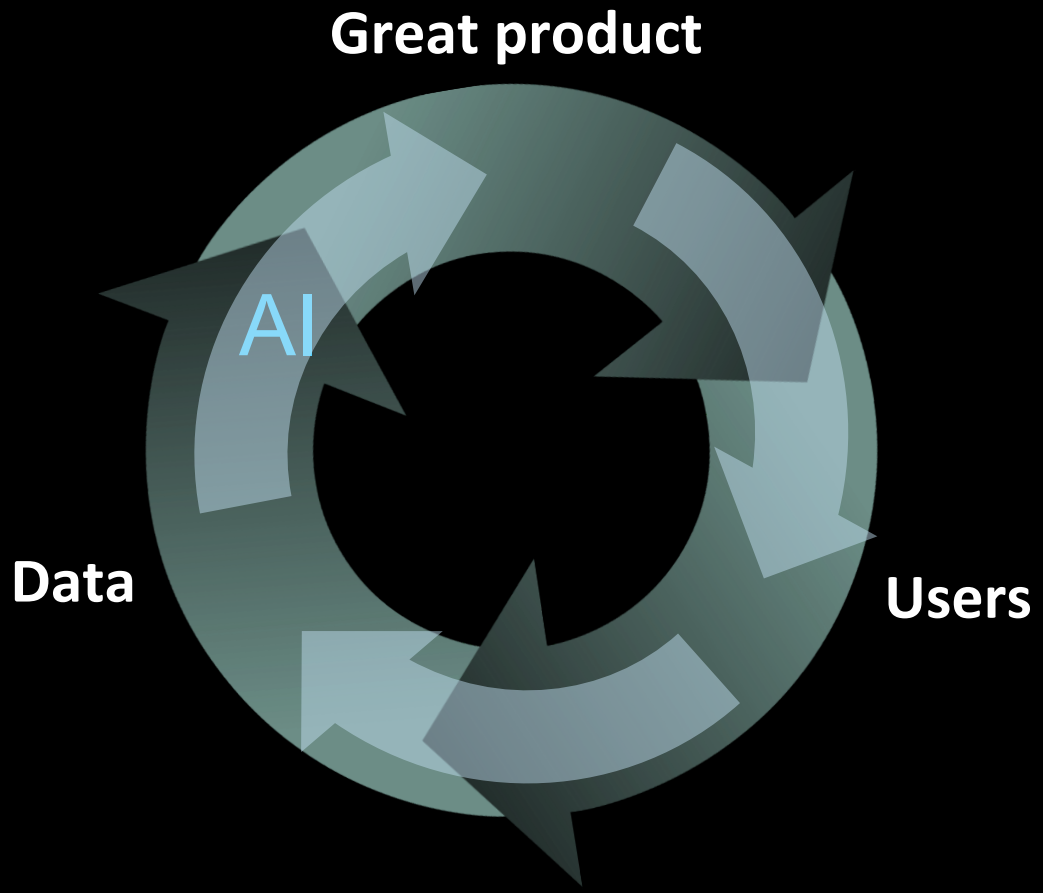
Deep Learning

Andrew Ng

Thanks to Adam Coates, Kai Yu, Tong Zhang, Sameep Tandon, Swati Dube, Brody Huval, Tao Wang, ….

Virtuous circle of AI



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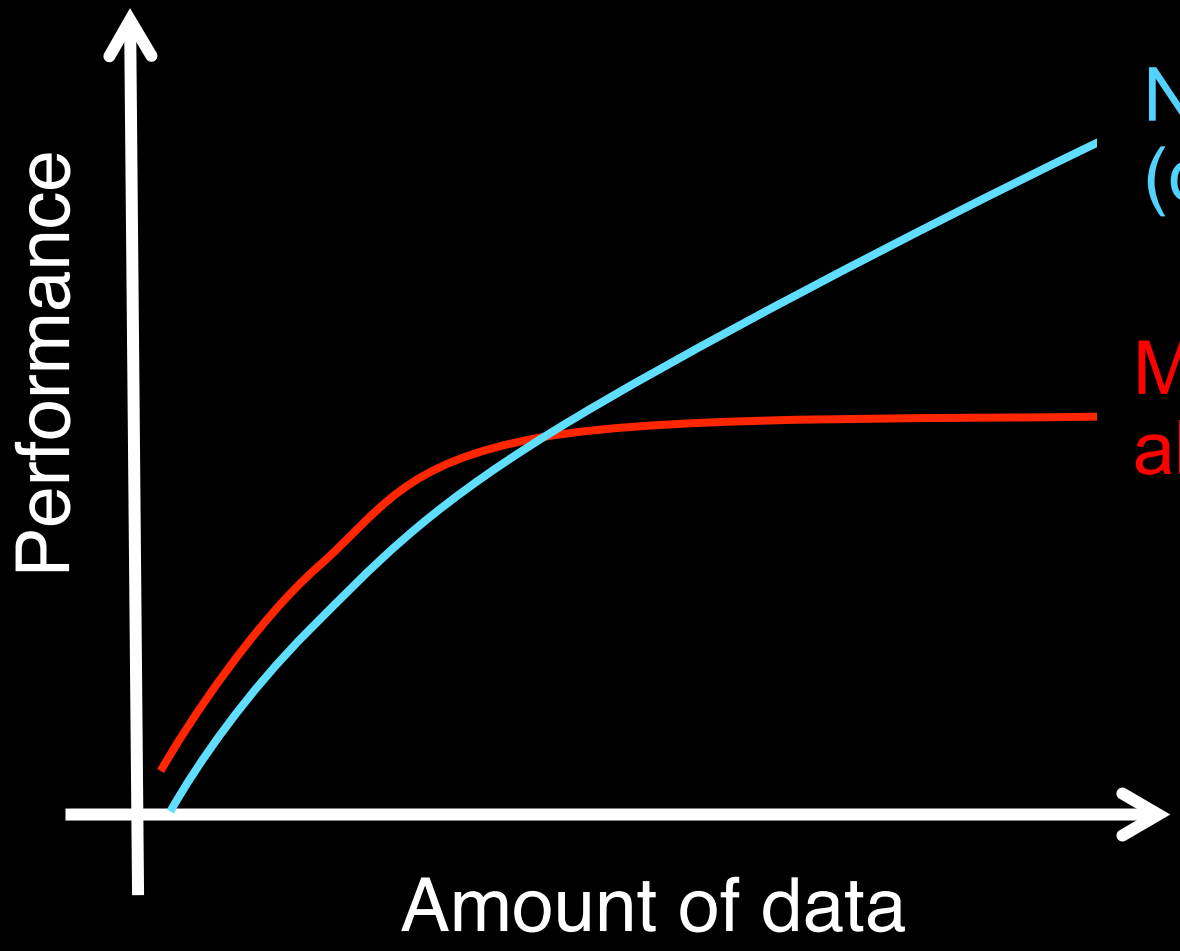
Data and machine learning



