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# Deep Learning Course Demo

## The Fundamentals of Deep Learning, with Applications

Dr. Jon Krohn

[jon@untapt.com](mailto:jon@untapt.com)

Slides available at [jonkrohn.com/talks](http://jonkrohn.com/talks)

September 27th, 2017

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nycdatascience.com/courses/deep-learning/

## Syllabus

### Unit 1: The Unreasonable Effectiveness of Deep Learning

- An Introduction to Neural Networks and Deep Learning
- Course Survey
- Interactive Visualization of an Artificial Neural Network
- Hardware Options for Deep Learning, including How to Build a Deep Learning Server
- Running a TensorFlow Jupyter Notebook within a Docker Container
- A Shallow Artificial Neural Network

### Unit 2: How Deep Learning Works

- Essential Theory I: Neural Units
- Interactive Visualization of Neural Units
- Essential Theory II: Cost Functions, Gradient Descent, and Backpropagation
- Interactive Visualization of a Deep Neural Network
- An Intermediate Neural Network
- Data Sets for Deep Learning
- **Your Deep Learning Project: Ideating**

### Unit 3: Building and Training a Deep Learning Network

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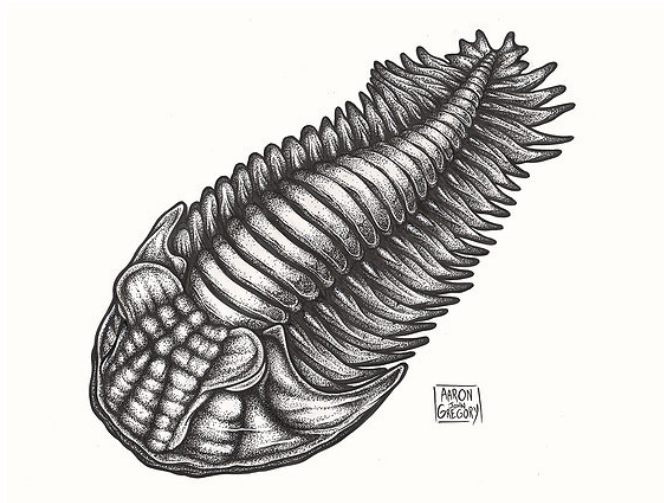
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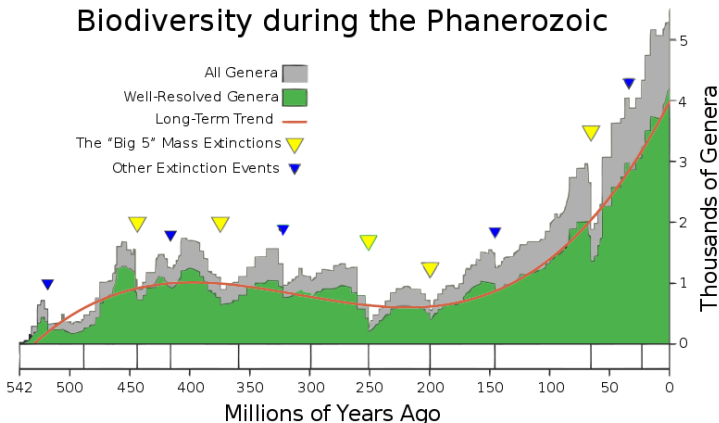
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# Biodiversity during the Phanerozoic



# Hubel & Wiesel (1959)

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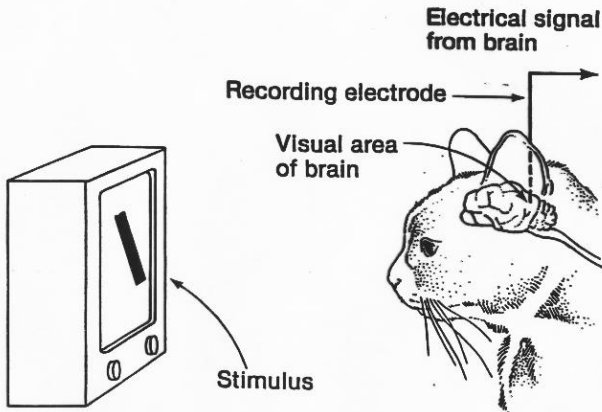
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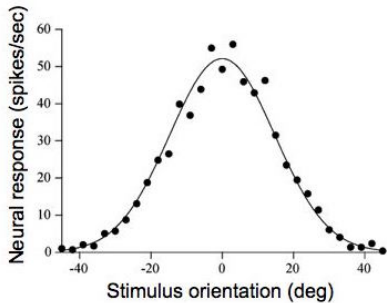
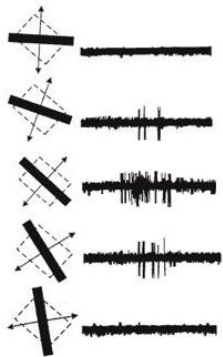
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Hubel & Wiesel, 1968

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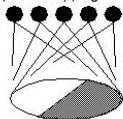
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topographical mapping



hyper-complex cells



complex cells



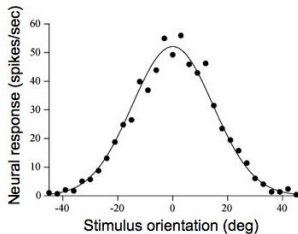
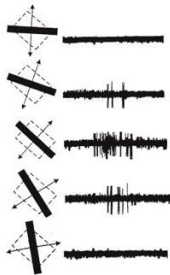
simple cells



high level

mid level

low level



Hubel & Wiesel, 1968

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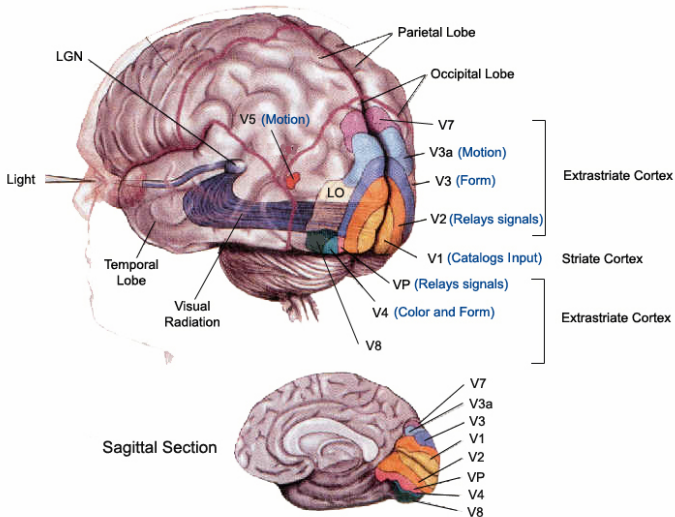
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### Visual Cortices



