

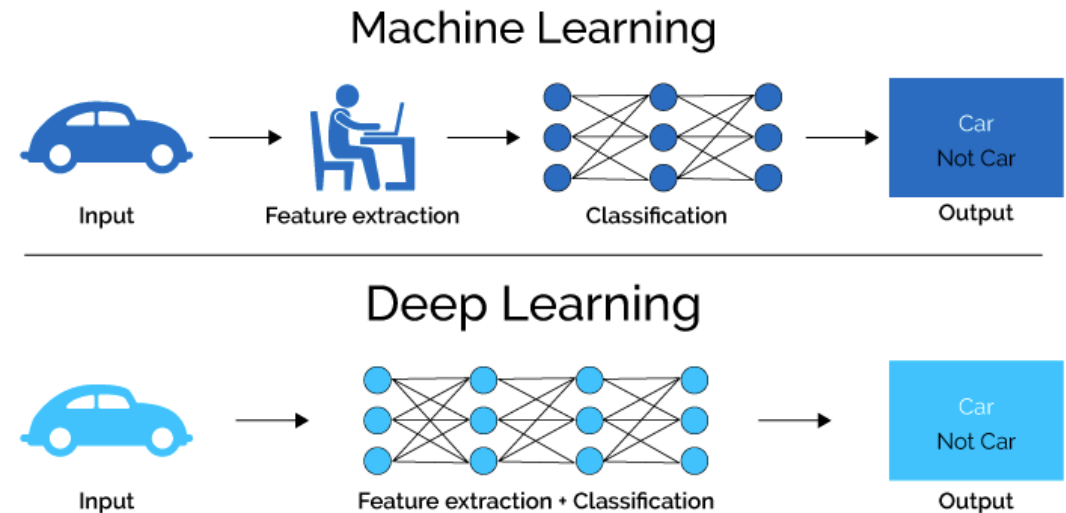
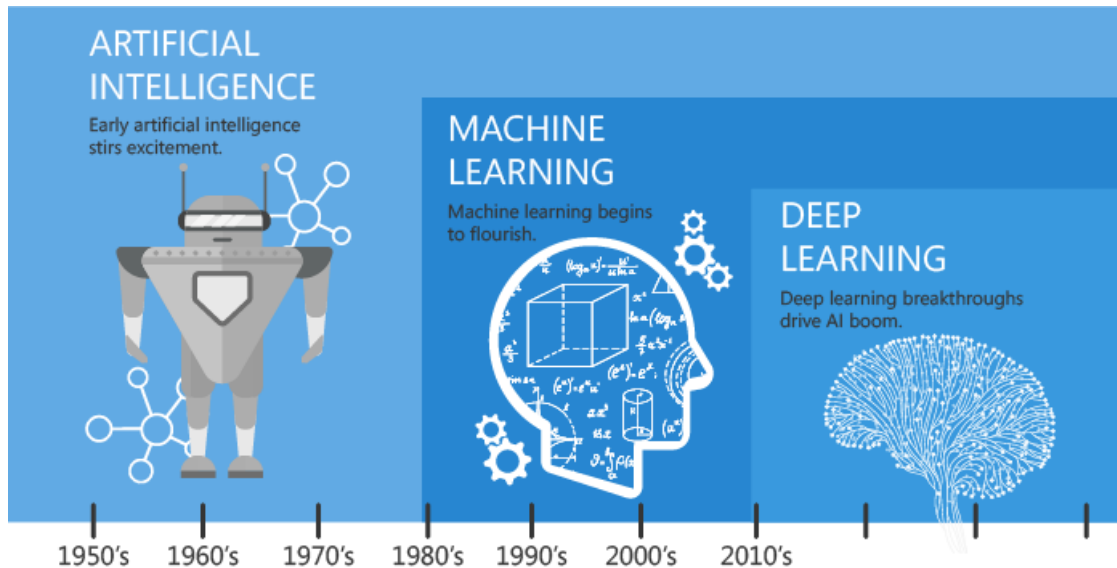
**MACHINE LEARNING DAY 2**

# **DEEP LEARNING**

## **Session I: Introduction to DL**

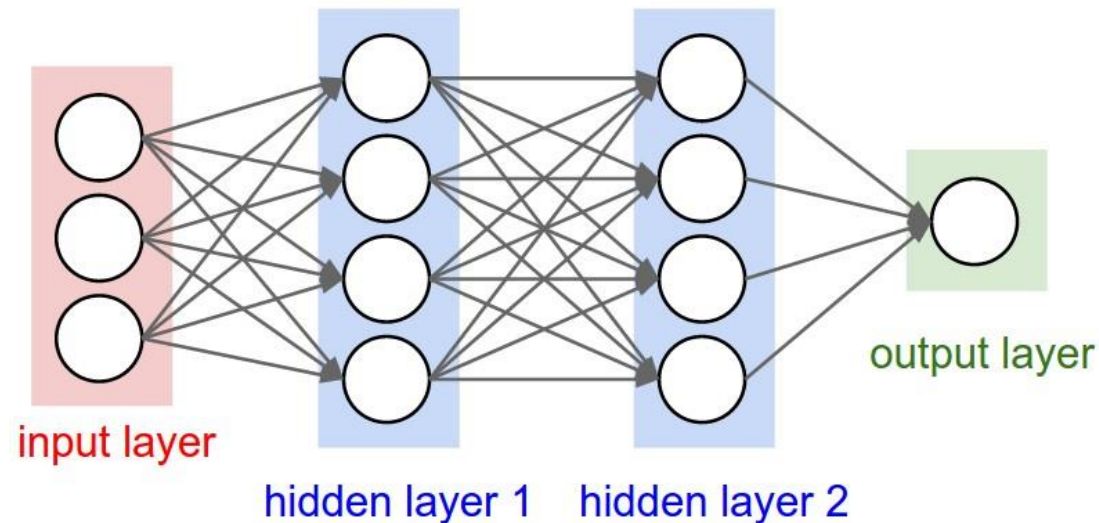
# AI / Deep Learning

Deep learning (DL) is a class of machine learning algorithms in which multiple layers of nonlinear processing units are used for feature extraction and transformation, with each successive layer taking the output from the previous layer as input.



# Deep Neural Network (DNN)

“A family of parametric, non-linear and hierarchical representation learning functions, which are massively optimized with stochastic gradient descent to encode domain knowledge, i.e. domain invariances, stationarity.” – Efstratios Gavves

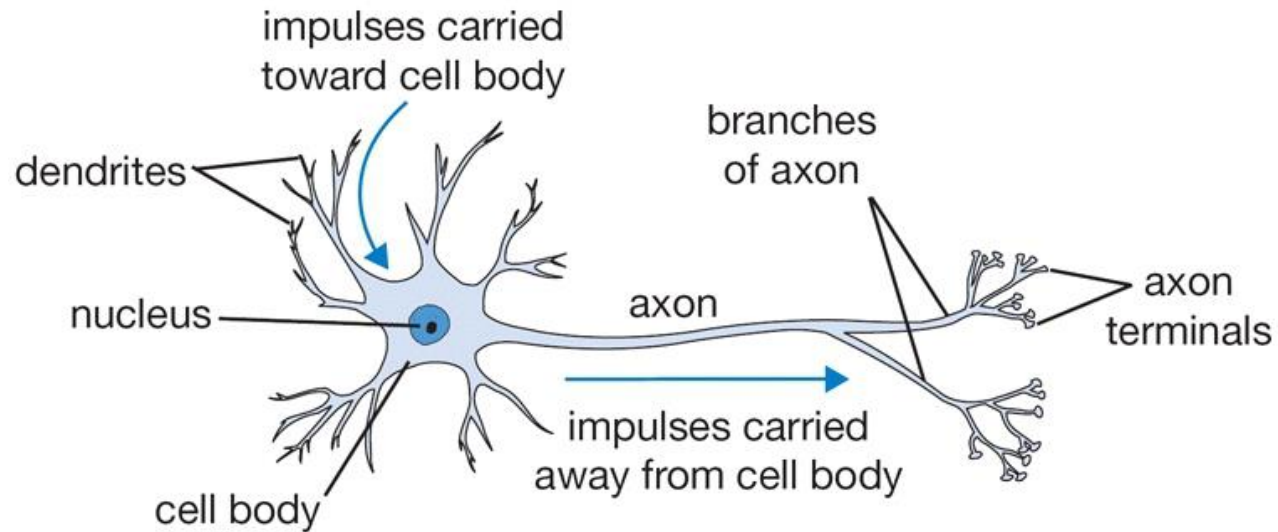


Example of a 3-layer Deep Neural Network (DNN)