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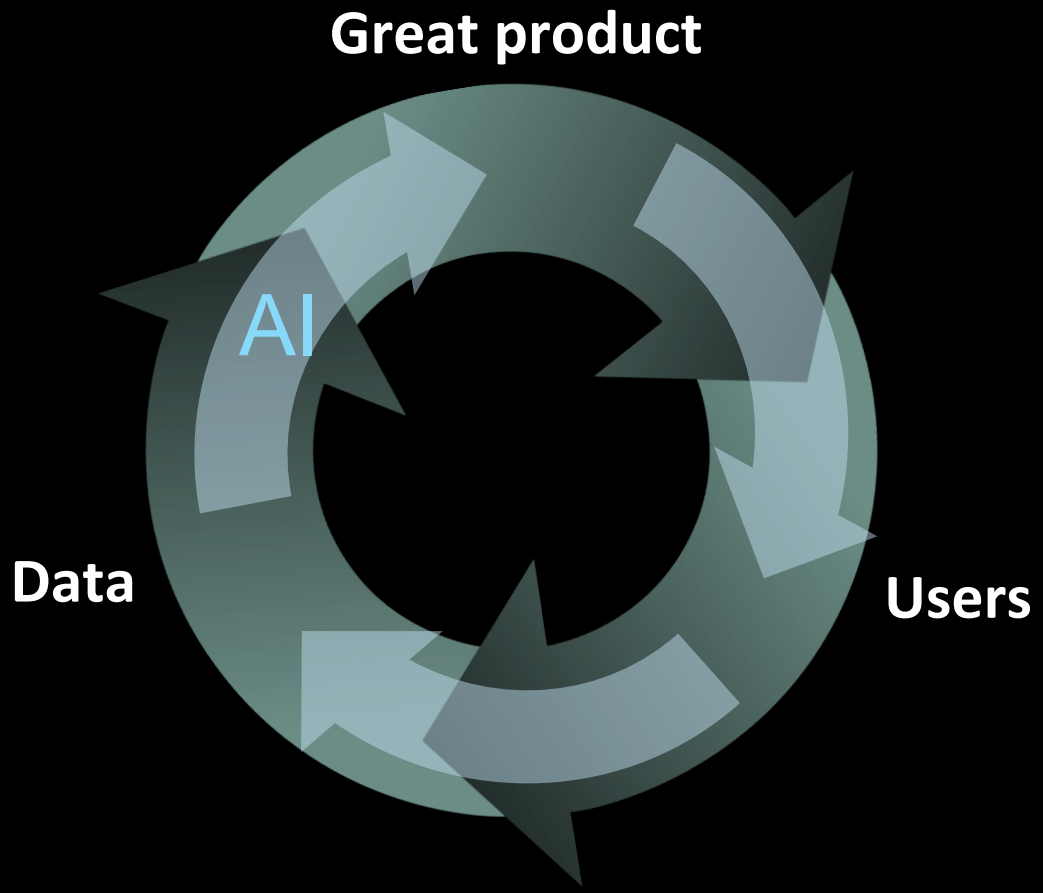
Virtuous circle of AI



Andrew Ng

Deep Learning

Adam Coates, Yoshua Bengio, Tom Dean, Jeff Dean, Nando de Freitas, Jeff Hawkins, Geoff Hinton, Quoc Le, Yann LeCun, Honglak Lee, Tommy Poggio, Ruslan Salakhutdinov, Yoram Singer, Josh Tenenbaum, Kai Yu, Tong Zhang, ….

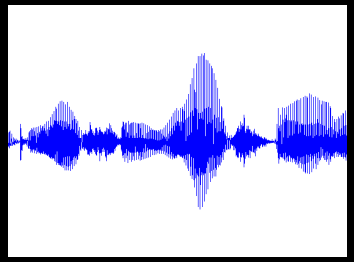
Andrew Ng

Things we want to do with data

Images

Label image

Audio



Speech recognition

Text

Web search

STanford AI Robot (STAIR)

