

Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Deep Learning

with Artificial Neural Networks

Jon Krohn

Slides available at jonkrohn.com/talks

Chief Data Scientist at untapt

July 9th, 2018



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- 1 Antecedents**
 - The Velocity of Technological Progress
 - Case Study: A History of Biological & Artificial Vision
 - Machine Intelligence
- 2 Theory**
 - Biological & Artificial Neurons
 - Neural Networks
 - Deep Neural Networks
- 3 Contemporary Applications**
 - Convolutional Neural Networks
 - Long Short-Term Memory Recurrent Neural Networks
 - Deep Learning at untapt
 - Deep Reinforcement Learning
 - Building Blocks
- 4 The Future**



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- 1 Antecedents**
 - The Velocity of Technological Progress
 - Case Study: A History of Biological & Artificial Vision
 - Machine Intelligence
- 2 Theory**
 - Biological & Artificial Neurons
 - Neural Networks
 - Deep Neural Networks
- 3 Contemporary Applications**
 - Convolutional Neural Networks
 - Long Short-Term Memory Recurrent Neural Networks
 - Deep Learning at untapt
 - Deep Reinforcement Learning
 - Building Blocks
- 4 The Future**



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- 1 Antecedents**
 - The Velocity of Technological Progress
 - Case Study: A History of Biological & Artificial Vision
 - Machine Intelligence
- 2 Theory**
 - Biological & Artificial Neurons
 - Neural Networks
 - Deep Neural Networks
- 3 Contemporary Applications**
 - Convolutional Neural Networks
 - Long Short-Term Memory Recurrent Neural Networks
 - Deep Learning at untapt
 - Deep Reinforcement Learning
 - Building Blocks
- 4 The Future**



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress

Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons

Neural Networks

Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks

Long Short-Term Memory Recurrent Neural Networks

Deep Learning at untapt

Deep Reinforcement Learning

Building Blocks

4 The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future

Jeanne Calment

(1875-1997 — i.e., 122 years)

21



1896

121



1996



Life in the Year 2138

Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

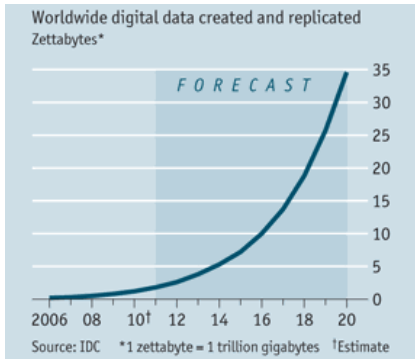
LSTMs

untapt

Reinforcement

Building Blocks

The Future



Deep Learning

Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress

Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons

Neural Networks

Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks

Long Short-Term Memory Recurrent Neural Networks

Deep Learning at untapt

Deep Reinforcement Learning

Building Blocks

4 The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

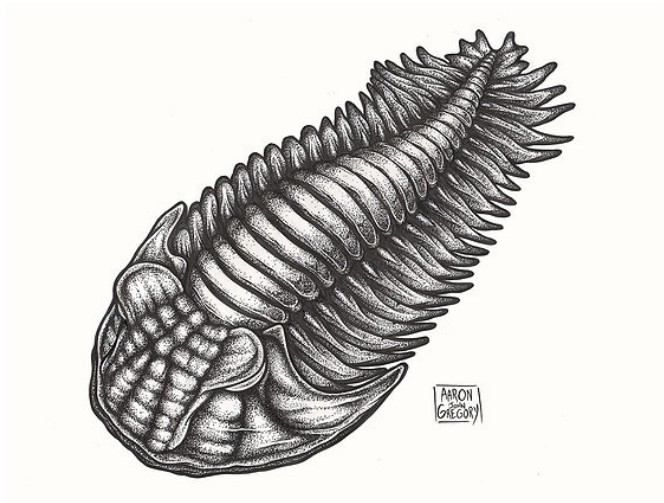
LSTMs

untapt

Reinforcement

Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

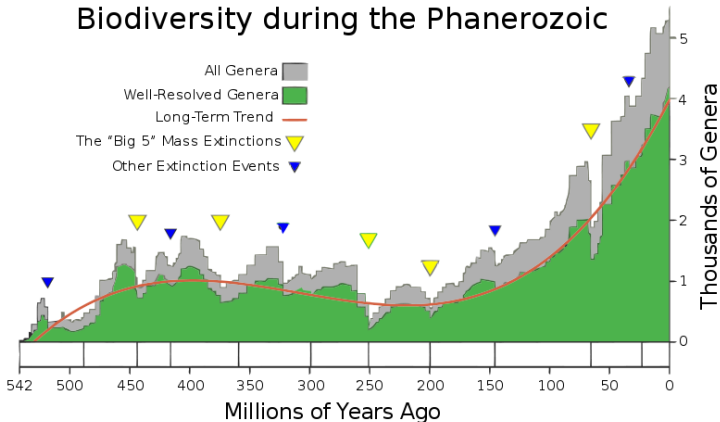
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

Biodiversity during the Phanerozoic



Hubel & Wiesel (1959)

Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

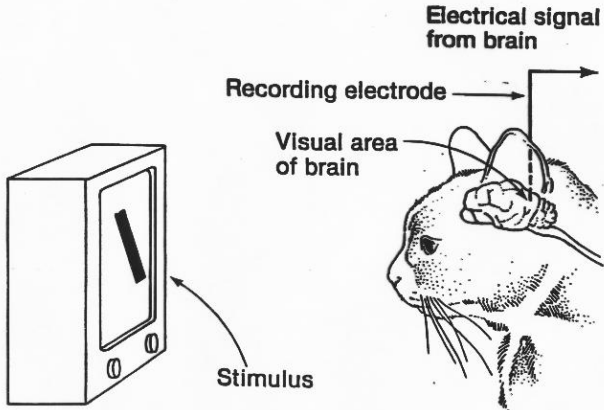
LSTMs

untapt

Reinforcement

Building Blocks

The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

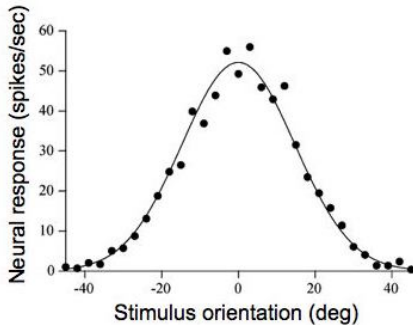
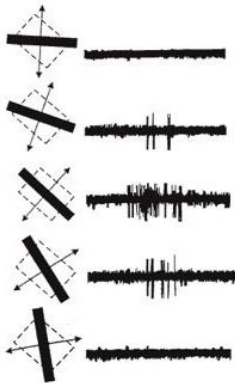
LSTMs

untapt

Reinforcement

Building Blocks

The Future



Hubel & Wiesel, 1968



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

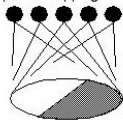
untapt

Reinforcement

Building Blocks

The Future

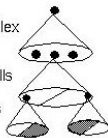
topographical mapping



hyper-complex cells

complex cells

simple cells

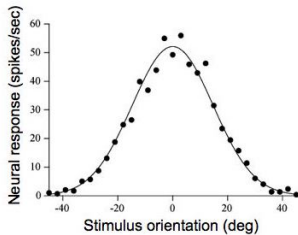
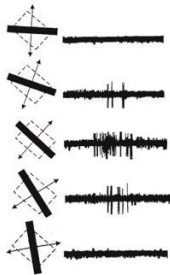


high level

mid level

low level

low level



Hubel & Wiesel, 1968



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

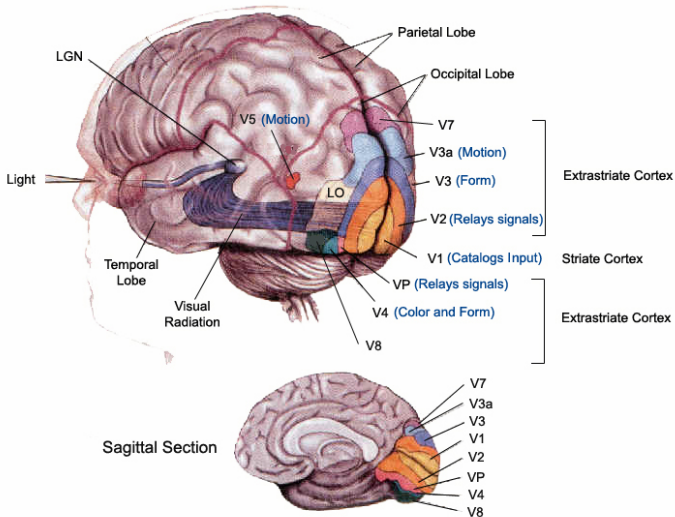
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

Visual Cortices



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

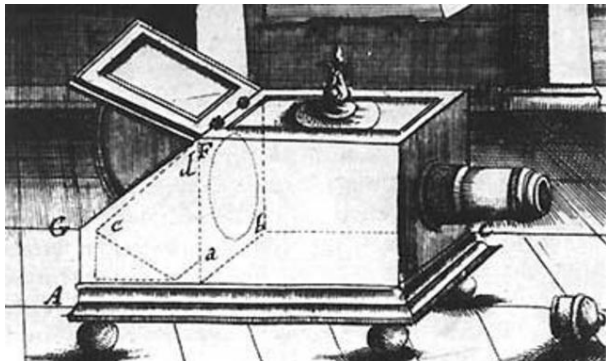
Reinforcement

Building Blocks

The Future

Camera Obscura

da Vinci (15th Century)



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

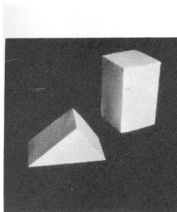
Reinforcement

Building Blocks

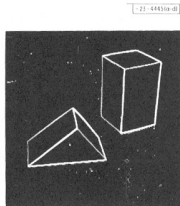
The Future

Block World

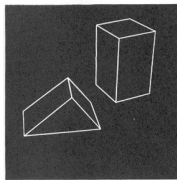
Larry Roberts (1965)



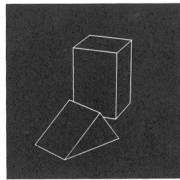
(a) Original picture.



