

Equity and Algorithm Development

Regina Barzilay

Disclosures

- SAB: Janssen, Amgen, Immunai, Fermentech
- BOD: Dewpoint Therapeutics
- Research Funding: MLPDS, DTRA, Darpa, Quanta, Novo Nordisk, NSF, NCI

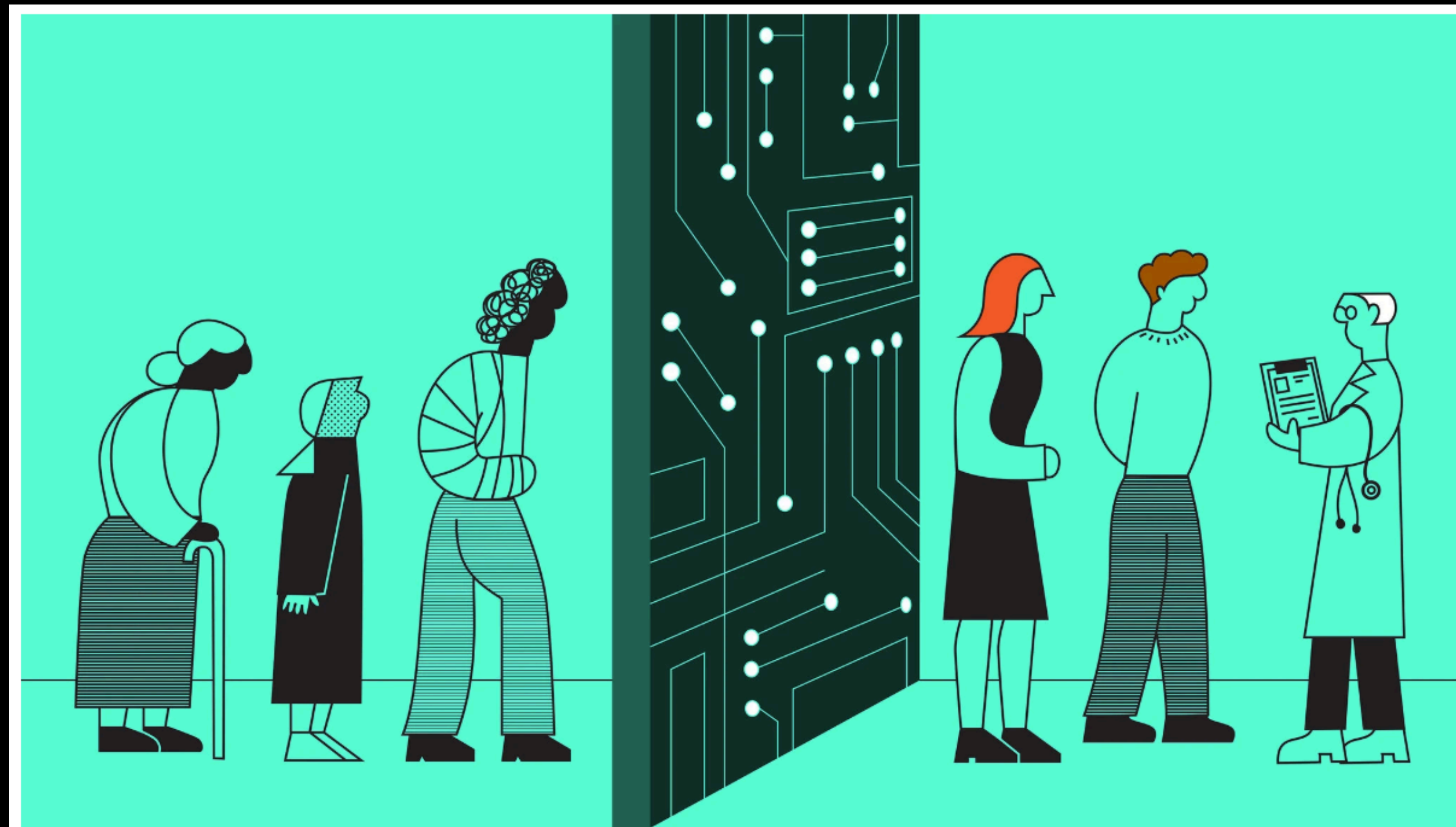
Handling Diversity

A.I. Could Worsen Health Disparities

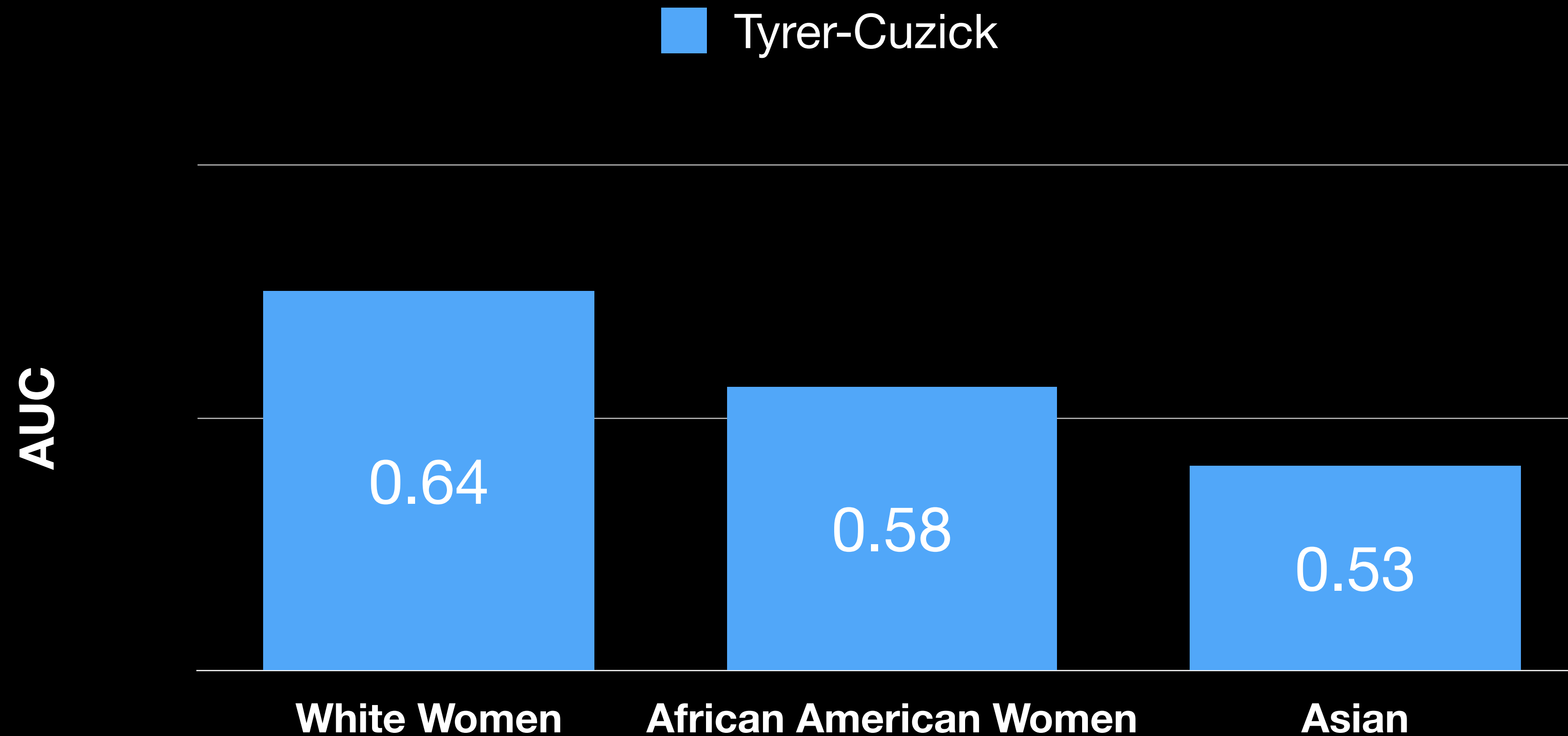
In a health system riddled with inequity, we risk making dangerous biases automated and invisible.

By Dhruv Khullar

Dr. Khullar is an assistant professor of health care policy and research.



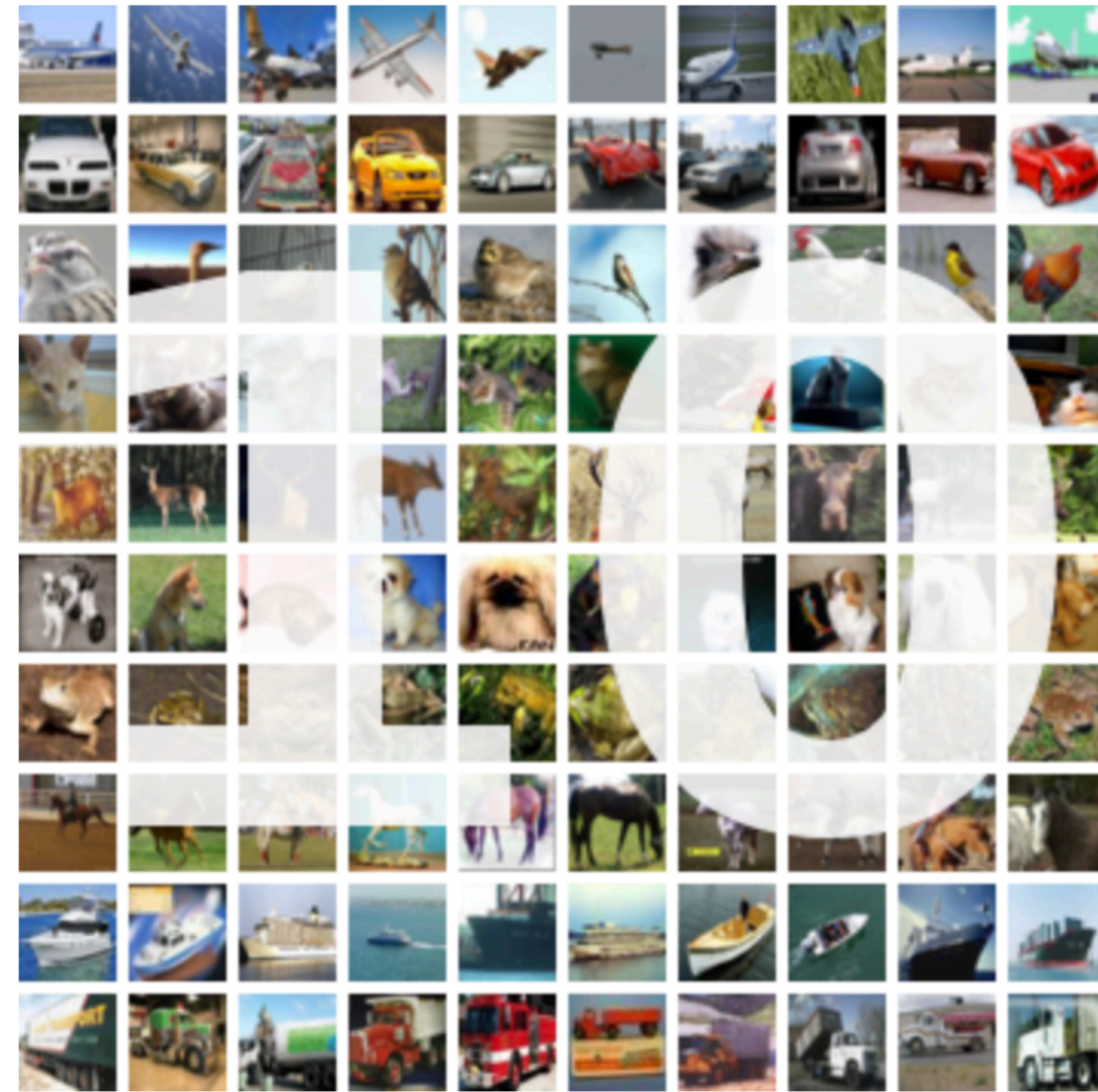
Biased Models Predate AI



A Deep Learning Mammography-based Model for Improved Breast Cancer Risk Prediction

