AI is to Medicine Today What the X-ray was to Medicine a Century Ago, and Much More…

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UTHealth
The University of Texas Health Science Center at Houston
School of Biomedical Informatics

TRANSFORMING DATA TO POWER HUMAN HEALTH™

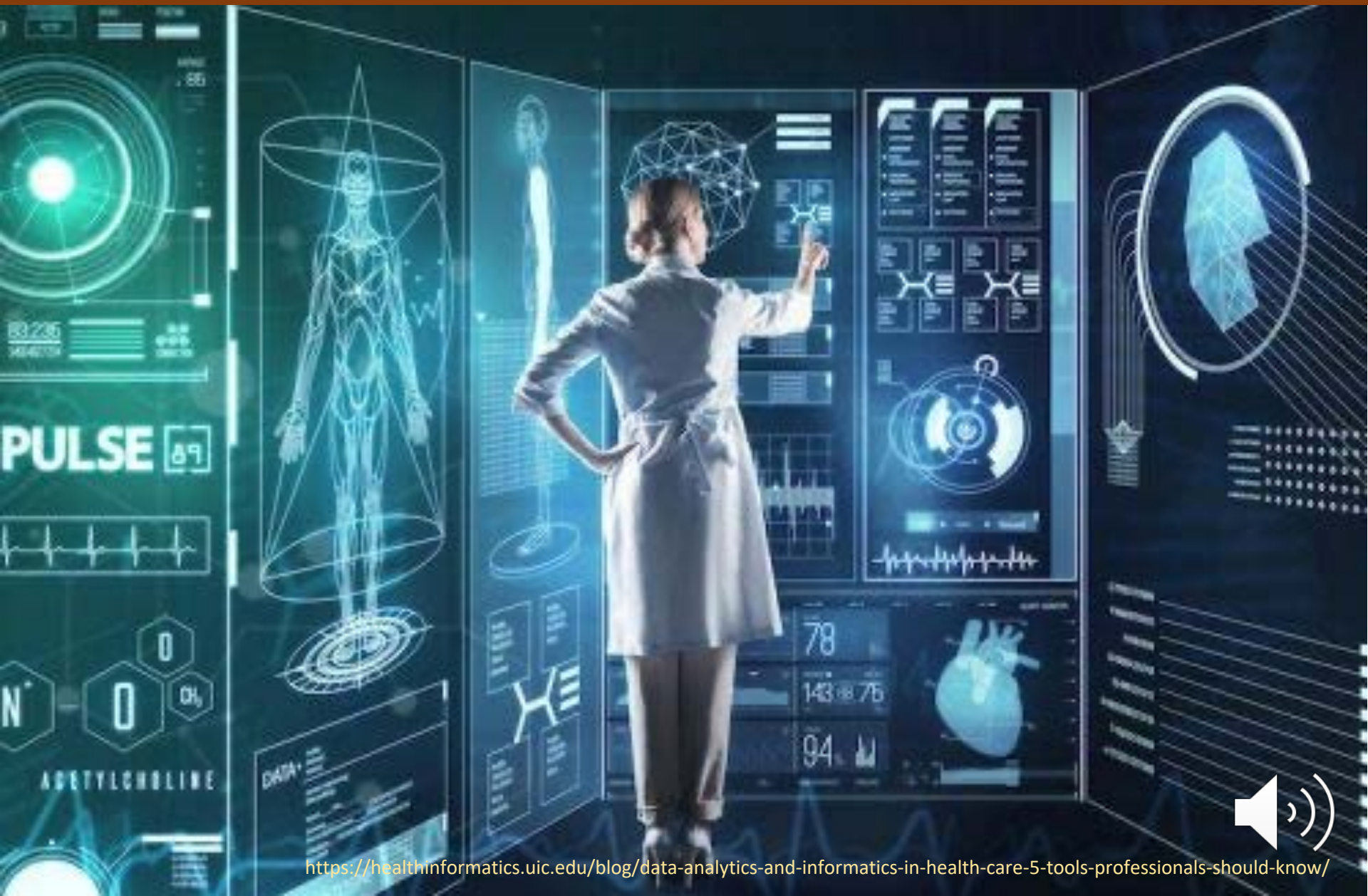
Outline

- Medical AI is the X-ray of the 21st Century.
- Medical AI is real, finally.
- Medical AI is easy.
- Medical AI is hard.
- Medical AI requires deep clinical integration.

Medical AI is the X-ray of the 21st Century.

A century ago, X-ray enabled doctors to see invisible structures inside the body.

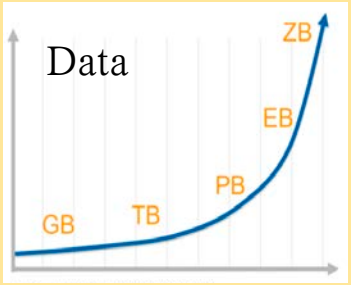
Today, AI is enabling doctors to not only see, but predict, previously unidentified patterns within massive medical and biological data.

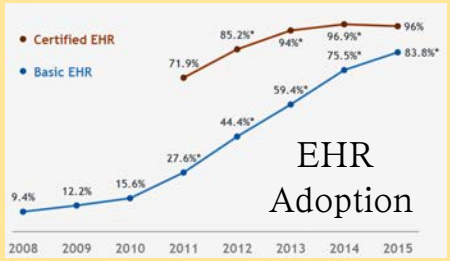


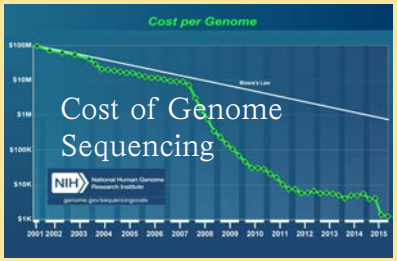
https://healthinformatics.uic.edu/blog/data-analytics-and-informatics-in-health-care-5-tools-professionals-should-know/

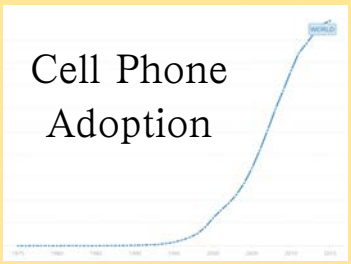
Medical AI is real, finally.