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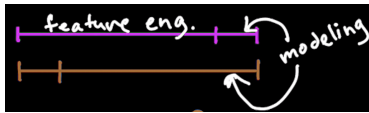
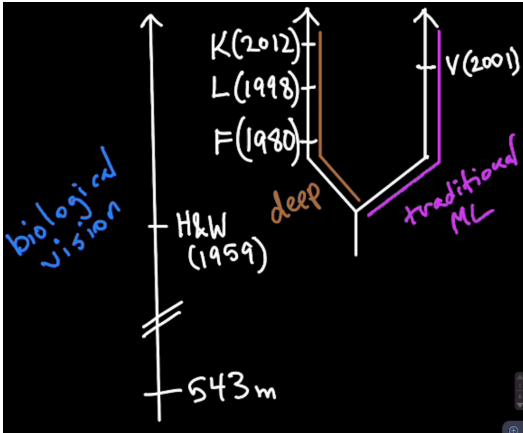
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# Neurocognitron

Fukushima (1980)

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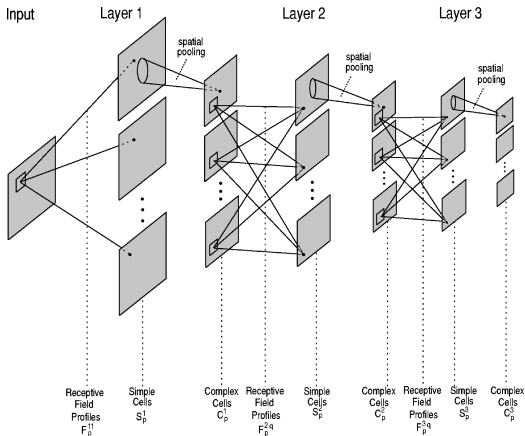
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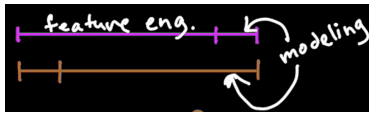
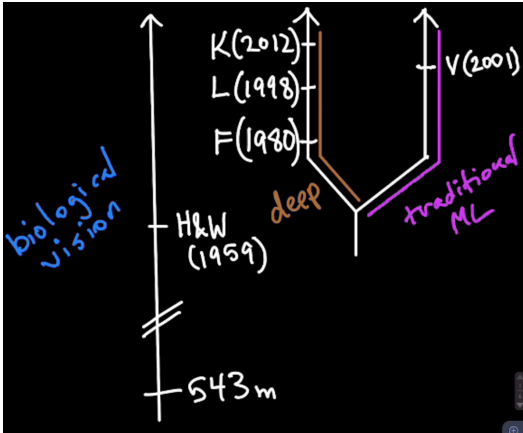
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# MNIST Digits & LeNet-5

LeCun, Boutou, Bengio & Haffner (1998)



PROC. OF THE IEEE, NOVEMBER 1998

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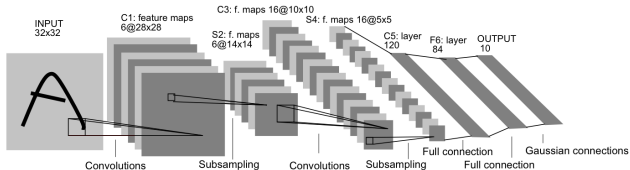


Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.

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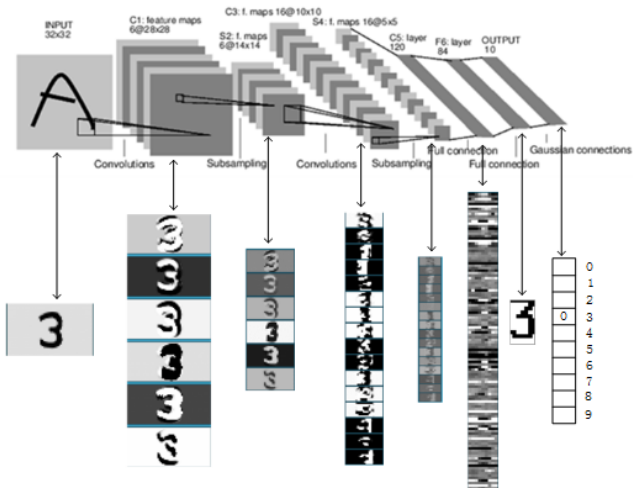
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# LeNet-5

LeCun, Boutou, Bengio & Haffner (1998)



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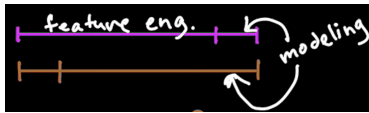
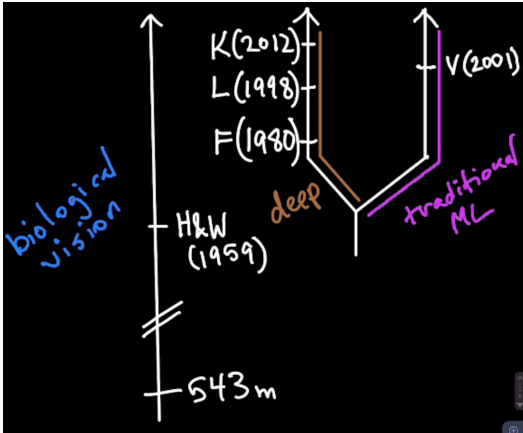
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# Viola & Jones (2001)

