

How is artificial intelligence helping medicine?

Michele Filannino, Ph.D.
(Postdoctoral fellow at SUNY & MIT)

Artificial Intelligence

What is it?

picture from Ex Machina, 2014



Artificial Intelligence

What is it?

picture from Terminator Genisys, 2015





Patrick Henry Winston

Ford Professor of Artificial Intelligence and Computer Science, MIT

“Artificial Intelligence is the study of ideas which enable computers to do the things that make people seem intelligent”

From Winston P. W., Artificial Intelligence, Addison-Wesley, Reading, Mass., (1977).

Playing chess?

1996

Chess is a two-player strategy board game played on a chessboard, a checkered game board with 64 squares arranged in an eight-by-eight grid.

It comes from India (around the 7th century) and was popularized and refined in Spain (15th century).

Gary Kasparov vs. IBM Deep Blue



Playing go?

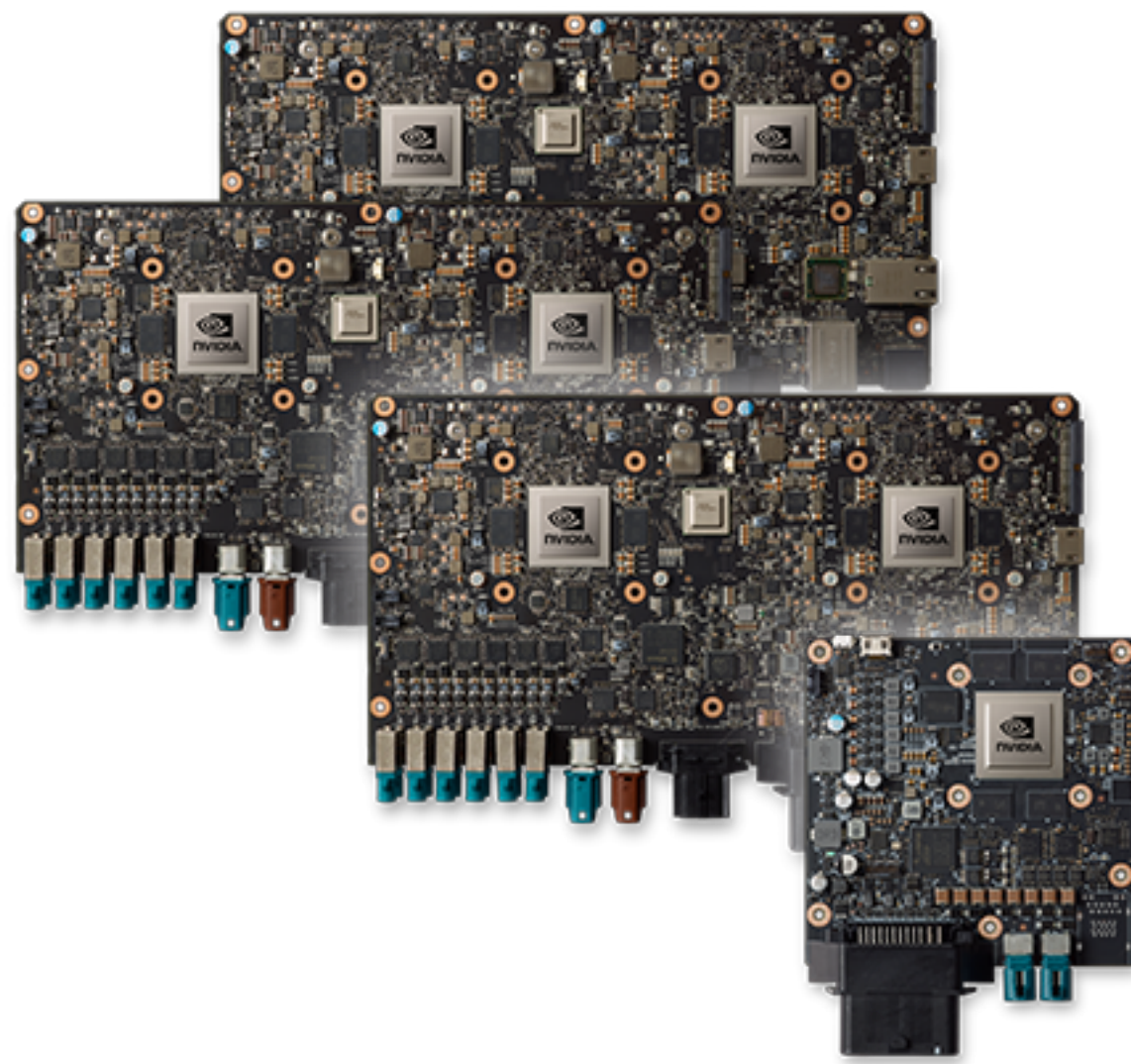
2016

Go is an abstract strategy board game for two players, in which the aim is to surround more territory than the opponent.

It's an ancient Chinese game. It's much more complex than chess, although its rules are very simple.

