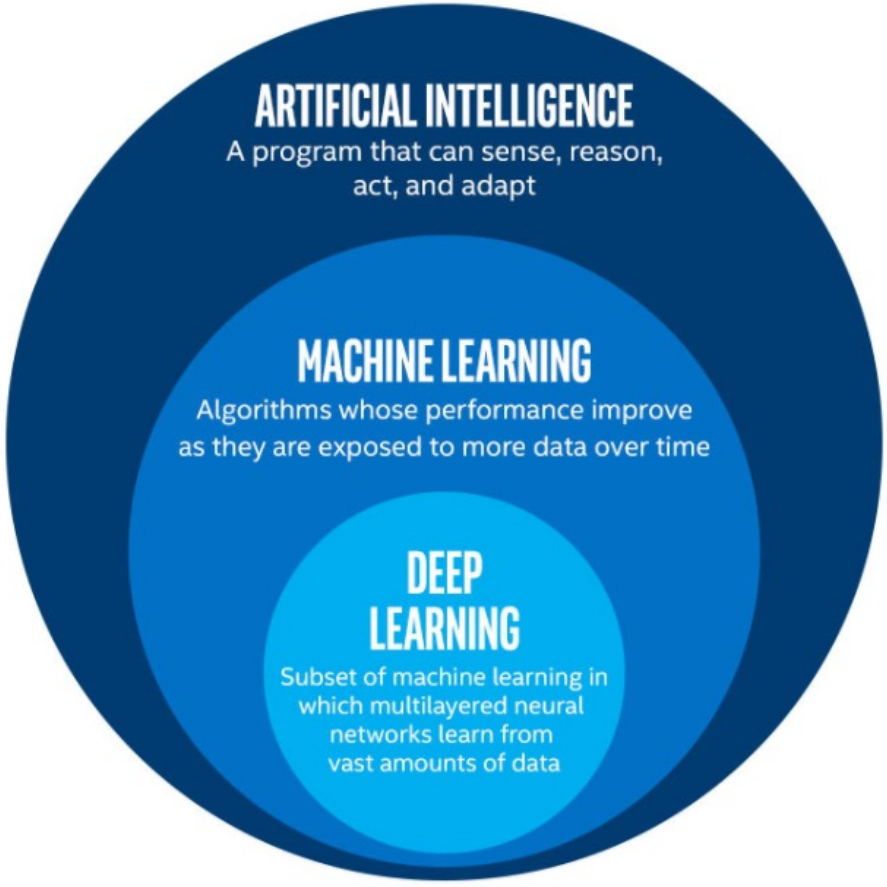
Introduction to Machine Learning

Introduction



What is machine learning?

For many problems, it's difficult to program the correct behavior by hand

- recognizing people and objects
- understanding human speech

Machine learning approach: program an algorithm to automatically learn from data, or from experience

Some reasons you might want to use a learning algorithm:

- hard to code up a solution by hand (e.g. vision, speech)
- system needs to adapt to a changing environment (e.g. spam detection)
- want the system to perform better than the human programmers
- privacy/fairness (e.g. ranking search results)

What is machine learning?

Types of machine learning

- **Supervised learning**: have labeled examples of the correct behavior
- **Reinforcement learning**: learning system receives a reward signal, tries to learn to maximize the reward signal
- **Unsupervised learning**: no labeled examples – instead, looking for interesting patterns in the data

What is machine learning?

