The Future of AI

David Cox
Director, MIT-IBM Watson AI Lab

MIT-IBM
Watson AI Lab

IBM

“Artificial Intelligence”

The evolution of AI

Narrow AI
Emerging

Broad AI
Disruptive and Pervasive

General AI
Revolutionary

▼ We are here

2050 and beyond

The evolution of AI

Narrow AI

Single task, single domain

Superhuman accuracy and speed for certain tasks

Broad AI

Multi-task, multi-domain

Multi-modal

Distributed AI

Explainable

General AI

Cross-domain learning and reasoning

Broad autonomy

The evolution of AI

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Broad autonomy

DEC 29, 2014 @ 11:37 AM 115,776

Sell In May & Walk Away: 6 Stocks to Dump

Tech 2015: Deep Learning And Machine Intelligence Will Eat The World

Anthony Wing Kosner, CONTRIBUTOR

Quantum of Content and innovations in user experience FULL BIO

Opinions expressed by Forbes Contributors are their own.

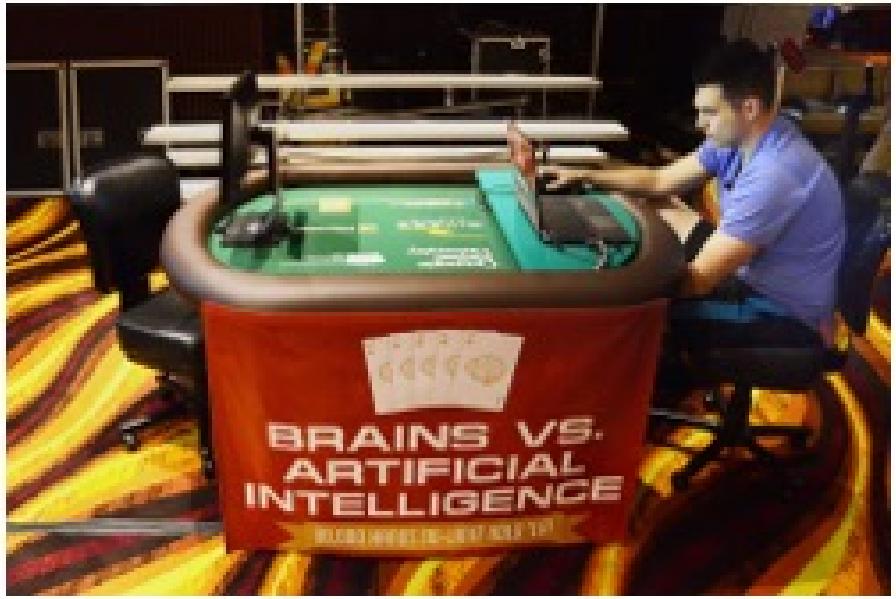
man in black shirt is playing guitar.

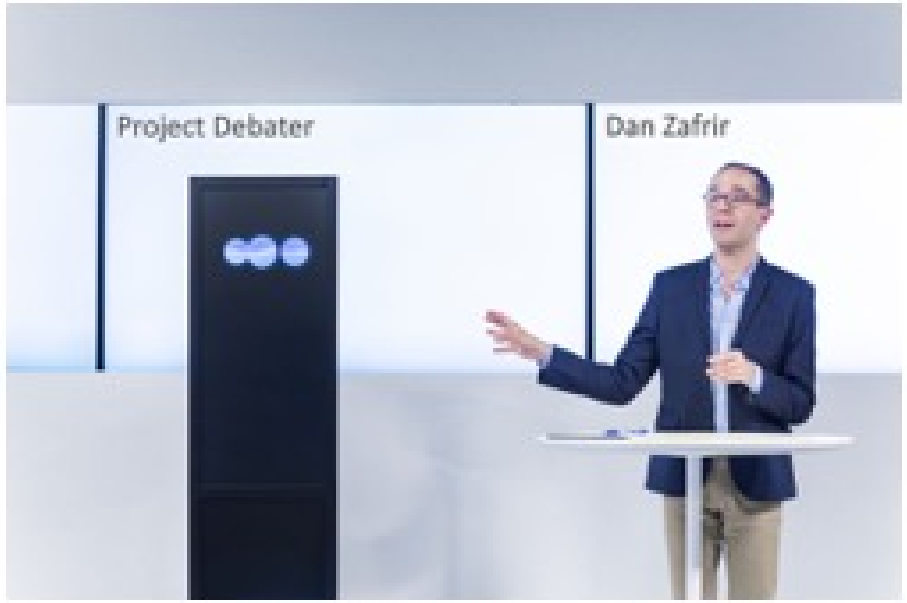
construction worker in orange safety vest is working on road.