(b) Differentiated picture.



(c) Line drawing.



(d) Rotated view.



Viola & Jones (2001)

Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

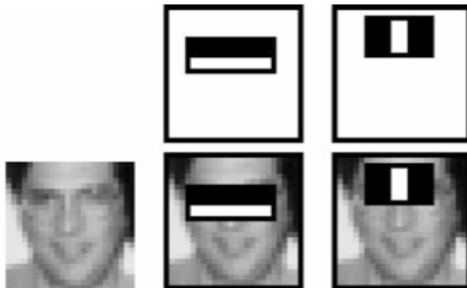
LSTMs

untapt

Reinforcement

Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

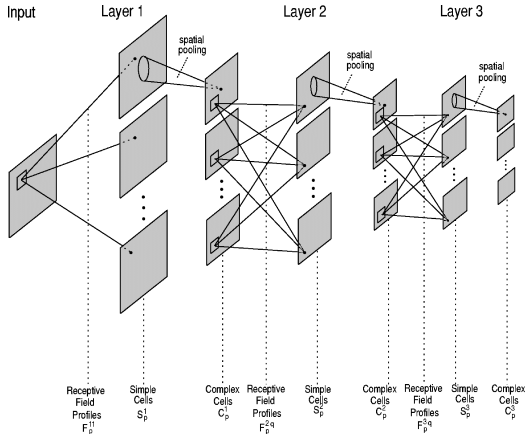
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



MNIST & LeNet-5

LeCun et al. (1998)



PROC. OF THE IEEE, NOVEMBER 1998

7

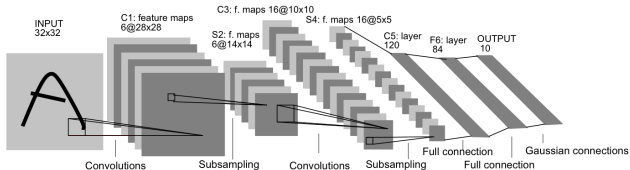


Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.



LeCun, Boutou, Bengio & Haffner (1998)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

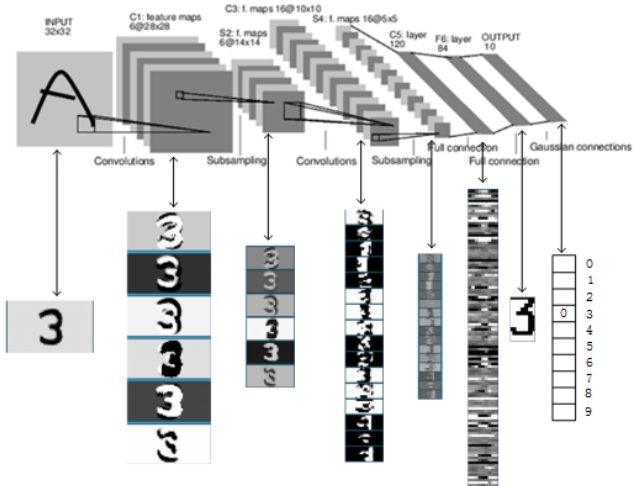
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



mite	container ship	motor scooter	leopard
mite	container ship	motor scooter	leopard
black widow	lifeboat	go-kart	jaguar
cockroach	amphibian	moped	cheetah
tick	fireboat	bumper car	snow leopard
starfish	drilling platform	golfcart	Egyptian cat



grille	mushroom	cherry	Madagascar cat
convertible	agaric	dalmatian	squirrel monkey
grille	mushroom	grape	spider monkey
pickup	jelly fungus	elderberry	titi
beach wagon	gill fungus	ffordshire bullterrier	indri
fire engine	dead-man's-fingers	currant	howler monkey



ImageNet Classification Error

Krizhevsky, Sutskever & Hinton (2012)

Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

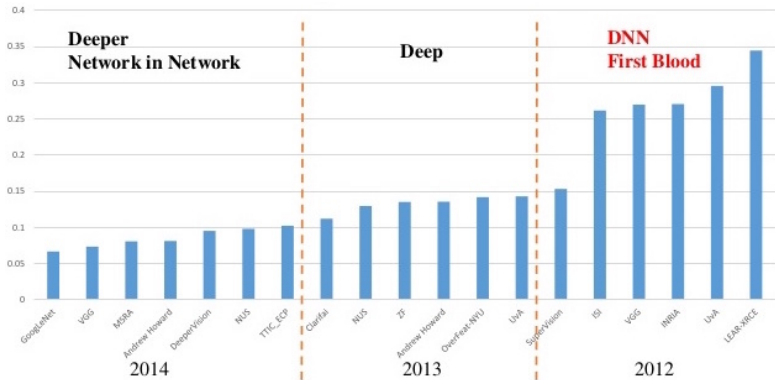
LSTMs

untapt

Reinforcement

Building Blocks

The Future



Krizhevsky et al. (2012)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

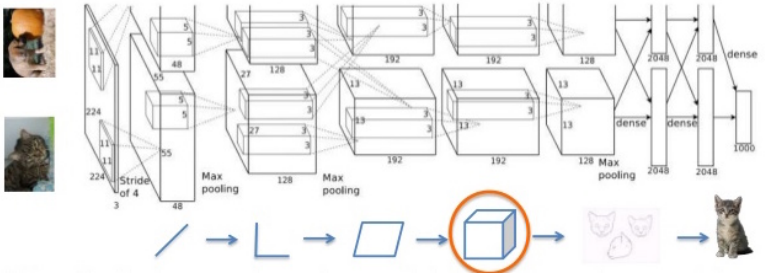
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity

Vision Case Study

Machine Intelligence

Theory

Neural Units

Neural Nets

Deep Neural Nets

Application

ConvNets

LSTMs

untapt

Reinforcement

Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress

Case Study: A History of Biological & Artificial Vision

Machine Intelligence

2 Theory

Biological & Artificial Neurons

Neural Networks

Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks

Long Short-Term Memory Recurrent Neural Networks

Deep Learning at untapt

Deep Reinforcement Learning

Building Blocks

4 The Future



Deep Learning

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

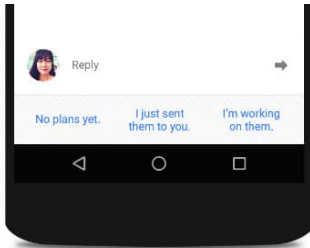
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Deep Learning

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

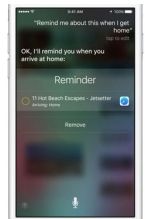
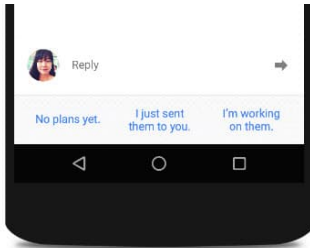
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Deep Learning

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

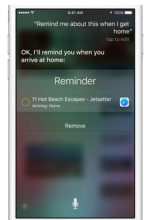
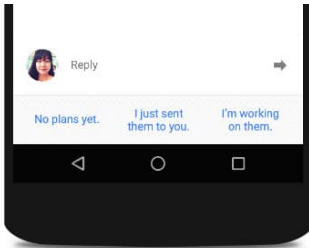
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

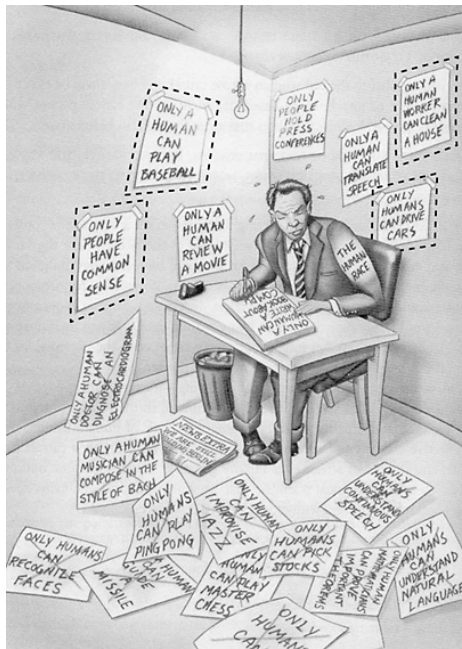
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- 1 Antecedents
 - The Velocity of Technological Progress
 - Case Study: A History of Biological & Artificial Vision
 - Machine Intelligence
- 2 Theory
 - Biological & Artificial Neurons**
 - Neural Networks
 - Deep Neural Networks
- 3 Contemporary Applications
 - Convolutional Neural Networks
 - Long Short-Term Memory Recurrent Neural Networks
 - Deep Learning at untapt
 - Deep Reinforcement Learning
 - Building Blocks
- 4 The Future