Lee Sedoi vs. Google Alpha Go

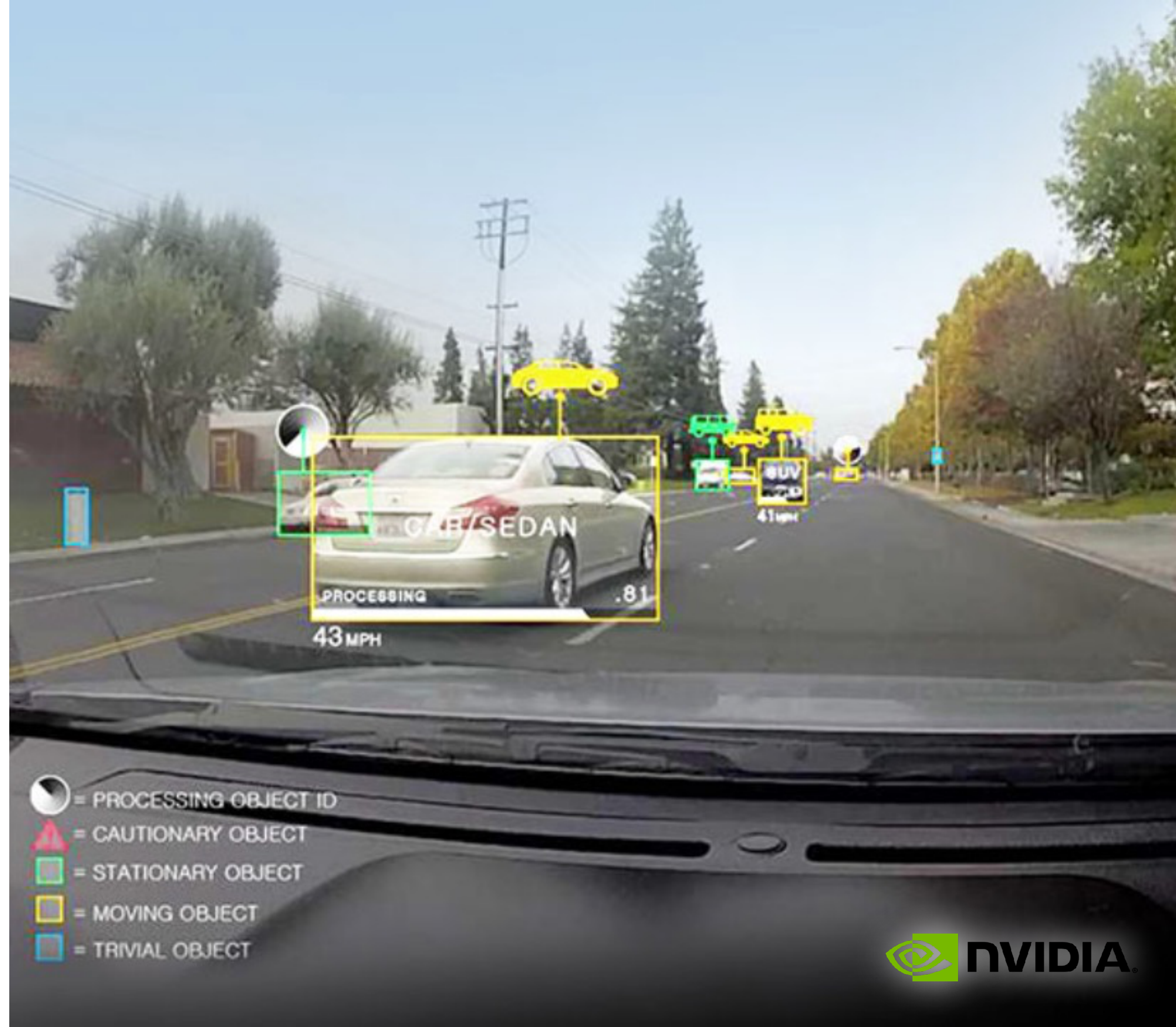


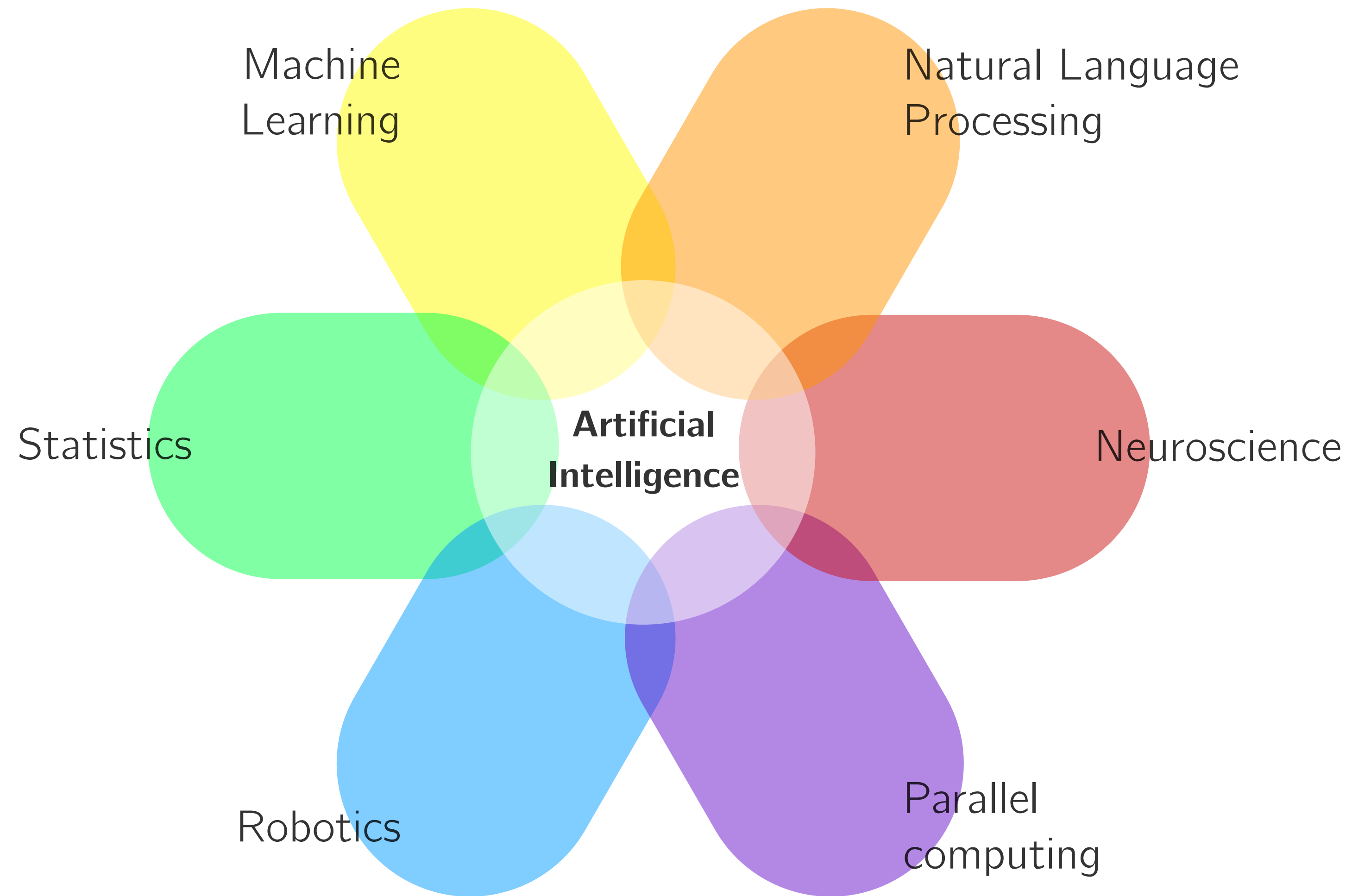


Driving a car?