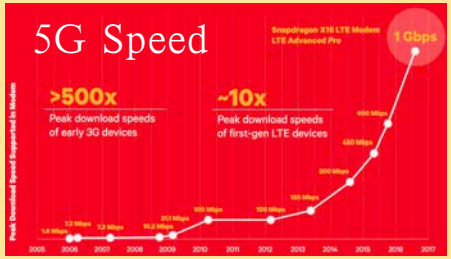
The Age of Acceleration

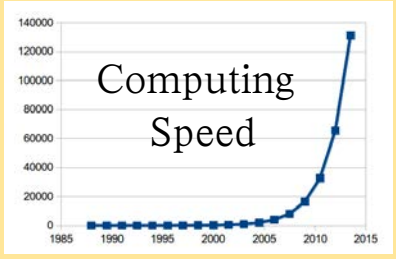


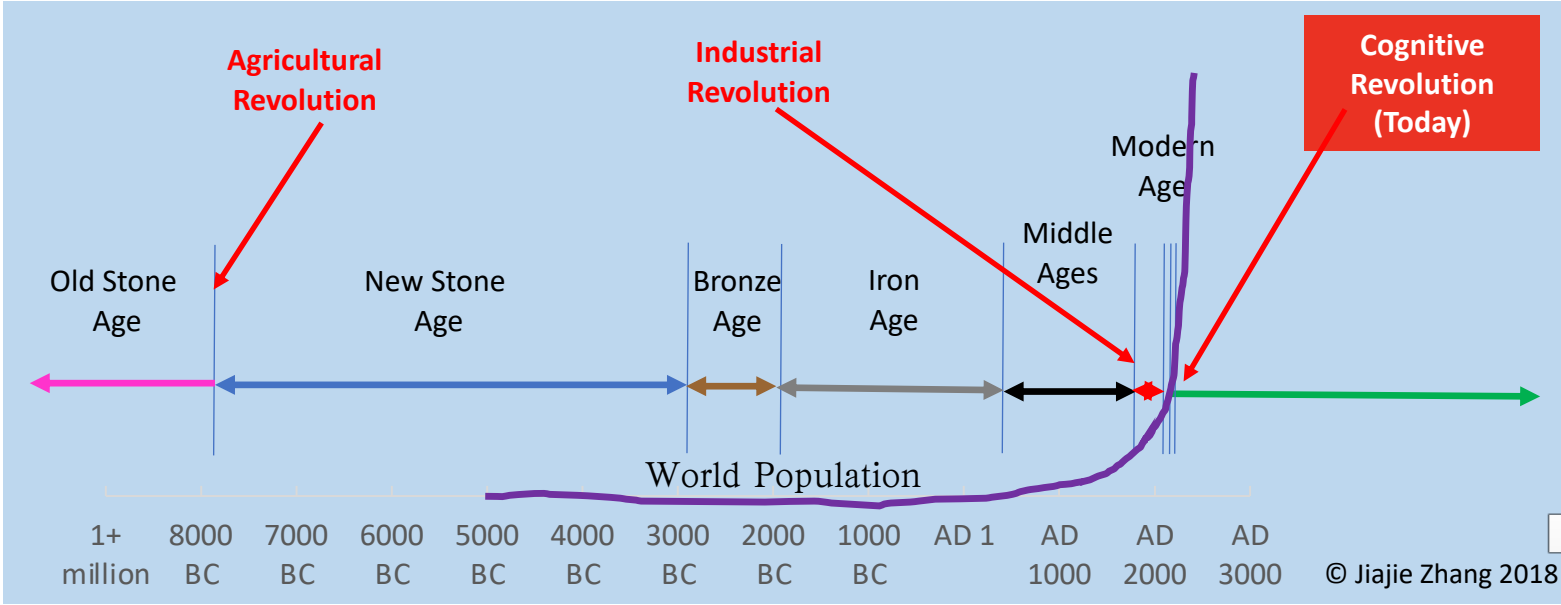












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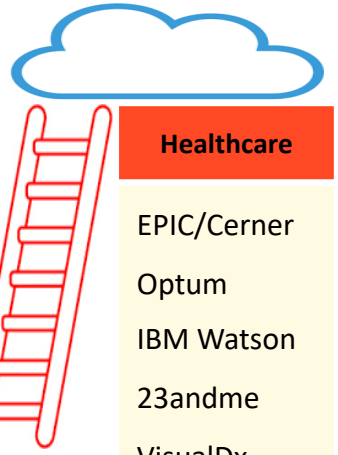
The Age of Disruption

"The past 20 or 30 years, and the next 20 or 30 years—really is historically unique. It is arguably the **largest economic disruption in recorded human history.**"
(Ben Sasse, US Senator, WSJ, April 21, 2017)



Information
- Yahoo
- Google
- Baidu
- Wikipedia
- Digital Pub

Communication
- Email
- Facebook
- Twitter
- iMessage
- Skype
- WeChat

Retail
- Amazon
- Alibaba
- eBay
- JD.com

Entertainment
- iTunes
- NetFlix
- YouTube
- Spotify

Travel
- Expedia
- AirBnB
- Uber

Finance
- PayPal
- ApplePay
- AliPay
- WeChat Pay
- Banking
- Credit
- Investment

Education
- MOOC
- edX
- Coursera
- Hybrid
- Modular

Healthcare
- EPIC/Cerner
- Optum
- IBM Watson
- 23andme
- VisualDx

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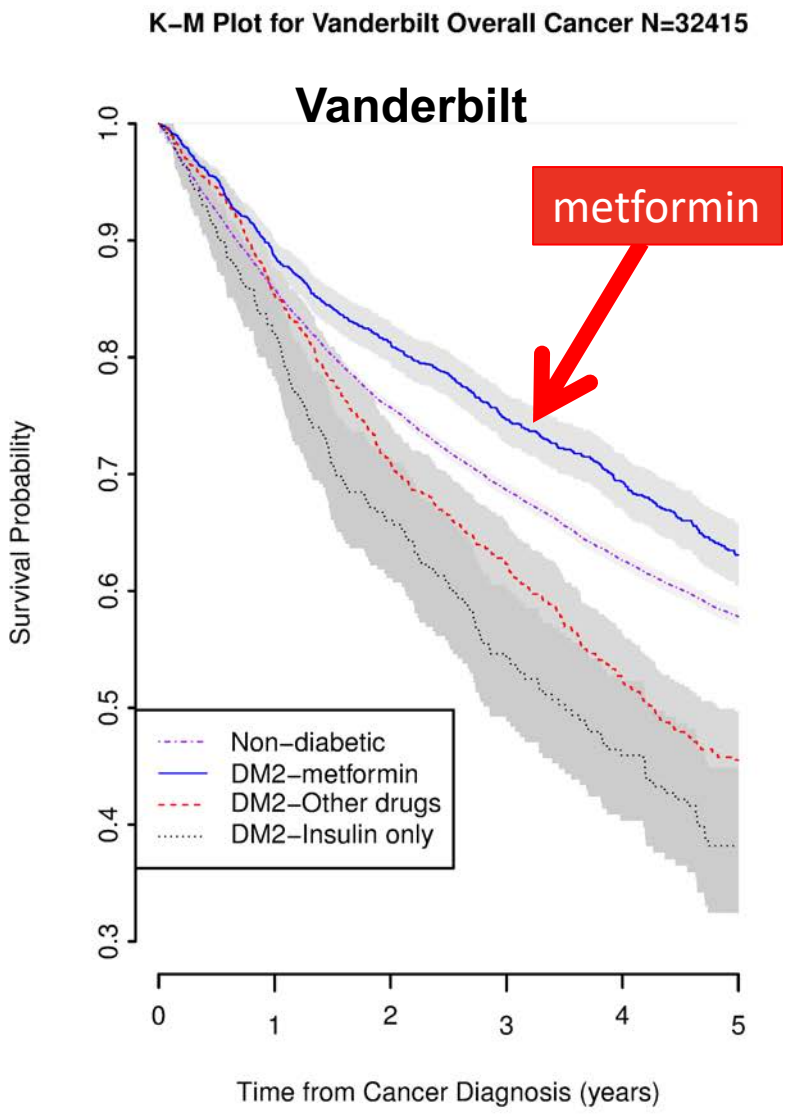
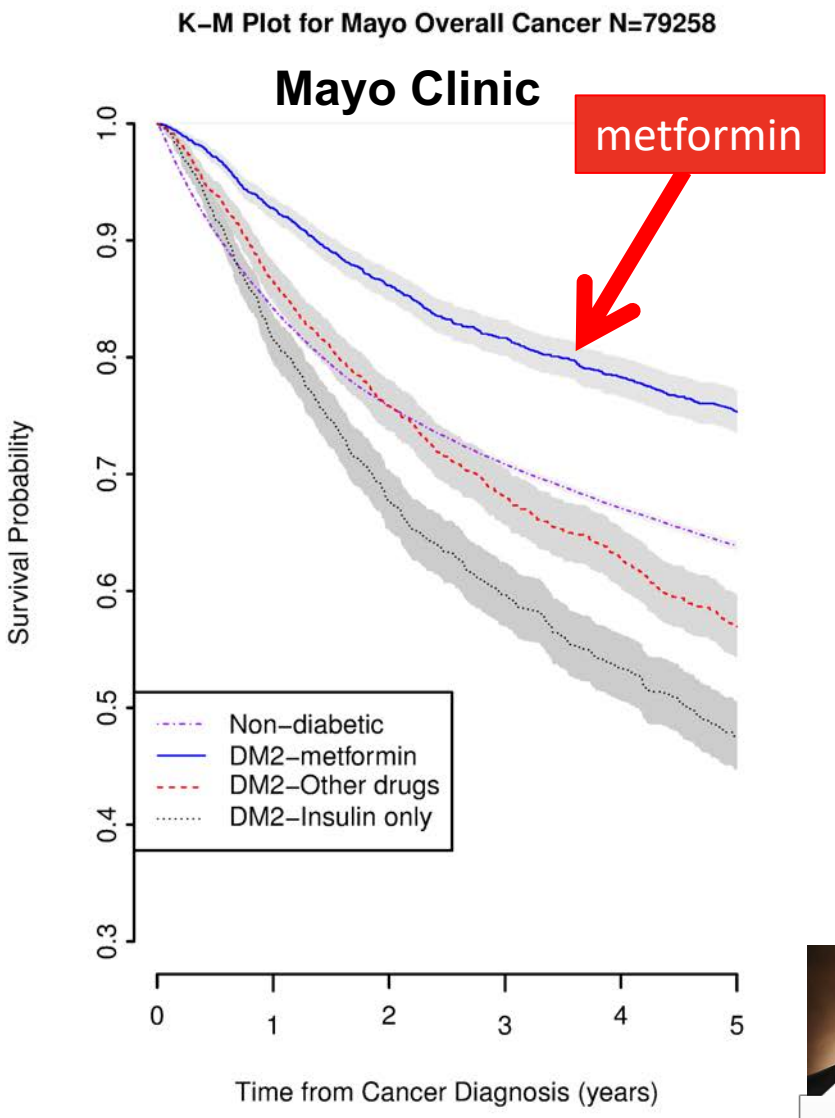
Examples of Medical AI Applications