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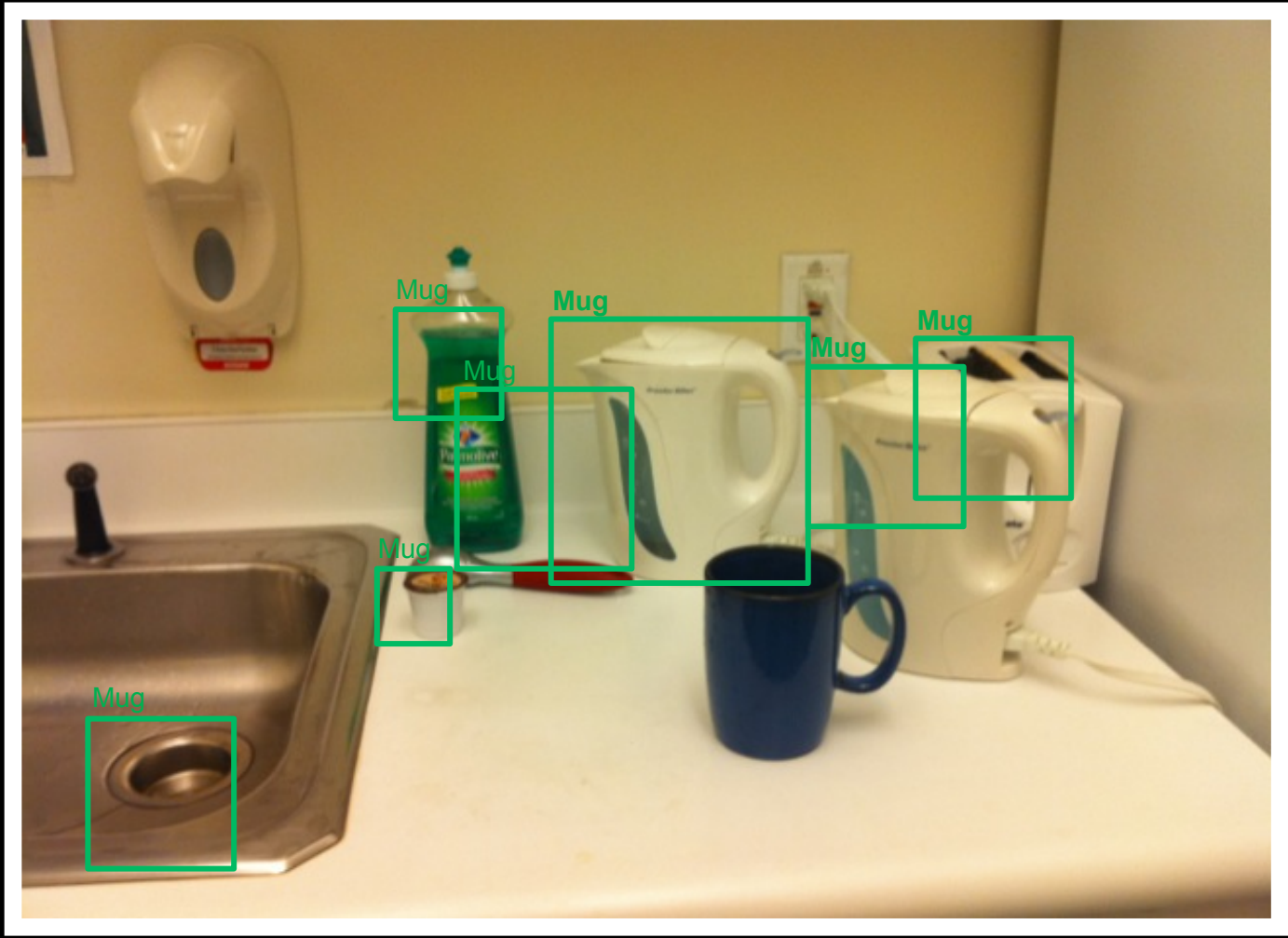
Computer vision: Identify coffee mug

Andrew Ng

Computer vision: Identify coffee mug



Why is computer vision hard?

The camera sees :

194	210	201	212	199	213	215	195	178	158	182	209
180	189	190	221	209	205	191	167	147	115	129	163
114	126	140	188	176	165	152	140	170	106	78	88
87	103	115	154	143	142	149	153	173	101	57	57
102	112	106	131	122	138	152	147	128	84	58	66
94	95	79	104	105	124	129	113	107	87	69	67
68	71	69	98	89	92	98	95	89	88	76	67
41	56	68	99	63	45	60	82	58	76	75	65
20	43	69	75	56	41	51	73	55	70	63	44
50	50	57	69	75	75	73	74	53	68	59	37
72	59	53	66	84	92	84	74	57	72	63	42
67	61	58	65	75	78	76	73	59	75	69	50