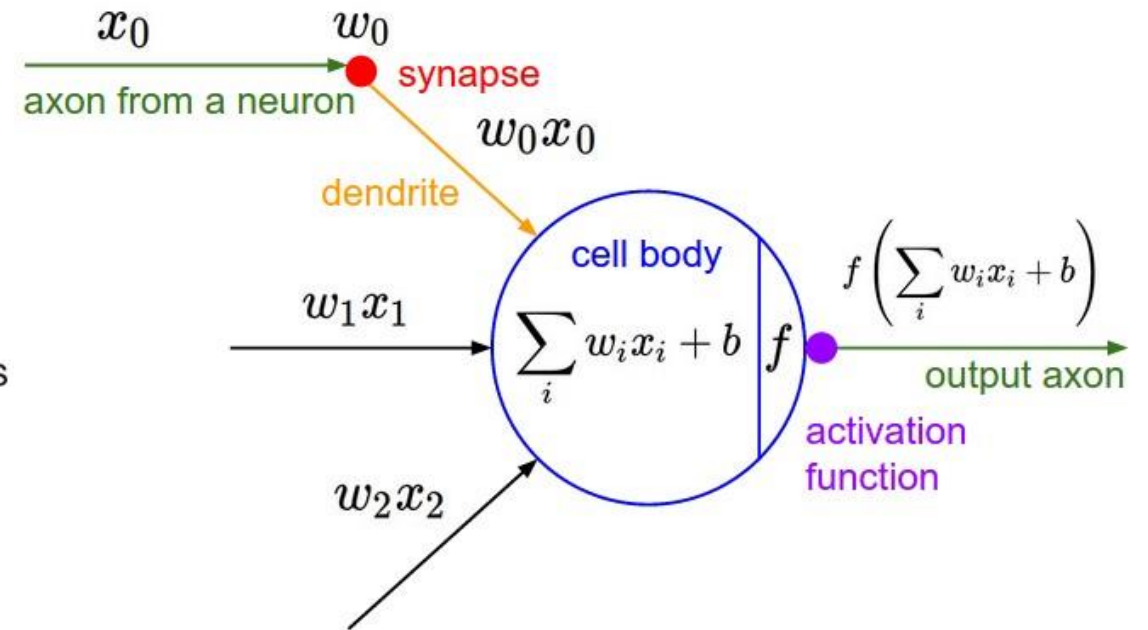
<http://cs231n.github.io/neural-networks-1/>

# Neural Network

<http://cs231n.github.io/neural-networks-1/>



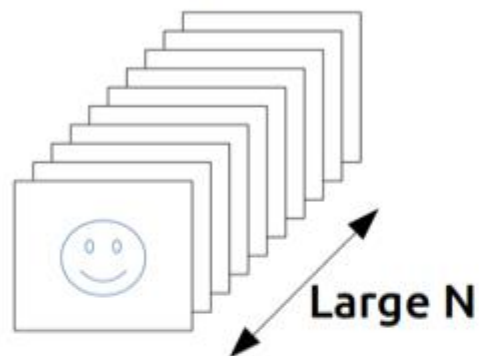
Biological neuron



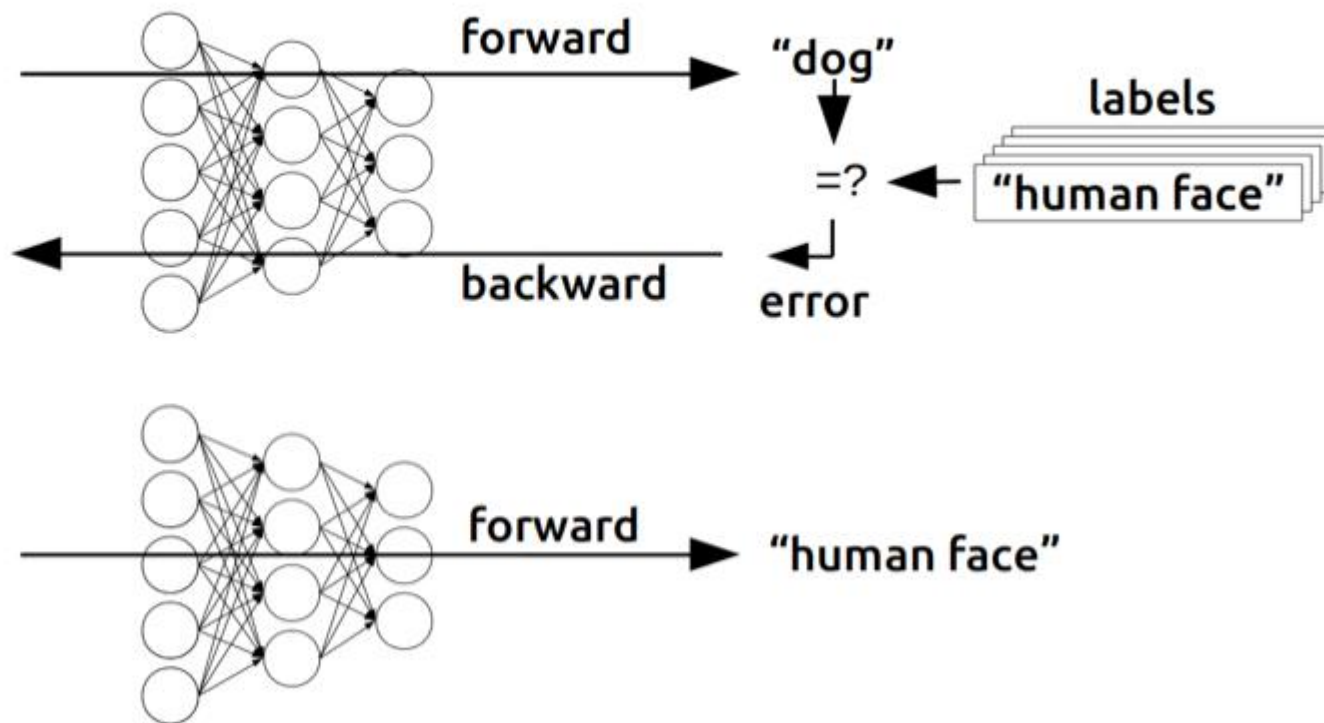
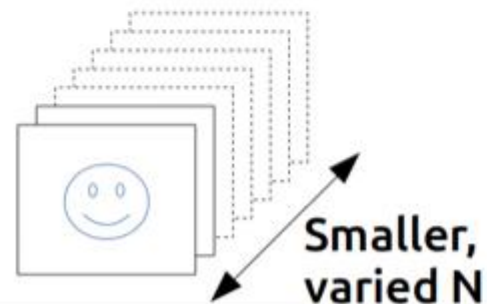
Mathematical model