2017

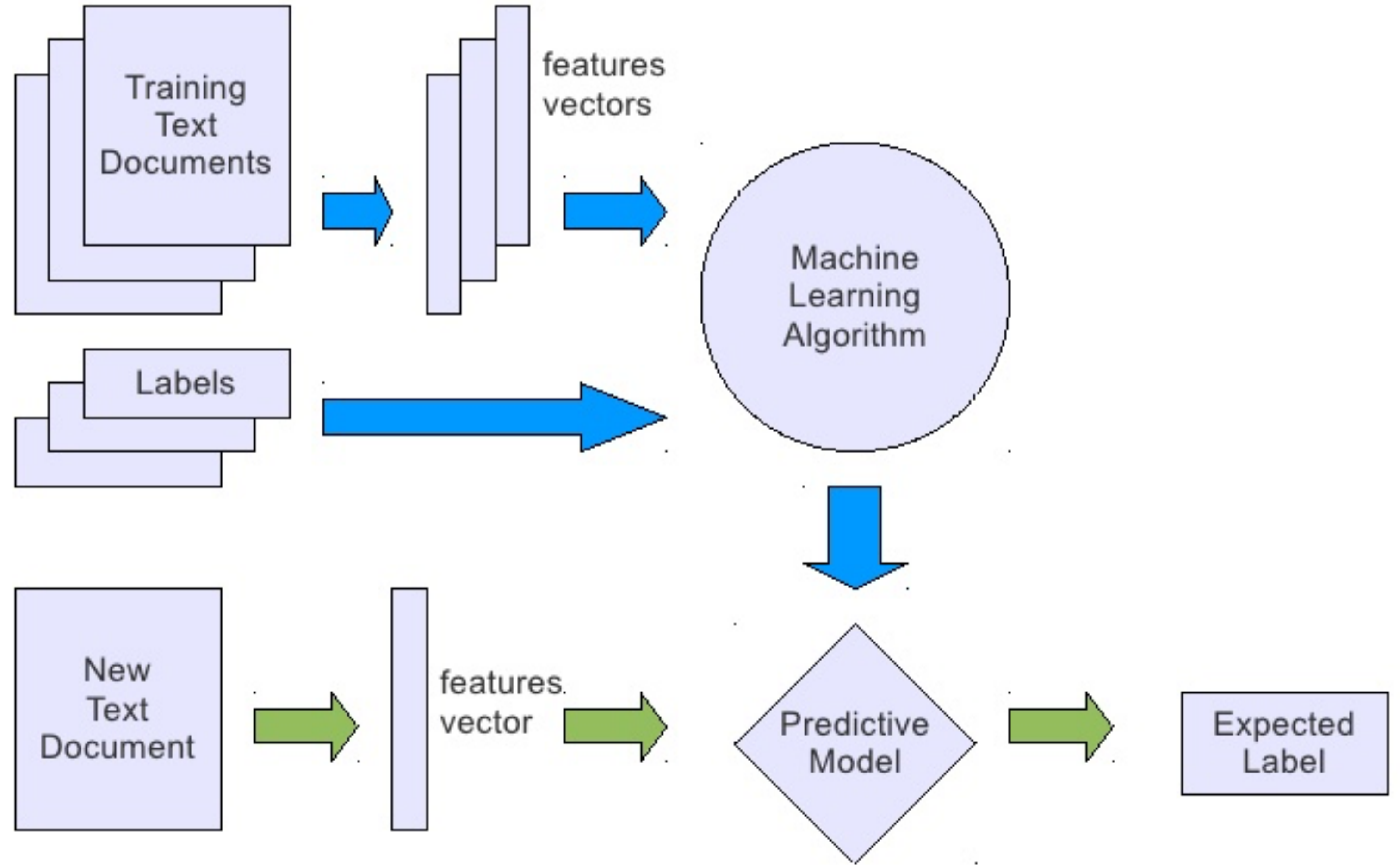
nVIDIA Drive PX 2 is the open AI car computing platform that enables automakers and their supplier to accelerate production of automated and autonomous vehicles.





supervised machine learning

summary



my heroes

I enjoy my work because of them.



Özlem Uzuner
SUNY



Amber Stubbs
Simmons college



Peter Szolovits
MIT



Kevin Buchan
Ph.D. student at SUNY



Carson Tao
Ph.D. student at SUNY



Oladimeji Farri
PHILIPS Healthcare

the US healthcare system

- spends \$3.05 trillion (17% of GDP)¹
(the equivalent of 10 Olympic games + the TOP 15 richest companies + the TOP 50 biggest private foundations)
 - \$9,245 per person
- wastes \$750 billion²:
(the equivalent to fund NASA for the last 50 years)
 - unnecessary services (\$210 billion annually)
 - inefficient delivery of care (\$130 billion)
 - excess administrative costs (\$190 billion)
 - inflated prices (\$105 billion)
 - fraud (\$60 billion)
 - prevention failures (\$55 billion)
- kills 400,000+ people by mistake³ (*preventable deaths*):
 - 1095+ people per day



¹ http://apps.who.int/iris/bitstream/10665/170250/1/9789240694439_eng.pdf

² <http://www.nationalacademies.org/hmd/Reports/2012/Best-Care-at-Lower-Cost-The-Path-to-Continuously-Learning-Health-Care-in-America.aspx>

³ James J.T. A New, Evidence-based Estimate of Patient Harms Associated with Hospital Care, *Journal of patient safety*, V. 9, I. 3, p.122-128, Sept. 2013

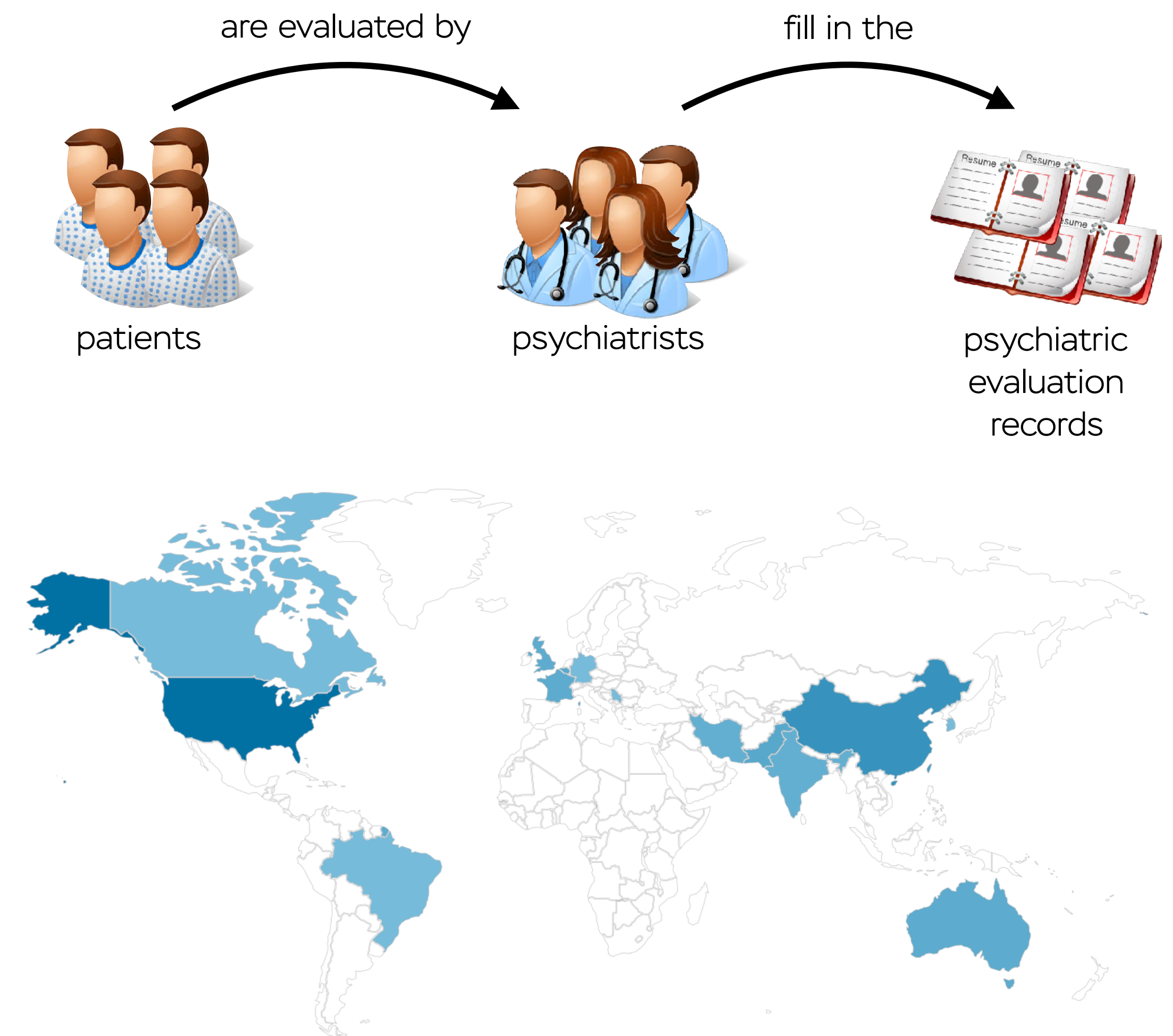
acts & programs

- 1996: HIPAA (Health Insurance and Accountability Act)
- 2009: ARRA (American Recovery and Reinvestment Act)
- 2009: HITECH (Health Information Technology for Economic and Clinical Health Act)
- 2015 EHFA (Electronic Health Fairness Act)
- 2016 EHR Incentive Program

Today more than 98% of hospitals and 88% of physician's offices use Electronic Health Records (EHRs).

