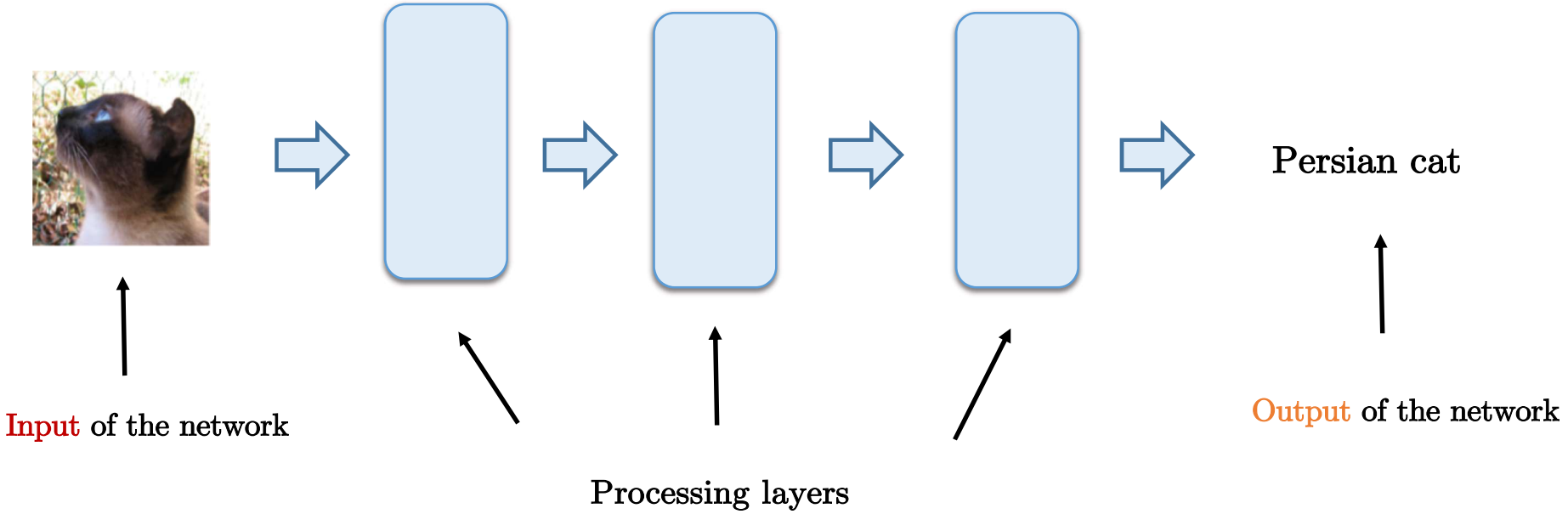
DL/NNs can be used for many tasks

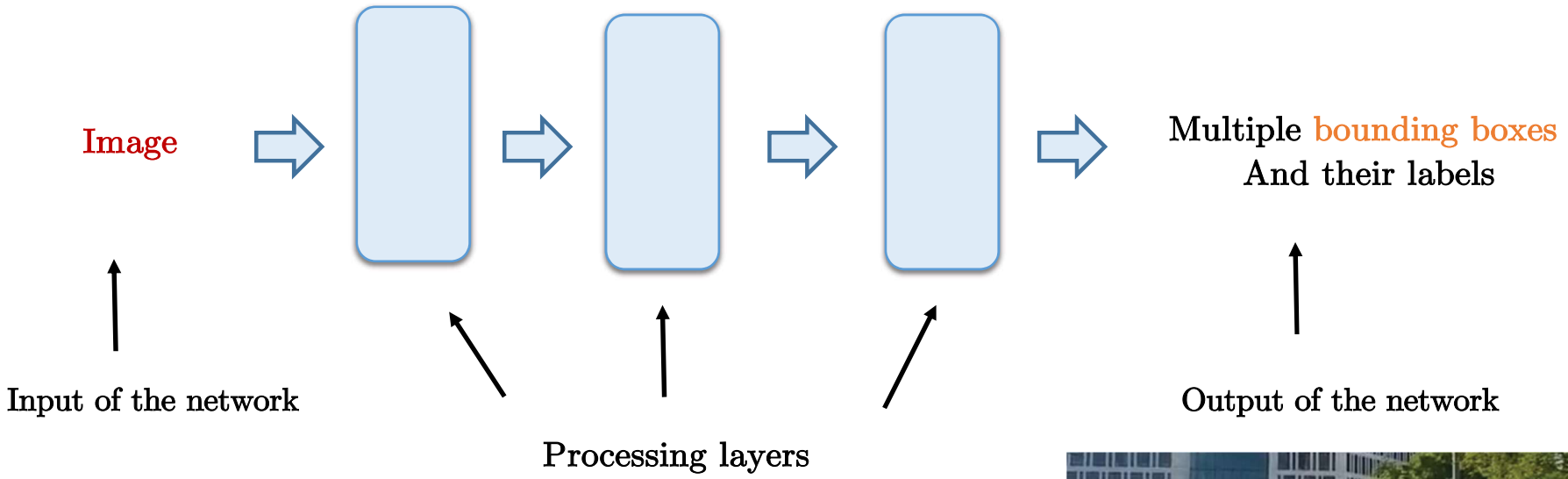
- Neural networks are universal learning techniques that can be applied to very distinct fields like computer vision, natural language processing, physics, chemistry, healthcare, biology, etc.

