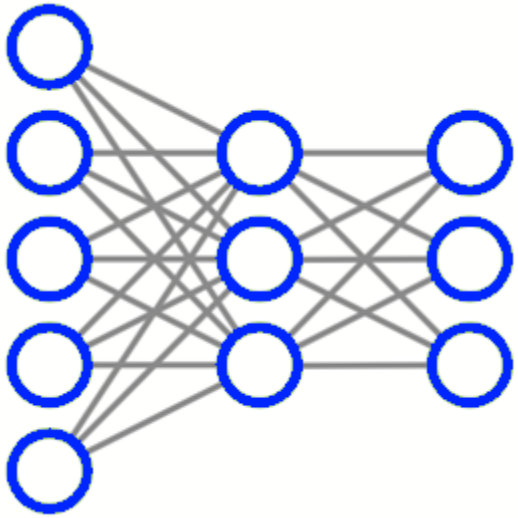
Pontificia Universidad Católica de Chile
Escuela de Ingeniería
Departamento de Ciencia de la Computación

IIC1005 – Computación: Ciencia y Tecnología del Mundo Digital

Introduction to Deep Learning



Hans Löbel

¿Why a class solely focused on Deep Learning?

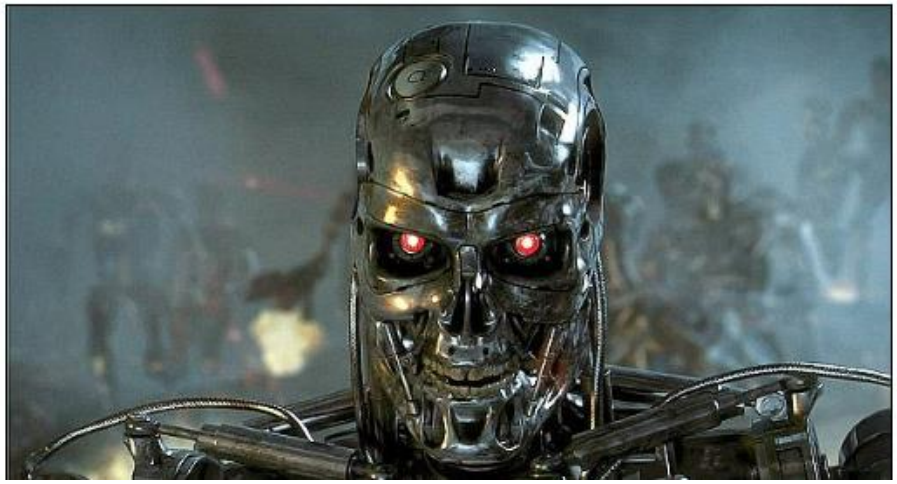
(aka why is Deep Learning so important?)

AlphaGo seals 4-1 vi
grandmaster Lee Se

DeepMind's artificial intelligence astoni
offers evidence computer software has

Rise of the machines: Google AI experiment may lead to robots that can learn WITHOUT human input

- Generative Adversarial Networks create digital content based on real-life
- Google project pits AI algorithms against each other to refine this output
- The results could one day lead to machines that can learn without human input



ot new course to

w and being trialled in south-east London now
be banned from driving?

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1955
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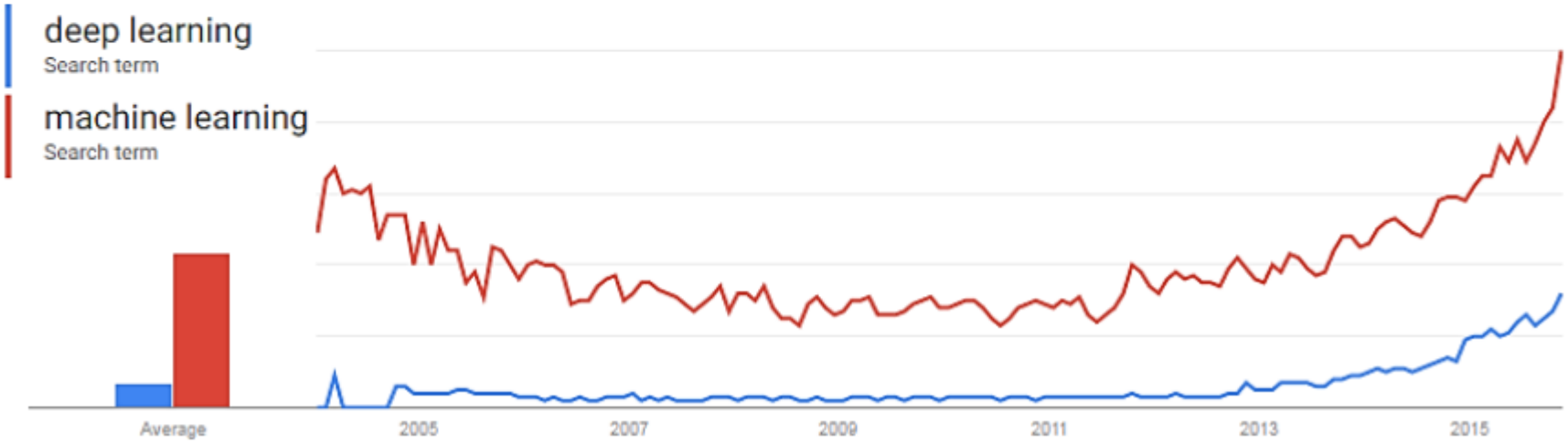
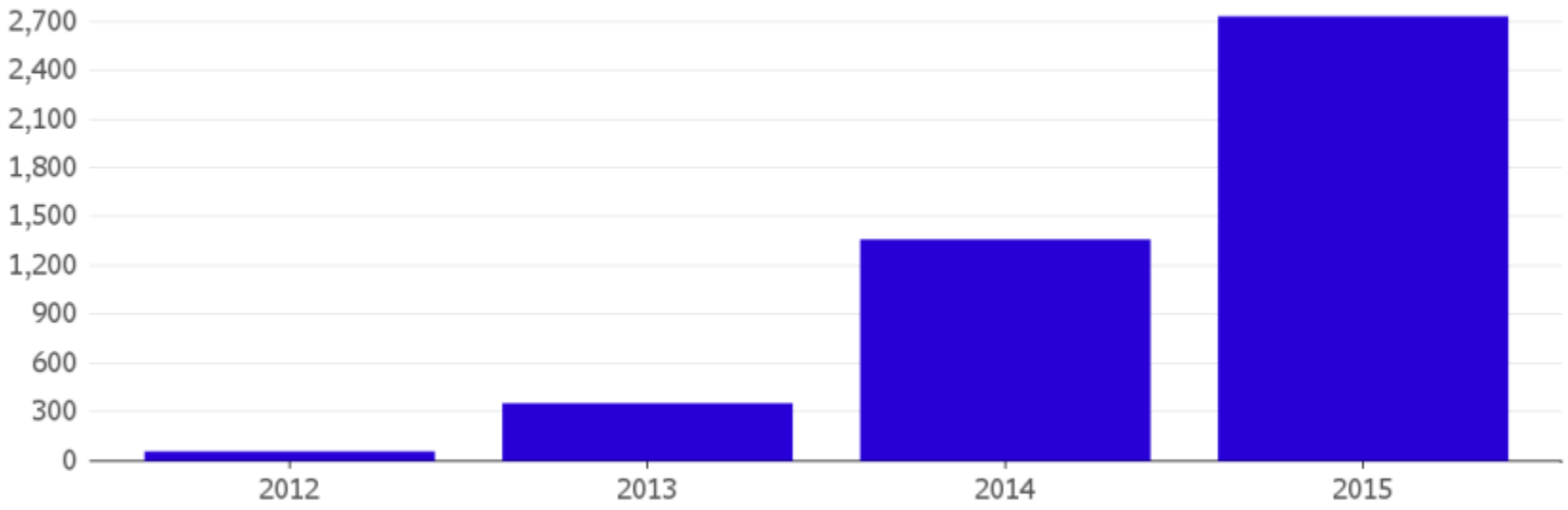
2005
Deep Learning


deep learning
Search term
machine learning
Search term
Average
2005
2007
2009
2011
2013
2015

Artificial Intelligence Takes Off at Google

Number of software projects within Google that uses a key AI technology, called Deep Learning.