Karpathy and Li, 2015


THINK
DENKE
$24,000
$77,147
$21,600


Mind
Match


BRAINS VS.
ARTIFICIAL
INTELLIGENCE

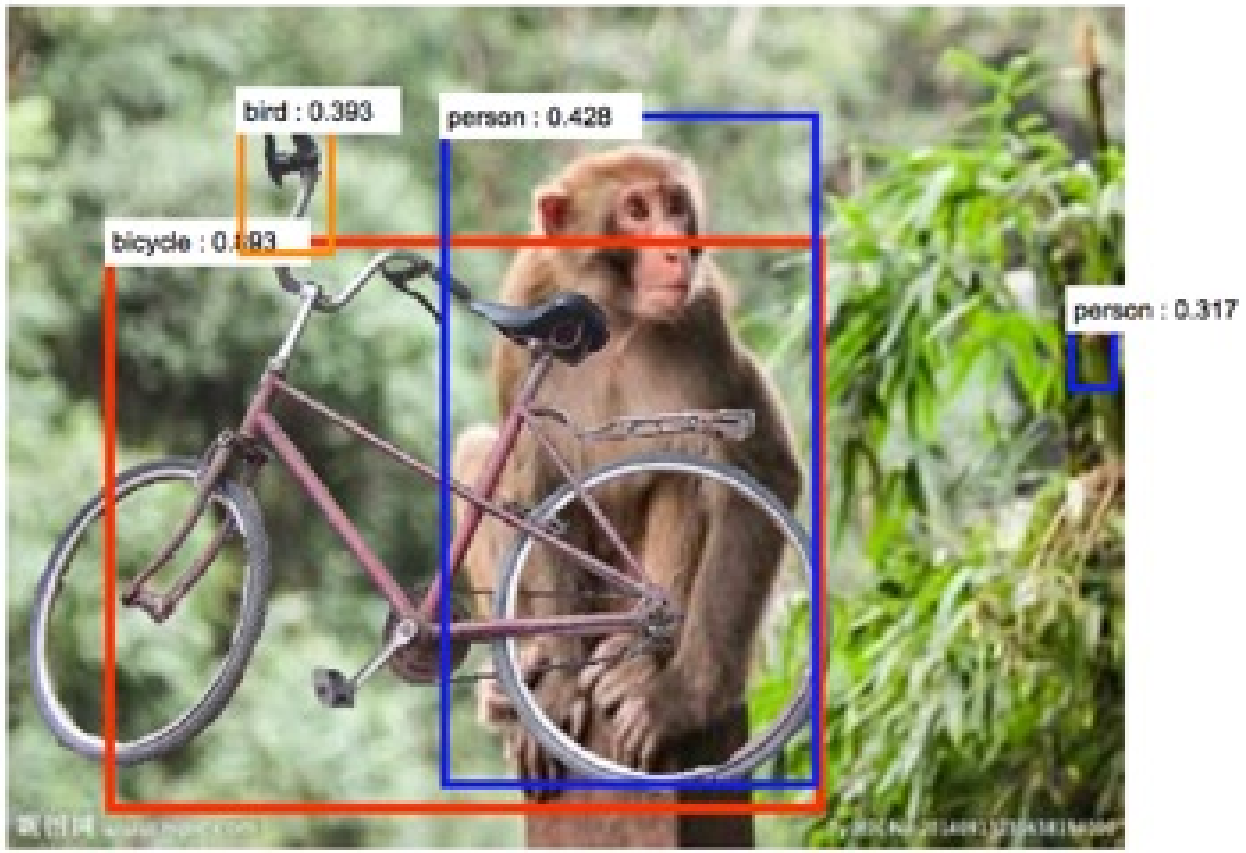

Project Debater
Dan Zafrir

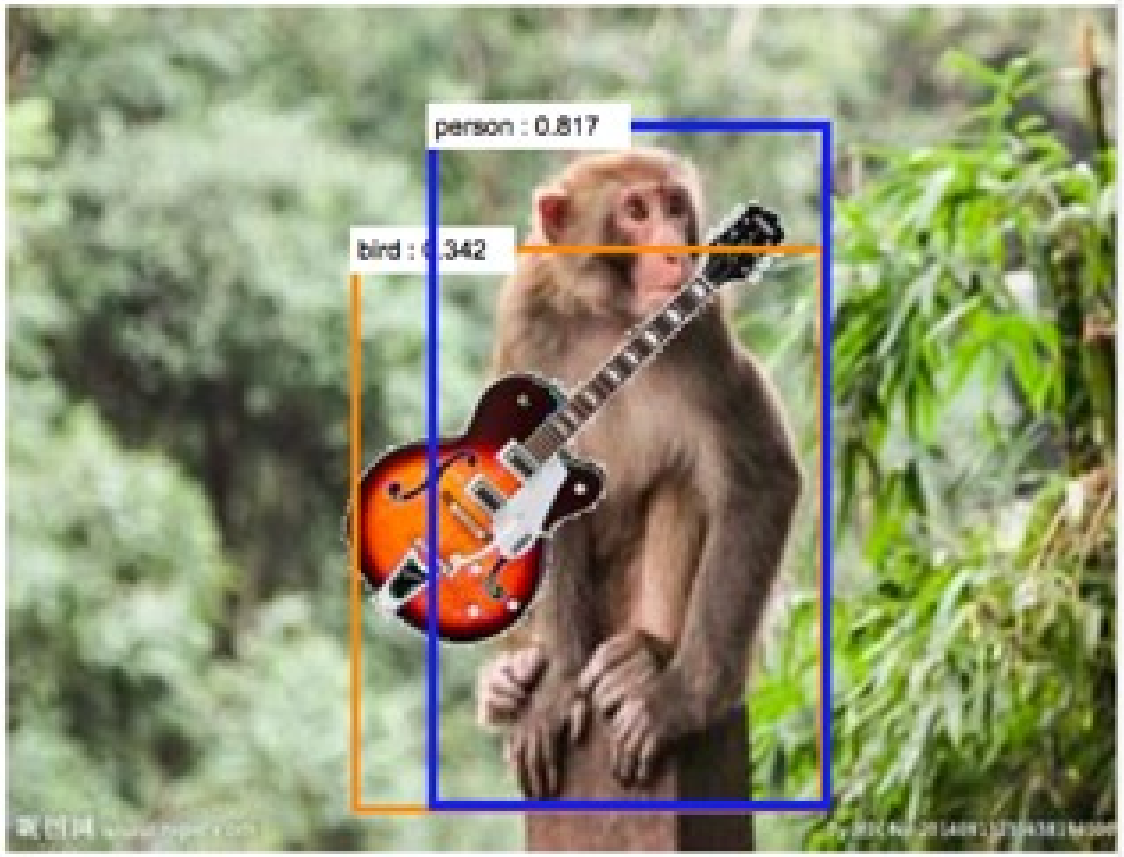
Gatys et al. 2015

Brock et al. 2018

“Teddy Bear”

Meret Oppenheim, *Le Déjeuner en fourrure*





Wang et al. 2018

man in black shirt is playing guitar.

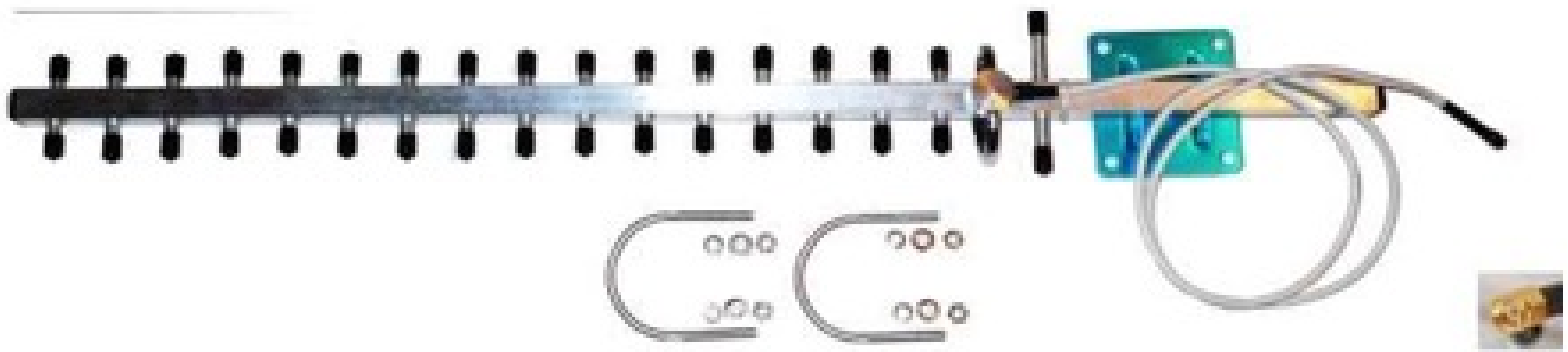
construction worker in orange safety vest is working on road.

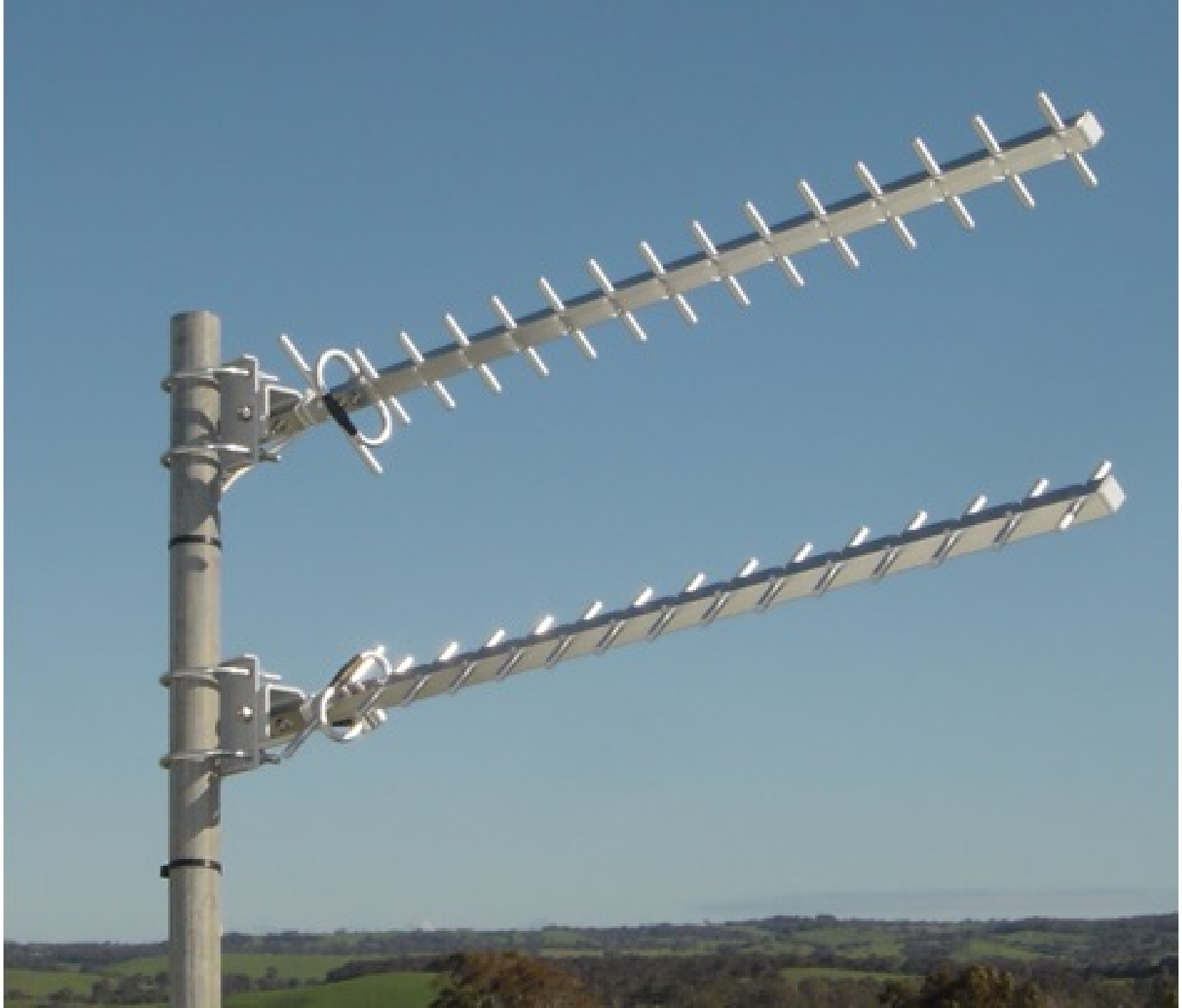
Karpathy and Li, 2015

a man riding a
motorcycle on a beach

Lake, Ullman, Tenenbaum & Gershman, 2016

What’s this?