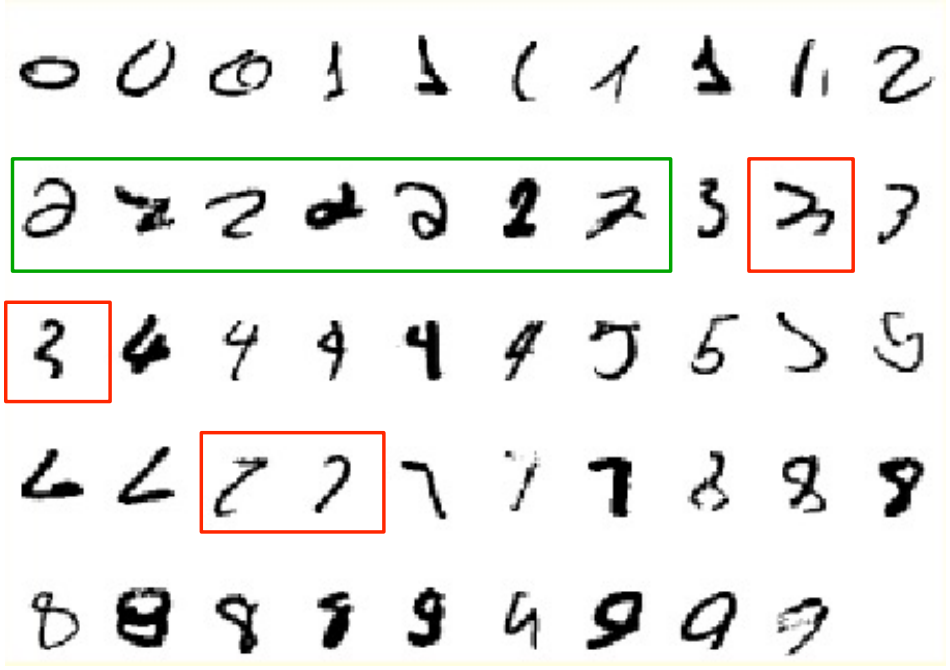
Supervised learning: have labeled examples of the correct behavior

e.g. Handwritten digit classification with the MNIST dataset

- **Task**: given an image of a handwritten digit, predict the digit class
  - **Input**: the image
  - **Target**: the digit class
- **Data**: 70,000 images of handwritten digits labeled by humans
  - **Training set**: first 60,000 images, used to train the network
  - **Test set**: last 10,000 images, not available during training, used to evaluate performance
- This dataset is the "fruit fly" of neural net research
- Neural nets already achieved > 99% accuracy in the 1990s, but we still continue to learn a lot from it

Supervised learning examples

What makes a “2”?



Supervised learning examples

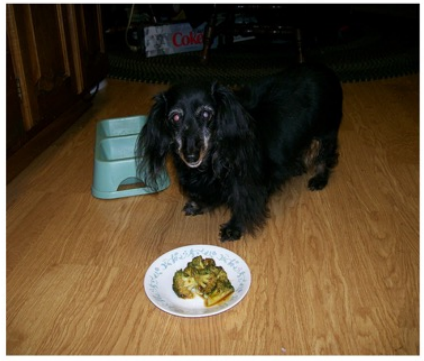
Caption generation

Only G: a car is driving down a street.

G+SA: a car is driving down a street with a traffic light.

G+SA+OA: a car is driving down a street with a group of people in the background.

(a)



Only G: a black dog sitting on the floor.

G+SA: a black dog sitting on the floor with a plate of food.

G+SA+OA: a black dog sitting on a wooden floor next to a plate of food.

(b)

Only G: a passenger jet sitting on the ground.

G+SA: a large passenger jet sitting on top of an airport tarmac.

G+SA+OA: a large passenger jet sitting on top of an airport tarmac next to a man.

(c)

Only G: a fire hydrant sitting on a sidewalk.

G+SA: a fire hydrant sitting in the middle of a sidewalk.