Source: Google

Note: 2015 data does not incorporate data from Q4

Bloomberg

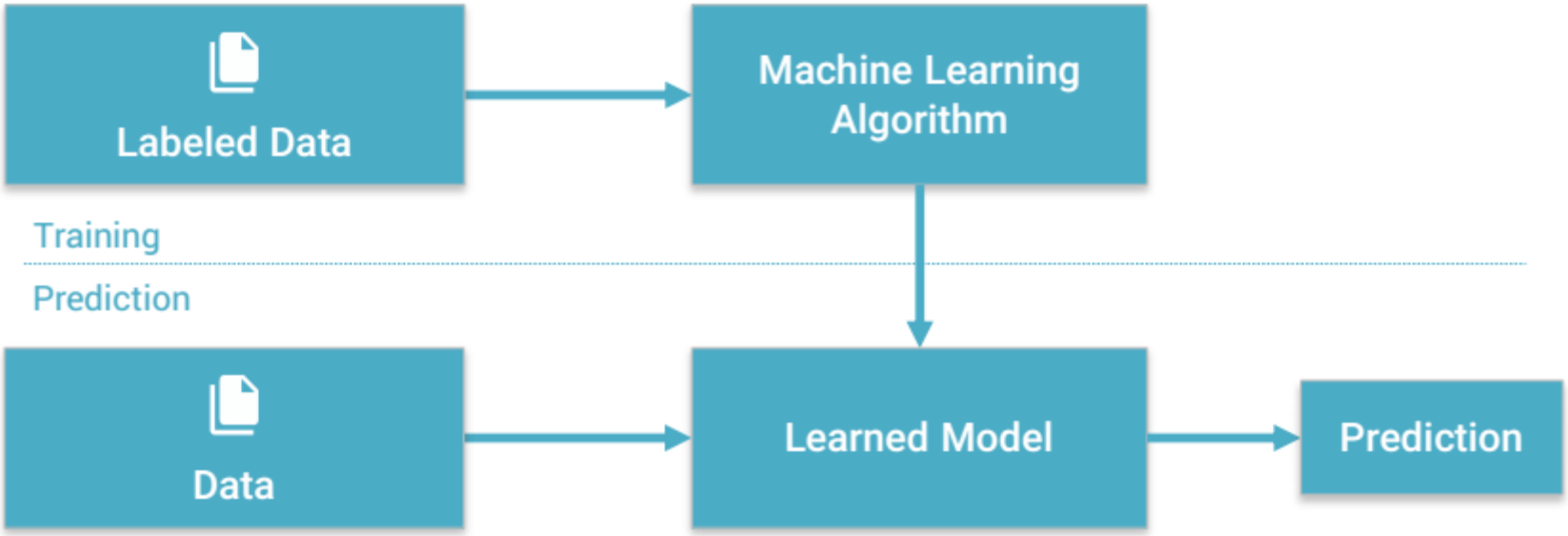
Andrej Karpathy

@karpathy

Following

Came to visit first class of @cs231n at Stanford. 2015: 150 students, 2016: 350, this year: 750. #aiinterestsingularity

Machine Learning is a type of Artificial Intelligence that provides computers with the ability to learn without being explicitly programmed.



Provides various techniques that can learn from and make predictions on data

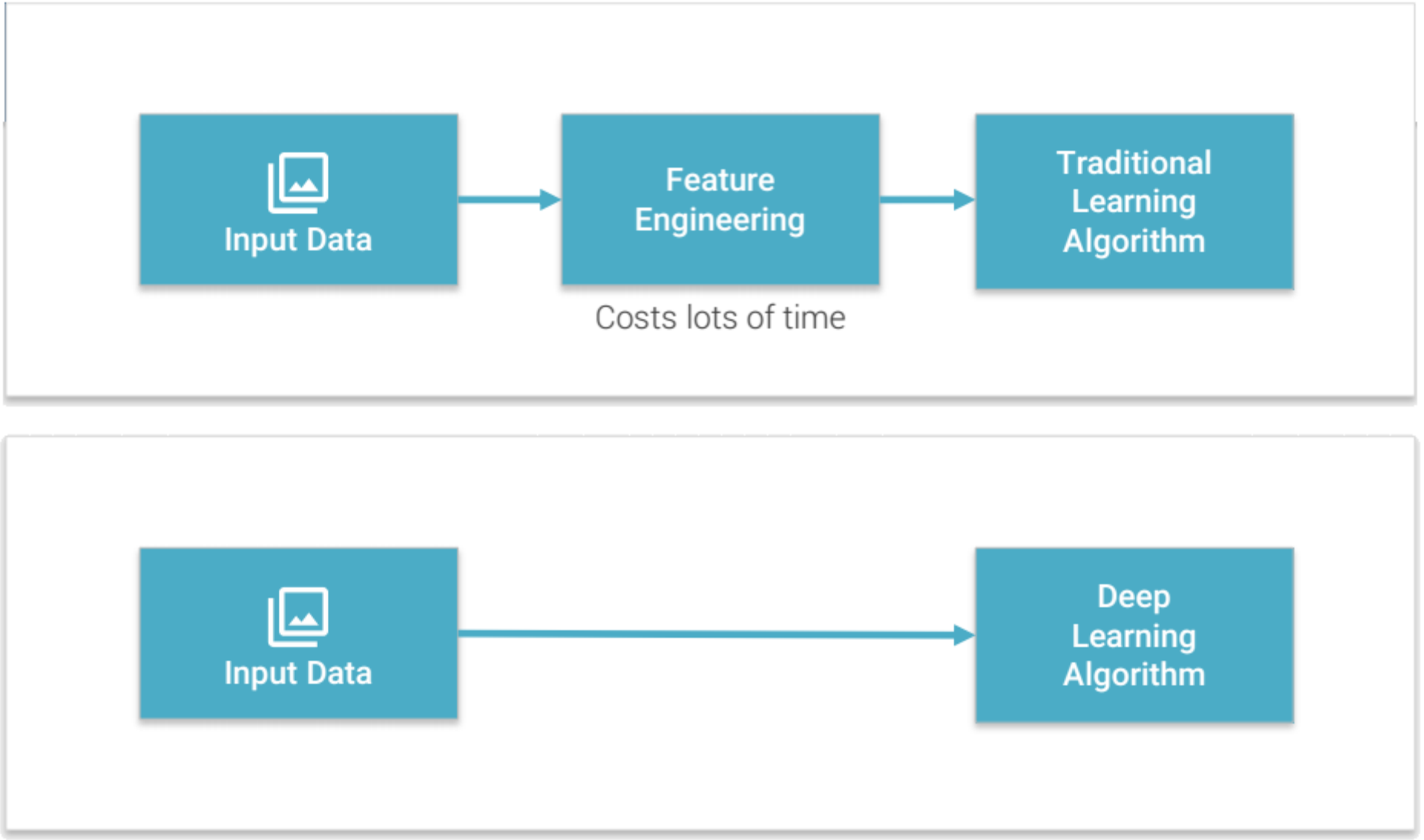
Deep Learning is currently the most popular tool/technique in Machine Learning

Part of the machine learning field of learning representations of data. Exceptional effective at learning patterns.