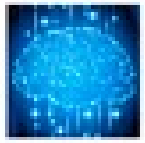


RADIOLOGY NEWS

CCTA usage rate rises sharply, but still eclipsed by MPI

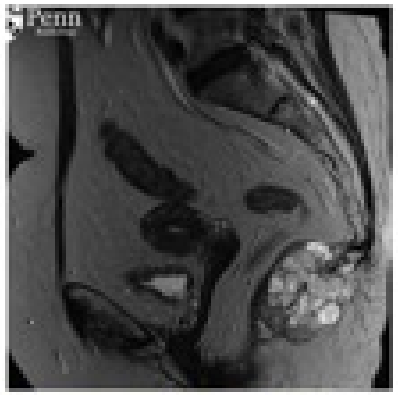
February 23, 2018 -- The use of coronary CT angiography (CCTA) to evaluate chest pain in the emergency department has grown exponentially, but clinicians are still using myocardial perfusion imaging (MPI) far more frequently, according to research published online February 15 in the *American Journal of Roentgenology*. Discuss

fMRI, machine learning could predict OCD therapy outcomes



February 23, 2018 -- By analyzing resting-state functional MRI (fMRI) brain scans with a machine-learning algorithm, researchers at the University of California, Los Angeles may have devised a way to predict treatment outcomes for people with obsessive-compulsive disorder (OCD), according to results

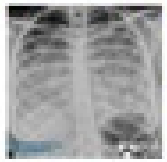
CASE OF THE DAY℠



51-year-old woman with incidental finding

View case | Discuss

Recent Cases



15-year-old girl with persistent cough

83-year-old

Original Top-3 inferred captions:

1. A red stop sign sitting on the side of a road.
2. A stop sign on the corner of a street.
3. A red stop sign sitting on the side of a street.

Adversarial Top-3 captions:

1. A brown teddy bear laying on top of a bed.
2. A brown teddy bear sitting on top of a bed.
3. A large brown teddy bear laying on top of a bed.

Chen et al. 2018

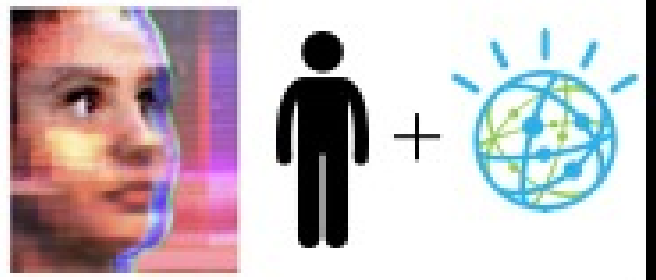
Pin-yu Chen
IBM

The path to Broad AI

Explainability

Security

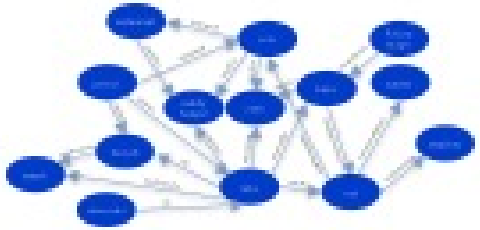
Ethics



Learn more from small data

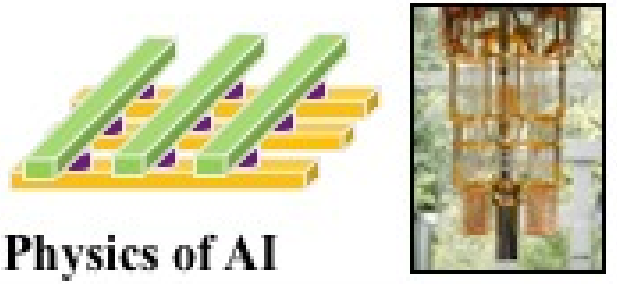
Learns to transfer

+



Reasons

Infrastructure



Physics of AI

INDUSTRY | ACADEMIA

AI | AI

INDUSTRY

ACADEMIA

INDUSTRY PROBLEMS

LIFE SCIENCES

CHEMISTRY

BIOLOGY

DATA

AI

AI

ECONOMICS

RESOURCES

PHYSICS

PHYSICS

By the numbers….

$240m investment

Roughly **100** full-time equivalent researchers (60 MIT / 40 IBM), working on **50** projects

10 year time horizon

What’s coming in the next few years in AI?