 Adam Yala ,  Constance Lehman,  Tal Schuster,  Tally Portnoi,  Regina Barzilay

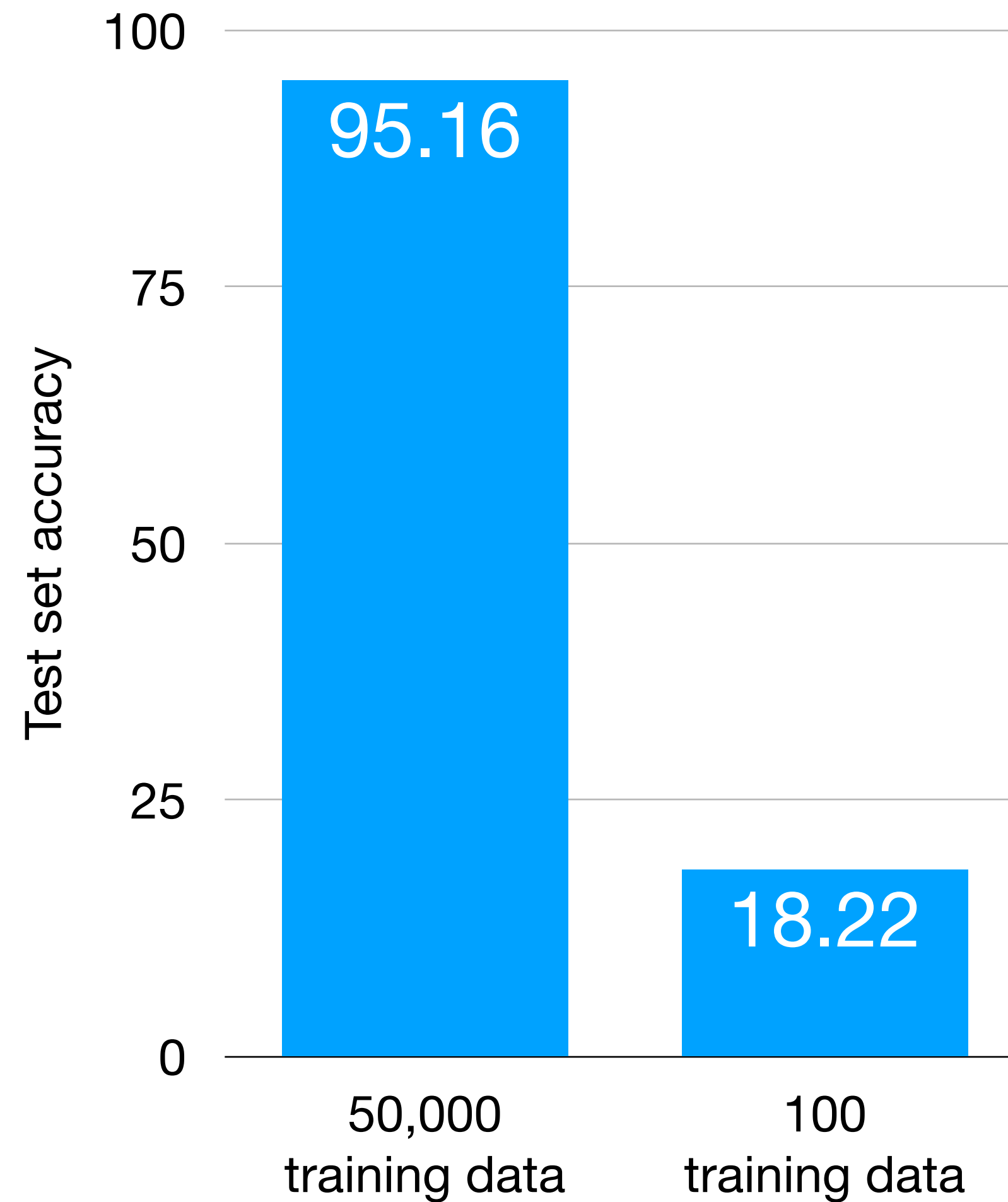
Problem 1: DNNs are Data Hungry



CIFAR-10 dataset

classes: 10

img per class: 5000

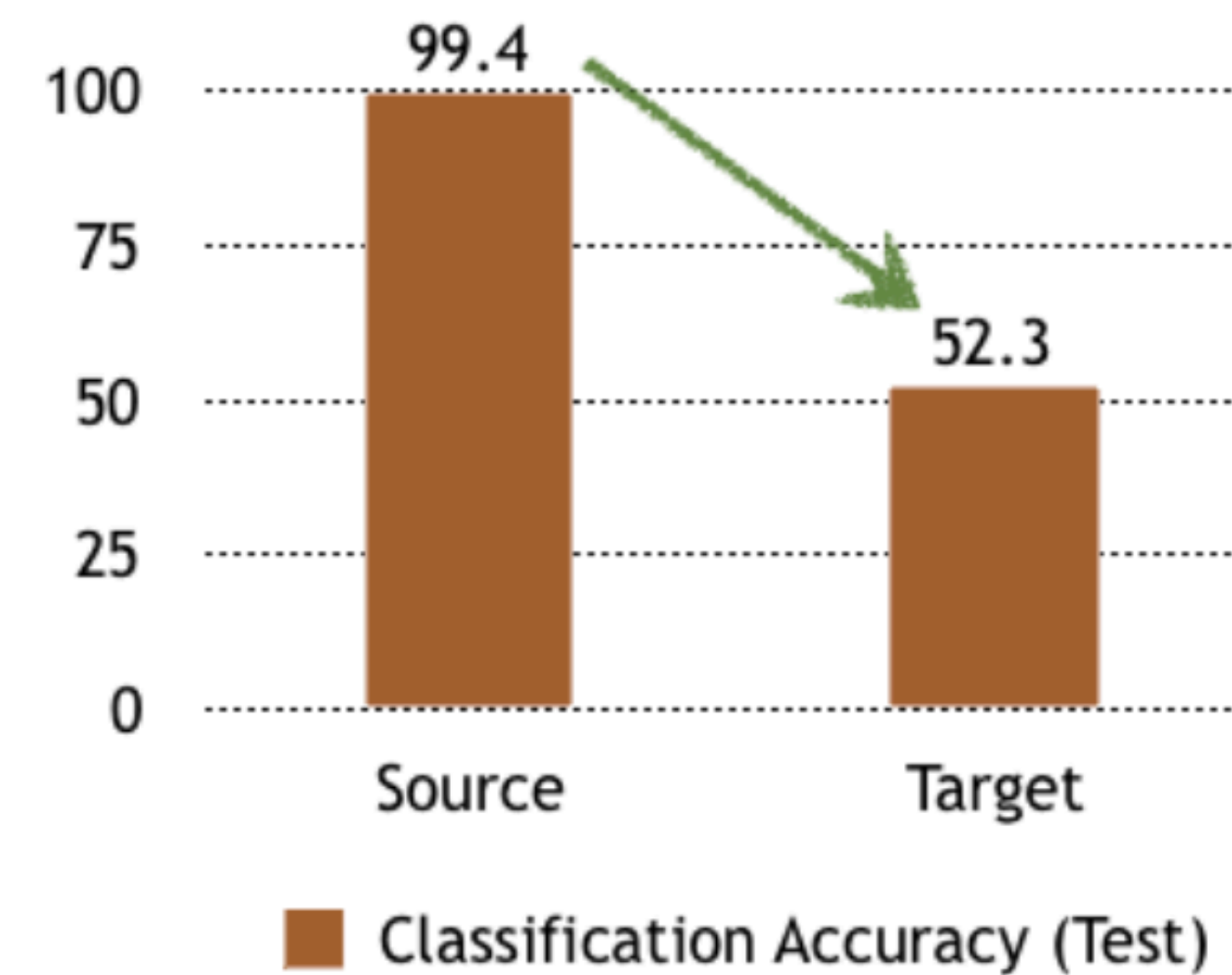
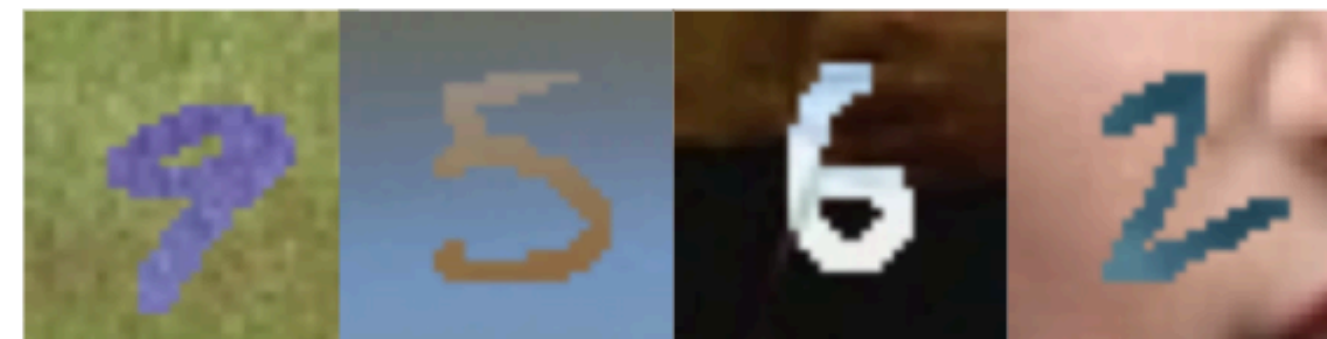


Problem 2: DNNs are not Robust Towards Distributional Shift

Source



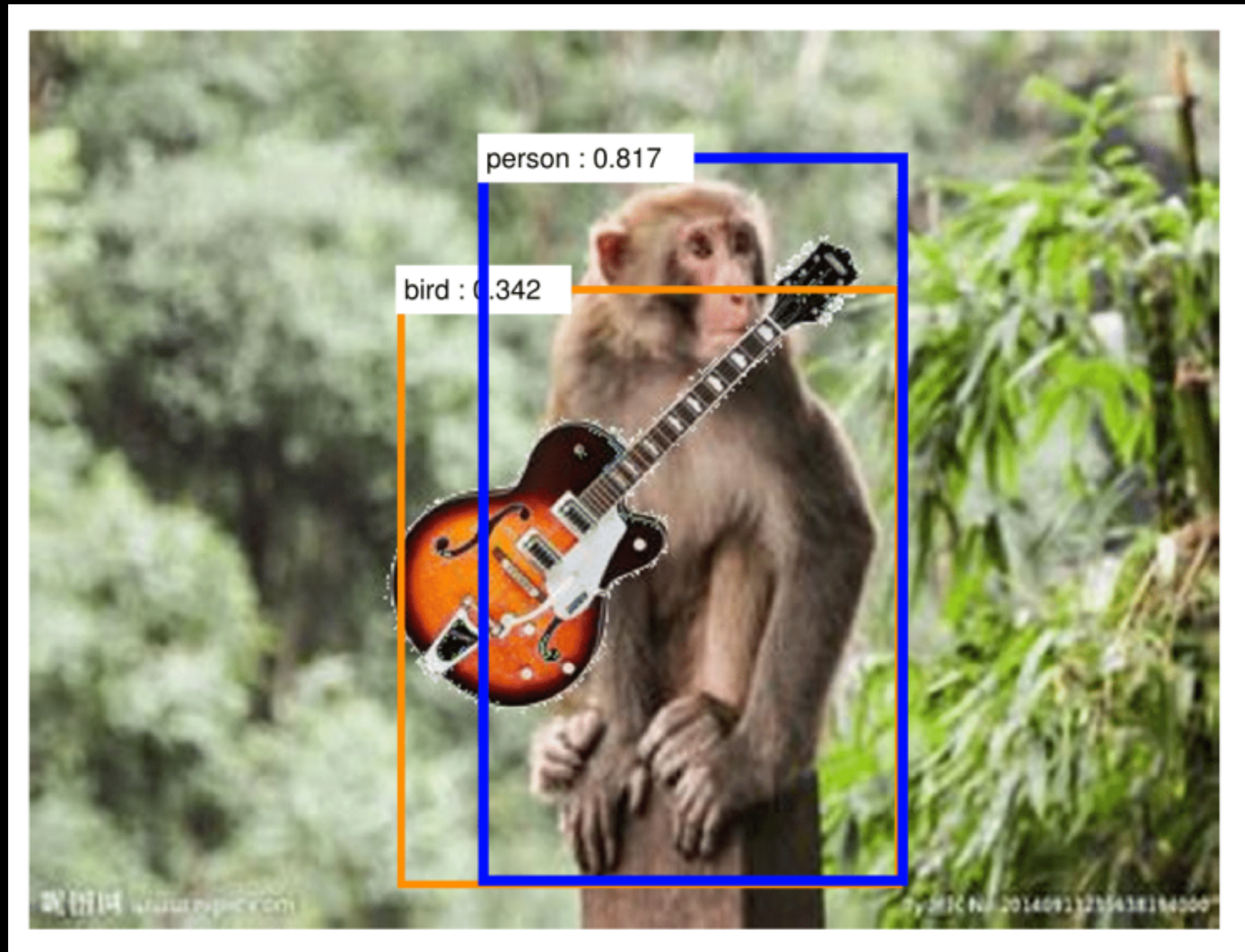
Target



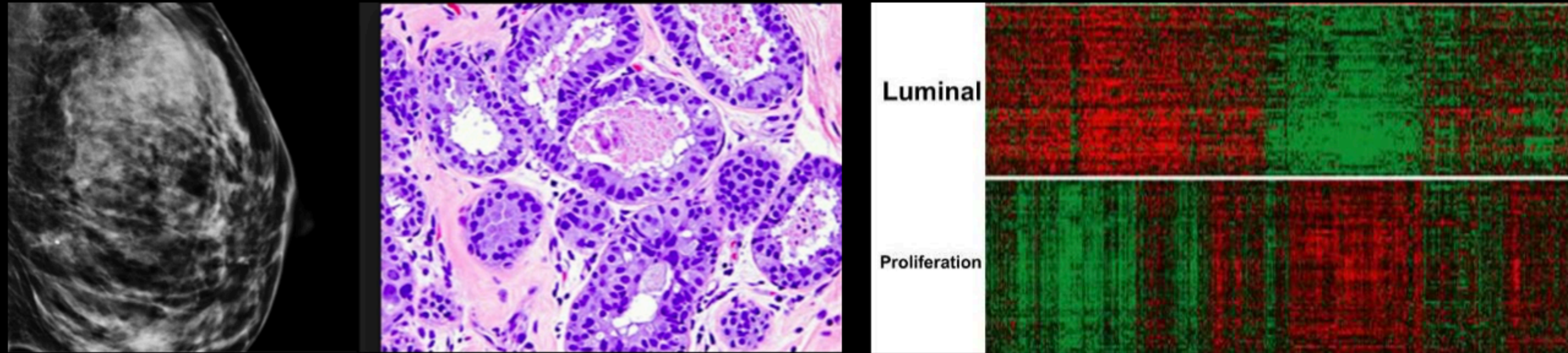
<https://arxiv.org/abs/1505.07818>

Problem 3:

DNNs learn Data Bias

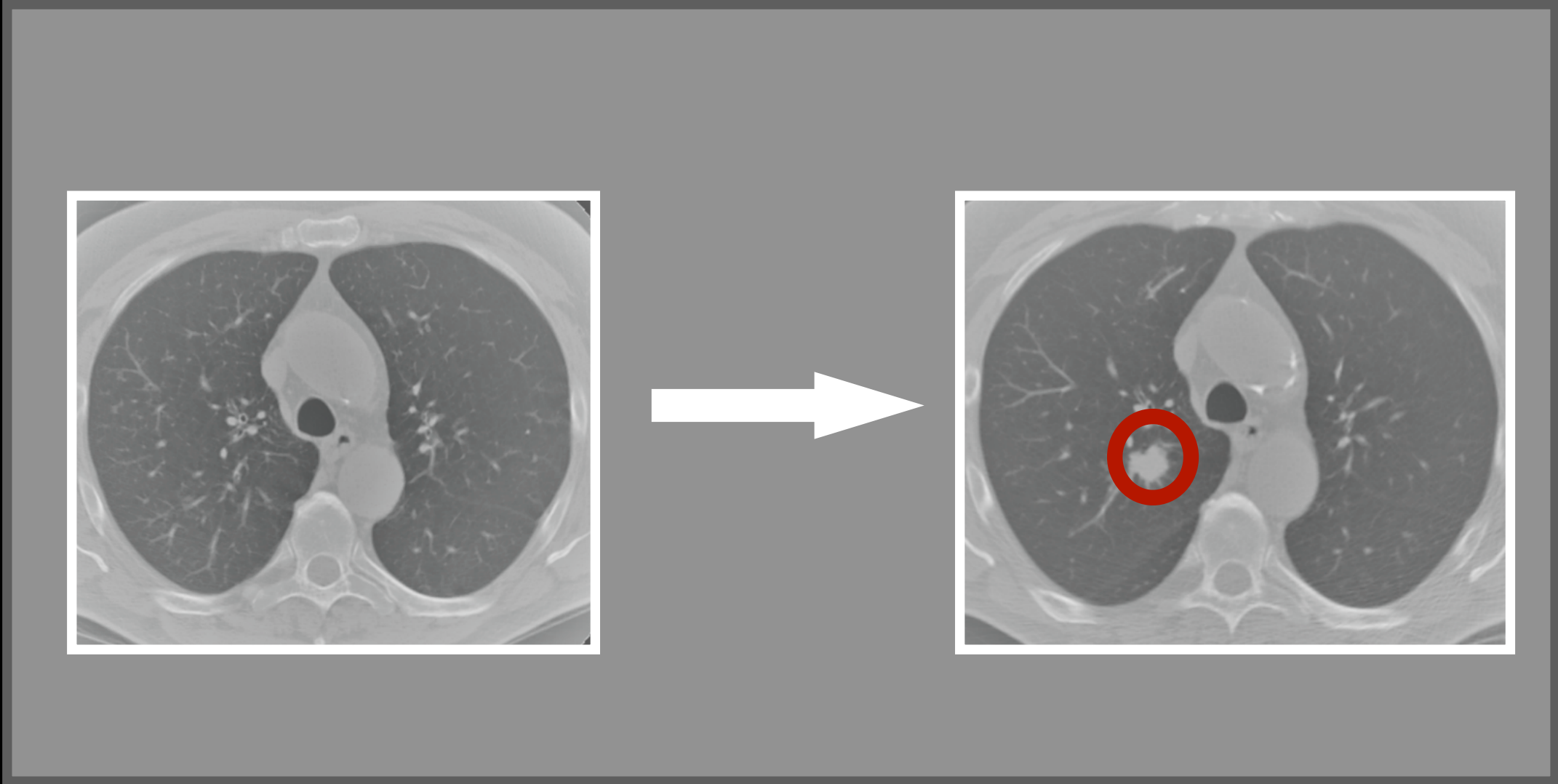
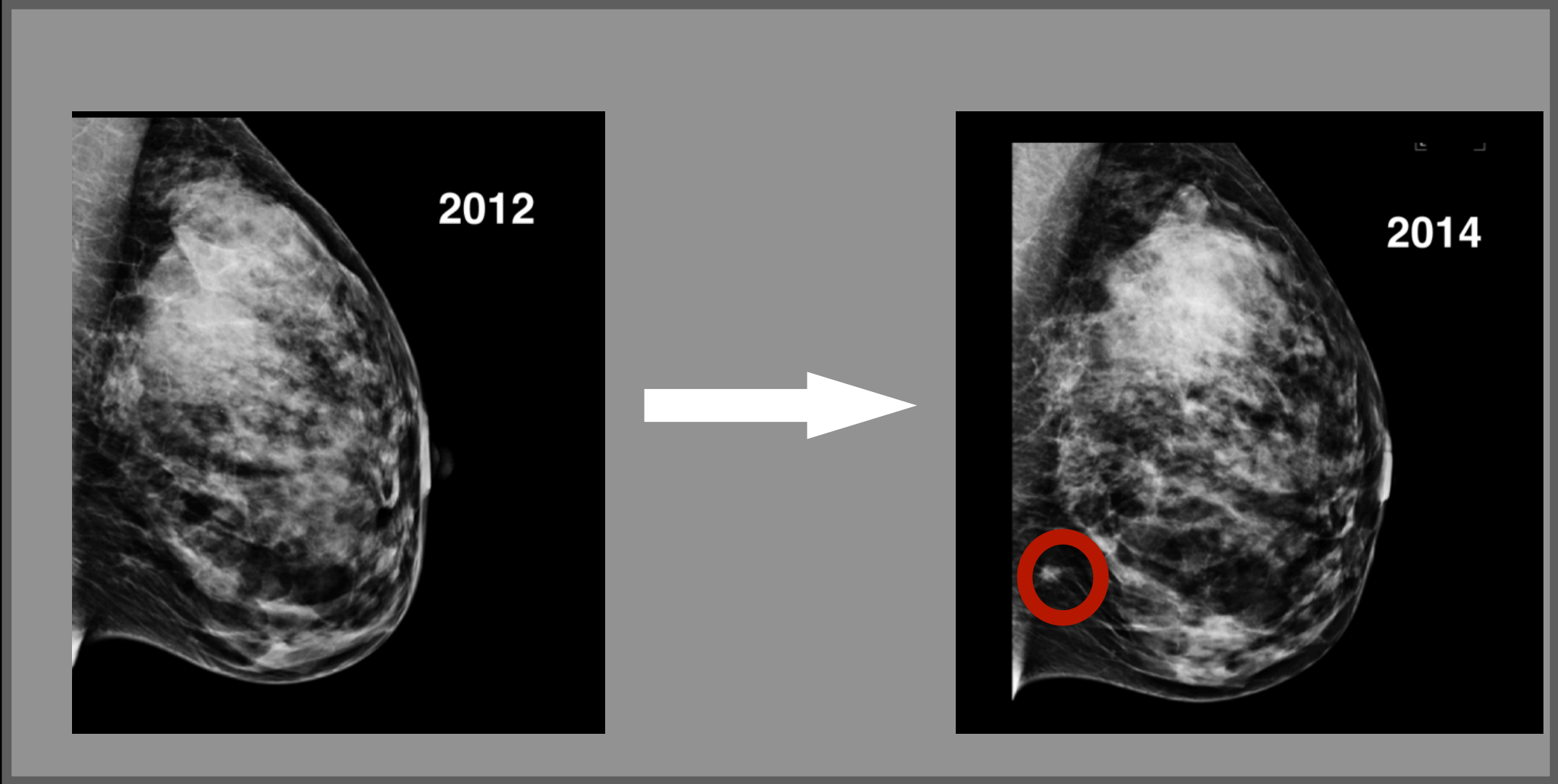


Most Diagnostics Tasks are Beyond Human Prediction Capacity



Predict Recurrences, Sensitivity to Treatment,
Population at Risk

Case Studies: Predicting Future Risk



SCIENCE TRANSLATIONAL MEDICINE | RESEARCH ARTICLE

CANCER

Toward robust mammography-based models for breast cancer risk

Adam Yala^{1,2*}, Peter G. Mikhael^{1,2}, Fredrik Strand^{3,4}, Gigin Lin⁵, Kevin Smith^{6,7}, Yung-Liang Wan⁵, Leslie Lamb⁸, Kevin Hughes⁹, Constance Lehman^{8†}, Regina Barzilay^{1,2†}

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ORIGINAL REPORTS | Breast Cancer

Multi-Institutional Validation of a Mammography-Based Breast Cancer Risk Model

Optimizing risk-based breast cancer screening policies with reinforcement learning

Adam Yala , Peter G. Mikhael, Constance Lehman, Gigin Lin, Fredrik Strand, Yung-Liang Wan, Kevin Hughes, Siddharth Satuluru, Thomas Kim, Imon Banerjee, Judy Gichoya, Hari Trivedi & Regina Barzilay

[Nature Medicine](#) 28, 136–143 (2022) | [Cite this article](#)

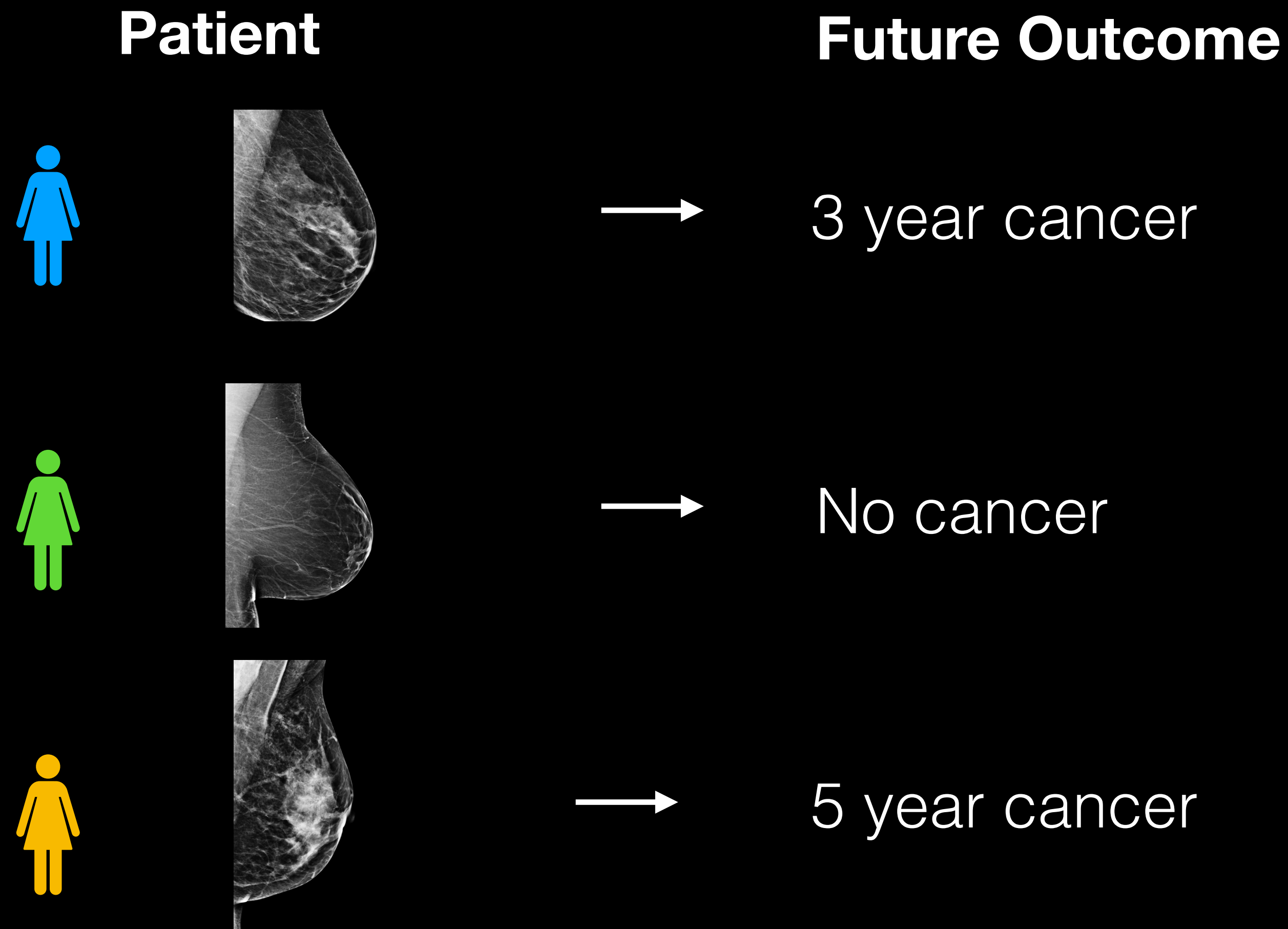
Journal of Clinical Oncology[®]
An American Society of Clinical Oncology Journal

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ORIGINAL REPORTS | Thoracic Oncology

Sybil: A Validated Deep Learning Model to Predict Future Lung Cancer Risk From a Single Low-Dose Chest Computed Tomography