CEGS N-GRID challenge

- 1000 initial psychiatric evaluation records
 - with surrogate personal health information (PHI)
- from Partners Healthcare
- mental health records:
 - **1st set ever released to the research community!**
- participation:
 - 15 countries, 50 teams, 65 institutions, 154 researchers



an example of the data

Subject: Patient Initial Visit Note -Identifying Information Date of Service:

09/14/2067CPT Code: 90792: With medical services
Age:

43Sex: Female
Interpreter Used: None needed
Chief Complaint / HPI Chief Complaint (Patients own words)

Valentina is a 43-year old female with a past psychiatric history significant for an underlying depressive disorder, anxiety disorder, binge eating disorder, no history of prior inpatient psychiatric hospitalizations, no history of prior suicide attempts, no known history of self-injurious behavior, no history of EtOH or illicit-substance use and a past medical history significant for DVT (8-years ago while on OCP) who presents to the EDCRP for continued psychopharmacologic care following her transfer from Dr. Yvonne Ellison's practice. Per Valentina, "I just need to continue these medications...they have been so helpful."

History of Present Illness and Precipitating Events

Valentina describes that she first presented for binge-eating disorder treatment approximately one-year prior to current presentation, when she notes that she was bingeing on a daily basis in the context of a number of stressors/transitions, including the birth of her two children within a year of each other, marriage to her college boyfriend at the age of 39, and ensuing conflicts with her mother as a result of the marriage. She notes that at that time, she binged daily, which steadily led to a marked increase in a 30-pound weight gain within 4-months. She states that she would binge in secret from her husband and two daughters and states that following each binge she felt "awful...ashamed." As a result, she states that her mood started to precipitously decline and states that she ultimately realized that she "could no longer fun from this...I had to seek treatment."

In an effort to seek treatment, she began seeing dietician, Frida Gibbons in Hubert, who she states was "helpful, but not enough." She subsequently purchased a diet book and worked through the exercises in the book and states that that, too, was helpful, but not enough. She ultimately contacted one of the authors of the book and arranged to undergo therapywithher via Skype. She states that that was helpful for approximately 6-months, at which time her therapist suggested that she seek local ED-specific care. As such, she underwent an evaluation with Dr. Deon Yarbrough 6/2066 and was subsequently referred to Dr. Tonya Alston for a 20-week course of CBT-E. Valentina states that her treatment with Dr. Alston was "phenomenal...it was exactly what I needed." She concurrently began seeing Dr. Yvonne Ellison for psychopharmacologic treatment of her underlying depressive/anxiety disorder and BED. She has since responded well to her current regimen of Zoloft, Vyvanse, and Topamax.

On further psychiatric review of symptoms, Valentina denies any curer nt feelings of depression and further denies all neurovegetative symptoms of depression. She denies any symptoms consistent with mania or psychosis. She denies any symptoms consistent with generalized anxiety and further denies any associated symptoms of panic. She further denies any history of EtOH or illicit-substance use.

Suicidal Behavior Hx of Suicidal Behavior: No
Hx of Non Suicidal Self Injurious Behavior: No
Violent Behavior Hx of Violent Behavior: No
-Psychiatric History Hx of Inpatient Treatment: No
Hx of Outpatient Treatment: Yes

-currently in psychodynamic therapist with Thelma Benson (Hubert), previously did course of CBT-E and booster sessions with Dr. Alston

-prior dx: ADHD , depression, binge-eating Disorder

Prior medication trials (including efficacy, reasons discontinued):

Ritalin (it made me anxious), and Celexa (no side-effects)Current
Therapist Name(s) and Phone #(s):

Thelma Benson Other Agency Involvement: No
Psychiatric Review of Systems DEPRESSION: Has the patient had periods of time lasting two weeks or longer in which, most of the day on most days, they felt little interest or pleasure in doing things, or they had to push themselves to do things: Yes
DEPRESSION: Has the patient had periods of time lasting two weeks or longer in which, most of the day on most days, they felt sad, down, or depressed: Yes
BIPOLAR: Has patient ever had a period of time when he/she felt "up" or "high" without the use of substances: No
BIPOLAR: Has patient ever had periods of being persistently irritable for several days, or had verbal/physical fights that seemed clearly out of character: No
PSYCHOSIS: Has the patient had unusual experiences that are hard to explain: No
PSYCHOSIS: Does the patient often have thoughts that make sense to them, but that other people say are strange: No
GAD: Has the patient had times when they worried excessively about day to day matters for most of the day, more days than not: Yes
PANIC: Has the patient had episodes of sudden intense anxiety with physical sensations such as heart palpitations, trouble breathing, or dizziness that reached a peak very quickly and presented without warning: No
ANXIETY SPECTRUM DISORDERS: Does the patient have persistent fear triggered by specific objects (phobias) or situations (social anxiety) or by thought of having a panic attack: No
OCD: Does the patient struggle with repetitive unwanted thoughts or behaviors for at least one hour per day: No

...

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History of Present Illness and Precipitating Events

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■ *Text* - ■ *Semi-structured information* - ■ *Typos*

de-identification in 2 flavors

- sight-unseen:
 - running existing de-id systems on the data “as they are”
 - how well do systems generalize to new data?
- regular:
 - design new systems (2 months, 60/40 training/test split)
 - advancing the state of the art in medical rec. de-identification