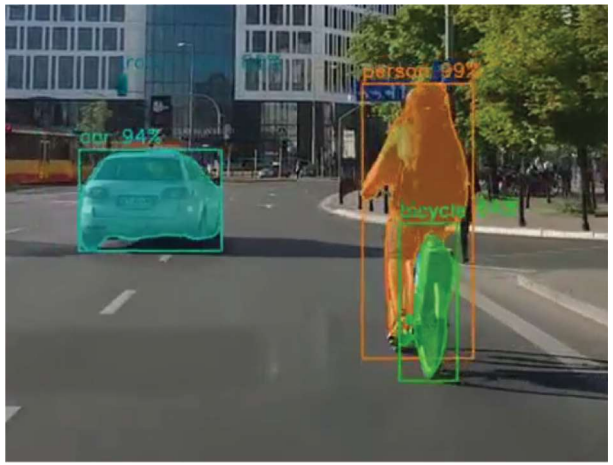
- Tasks where NNs provide the best performance (SOTA):
  - Image recognition
  - Object detection
  - Voice recognition
  - Speech synthesis
  - Translation
  - Recommender systems
  - ...

Image recognition



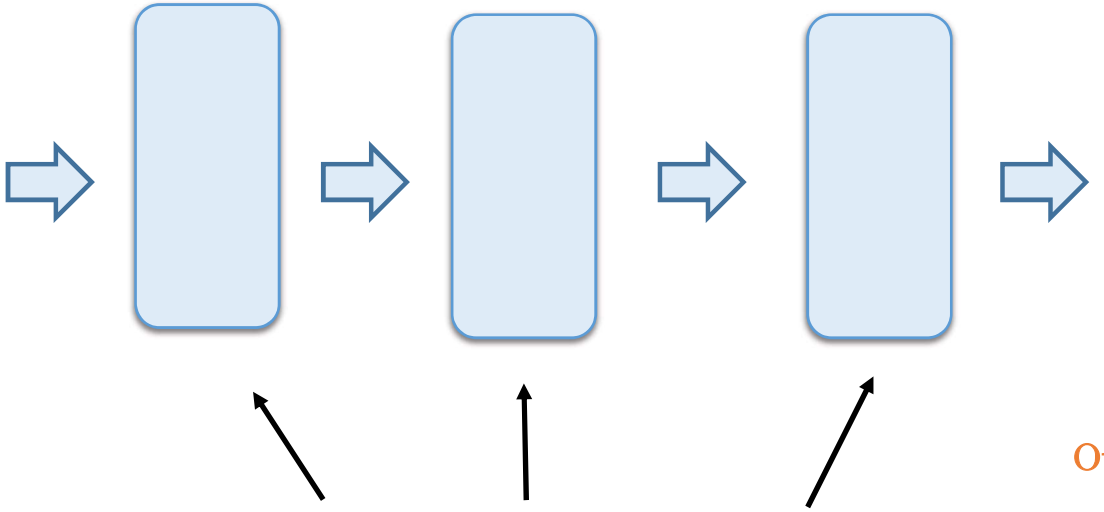
Object detection & recognition





Voice recognition (speech-to-text)

