Workshop: Building your first Convolutional Neural Network

Domen Rački, Andraž Mehle | Ljubljana, December 2018

Foreword

- The workshop is split into two parts

- Part 1: Intuitive deep-learning crash course
  - Domen Rački

- Part 2: Implementation example in Python with Keras and Tensorflow
  - Andraž Mehle
  - https://github.com/MehoMehoMeho/Fashion_MNIST_example

- The workshop's sponsor is
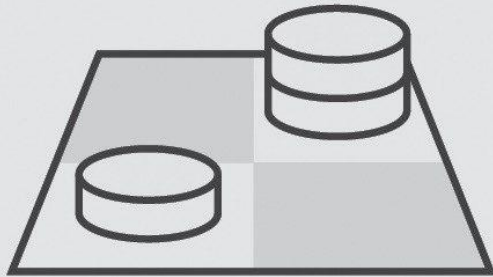 Sensum, Computer Vision Systems
  - www.sensum.eu
  - jobs@sensum.eu

What is deep learning?

ARTIFICIAL INTELLIGENCE

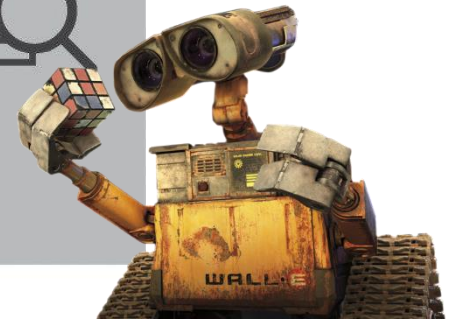Artificial Intelligence captures the imagination of the world.

MACHINE LEARNING

Machine learning starts to gain traction.

DEEP LEARNING

Deep learning catapults the industry.

Edward Shortliffe writes MYCIN, an Expert or Rule based System, to classify blood disease 1970s

ImageNet Feeds Deep Learning 2009

Turing Test Devised 1950

ELIZA 1964 - 1966

IBM Deep Blue defeats Grand Master Garry Kasparov in chess 1996

AlphaGo defeats Go champion Lee Sedol 2016

1950s	1960s	1970s	1980s	1990s	2000s	2010s

What is deep learning?

- ## Artificial Intelligence (AI)
  - Any algorithm or process that enables machines to mimic, develop and demonstrate human 'cognitive' functions such as 'learning' and 'problem solving'
  - You would need a lot of experience to devise some type of algorithm

- ## Machine Learning (ML)
  - Algorithms and statistical methods that give machines the ability to 'learn' from some form of data representation without being explicitly programmed
  - You would need formatted data and relevant statistical knowledge