Biological Neuron Morphology

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

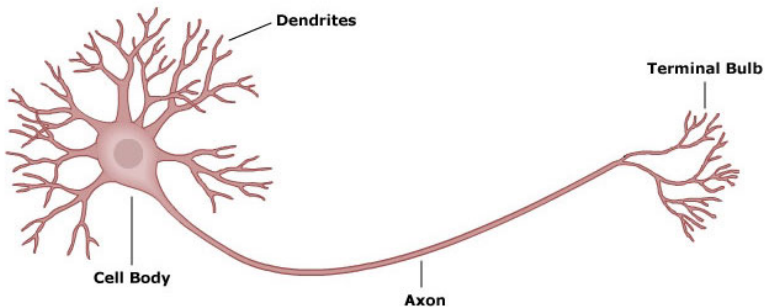
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Perceptron

Rosenblatt (1957)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

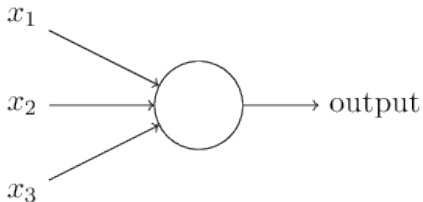
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



$$\text{output} = \begin{cases} 0 & \text{if } \sum_j w_j x_j \leq \text{threshold} \\ 1 & \text{if } \sum_j w_j x_j > \text{threshold} \end{cases}$$



Multi-Layer Perceptron

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

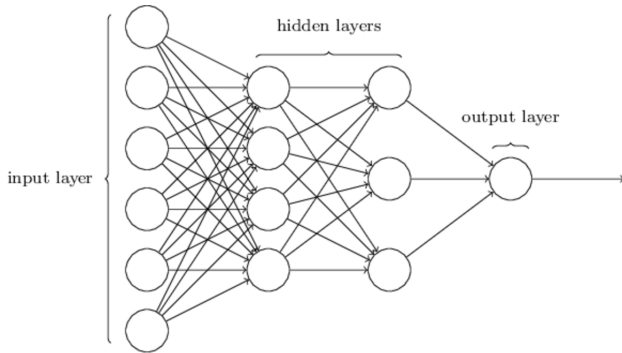
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Multi-Layer Perceptron

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

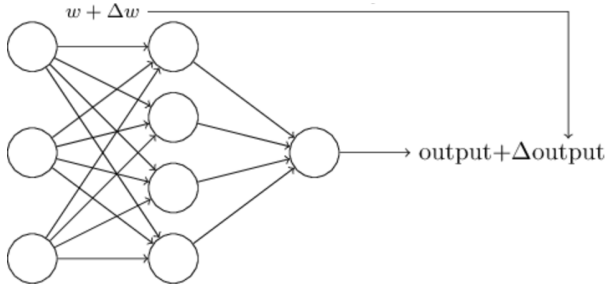
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



MNIST

Handwritten Digits

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets**
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Fully-Connected Neural Net

Single Hidden Layer

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

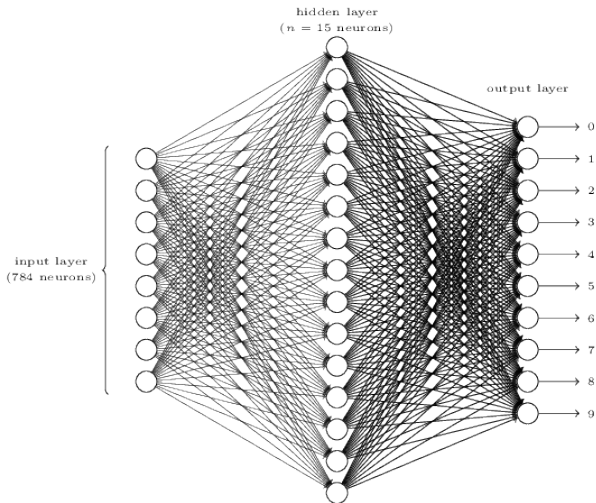
Theory

- Neural Units
- Neural Nets**
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Popular Libraries

Never pay for software

- TensorFlow [demo]
- Torch
- Caffe
- MXNet

Higher-Level APIs:

- TFLearn
- Keras



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Popular Libraries

Never pay for software

- TensorFlow [demo]
- Torch
- Caffe
- MXNet

Higher-Level APIs:

- TFLearn
- Keras



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Popular Libraries

Never pay for software

- TensorFlow [demo]
- Torch
- Caffe
- MXNet

Higher-Level APIs:

- TFLearn
- Keras



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Popular Libraries

Never pay for software

- TensorFlow [demo]
- Torch
- Caffe
- MXNet

Higher-Level APIs:

- TFLearn
- Keras



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Popular Libraries

Never pay for software

- TensorFlow [demo]
- Torch
- Caffe
- MXNet

Higher-Level APIs:

- TFLearn
- Keras



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Popular Libraries

Never pay for software

- TensorFlow [demo]
- Torch
- Caffe
- MXNet

Higher-Level APIs:

- TFLearn
- Keras



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



Deep Fully-Connected Net

3 (or more) Hidden Layers

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

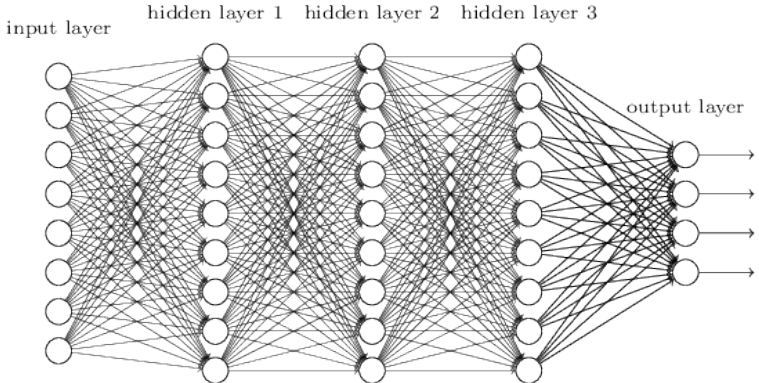
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Synaptic Pruning

Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

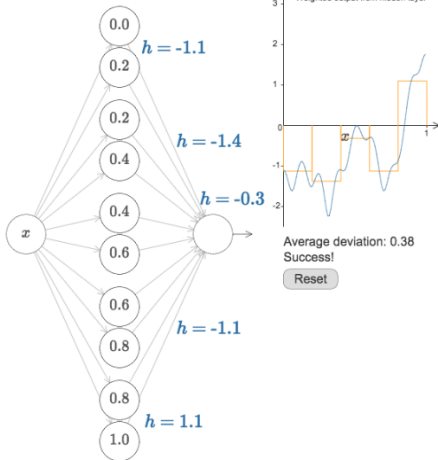
Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

Universality

Solve Any Continuous Function (Nielsen, 2015)



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

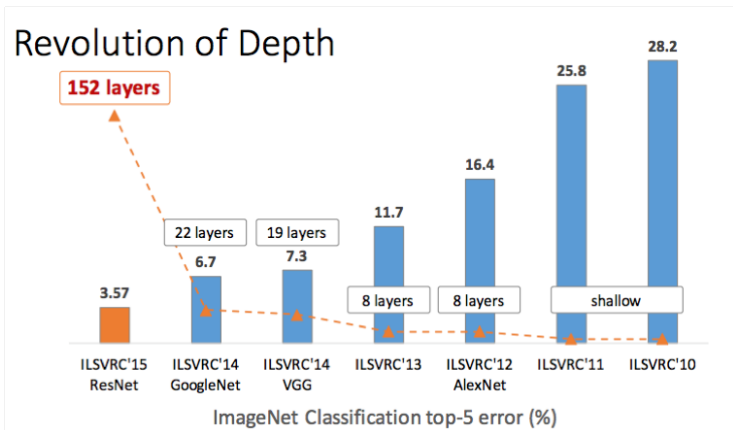
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

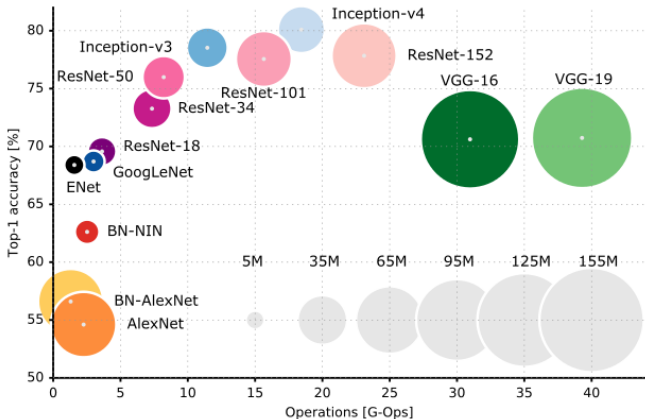
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



Hubel & Wiesel (1959)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

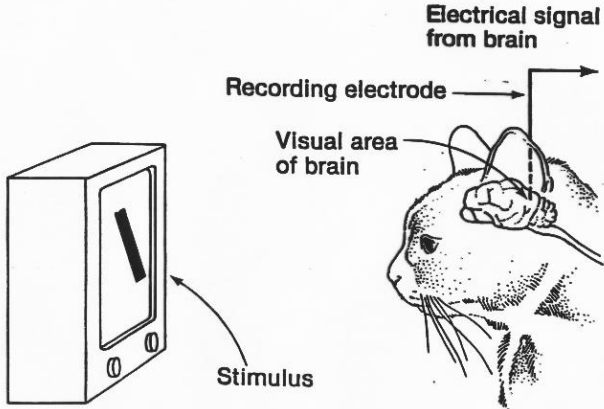
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