- Read images (X-Ray, CT, skin, retina, etc.)
- Predict which COVID patients need ventilators
- Predict sepsis onset before detection
- Use Natural Language Processing (NLP) to process notes, reports, etc.
- Make diagnosis for common and rare diseases
- Calculate risks (MI, heart failure, readmission, etc.)
- Predict disease progression (e.g., diabetes to retinopathy to kidney failure)
- Detect Parkinson's from keyboard typing or smartphone touching
- Discover new functions of existing drugs
- Discover genetic mutations of cancers
- Take medical license exams
- Discover and predict insurance claims
- Optimize coding for billing
- More, more, more…

Drug Repurposing: Metformin for Cancer Treatment





Hua Xu et al. (2015). Validating drug repurposing signals using electronic health records: a case study of metformin associated with reduced cancer mortality. Journal of American Medical Informatics Association, 22 (1), 179–191

Hua Xu

Degui Zhi

A study of Generalizability of Recurrent Neural Network-Based Predictive Models for Heart Failure Onset Risk using a Large and Heterogeneous EHR Data set

J Biomed Inform. 2018 August ; 84: 11–16. doi:10.1016/j.jbi.2018.06.011

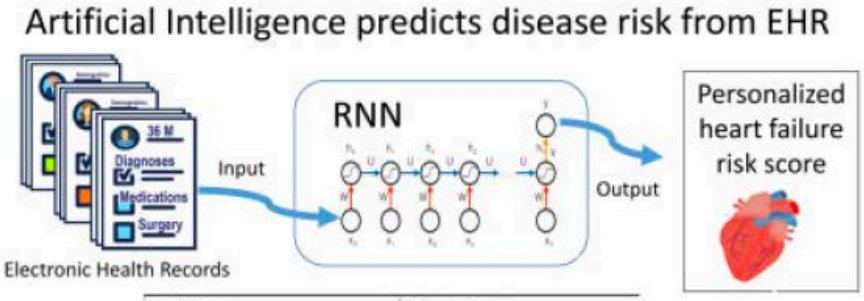
Laila R Bekhet[1], **Yonghui Wu**[2], **Ningtao Wang**[3], **Xin Geng**[1], **Wenjin Jim Zheng**[1], **Fei Wang**[4], **Hulin Wu**[3], **Hua Xu**[1,*], and **Degui Zhi**[1,*]

Heart Failure

- the heart can't pump enough blood to meet the body's needs.
- 5 million US patients in 2016
- $30 billion cost

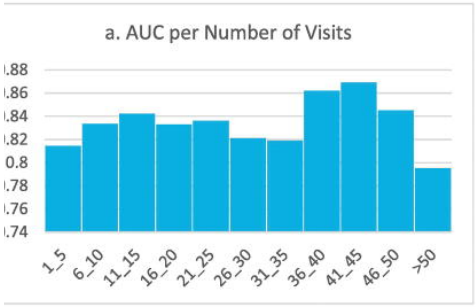
Cerner Healthfacts Database

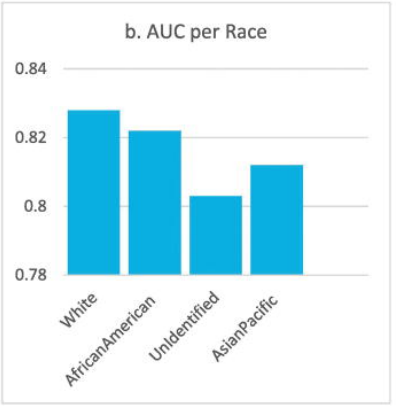
- 600 hospitals/clinics
- 50 million unique patients
- > 10 years of records
- 110 million patient visits

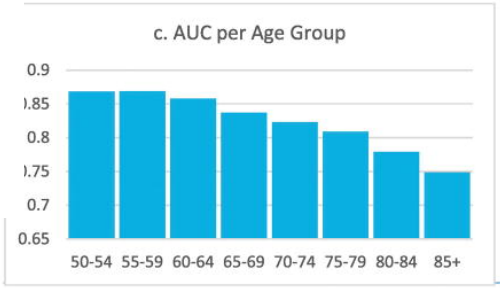


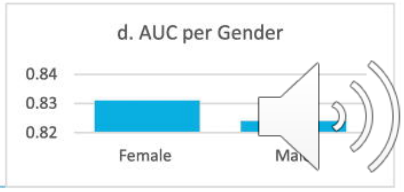
Before	Our Study
3,884 patients	152,790 patients
1 health systems	81 health systems
AUC 87%	AUC 79 – 85% across hospitals

