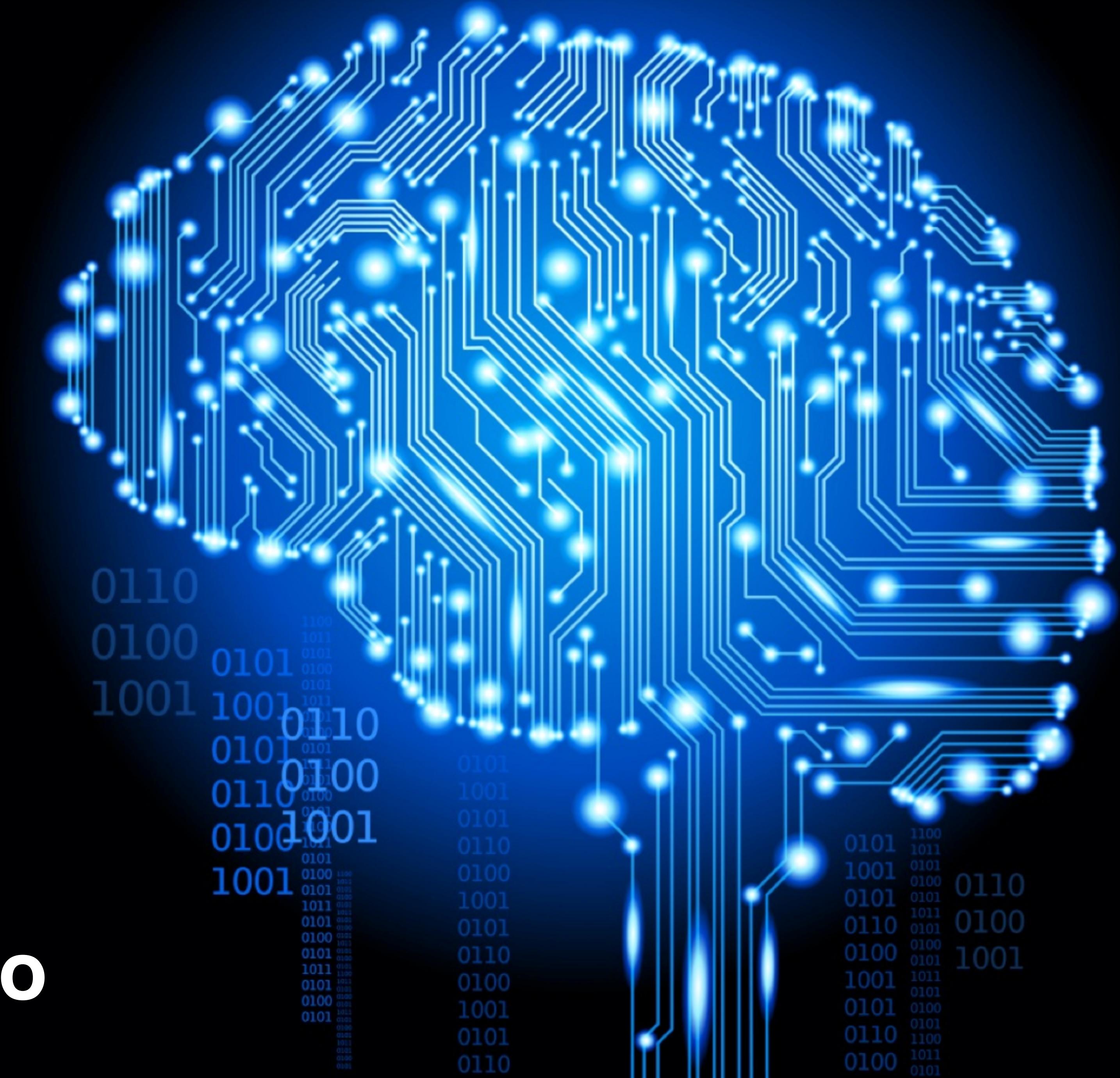
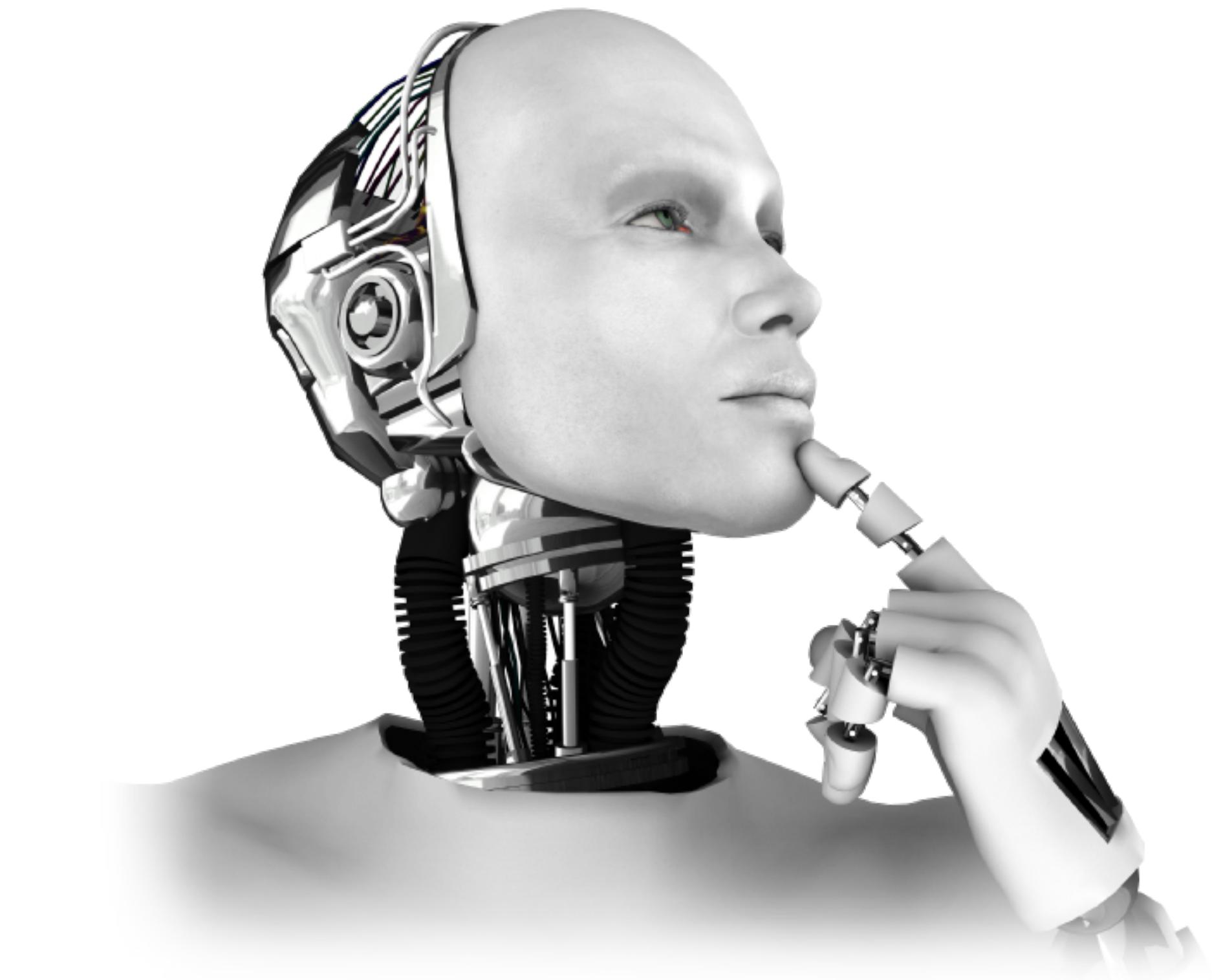


Deep Learning

professor
Eugenio Culurciello



GOAL



How do we perceive the world, learn about the world, operate intelligently in the world to increase our collective benefit

GOAL



*Introduce complex visual capabilities in
computers, appliances, mobiles, applications*

INTRODUCTION

what is deep learning?

WIRED

Facebook's Quest to Build an Artificial Depends on This Guy

BY DANIELA HERNANDEZ 08.14.14 | 6:30 AM | PERMALINK

[Share](#) 470 [Tweet](#) 790 [g+1](#) 164 [in Share](#) 160 [Pin it](#)



Yann LeCun, the new head of artificial intelligence at Facebook. Josh Val

VB | NEWS

Channels Videos Newsletters Jobs Got news? Tell us!

EVENTS



Big Data

Why a deep-learning genius left Google & joined Chinese tech sh Baidu (interview)



WIRED GEAR SCIENCE ENTERTAINMENT BUSINESS SECURITY DESIGN

The IBM Cloud can help businesses take the next step.

ENTERPRISE analytics google machine learning neural networks

Google Hires Brains that Helped Supercharge Machine Learning

BY ROBERT MCMILLAN 03.13.13 | 6:30 AM | PERMALINK

[Share](#) 0 [Tweet](#) 1 [g+1](#) 140 [in Share](#) 1 [Pin it](#) 3



Geoffrey Hinton (right) Alex Krizhevsky, and Ilya Sutskever (left) will do machine learning work Google. Photo: U of T

what is deep learning?



News TCTV Events

DISRUPT Get Your TC Disrupt SF Tickets!

Search

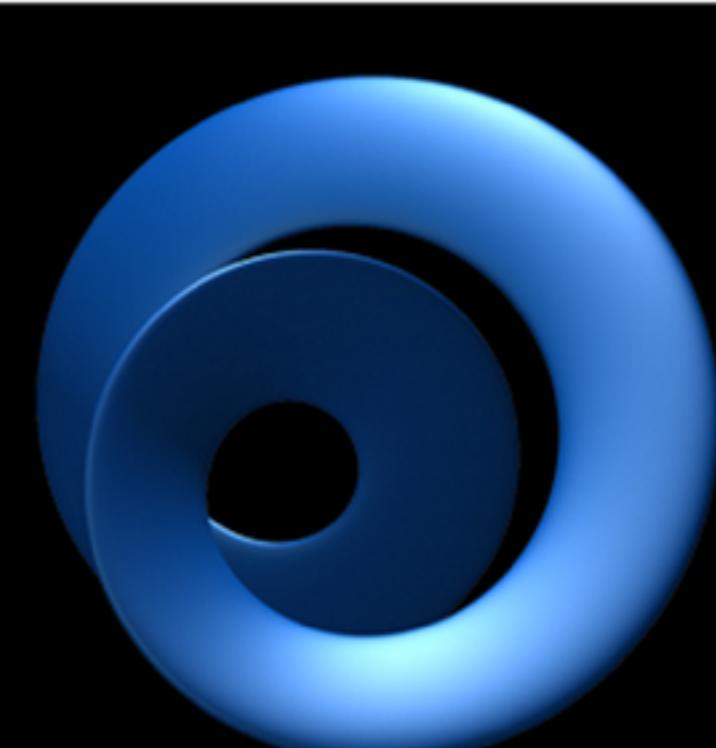
Updated AOL Privacy Policy ar

Europe acquisition Google DeepMind Technologies DeepMind

Google Acquires Artificial Intelligence Startup DeepMind For More Than \$500M

Posted Jan 26, 2014 by Catherine Shu (@catherineshu)

75 Share 8.3k Share 678 Tweet 2,209



DEEPMIND

ADVERTISEMENT

WIR ED GEAR SCIENCE ENTERTAINMENT BUSINESS SECURITY DESIGN

The IBM Cloud is the cloud for business. Business on the cloud is made with IBM.