The path to Broad AI

1. Extend

2. Understand

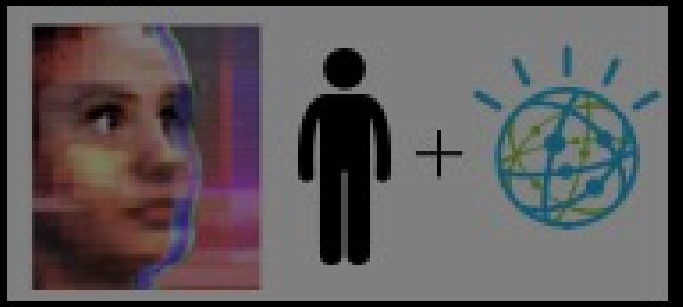
3. Accelerate

Understand

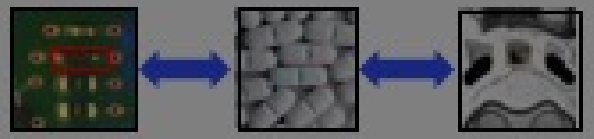
Explainability

Security

Ethics

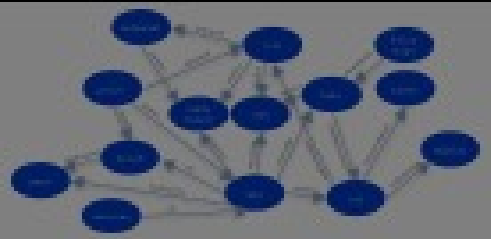


Learn more from small data



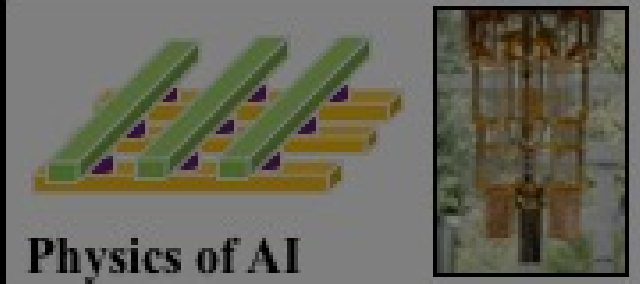
Learns to transfer

+



Reasons

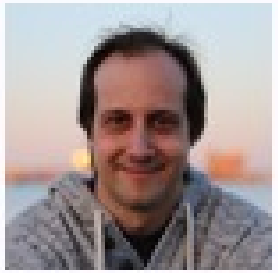
Infrastructure



Physics of AI

Errors in Artificial Neural Networks

Debugging neural networks enables trust and transparency



Antonio Torralba
MIT

Stefanie Jegelka
MIT

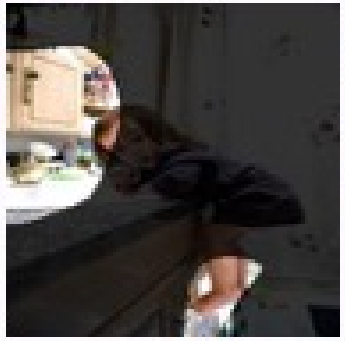
Hendrik Strobelt
IBM

AI: Washing dishes

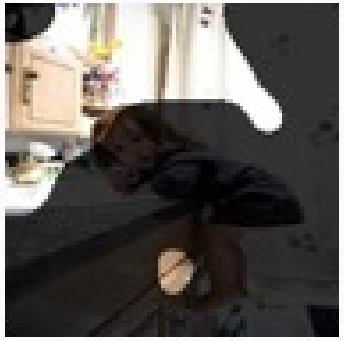
Truth: Brushing teeth

neuron 1679:
Bathroom

neuron 867:
Kitchen



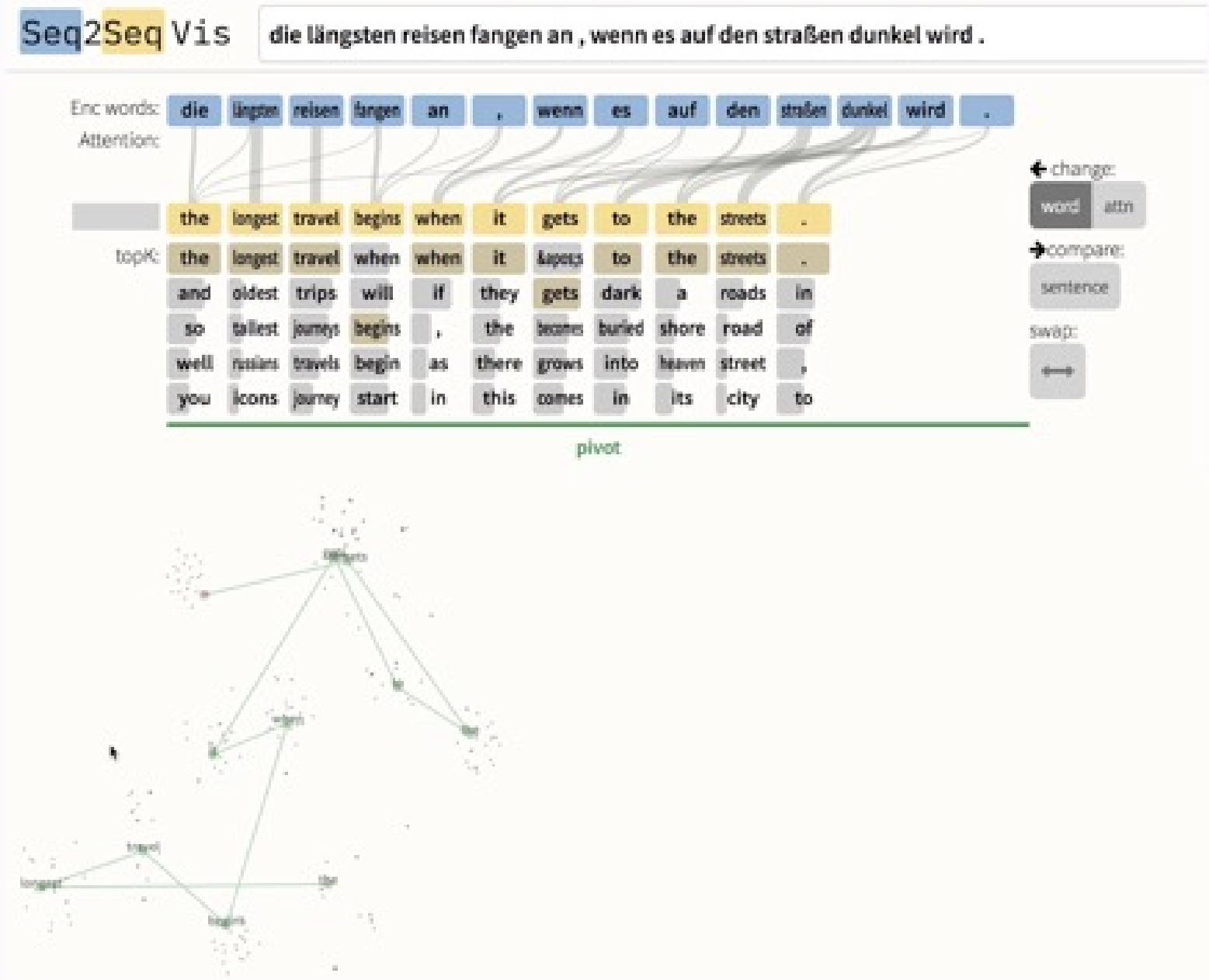
neuron 1749:
House



neuron 795:
Bathroom

neuron 1978:
Person

Network confused about the scene and did not detect the brush.



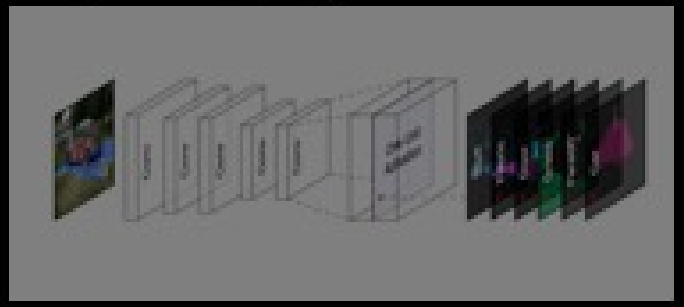
Hendrik Strobelt
IBM

Sasha Rush
Harvard

http://seq2seq-vis.io/

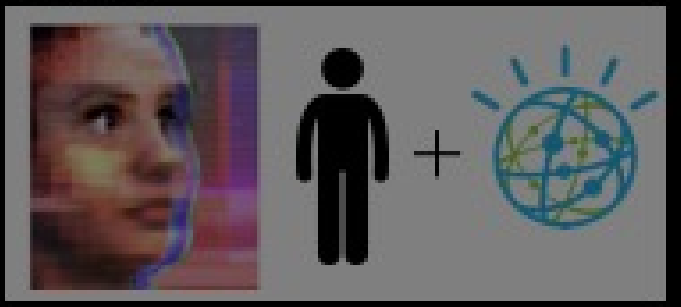
Extend

Explainability

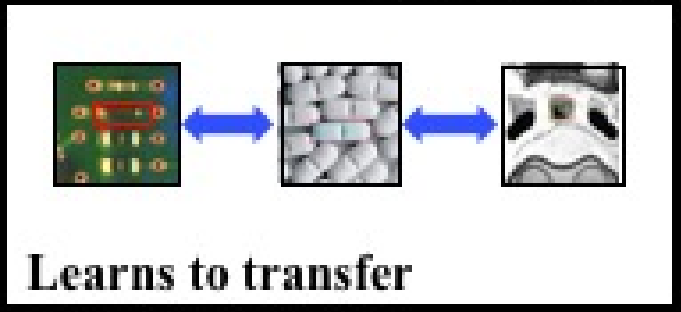


Security

Ethics



Learn more from small data



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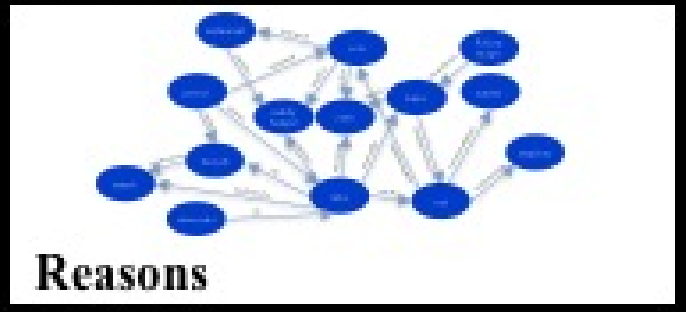
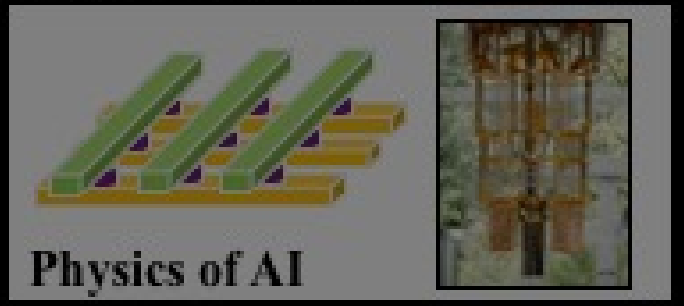


Infrastructure

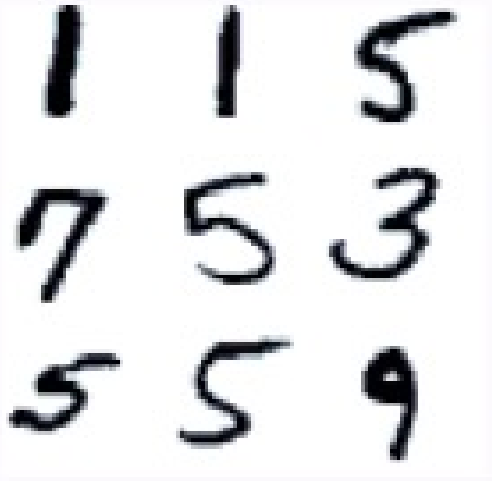


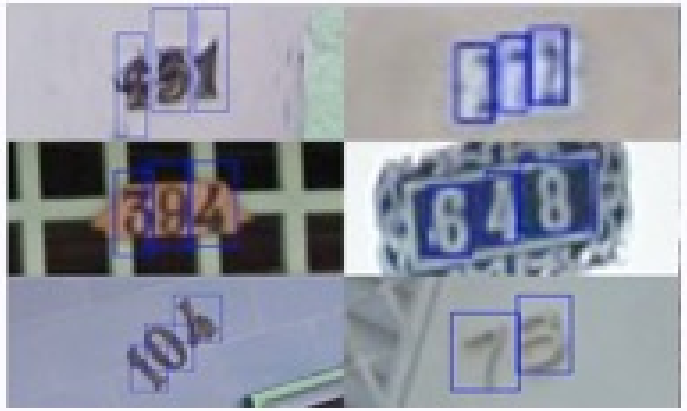
Methods for Exploiting Unlabeled Data in Supervised Learning

Doing more with less annotation

Prasanna Sattigieri
IBM

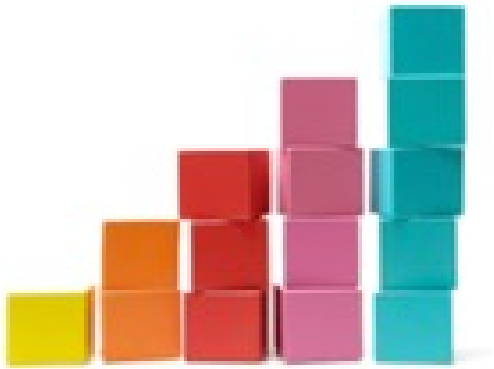
Greg Wornell
MIT





Kumar et al. NIPS 2018. Alignment for Unsupervised Domain Adaptation

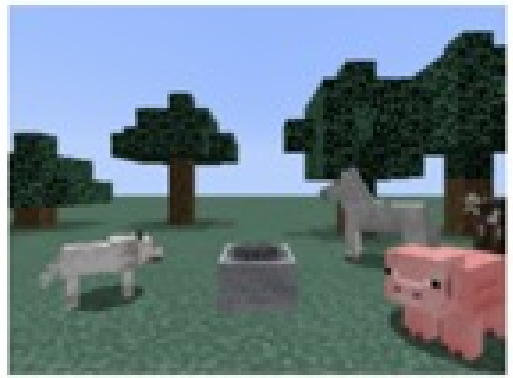
What’s coming in the next 3-5 years?