# DL: Training / Inference

## Training



## Inference

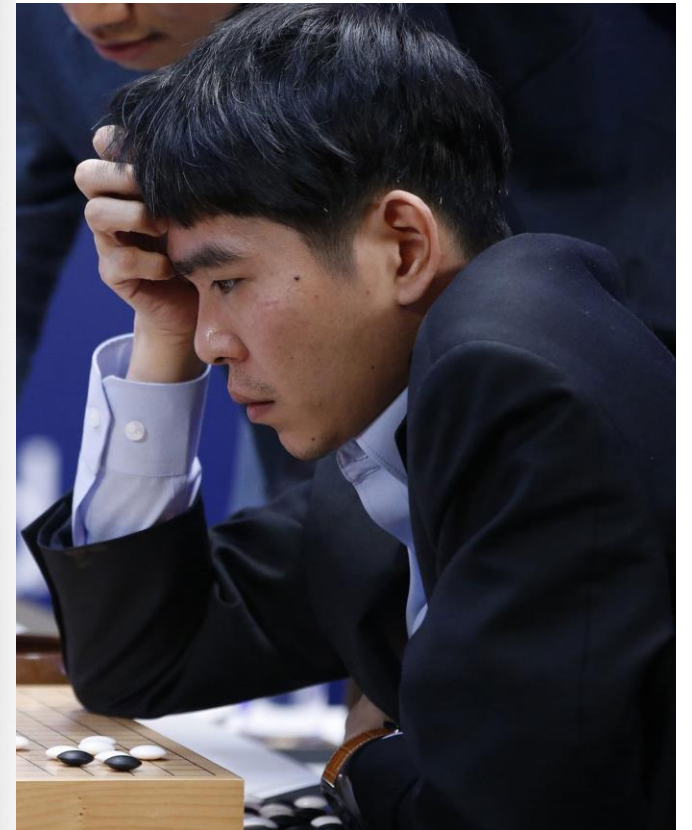
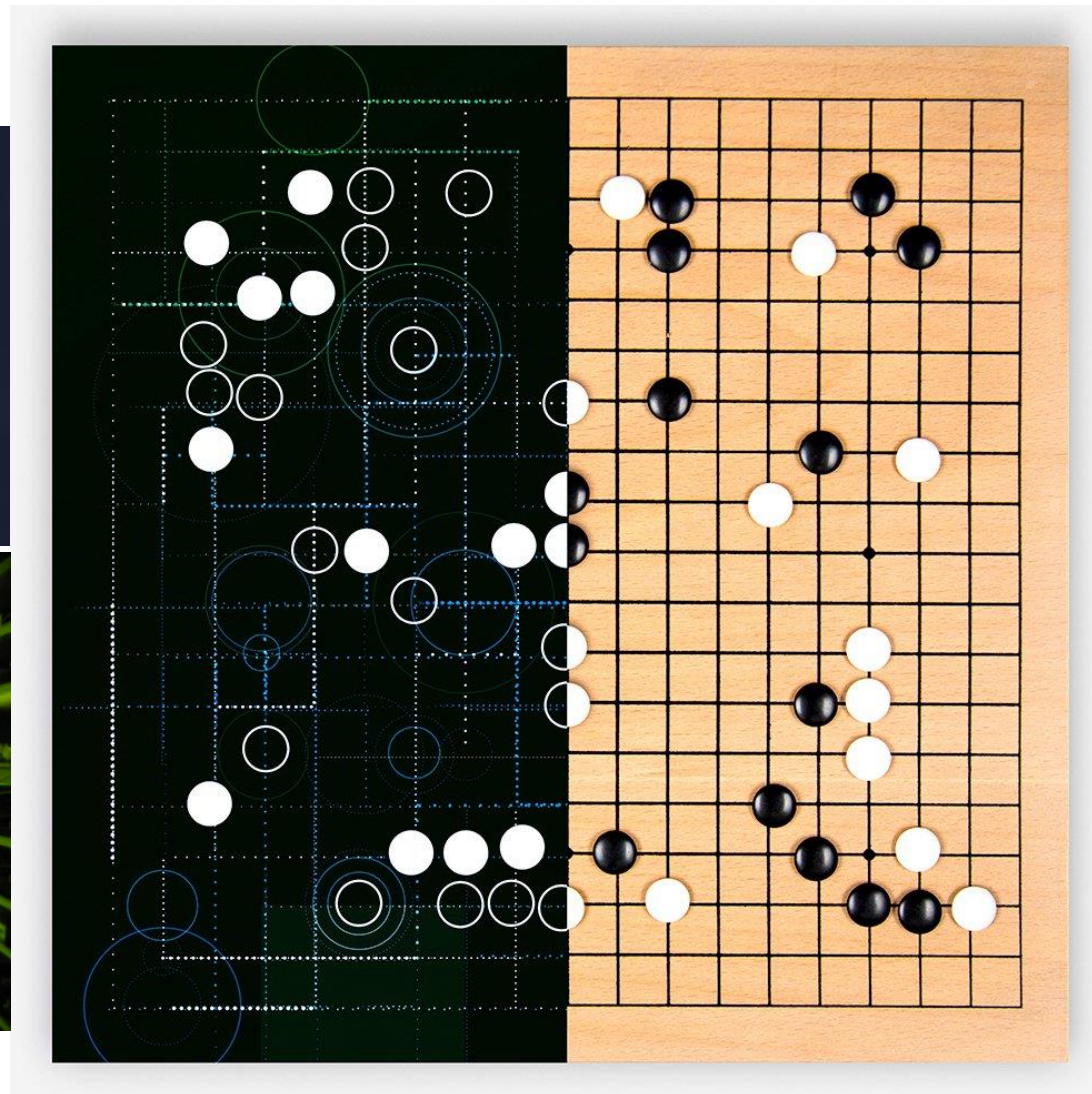


<https://devblogs.nvidia.com/inference-next-step-gpu-accelerated-deep-learning/>



DL is powering many real-world problems

# AlphaGo



<https://deepmind.com/research/case-studies/alphago-the-story-so-far>

DL is powering many real-world problems

# Image classification

## ImageNet Challenge

IMAGENET

- 1,000 object classes (categories).
- Images:
  - 1.2 M train
  - 100k test.



<https://www.image-net.org>



DL is powering many real-world problems

# Object detection

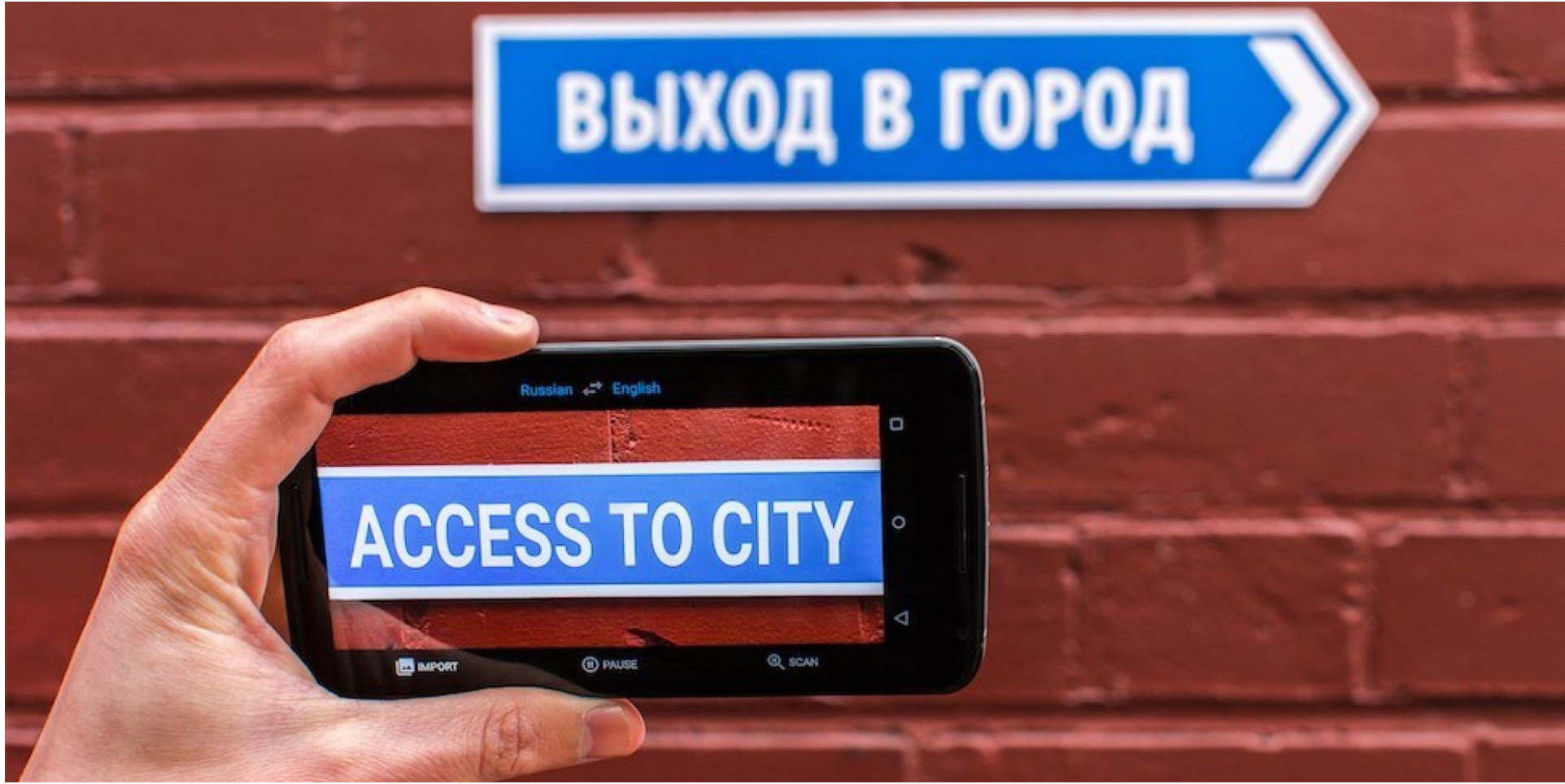


<https://www.teslarati.com/teslas-full-self-driving-capability-arrive-3-months-definitely-6-months-says-musk/>