Computer vision

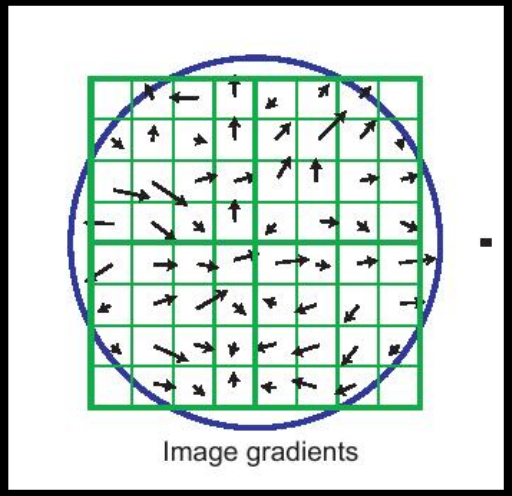
Learning algorithm

Computer vision

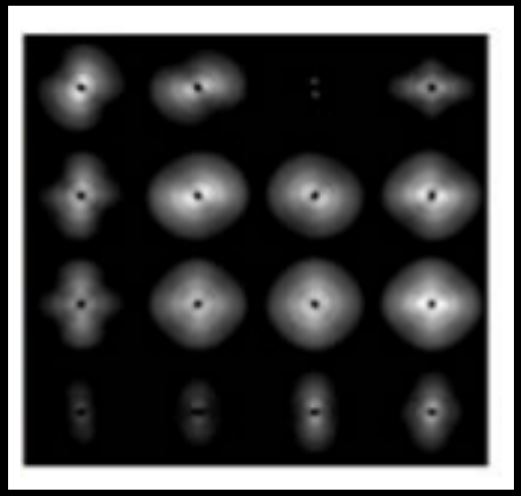
Feature representation

Learning algorithm

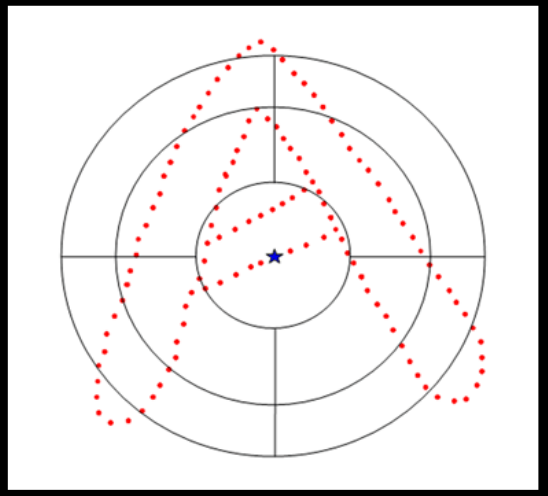
Features for vision



SIFT



GIST

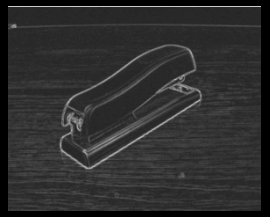


Shape context

Features for machine learning

Images

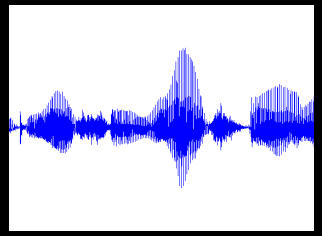
Image



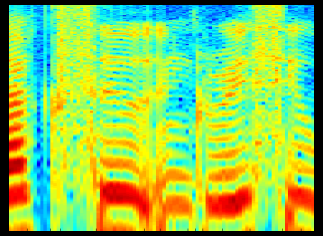
Vision features

Detection

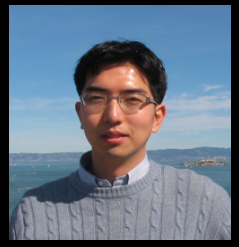
Audio



Audio



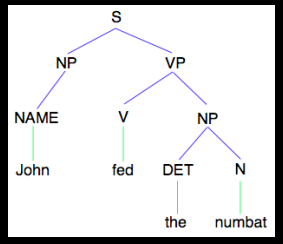
Audio features



Speaker ID

Text

Text

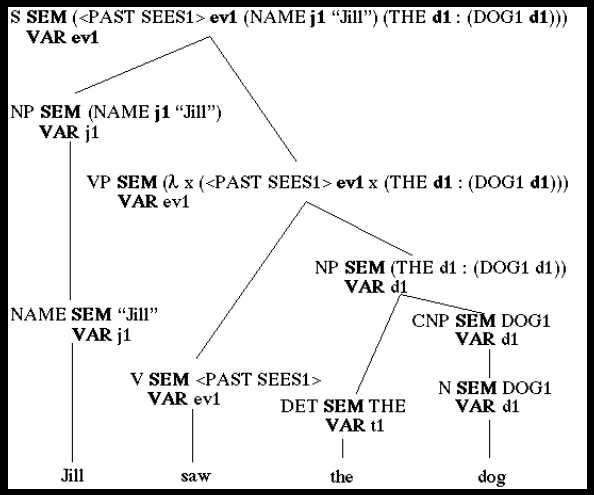


Text features

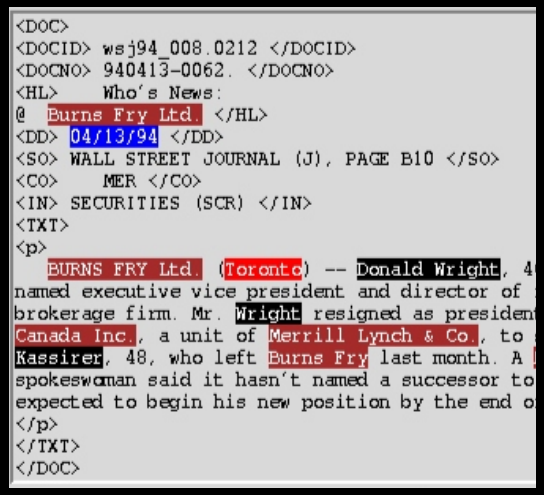
Web search

…

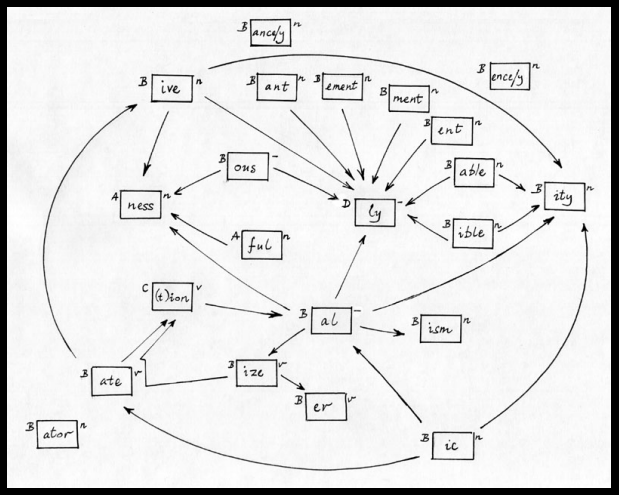
Features for text



Parser



Named entity



Stemming

The idea:

Most perception (input processing) in the brain may be due to one learning algorithm.

The idea:

Build learning algorithms
that mimic the brain.

Most of human intelligence may
be due to one learning algorithm.

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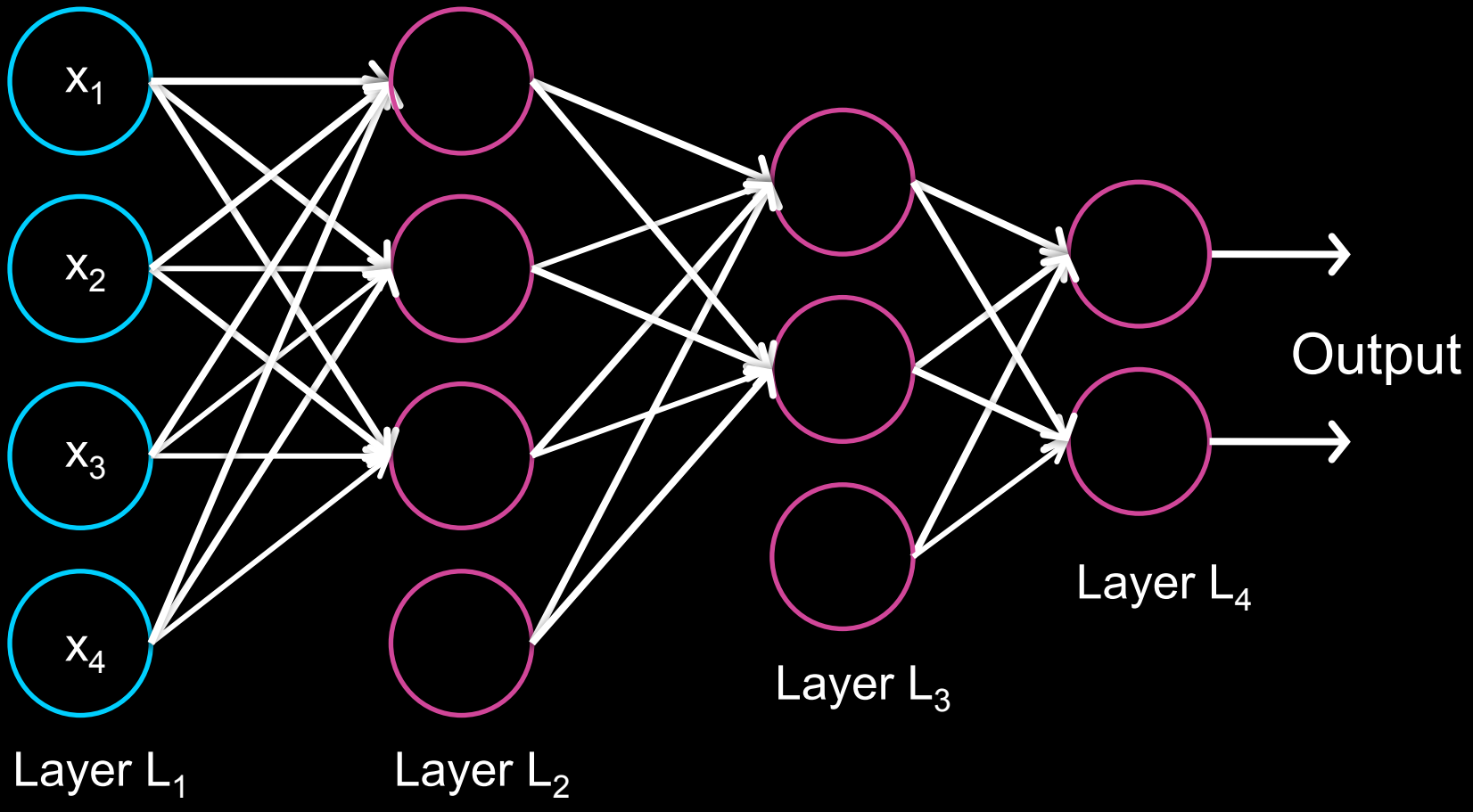
Neurons in the brain