How many blocks are on the right of the three-level tower?

Will the block tower fall if the top block is removed?

What is the shape of the object closest to the large cylinder?



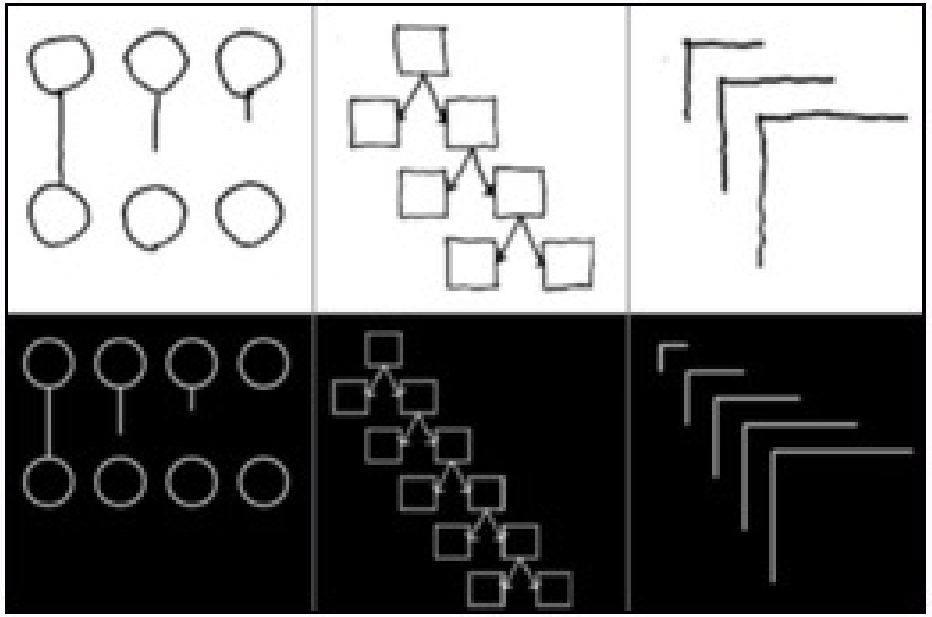
Are there more trees than animals?

Neuro-symbolic Program Induction

Inferring generative neural *programs* from data to enable reasoning on complex data and enhance explainability of AI

Josh Tenenbaum
MIT

Michael Witbrock
IBM



Top row: hand drawn figures
bottom row: outputs of inferred generative programs

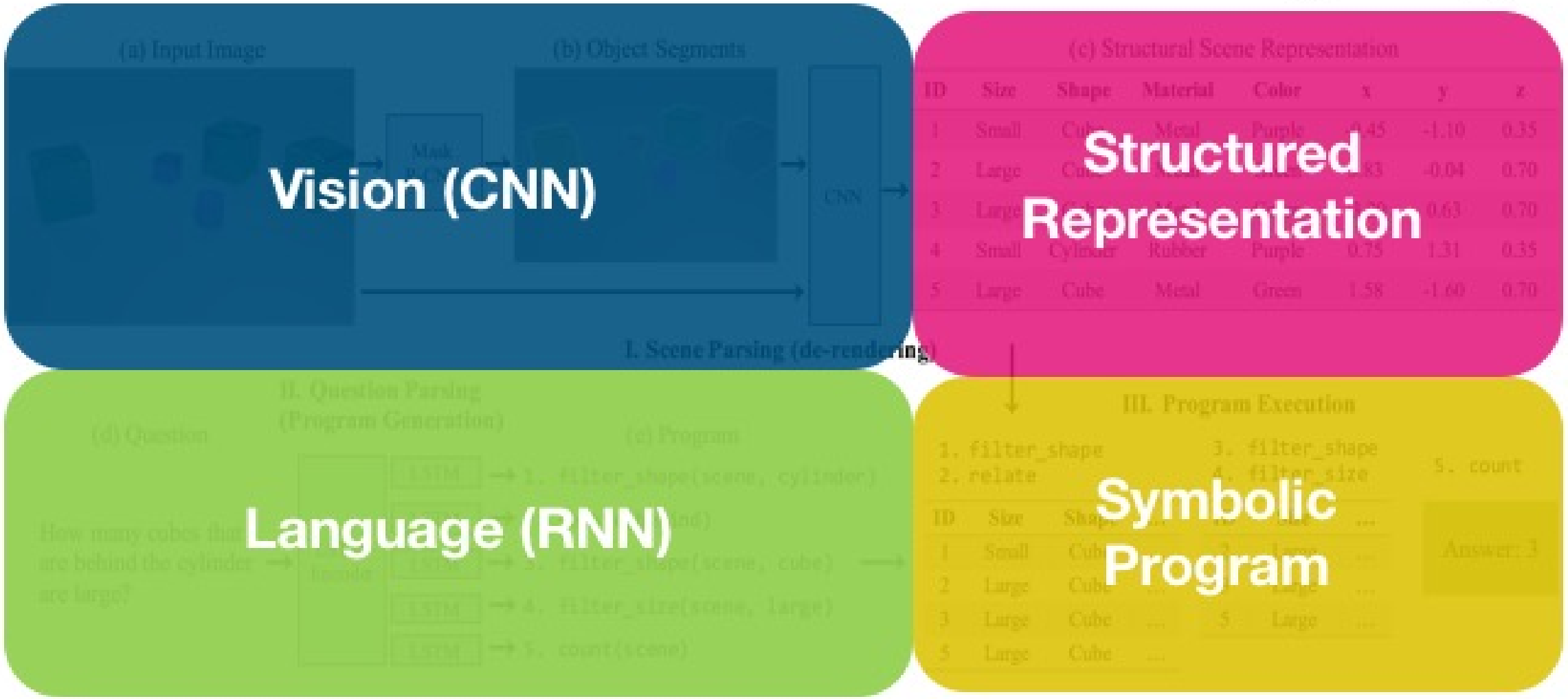
Diego Castillo & Isabel Foster, 2006	→	Castillo et al. (2006)
Felix Nugee, 2000		Nugee (2000)
Lauren Dodi and Umair Ahmed, 1998		Dodi et al. (1998)

Inferring text transformation programs from examples, to clean and standardize data, reason about complicated structured text, enhance explainability

Jiajun Wu
MIT

Chuang Gan
IBM

Josh Tenenbaum
MIT



Methods	Count	Exist	Compare Number	Compare Attribute	Query Attribute	Overall
Humans [Johnson et al., 2017b]	86.7	96.6	86.4	96.0	95.0	92.6
CNN+LSTM+SA+MLP [Johnson et al., 2017b]	59.7	77.9	75.1	70.8	80.9	73.2
N2NMN* [Hu et al., 2017]	68.5	85.7	84.9	88.7	90.0	83.7
Dependency Tree [Cao et al., 2018]	81.4	94.2	81.6	97.1	90.5	89.3
CNN+LSTM+RN [Santoro et al., 2017]	90.1	97.8	93.6	97.1	97.9	95.5
IEP* [Johnson et al., 2017b]	92.7	97.1	98.7	98.9	98.1	96.9
CNN+GRU+CBN [Perez et al., 2018]	94.5	99.2	93.8	99.0	99.2	97.6
DDRprog* [Suarez et al., 2018]	96.5	98.8	98.4	99.0	99.1	98.3
MAC [Hudson and Manning, 2018]	97.1	99.5	99.1	99.5	99.5	98.9
TbD+reg+hres* [Mascharka et al., 2018]	97.6	99.2	99.4	99.6	99.5	99.1
Ours (100 programs)	54.0	81.0	50.2	59.5	75.4	66.0
Ours (200 programs)	84.6	91.3	72.9	85.9	88.7	86.1
Ours (500 programs)	**99.7**	**99.9**	**99.9**	**99.8**	**99.8**	**99.8**

Effectively perfect!

Table 1: Our model outperforms current state-of-the-art methods on CLEVR and achieves near-perfect question answering accuracy. (*): training relies on all program annotations (700k).