Transfer to other hospitals with only 3.6% reduction of AUC



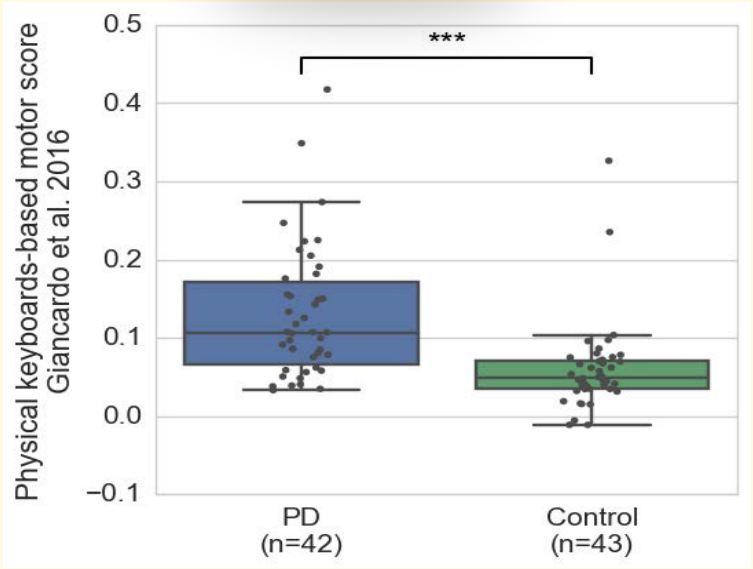


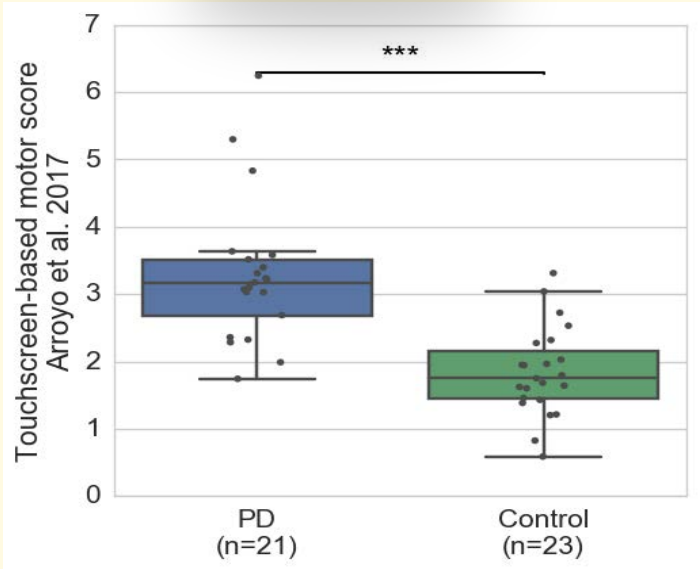




Detect Parkinson's Disease from Typing or Touching

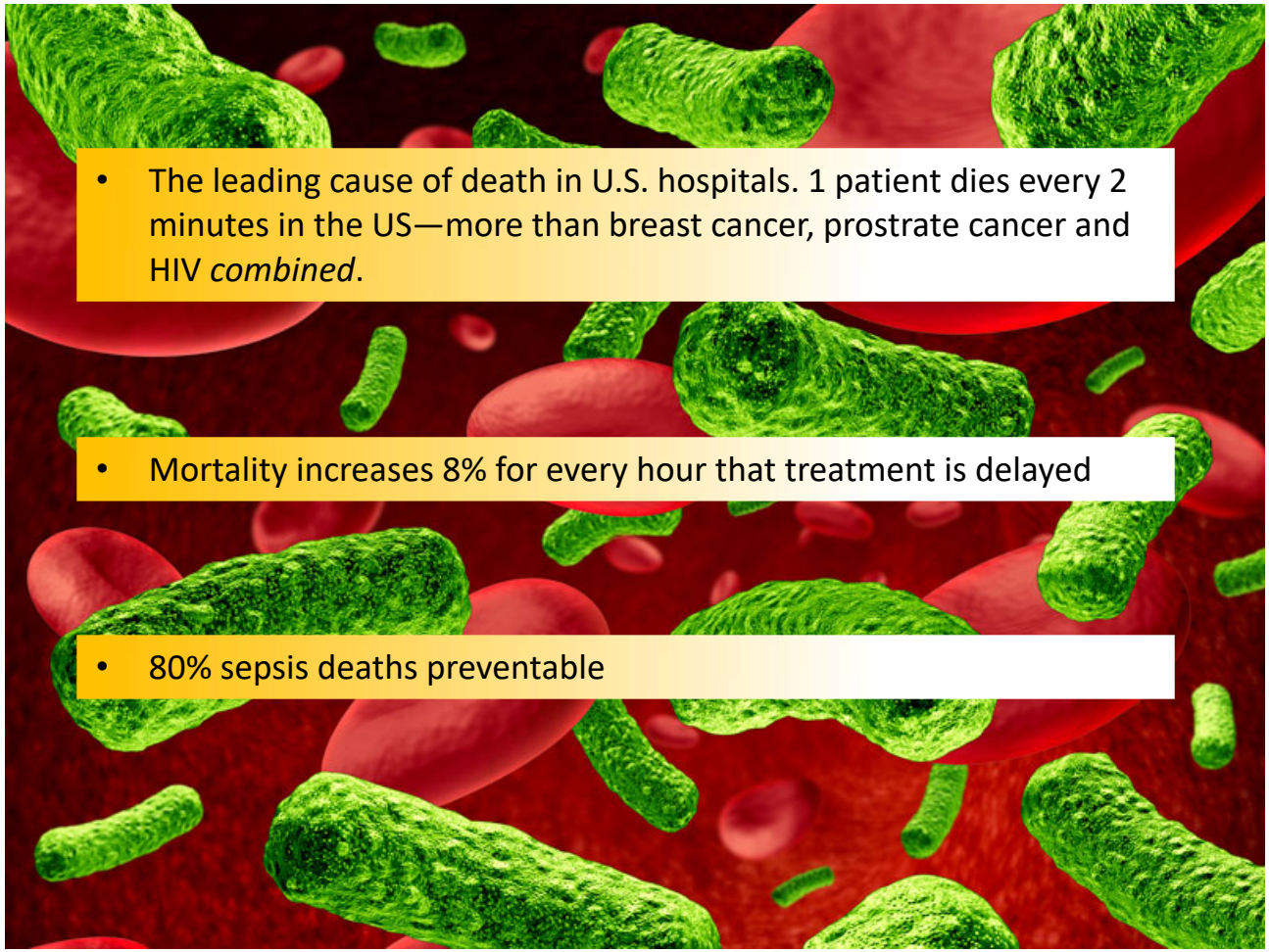
Luca Giancardo





Giancardo et al., Psychomotor Impairment Detection via Finger Interactions with a Computer Keyboard During Natural Typing. *Nature Scientific Reports, 2015*.

Sepsis Prediction Before Onset



- The leading cause of death in U.S. hospitals. 1 patient dies every 2 minutes in the US—more than breast cancer, prostrate cancer and HIV *combined*.
- Mortality increases 8% for every hour that treatment is delayed
- 80% sepsis deaths preventable

UTHealth Project:

4 Hour **Prediction** of Severe Sepsis:

Model: Deep LSTM

Performance (AUC)