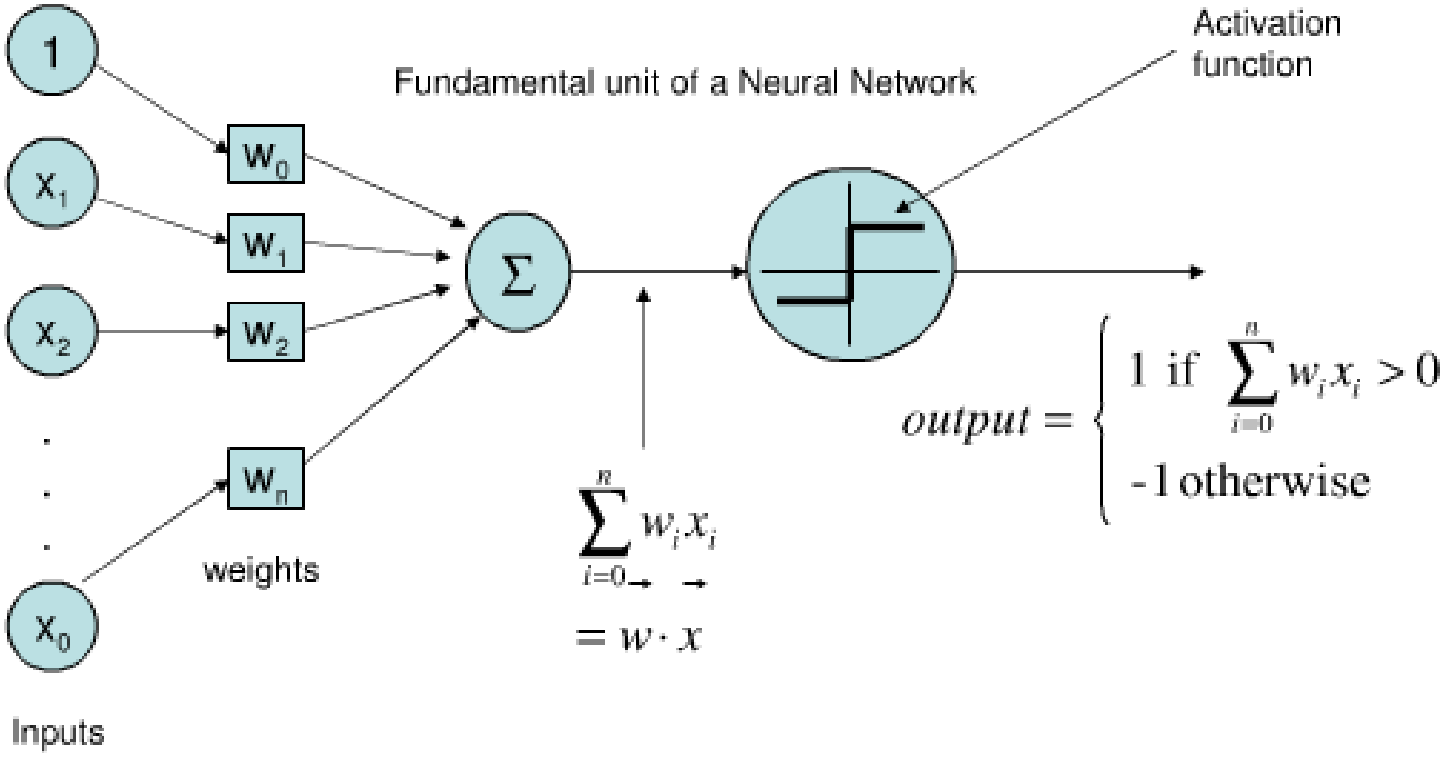
Utilizes learning algorithms that derive meaning out of data by using a hierarchy of multiple layers that mimic the neural networks of our brain.

If you provide the system tons of information, it begins to understand it and respond in useful ways.

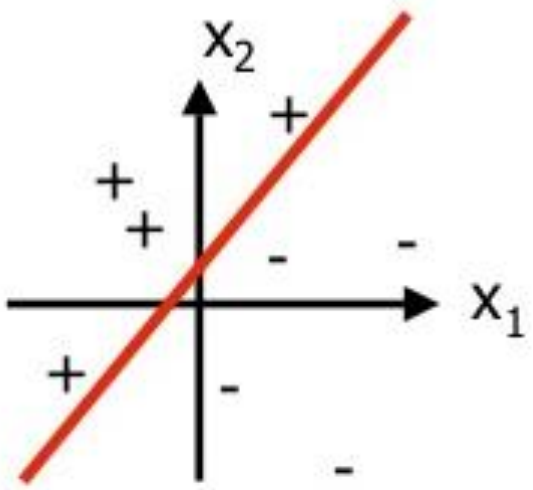
Deep Learning's power comes from its ability to learn a hierarchy of meaningful representations from data



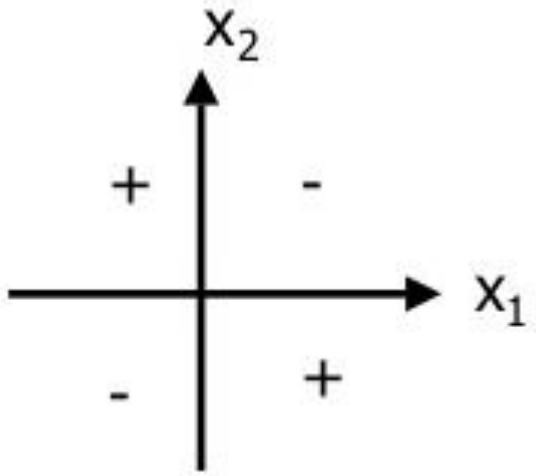
All started with a tiny Perceptron



…but it wasn't very powerful



Linearly separable



Non-Linearly separable

1958 Perceptron

1969
Perceptron criticized

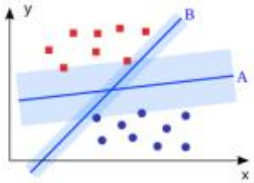
1974 Backpropagation

Convolution Neural Networks for Handwritten Recognition

1998

awkward silence (AI Winter)