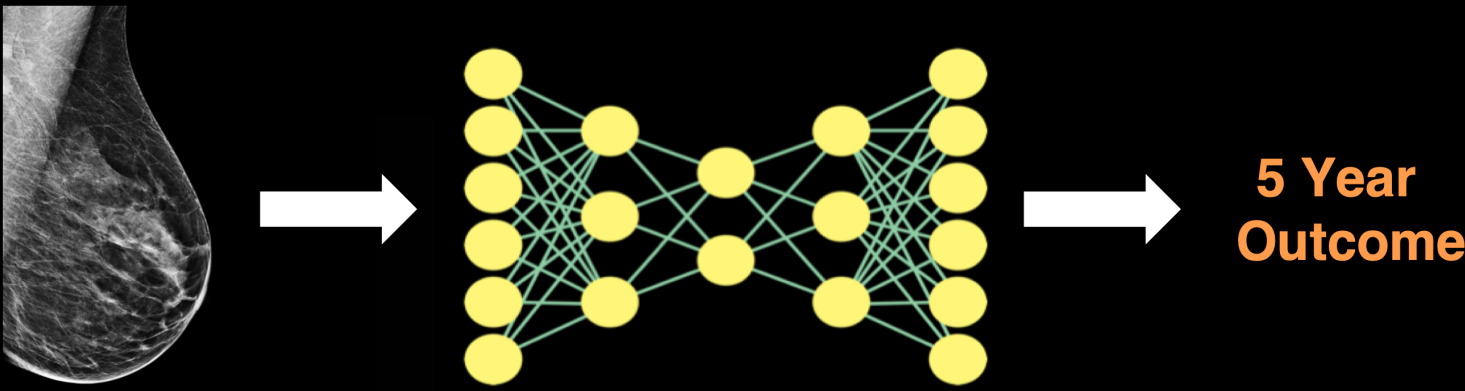
Learning to predict future cancer



CANCER

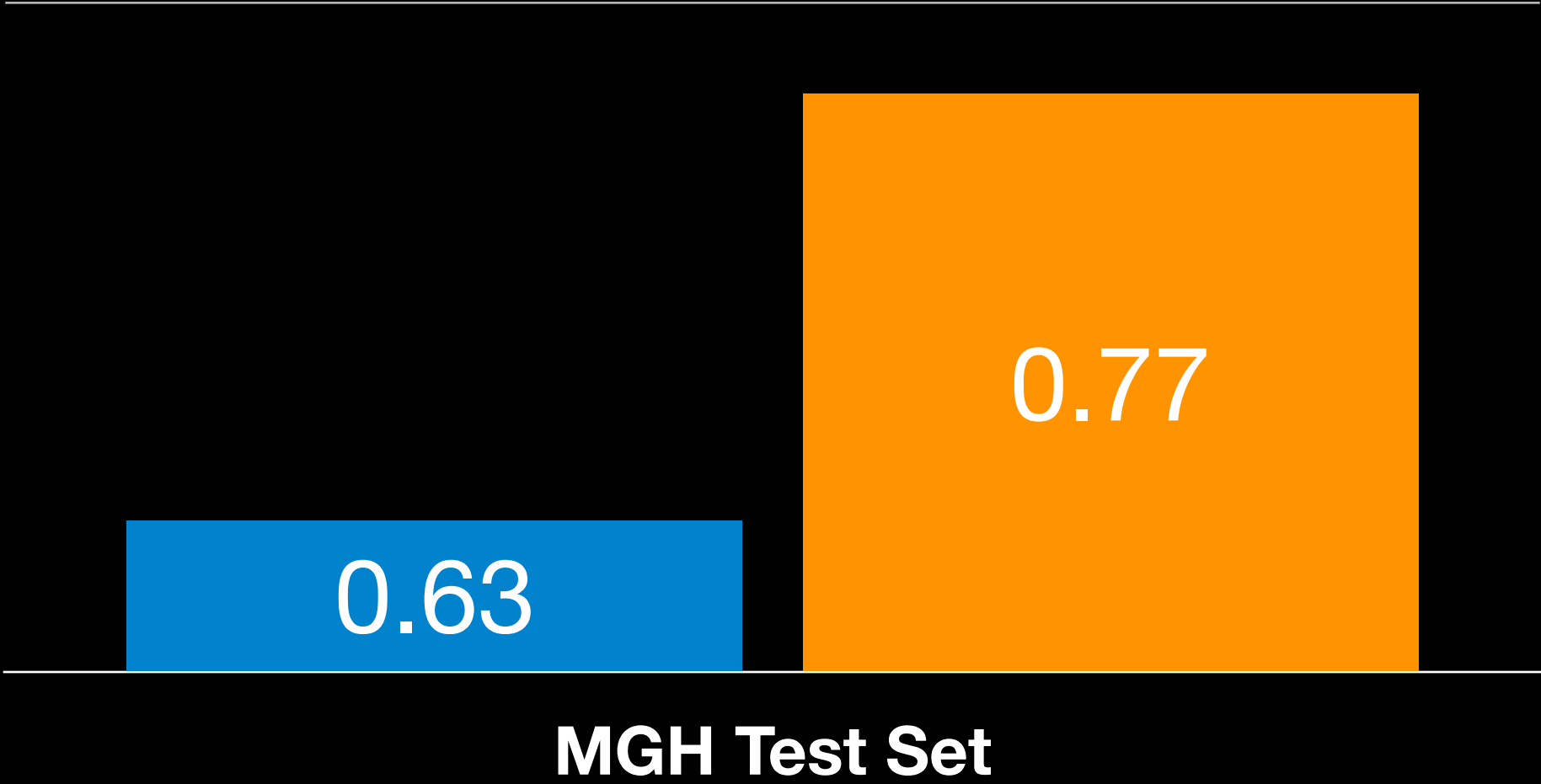
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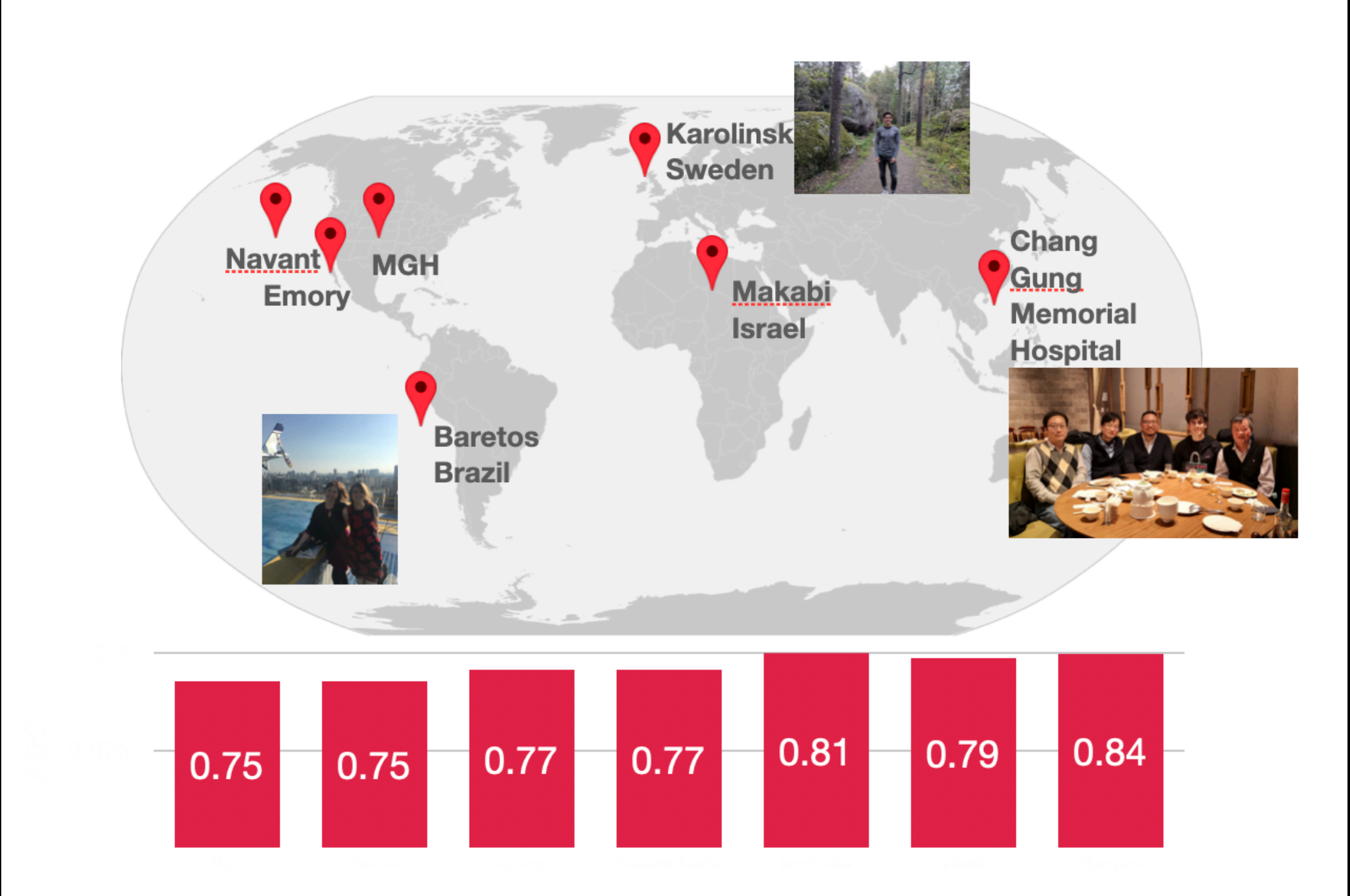


- Tyrer-Cuzick (Prior State of the Art)
- MIRAI (Ours - New Result)

Uno's C-index



2020: Multi-Institutional Validation



SCIENCE TRANSLATIONAL MEDICINE | RESEARCH ARTICLE

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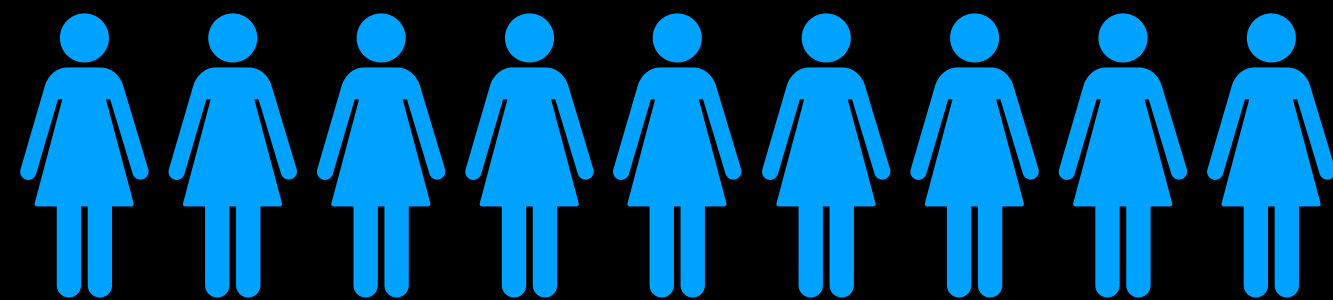
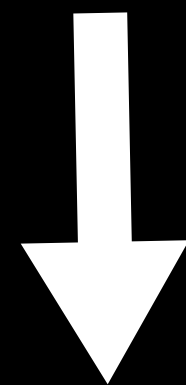
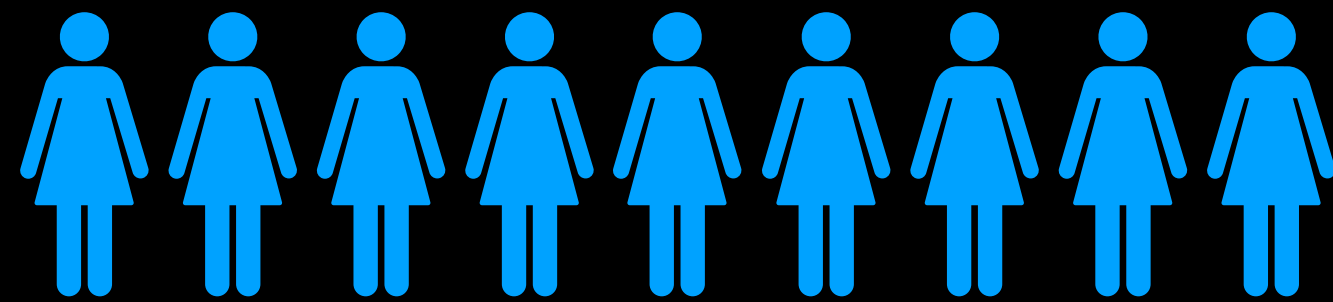


J-Clinic
ABDUL LATIF JAMEEL CLINIC FOR
MACHINE LEARNING IN HEALTH

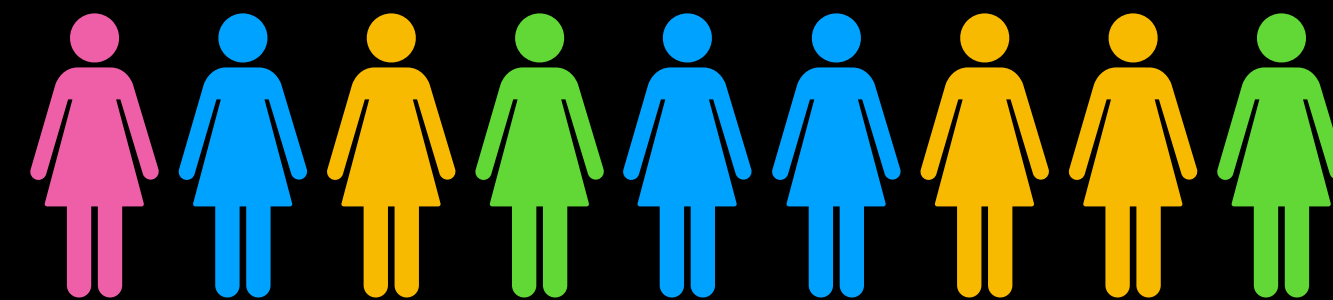
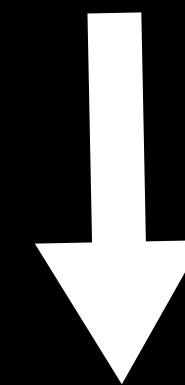
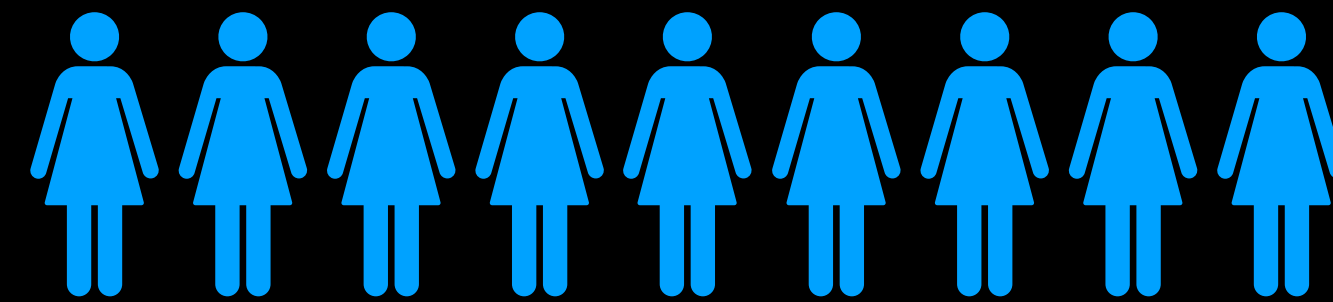
2023: Hospital Network Deployment