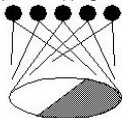
Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

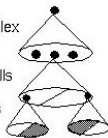
topographical mapping



hyper-complex cells

complex cells

simple cells

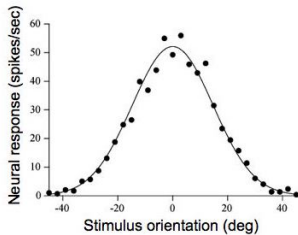
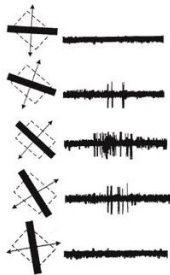


high level

mid level

low level

low level



Hubel & Wiesel, 1968



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

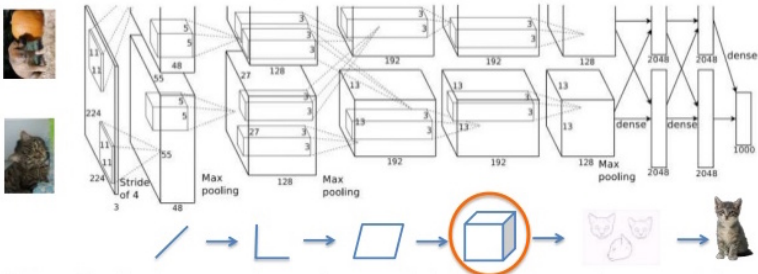
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

DeConvNet

Yosinski et al. (2015)

[Deep Visualization Toolbox]



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

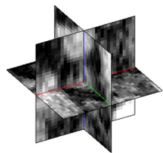
Application

- ConvNets**
- LSTMs
- untapt
- Reinforcement
- Building Blocks

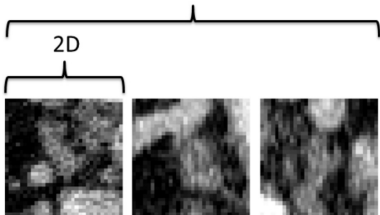
The Future

“2.5-dimension” CT Scans

Roth et al. (2015)



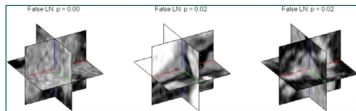
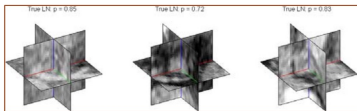
2.5D



Computer-Aided Detection

Shin et al. (2016); Roth et al. (2016)

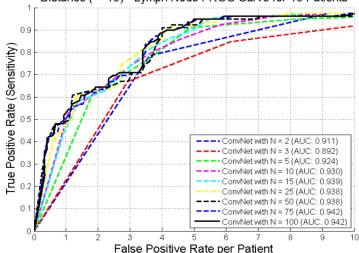
Experimental Results (~100% sensitivity but ~40 FPs/patient at candidate generation step; then 3-fold CV with data augmentation)



Mediastinum

71% @ 3 FPs (was 55%)

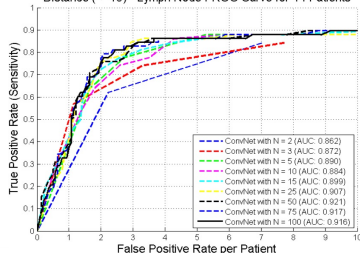
Distance (≤ 15) - Lymph Node FROC Curve for 15 Patients



Abdomen

83% @ 3 FPs (was 30%)

Distance (≤ 15) - Lymph Node FROC Curve for 14 Patients



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

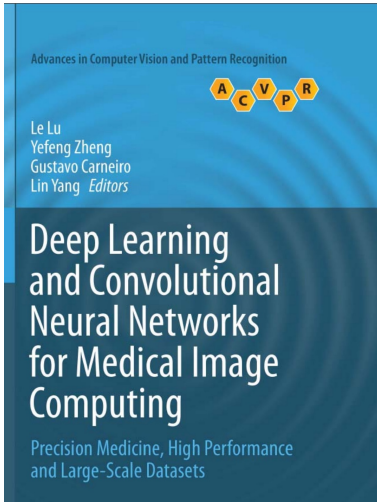
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets**
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

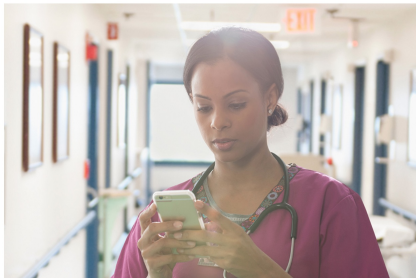
Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

DAILY NEWS 22 November 2016

Google's DeepMind agrees new deal to share NHS patient data



Phone alerts could save lives
Jose Luis Pelaez Inc/Getty

By Victoria Turk

Google's DeepMind has announced a five-year agreement with a UK National Health Service (NHS) trust that will give it access to patient data to develop and deploy its healthcare app, Streams.



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



Long Short-Term Memory

Hochreiter & Schmidhuber (1997)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

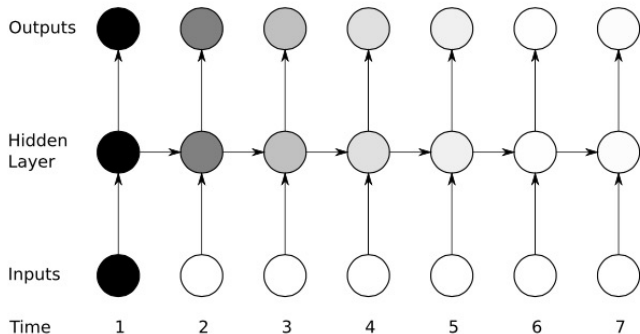
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Word2Vec

Mikolov, Sutskever, Chen, Corrado & Dean (2013)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

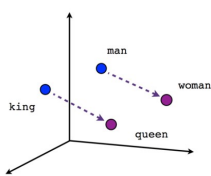
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

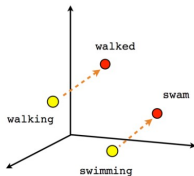
Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

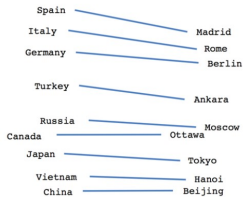
The Future



Male-Female



Verb tense



Country-Capital



Hinton & van der Maaten (2008)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

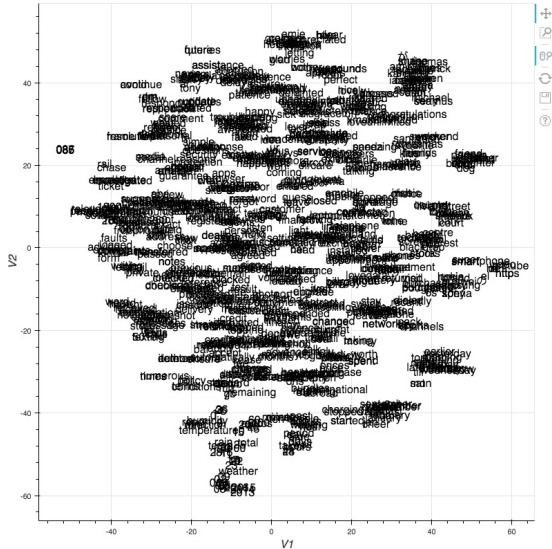
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Word2Vec + t-SNE

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

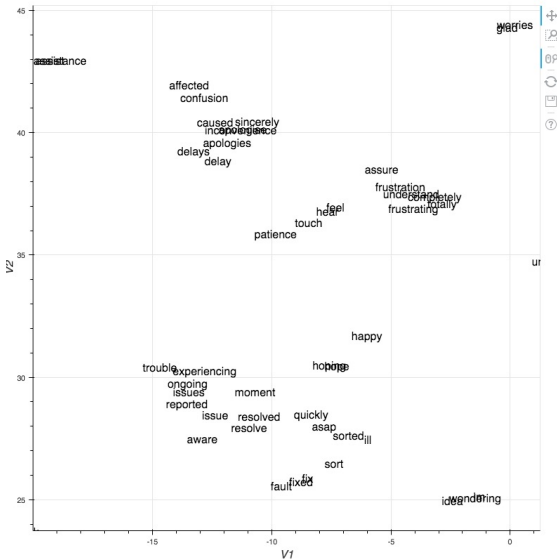
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Word2Vec + t-SNE