1995
SVM reigns



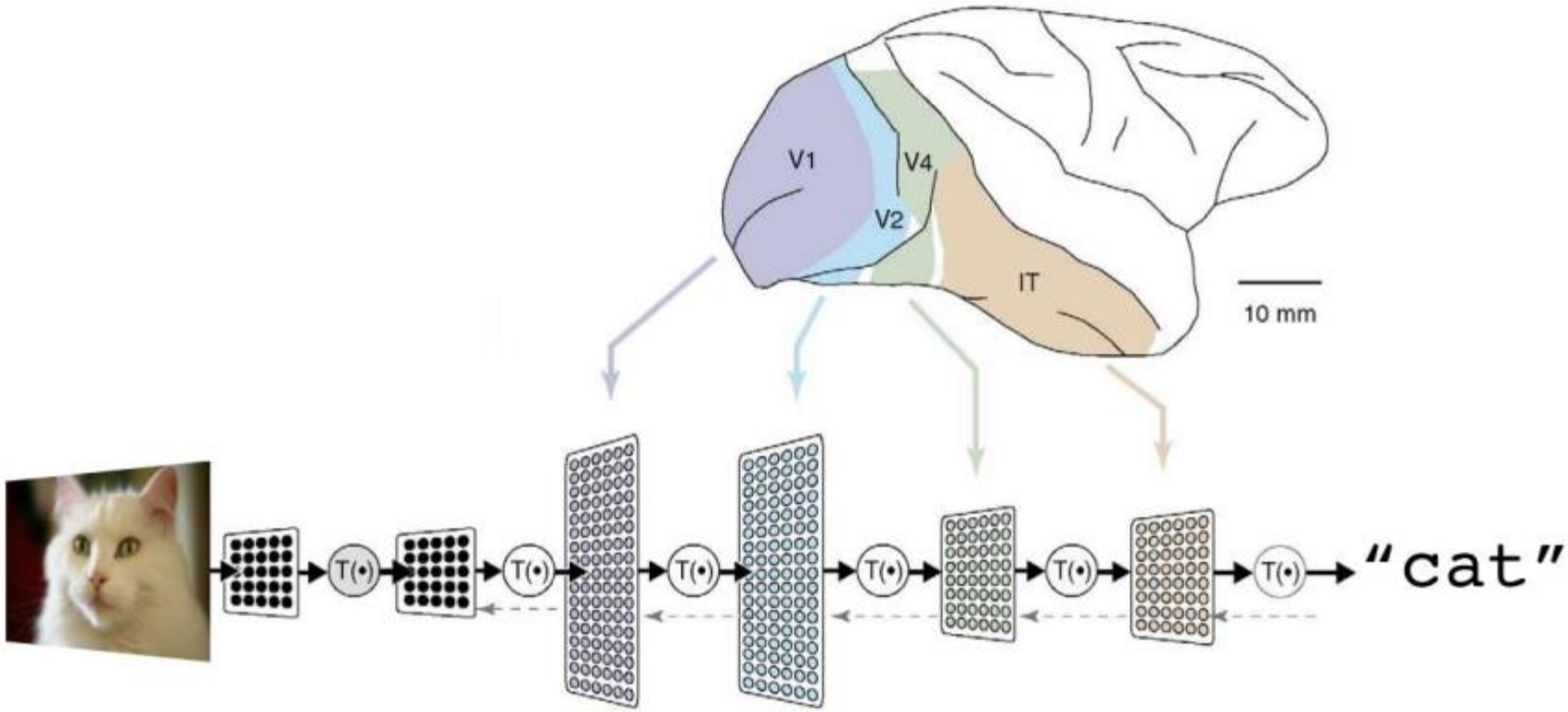
2006
Restricted Boltzmann Machine

Google Brain Project on 16k Cores

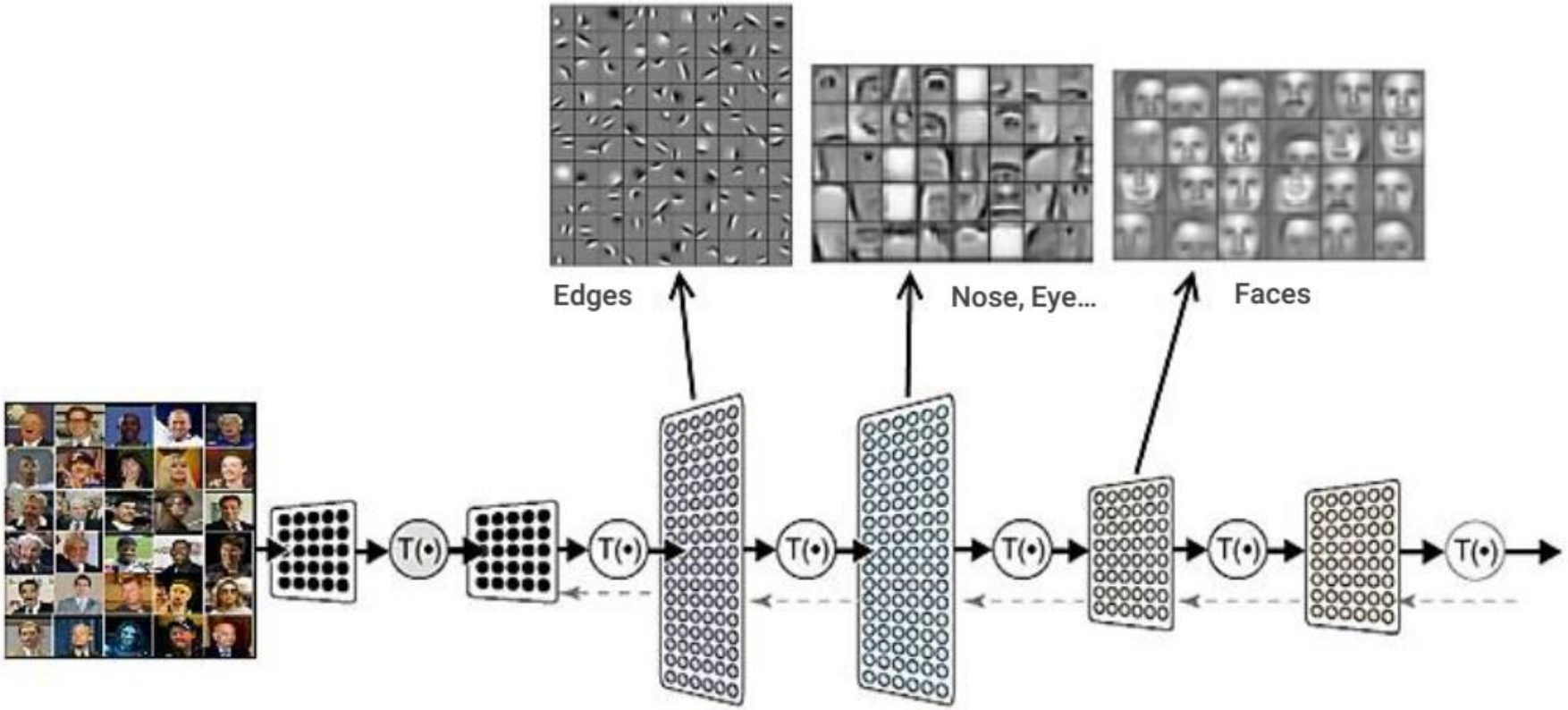
2012

2012
AlexNet wins ImageNet

IMAGENET



A deep neural network consists of a hierarchy of layers, whereby each layer transforms the input data into more abstract representations (e.g. edge -> nose -> face). The output layer combines those features to make predictions.


Edges
Nose, Eye...
Faces
T(•)
T(•)
T(•)
T(•)
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Unbeatable in many domains