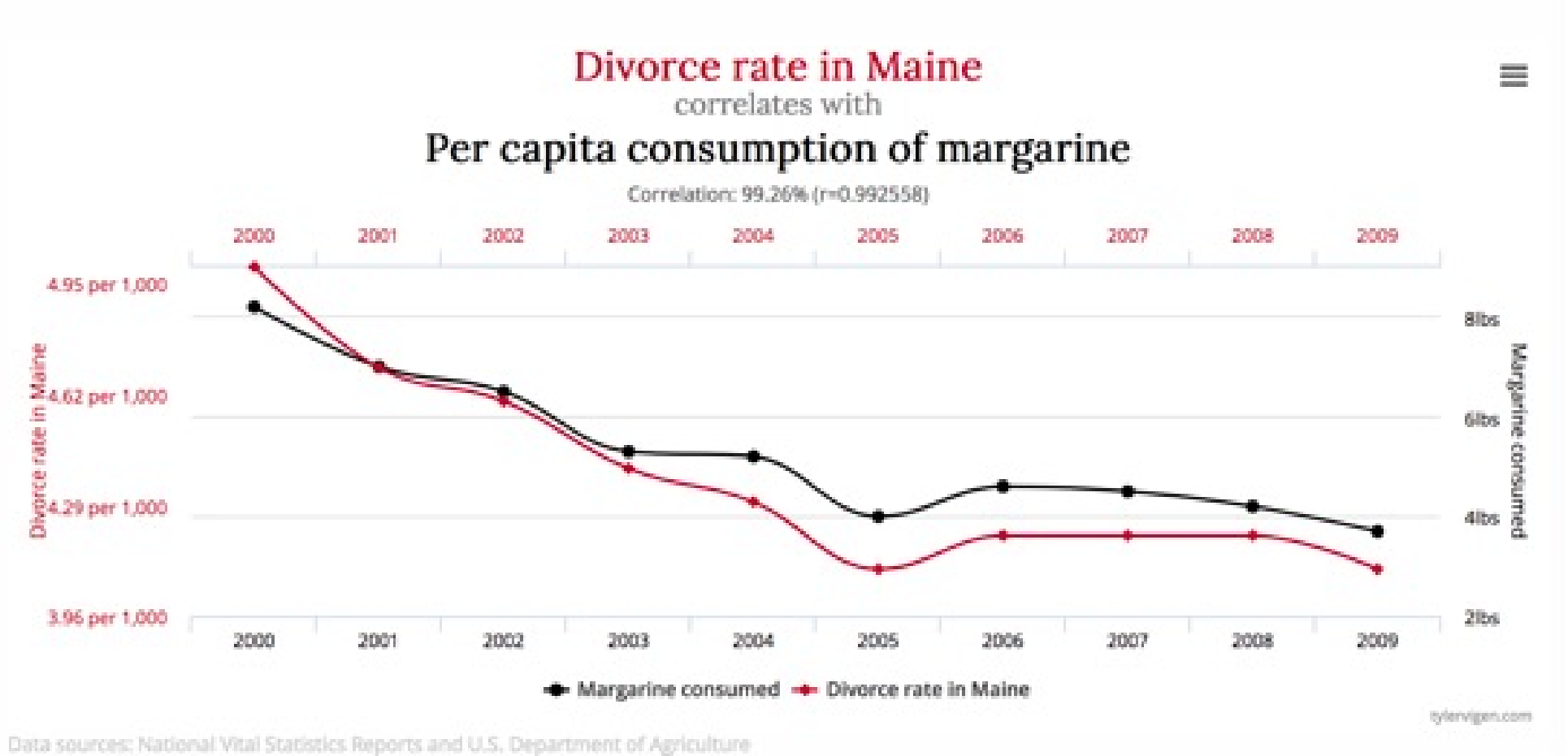
Causal Inference

Beyond Correlation—inferring and testing for causal relationships in complex systems

Caroline Uhler
MIT

Guy Bresler
MIT

Karthikeyan Shanmugam
IBM



http://tylervigen.com/spurious-correlations

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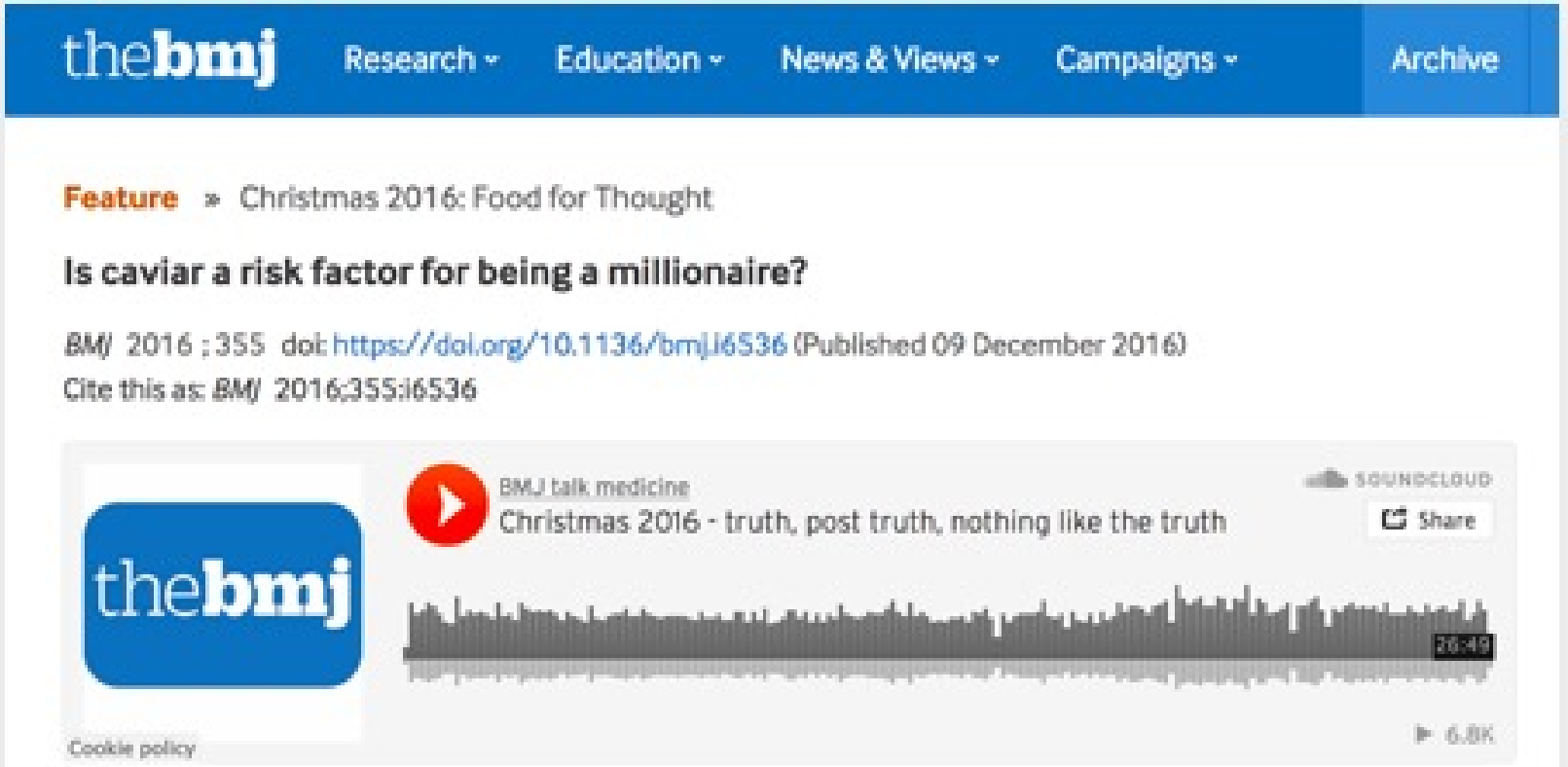