- ## Deep Learning (DL)
  - Algorithms and methods based on learning data representations, opposed to task-specific algorithms
  - You will learn how to classify fashion objects in less than one hour
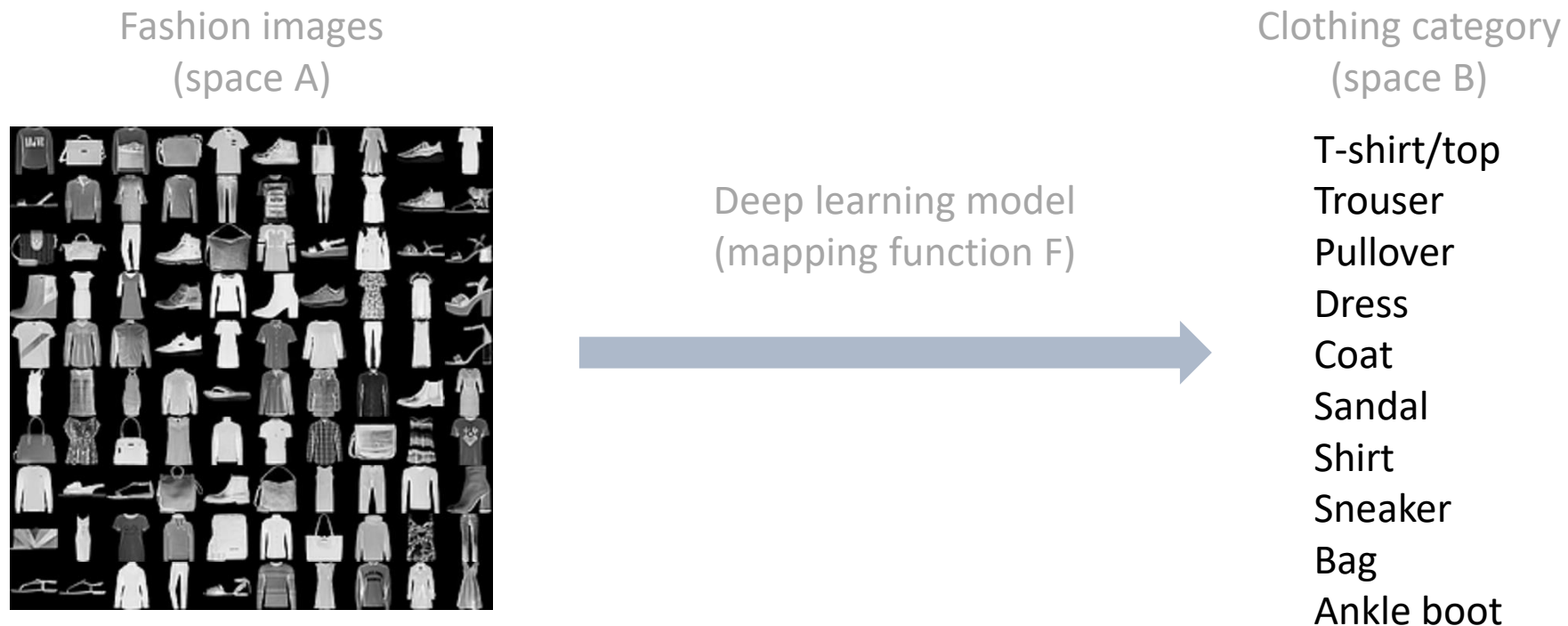
[Slide credit: Wikipedia]

Why is deep learning useful?

- Deep learning removes the manual identification of features in data
- It relies on a training process in order to discover useful patterns
- This makes training a neural network easier and faster
- Solves problems that were very hard to solve beforehand

- Deep learning is used for:
  - Image object detection and classification
  - Voice recognition and language translation
  - Text generation and image captioning
  - Autonomous vehicles and pedestrian detection
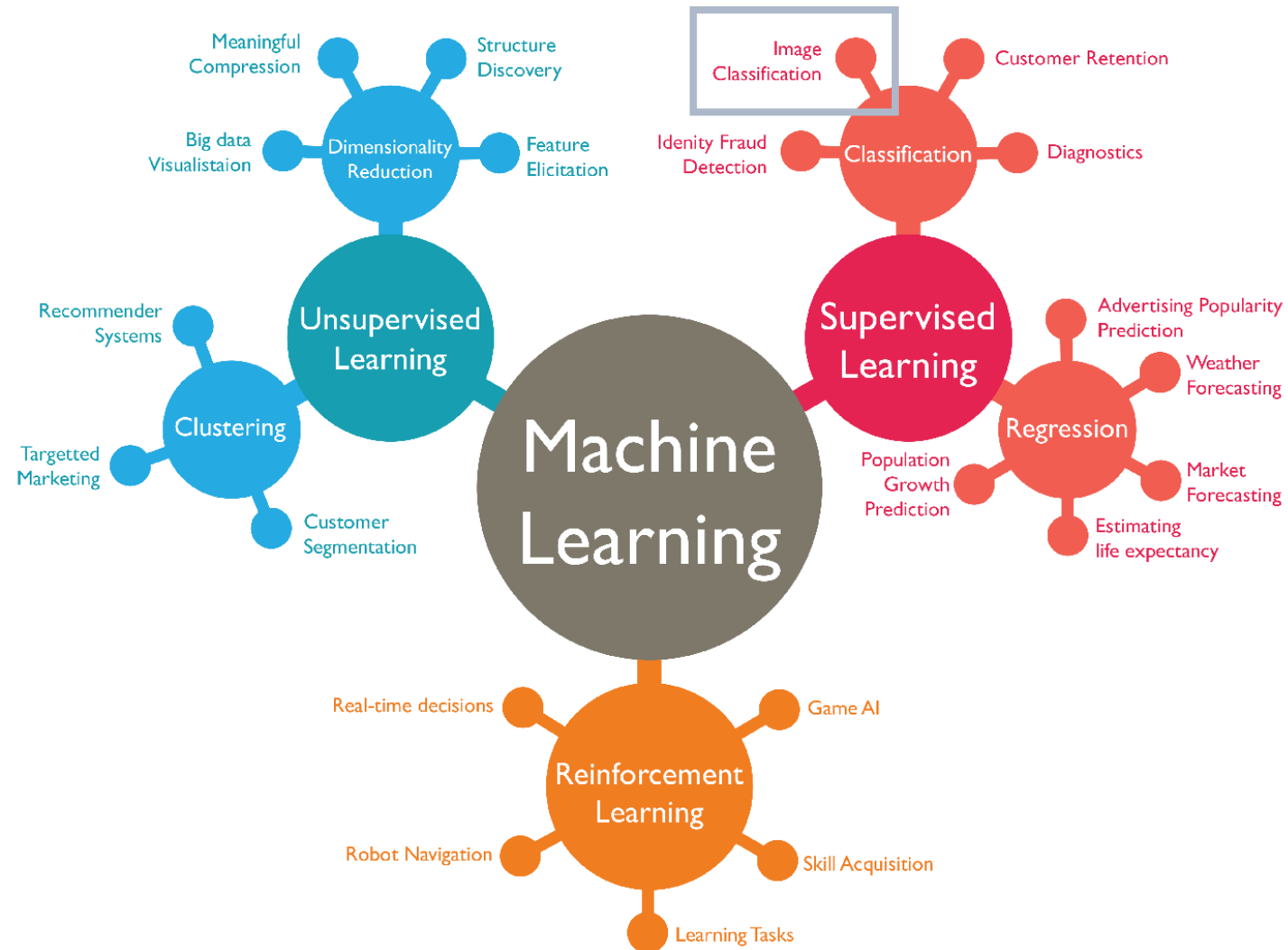 - Coloring black-and-white images and videos