Speech Recognition

Computer Vision

Natural Language Processing

The right elements at the right time

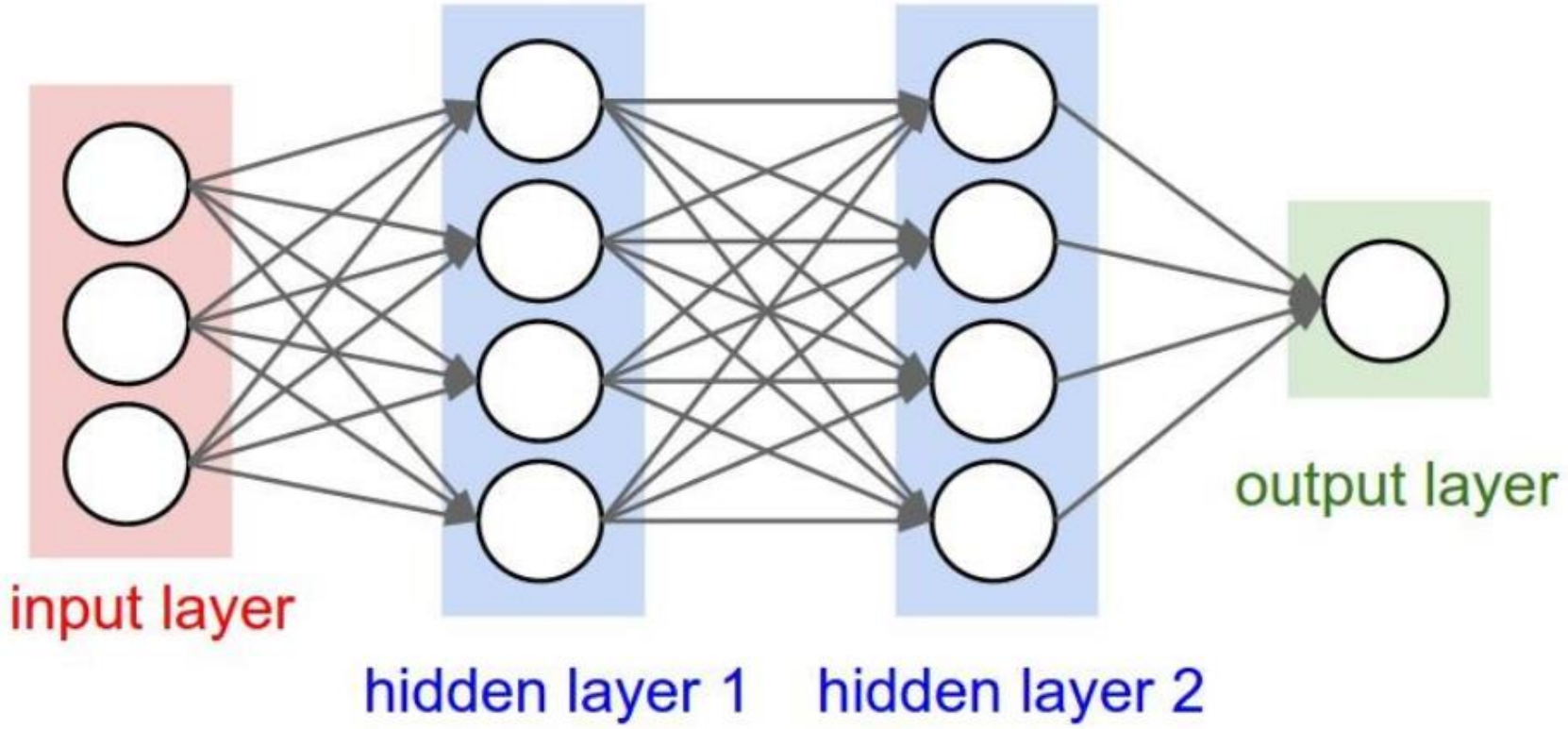
Big Data
(Digitalization)

Computation
(Moore's Law, GPUs)

Algorithmic
Progress

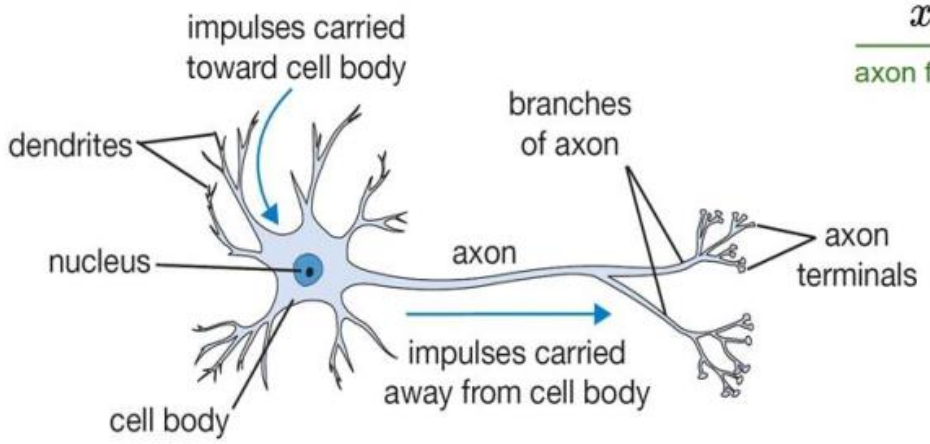
There won't be a new "AI winter" (hopefully)

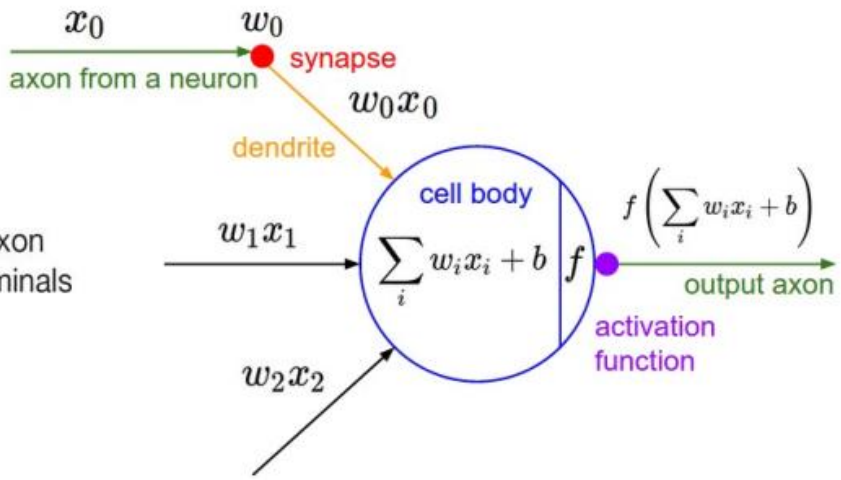
Let's get serious



Consists of one input, one output and multiple fully-connected hidden layers in-between. Each layer is represented as a series of neurons and progressively extracts higher and higher-level features of the input until the final layer essentially makes a decision about what the input shows. The more layers the network has, the higher-level features it will learn.

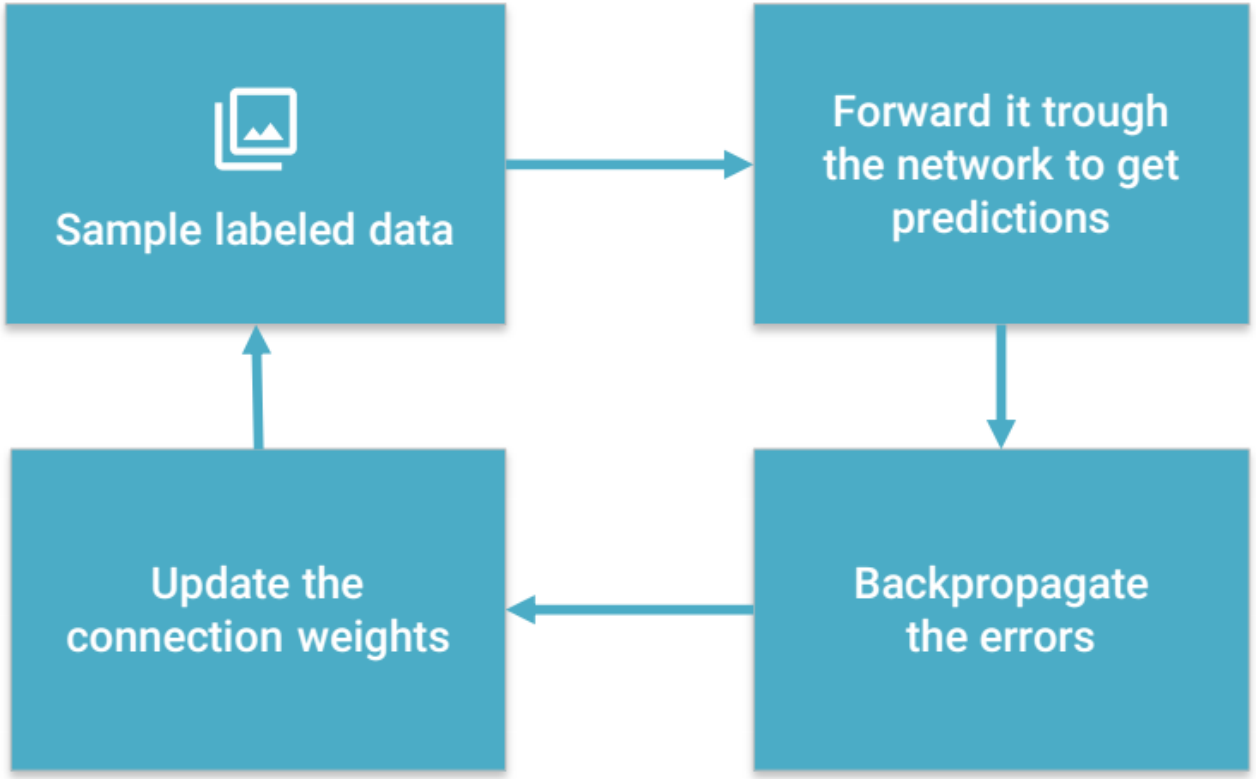
Artificial neurons are somewhat similar to real neurons