Tap into the IBM Cloud.

ENTERPRISE | deep learning | Deepmind | google | Madbits

Buying Madbits, Twitter Wants Image-Search Super Powers

Google Buys Jetpac: Former iOS App's Deep Learning Artificial Intelligence Useful for Maps, Advertising

0 Comments

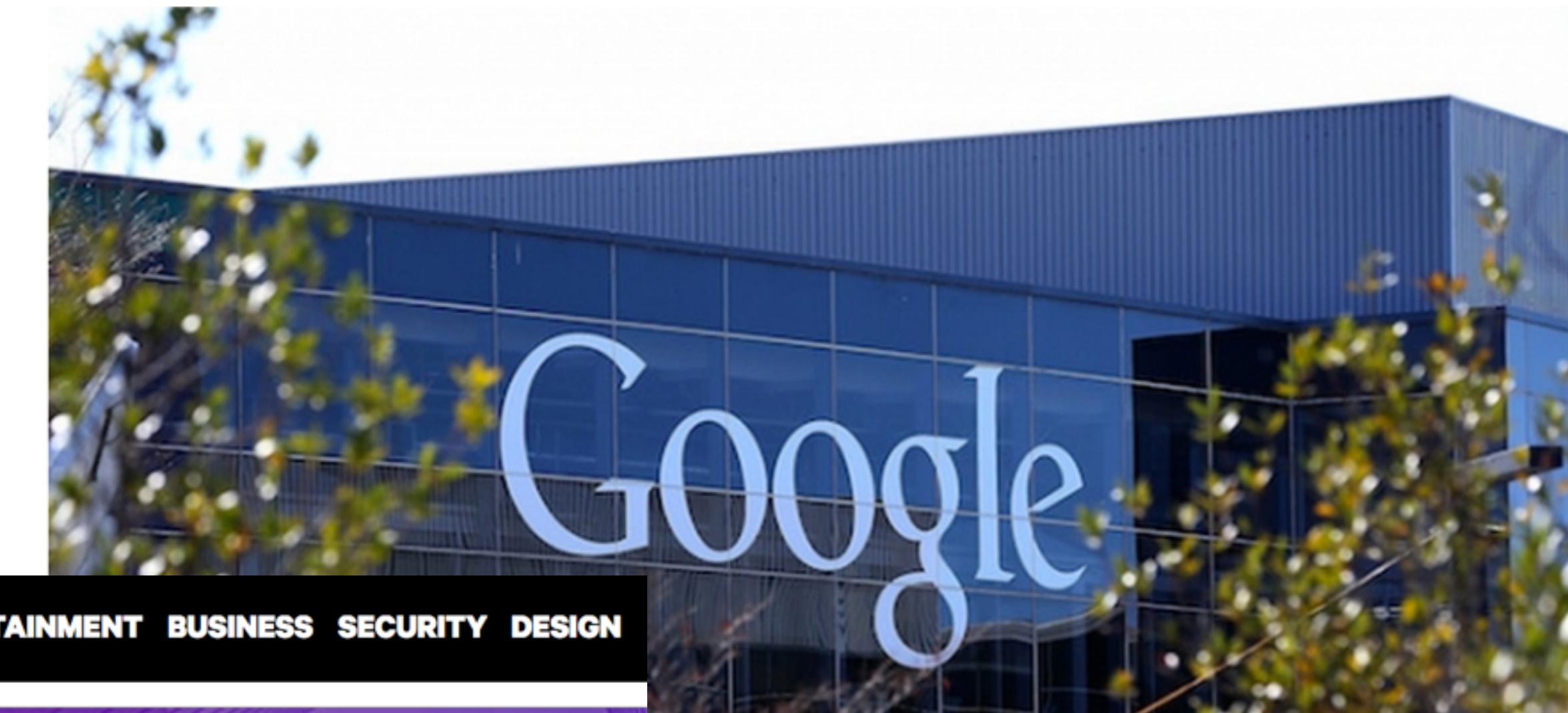
E-mail

By Kevin Li (staff@latinpost.com)

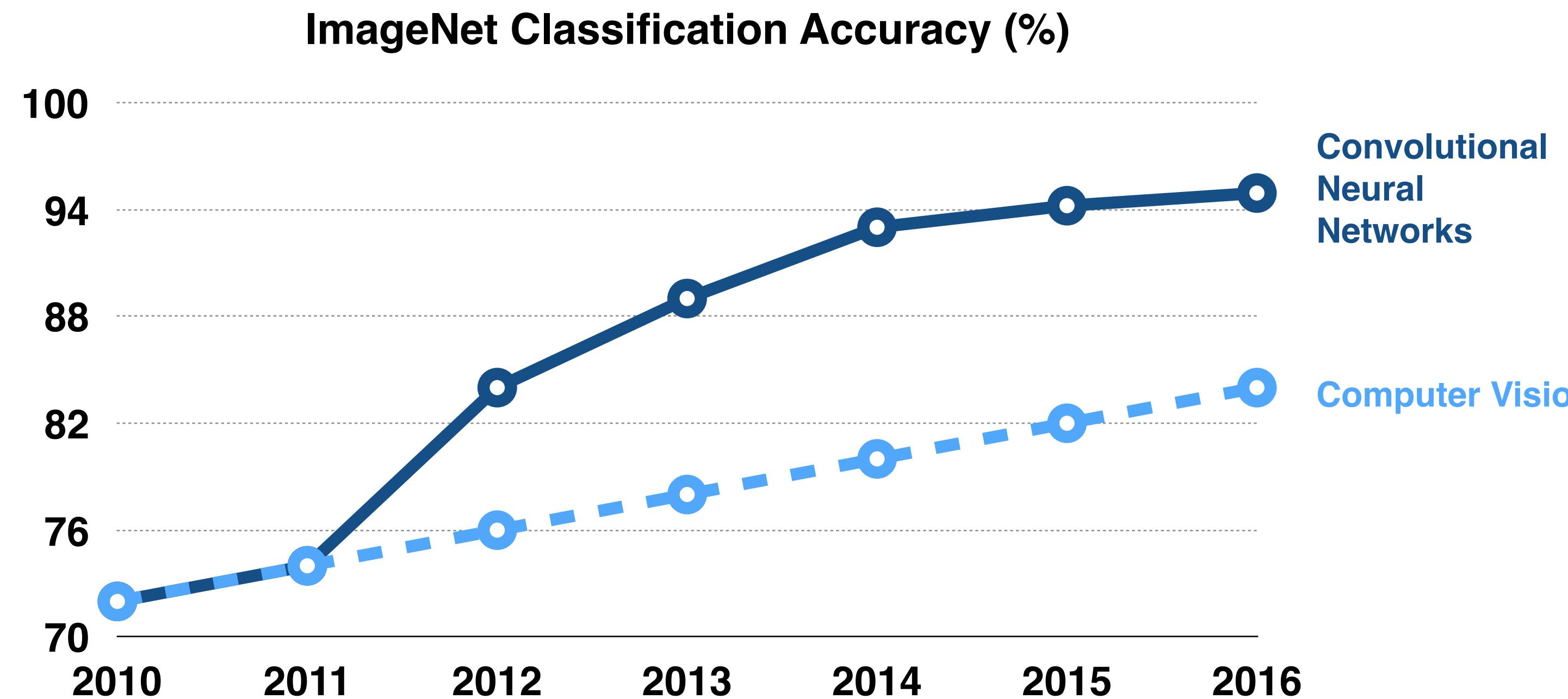
First Posted: Aug 17, 2014 02:29

SHARE THIS

TWEET THIS



deep learning



83.6% top5 accuracy — “ImageNet Classification with Deep Convolutional Neural Networks”, Krizhevsky et al., 2012

88.9% top5 accuracy — “OverFeat: Integrated Recognition, Localization and Detection using Convolutional Networks”, Zeiler and Fergus, 2013

92.7% top5 accuracy — “Very Deep Convolutional Networks for Large-Scale Visual Recognition”, Simonyan and Zisserman, 2014

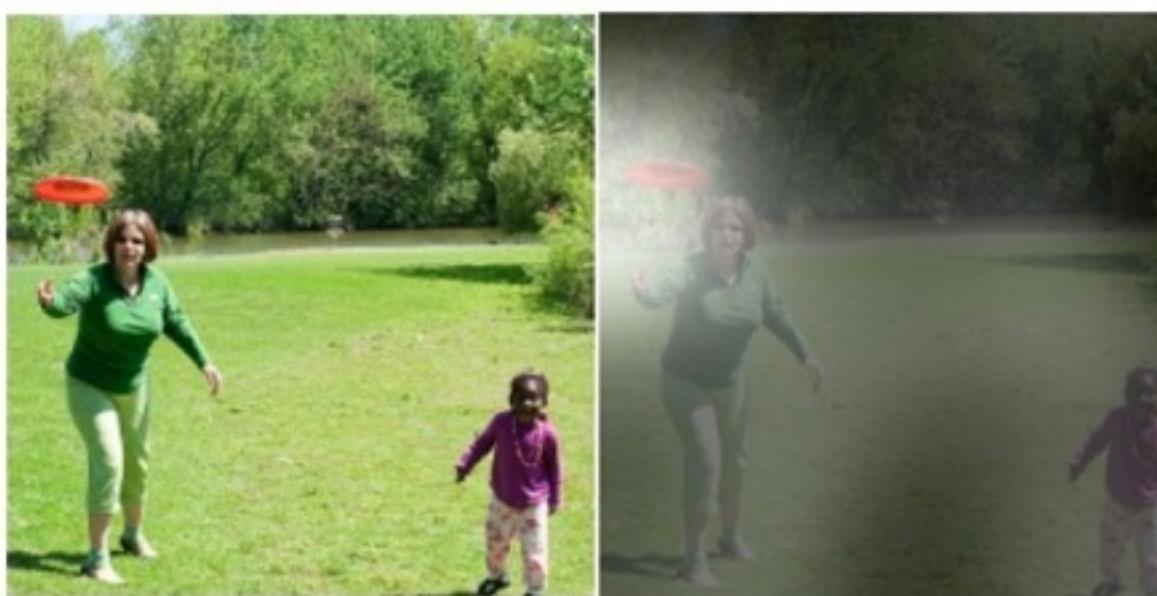
96.43% top5 accuracy — “Deep Residual Learning for Image Recognition”, <https://arxiv.org/abs/1512.03385>