Neural Network (Deep Learning)



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Deep Learning trends

Now

0-2 years
Tagged data

3-5 years
Tagged & untagged data

Learning from tagged data (supervised)

Coffee mug

Coffee mug

Coffee mug

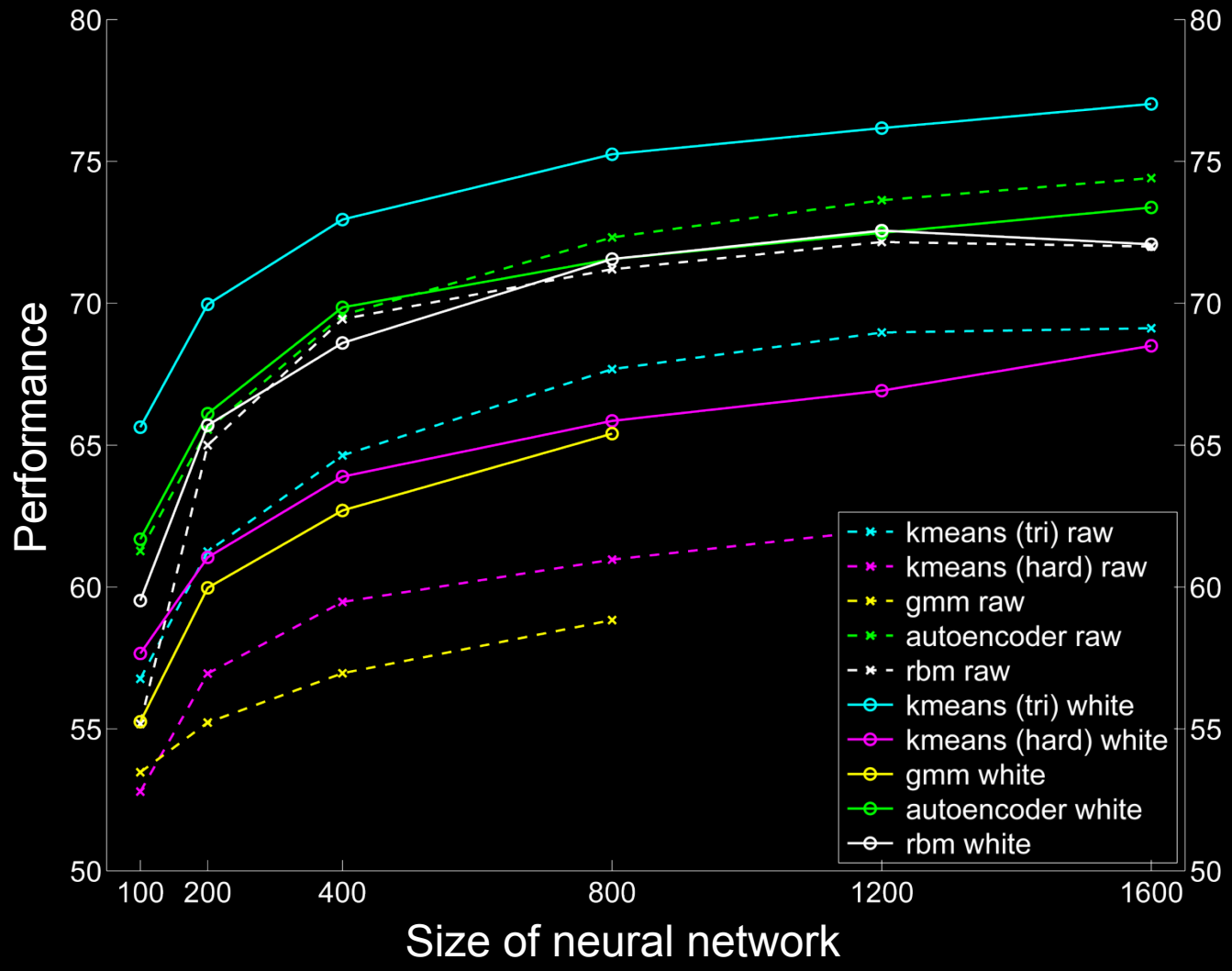
Coffee mug

Coffee mug

Coffee mug

Testing: What is this?

Bigger is better



[Adam Coates]

Google Brain

Andrew Ng

AI as a computer systems problem

10 million connections

1 billion connections

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Speech recognition, and more….