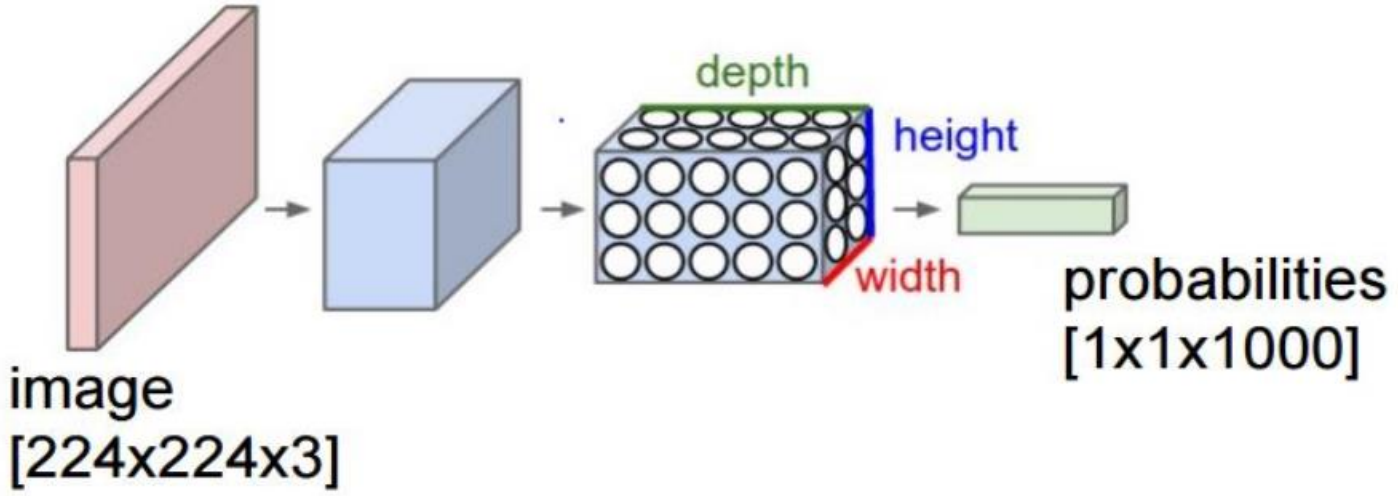
An artificial neuron contains a nonlinear activation function and has several incoming and outgoing weighted connections.

Neurons are trained to filter and detect specific features or patterns (e.g. edge, nose) by receiving weighted input, transforming it with the activation function und passing it to the outgoing connections.

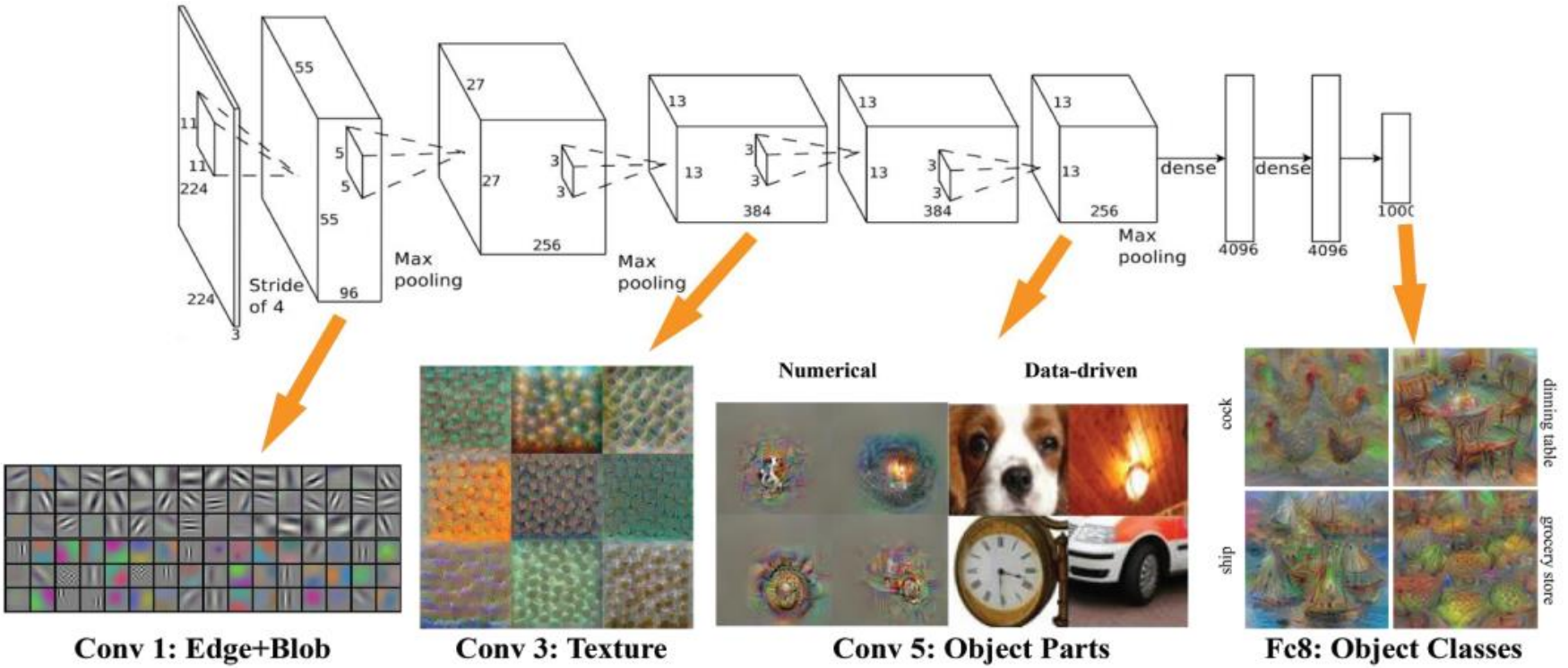


Learns by generating an error signal that measures the difference between the predictions of the network and the desired values and then using this error signal to change the weights (or parameters) so that predictions get more accurate.

Convolutional Neural Networks learn a complex representation of visual data using vast amounts of data. They are inspired by the human visual system and learn multiple layers of transformations, which are applied on top of each other to extract a progressively more sophisticated representation of the input.