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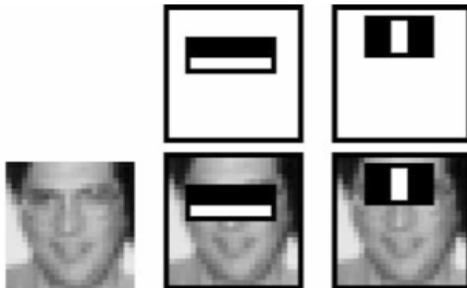
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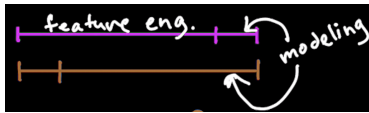
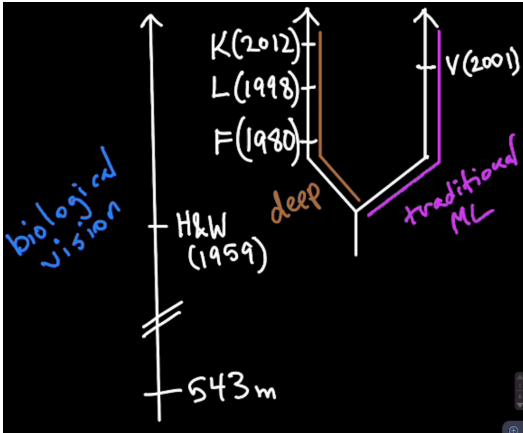
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# ImageNet

Fei-Fei Li et al. (2009), 14m images, 22k categories

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**mite                      container ship                      motor scooter                      leopard**

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



**grille                      mushroom                      cherry                      Madagascar cat**

	<p><b>convertible</b></p> <p>grille</p> <p>pickup</p> <p>beach wagon</p> <p>fire engine</p>		<p><b>agaric</b></p> <p>mushroom</p> <p>jelly fungus</p> <p>gill fungus</p> <p>dead-man's-fingers</p>		<p><b>dalmatian</b></p> <p>grape</p> <p>elderberry</p> <p>ffordshire bullterrier</p> <p>currant</p>		<p><b>squirrel monkey</b></p> <p>spider monkey</p> <p>titi</p> <p>indri</p> <p>howler monkey</p>
--	---	--	---	--	---	--	--

# ImageNet Classification Error

ILSVRC: 1.4m, 1k object classes

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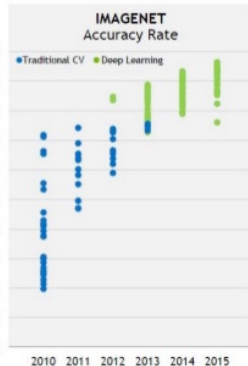
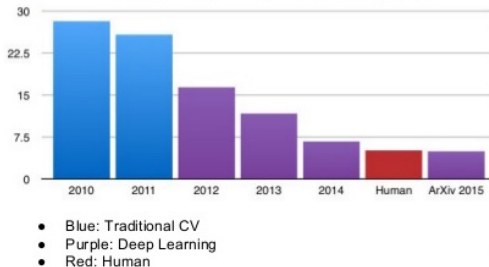
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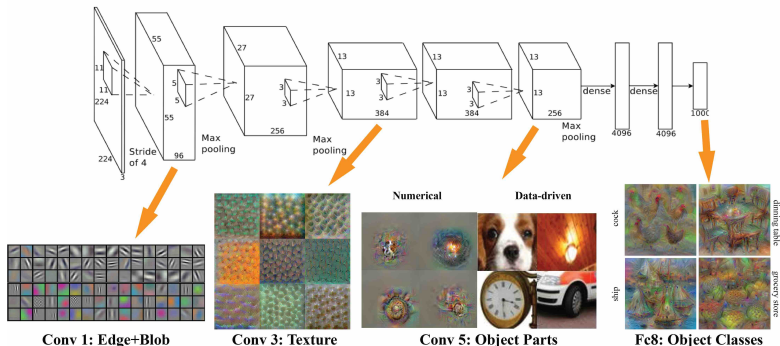
ILSVRC top-5 error on ImageNet





# AlexNet

Krizhevsky, Sutskever & Hinton (2012)



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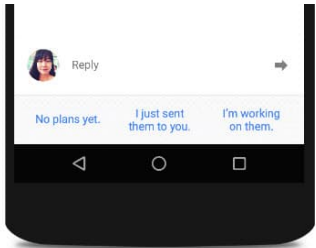
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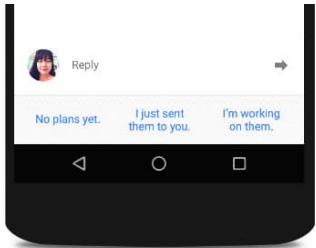


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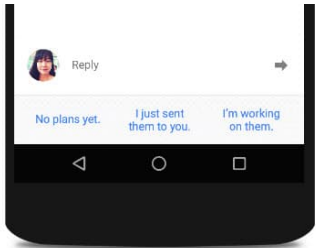


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[TensorFlow Playground]

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- local machine
- (Tesla K80) cloud instance
- (GTX 1080ti) monster box

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# Jupyter Notebooks

+ Docker + Nvidia GPU + TensorFlow

[Dockerfile]

[notebook server]

# A Shallow Neural Network

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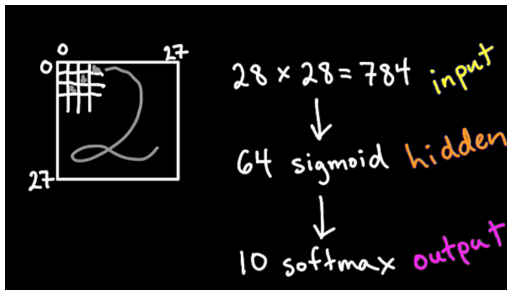
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[shallow notebook]