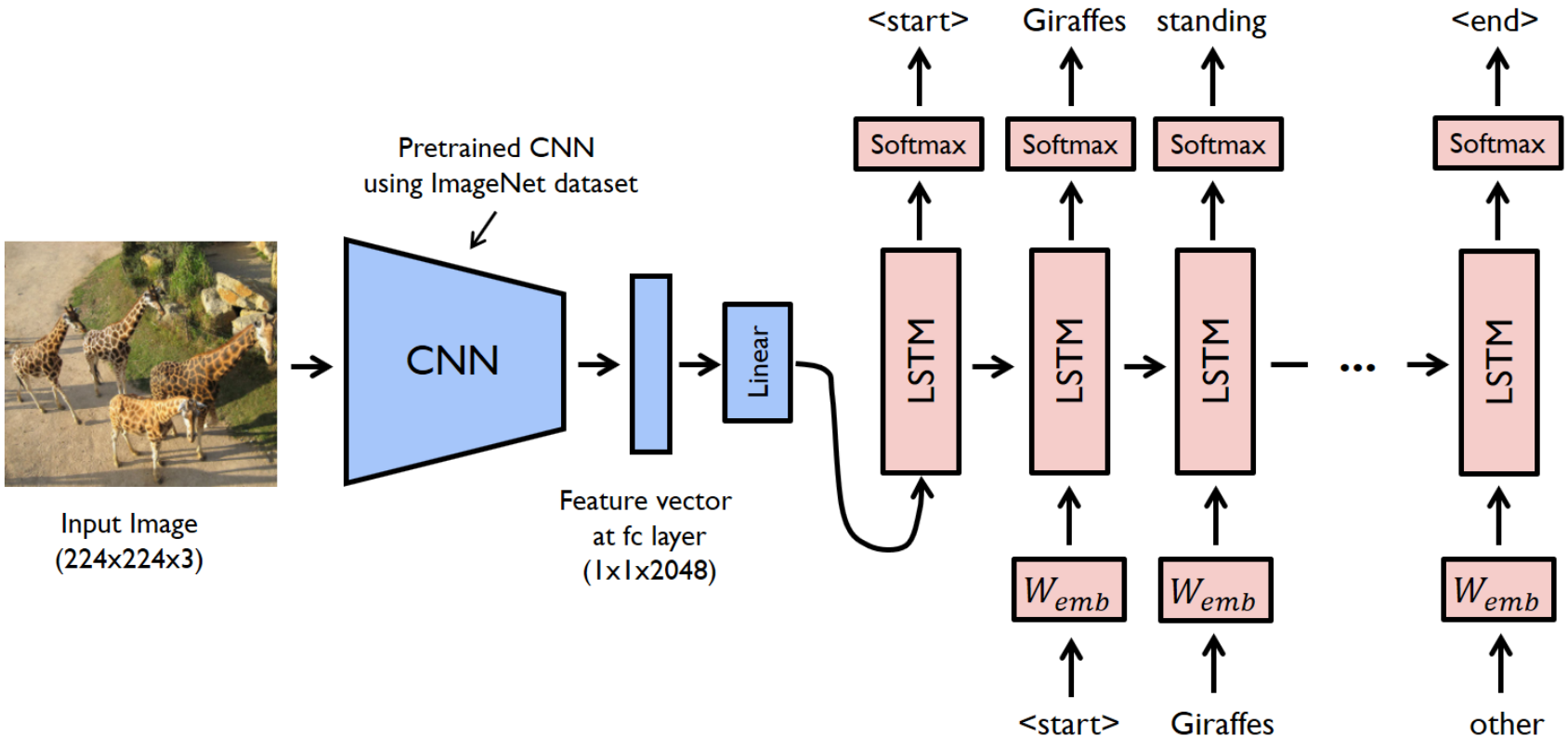
G+SA+OA: a yellow fire hydrant sitting on the side of a road.

(d)

G: global image feature; **SA**: spatial attention; **OA**: object attention.

Supervised learning examples

Caption generation



Supervised learning examples

Caption generation

A woman is throwing a frisbee in a park.

A dog is standing on a hardwood floor.

A stop sign is on a road with a mountain in the background.

A little girl sitting on a bed with a teddy bear.