DL is powering many real-world problems

# Language Translation



<http://didarc.com/en/news/deep-learning-mechanism>

DL is powering many real-world problems

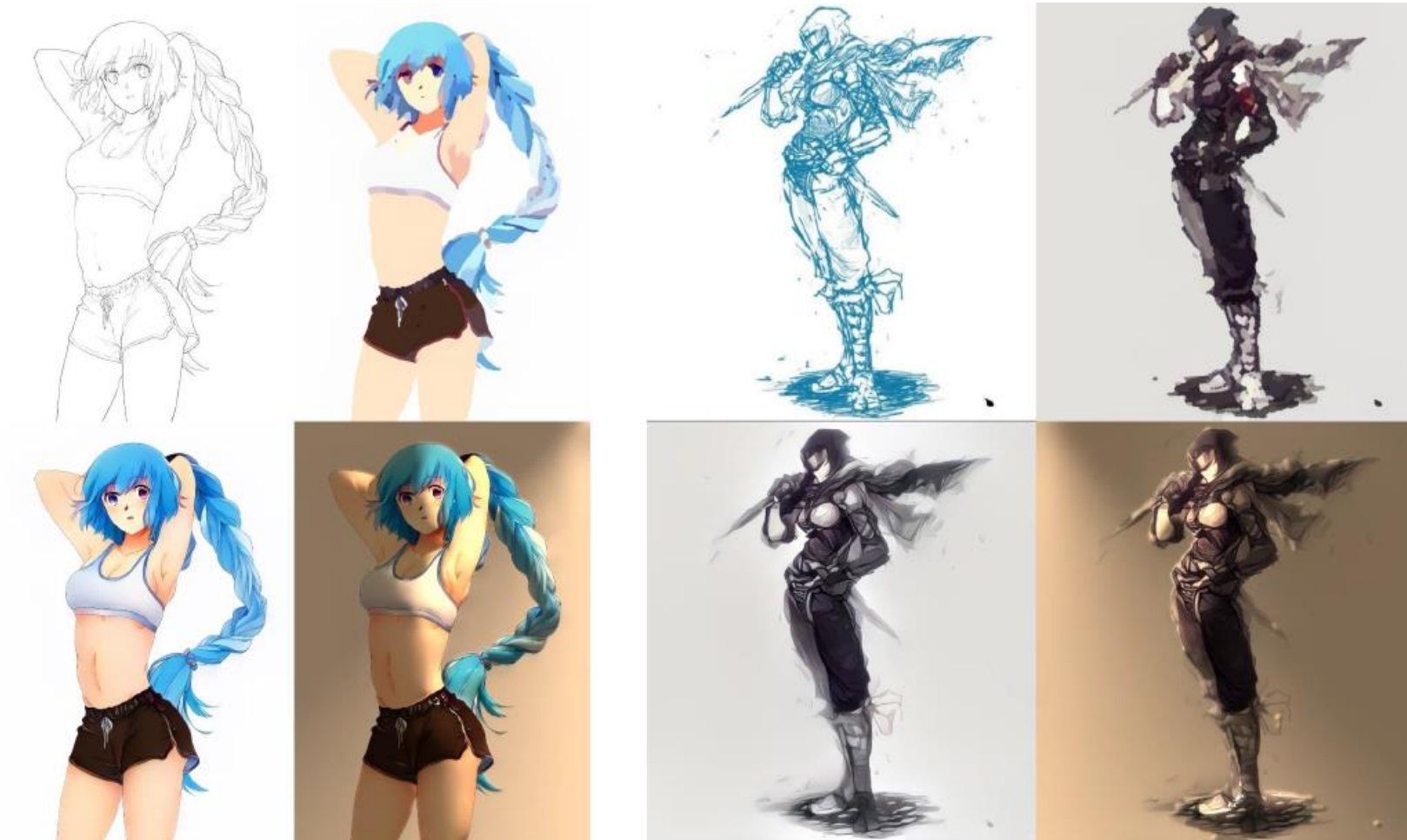
# Image generation (Style transfer)





DL is powering many real-world problems

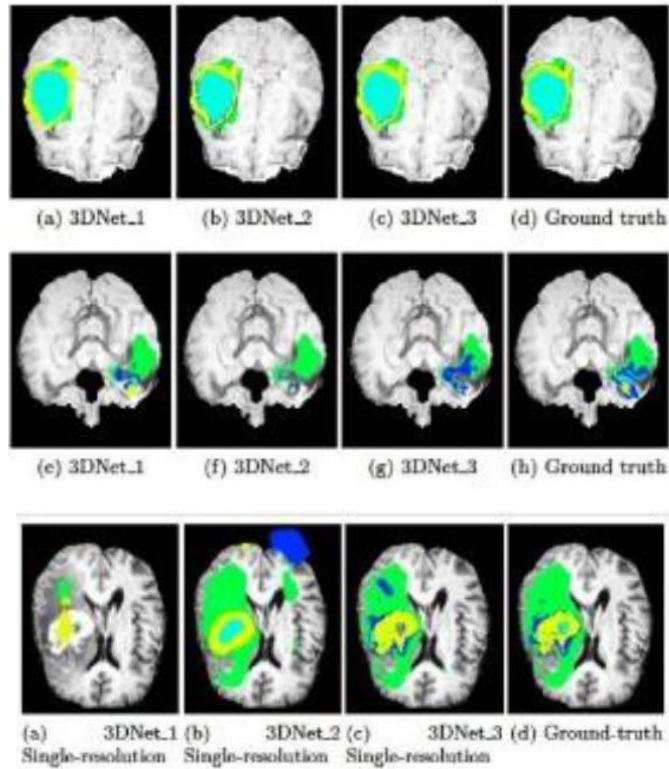
# Image generation (Style2Paints)



<https://github.com/Illyasviel/style2paints>

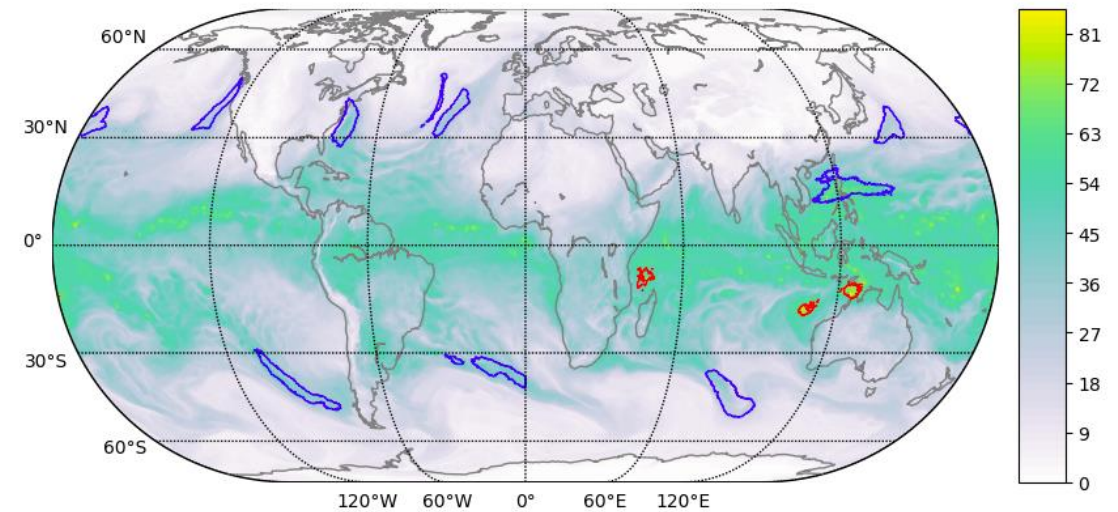
DL is powering many real-world problems

# Segmentation



Tumor segmentation

<https://www.slideshare.net/xavigiro/medical-imaging-d3l3-2017-upc-deep-learning-for-computer-vision>