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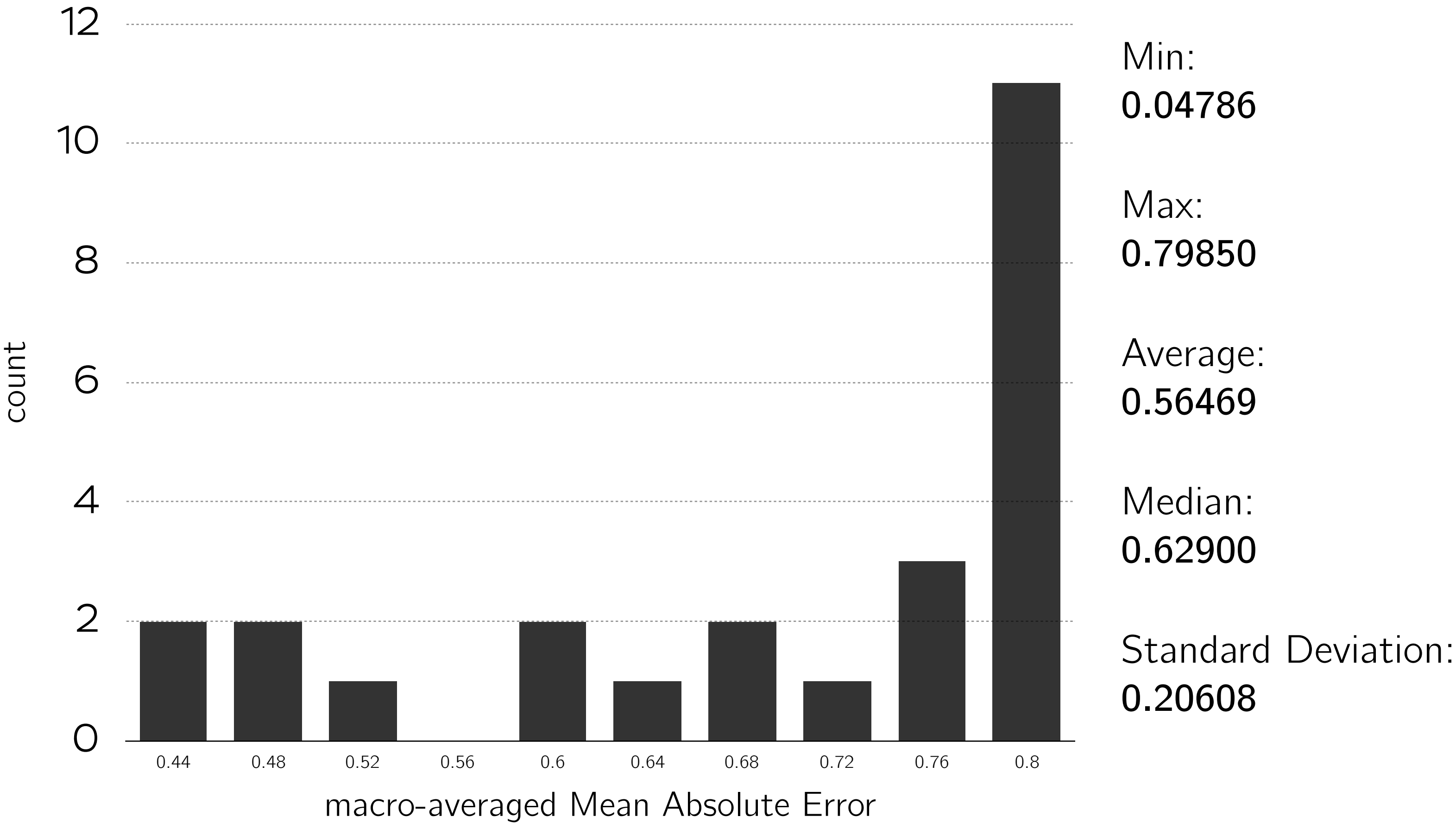
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sight-unseen: data split

records

600

sight-unseen: overall results



sight-unseen: TOP 10 (best runs)

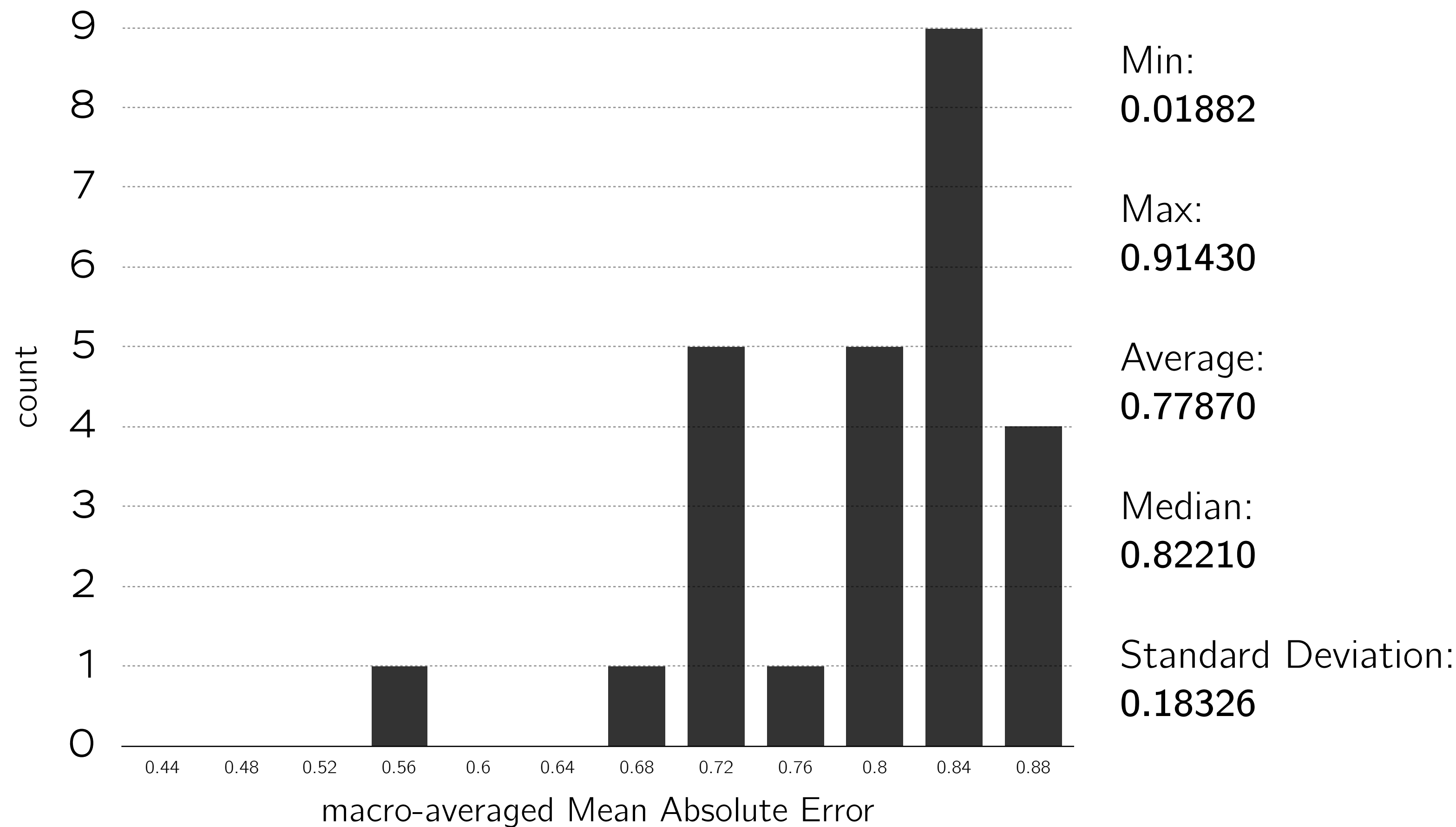


Rank	Institutions	Score
1	Harbin Institute of Technology Shenzhen Grad. Sc.	0.79850
2	University of Texas Health Science Center at Houston	0.74260
3	Harbin Institute of Technology	0.68680
4	The University of Manchester	0.64450
5	LIMSI-CNRS	0.52660
6	MITRE	0.49680
7	Med Data Quest Inc.	0.18610

regular: data split



regular: overall results



regular: TOP 10 (best runs)



Rank	Institutions	Score
1	Harbin Institute of Technology Shenzhen Graduate	0.91430
2	University of Texas Health Science Center at Houston	0.90740
3	The University of Manchester	0.87690
4	University of Alabama at Birmingham	0.87310
5	Harbin Institute of Technology	0.85700
6	National Taitung University	0.82210
7	MITRE	0.80590
8	LIMSI-CNRS	0.76430
9	National Central University	0.75960
10	University of Utah	0.71750

symptom severity classification

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SEVERE

MODERATE

MILD

NONE

- RDoC: framework for studying mental disorders
- integrates many levels of information (from genomics to self-report) to understand the basic dimensions of human behavior (from normal to abnormal)
- 5 domains:
 - **positive valence***, negative valence, cognitive, social processes, arousal and regulatory systems
- how good systems are at predicting patients' symptom severity, based on initial psychiatric evaluation records?