Distributional Shift from Training



90%



~~90%~~

Distributional Shift from Training

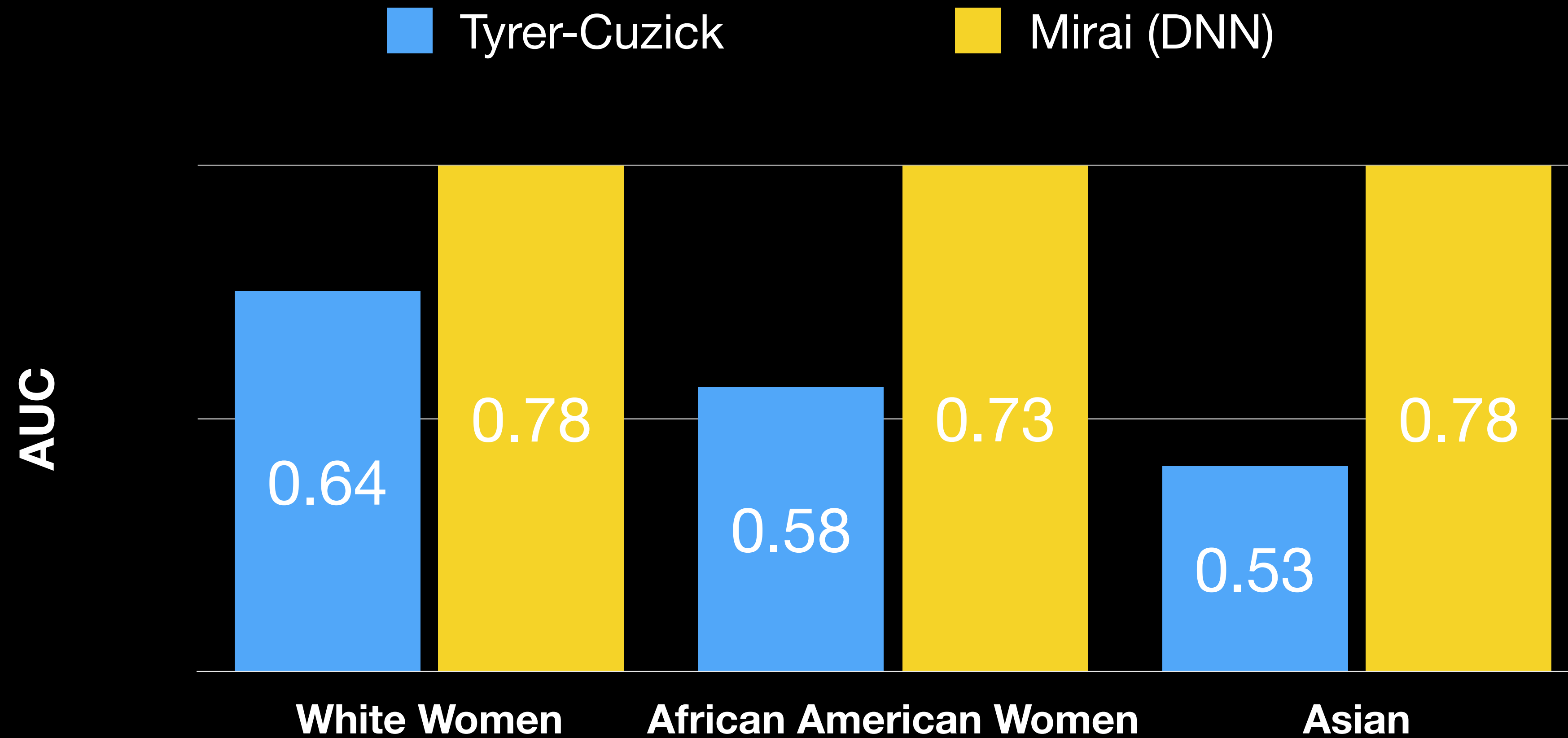
Demographics

Clinical Setting

Device



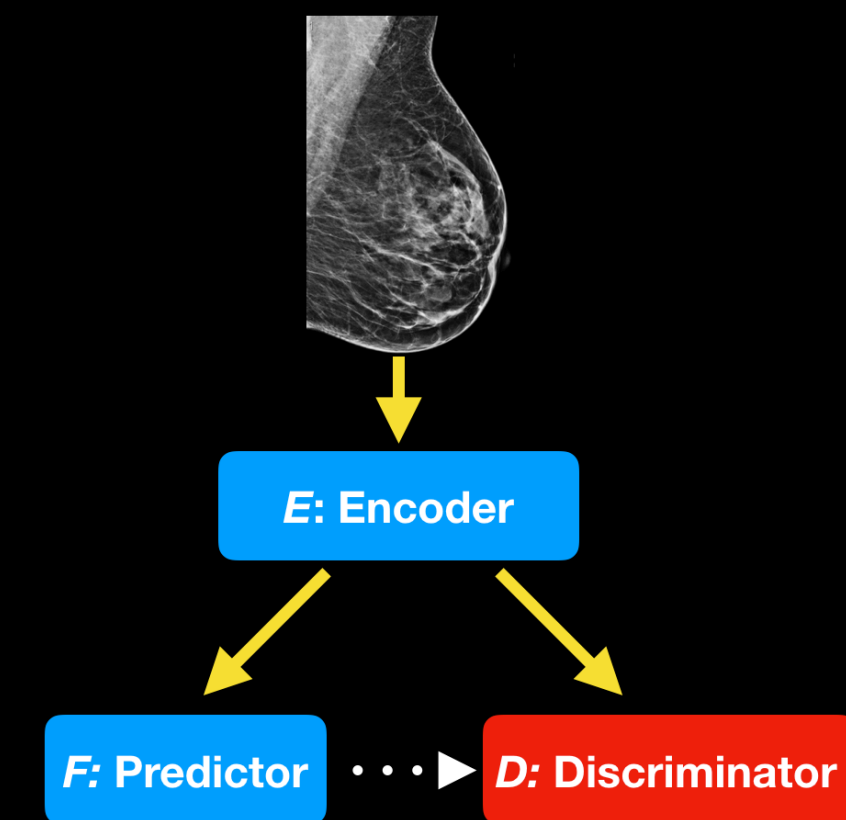
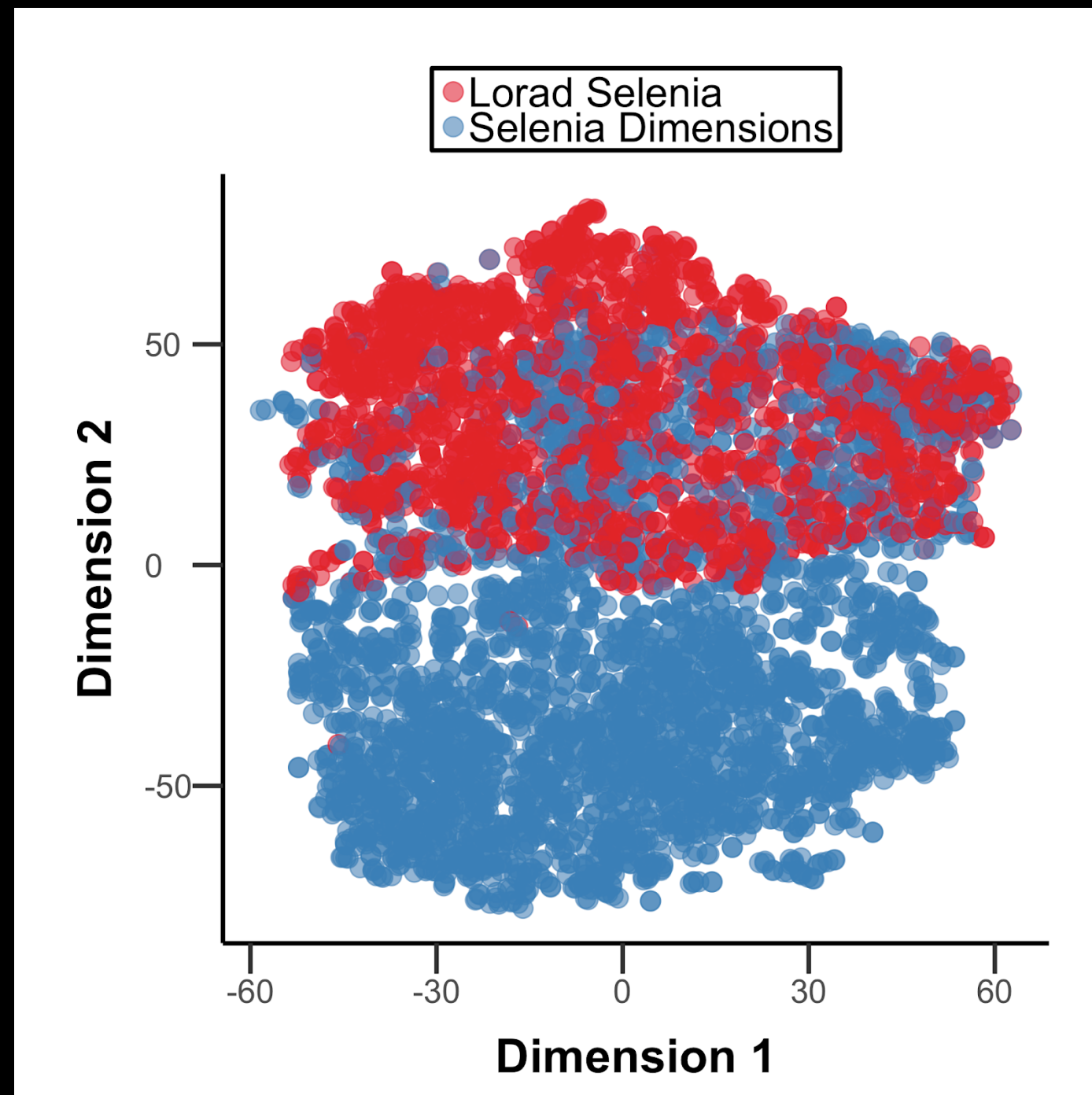
Training from Diverse Data Helps



