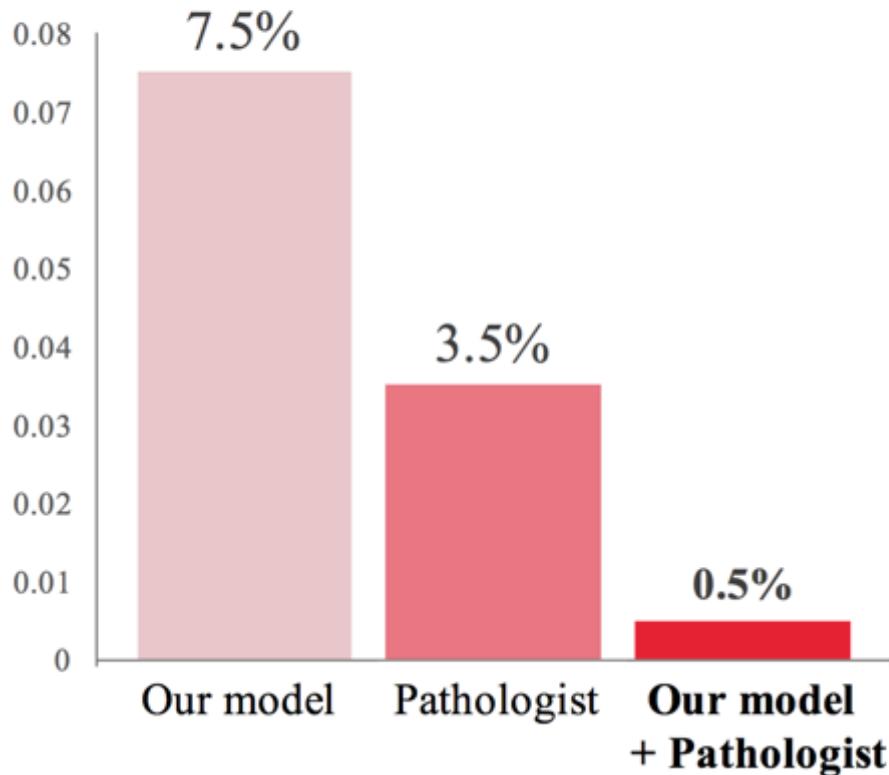
(C) System performance on the Persistence of Delusion Task



What We Can Do

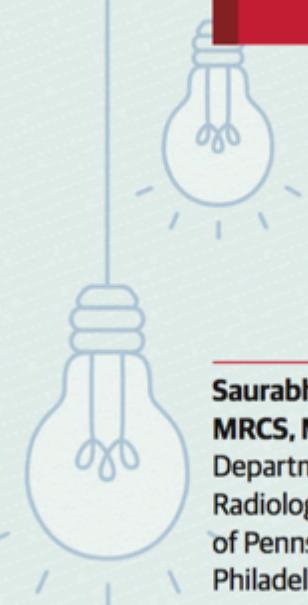
- Find good problems, collect reliable data
- Collaboration > Expert or AI only
 - Expert: high-level integration, interpretation and decision making (learn Bayesian logic, statistics, and data science and be aware of other sources of information!)
 - AI: pattern recognition and massive repetitive tasks
- 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)



VIEWPOINT

Saurabh Jha, MBBS,
MRCS, MS

Department of
Radiology, University
of Pennsylvania,
Philadelphia.

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

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 imaging has changed the role of radiologists. Radiology, once confined to two-dimensional images, such as chest radiographs, has moved to three-dimensional and data rich. Cross-sectional imaging, such as computed tomography and magnetic resonance, by showing structures in greater clarity, has made diagnosis easier in many circumstances; for example, a ruptured abdominal aortic aneurysm can be seen on a chest radiograph but actually seems to be in the abdomen. This has come at a price—the amount of radiation exposure has increased markedly. For example, a radiologist may view up to 4000 images in a CT scan of multi-

Jha. JAMA 2016

Take Home Message

- Problems and reliable data source > Big data and algorithms
- AI is part of the healthcare workforce
- Human-machine collaboration
- Share your data and knowledge
- Learn from AI, 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