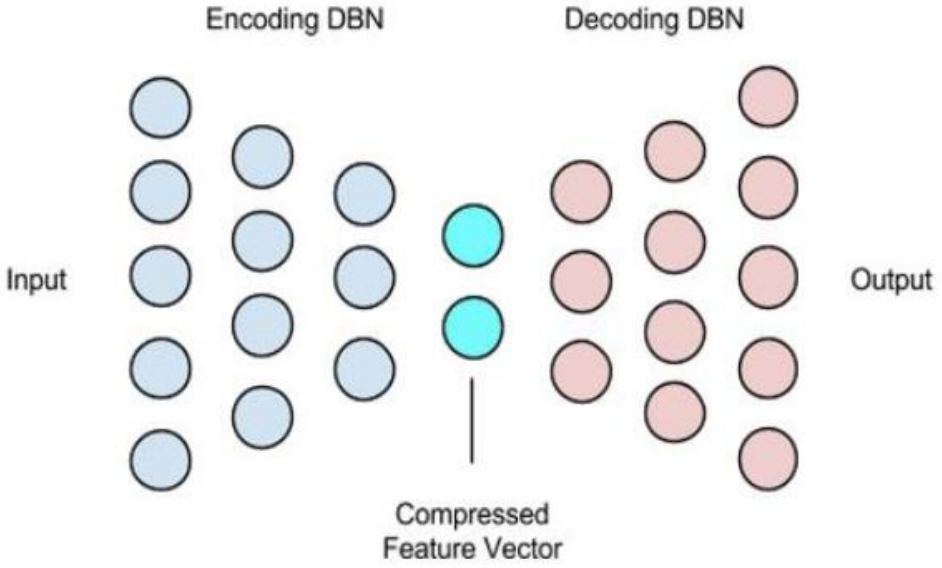
Every layer of a CNN takes a 3D volume of numbers and outputs a 3D volume of numbers. E.g. Image is a 224*224*3 (RGB) cube and will be transformed to 1*1000 vector of probabilities.



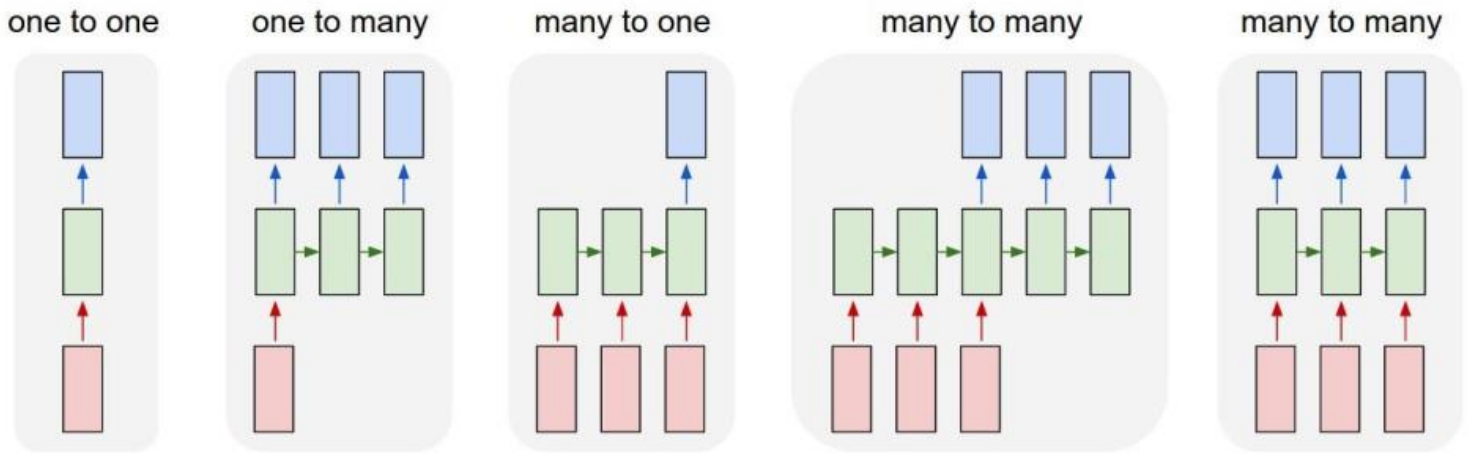
Convolution layer is a feature detector that automagically learns to filter out not needed information from an input by using convolution kernel.

Pooling layers compute the max or average value of a particular feature over a region of the input data *(downsizing of input images).* Also helps to detect objects in some unusual places and reduces memory size.

If there is no supervision available, we can use Autoencoders

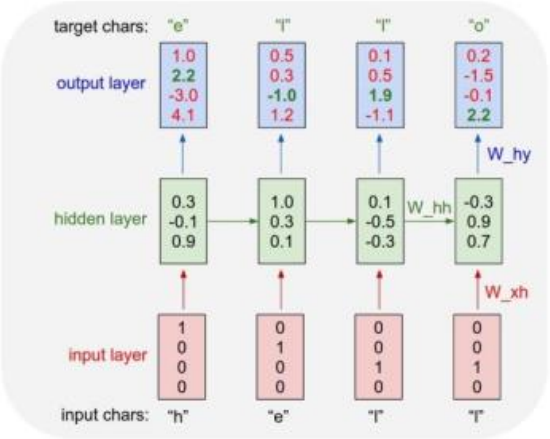


Composed of two symmetrical deep-belief networks. The encoding network learns to compresses the input to a condensed vector (dimensionality reduction). The decoding network can be used to reconstruct the data.



RNNs are general computers which can learn algorithms to map input sequences to output sequences (flexible-sized vectors). The output vector's contents are influenced by the entire history of inputs.

State-of-the-art results in time series prediction, adaptive robotics, handwriting recognition, image classification, speech recognition, stock market prediction, and other sequence learning problems. *Everything can be processed sequentially.*

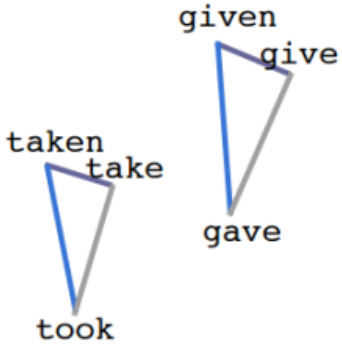


To train the RNN, insert characters sequentially and predict the probabilities of the next letter. Backpropagate error and update RNN's weights to increase the confidence of the correct letter (green) and decrease the confidence of all other letters (red).

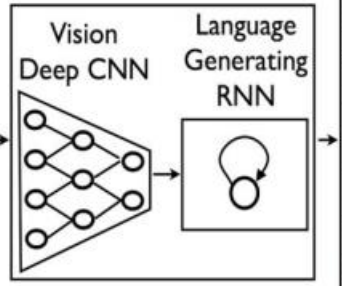
```
The emperor travelled back to [[Antioch, Perth, October 25|21]] to note, the Kingdom
of Costa Rica, unsuccessful fashioned the [[Thrales]], [[Cynth's Dajoard]], known
in western [[Scotland]], near Italy to the conquest of India with the conflict.
Copyright was the succession of independence in the slop of Syrian influence that
was a famous German movement based on a more popular servicious, non-doctrinal
and sexual power post. Many governments recognize the military housing of the
[[Civil Liberalization and Infantry Resolution 265 National Party in Hungary]],
that is sympathetic to be to the [[Punjab Resolution]]
(PJS)[http://www.humah.yahoo.com/guardian.cfm/7754800786d17551963s89.htm]
```

Trained on structured Wikipedia markdown. Network learns to spell English words completely from scratch and copy general syntactic structures.