Input of the network

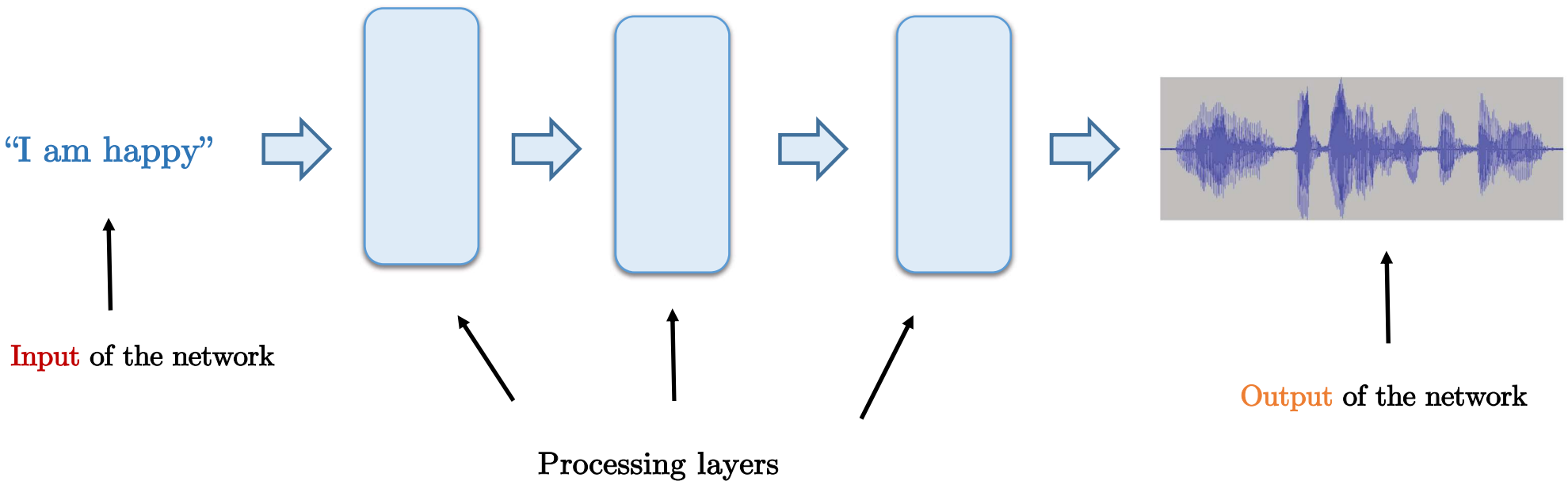


Processing layers

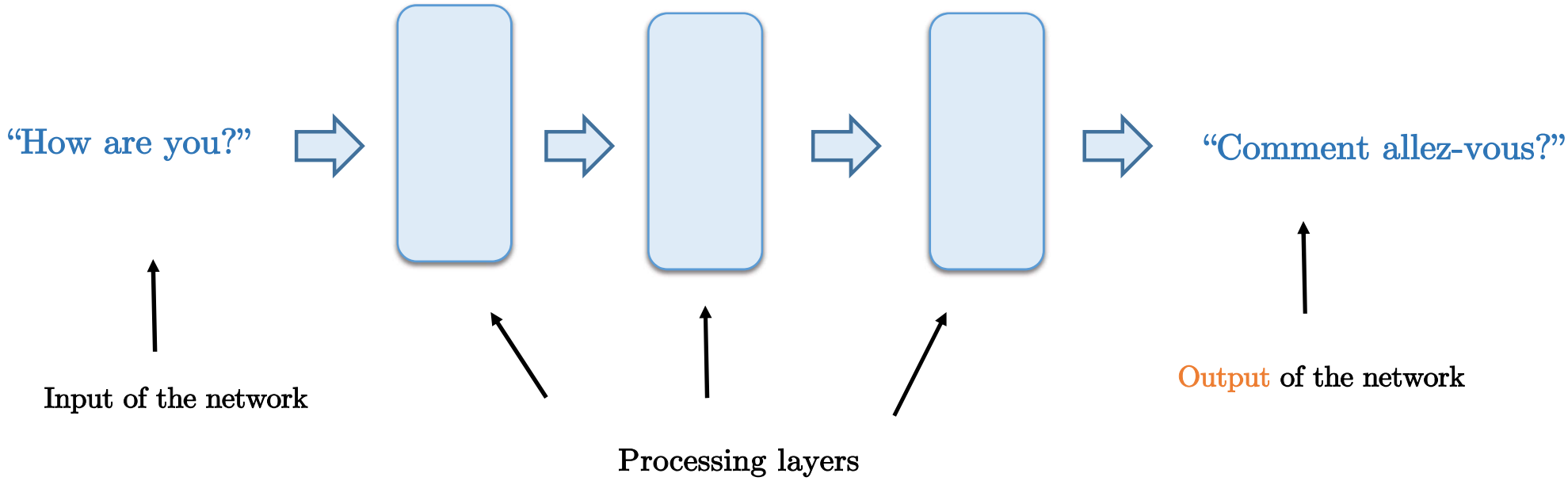
"What is your name?"