** Systems primarily responsible for responses to positive motivational situations or contexts, such as reward seeking, consummatory behavior, and reward/habit learning (alcohol, drink, abuse, repetitive, stereotypy, drug, gamble, count, craving, compulsive)*

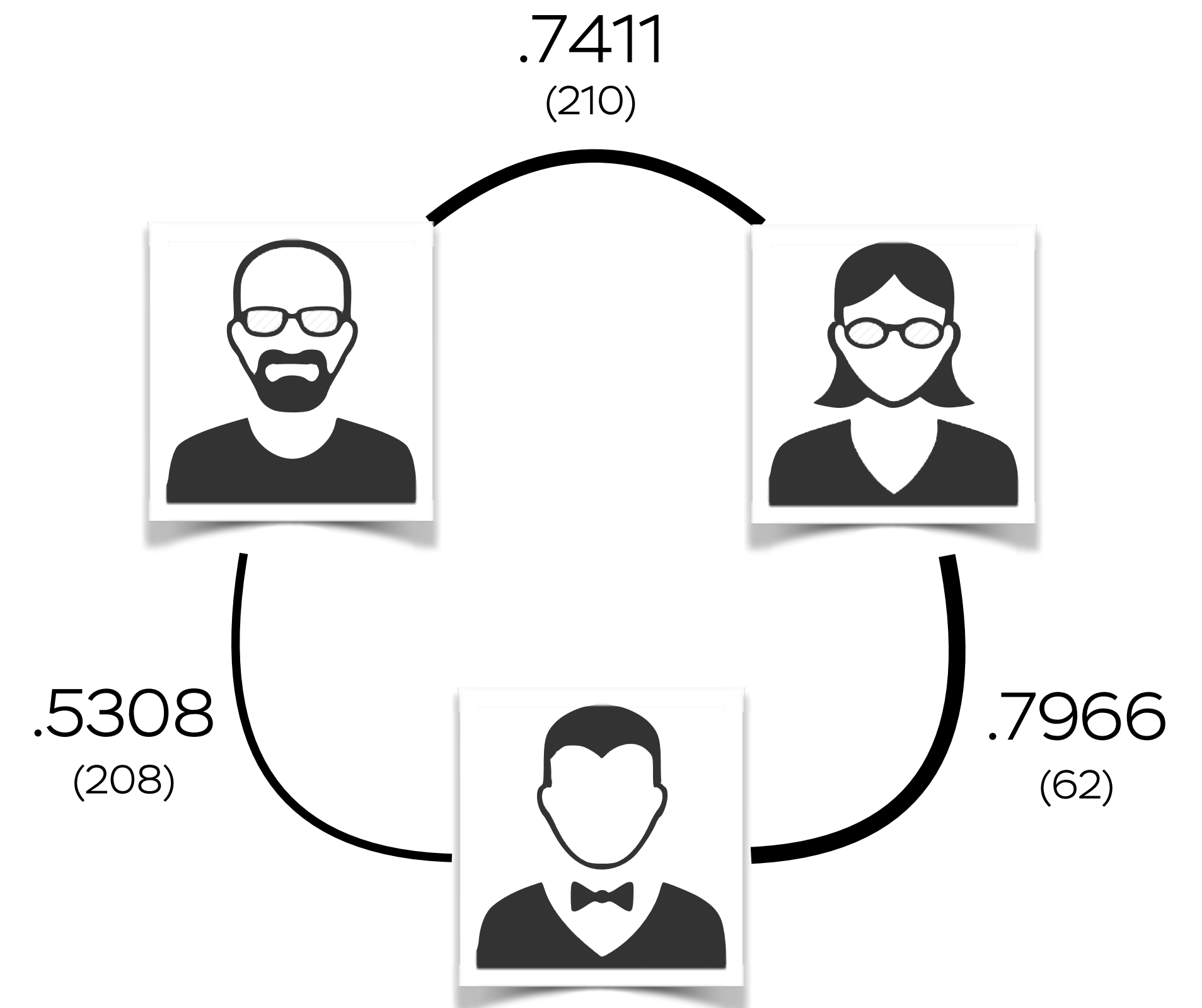
research domain criteria



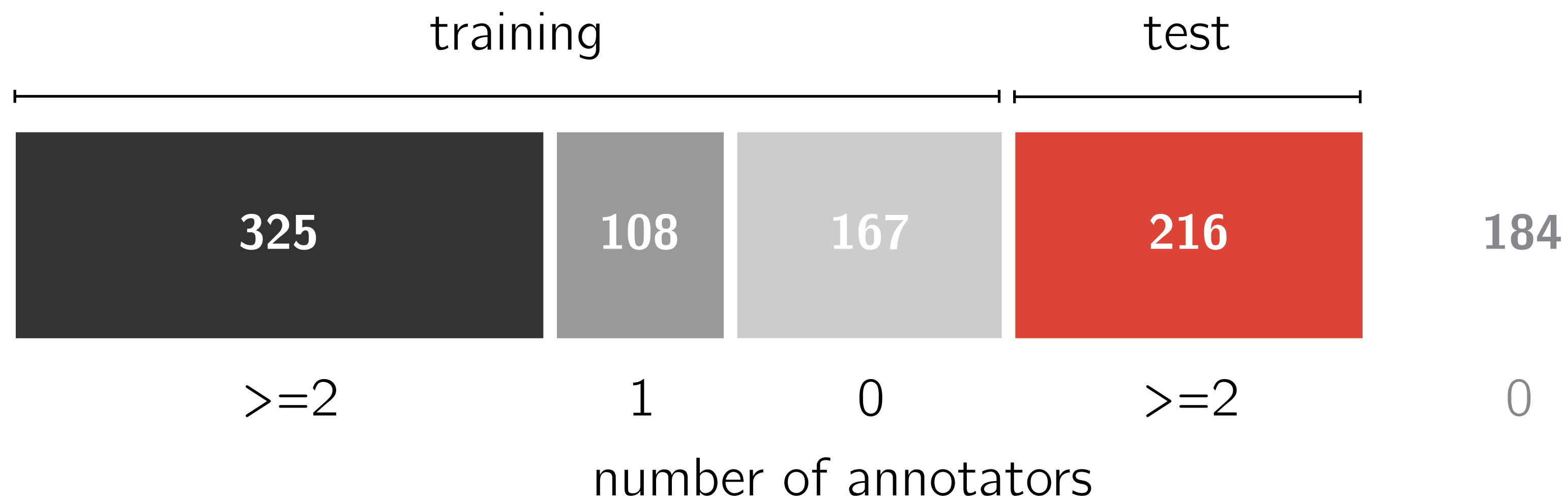
Construct/Subconstruct		Genes	Molecules	Cells	Circuits	Physiology	Behavior	Self-Report	Paradigms
Approach Motivation	Reward Valuation		Elements		Elements			Elements	Elements
	Effort Valuation / Willingness to Work		Elements		Elements	Goal tracking Pavlovian approach Reward-related speeding Sign tracking		Elements	Elements
	Expectancy / Reward Prediction Error		Elements		Elements	Elements	Elements	Elements	Elements
	Action Selection / Preference-Based Decision Making	DAT, DR2, TREK1		Dopamine, Serotonine	Elements				Elements
Initial Responsiveness to Reward Attainment		Elements	Elements		Elements		Elements	Elements	Elements
Sustained/Longer-Term Responsiveness to Reward Attainment			Elements		Elements	Elements	Elements	Elements	Elements
Reward Learning		Elements	Elements	Elements	Elements	Compulsive behaviors Repetitive behaviors Stereotypic behaviors	Elements	Elements	Elements
Habit		Elements	Elements	Elements	Elements		Elements	Elements	Elements