[with Vincent Vanhoucke]

Deep Learning applications

Speech recognition

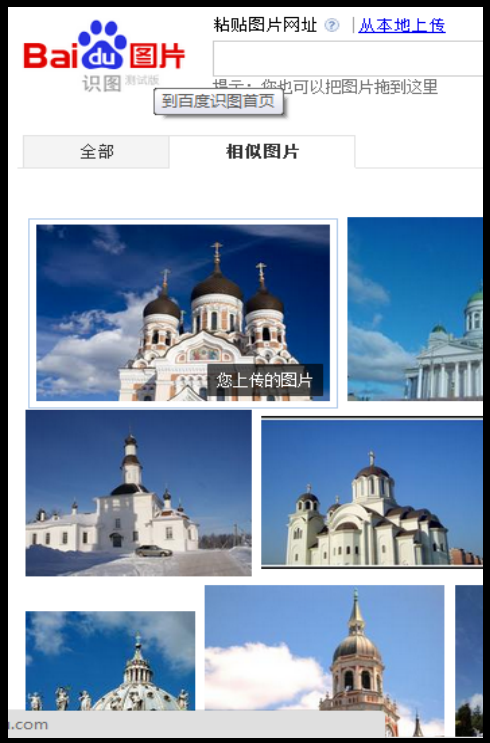


Image Search

Ads; Web search

Tagged vs. untagged data

Coffee mug

Coffee mug

Coffee mug

Coffee mug

Coffee mug

Coffee mug

Untagged data (unsupervised learning)

Unknown

Unknown

Unknown

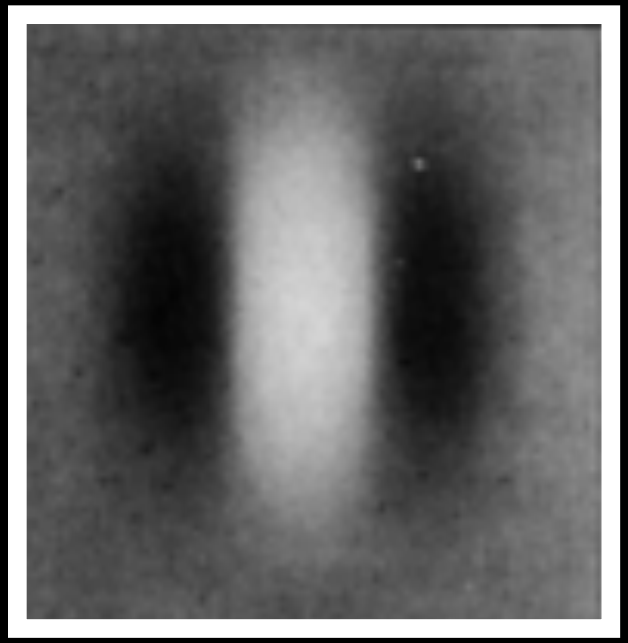
Unknown

Unknown

Unknown

How does the brain process images?

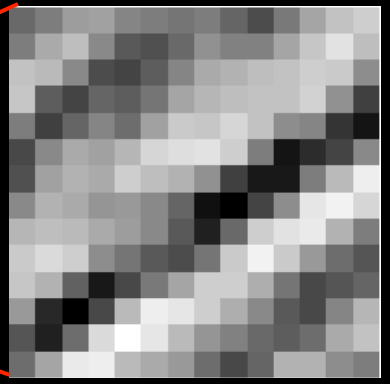
Visual cortex looks for lines/edges.



Neuron #1 of visual cortex (model)

Neuron #2 of visual cortex (model)

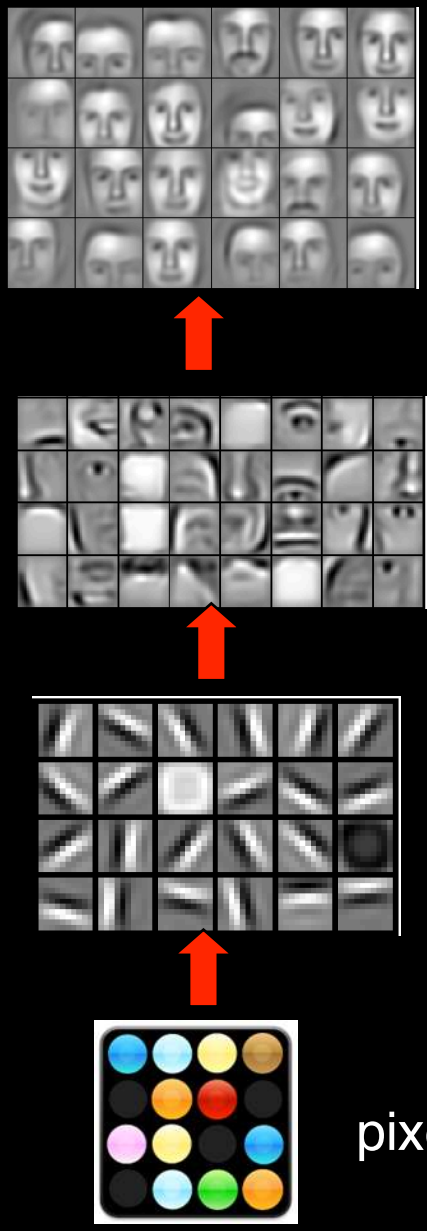
Start with Image patches



152	147	128	84
129	113	107	87
98	95	89	88
60	82	58	76
51	73	55	70

$R^{14 \times 14}$

Deep Learning



16,000 CPUs is expensive

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GPUs (Graphics Processor Unit)

[Adam Coates, Bryan Catanzaro, et al.]