Output of the network

Speech Synthesis (text-to-speech)

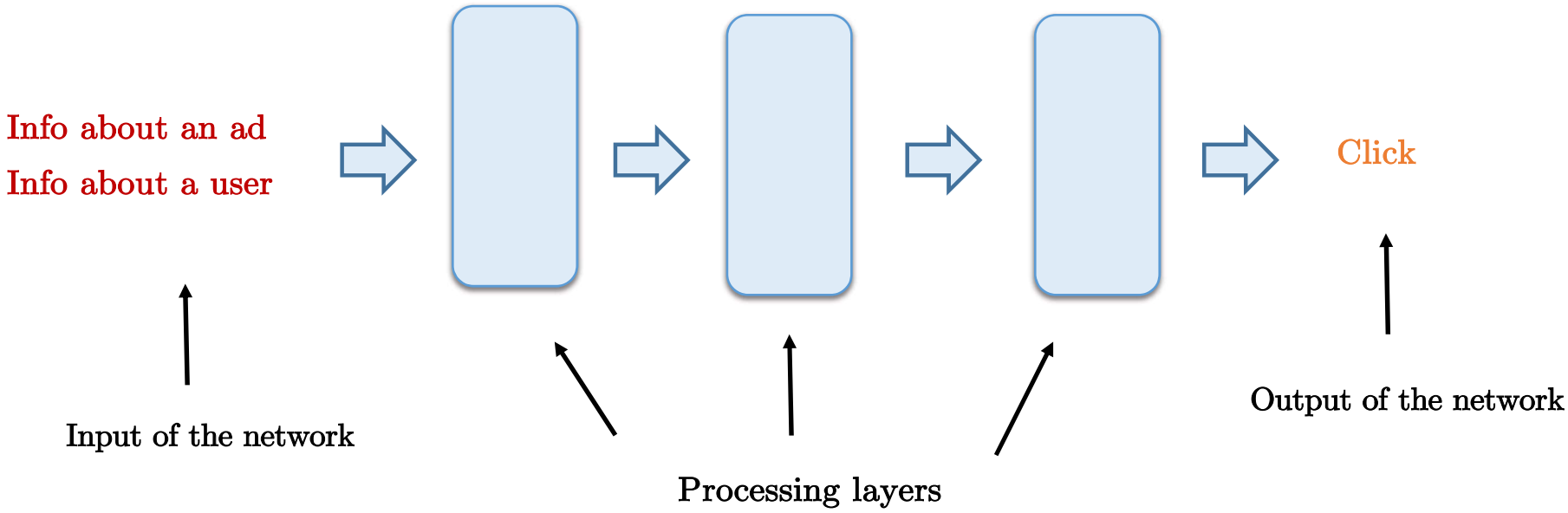


Translation (sequence-to-sequence)



Online advertisement

- Will this user click on this ad?