96.92% top5 accuracy — “Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning”, <http://arxiv.org/abs/1602.07261>

Show, Attend and Tell: Neural Image Caption Generation with Visual Attention

Kelvin Xu
Jimmy Lei Ba
Ryan Kiros
Kyunghyun Cho
Aaron Courville
Ruslan Salakhutdinov
Richard S. Zemel
Yoshua Bengio

KELVIN.XU@UMONTREAL.CA
JIMMY@PSI.UTORONTO.CA
RKIROOS@CS.TORONTO.EDU
KYUNGHYUN.CHO@UMONTREAL.CA
AARON.COURVILLE@UMONTREAL.CA
RSALAKHU@CS.TORONTO.EDU
ZEMEL@CS.TORONTO.EDU
FIND-ME@THE.WEB



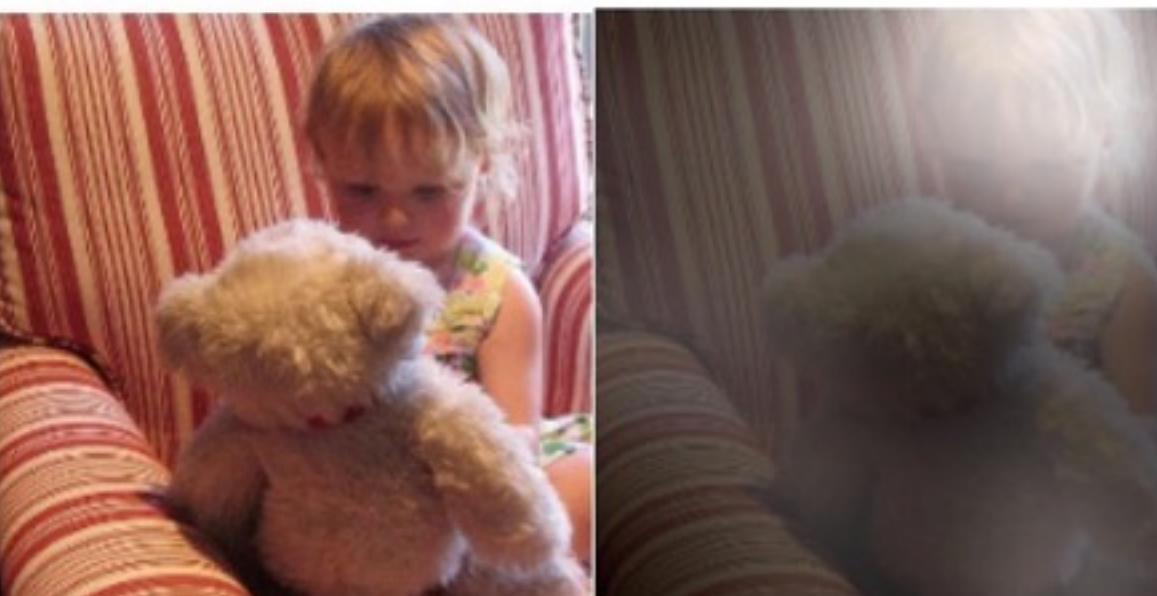
A woman is throwing a frisbee in a park.



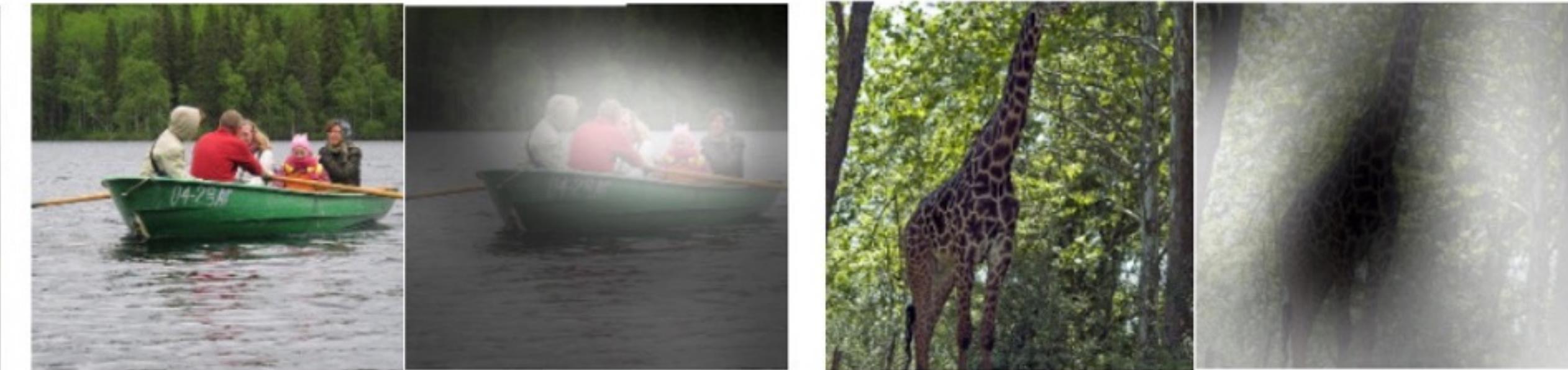
A dog is standing on a hardwood floor.



A stop sign is on a road with a mountain in the background.



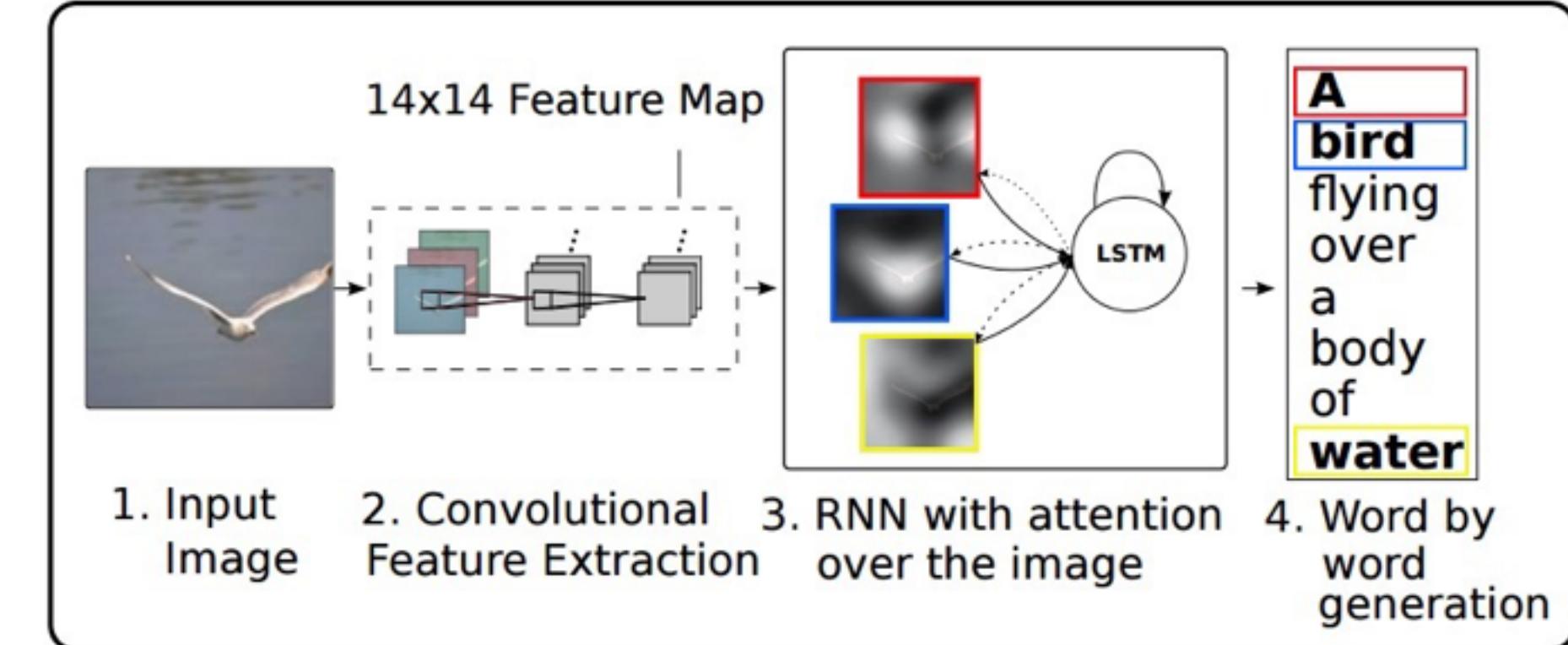
A little girl sitting on a bed with a teddy bear.



A group of people sitting on a boat in the water.



A giraffe standing in a forest with trees in the background.



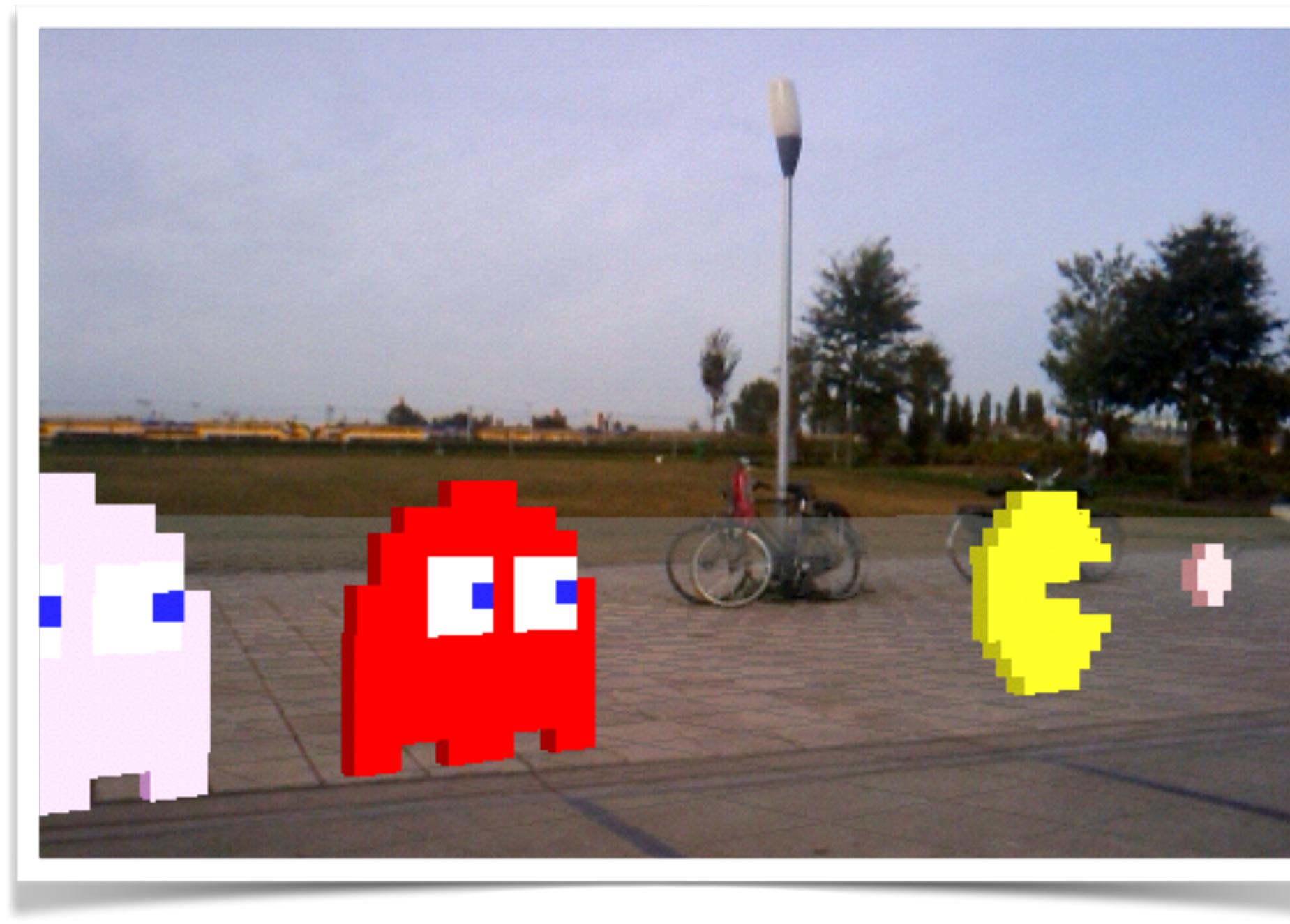
Deep Learning is the de-facto standard
for understanding images, videos!