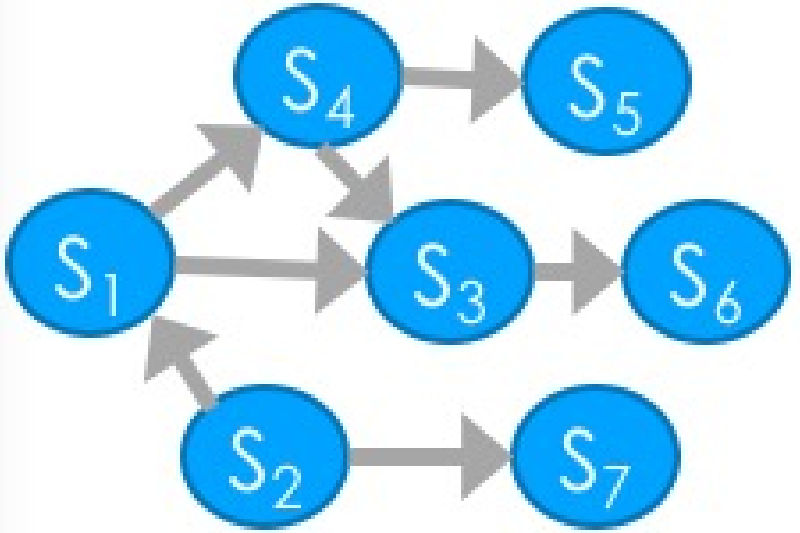

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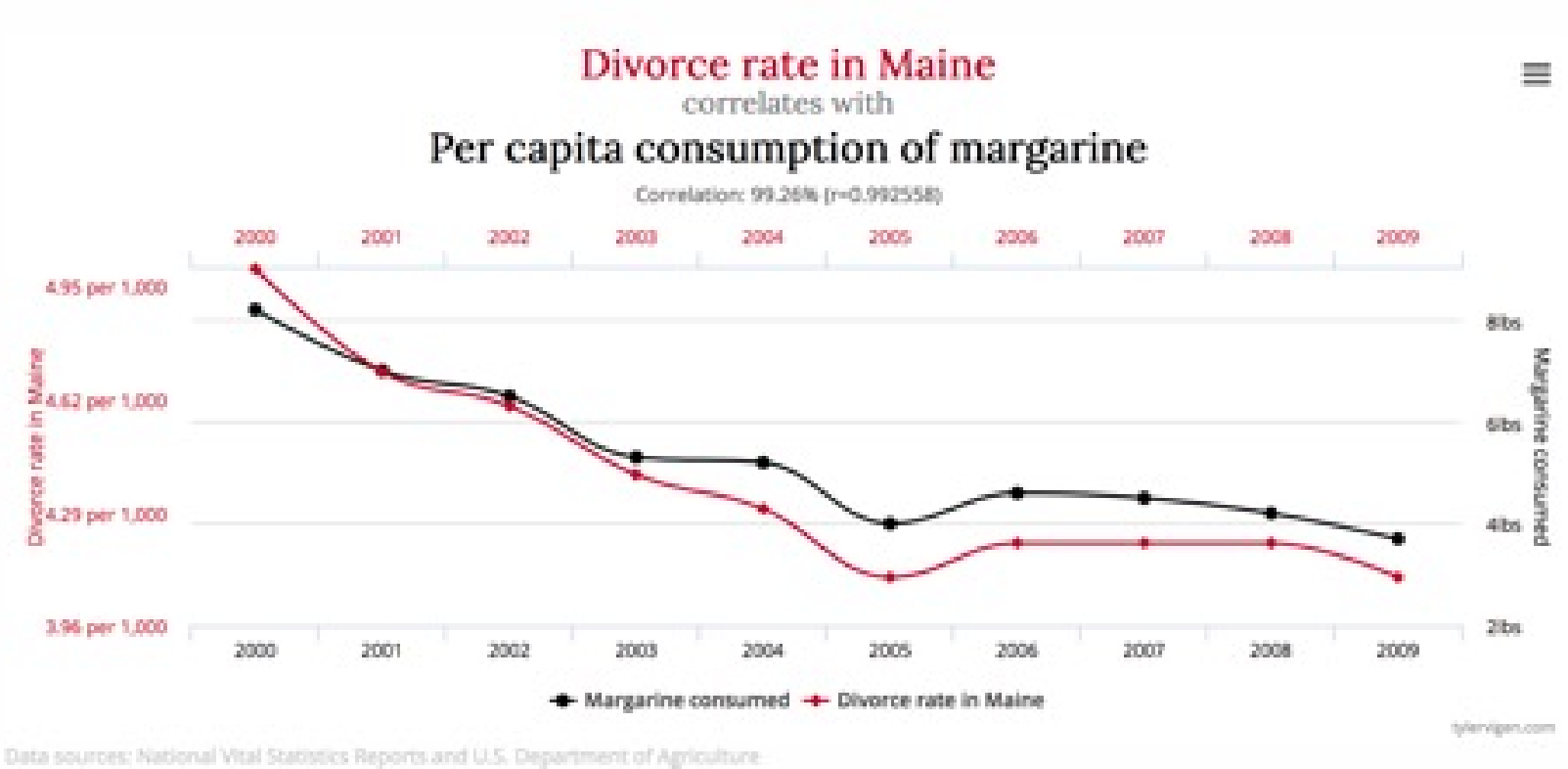
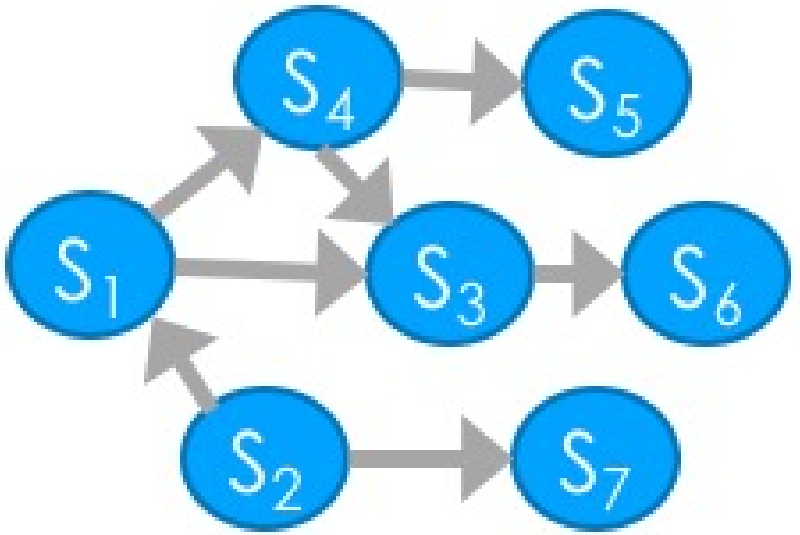
IBM





http://tylervigen.com/spurious-correlations

Using AI to Accelerate Protein Design and Discovery

One third of global food production goes to waste because of spoilage. Can we use AI to design proteins to prevent that?

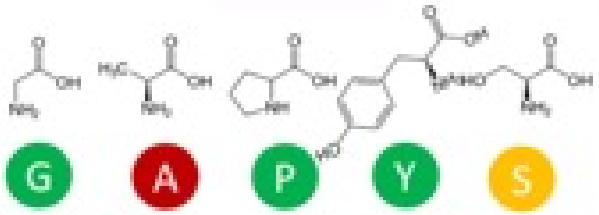

Benedetto Marelli
MIT


Markus Buehler
MIT


Pin-yu Chen
IBM


Lingfei Wu
IBM

Protein Synthesis



Amino Acid
(building block)

Structure
(AA sequence with distinct 3D organization)

Protein
(distinct sequence of amino acid providing specific structure and function)

Analogy to Text

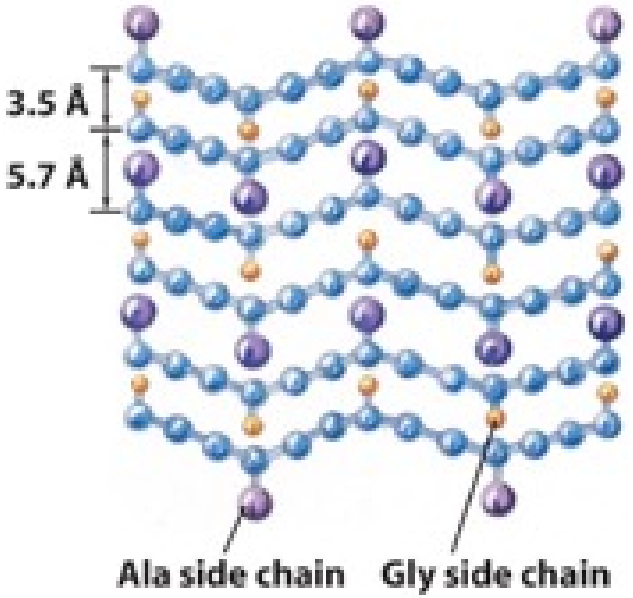
d g u s t

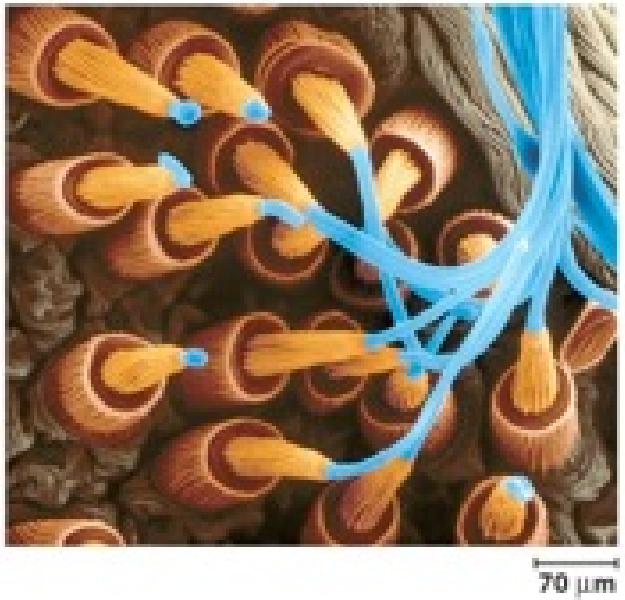
Letter
(building block)