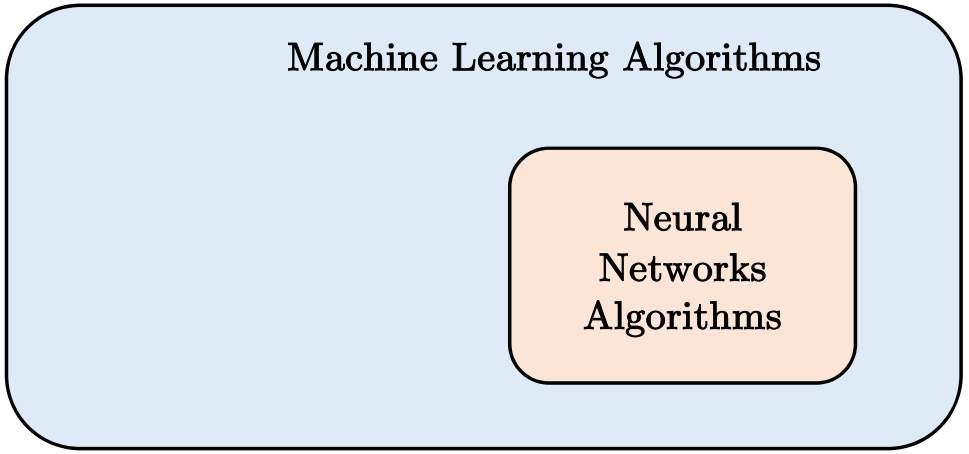


Outline

- AI/DL case studies
- A brief history of DL
- 2012 DL breakthrough
- DL is a universal learning technique
- **Terminology AI/ML/DL**
- Key ingredients of DL
- AI is the new electricity
- Limitations of AI

AI/ML/DL

- A.I. : Artificial intelligence, a vague term that can mean many things (no definition exists).
- Machine learning : Techniques that solve tasks from data learning.
- Deep Learning : Neural networks with many layers
- Nowadays, A.I. advances are exclusively based on deep learning algorithms.

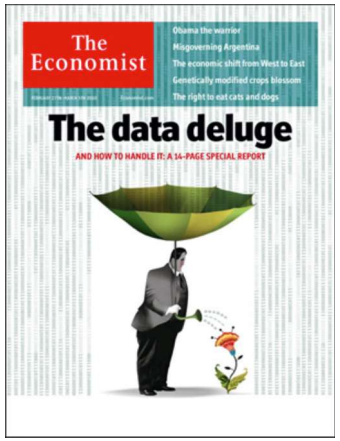


Outline

- AI/DL case studies
- A brief history of DL
- 2012 DL breakthrough
- DL is a universal learning technique
- Terminology AI/ML/DL
- **Key ingredients of DL**
- AI is the new electricity
- Limitations of AI

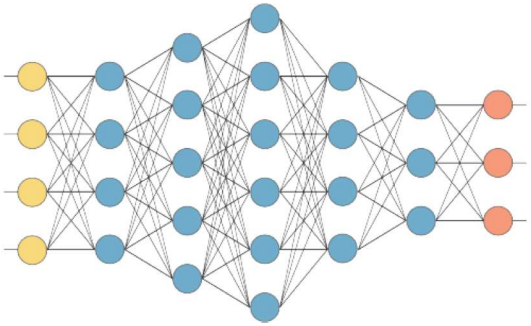
Key successful ingredients

- Deep Learning success = Big data + GPUs + Neural Networks



+

+



Big data

- We live in a digital society:
  - Eric Schmidt : "Every 2 days we create as much information as we did up to 2003."
  - Moore's law of data : Volume of data double every 1.5 years.

- Some datasets:
  - ImageNet : 1.4 millions images
  - Baidu faces : Baidu use a training set of 200 millions images for their face recognition system
  - Translation : Europarl parallel corpus
    - Extracted from the proceedings of the European parliament.
    - 2 million sentences translated in all of the languages of the EU
  - Self-driving cars : Uber's Self-Driving Cars Hit 2 Million Miles