enabling technology



enabling always-on real-time hardware
tagging videos on mobile devices!

enabling technology



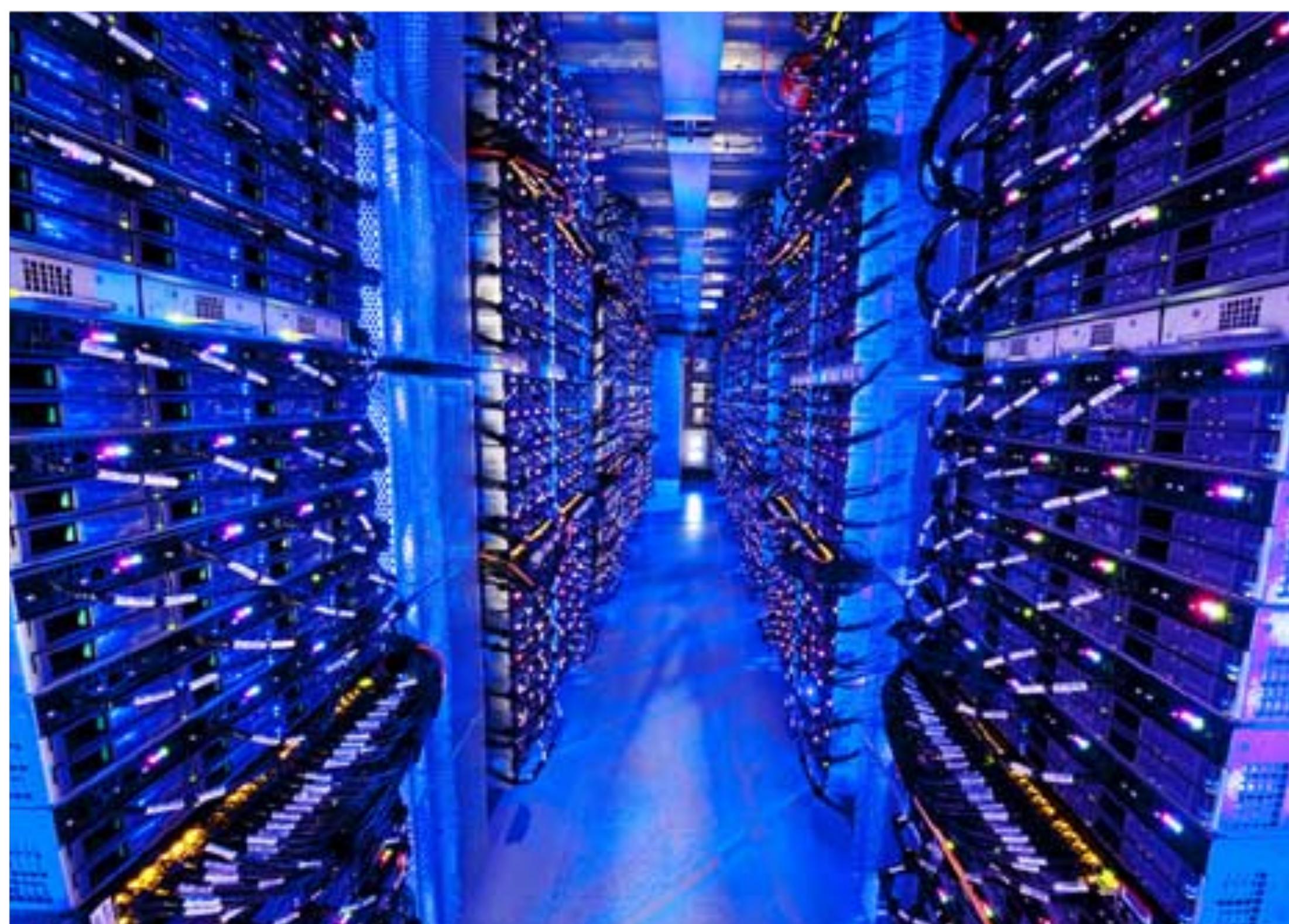
enabling augmented reality that can
understand the environment around us!

enabling technology



enabling always-on on-device
speech parsing and recognition!