Deep learning is a mapping

- A mapping from some space A to some space B
- Via some mapping function F (deep learning model)

Fashion images
(space A)

Clothing category
(space B)

Deep learning model
(mapping function F)

T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot

[Han Xiao et. al., Fashion-MNIST]

Different types of learning

[Image credit: kisspng.com]
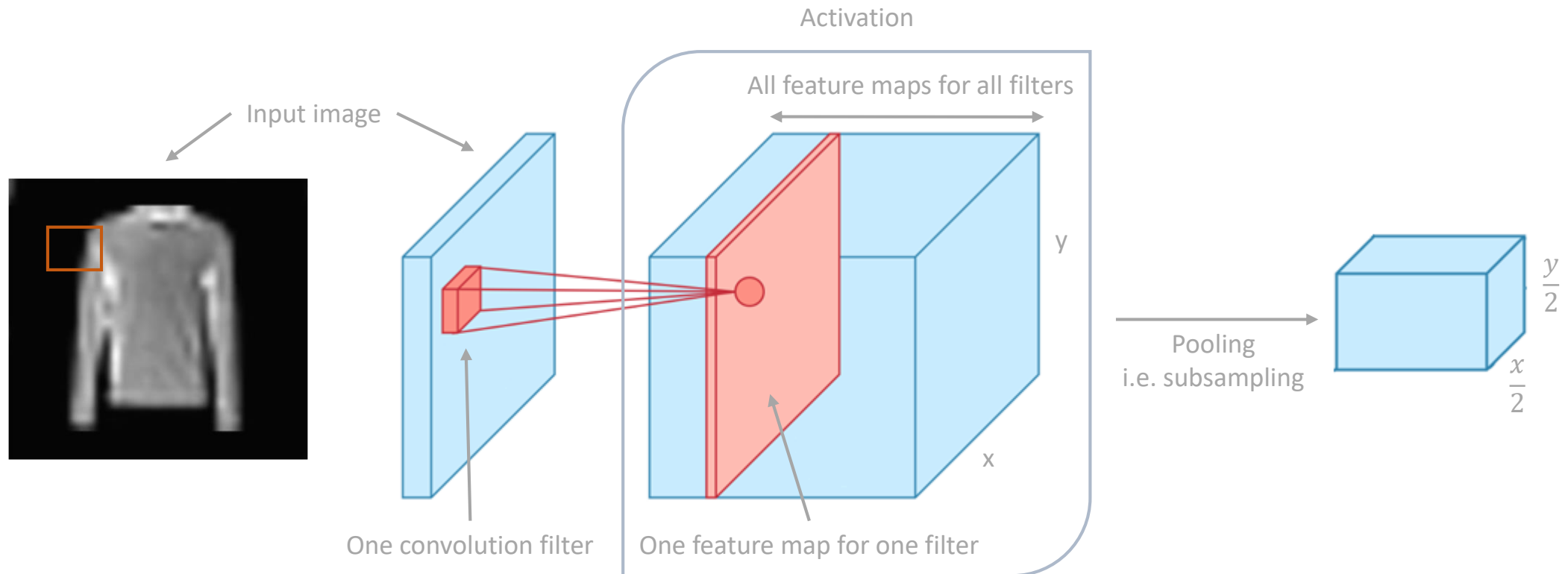
What is a Neural Network?