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

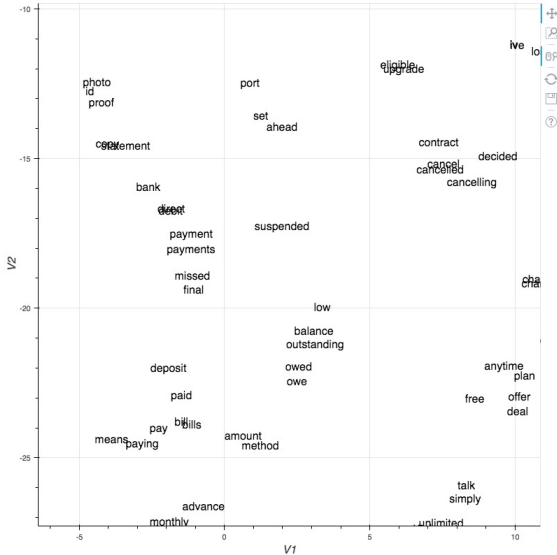
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

```
model.most_similar(positive=['angular'])
```

```
[('angularjs', 0.9534549117088318),  
 ('backbonejs', 0.9315043687820435),  
 ('ember', 0.905410647392273),  
 ('emberjs', 0.9029799103736877),  
 ('reactjs', 0.896049439907074),  
 ('requirejs', 0.8759748339653015),  
 ('coffeescript', 0.8645504713058472),  
 ('bootstrap', 0.8554328083992004),  
 ('nodejs', 0.8515532612800598),  
 ('backbone', 0.8443130254745483)]
```

```
model.most_similar(positive=['managed'])
```

```
[('oversaw', 0.8659406900405884),  
 ('directed', 0.8491166234016418),  
 ('supervised', 0.8058902621269226),  
 ('coordinated', 0.7858685851097107),  
 ('led', 0.7539615035057068),  
 ('orchestrated', 0.7211644649505615),  
 ('supported', 0.7198437452316284),  
 ('comanaged', 0.6774874925613403),  
 ('encompassing', 0.6726169586181641),  
 ('administered', 0.6706464886665344)]
```



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

untapt

Digital Recruitment Platform



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

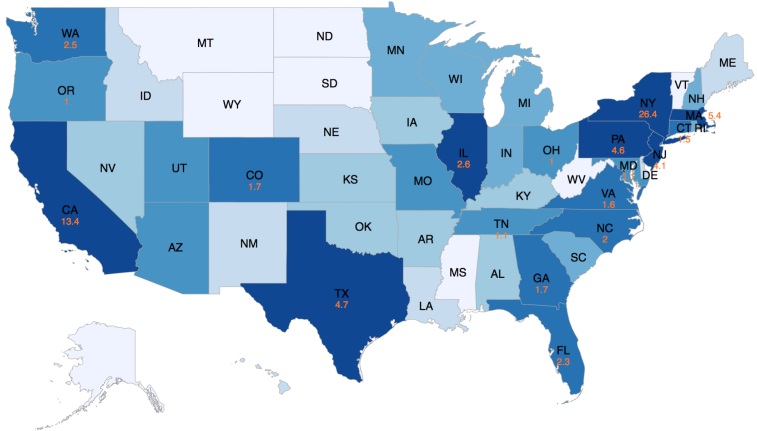
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt**
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

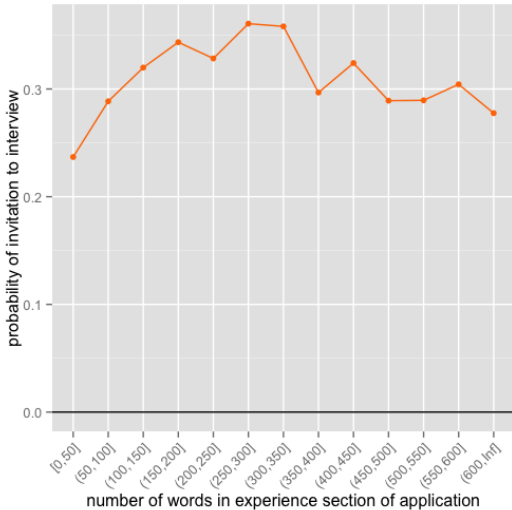
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt**
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

untapt

Client-Side Feedback



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

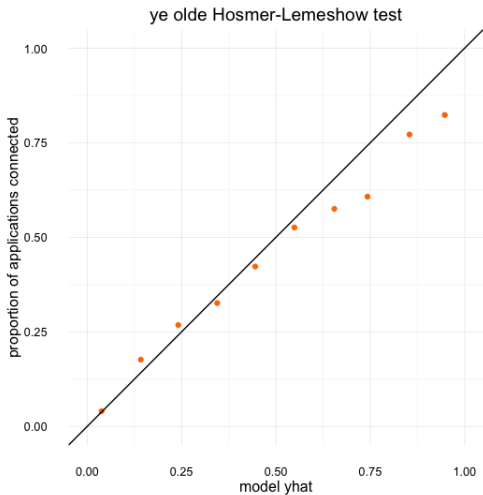
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt**
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt

Reinforcement

Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



AlphaGO

Silver et al. (2016)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt

Reinforcement

- Building Blocks

The Future



Deep Q-Learning

Mnih et al. (2015)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

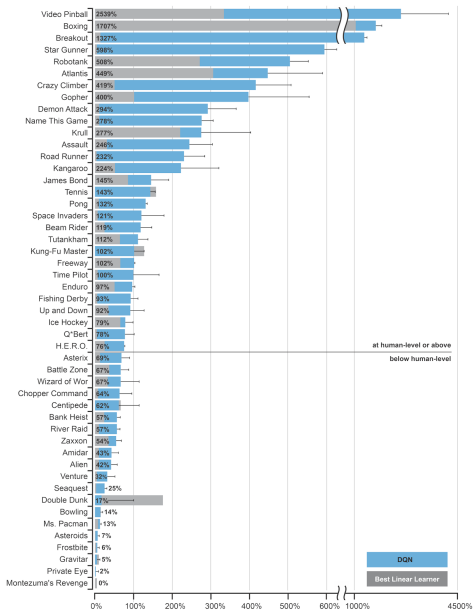
Application

- ConvNets
- LSTMs
- untapt

Reinforcement

- Building Blocks

The Future



[Atari Games]



Deep Q-Learning

Mnih et al. (2015)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

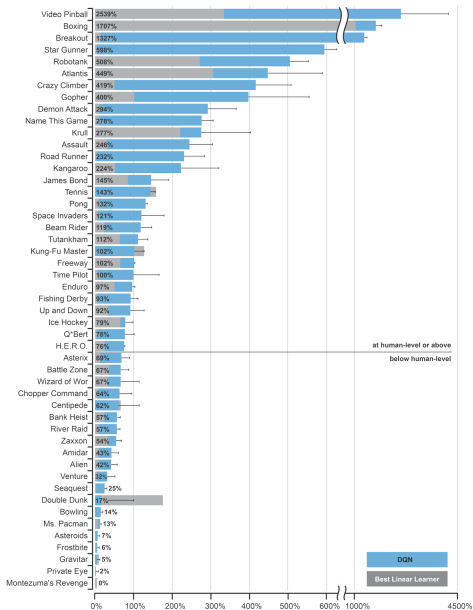
Application

- ConvNets
- LSTMs
- untapt

Reinforcement

- Building Blocks

The Future

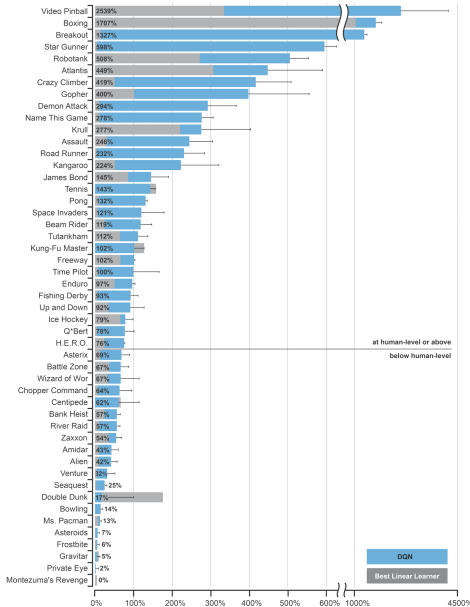


[Atari Games]



Deep Q-Learning

Mnih et al. (2015)



[Atari Games]



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt

Reinforcement

Building Blocks

The Future

[OpenAI Universe]

[Google DeepMind Lab]

[Unity ML Agents]



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

1 Antecedents

The Velocity of Technological Progress
Case Study: A History of Biological & Artificial Vision
Machine Intelligence

2 Theory

Biological & Artificial Neurons
Neural Networks
Deep Neural Networks

3 Contemporary Applications

Convolutional Neural Networks
Long Short-Term Memory Recurrent Neural Networks
Deep Learning at untapt
Deep Reinforcement Learning
Building Blocks

4 The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- **local machine**
- build your own server
- AWS
- GPU(s) / TPU(s)



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- local machine
- build your own server
- AWS
- GPU(s) / TPU(s)



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- local machine
- build your own server
- **AWS**
- GPU(s) / TPU(s)



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

- local machine
- build your own server
- AWS
- GPU(s) / TPU(s)



Resources for Human Learning

Antecedents

Tech Velocity
 Vision Case Study
 Machine Intelligence

Theory

Neural Units
 Neural Nets
 Deep Neural Nets

Application

ConvNets
 LSTMs
 unrap
 Reinforcement
 Building Blocks

The Future

Data Science Resources — Jon Krohn

www.jonkrohn.com/resources/

Deep Learning

First Steps. For people in New York, I founded a **Deep Learning Study Group**. If you're further afield, you can track our progress via GitHub. Otherwise, get a lay of the land from:

- the sequence of courses suggested by Greg Brockman, or
- this (more comprehensive) introductory resource post from Ofir Press

Textbooks. Relative to viewing lectures, I prefer reading and working through problems. The stand-out resources for this, in the order they ought to be tackled are:

- Michael Nielsen's e-book *Neural Networks and Deep Learning*
- the in-press *Deep Learning* textbook by Goodfellow, Bengio and Courville

Interactive Demos. Top-drawer interactive demos you can develop an intuitive sense of neural networks from are provided by:

- Chris Olah
- the illustrious Andrej Karpathy


Applications. Scroll down to see my recommendations for high-quality data sources as well as global issues in need of solutions. Problems worth solving with deep learning approaches in particular are curated by OpenAI.