annotation process

- 3 expert psychiatrists with several years of experience
- Mass General Hospital and Harvard Medical School
- 2 annotation:
 - tie-broken by the 3rd
 - adjudicated by the most experienced
- 1 annotation:
 - the most experienced

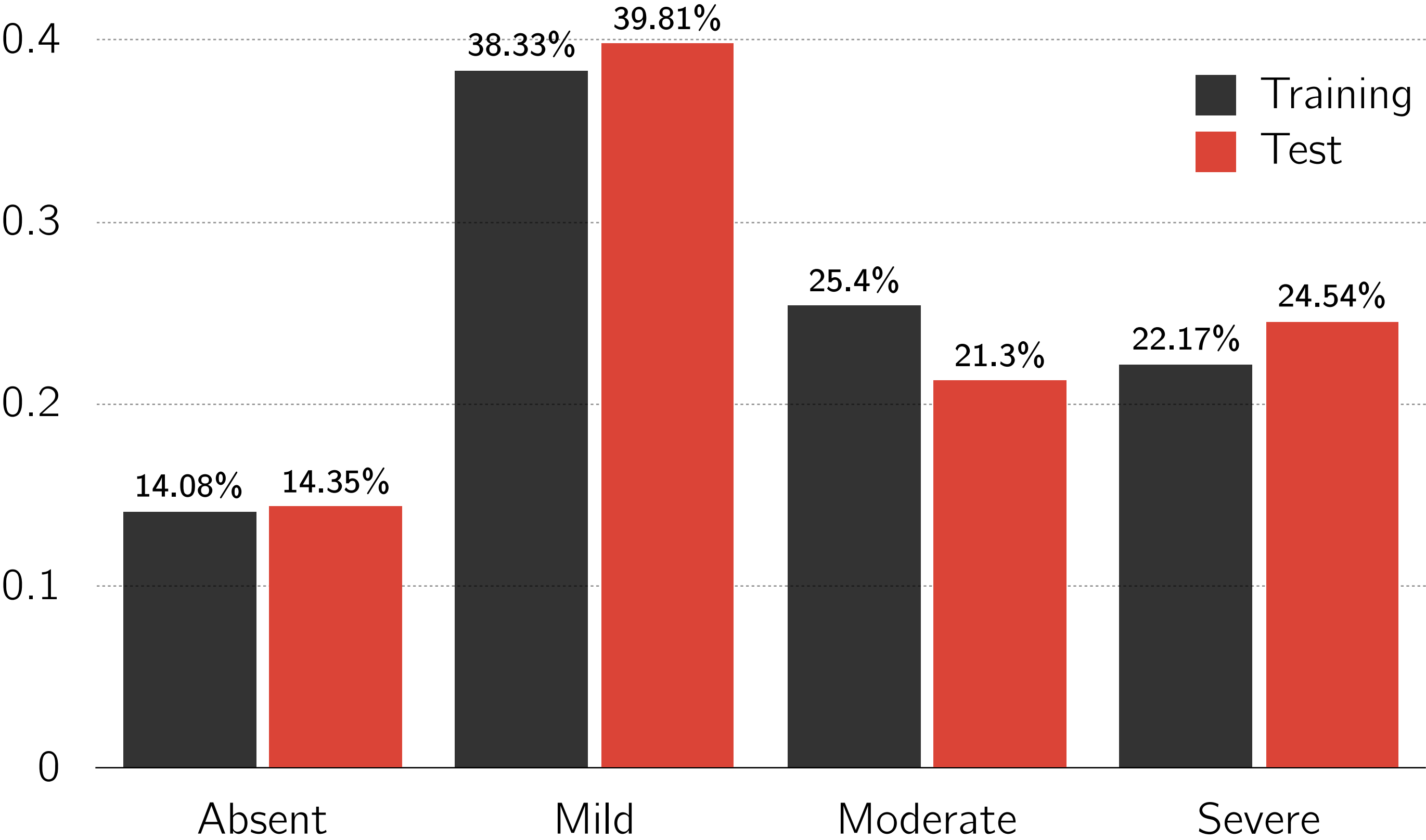


data split



classes distribution

consistent between training and test sets



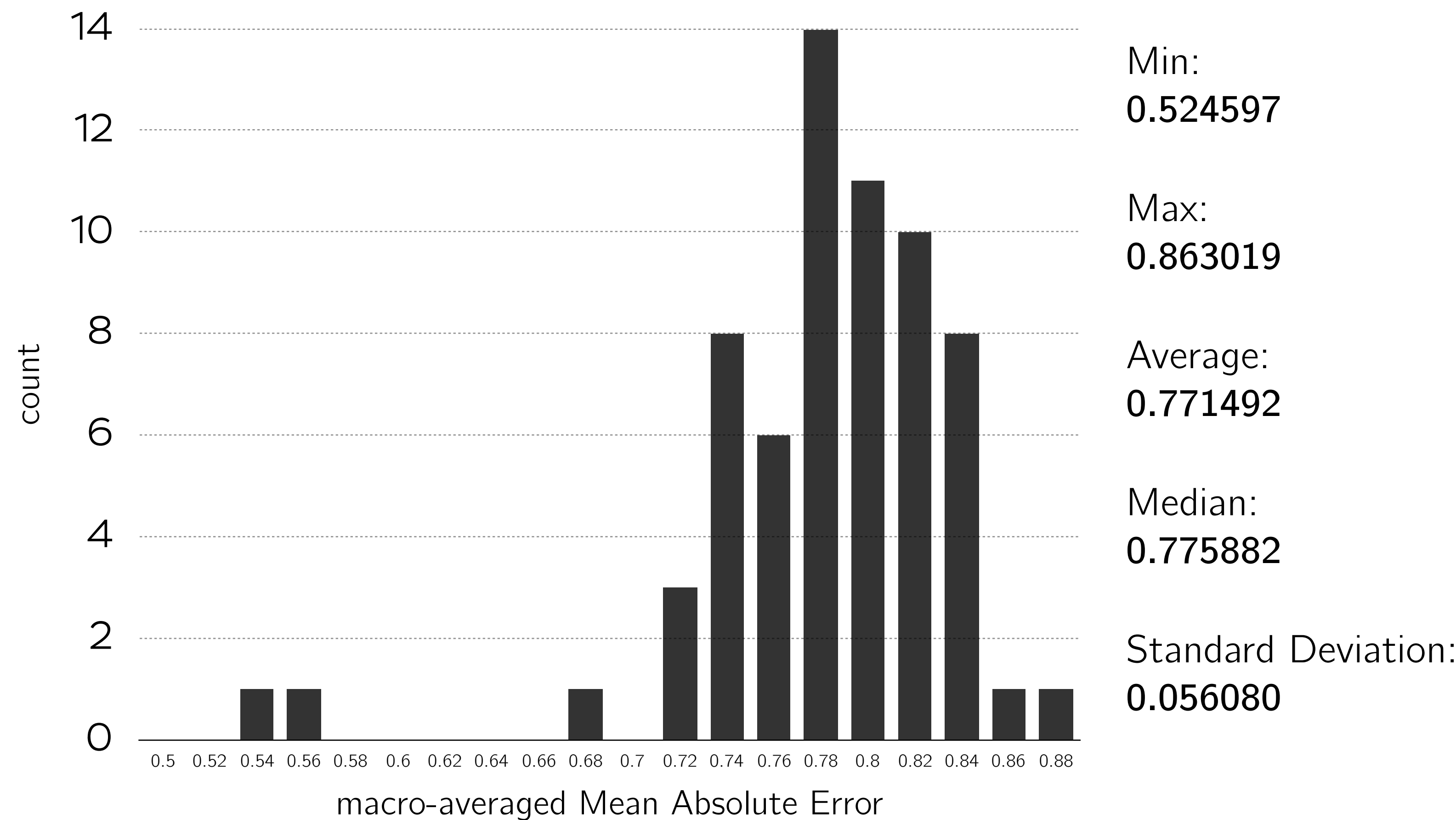
error measure

fair & robust

- it copes with imbalanced data
 - the under-represented classes counts as any other class, rather than proportionally to their frequencies
- systems cannot be artificially tuned to improve the performance

$$MAE^M(h, Te) = \frac{1}{|C|} \sum_{j=1}^{|C|} \frac{1}{|Te_j|} \sum_{\mathbf{x}_i \in Te_j} |h(\mathbf{x}_i) - y_i|$$

overall results



TOP 10 (best runs)



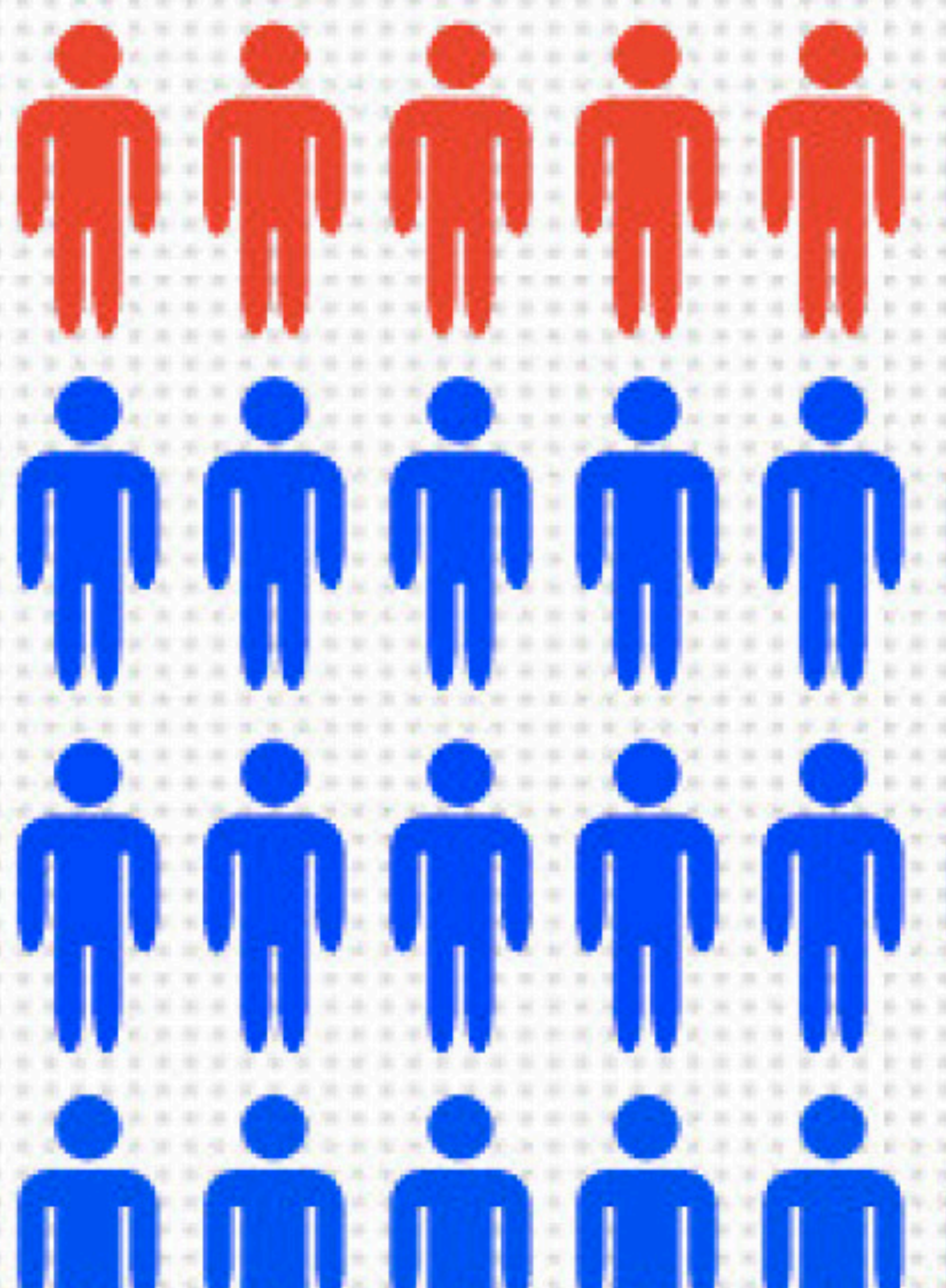
Rank	Institutions	Score
1	SentiMetrix Inc.	0.863019
2	The University of Texas at Dallas	0.840963
3	University of Kentucky	0.838615
4	University of Pittsburgh	0.825594
5	Med Data Quest Inc.	0.817474
6	Harbin Institute of Technology Shenzhen Graduate	0.816844
7	University of Minnesota	0.814971
8	Antwerp University Hospital	0.806356
9	LIMSI-CNRS	0.801738
10	The University of Manchester	0.801143

24 teams -> 24 best runs

A close-up photograph of a person's open palm holding two small, round, white tablets. The hand is positioned with the palm facing up, and the pills are resting in the center. The background is a soft, out-of-focus light color.

future works

Identifying adverse
medication events



Cohort selection for
clinical trials



Coronary Artery Disease
early detection

Thank you!

filannim@csail.mit.edu

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NIH 4R13LM011411 (PI: Ozlem Uzuner).