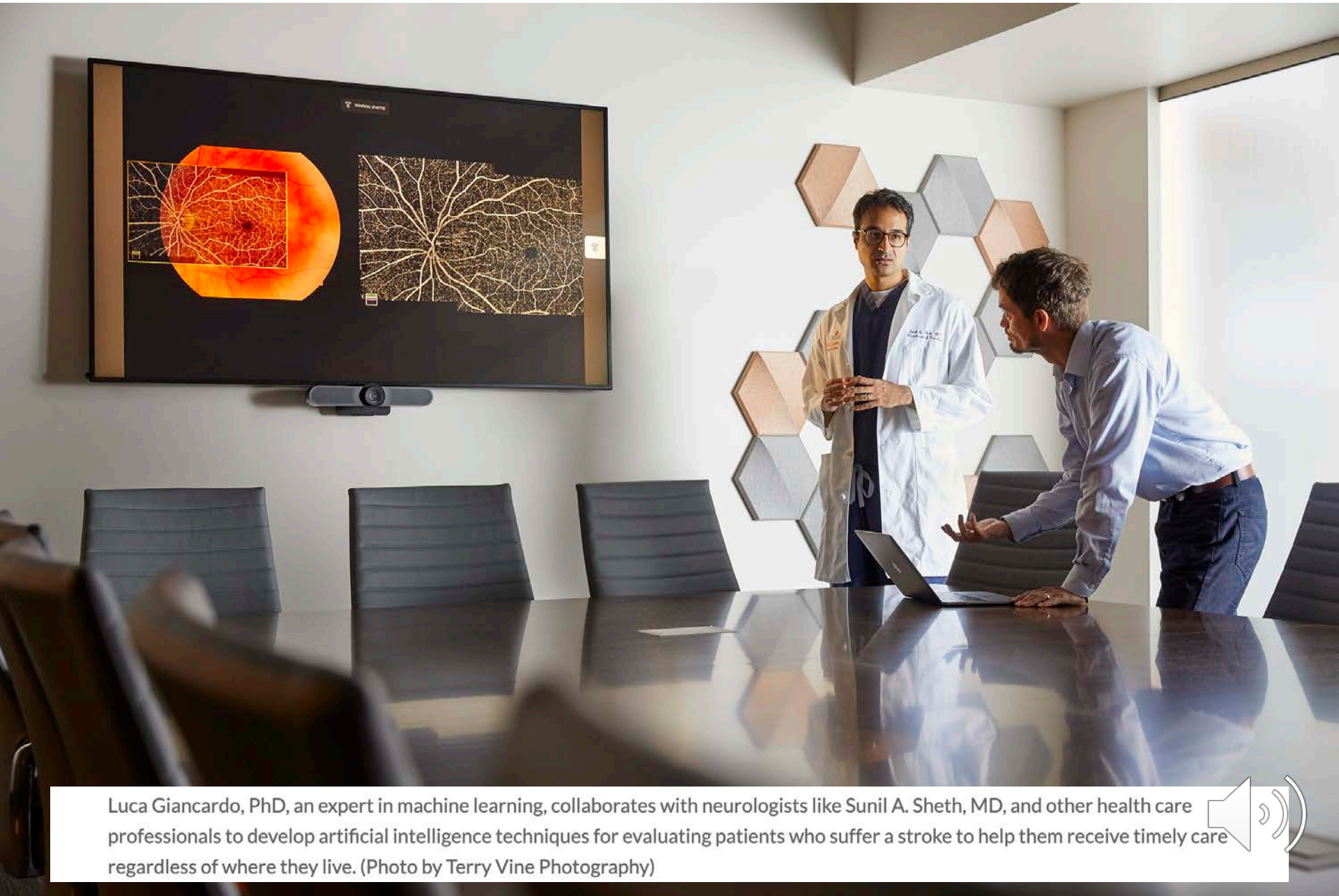
- AUC = 0.92
- Status Quo 0.85

Bella Patel, MD

Xiaoqian Jiang, PhD

Robert Murphy, MD

The Eyes Are The Windows Of Health

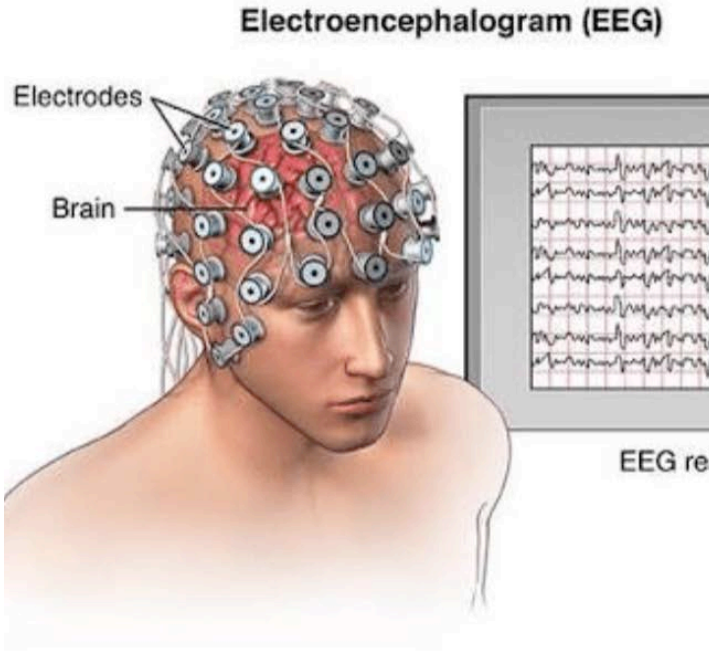


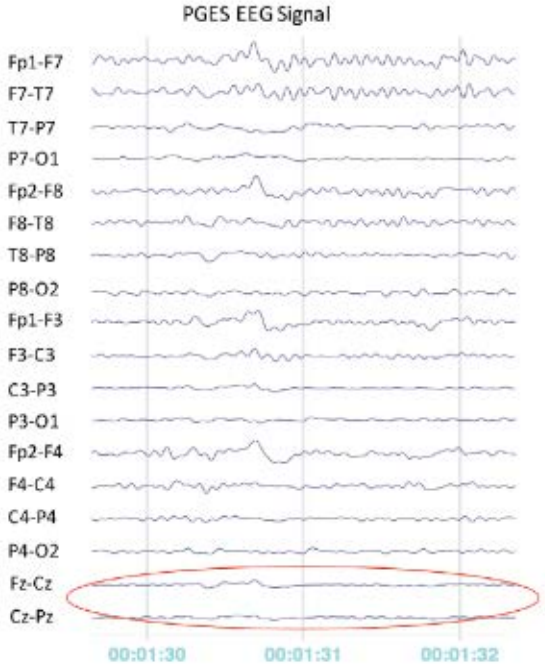
Luca Giancardo, PhD, an expert in machine learning, collaborates with neurologists like Sunil A. Sheth, MD, and other health care professionals to develop artificial intelligence techniques for evaluating patients who suffer a stroke to help them receive timely care regardless of where they live. (Photo by Terry Vine Photography)

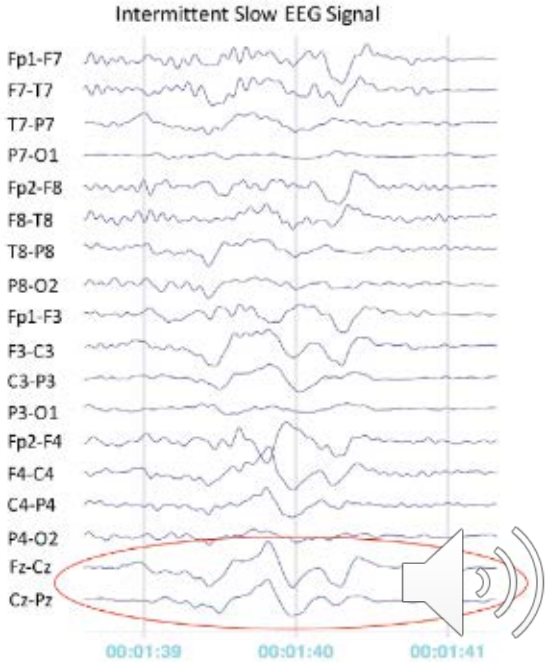
Medical AI is easy.

Predict
Sudden Unexpected Death in Epilepsy (SUDEP)

- 35 students from Rice, UTHealth, TAMU, University of Houston, etc.
- Detect the onset of slow activity after seizures based on messy EEG signals
- AUC 0.84 from the best model
- Published 5 papers in a BMC special issue