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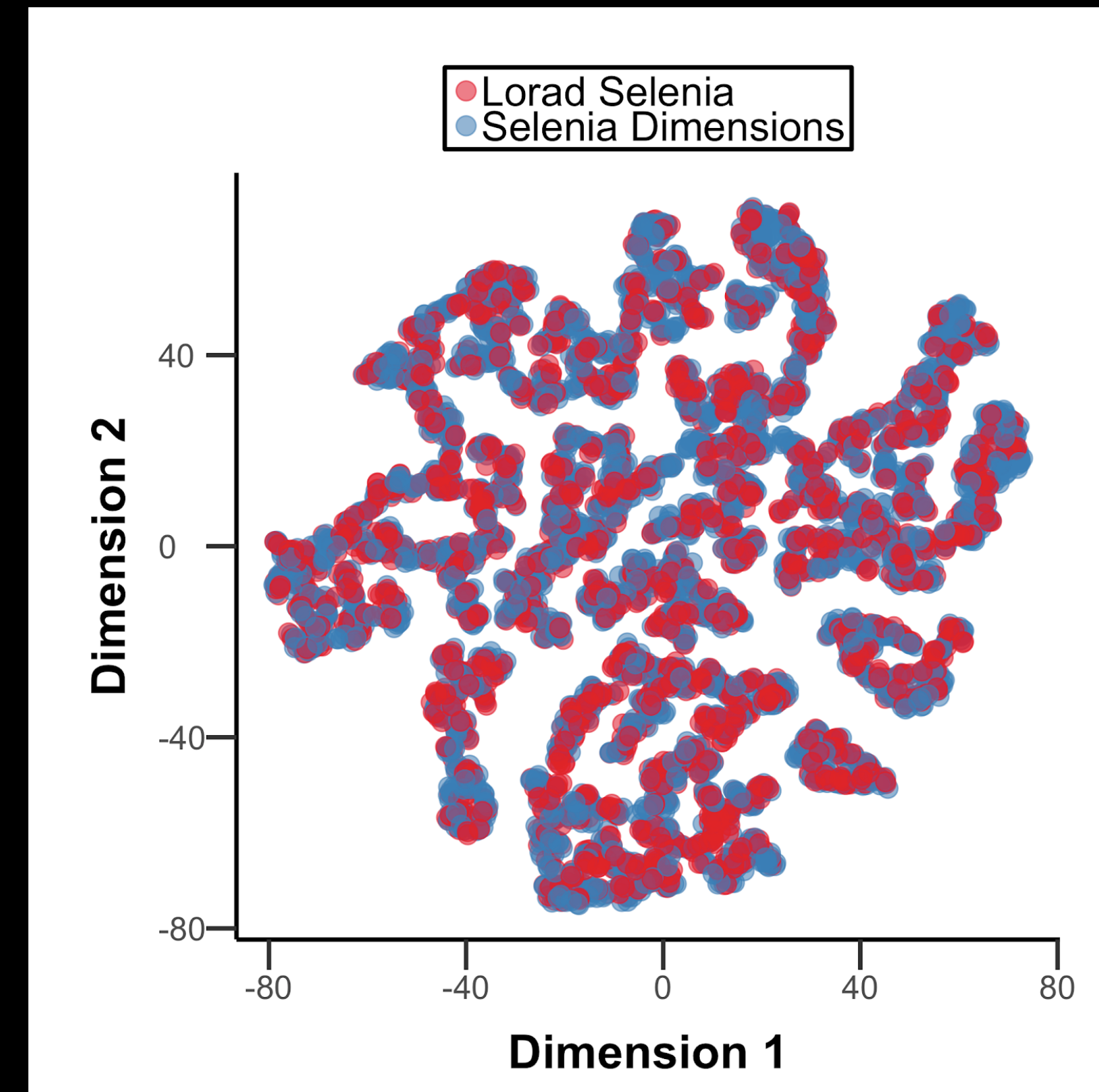
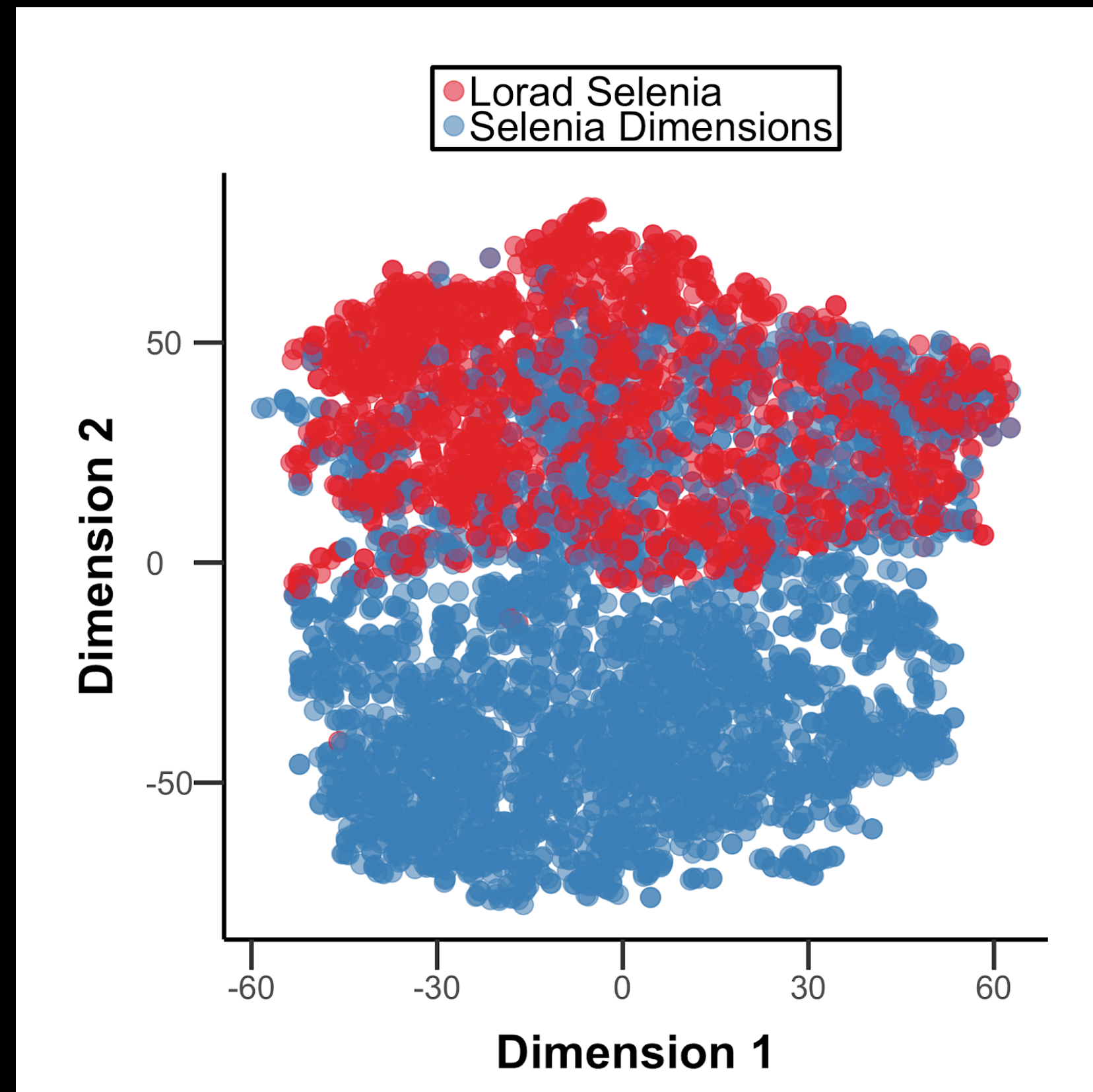
Algorithmic Solution 1: Anti-Bias Training Algorithms: Learning Invariant Representations



Predicting which device was used:
 $d = D(y, h)$

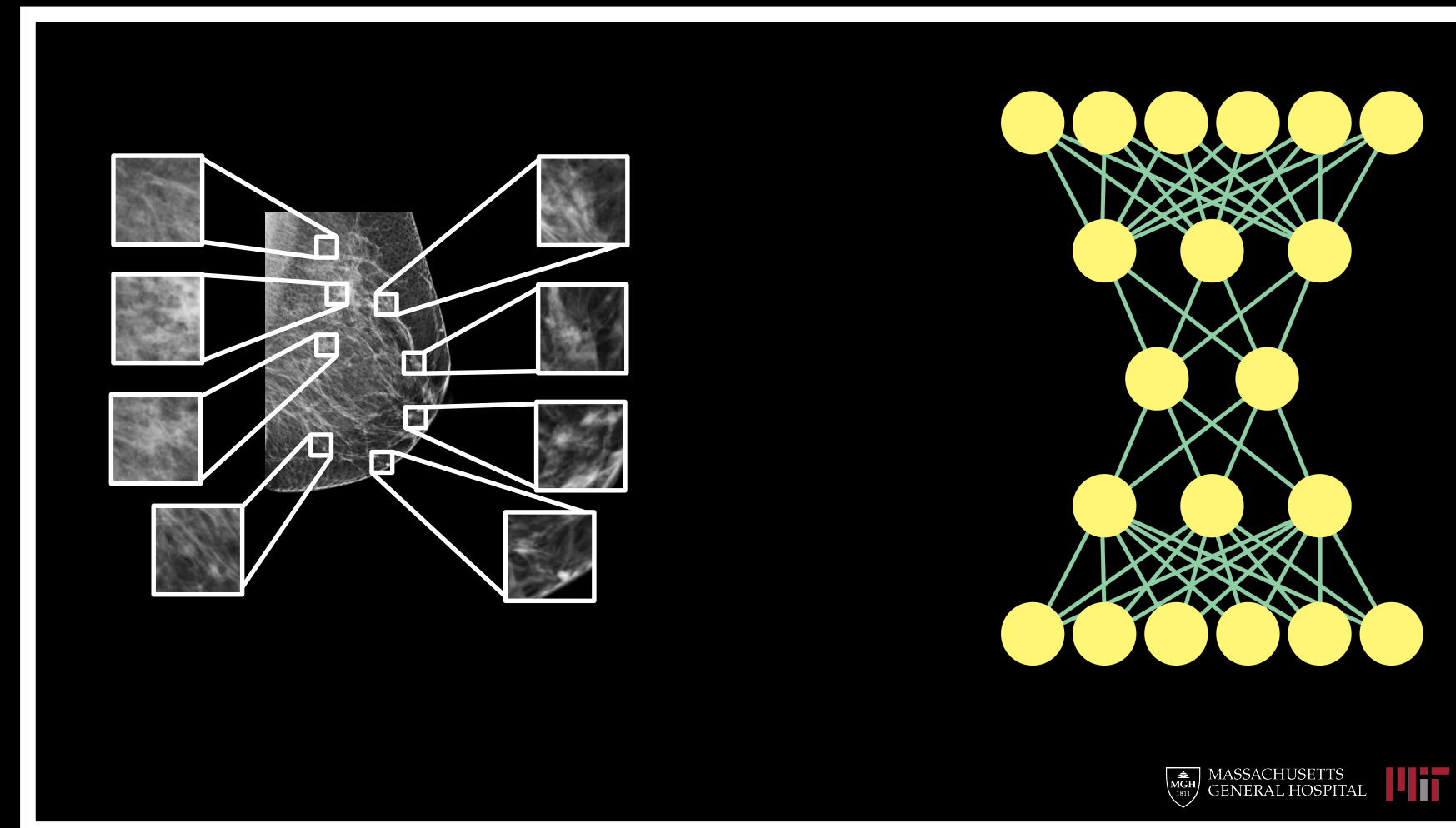
Objective:
Max accuracy **Predictor**
Min accuracy **Discriminator**

Anti-Bias Training Algorithms: Learning Invariant Representations



When Data Bias is Unknown

Case 1: Mystery of 99%



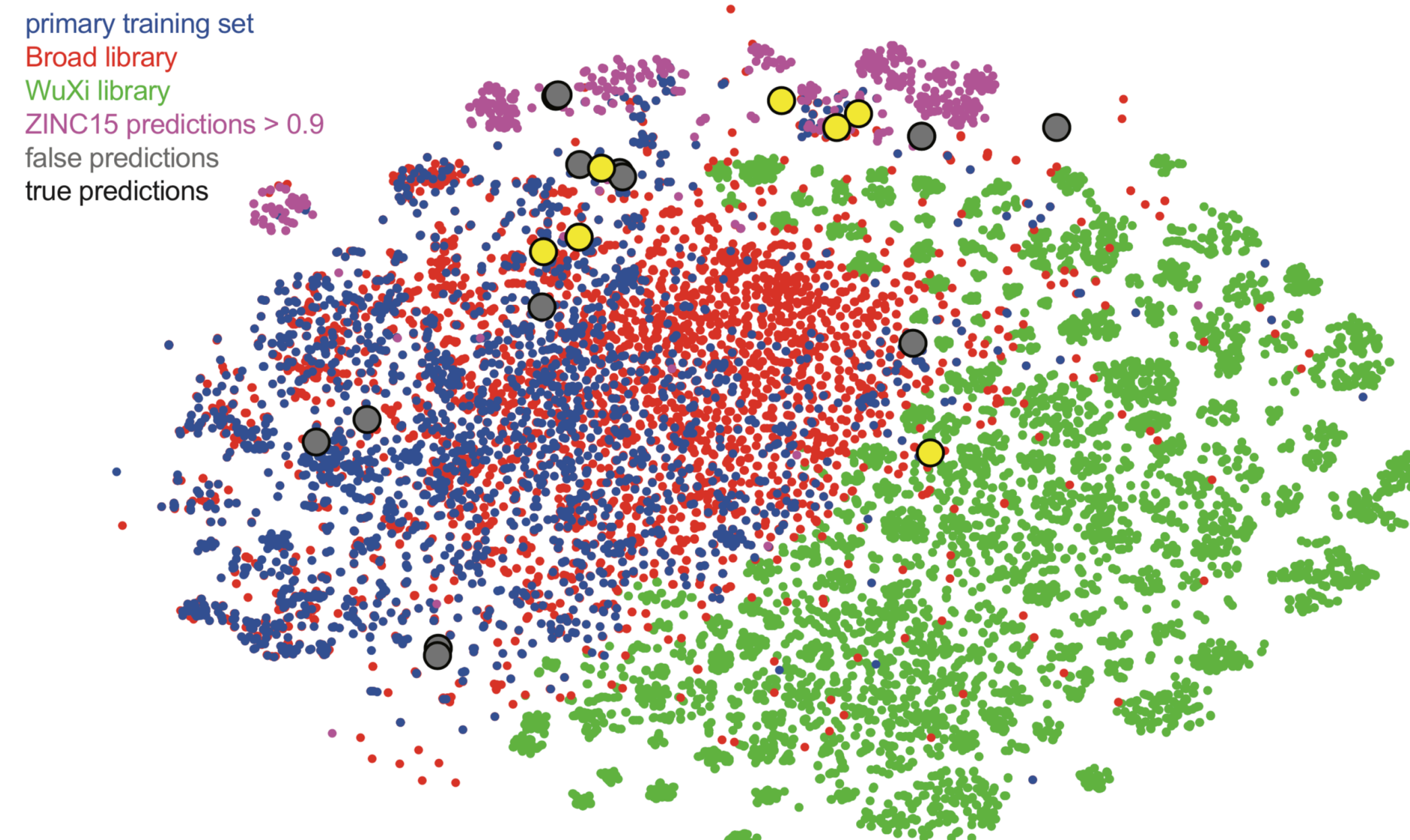
Case 2: Learning from Wrong Information

Variable generalization performance of a deep learning model to detect pneumonia in chest radiographs: A cross-sectional study

John R. Zech , Marcus A. Badgeley , Manway Liu, Anthony B. Costa, Joseph J. Titano, Eric Karl Oermann 

Published: November 6, 2018 • <https://doi.org/10.1371/journal.pmed.1002683>

Data Split: Art or Science?