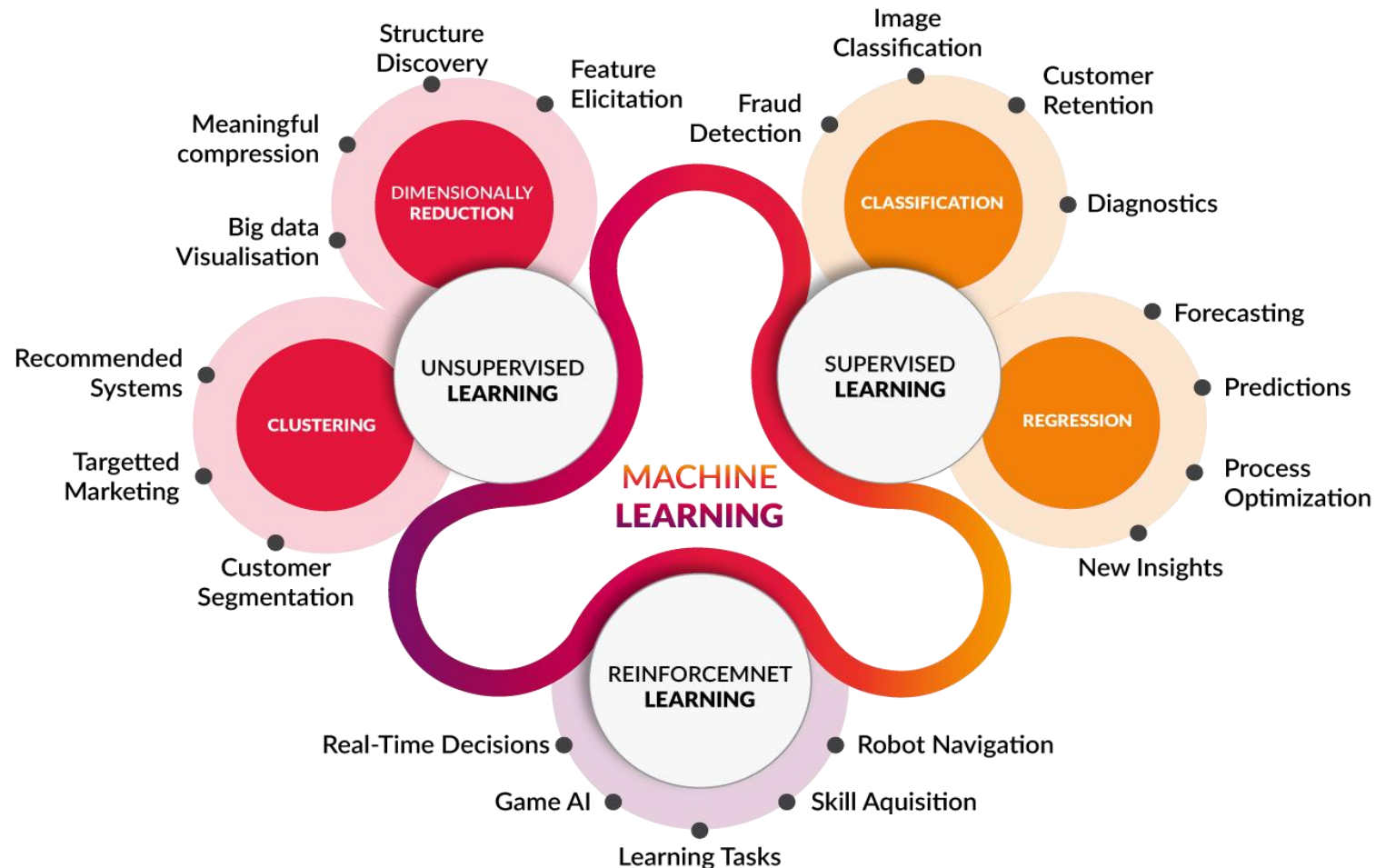


Climate segmentation

Exascale Deep Learning for Climate Analytics,  
Thorsten K. <https://arxiv.org/abs/1810.01993>



# What can we do with AI?



# Landscape of Science problems

	High Energy Physics			Biological and Environment		Basic Energy		Nuclear Physics	Fusion Energy
	Astronomy	Cosmology	Particle Physics	Climate	Genomics	Light Sources	Materials	Heavy Ion Colliders	Plasma Physics
Classification	X		X	X	X	X	X	X	X
Regression	X	X	X	X	X	X	X	X	X
Clustering	X	X	X	X	X	X	X	X	X
Dimensionality Reduction				X				X	
Surrogate Models	X	X	X	X			X	X	X
Design of Experiments		X		X		X	X		X

Analytics

Simulations

Control

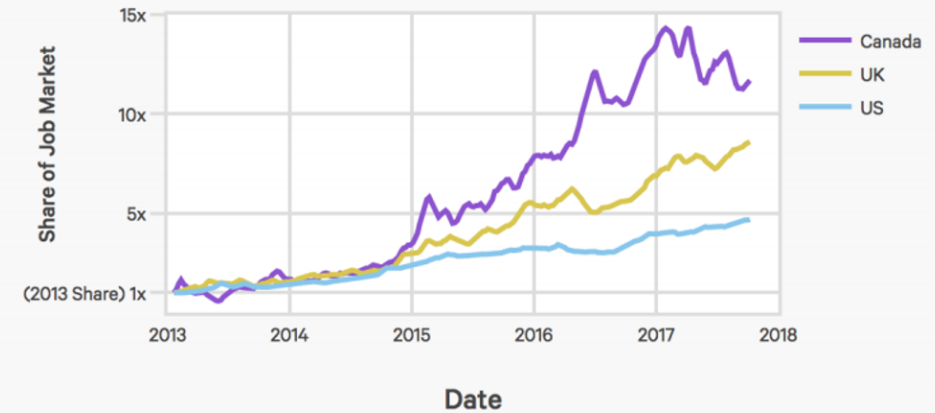
# DL use cases and growth trends

Share of US Jobs Requiring AI Skills (Indeed.com)



Sources: Indeed.com

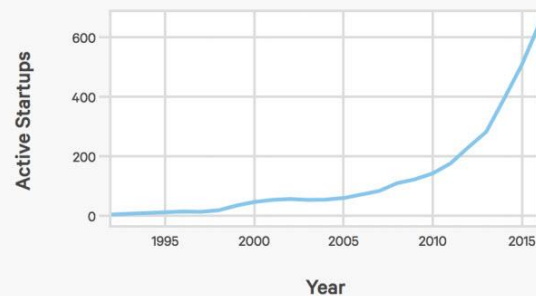
Share of Jobs Requiring AI Skills (Indeed.com)



AIINDEX.ORG Source: Indeed.com

AIINDEX.ORG

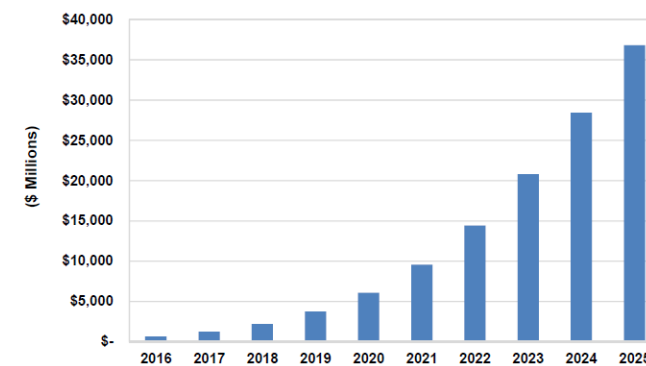
Startups Developing AI Systems



Sources: Crunchbase, VentureSource, Sand Hill Econometrics

AIINDEX.ORG

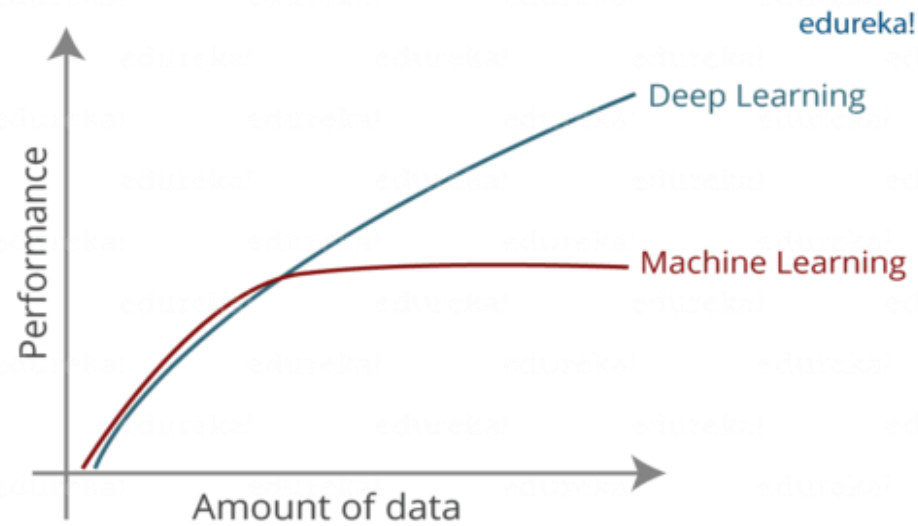
Chart 1.1 Artificial Intelligence Revenue, World Markets: 2016-2025