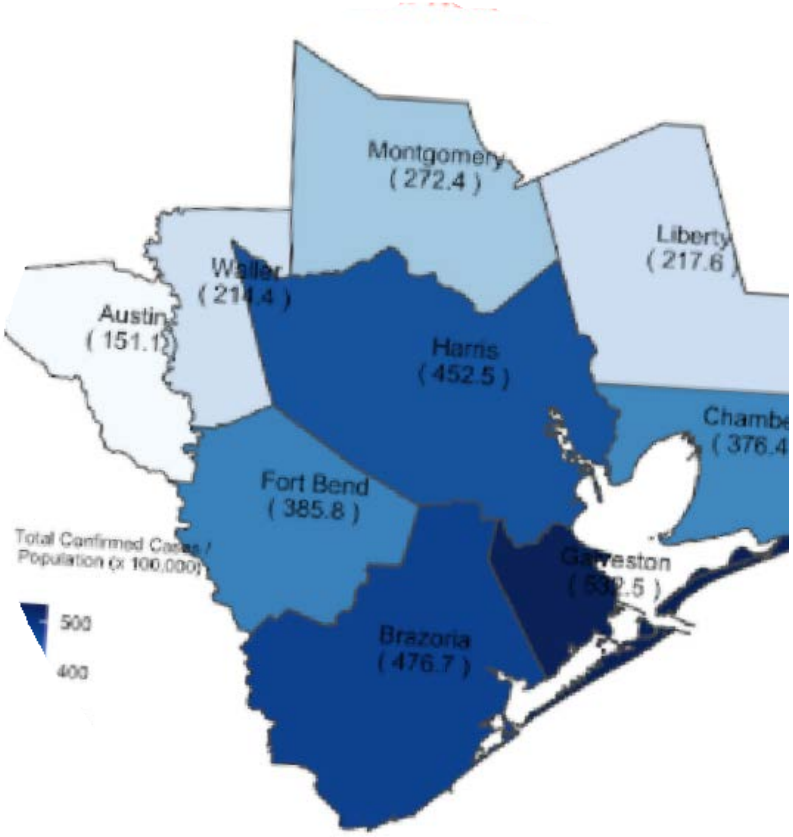


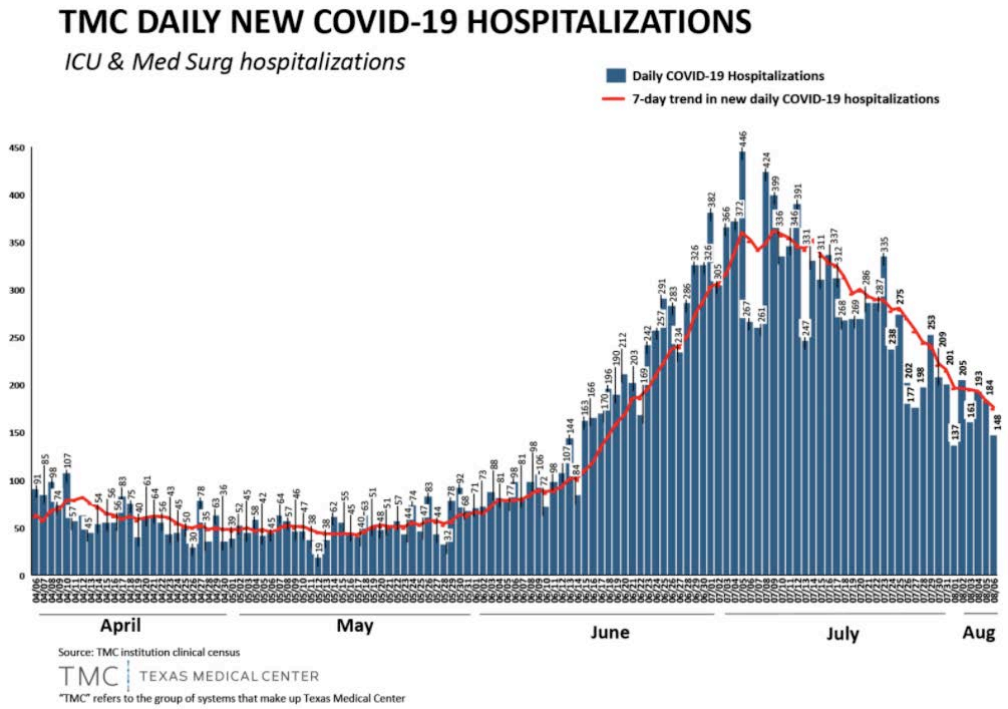




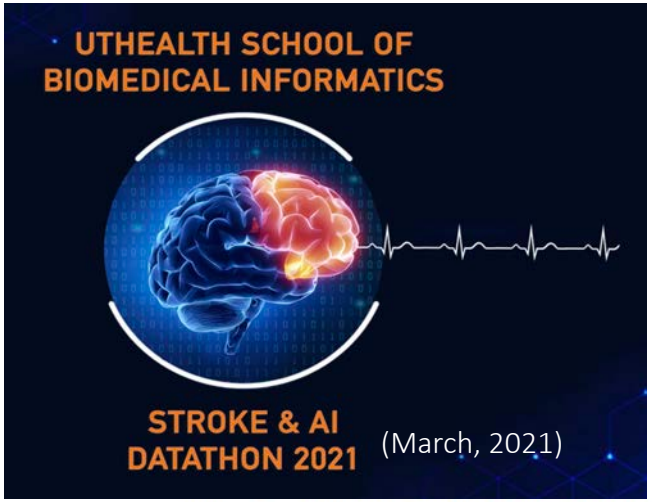
COVID-19 HOUSTON

DATATHON 2020



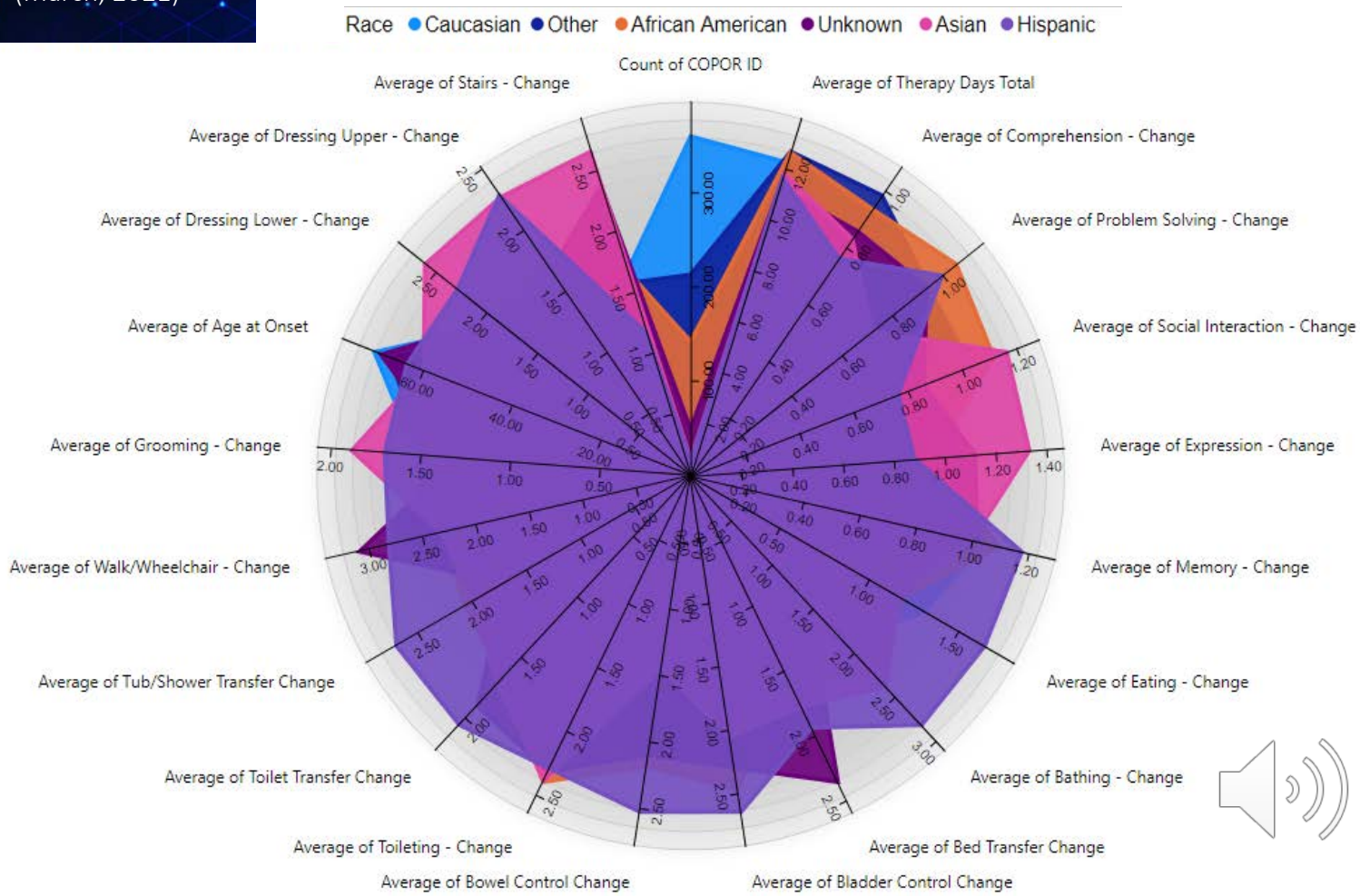


- Predict COVID-19 hospitalization and mortality in Houston Metro Area
- Data available:
  - historical hospitalization and mortality rates;
  - infection, recovery, active, and test cases (9 counties)
  - population mobility, demographics, and mask usage
- 34 students from Rice, UTHealth, U. of Houston, etc.
- Best model performance:
  - Mean Squared Logarithmic Error (MSLE) for 8 counties is 16.5

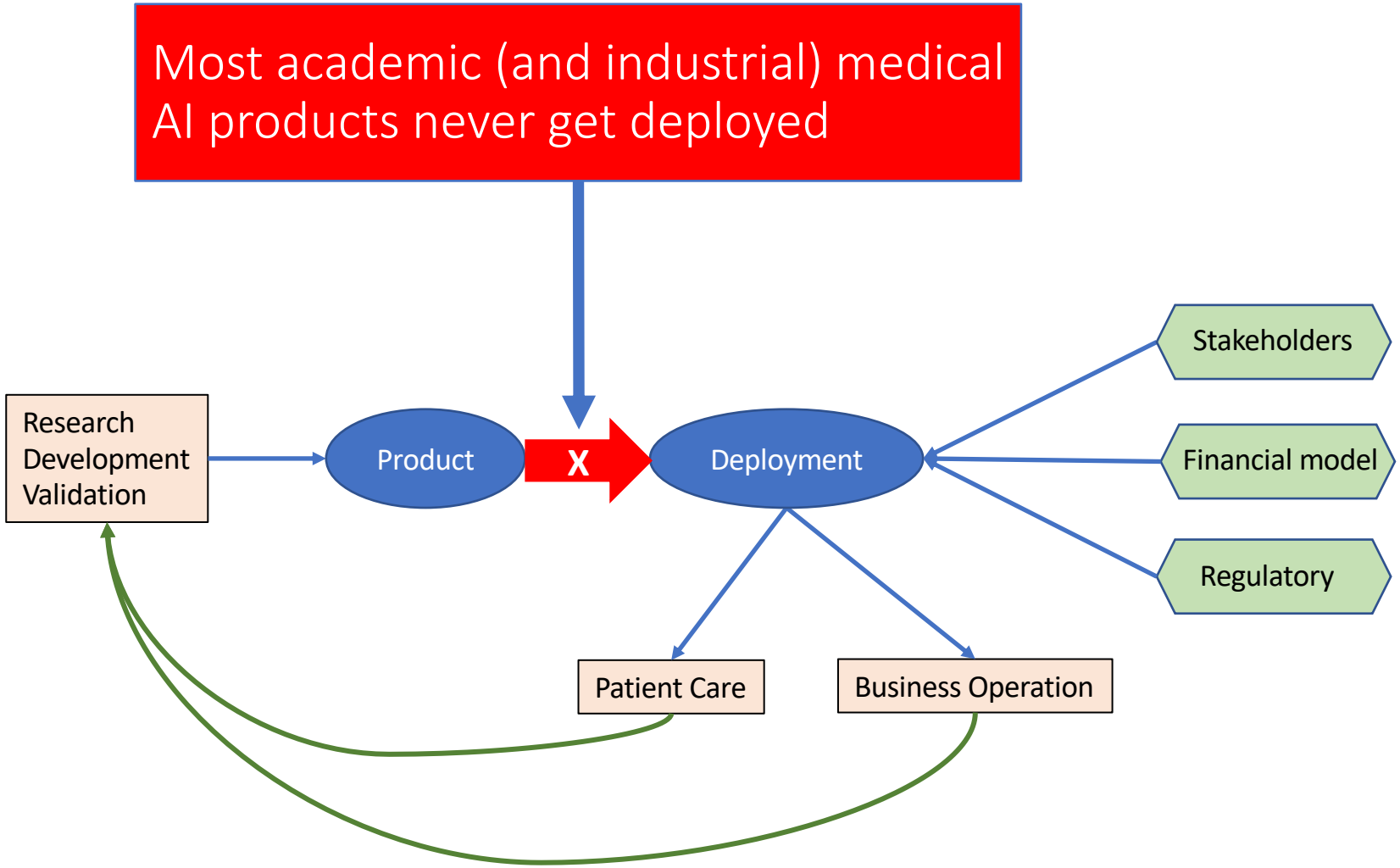


(March, 2021)

- In 2017, 7.8 million US adults survived a stroke. Stroke remains a leading cause of morbidity and disability.
- Develop algorithms to predict changes in cognitive and Functional Independence Measure (FIM) scores
- 27 students from Rice, UTHealth, TAMU, University of Houston, etc.
- Best model performance:
  - L1 (Manhattan) distance = 14.36 on 18 FIM scores