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# Essential Theory I

## Neural Units

[“whiteboarding”]

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# Essential Theory II

## Cost Functions, Gradient Descent, and Backpropagation

["whiteboarding"]



# An Intermediate Neural Network

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[intermediate notebook]

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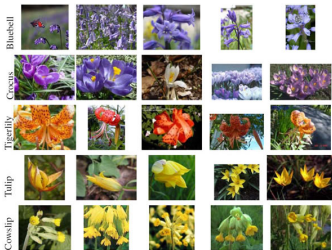
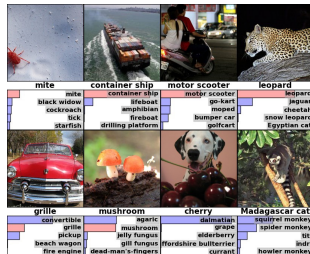
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Dataset	Classes	Train Samples
AG's News	4	120,000
Sogou News	5	450,000
DBpedia	14	560,000
Yelp Review Polarity	2	560,000
Yelp Review Full	5	650,000
Yahoo! Answers	10	1,400,000
Amazon Review Full	5	3,000,000
Amazon Review Polarity	2	3,600,000

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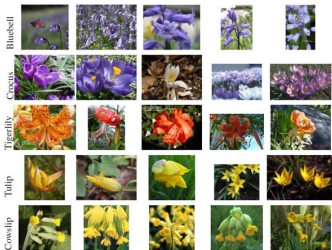
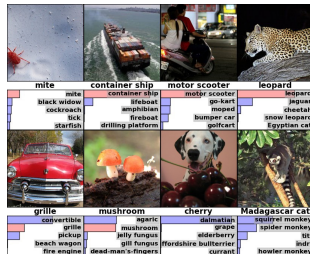
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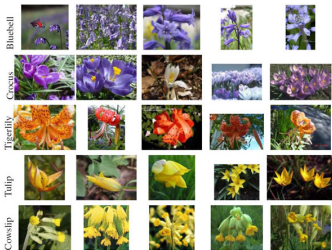
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Contact

**Open Data Sources**

To train a powerful model, the larger the data set, the better -- if it's well-organised and open, that's ideal. The following repositories are standouts that meet all these criteria:

- [Data.gov](#) (home of >150k US government-related datasets),
- [Govcode](#), a collection of government open source projects,
- the [Open Data Stack Exchange](#), and
- this curated list of 'awesome' [public datasets](#)
- this well-annotated list of [data sets for natural language processing](#)
- for biomedical and health data specifically, check out:
  - this [University of Minnesota](#) resource
  - this [Medical Data for Machine Learning](#) GitHub repo

For machine learning models that require a *lot* of *labelled* data, check out:

- [UC Irvine's repository](#)
- Yahoo's massive 13TB [data set](#) comprised of 100 billion user interactions with news items
- Google's [image](#) and [video](#) data sets
- Luke de Oliveira's [Greatest Public Datasets for AI](#) blog post
- CrowdFlower's [Data for Everyone](#)

Finally, here are extensive pages on importing data from the Web into R, provided by [CRAN](#) and [MRAN](#).

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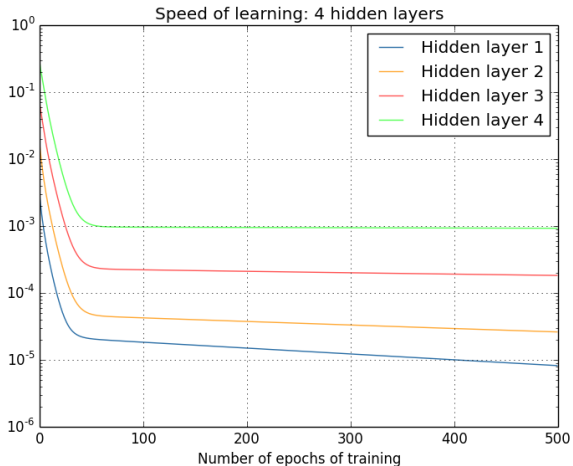
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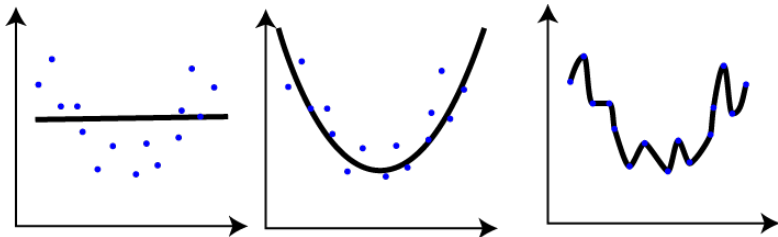
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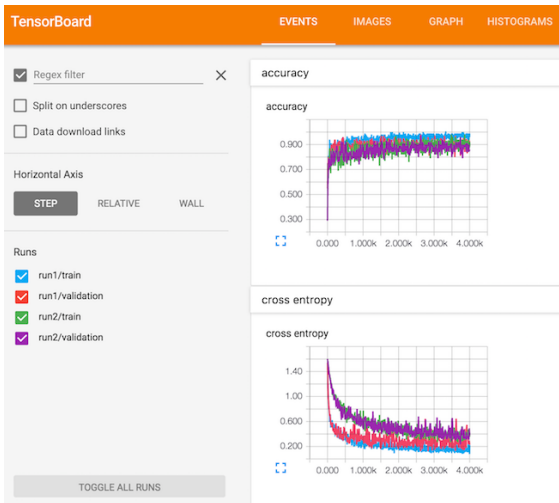
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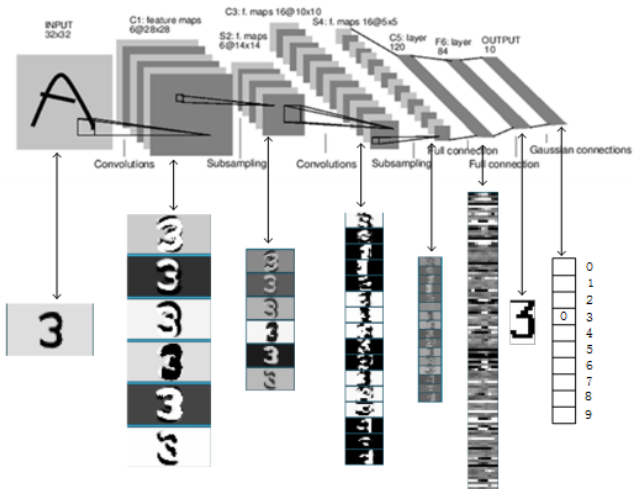
# Intro to ConvNets