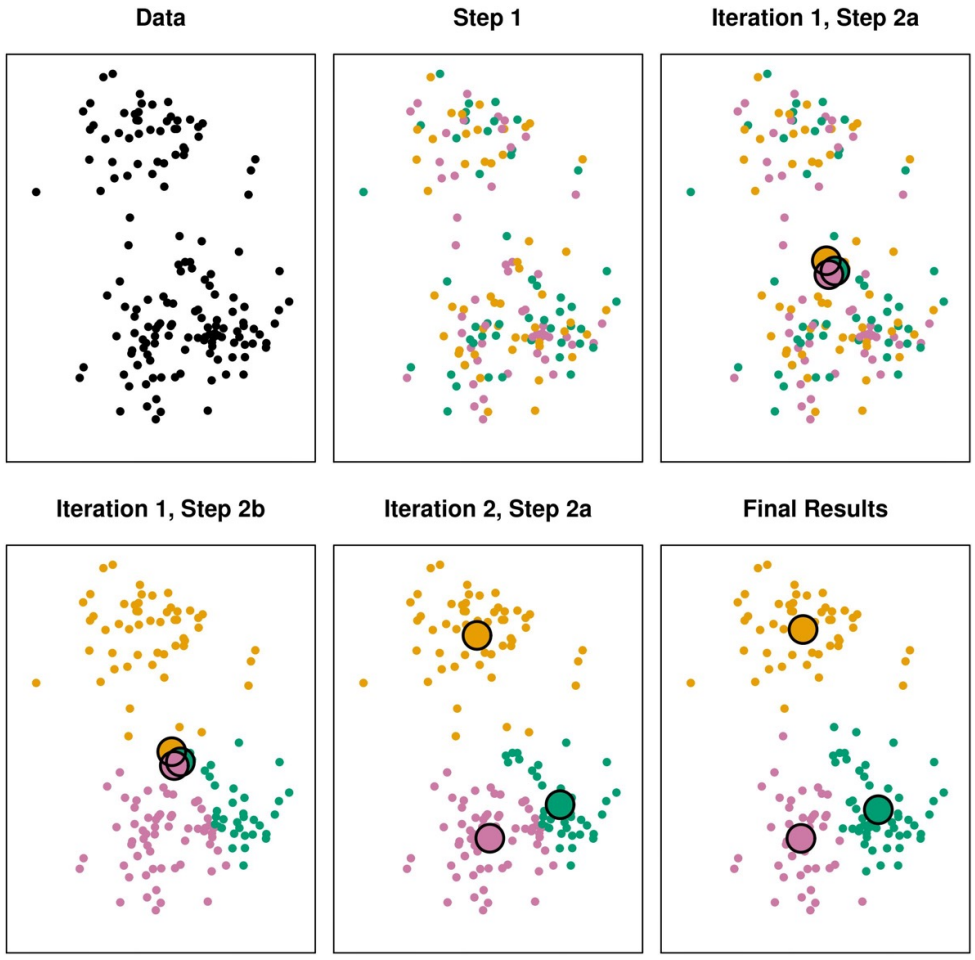
A group of people sitting on a boat in the water.

A giraffe standing in a forest with trees in the background.

Image captioning with attention

Unsupervised learning examples

- K-means clustering



K-means clustering iterations

Generative model

- In **generative modeling**, we want to learn a distribution over some dataset, such as natural images.