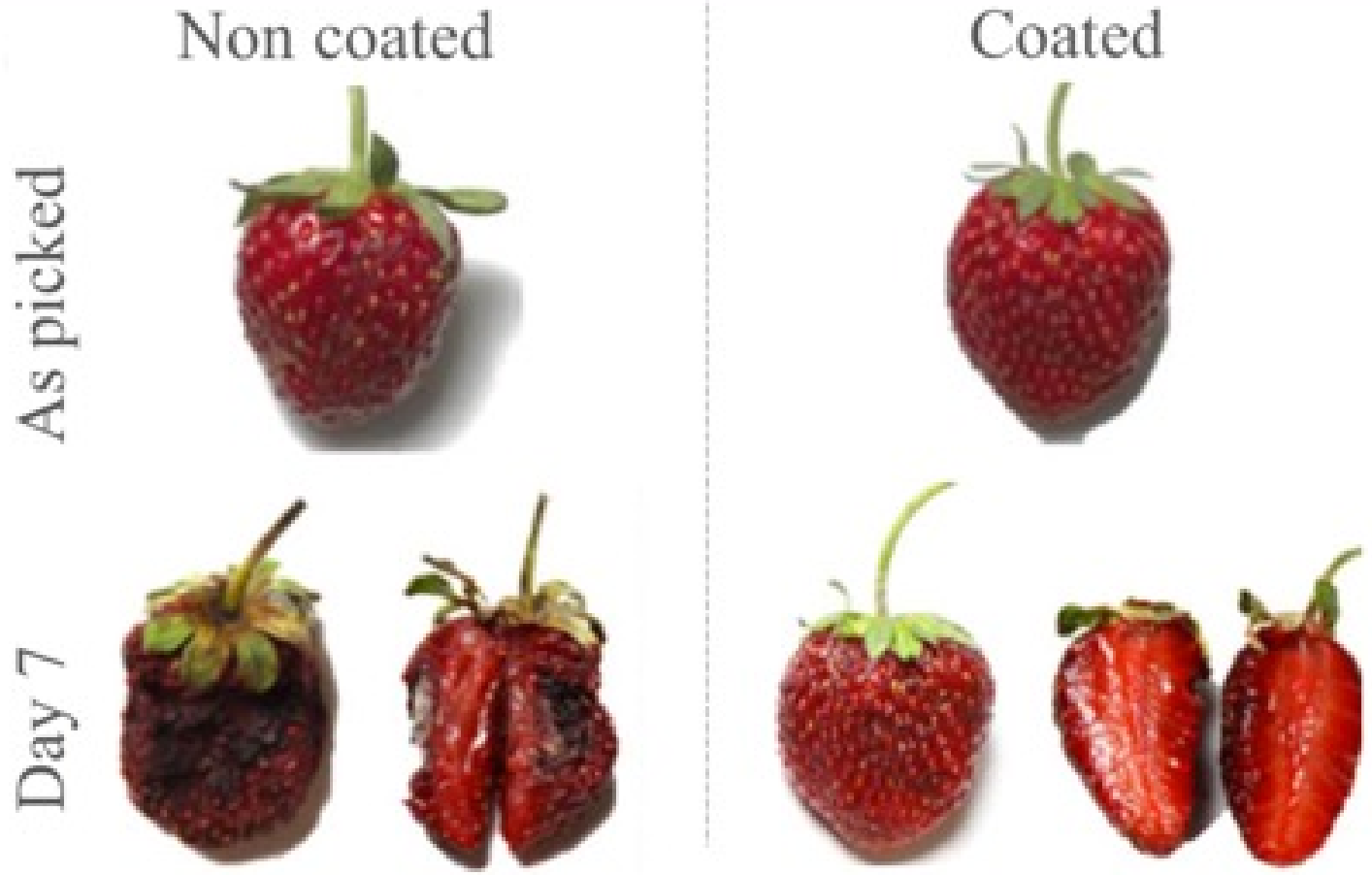
dog sit couch

Word
(letter sequence with distinct meaning)

Paragraph
(distinct section of a document dealing with a specific topic)


3.5 Å
5.7 Å
Ala side chain
Gly side chain


70 μm

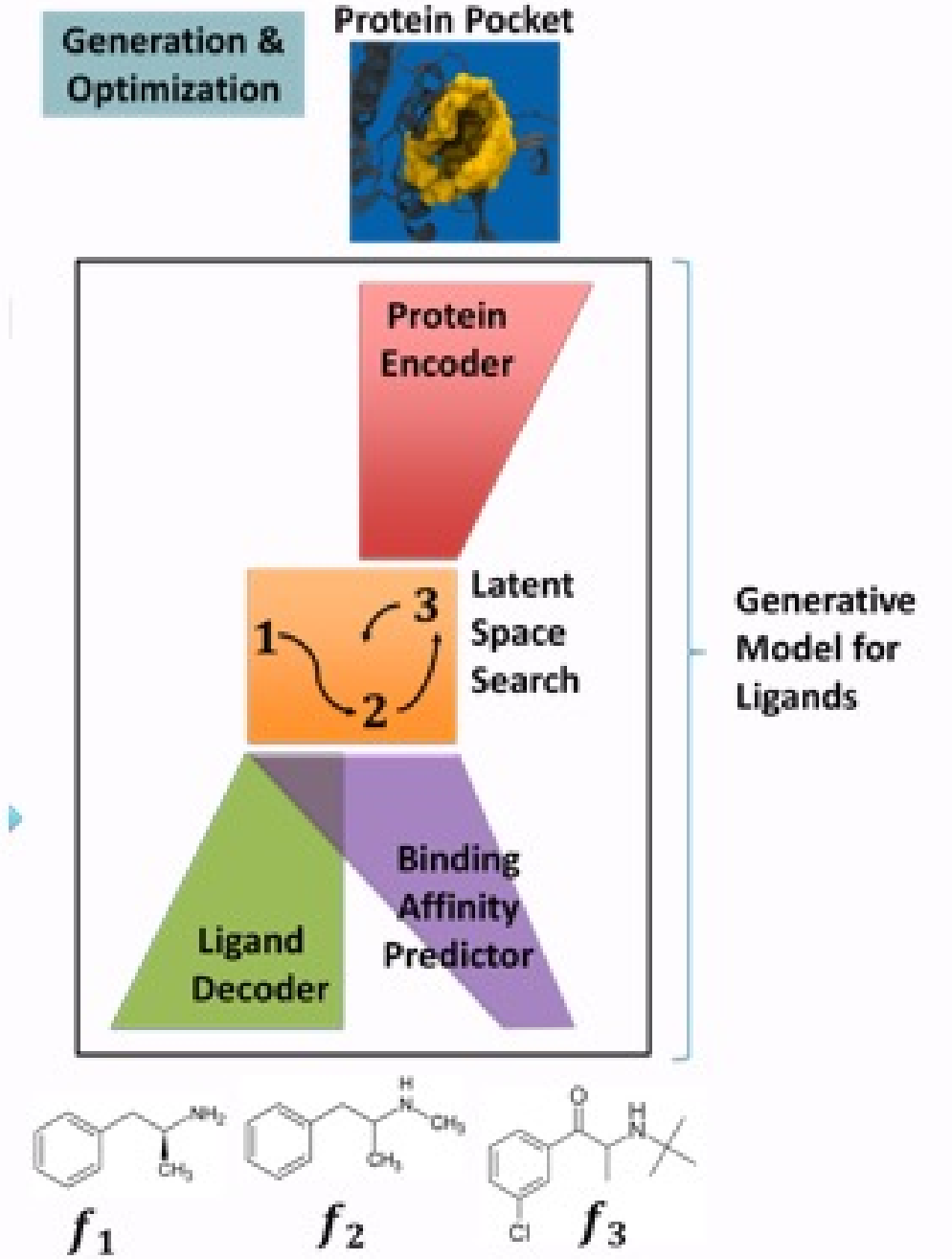

Non coated
Coated
As picked
Day 7

Protein2Drug: Generative AI for Drug Design

How can we use powerful new generative neural network techniques to generate drugs tailored to targeting specific binding pockets

Payel Das
IBM

Rafael Gomez-Bombarelli
MIT

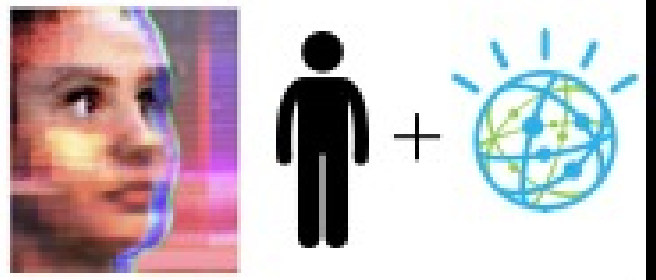


The path to Broad AI

Explainability

Security

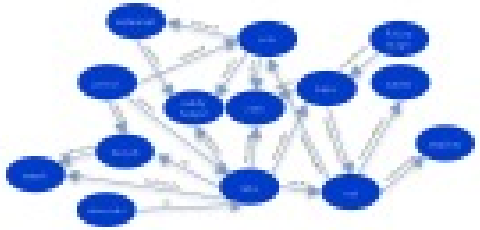
Ethics



Learn more from small data

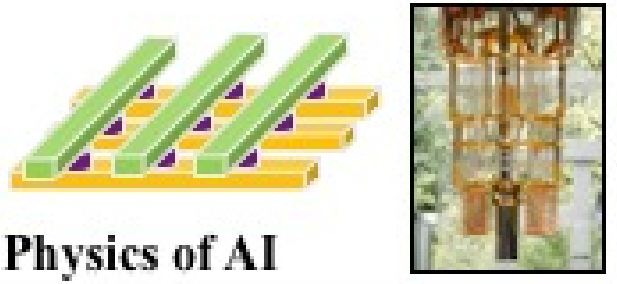
Learns to transfer

+



Reasons

Infrastructure



Physics of AI