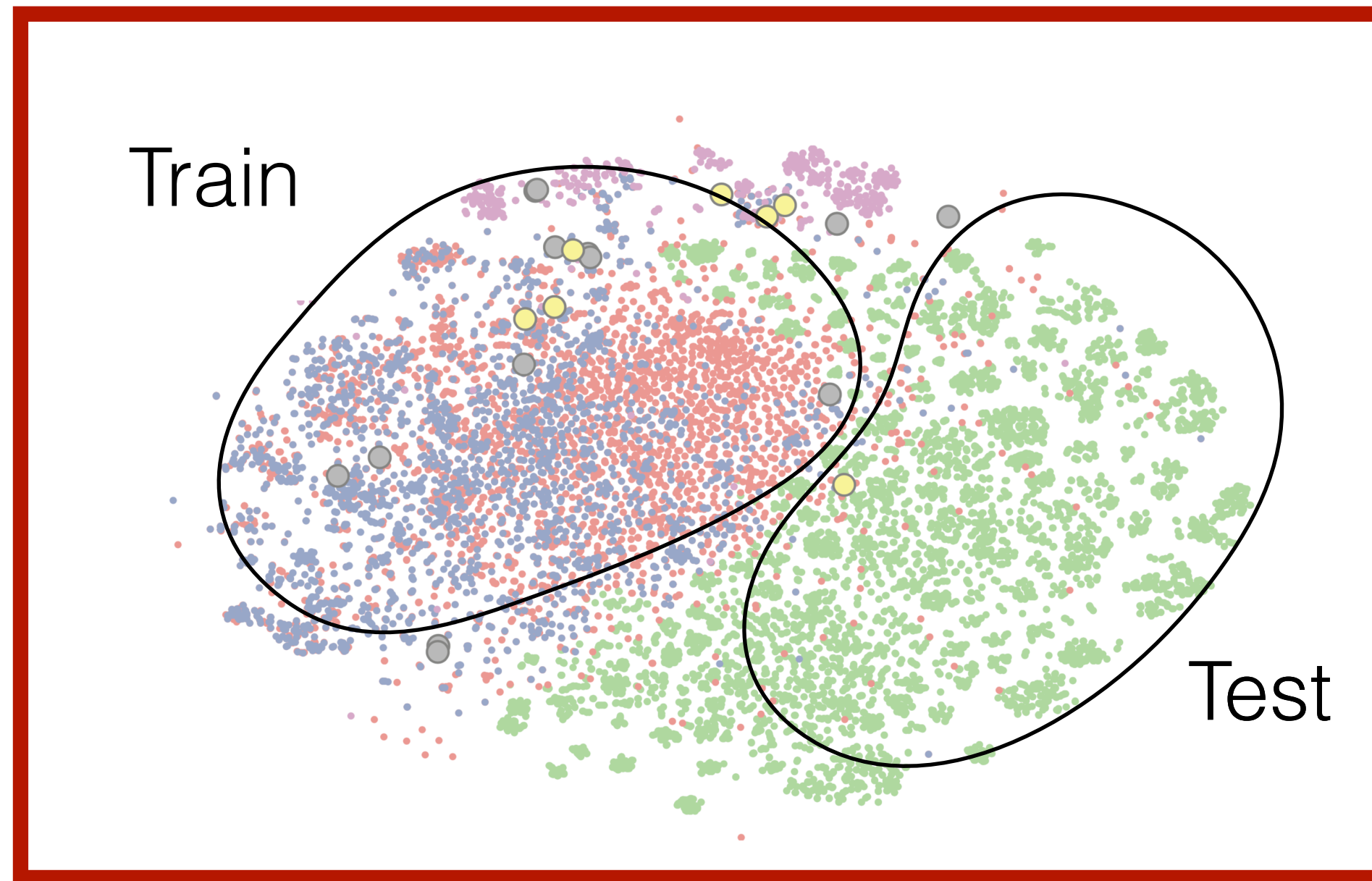
Let's do **scaffold** split.

Temporal split has better performance.

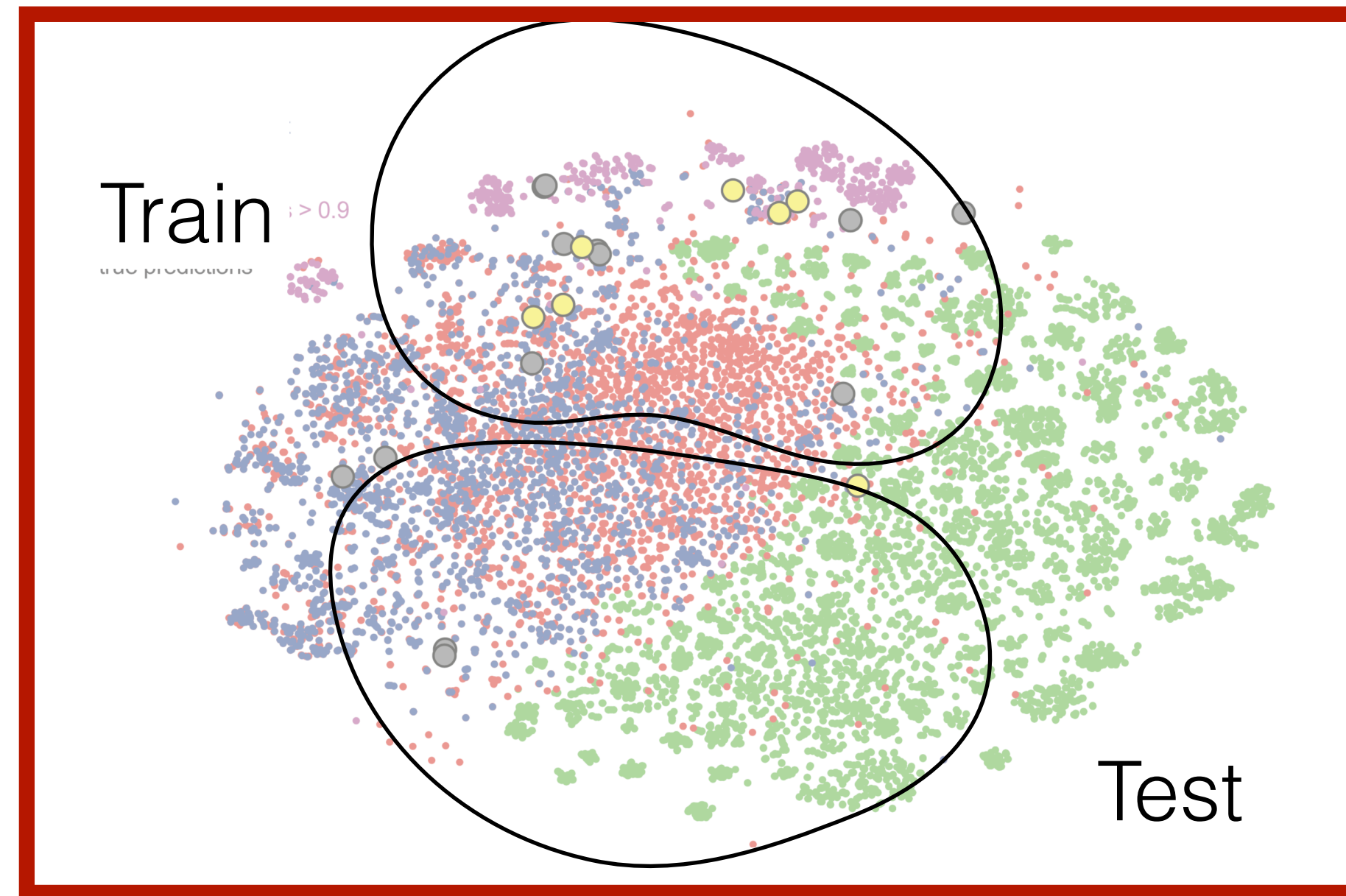


Batch split works well in biology.

Splitting Strategies Vary



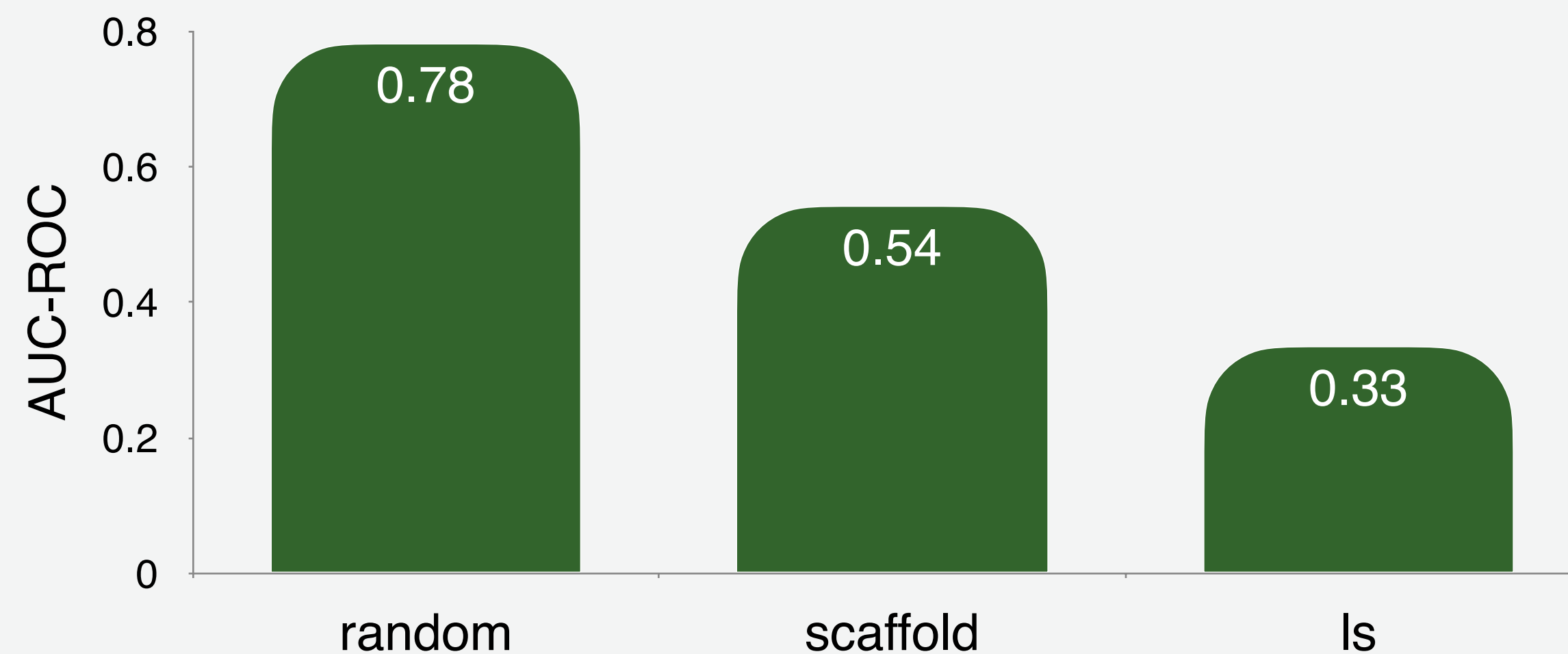
Scaffold Split



Random Split

- Standard in Chemistry: scaffold split
- Split is driven by graph similarity

Finding Harder Splits

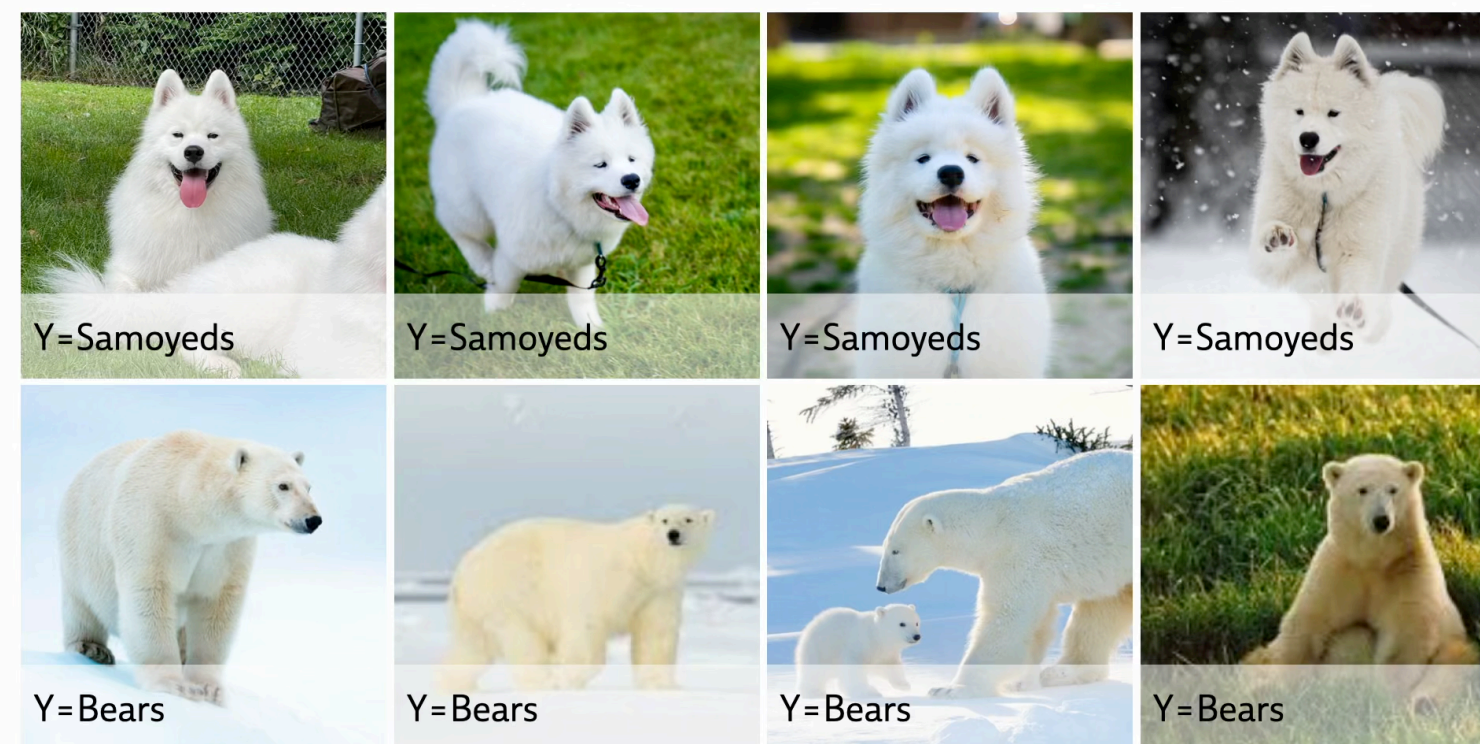


Learning to Split for Automatic Bias Detection

Yujia Bao, Regina Barzilay

Algorithmic Solution #2: Learning to Split for Automatic Bias Detection

Given a dataset with input-label pairs



Learn to **split** the dataset such that predictors trained on the training set **cannot generalize** to the testing set.

Bi-level optimization

Splitter

Generate a train-test split of the dataset.