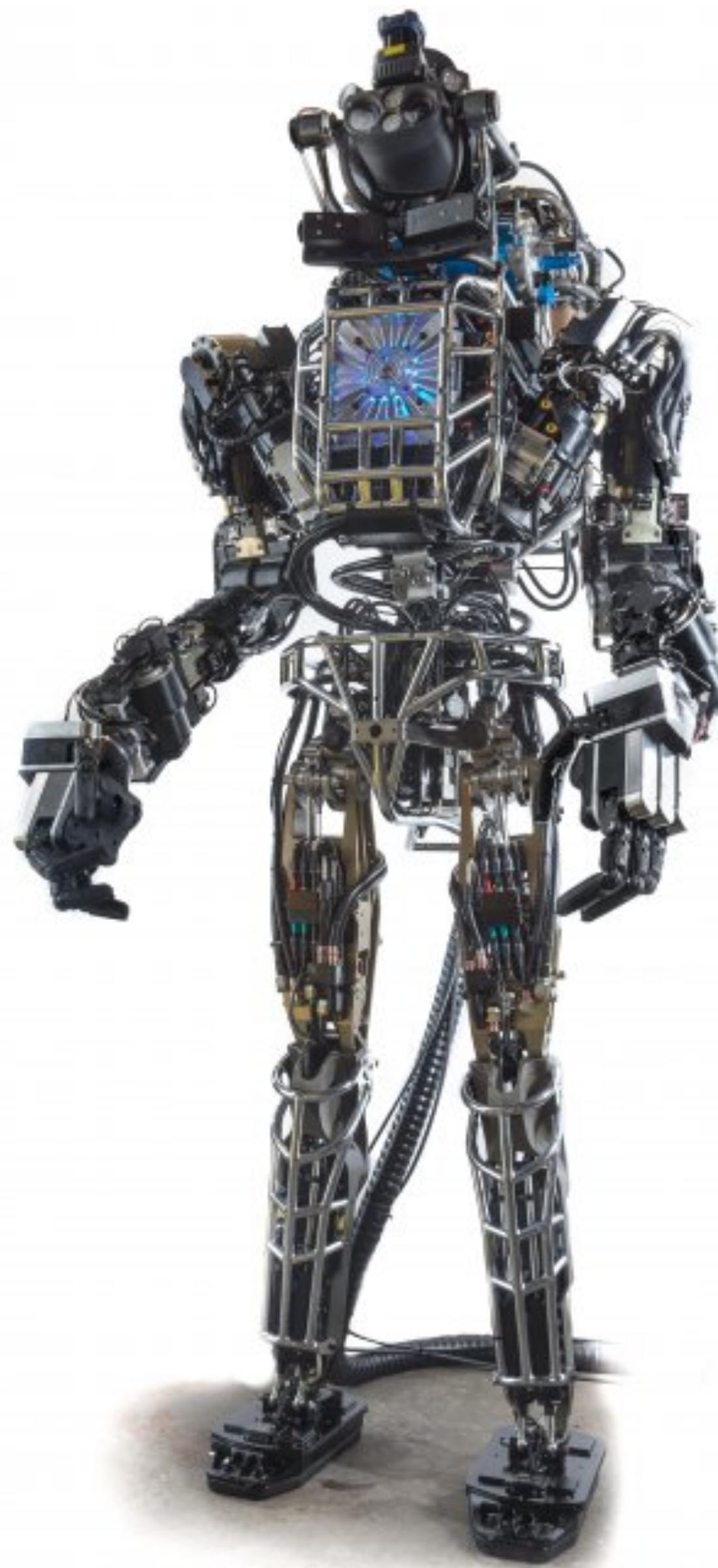
enabling technology



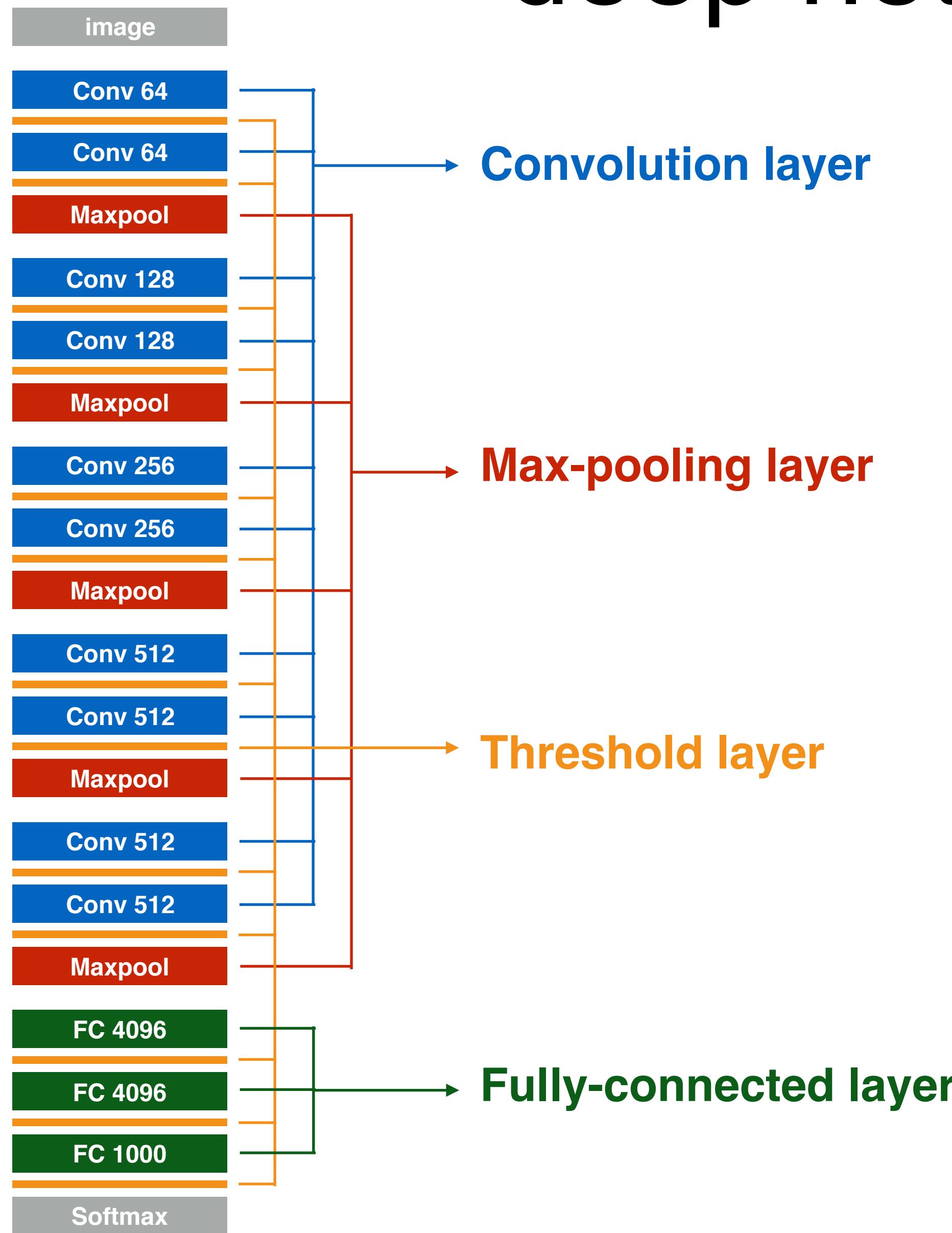
enabling **low-power** servers for parsing big data, images, videos!

enabling technology

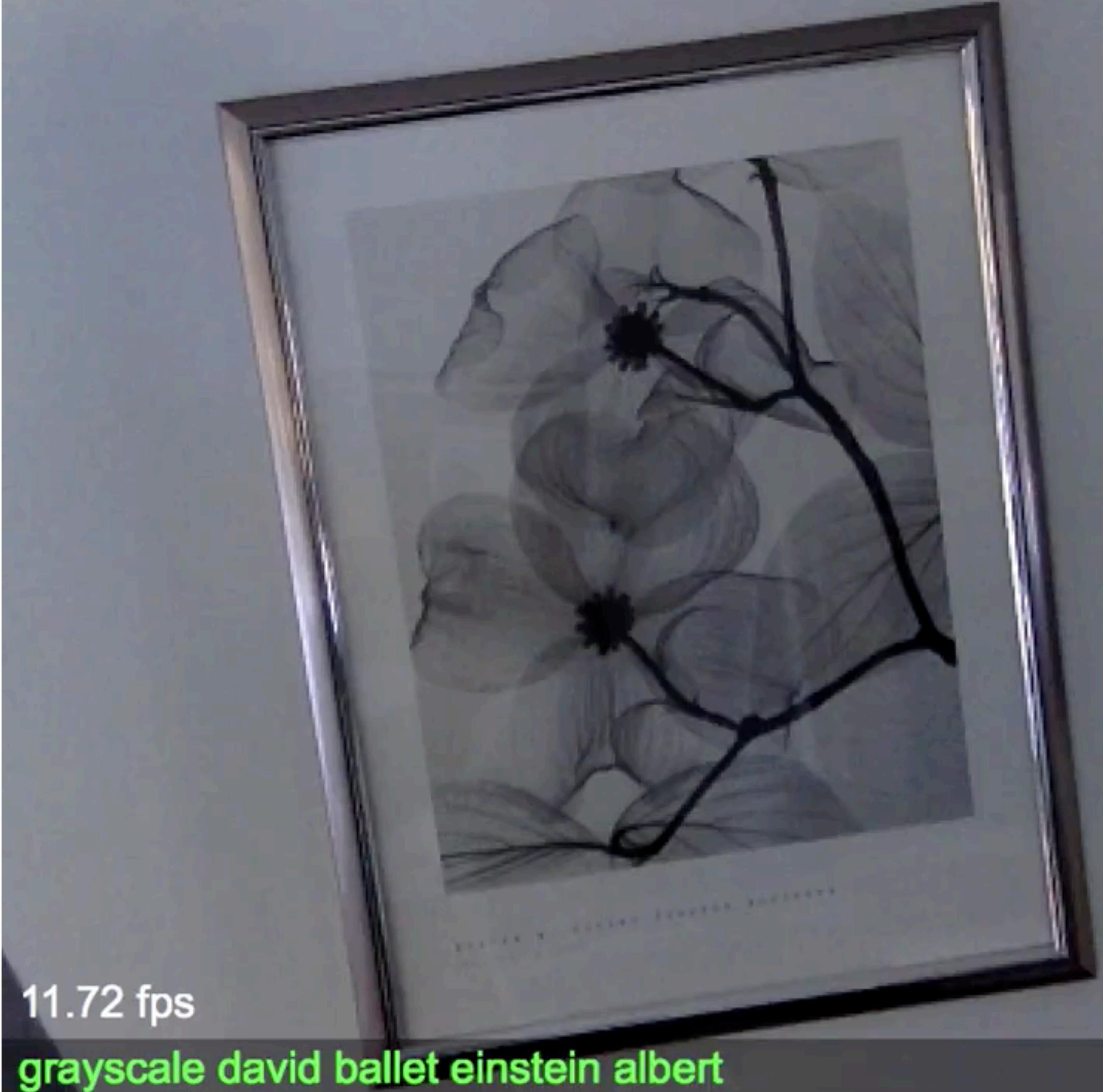
enabling robots to
perceive the world
and start becoming
useful!



deep networks



A Deep Neural Network:
deep, invariant,
trained on data,
model of visual
system,
state-of-art