## for Visual Recognition

[deepvis]

# LeNet-5

## Classic ConvNet Architecture I



[notebook]

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# AlexNet

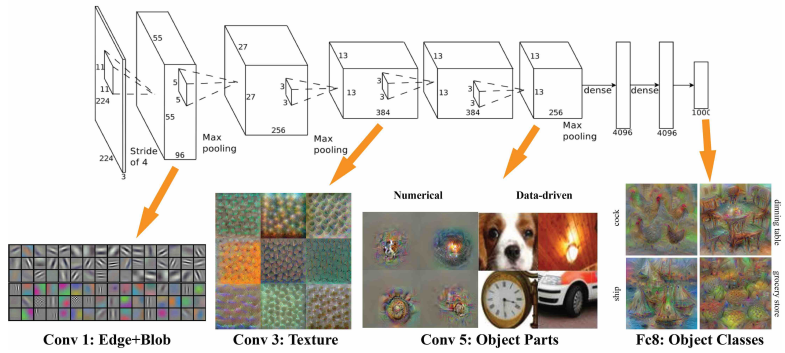
## Classic ConvNet Architecture II

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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

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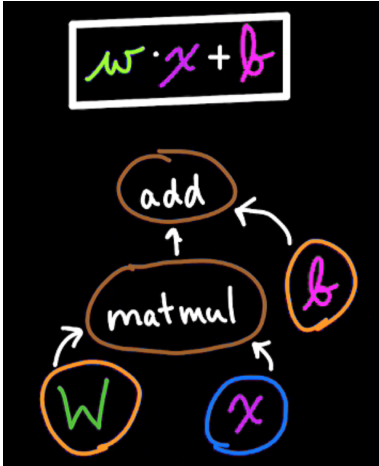
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	Caffe	Torch	Theano	TensorFlow
<i>language</i>	Python, C++	Lua, <u>PyTorch</u>	Python	Python, Java, C, Go
<i>pre-trained models</i>	Model Zoo	ModelZoo	Lasagne	Inception, others
<i>parallel GPUs: data</i>	Yes	Yes	Yes	Yes
<i>parallel GPUs: model</i>		Yes		Yes
<i>source code</i>	Readable	Readable		
<i>for RNNs</i>			Good	Best
<i>high-level APIs</i>			Keras	Keras, TFLearn

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...in lenet\_in\_keras.ipynb:

```
model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3), activation='relu', input_shape=(28, 28, 1)))
model.add(Conv2D(64, kernel_size=(3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(n_classes, activation='softmax'))
```

...in lenet\_in\_tensorflow.ipynb:

```
# max pooling layer:
pool_size = 2
mp_layer_dropout = 0.25

# dense layer:
n_dense = 128
dense_layer_dropout = 0.5

# convolutional and max-pooling layers:
conv_1 = conv2d(square_x, weights['W_c1'], biases['b_c1'])
conv_2 = conv2d(conv_1, weights['W_c2'], biases['b_c2'])
pool_1 = maxpooling2d(conv_2, mp_size)
pool_1 = tf.nn.dropout(pool_1, 1-mp_dropout)

# dense layer:
flat = tf.reshape(pool_1, [-1, weights['W_d1'].get_shape().as_list()[0]])
dense_1 = dense(flat, weights['W_d1'], biases['b_d1'])
dense_1 = tf.nn.dropout(dense_1, 1-dense_dropout)
```

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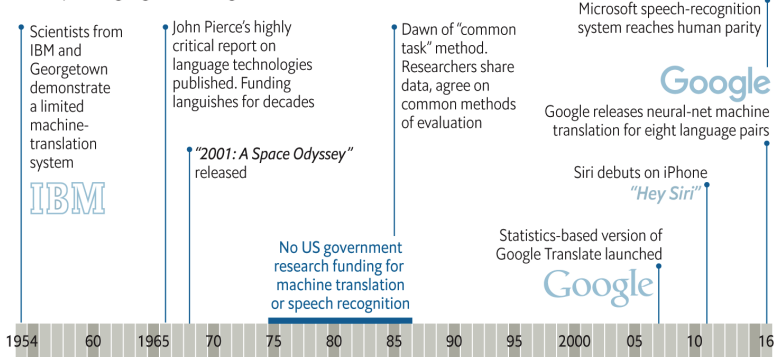
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### A history of language technologies



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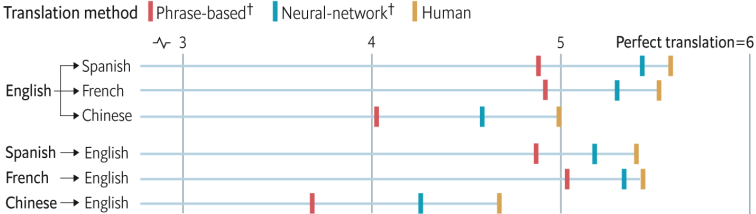
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TNT. GRIP

We see H pull a book from a shelf, flip through it while speaking, and then put it back.

H

In a future with mass unemployment, young people are forced to sell blood. That's the first thing I can do.

H2

You should see the boys and shut up. I was the one who was going to be a hundred years old.

H

I saw him again. The way you were sent to me... that was a big honest idea. I am not a bright light.