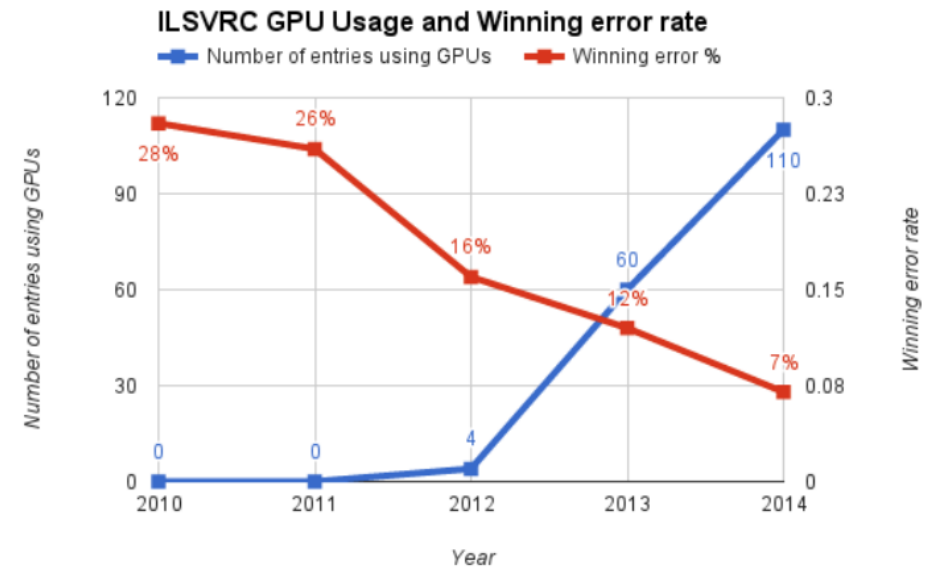
(Source: Tractica)

# Why now?

## 1) Data: large curated datasets



## 2) GPUs: linear algebra accelerators



<https://devblogs.nvidia.com/nvidia-ibm-cloud-support-imagenet-large-scale-visual-recognition-challenge/>

## 3) Algorithmic advances: optimizers, regularization, normalization ... etc.



# DL frameworks

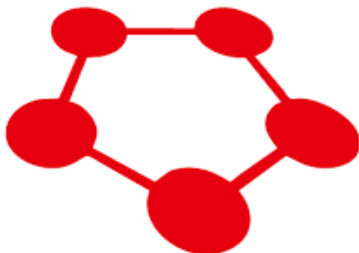
Caffe

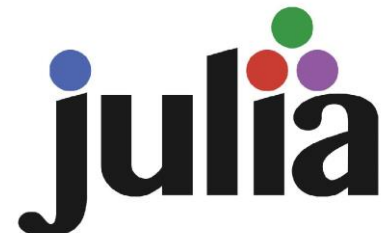


 PyTorch

The PyTorch logo features a red circular icon with a white flame-like shape inside. To the right of this icon, the word "PyTorch" is written in a black, sans-serif font.

 mxnet

The mxnet logo features a blue circular icon with the word "mxnet" written in a white, sans-serif font.

julia

The Julia logo features a black, sans-serif font with the word "julia" in lowercase. Above the letter "i" are four small colored dots: blue, green, red, and purple.

# TensorFlow

- The most widely used framework open-sourced by Google
- Replaced Google's DistBelief framework
- Runs on almost all architectures (CPU/GPU/TPU/etc)
- Define-and-Run type for neural networks
- Version 2.0 has Define-by-Run component(Eager execution)
- <https://github.com/tensorflow/tensorflow>

```
[isaac@cedar1 ~]$ avail_wheels "tensorflow*"
name          version    build      python    arch
-----
tensorflow_cpu 2.1.0      cp37       cp37       generic
tensorflow_cpu 2.1.0      cp36       cp36       generic
tensorflow_cpu 2.1.0      cp35       cp35       generic
tensorflow_estimator 2.1.0    py2.py3    py2.py3    generic
tensorflow_gpu 2.1.0      cp37       cp37       generic
tensorflow_gpu 2.1.0      cp36       cp36       generic
tensorflow_gpu 2.1.0      cp35       cp35       generic
tensorflow_tensorboard 1.5.1    py3        py3        generic
tensorflow_tensorboard 1.5.1    py2        py2        generic
[isaac@cedar1 ~]$
```



# PyTorch

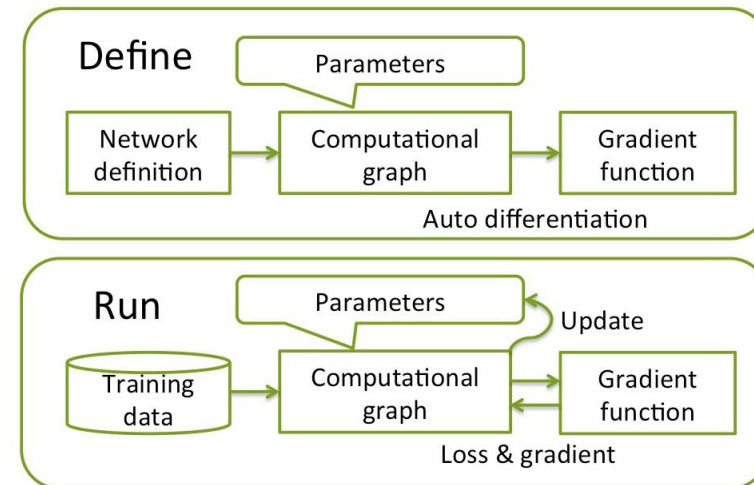
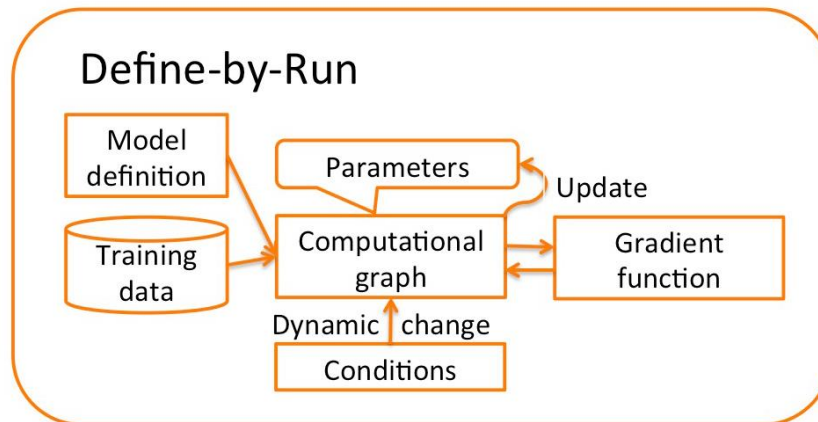
- Rapidly growing in research community for deep learning framework developed by Facebook
- A Python adaptation of Torch
- Caffe2 has been merged to PyTorch
- Define-by-Run type for neural networks
- Ease of expression and use
- <https://github.com/pytorch/pytorch>



```
[isaac@cedar1 ~]$ avail_wheels "torch_*"
name          version  build  python  arch
-----
torch_cluster 1.4.5    cp37   cp37     generic
torch_cluster 1.4.5    cp36   cp36     generic
torch_cluster 1.4.5    cp35   cp35     generic
torch_cpu     1.0.0    cp37   cp37     avx2
torch_cpu     1.0.0    cp36   cp36     avx2
torch_cpu     1.0.0    cp35   cp35     avx2
torch_cpu     1.0.0    cp27   cp27     avx2
torch_geometric 1.4.2    py3    py3      generic
torch_gpu     1.0.0    cp37   cp37     avx2
torch_gpu     1.0.0    cp36   cp36     avx2
torch_gpu     1.0.0    cp35   cp35     avx2
torch_gpu     1.0.0    cp27   cp27     avx2
```