Building huge neural networks

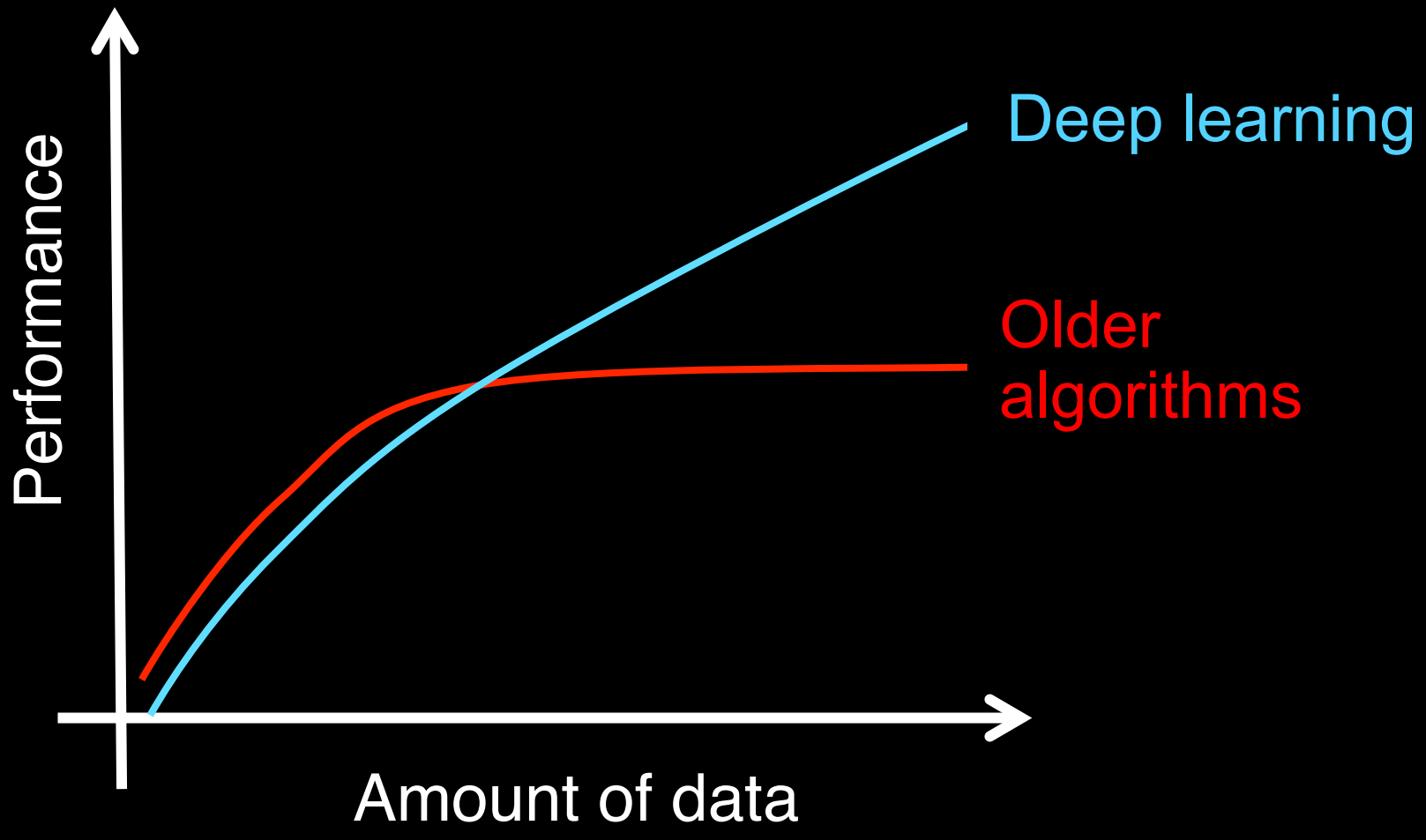
10 million connections

1 billion connections

10 billion connections

[Adam Coates, Bryan Catanzaro]

Learning from tagged data



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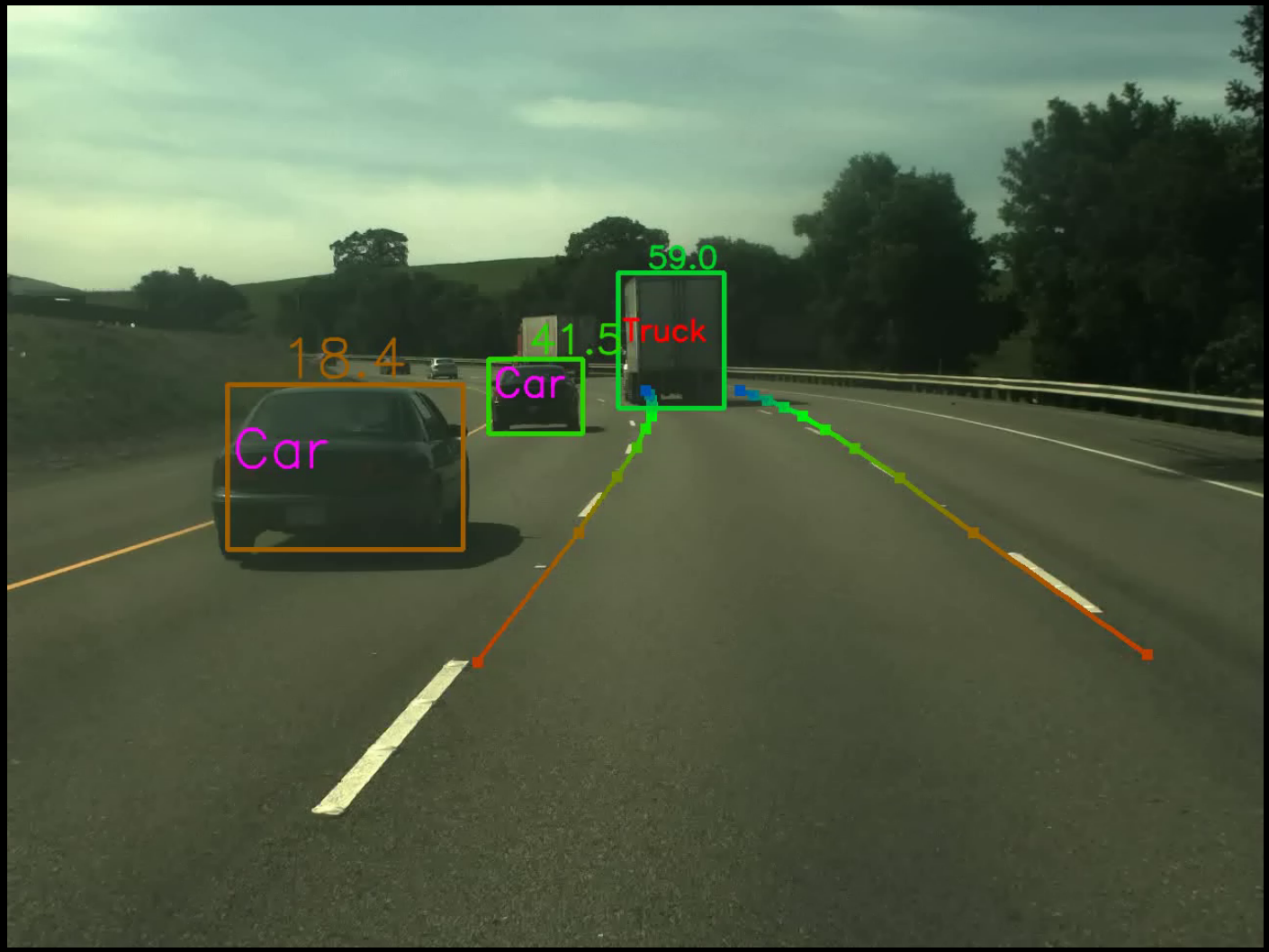
Highway perception