C

Well, I have to go to the skull. I don't know.

He picks up a light screen and fights the security forces of the particles of a transmission on his face.

H

(continuing)  
What do you mean?

C

(smiling)  
I don't know anything about any of this.

H

(to Hank, taking his eyes from his mouth)  
Then what?

H2

There's no answer.

C

(frowning)  
We're going to see the money.

H

(reading)  
"All right," you can't tell me that."

steps back. coffee is still going through.

I was coming to that thing because you were so pretty.

H

I don't know. I don't know what you're talking about.

C

That's right.

H

So what are you doing?

H2

I don't want to be honest with you.

H

He looks at him for a moment, then smiles at him.

H

You don't have to be a doctor.

H2

I am not sure. I don't know what you're talking about.

H

I want to see you too.

H2

What do you mean?

H

I'm sorry, but I'm sure you wouldn't even touch me.

H2

I don't know what you're talking about.

H

The principle is completely contrived for the same time.

H2

(smiling)  
It was all about you to be true.

H

You didn't even see the movie with the rest of the team.

H2

I don't know.

H

I don't care.

H2

I know that it's a consequence. Whatever you want to know about the presence of the story, I'm a little bit of a boy on the floor.

H

I don't know. I just have to ask you to explain to me what you say.

H2

What do you mean?

H

Because I don't know what you're talking about.

H2

That was all the time.

H

I know that.

H2

I don't know.

H

(angry)  
It would be a good time. I think I could have been my life.

He starts to shake.

H

(COMTE)  
It may never be forgiven, but that is just too bad. I have to leave, but I'm not free of the world.

H

Yes. Perhaps I should take it from here. I'm not going to do something.

H

You can't afford to take this anywhere. It's not a dream. But I've got a good time to stay there.

C

Well, I think you can still be back on the table.

H

Man. It's a damn thing scared to say. Nothing is going to be a thing but I was the one that put on this rock with a child and then I left the other two.

He is standing in the stairs and sitting on the floor. He takes a seat on the counter and pulls the covers over to his back. He stares at it. He is on the phone. He puts the phone down from the edge of the room and puts it in his mouth. He sees a black hole in the floor leading to the man on the roof.

He comes up behind him to protect him. He is still standing next to him.

He looks through the door and the door closes. He looks at the bag from his backpack, and starts to cry.

T

Well, there's the situation with me and the light on the ship. The guy was trying to stop me. He was like a baby and he was gone. I was worried about him, but even if he would have done it all. He couldn't come any more. I didn't mean to be a virgin. I mean, he was weak. And I thought I'd change my mind. He was crazy to get it out. It was a long time ago. He was a little late. I was going to be a woman. I just wanted to tell you that I was much better than he did. I had to stop him and I couldn't even tell. I didn't want to hurt him. I'm sorry. I know I don't like him. I can go home and be on bed and I love him. So I can get him all the way one here and find the square and go to the game with him and she won't show up. Then I'll check it out. But I'm going to see him when he gets it on. He looks like he'd be through me out of his eyes. Then he said he'd go to bed with me.

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[vse 2000]

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[multi-ConvNet notebook]

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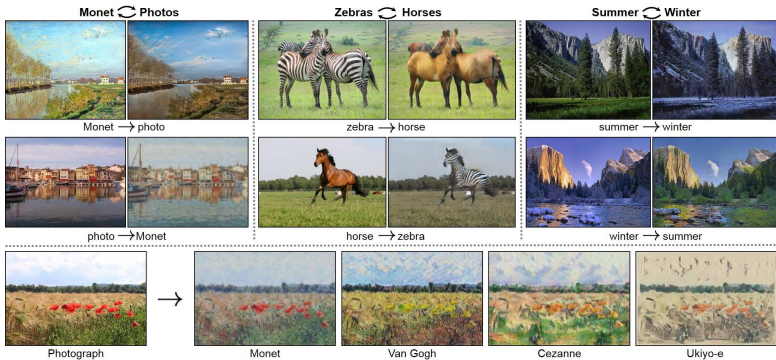
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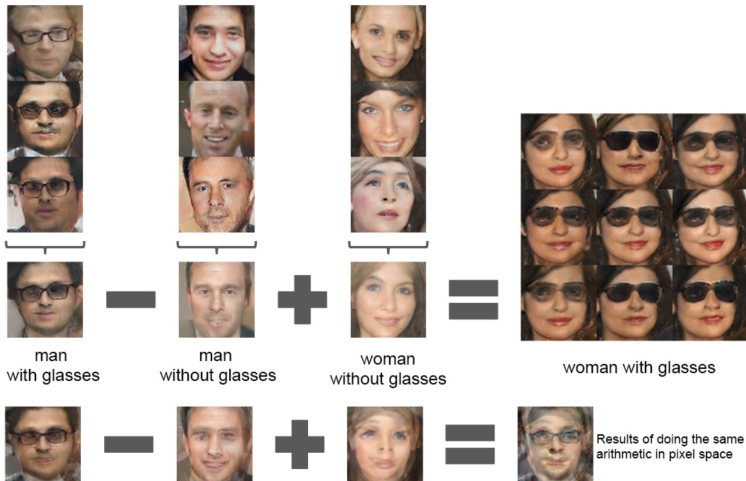
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[Quick, Draw!]