Pros	Easy to use (Python support) Intuitive Dynamic graphs Research community prefers	Large community Heterogeneous architecture TF 2.0: Eager execution(Define-by-Run) Tensorboard (visualizing), Keras
Cons	Small community Less additional tools	Verbose Static graphs

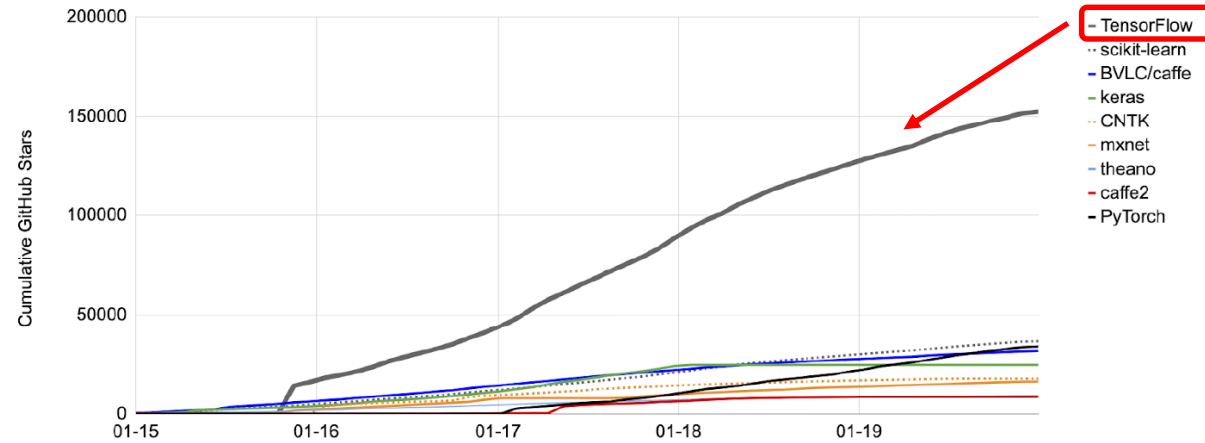




# DL frameworks trend

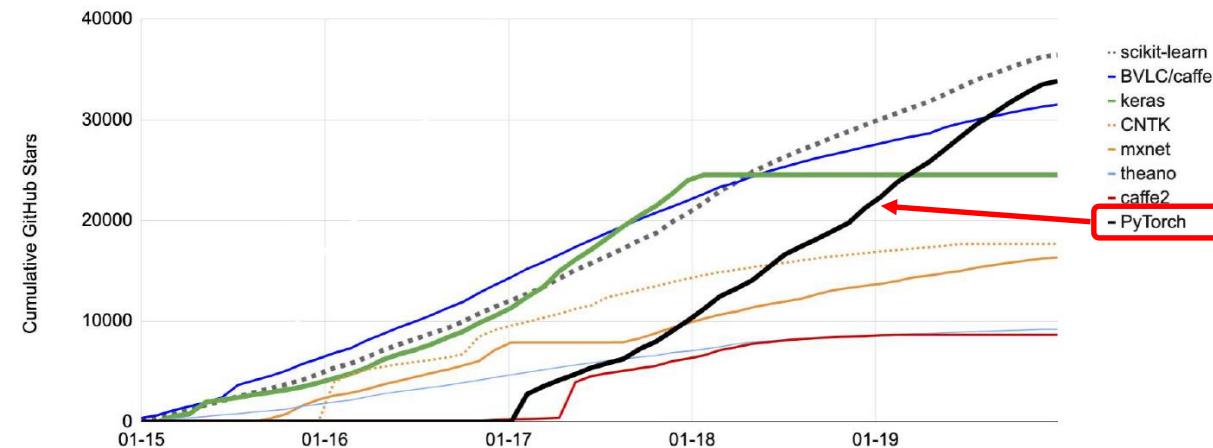
Cumulative GitHub stars by AI library (2015—2019)

Source: Github, 2019.

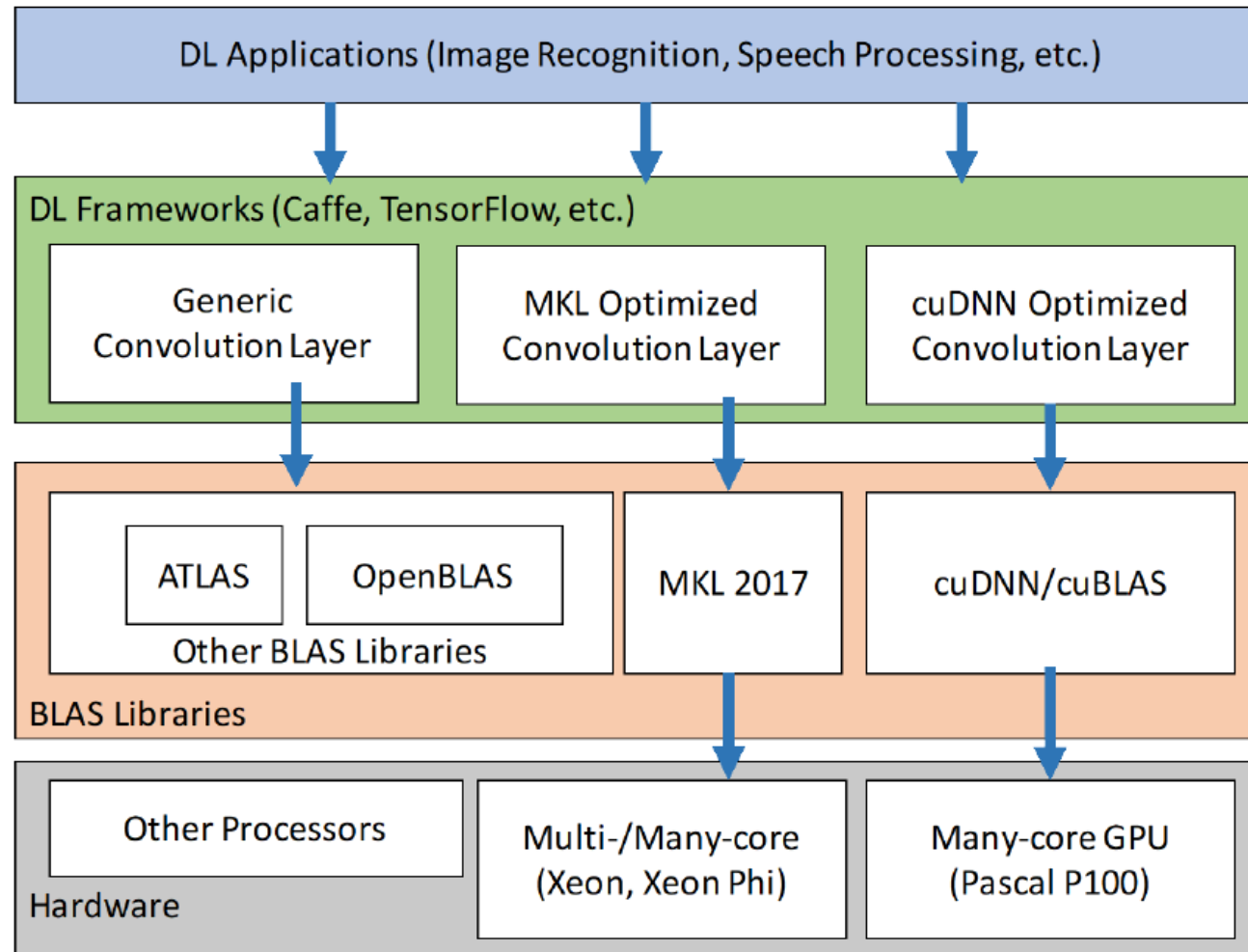


Cumulative GitHub stars by AI library, not including TensorFlow (2015—2019)