Big data

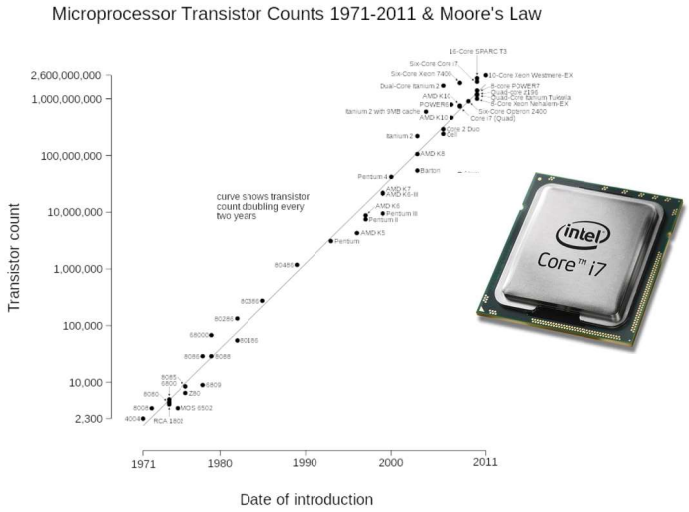
- How much data to get to super-human performances?
  - Rule of thumb: $n=d/\varepsilon$, d number of data features, ε is the accuracy
  - Example: ImageNet $d=256^2 \approx 1M$ and $\varepsilon \approx 1 \Rightarrow n=1.4M$ and 16% error (human error is 5%)
- Collecting data is easy but labeling data is challenging:
  - Labeling is time consuming (each data to a class).
  - It requires humans (learning ability bounded by human intelligence and bias).
  - Some important data is not accessible (e.g. medical data, nuclear meltdown).
- Deep learning is designed for labeled data (supervised learning). It is greedy in (labeled) data.
- Deep learning for unlabeled data is an open problem (unsupervised learning) $\Rightarrow$ Next AI revolution !

Rise of computational power

- Moore's law : 100x faster every decade
  - CPU, GPU, TPU, Cloud computing

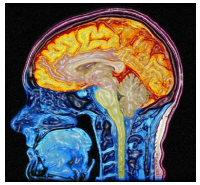
1st GPU in 1999

Amazon cloud in 2006



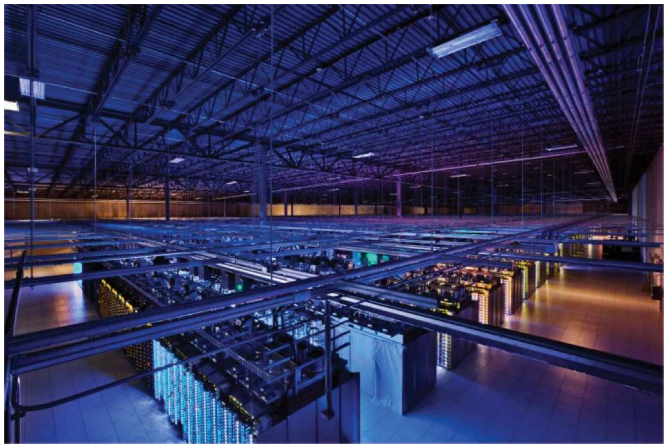
- Brain has 10^{14} synapses/10^3 Tflops = Computers in 2030 (100 times faster than today)