Academic Papers. If you're looking for the latest deep learning research, bookmark:

- Flood Sung's *roadmap* for deep learning papers
- Adit Deshpande's list of *nine key papers*
- this thorough, subcategorized reading list
- Karpathy's *arXiv Sanity Preserver*
- GitXiv for open-source implementations of popular arXiv papers

Home
Posts
Resources
Publications
Talks
Applications

Academia
 Photography
 Quotations
 Contact

 HOP

Jon Krohn, Cajoler of Datasets



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future

Jeanne Calment

(1875-1997 — i.e., 122 years)

21



1896

121



1996



Life in the Year 2138

Antecedents

Tech Velocity
Vision Case Study
Machine Intelligence

Theory

Neural Units
Neural Nets
Deep Neural Nets

Application

ConvNets
LSTMs
untapt
Reinforcement
Building Blocks

The Future



Thiel & Masters (2014)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

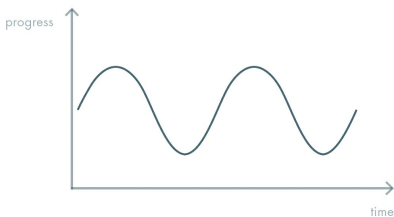
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

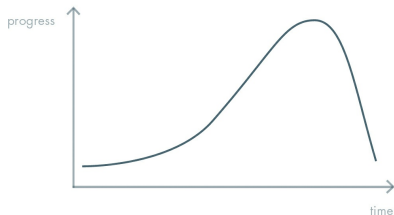
- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

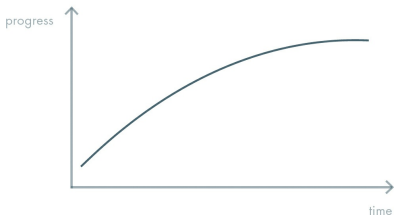
RECURRENT COLLAPSE



EXTINCTION



PLATEAU



TAKEOFF



Thiel & Masters (2014)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

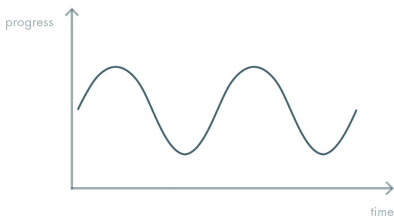
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

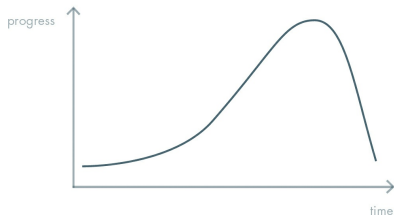
- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

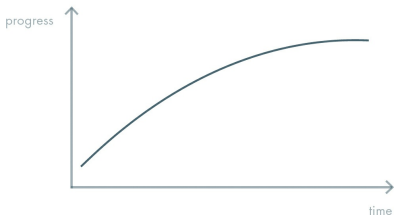
RECURRENT COLLAPSE



EXTINCTION



PLATEAU



TAKEOFF



Thiel & Masters (2014)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

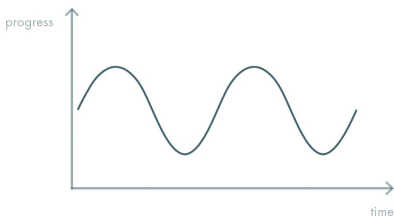
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

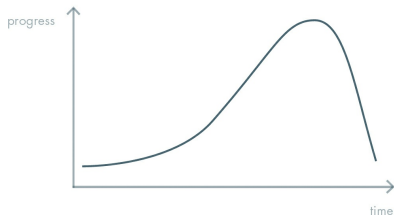
- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

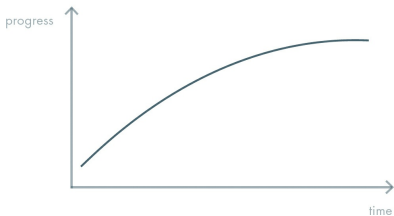
RECURRENT COLLAPSE



EXTINCTION



PLATEAU



TAKEOFF



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

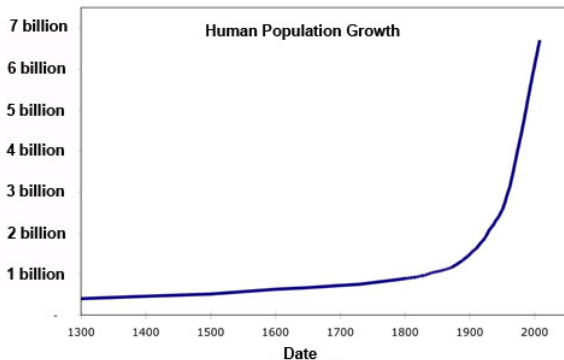
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

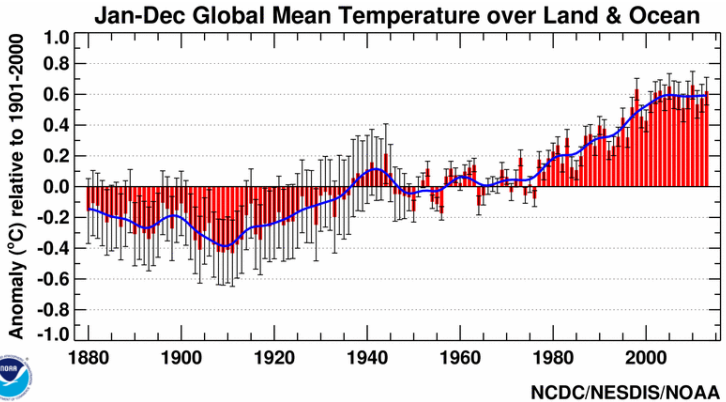
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

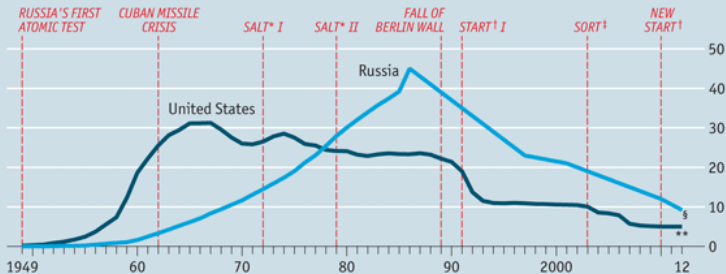
Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

Still lots to go around

Nuclear-warhead stockpile, '000



Source: Bulletin of the Atomic Scientists
*Strategic Arms Limitation Treaty †Strategic Arms Reduction Treaty
‡Strategic Offensive Reductions Treaty §Includes 5,500 retired warheads awaiting dismantling
**Excludes retired warheads



Pinker & Mack (2014)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

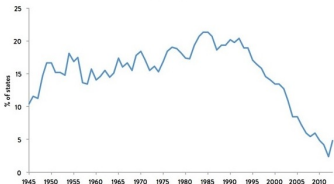
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

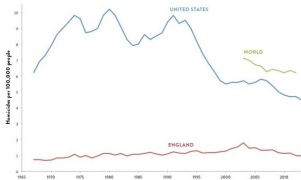
The Future

**PREVALENCE OF MASS KILLINGS
1945-2013**



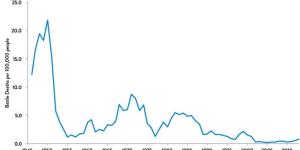
Source: Early Warning Project, <https://earlywarning.worldpress.com/>; Ulfelder, Jay and Valentino, Benjamin, "Assessing Risks of State-Sponsored Mass Killing" (Feb. 1, 2006). Available at SSRN: <http://dx.doi.org/10.2139/ssrn.1034426>

**HOMICIDE RATES IN THE US AND ENGLAND
1967-2013, AND THE WORLD, 2003-2012**



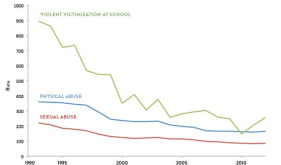
Sources: U.S. FBI Uniform Crime Reports, England (including Wales) U.K. Office for National Statistics, World U.N. Office on Drugs and Crime, reported in U.N. Economic and Social Council's World Crime Trends and Emerging Issues and Responses in the Field of Crime Prevention and Social Justice", Feb. 12, 2014, Figure 1. The percentages were converted to homicide rates by setting the 2012 rate at 6.2, the figure reported in the UNODC Global Study on Homicide 2013, Page 12.

**RATE OF BATTLE DEATHS IN ARMED CONFLICTS
1946-2013**



Source: Utopia Conflict Data Program Battle-Related Deaths Dataset v5-2014, 1999-2013, "Best Estimates" Missing estimate for 2013 for the Syria civil war calculated from a revised ICDIP "Low Estimate" and a "High Estimate" from the Peace Research Institute Oslo (both obtained in consultation with Erik Meisler of ICDIP, The "High Estimate" is for May 2013-April 2014, rather than calendar year 2013, and comes from Page 9 of H. Price, A. Gendau, & P. Ekl, "Unsettled Status: Local Analysis of Documentation of Killings in the Syria Arab Republic," Human Rights Data Analysis Group, http://www.hrdag.org/Documents/Countries/SY/HRDAG_LocalAnalysisPaperAug2014.pdf. World population figures from U.S. Census Bureau, http://www.census.gov/population/international/data/worldpop/stable_population.php

**VICTIMIZATION OF CHILDREN IN THE US
1990-2012**



Rates for physical and sexual abuse are per 100,000 children younger than 18. Rates for violent victimization at school are per 10,000 children age 12-17.