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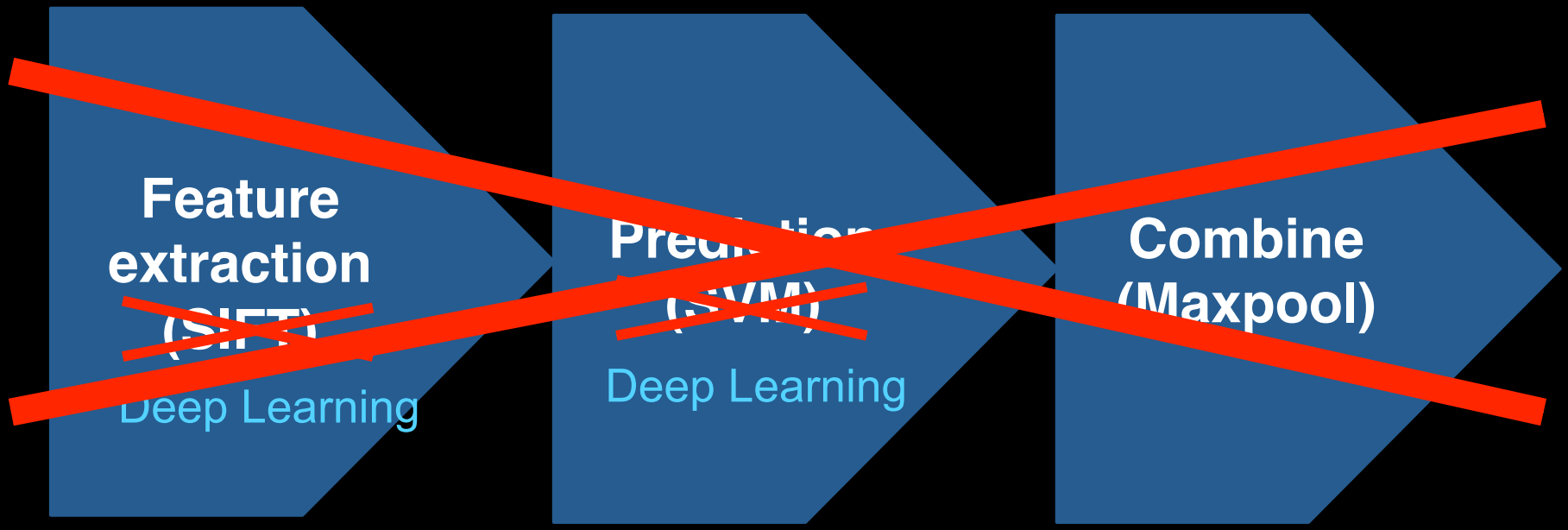
Deep Learning trends

0-2 years
Tagged data

3-5 years
Tagged & untagged data

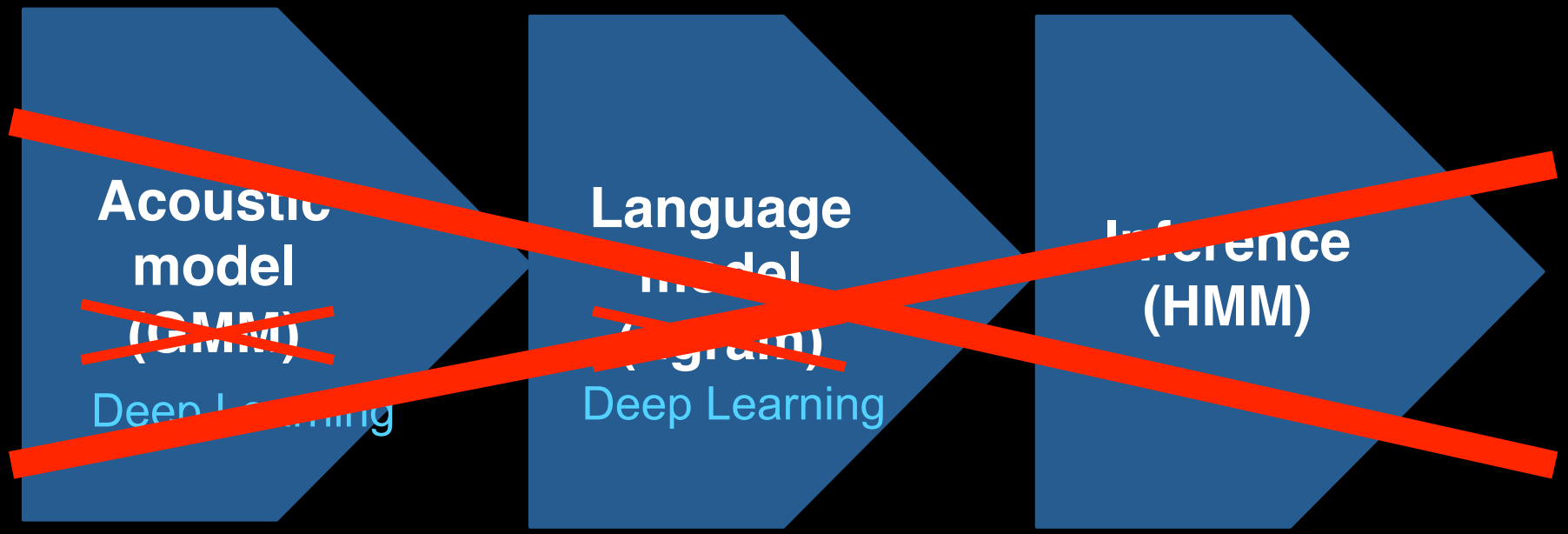
Untagged data and AI (unsupervised learning)

Computer vision (~6 years)



Deep Learning

Speech recognition (next 2-3 years?)



Deep Learning

AI will transform the internet

Speech

Images

Text

Speech

Images

From Control to Perception

AI will transform the internet

Technology areas with potential for paradigm shift:

- Computer vision
- Speech recognition & speech synthesis
- Language understanding: Machine translation; Web search; Dialog systems; ….
- Advertising
- Personalization/recommendation systems
- Robotics

All this is hard: scalability, algorithms.

Andrew Ng

Thank you.

Thanks to Adam Coates, Yu Kai, Zhang Tong, Sameep Tandon, Swati Dube, Brody Huval, Tao Wang, ….

Tutorial: deeplearning.stanford.edu

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