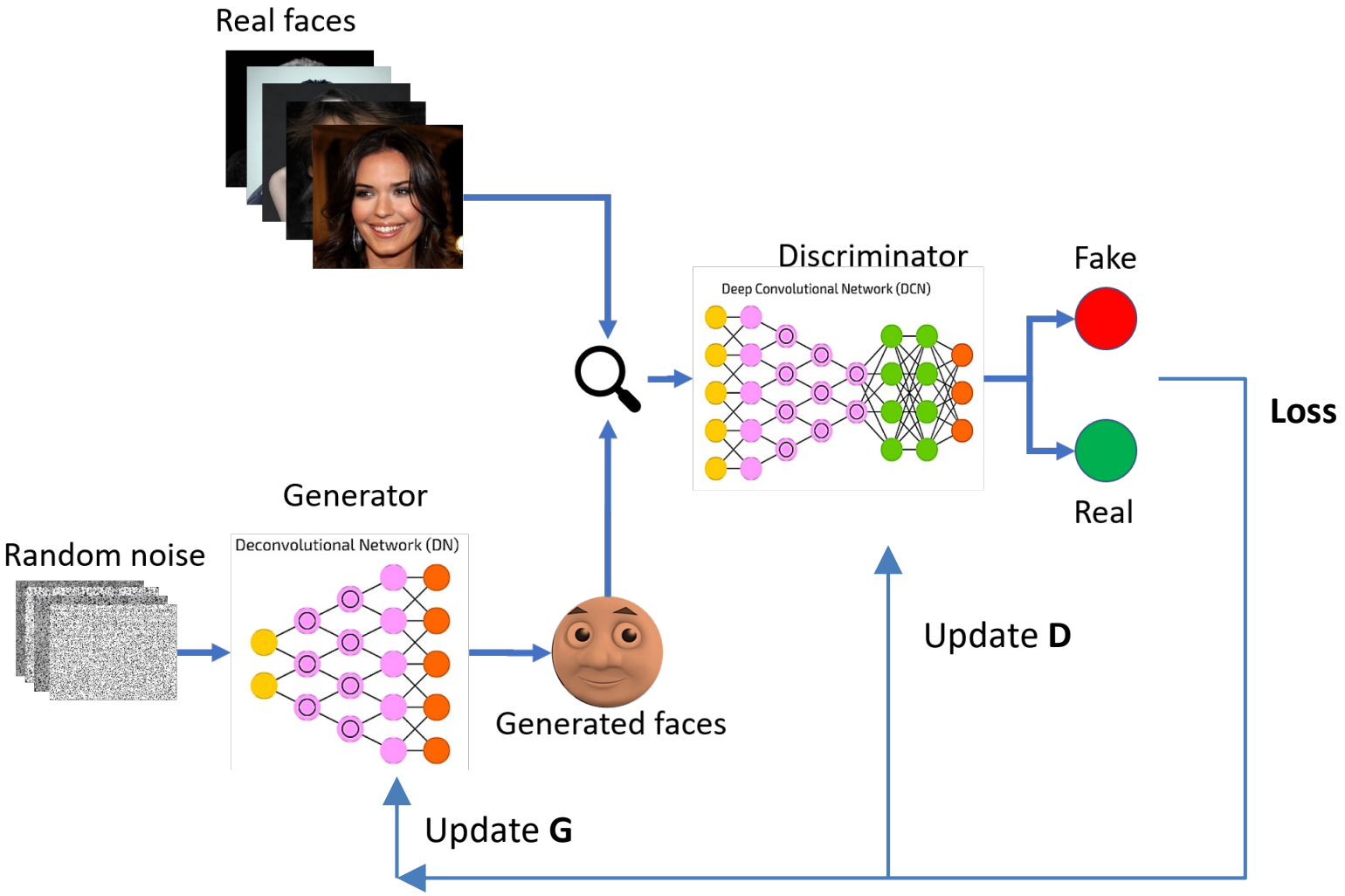
Noise ~ N(0,1)

Generative Model

Generative Adversarial Network (GAN)

Generative model

Generative Adversarial Network (GAN)



Generative model

Generative Adversarial Network (GAN)