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# AlphaGO

Silver et al. (2016)



# Deep Q-Learning

Mnih et al. (2015)

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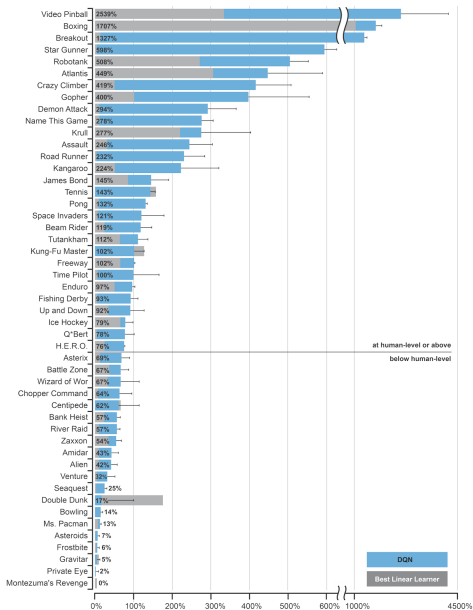
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Mnih et al. (2015)

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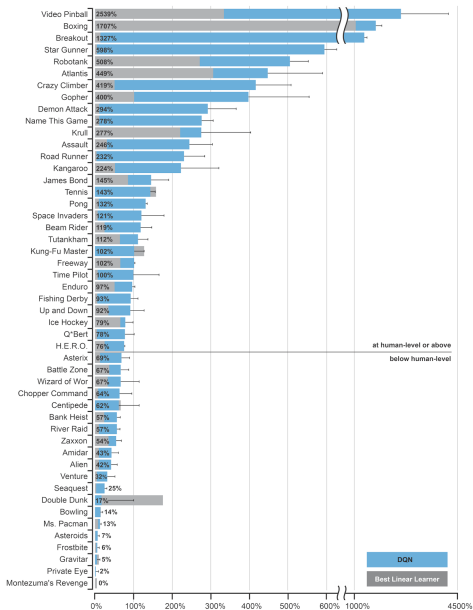
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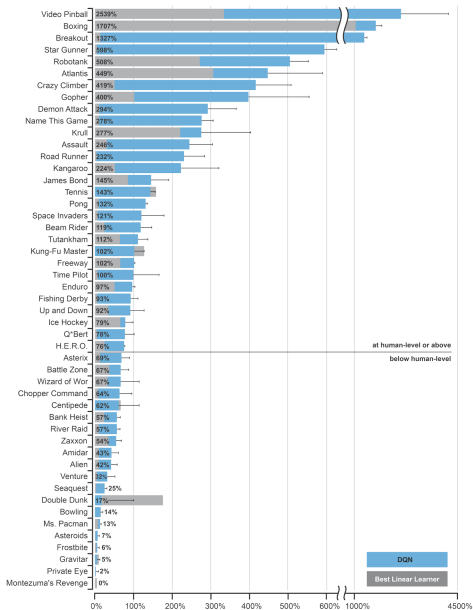
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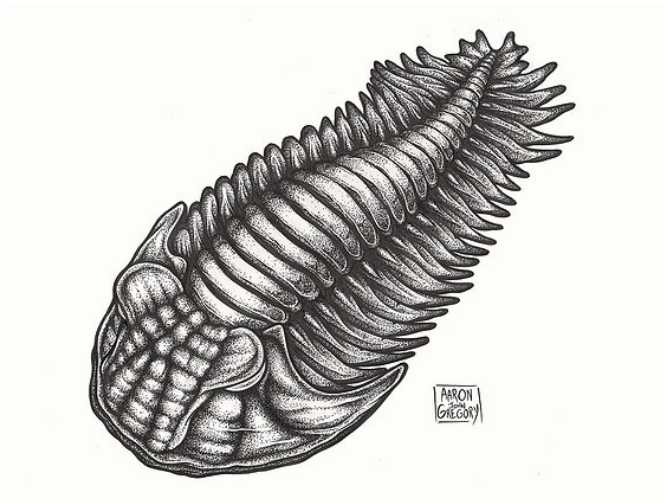
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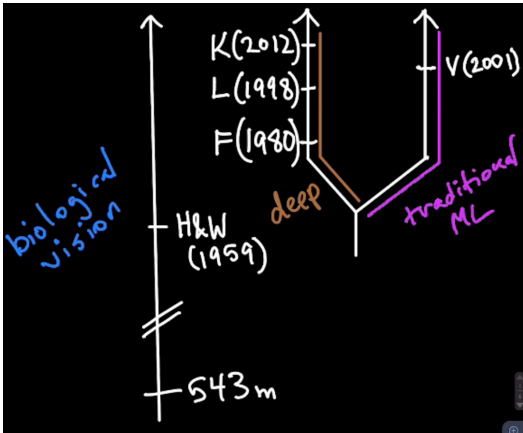
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- 3 cheap sensors appearing everywhere
- 4 Deep Learning techniques refined in academia and in industry