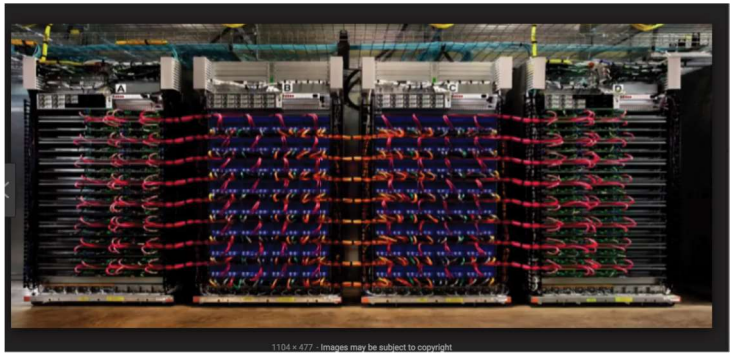
2030
=



Deep learning infrastructure

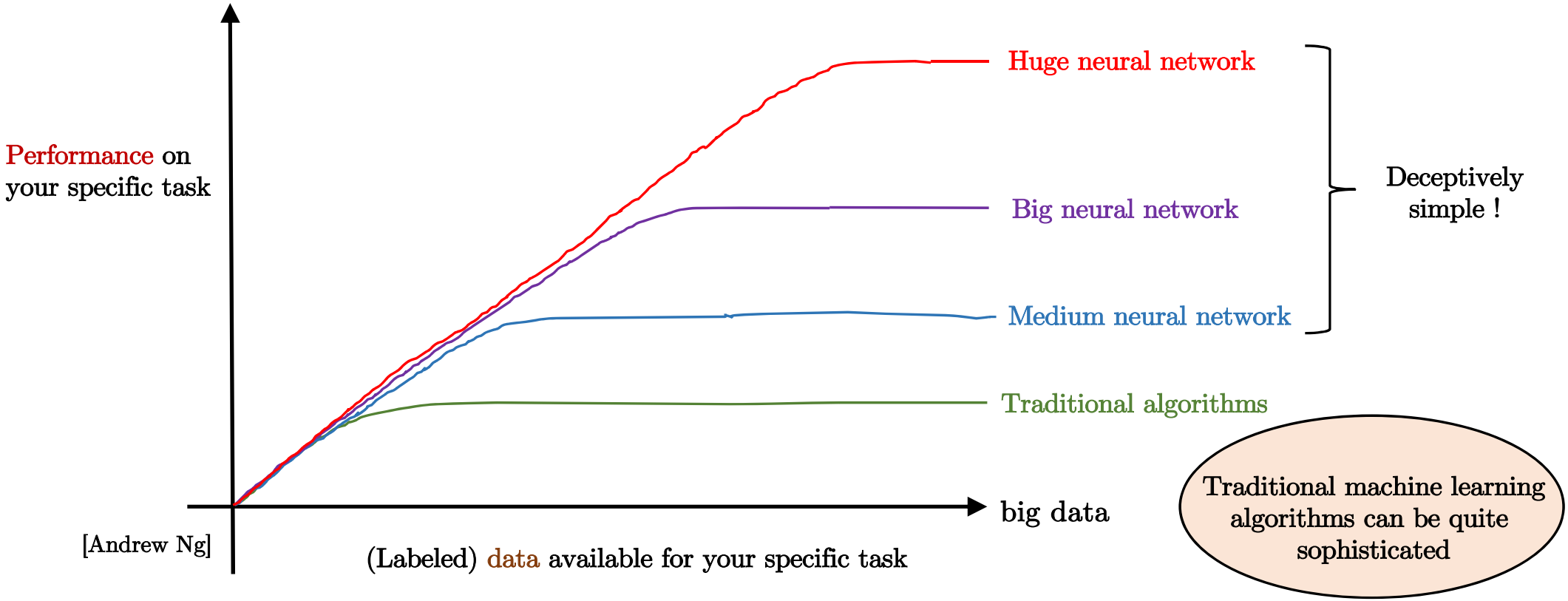
- Google Tensor Processing Unit (TPU) :
  - 2013: Google projects that they would need to double their datacenter to meet demand for speech recognition.
  - The TPU was designed, verified, built and deployed in data centers in just 15 months.





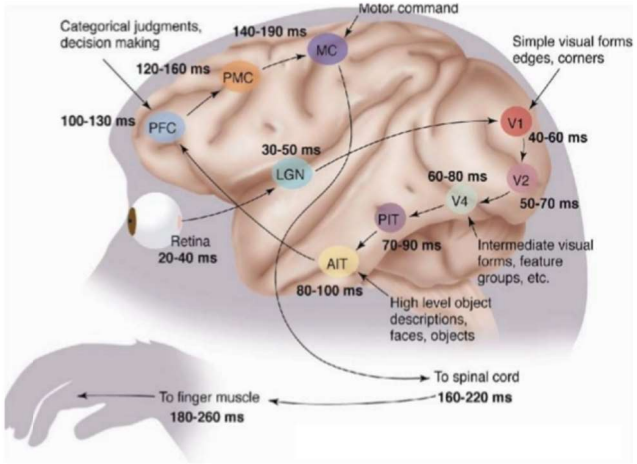
Machine learning algorithms

- Only deep learning systems are able to absorb (exploding) big data :