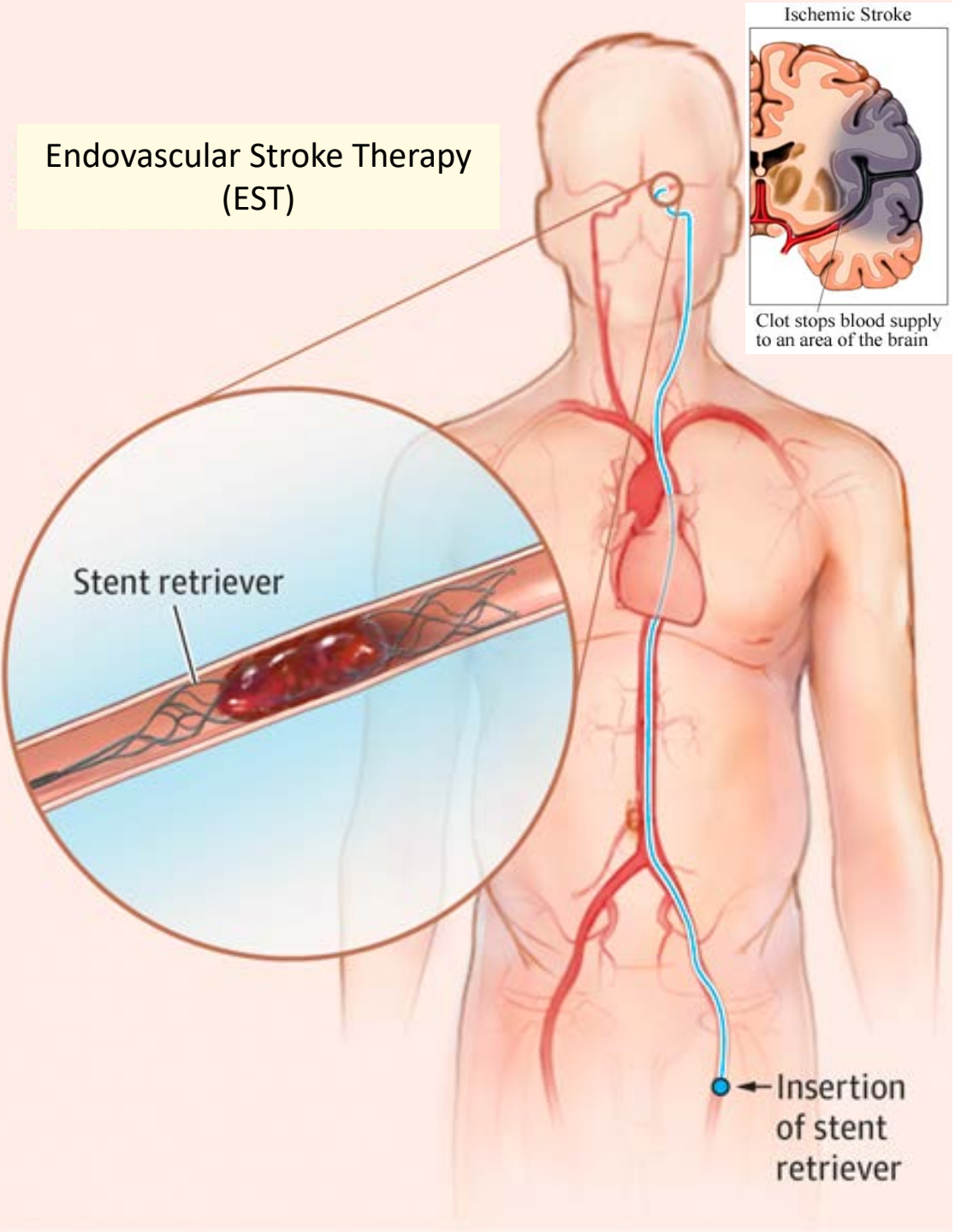


Medical AI is hard.


Most academic (and industrial) medical AI products never get deployed
Research
Development
Validation
Product
X
Deployment
Stakeholders
Financial model
Regulatory
Patient Care
Business Operation

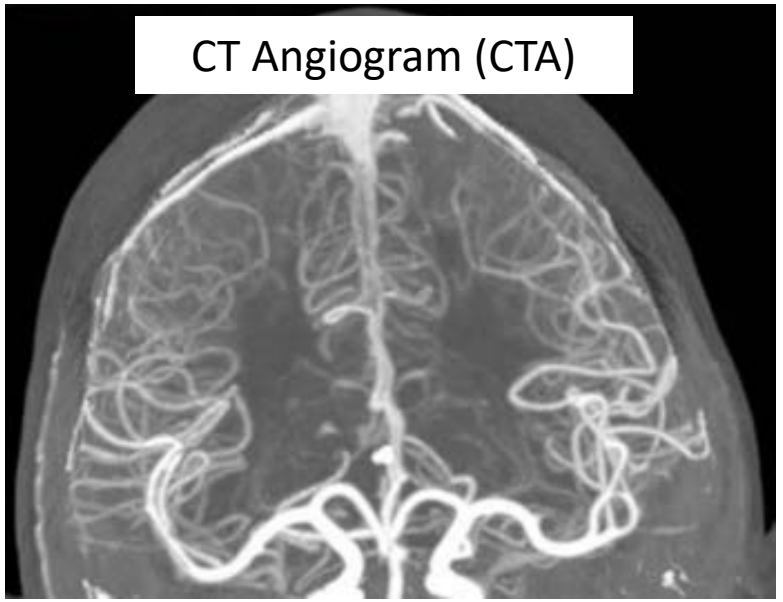
A Case Study:
CT Imaging for Stroke

Endovascular Stroke Therapy (EST)



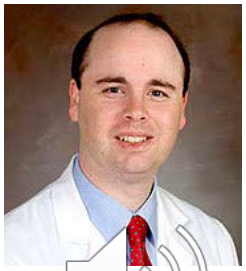
- Ischemic Stroke: 87% of all strokes
- Endovascular Stroke Therapy (EST) significantly improves stroke outcomes
- CT Perfusion (CTP) is not widely available
- CT Angiogram (CTA) can help determine eligibility

CT Angiogram (CTA)



Luca Giancardo PhD

Sunil Sheth MD



Sean Savitz MD

Current Stroke Care

65 minutes (median)

Patient with possible AIS arrives in the ER → Rapid clinical exam and CT imaging performed → ~ 5 min. → Imaging sent to PACS → Radiologist → Radiologist Report → Neurologist/ER Physician → **Treatment Decision**

DeepSymNet Care

Brain images automatically analyzed by DeepSymNet, a machine learning based algorithm

Alerts indicating the most likely stroke type

1 minute

Patient with possible AIS arrives in the ER → Rapid clinical exam and CT imaging performed → ~ 5 min. → Imaging sent to PACS → Radiologist → Radiologist Report → Neurologist/ER Physician → **Treatment Decision**

DeepSymNet reduces the time to treatment decision

MEMORIAL HERMANN

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Current Status

- The algorithm works well as stroke alert generation
- 1,985 unique subjects from 1/15/2020 to 1/10/2021.
- Pipeline running time < 1 min
- Pipeline integrated in 4 hospitals at Memorial Hermann System

New LHC Relevant Study. LVO likely.

LS

lhc-stroke@googlegroups.com <lhc-stroke@googlegroups.com>
on behalf of LHC server <deepsymnet@gmail.com>
To: lhc-stroke@googlegroups.com

ATT00001.png
446.3 KB

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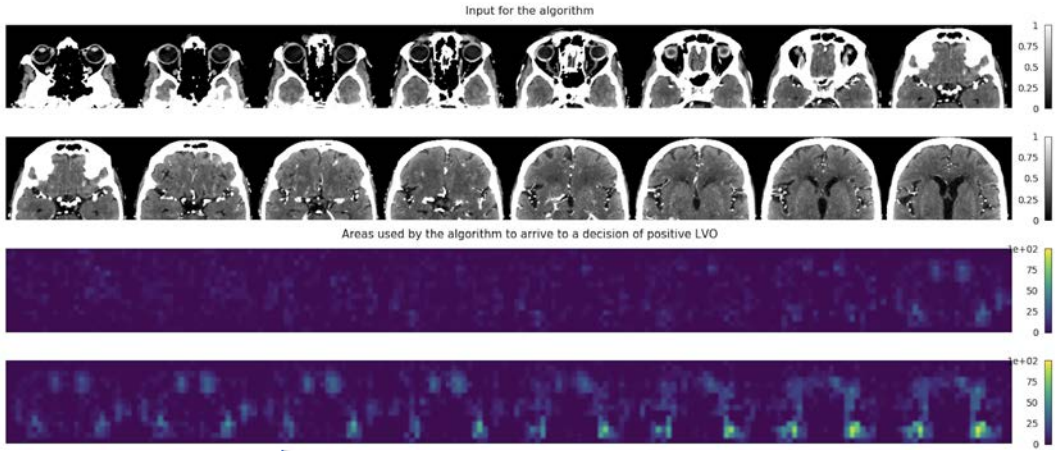
**** EXTERNAL EMAIL ****