Sources: Physical and sexual abuse, National Child Abuse and Neglect Data System, analyzed by David Brothman, 2014 in "Trends in Child Welfare," Presentation at the Carney Institute Policy Series, March 30, 2014. Victimization at school, Bureau of Economic Analysis (top.gov), using the National Crime Victimization Survey Victimization Analysis Tool.



Pinker & Mack (2014)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

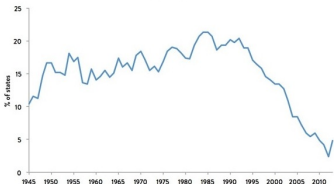
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

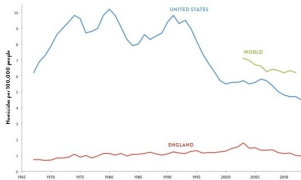
The Future

**PREVALENCE OF MASS KILLINGS
1945-2013**



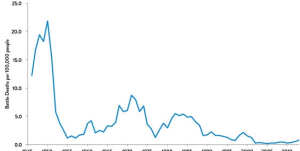
Source: Early Warning Project, <https://earlywarning.worldpress.com/>; Uffelder, Jay and Valentino, Benjamin, "Assessing Risks of State-Sponsored Mass Killing" (Feb. 1, 2006). Available at SSRN: <http://dx.doi.org/10.2139/ssrn.1034426>

**HOMICIDE RATES IN THE US AND ENGLAND
1967-2013, AND THE WORLD, 2003-2012**



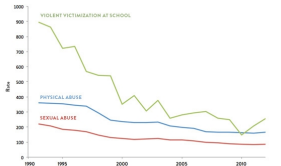
Sources: U.S. FBI Uniform Crime Reports, England (including Wales) U.K. Office for National Statistics, World U.N. Office on Drugs and Crime, reported in U.N. Economic and Social Council's World Crime Trends and Emerging Issues and Responses in the Field of Crime Prevention and Social Justice", Feb. 12, 2014, Figure 1. The percentages were converted to homicide rates by setting the 2012 rate at 6.2, the figure reported in the UNODC Global Study on Homicide 2013, Page 12.

**RATE OF BATTLE DEATHS IN ARMED CONFLICTS
1946-2013**



Source: Utopia Conflict Data Program Battle-Related Deaths Dataset v5-2014, 1999-2013, "Best Estimates" Missing estimate for 2013 for the Syria civil war calculated from a revised ICDIP "Low Estimate" and a "High Estimate" from the Peace Research Institute Oslo (both obtained in consultation with Erik Meisler of ICDIP, The "High Estimate" is for May 2013-April 2014, rather than calendar year 2013, and comes from Page 9 of H. Price, A. Gendau, & P. East, "Underestimated: Statistical Analysis of Documentation of Killings in the Syria Arab Republic," Human Rights Data Analysis Group, <http://www.hrdag.org/Documents/Countries/SY/HRDAGUpdateReportAug2014.pdf>. World population figures from U.S. Census Bureau, http://www.census.gov/population/international/data/worldpop/stable_population.php

**VICTIMIZATION OF CHILDREN IN THE US
1990-2012**



Rates for physical and sexual abuse are per 100,000 children younger than 18. Rates for violent victimization at school are per 10,000 children age 12-17.

Sources: Physical and sexual abuse, National Child Abuse and Neglect Data System, analyzed by David Brothman, 2014, in "Trends in Child Welfare," Presentation at the Carney Institute Policy Series, March 30, 2014. Victimization at school, Bureau of Economic Analysis (top.gov), using the National Crime Victimization Survey Victimization Analysis Tool.



Pinker & Mack (2014)

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

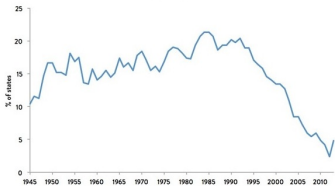
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

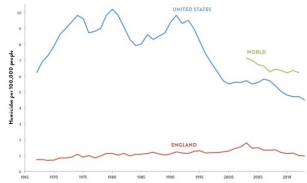
The Future

**PREVALENCE OF MASS KILLINGS
1945-2013**



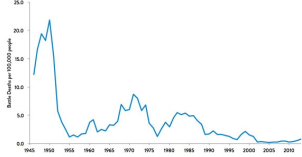
Source: Early Warning Project, <https://earlywarning.worldpress.com/>; Uffelder, Jay and Valentino, Benjamin, "Assessing Risks of State-Sponsored Mass Killing" (Feb. 1, 2006). Available at SSRN: <http://dx.doi.org/10.2139/ssrn.1034426>

**HOMICIDE RATES IN THE US AND ENGLAND
1967-2013, AND THE WORLD, 2003-2012**



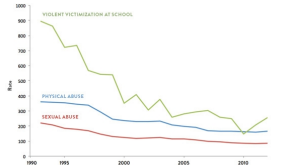
Sources: U.S. FBI Uniform Crime Reports, England (including Wales) U.K. Office for National Statistics, World U.N. Office on Drugs and Crime, reported in U.N. Economic and Social Council's World Crime Trends and Emerging Issues and Responses in the Field of Crime Prevention and Social Justice", Feb. 12, 2004, Figure 1. The percentages were converted to homicide rates by setting the 2012 rate at 6.2, the figure reported in the UNODC Global Study on Homicide 2013, Page 12.

**RATE OF BATTLE DEATHS IN ARMED CONFLICTS
1946-2013**



Source: Uppsala Conflict Data Program Battle-Related Deaths Dataset v5-2014, 1999-2013, "Best Estimates" Missing estimate for 2013 for the Syria civil war calculated from a revised ICDIP "Low Estimate" and a "High Estimate" from the Peace Research Institute Oslo (both obtained in consultation with Erik Meisler of ICDIP, The "High Estimate" is for May 2013-April 2014, rather than calendar year 2013, and comes from Page 9 of H. Price, A. Gendoo, & P. East, "Underestimated: Global Analysis of Documentation of Killings in the Syria Arab Republic," Human Rights Data Analysis Group, http://www.hrdag.org/Documents/Countries/SY/HRDAG_GlobalReportAug2014.pdf. World population figures from U.S. Census Bureau, http://www.census.gov/population/international/data/worldpop/stable_population.php

**VICTIMIZATION OF CHILDREN IN THE US
1990-2012**



Rates for physical and sexual abuse are per 100,000 children younger than 18. Rates for violent victimization at school are per 10,000 children age 12-17.

Sources: Physical and sexual abuse, National Child Abuse and Neglect Data System, analyzed by David Brothman, 2014. in "Trends in Child Welfare," Presentation at the Carney Institute Policy Series, March 30, 2014. Victimization at school, Bureau of Economic Analysis (top.gov), using the National Crime Victimization Survey Victimization Analysis Tool.



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

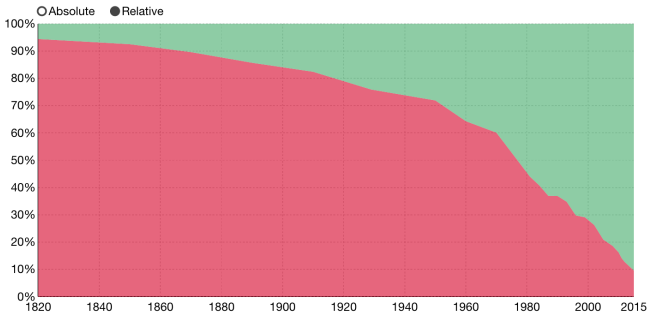
- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

World population living in extreme poverty, 1820 to 2015



Share of people living in extreme poverty (red) Share of people not in extreme poverty (green)



Data source: World Poverty in absolute numbers (Max Roser based on World Bank and Bourguignon and Morrisson (2002))



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

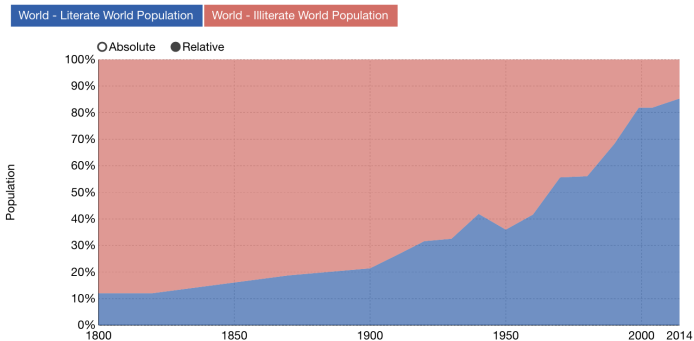
- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

Literate and illiterate world population, 1800 to 2014



Data source: Literate World Population (Our World In Data based on OECD and UNESCO)



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

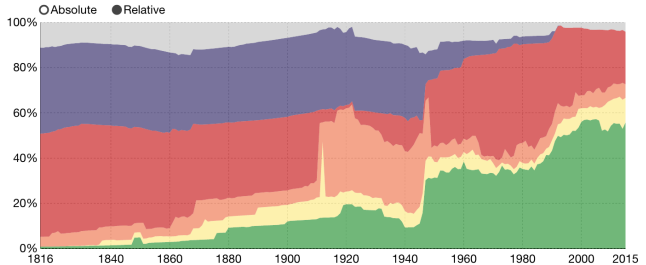
- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

Number of world citizens living under different political regimes



The Polity IV score captures the type of political regime for each country on a range from -10 (full autocracy) to +10 (full democracy). Regimes that fall into the middle of this spectrum are called anocracies.