11.72 fps

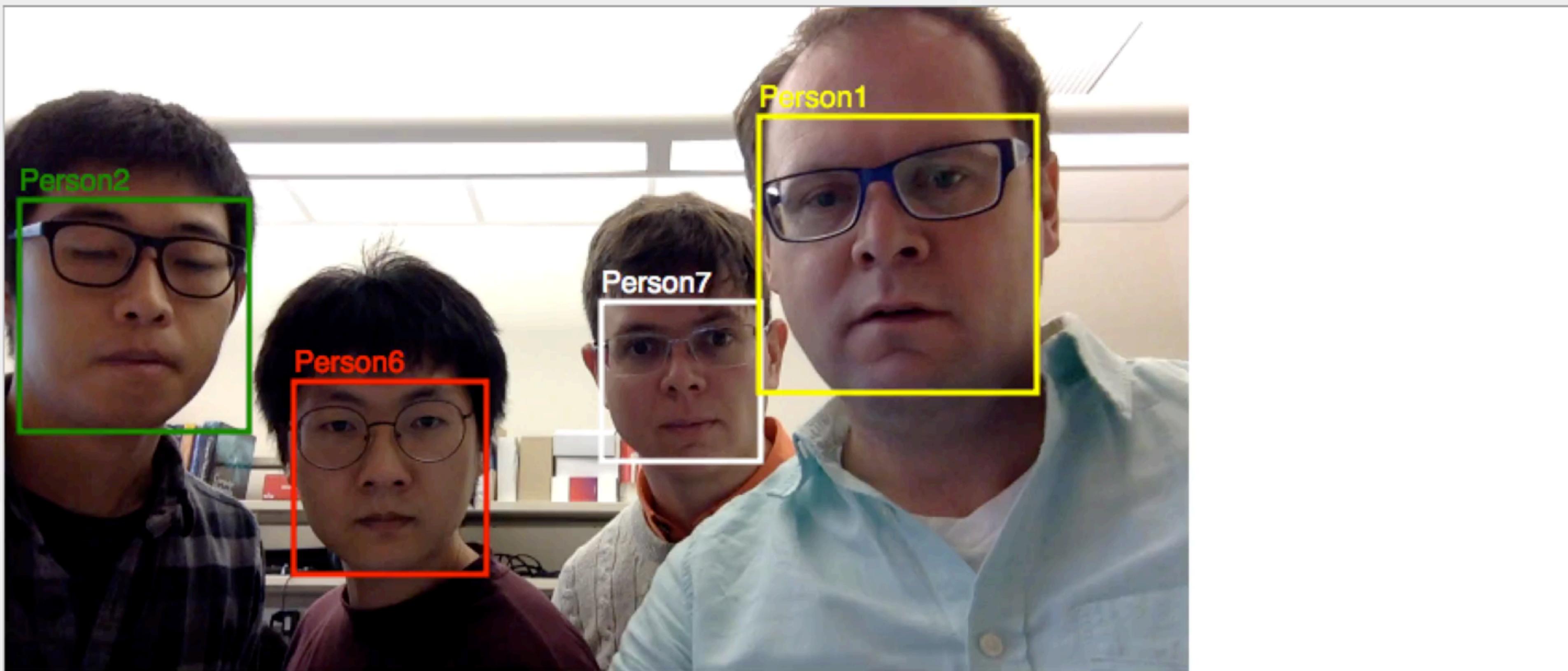
grayscale david ballet einstein albert

<https://www.youtube.com/user/culurciello/videos>

Eugenio Culurciello
© 2016

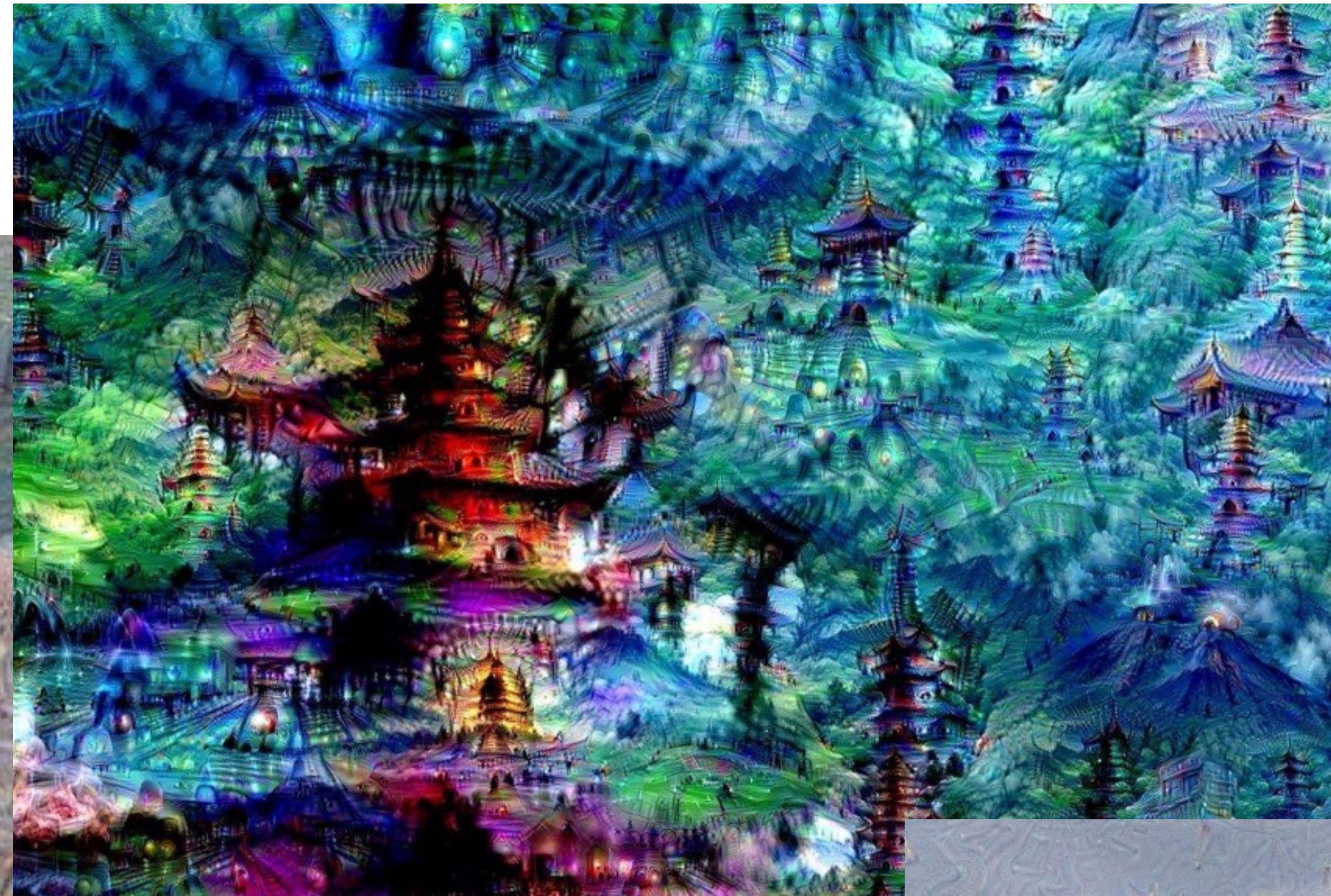
Status Database 33 faces for 8 identities | Reset Save Load Prune

ID Name | Update Resume Stop Close



0.17 fps





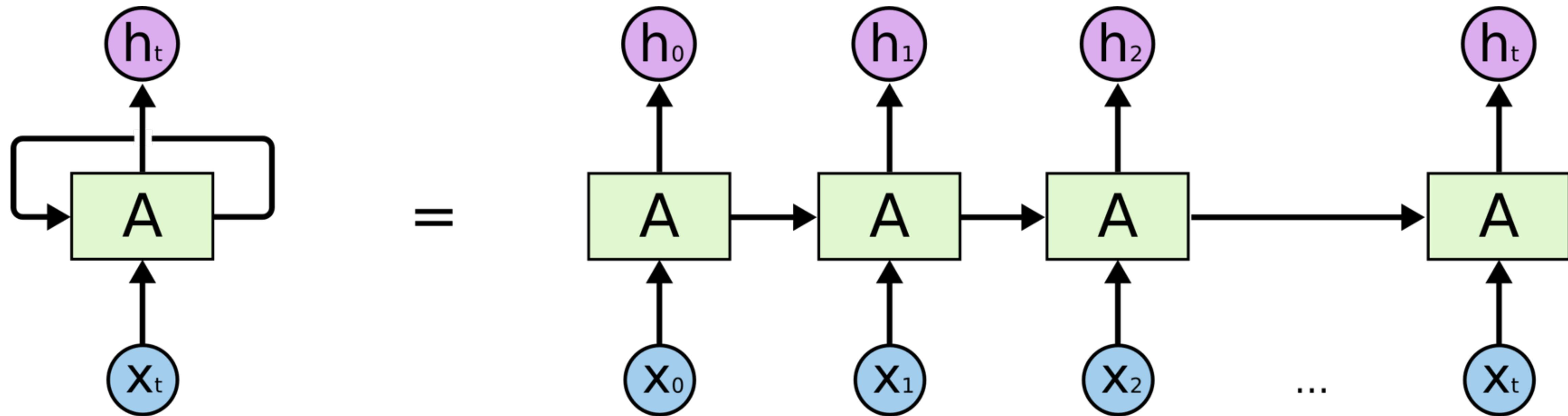
Deep Learning is the de-facto standard
for creating images, videos!



<https://github.com/jcjohnson/neural-style>

Deep Learning is the de-facto standard
for creating images, videos!

recurrent neural networks



deep learning: RNN write text

more of national temperament
more of national temperament

**Deep Learning is the de-facto standard
for learning sequences, text, etc!**

deep learning: RNN language translation



e-Lab

result

seeding with:

"Devo andare a dormire.<"

It should go to sleep.>

seeding with:

"Mi piacerebbe tanto andare in Giappone.<"

She wants to live in Japan

seeding with:

"Sei sicuro?<"

Are you sure of this?>

seeding with:

"Non è importante.<"

I have important taller.>

seeding with:

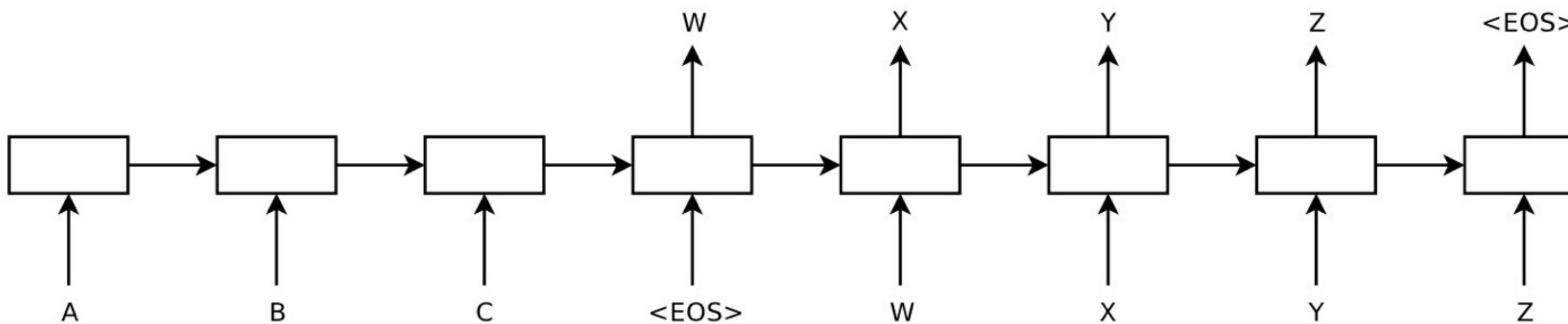
"E allora?<"

What is the time?>

seeding with:

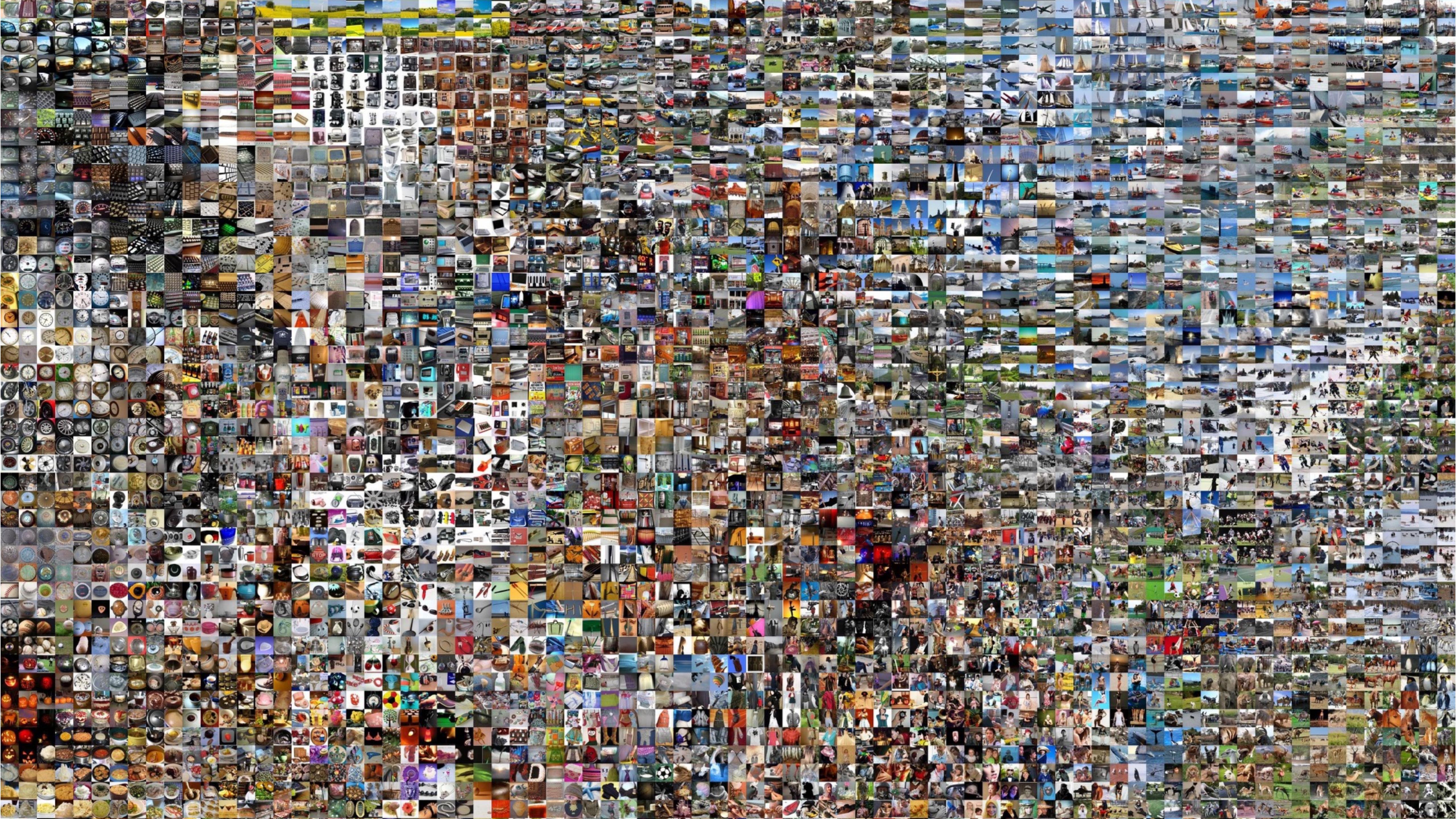
"Non è importante.<"