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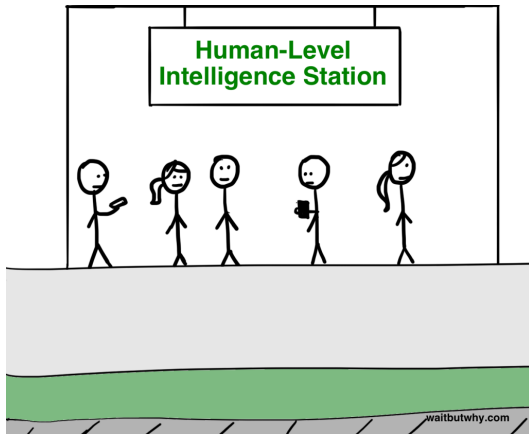
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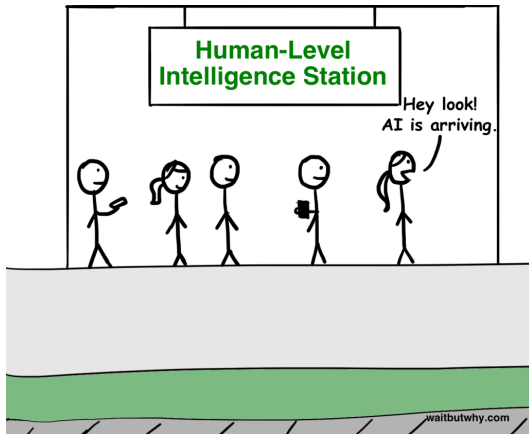
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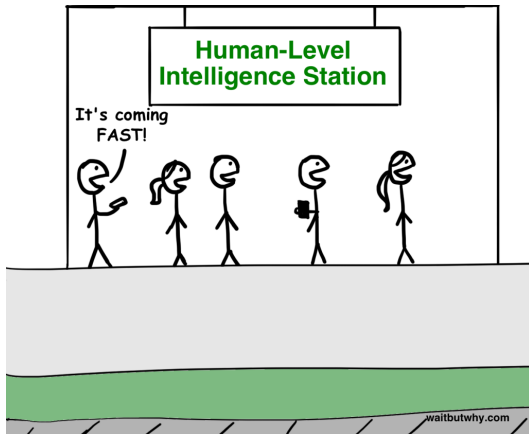
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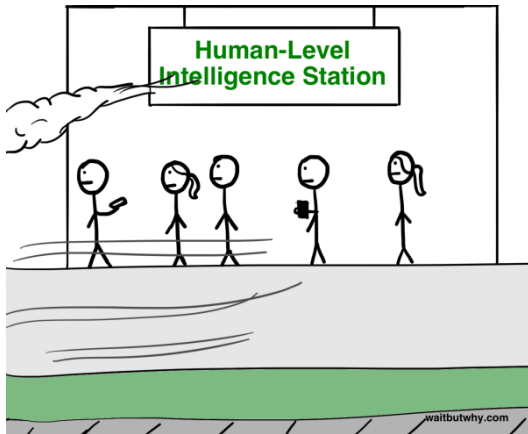
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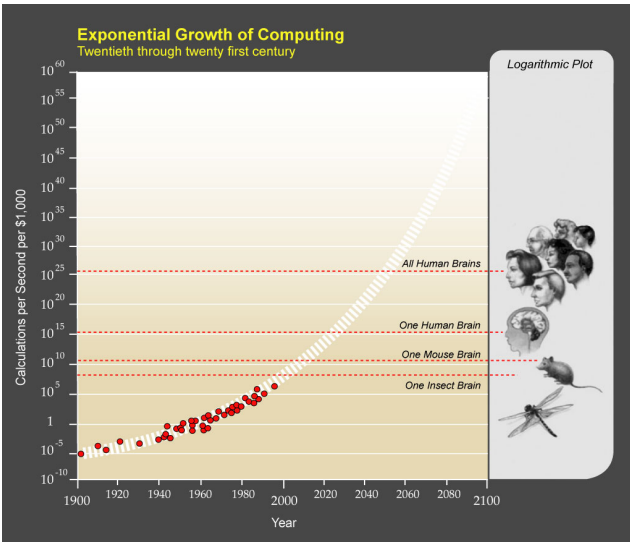
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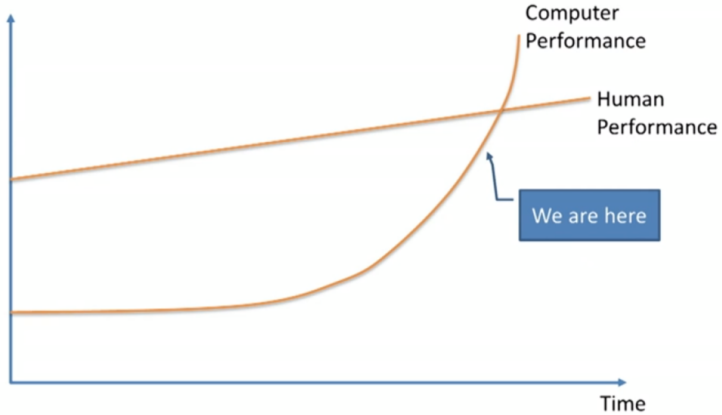
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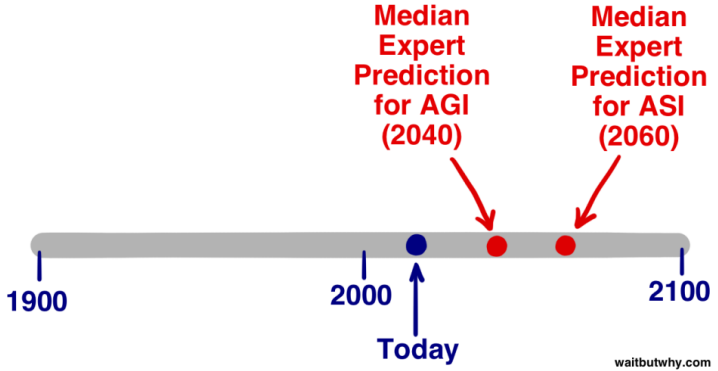
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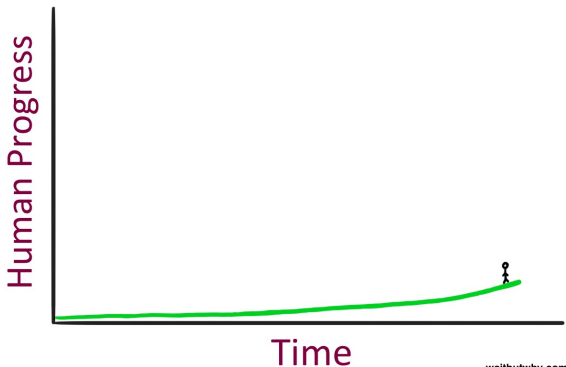
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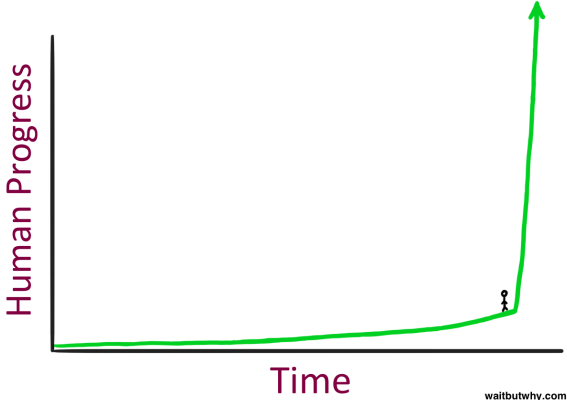
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