Predictor

Minimize the loss on the training set.*

Estimate the generalization error on the testing set.

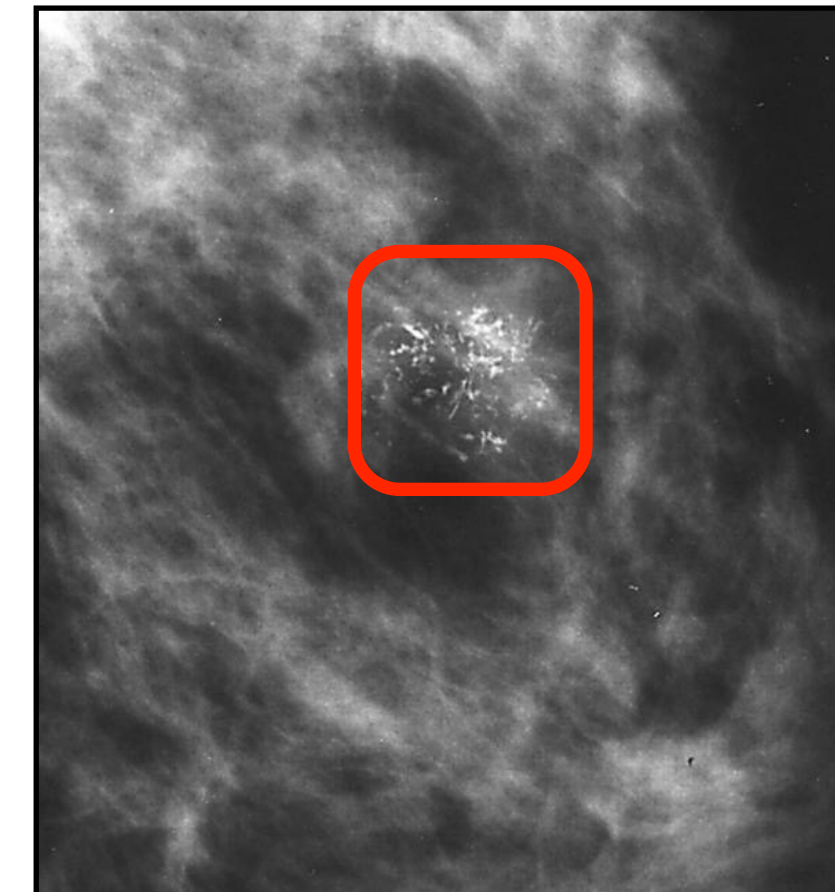
Maximize the generalization error subject to constraints

There is no evidence of extranodal extension.

BREAST (RIGHT), EXCISIONAL BIOPSY:

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

... ..



VIEWPOINT | VOLUME 3, ISSUE 11, E745-E750, NOVEMBER 2021

The false hope of current approaches to explainable artificial intelligence in health care

Marzyeh Ghassemi, PhD • Luke Oakden-Rayner • Andrew L Beam, PhD  

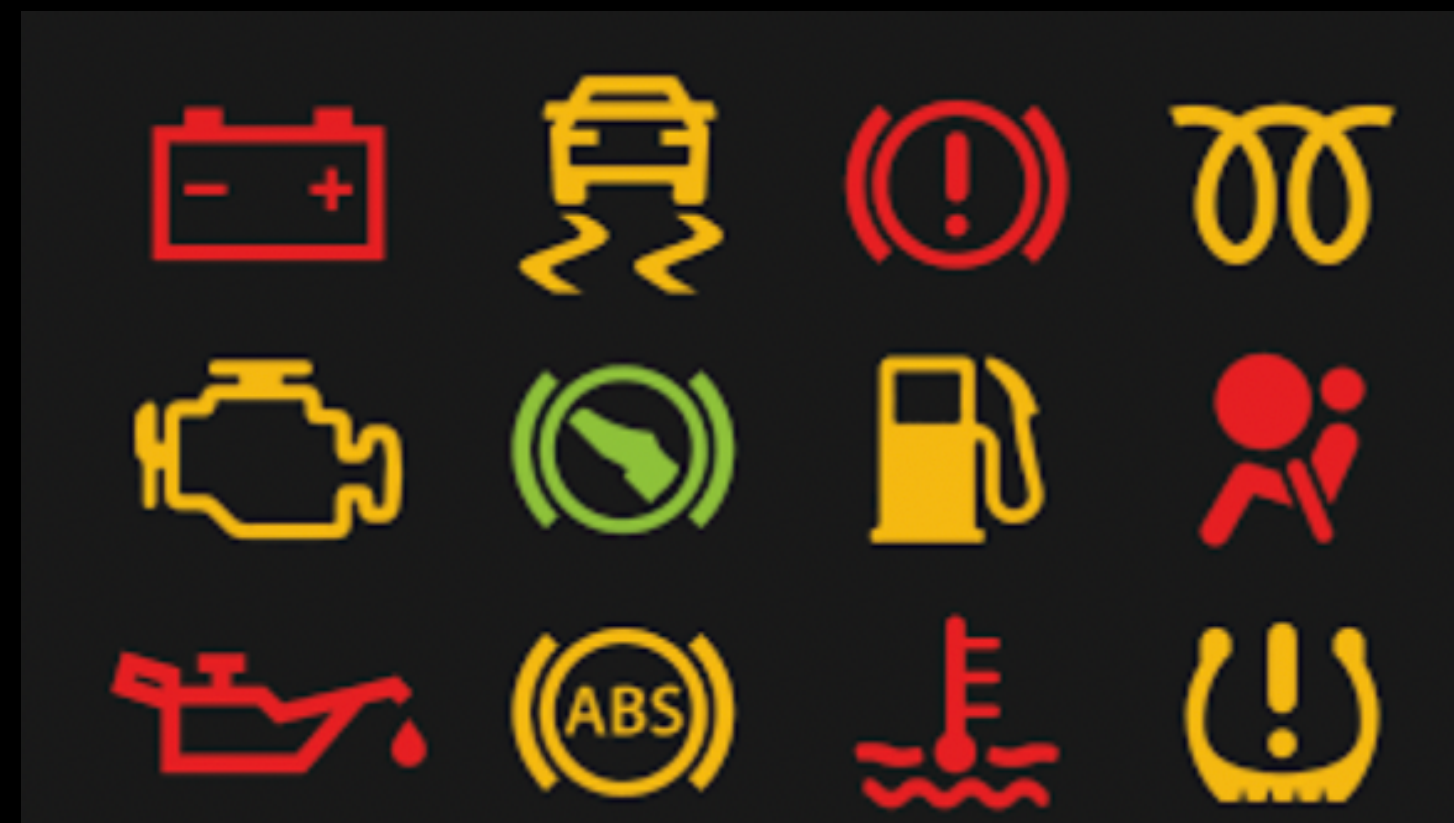
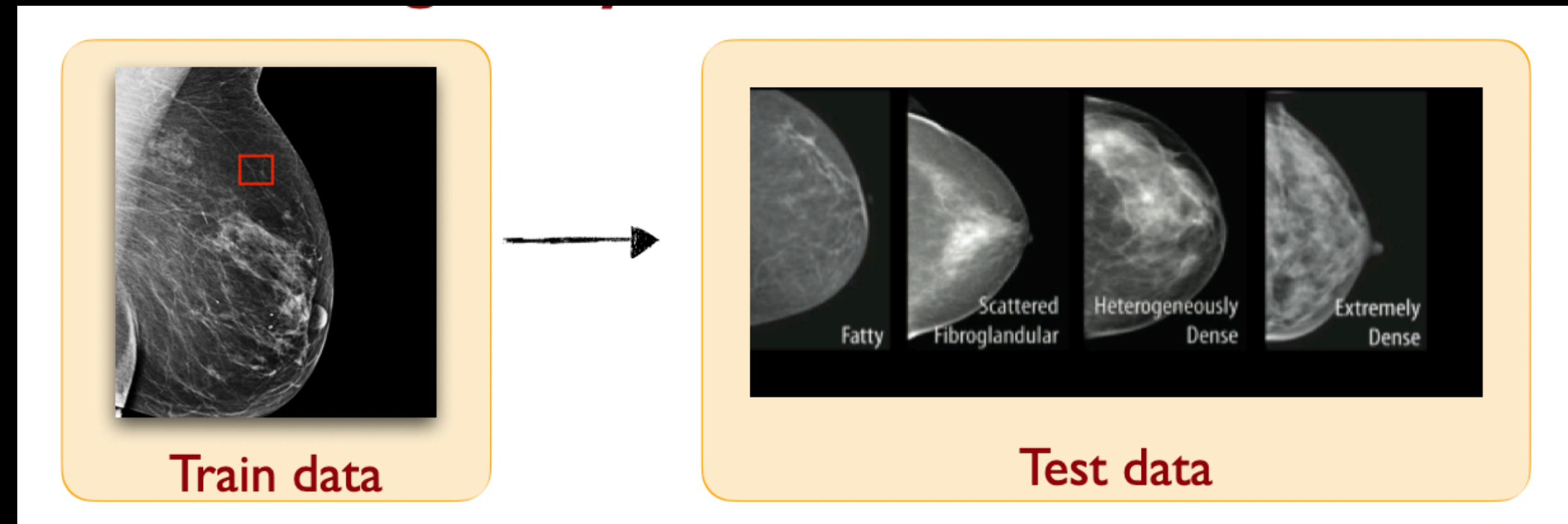
3. Patient-Centered Approach Incorporating Transparency to Users

What we heard: **Stakeholders called for further discussion with FDA on how AI/ML-based technologies interact with people, including their transparency to users and to patients more broadly.**

What we'll do: **Following up on the Agency's recent Patient Engagement Advisory Committee meeting on AI/ML-based devices, our next step will be to hold a public workshop on how device labeling supports transparency to users and enhances trust in AI/ML-based devices**

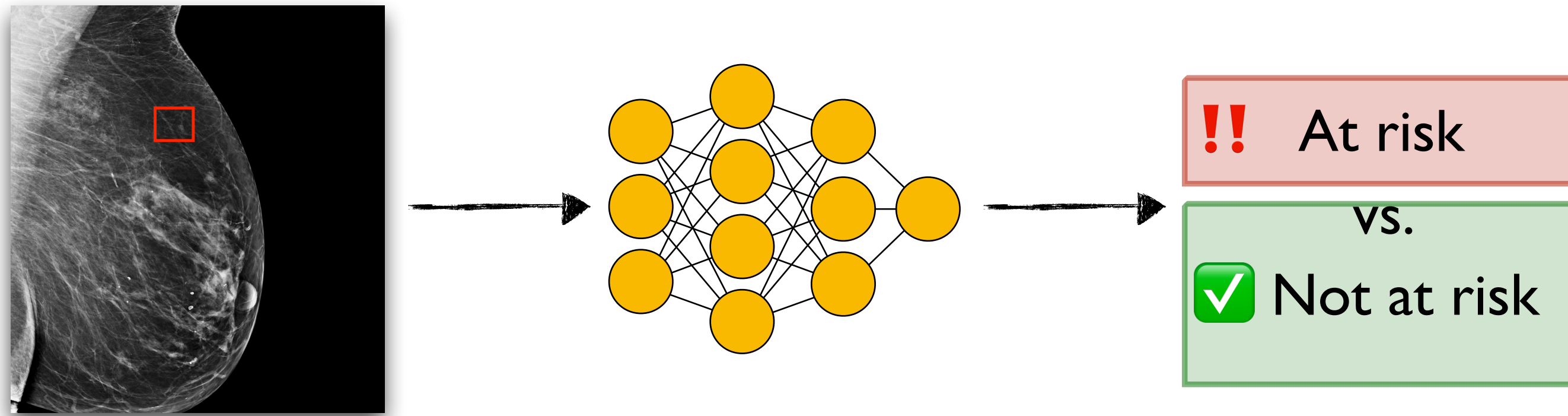
The Agency acknowledges that AI/ML-based devices have unique considerations that necessitate a proactive patient-centered approach to their development and utilization that takes into account issues including usability, equity, trust, and accountability. One way that FDA is addressing these issues is through the promotion of the transparency of these devices to users, and to patients more broadly,

Selective Classification



Learn to abstain on uncalibrated examples

Algorithmic Solution #3: Out-of-domain Calibration



- Suppose we train a model. When can we trust its predictions?
- We can answer these questions if predictions are **well-calibrated**.

Calibrated Selective Classification

Adam Fisch, Tommi S. Jaakkola, Regina Barzilay, January 2023

[\[openreview\]](#) [\[pdf\]](#) [\[bib\]](#) [\[code\]](#)

Algorithmic Solutions for Safe and Equitable AI development

**Uncertainty
Quantification**

**Anti-Bias
Training**

**Distribution Shift
Detection**

MIT-MGB AI Cures Conference

April 24, 2023 | Samberg Center, MIT

Featured Speakers

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President & CEO, Mass General Brigham

Cynthia Barnhart
Provost, MIT

Paul Anderson
Acting Chief Academic Officer, MGB

Regina Barzilay
Distinguished Professor & Faculty Lead, MIT

Dina Katabi
Thuan and Nicole Pham Professor, MIT

Collin Stultz
Nina T. and Robert H. Rubin Professor, MIT/MGB

Polina Golland
Professor, MIT

David Sontag
Professor, MIT

Marzyeh Ghassemi
Assistant Professor, MIT

David Bates
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What is AI Cures?

Building on the combined expertise of MIT and MGB in AI and clinical practice, our ultimate goal is to facilitate the translation and adoption of these technologies for improving diagnostics, treatment and long term outcomes for diverse patient populations. Hosted by MIT Jameel Clinic, AI Cures showcases ongoing collaborative projects in clinical AI, highlighting cutting-edge research and their impact on patient care. Equally important is the process for collecting the data required to train clinical AI algorithms, with a focus on privacy, diversity, and quality.



 Mass General Brigham

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