Data source: World Population by Political Regime they live in (by Our World In Data)



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

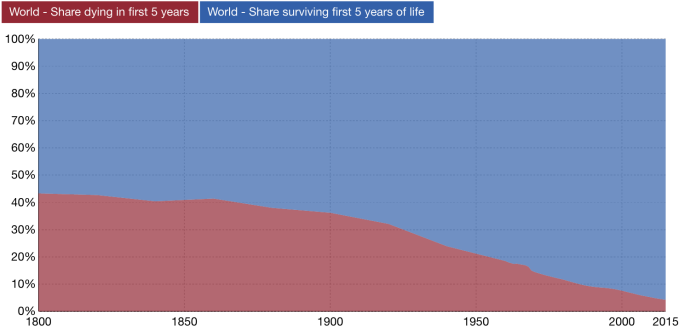
Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future

Global child mortality, 1800 to 2015

Share of the world population dying and surviving the first 5 years of life.



Data source: Global child mortality (since 1800) based on Gapminder and World Bank



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

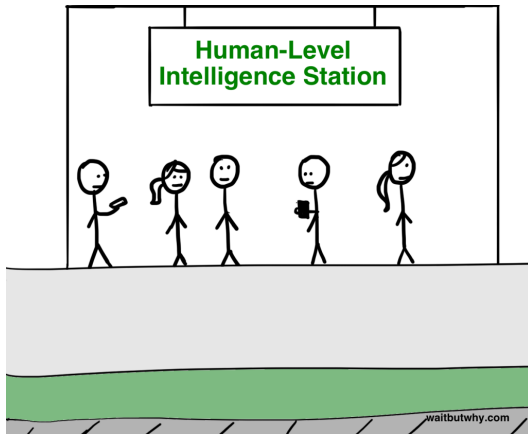
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

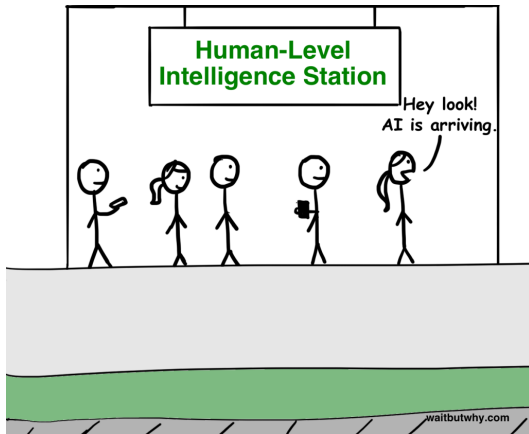
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

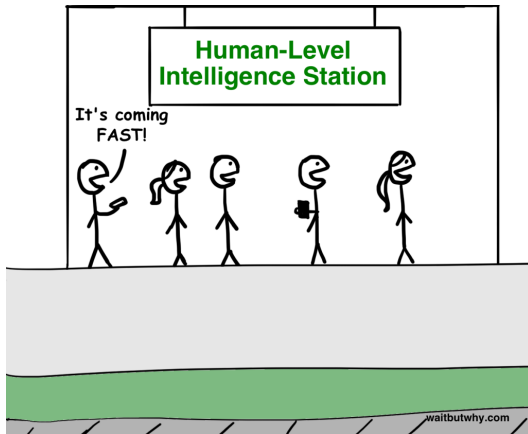
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

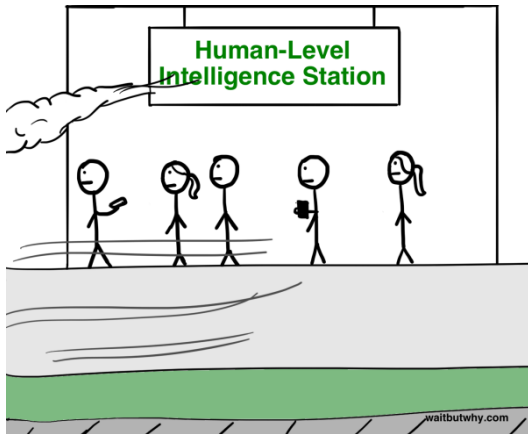
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Deep Learning

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

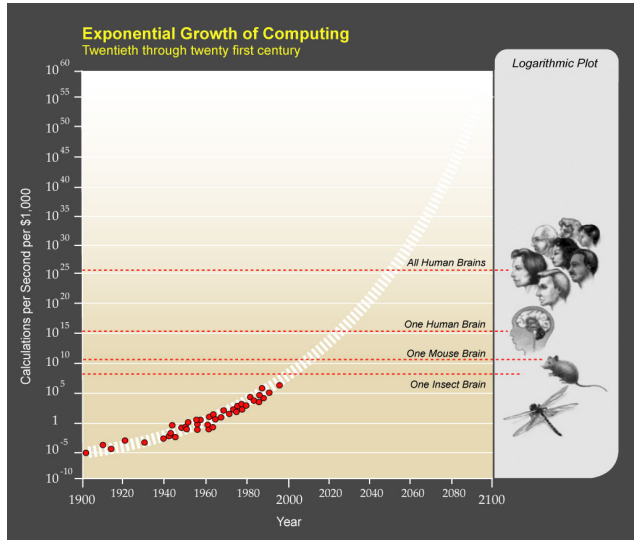
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Deep Learning

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

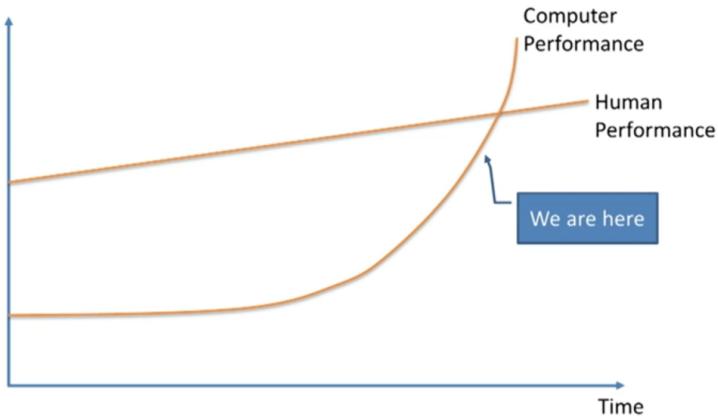
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



Deep Learning

Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

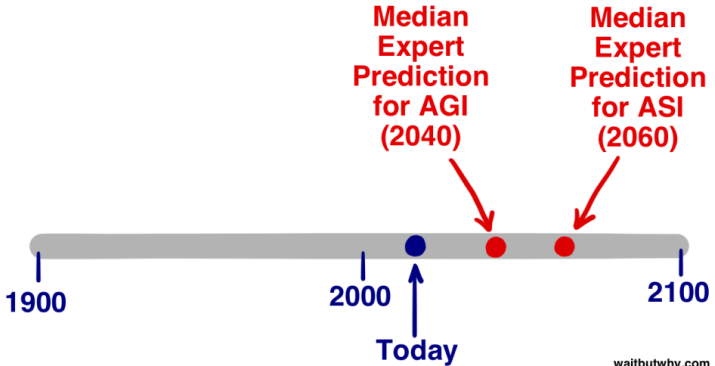
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



waitbutwhy.com



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

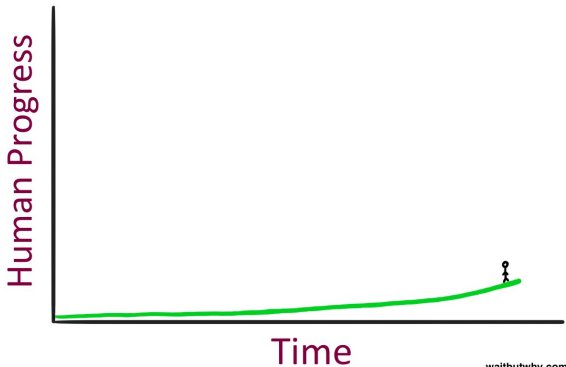
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



waitbutwhy.com



Antecedents

- Tech Velocity
- Vision Case Study
- Machine Intelligence

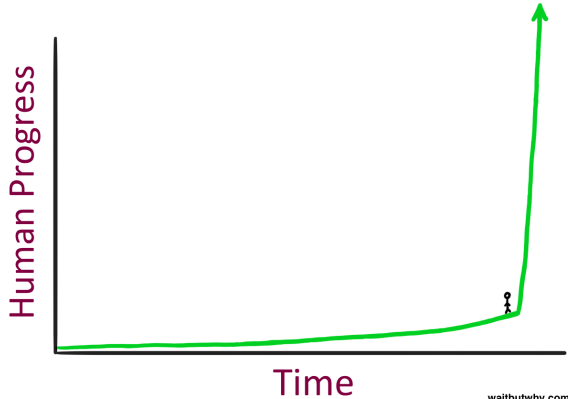
Theory

- Neural Units
- Neural Nets
- Deep Neural Nets

Application

- ConvNets
- LSTMs
- untapt
- Reinforcement
- Building Blocks

The Future



waitbutwhy.com