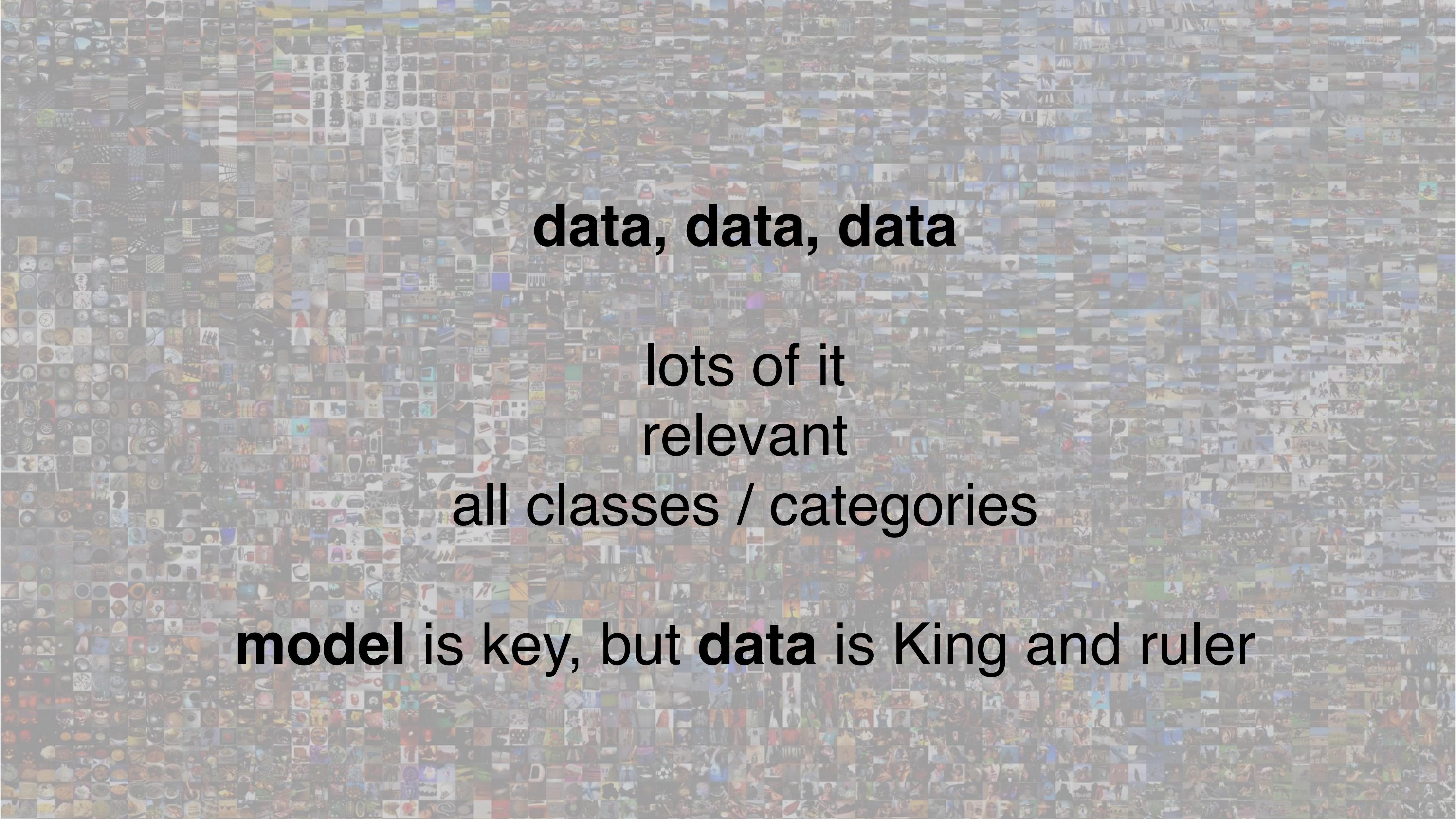
It's important.>



Deep Learning is the de-facto standard
for learning sequences, translating text

TRAINING

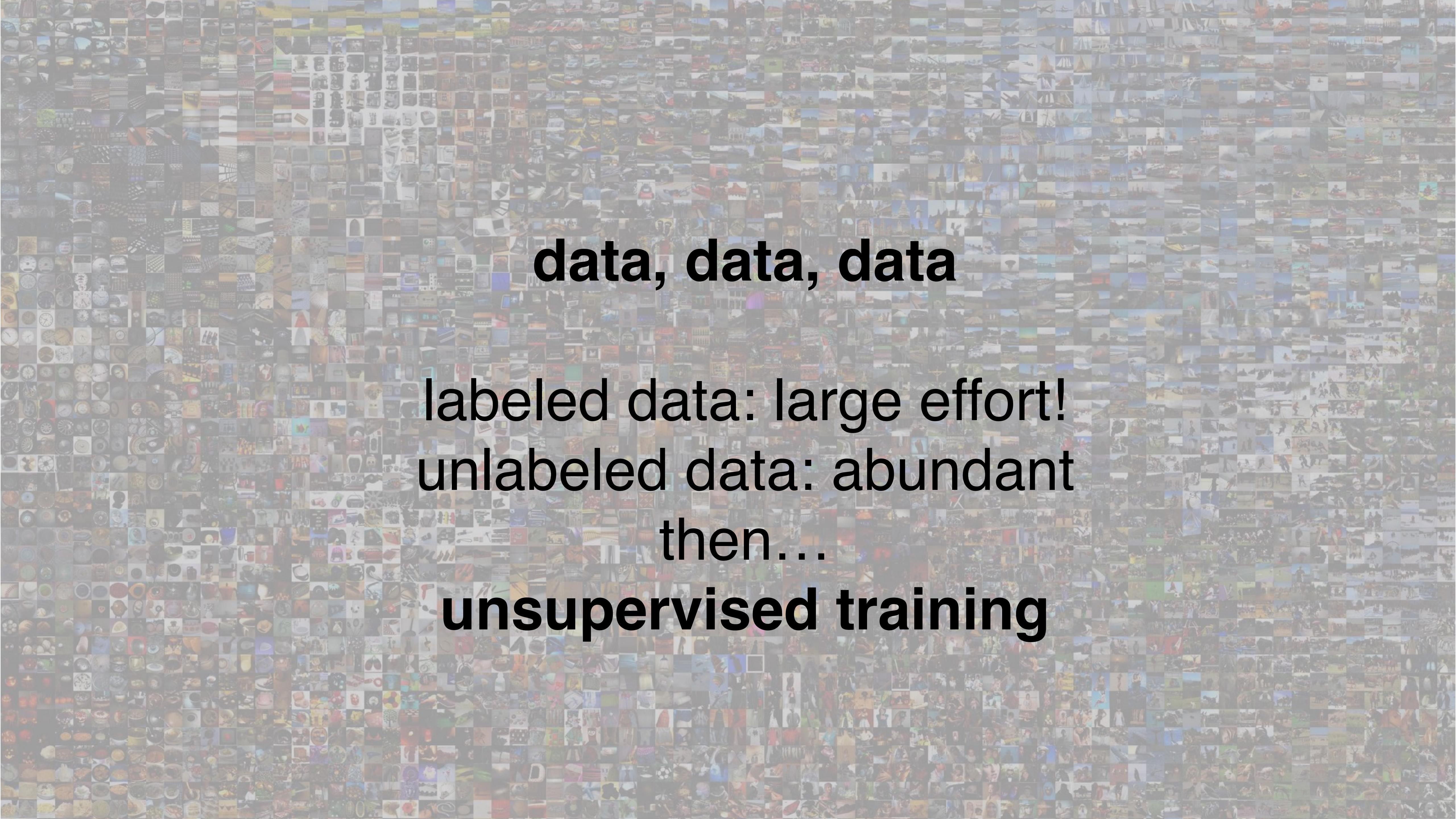




data, data, data

lots of it
relevant
all classes / categories

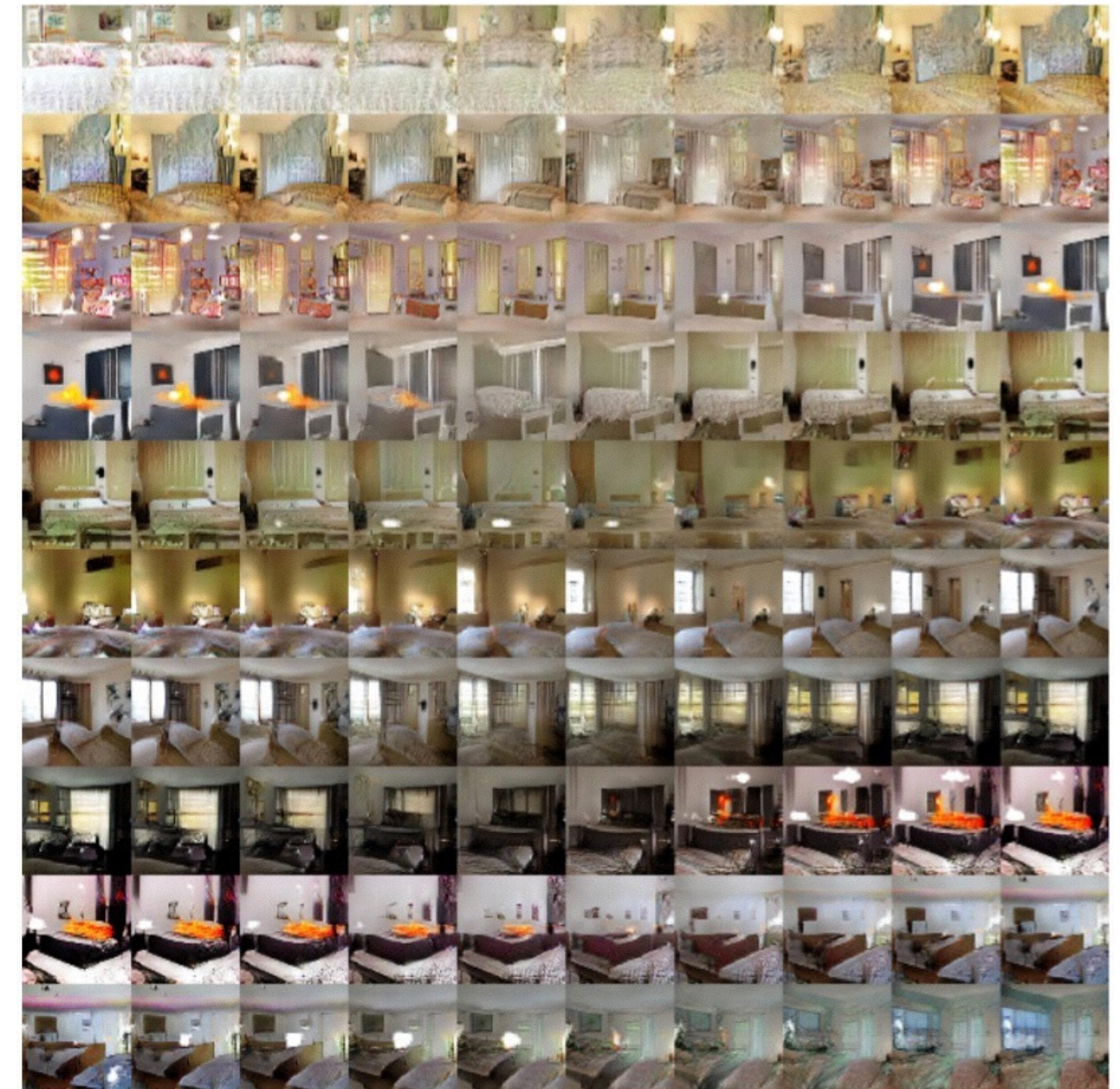
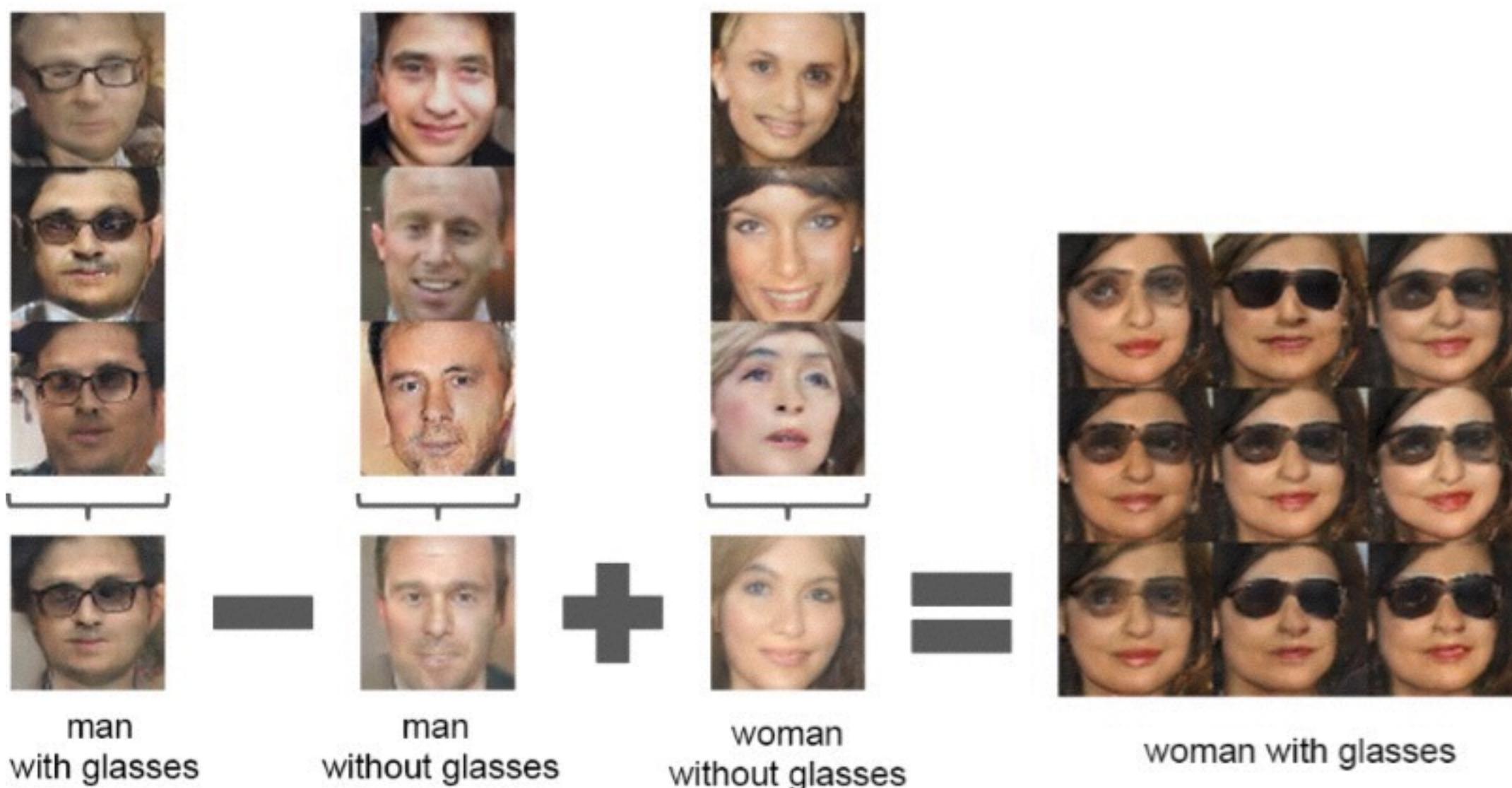
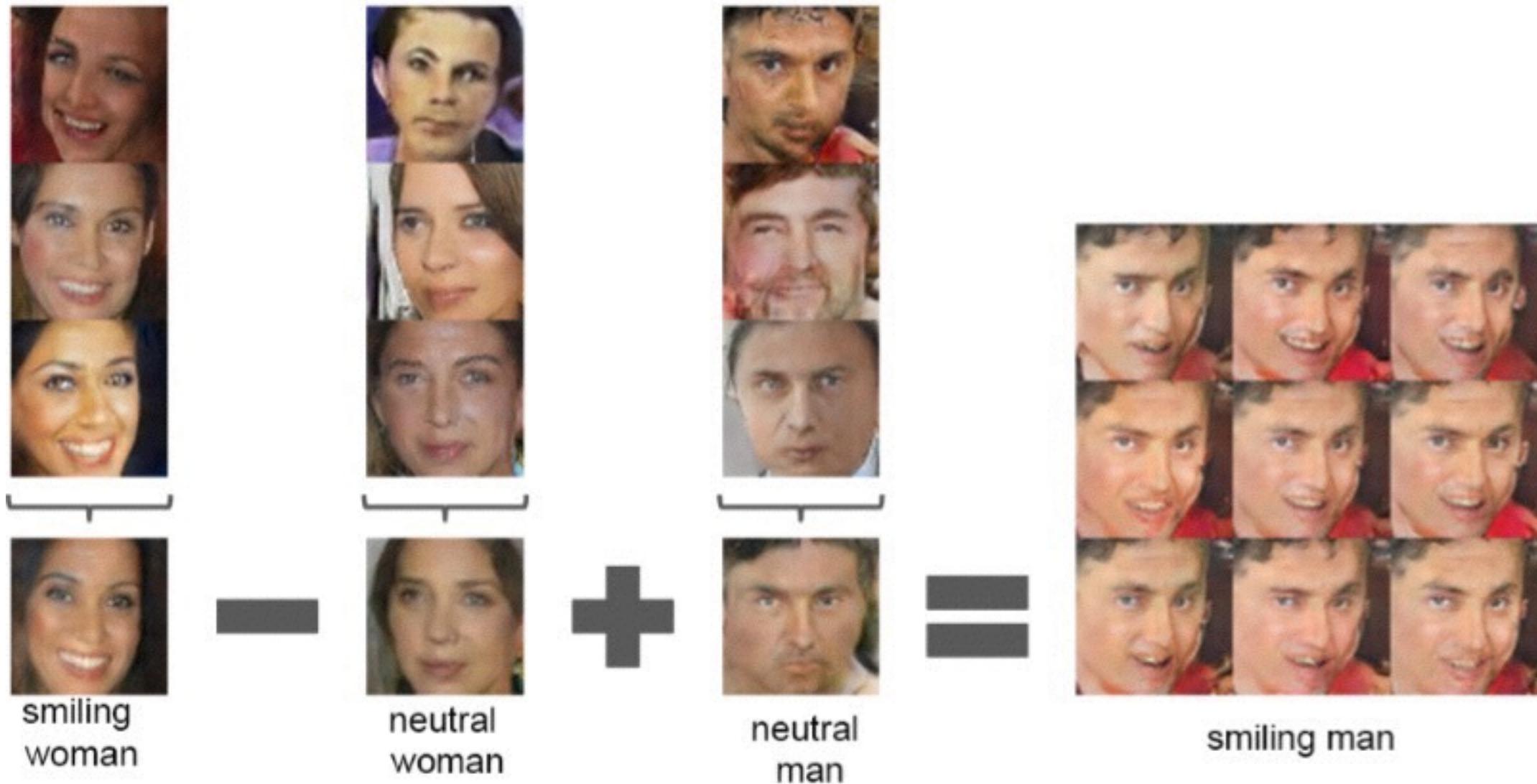
model is key, but data is King and ruler



data, data, data

labeled data: large effort!
unlabeled data: abundant
then...
unsupervised training

unsupervised learning



unsupervised learning

this small bird has a pink breast and crown, and black primaries and secondaries.



the flower has petals that are bright pinkish purple with white stigma



this magnificent fellow is almost all black with a red crest, and white cheek patch.



this white and yellow flower have thin white petals and a round yellow stamen



Learn about 3 dimensions



<https://github.com/piiswrong/deep3d>

LEARN, ENJOY, PRODUCE

similar courses

DeFreitas Oxford:

[https://www.cs.ox.ac.uk/people/nando.defreitas/
machinelearning/](https://www.cs.ox.ac.uk/people/nando.defreitas/machinelearning/)

FeiFei Stanford:

<http://cs231n.stanford.edu/>

Poggio MIT

<http://www.mit.edu/~9.520/fall16/>

Ng Stanford:

<https://www.coursera.org/learn/machine-learning>

about the instructor

Eugenio Culurciello: BME faculty trained in ECE on mixed-signal circuit design, SoC ~ really an electrical engineer!

Working in neuromorphic engineering and bio-inspired system since 1997. Focused on Deep Learning, large-scale neural networks since 2004.

Worked with Yann LeCun while at Yale.

Interested in algorithms to replicate human vision, pato-temporal cognition, from raw-data to AI. Interested in hardware to speed up computation of neural networks and machine learning algorithms.

class format

requirements: course uses programming, requires some experience in unix, data manipulation routines, basic CS / ECE / engineering programming course required

inverted class: pre-recorded lectures

class-time: problem solving, in-depth analysis

final project: practical use of deep learning system to solve actual problem, chosen by student [groups]

tools: torch7 scientific computing <http://torch.ch/>

class schedule

Week 1: Introduction

Week 2: Neural networks

Week 3: Back-propagation

Week 4: Training neural networks

Week 5: Datasets and learning

Week 6: Deep neural networks models

Week 7: Tools for neural networks

Week 8: Computer vision with Deep Learning

Week 9: Full-scene understanding

Week 10: Recurrent neural networks

Week 11: Learning to predict motion and actions

Week 12: Unsupervised learning

Week 13: Final project proposals

Week 14: Reinforcement learning and applications

Week 16: Final project reports and presentations

class evaluation

Class participation: 30%

Homework: 30%

Project: 40% of which:

10% problem analysis and initial system design

15% software implementation

10% simulation results and demonstrations

5% coding practices and scalability of implementation