New Study
InstitutionName: 'Memorial Hermann MC'
StationName: 'MCSIECTER1'
StudyDescription: 'BRAIN/NECK STROKE CTA'
SeriesDescription: 'Scout', 'Patient Protocol', 'CTA', 'Angio 0.6', 'Cor-MIP', 'Sag- MIP', 'Sagittal', 'Coronal', '1mm Sag- MIP', '1mm Cor-MIP'
Acquisition date and time: Wed Jul 15 12:40:41 2020 - Wed Jul 15 12:40:56 2020

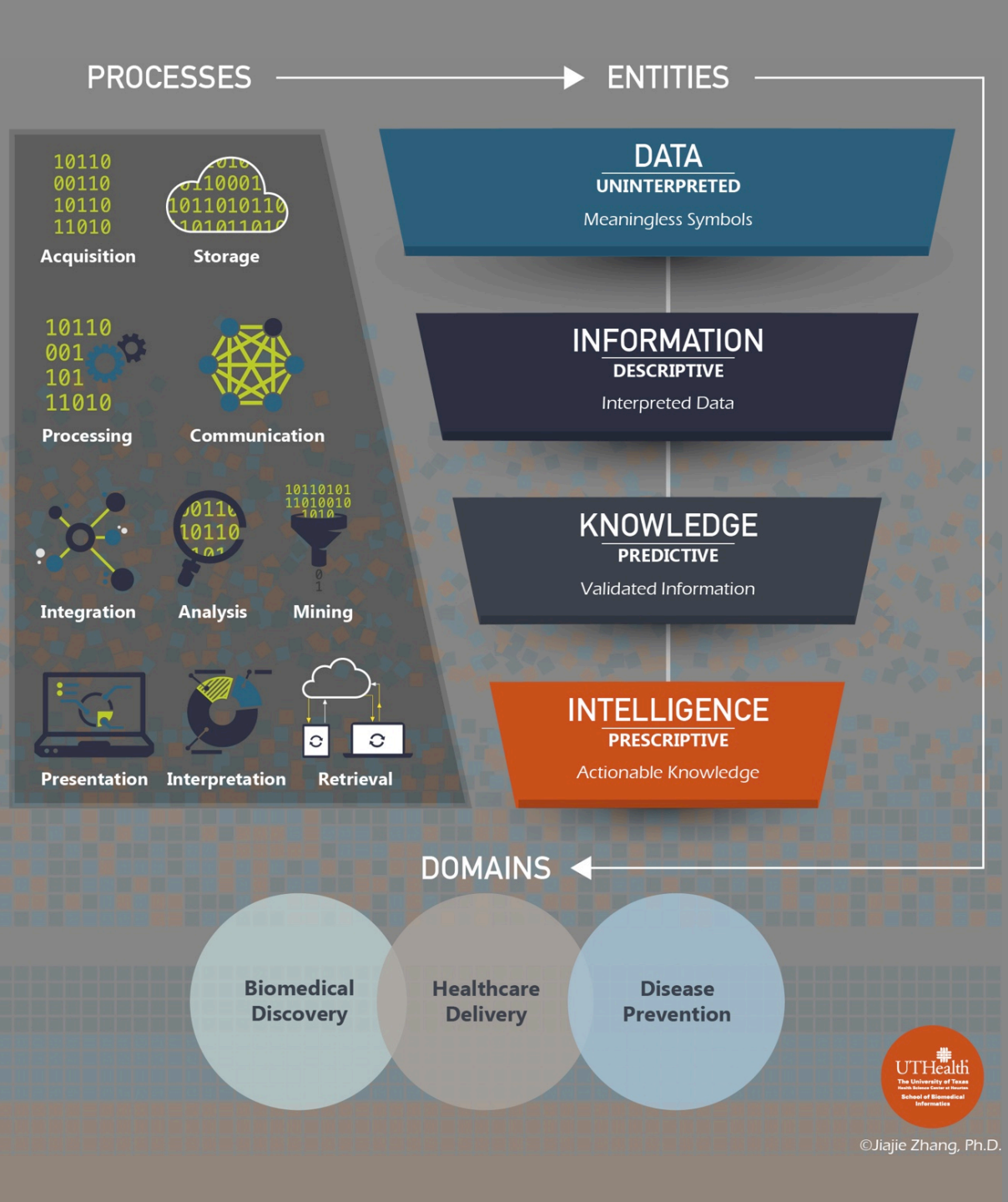
========ML analysis
LVO score from CTA: 0.54
CTA Series Used: Angio 0.6

IQR for non-LVO subjects 0.03 - 0.13
IQR for LVO subjects 0.13 - 0.93
(estimated on validation set n=441, AUC=0.85)
model ver. exp34-newnet-p2



- Record FAST time of “bench-to-bedside”. It took a year to go from idea to implementation in the hospital
- First “in-house” multisite live imaging / machine learning pipeline in the UTHealth-Memorial Hermann
- This framework can be expanded to many other projects

Medical AI requires deep clinical integration.


PROCESSES
ENTITIES
Acquisition
Storage
Processing
Communication
Integration
Analysis
Mining
Presentation
Interpretation
Retrieval
DATA
UNINTERPRETED
Meaningless Symbols
INFORMATION
DESCRIPTIVE
Interpreted Data
KNOWLEDGE
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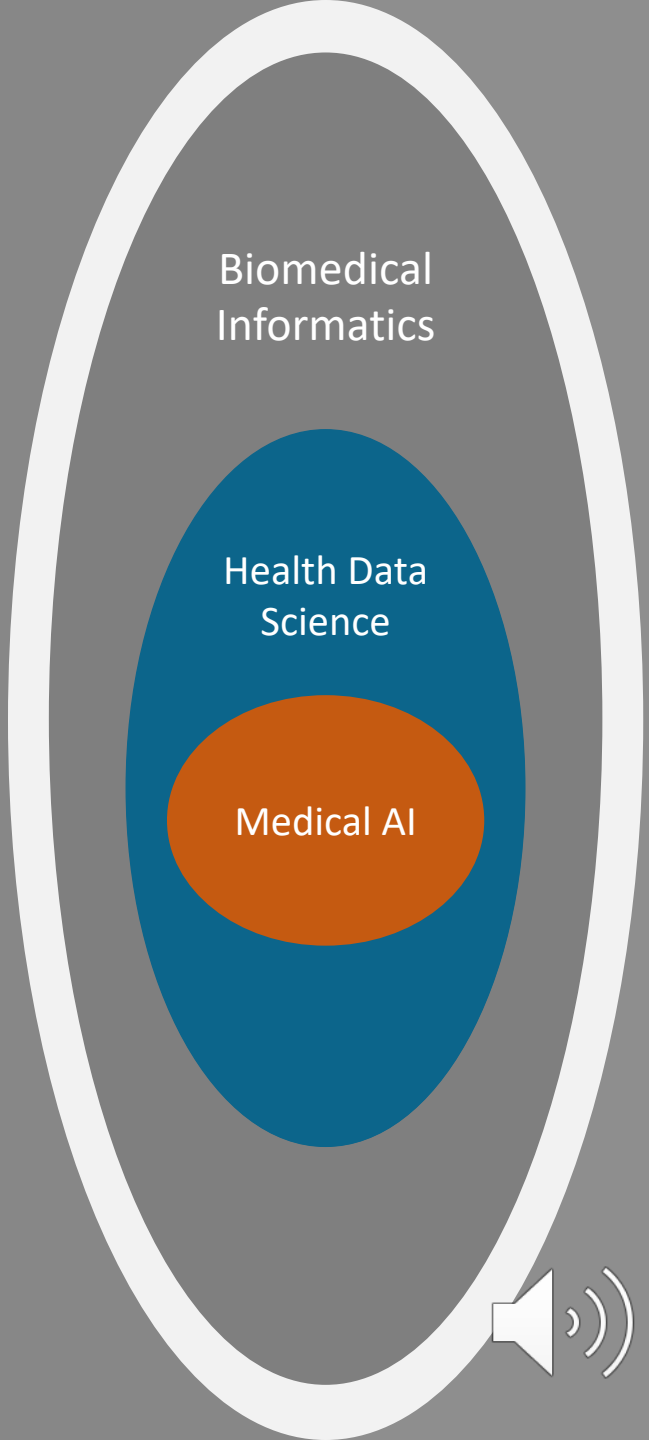
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