Generative model

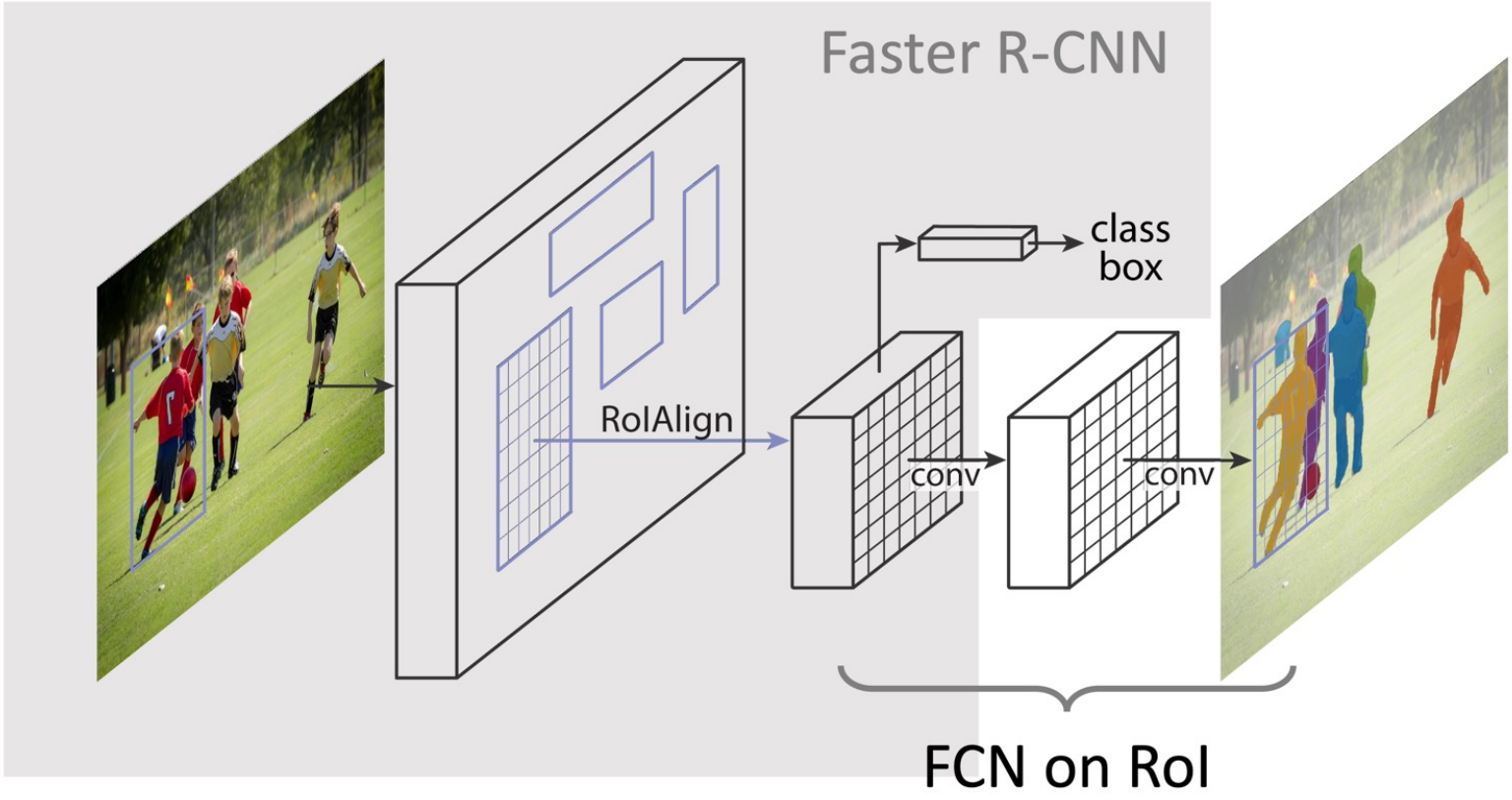
Recent exciting result: a model called the **CycleGAN** takes lots of images of one category (e.g. horses) and lots of images of another category (e.g. zebras) and learns to translate between them.