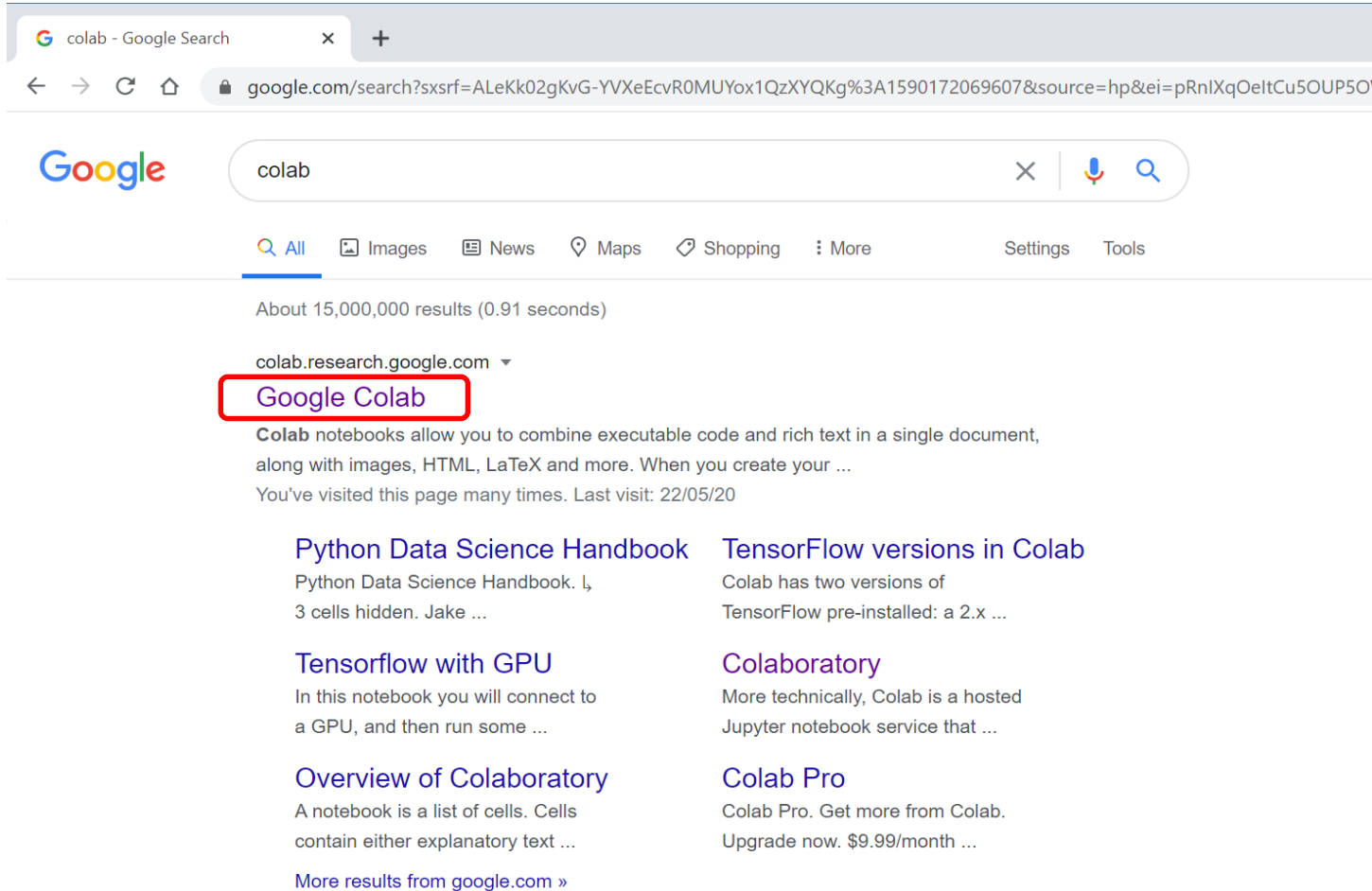
Source: Github, 2019.



# DL framework outline



# Lab 1: Working environment



The screenshot shows a Google search for 'colab'. The search bar contains 'colab' and the search button is visible. Below the search bar, the results are displayed. The first result is 'colab.research.google.com' with a red box highlighting the link 'Google Colab'. Below this link, there is a description: 'Colab notebooks allow you to combine executable code and rich text in a single document, along with images, HTML, LaTeX and more. When you create your ...'. Below the description, there is a link to 'Python Data Science Handbook' and a link to 'TensorFlow versions in Colab'. Below these links, there is a link to 'Tensorflow with GPU' and a link to 'Colaboratory'. Below these links, there is a link to 'Overview of Colaboratory' and a link to 'Colab Pro'. Below these links, there is a link to 'More results from google.com »'.

colab - Google Search

google.com/search?xsrf=ALeKk02gKvG-YVXeCvR0MUyox1QzXYQKg%3A1590172069607&source=hp&ei=pRnIXqOeltCu5OUP5O'

Google

colab

Google

About 15,000,000 results (0.91 seconds)

colab.research.google.com

**Google Colab**

Colab notebooks allow you to combine executable code and rich text in a single document, along with images, HTML, LaTeX and more. When you create your ...

You've visited this page many times. Last visit: 22/05/20

[Python Data Science Handbook](#)

Python Data Science Handbook. I, 3 cells hidden. Jake ...

[Tensorflow with GPU](#)

In this notebook you will connect to a GPU, and then run some ...

[Overview of Colaboratory](#)

A notebook is a list of cells. Cells contain either explanatory text ...

[More results from google.com »](#)

[TensorFlow versions in Colab](#)

Colab has two versions of TensorFlow pre-installed: a 2.x ...

[Colaboratory](#)

More technically, Colab is a hosted Jupyter notebook service that ...

[Colab Pro](#)

Colab Pro. Get more from Colab. Upgrade now. \$9.99/month ...

We will use Google Colab for most of simple runs!

# Lab 1: playing around Google Colab

1. Go to <https://colab.research.google.com>
2. Open a new Jupyter notebook
3. Check Runtime type (GPU/TPU) and settings
4. Editor (Code/text block)
5. Be careful of running order
6. Make sure where you can find your code



# Lab 1: Code comparison(calculating gradient)

```
1 import numpy as np
2 np.random.seed(0)
3
4 N, D = 3, 4
5
6 x = np.ones((N,D))
7 y = 2*np.ones((N,D))
8 z = 3*np.ones((N,D))
9
10 print(x)
11 print(y)
12 print(z)
13
14 a = x * y
15 b = a + z
16 c = np.sum(b)
17 print(c)
18
19 grad_c = 1.0
20 grad_b = grad_c * np.ones((N,D))
21 grad_a = grad_b.copy()
22 grad_z = grad_b.copy()
23
24 grad_x = grad_a*y
25 grad_y = grad_a*x
26
27 print(grad_x)
```

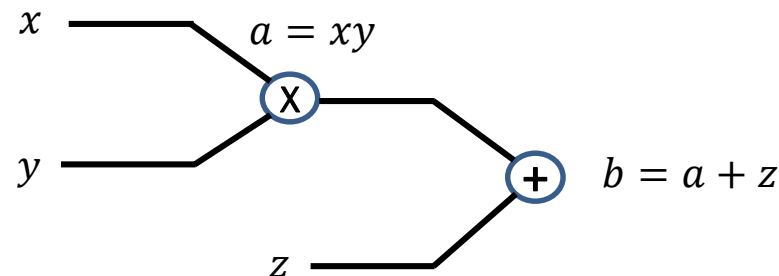
NumPy

```
1 import torch
2 print(torch.__version__)
3
4 N, D = 3, 4
5
6 x = torch.ones(N,D, requires_grad=True)
7 y = 2*torch.ones(N,D)
8 z = 3*torch.ones(N,D)
9
10 print(x)
11 print(y)
12 print(z)
13
14 a = x*y
15 b = a+z
16 c = torch.sum(b)
17 print(c)
18
19 c.backward()
20 print(x.grad)
```

PyTorch

```
1 import numpy as np
2 import tensorflow as tf
3 print(tf.__version__)
4
5 N, D = 3, 4
6
7 x = tf.ones([N,D])
8 y = 2*tf.ones([N, D])
9 z = 3*tf.ones([N, D])
10
11 print(x)
12 print(y)
13 print(z)
14
15 with tf.GradientTape(persistent=True) as g:
16     g.watch(x)
17     a = x * y
18     b = a + z
19     c = tf.reduce_sum(b)
20 grad_x = g.gradient(b,x)
21 print(c)
22 print(grad_x)
```

TensorFlow



Break  
room

**Session break:**

**Please come back by 10:45 AM**