FRANCE	JESUS	XBOX	REDDISH	SCRATCHED	MEGABITS
AUSTRIA	GOD	AMIGA	GREENISH	NAILED	OCTETS
BELGIUM	SATI	PLAYSTATION	BLUISH	SMASHED	MB/S
GERMANY	CHRIST	MSX	PINKISH	PUNCHED	BIT/S
ITALY	SATAN	IPOD	PURPLISH	POPPED	BAUD
GREECE	KALI	SEGA	BROWNISH	CRIMPED	CARATS
SWEDEN	INDRA	PSNUMBER	GREYISH	SCRAPED	KBIT/S
NORWAY	VISHNU	HD	GRAYISH	SCREWED	MEGAHERTZ
EUROPE	ANANDA	DREAMCAST	WHITISH	SECTIONED	MEGAPIXELS
HUNGARY	PARVATI	GEFORCE	SILVERY	SLASHED	GBIT/S
SWITZERLAND	GRACE	CAPCOM	YELLOWISH	RIPPED	AMPERES



Woman – Man ≈ Aunt - *Uncle*
King - Male + Female ≈ *Queen*
Human - Animal ≈ *Ethics*



A group of people shopping at an outdoor market.

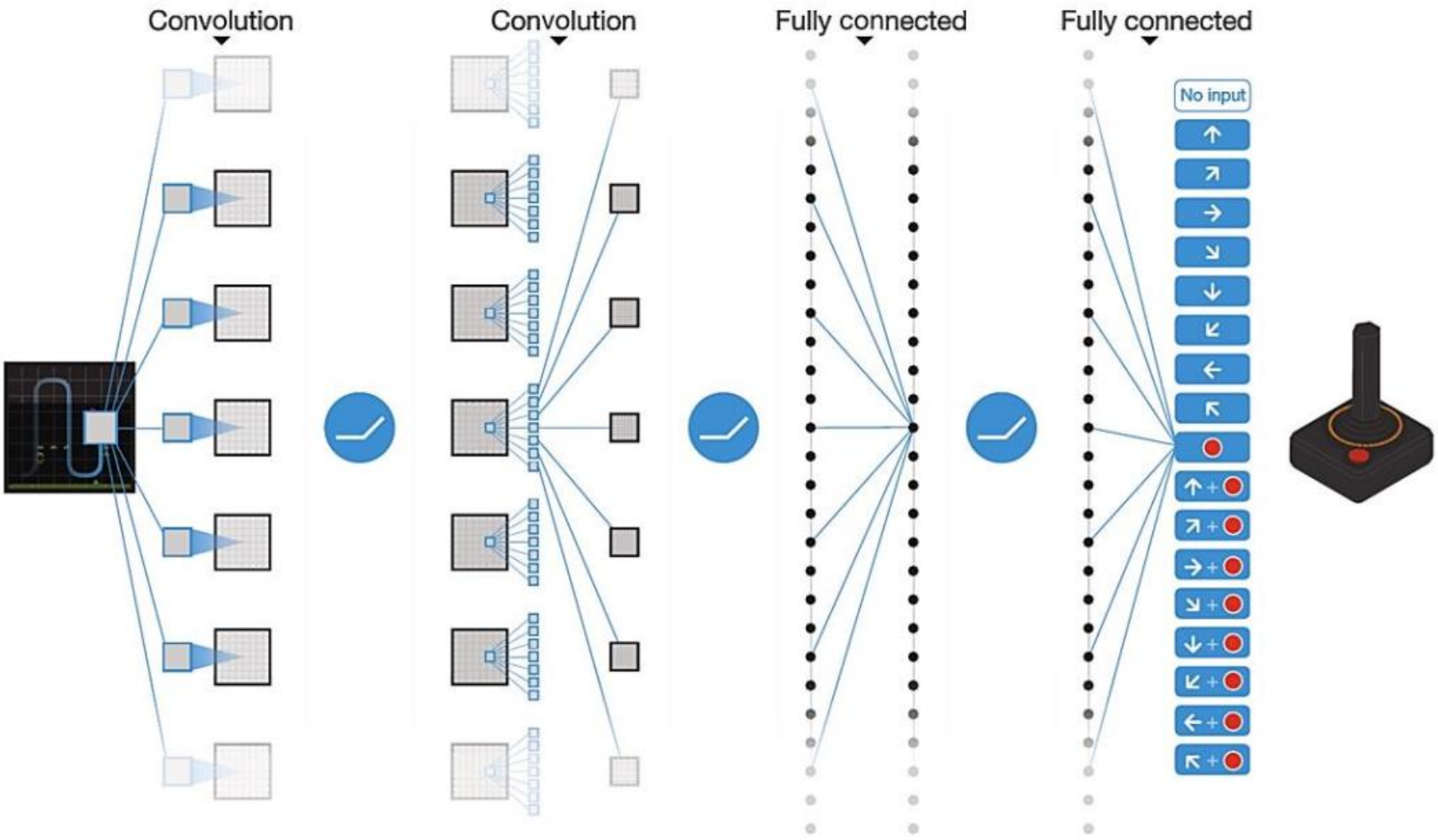
There are many vegetables at the fruit stand.

Neural Image Caption Generator generates fitting natural-language captions only based on the pixels by combining a vision CNN and a language-generating RNN.

A close up of a child holding a stuffed animal

Two pizzas sitting on top of a stove top oven

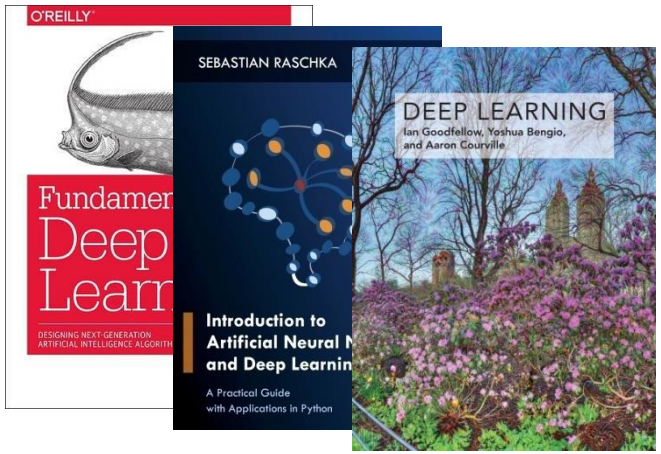
A man flying through the air while riding a skateboard



Deep Q-Learning (DQN) is a model-free approach to reinforcement learning using deep networks in environments with discrete action choices

Ok, I'm sold, what should I do next

(besides taking Machine Learning courses)



Read about it
(serious reading)

coursera
education for everyone

Udemy

UDACITY

MOOCs

Most frameworks are open source

Great team, great professors, great research

Domingo Mery

Álvaro Soto

Jorge Baier

Karim Pichara

Cristian Ruz

Denis Parra

Hans Löbel

Great team, great professors, great research

Takeaways

- Deep Learning is not magic! Just statistics and optimization in a black box.
- Exceptionally effective at recognizing patterns.
- Still no common sense (can be even racist).
- If you're interested, learn it now.
- If not, learn it anyways, at least the basics.
- This is one of the technologies that will change the world.

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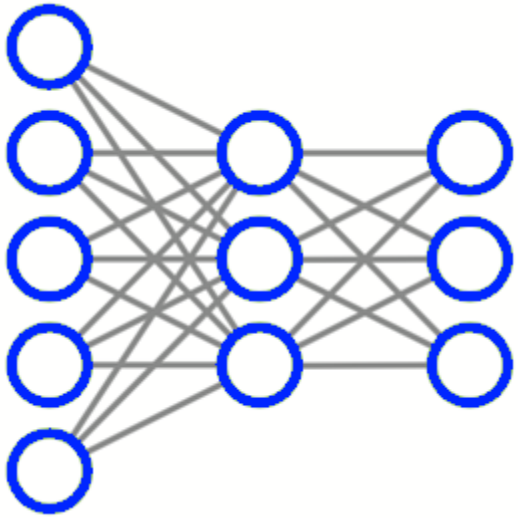

Hans Löbel