CycleGAN

Deep learning

Deep learning: many layers (stages) of processing

E.g. this network can recognize and segment objects in images

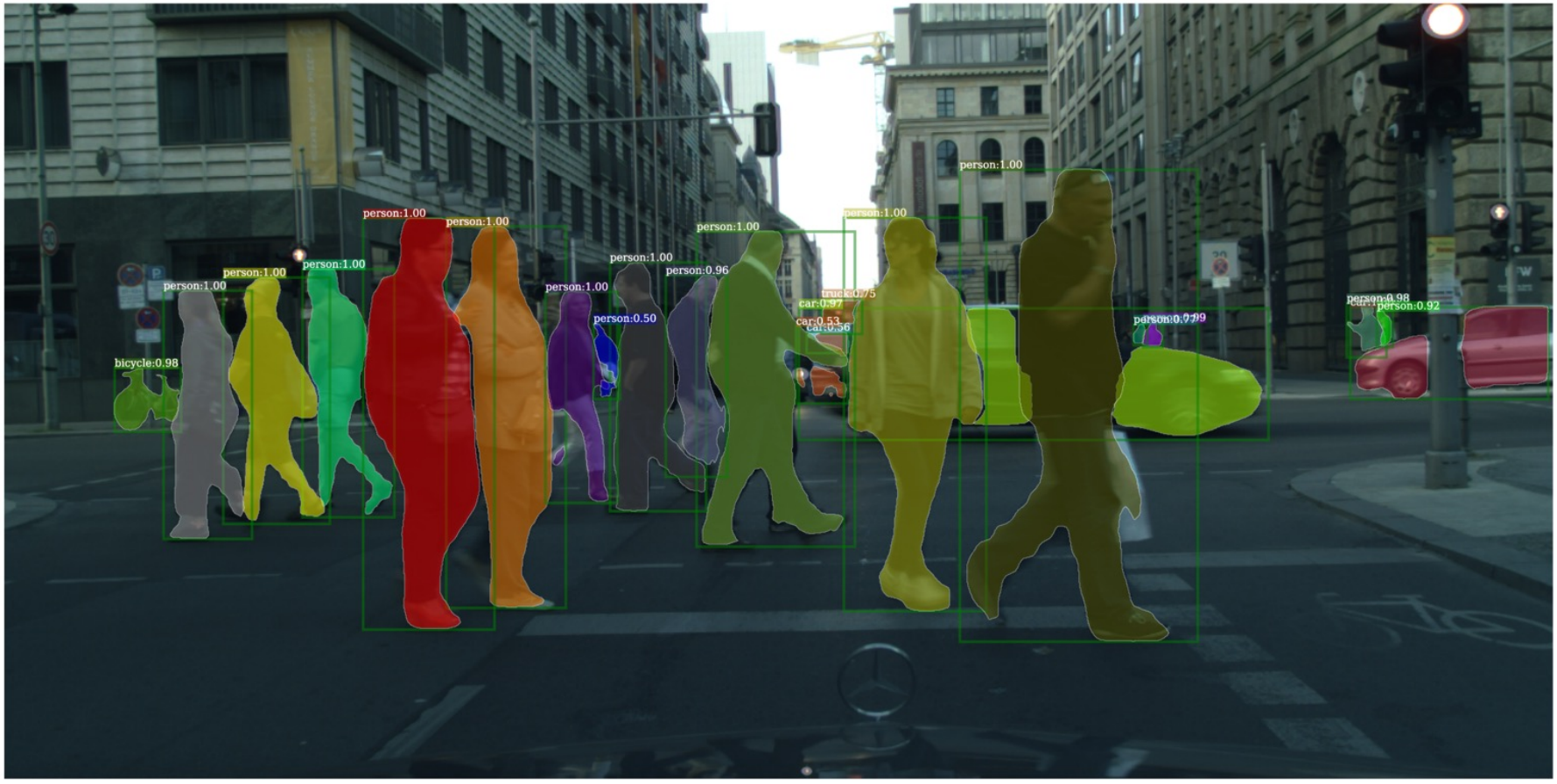


Mask R-CNN

Deep learning

Deep learning: many layers (stages) of processing

E.g. the network can recognize and segments objects in images



Mask R-CNN results on CityScapes

What are neural networks?

Why neural nets?

- Inspiration from the brain: proof of concept that a neural architecture can see and hear!
- Very effective across a range of applications (vision, text, speech, medicine, robotics, etc.)
- Widely used in both academia and the tech industry
- Powerful software frameworks let us quickly implement sophisticated algorithms

Software frameworks

Array processing (NumPy)

- **Vectorize** computations (express them in terms of matrix/vector operations) to exploit hardware efficiency

Neural net frameworks:

- Automatic differentiation
- Compiling computation graphs
- Libraries of algorithms and network primitives
- Support for graphics processing units (**GPUs**)

Book for this course:

- **Deep Learning**, Ian Goodfellow and Yoshua Bengio and Aaron Courville http://www.deeplearningbook.org/

Q&A

Thank you