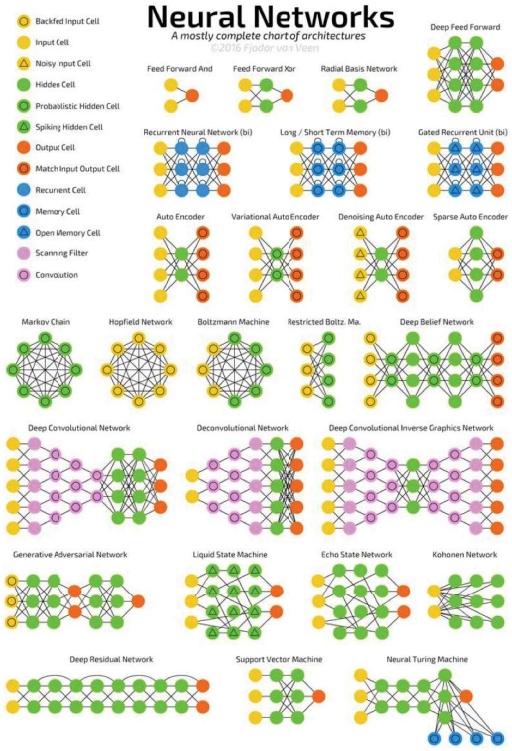


Deep learning architectures

- Most research works focus on the best architecture that solves a specific task (there is no DL model that can solve several tasks like the human brain).



Biological neural network



Artificial neural networks

- Most successful architectures:
  - Convolutional Neural Networks: Computer Vision, Video
  - Recurrent Neural Networks: NLP, Machine translation, speech-to-text


G. Hinton


Y. LeCun


Y. Bengio


Y. Schimdhuber

Turin Award 2019 !

Outline

- AI/DL case studies
- A brief history of DL
- 2012 DL breakthrough
- DL is a universal learning technique
- Terminology AI/ML/DL
- Key ingredients of DL
- **AI is the new electricity**
- Limitations of AI

AI is the new electricity

- "AI is the new electricity" - Andrew Ng

  Electricity has changed the whole industry, sector after sector like transport, manufacturing, agriculture, etc ⇒ AI has the same potential.

- Industrial revolutions :
  - 1st industrial revolution (machine revolution) [1760-1840]: From hand-tools to first machines (agriculture)
  - 2nd industrial revolution (electrical revolution) [1870-1914]: From mechanical machines to electricity
  - 3rd industrial revolution (digital revolution) [1947-2012]: From analogue electronic technology to digital (internet, smartphones)
  - 4th industrial revolution (smart digital revolution) [2012-]: From digital data to augmented intelligence

Outline

- AI/DL case studies
- A brief history of DL
- 2012 DL breakthrough
- DL is a universal learning technique
- Terminology AI/ML/DL
- Key ingredients of DL
- AI is the new electricity
- **Limitations of AI**

Current state of AI

- Modern AI breakthrough started in 2012 and there is no coming back – AI will be part of any machine systems.
- AI has a few impressive results but AI is in its infancy – immature engineering field (solutions are empirical, not robust, not scalable, not transferable).
- It will take (at least) a decade to develop a solid software, a hardware environment and a mathematical framework (statistics, optimization, etc) for AI.
- AI is a buzzword – Machine learning and data science are better names.
- Success is limited to perceptual tasks (vision, hearing) – no breakthrough results in cognitive tasks (reasoning, planning, common sense).

AI vs IA

- AI (Artificial Intelligence):
  - Terminator, Hollywood movies – Machines take over the world.
  - No sense
  - Definition of intelligence is unclear.

M. Jordan

- IA (Intelligence Augmentation):
  - Lots of sense – under development (will have a huge impact in our lives)
  - Better search engines, recommendation systems, natural language translation, Q&A's.
  - Augment people skills.

What is possible and not yet possible?

- Computer vision
  - Possible: Labeling of objects in visual scenes
  - Not yet possible: Predict what happens next, common-sense understanding of visual scenes
- Speech analysis
  - Possible: Speech-to-text and text-to-speech in many languages
  - Not yet possible: Common-sense understanding of auditory scenes
- Natural language processing
  - Possible: Adequate translation and Q&A (chatbot)
  - Not yet possible: Semantic/abstraction understanding of language, human-level dialog (Turing test)
- Robotics
  - Possible: Industrial programmed robots
  - Not yet possible: Robots that interact with humans and are autonomous.

Questions?