- Mathematical model vaguely inspired by biological neural networks in the brain
- Why is it called deep learning?
  - Because learning is done with a grater number of (hidden) layers
- What is a Convolutional Neural Network (CNN)?
  - A class of neural networks commonly applied to analysing images
  - More precisely, analysing image pixels via the convolution operation
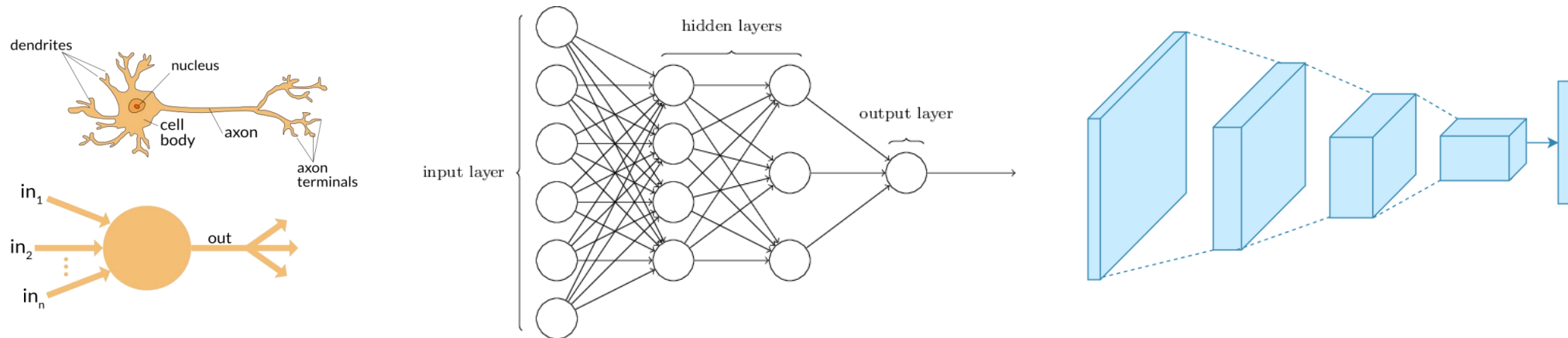
[Image credit: analyticsvidhya.com, neuralnetworksanddeeplearning.com, Applied Deep Learning]

How does a CNN work?

- Convolution, activation, pooling, repeat

Activation

All feature maps for all filters

Input image

One convolution filter

One feature map for one filter

Pooling
i.e. subsampling

$\frac{y}{2}$

$\frac{x}{2}$

[Image credit: A. Dertat, Applied Deep Learning]

How do I do deep learning?

- Step 0: Set up a DL environment
- Step 1: Split your data
- Step 2: Construct a model
- Step 3: Choose a loss function
- Step 4: Choose an optimization algorithm
- Step 5: Train and evaluate your network

Setting up a DL environment

- Step 1: Download and Install Anaconda 3.7
  - `https://www.anaconda.com/download/`

- Step 2: Set up Anaconda environment
  - Open console and create anaconda environment:
    `conda create -n tfenv python=3.5 anaconda`

- Step 3: Install Tensorflow
  - Activate anaconda environment: `activate tfenv`
  - Install tensorflow: `pip install --ignore-installed --upgrade https://storage.googleapis.com/tensorflow/windows/cpu/tensorflow-1.12.0-cp35-cp35m-win_amd64.whl`

- Step 4: Check Tensorflow version:
  - `ipython`
  - `import tensorflow as tf`
  - `tf.__version__`
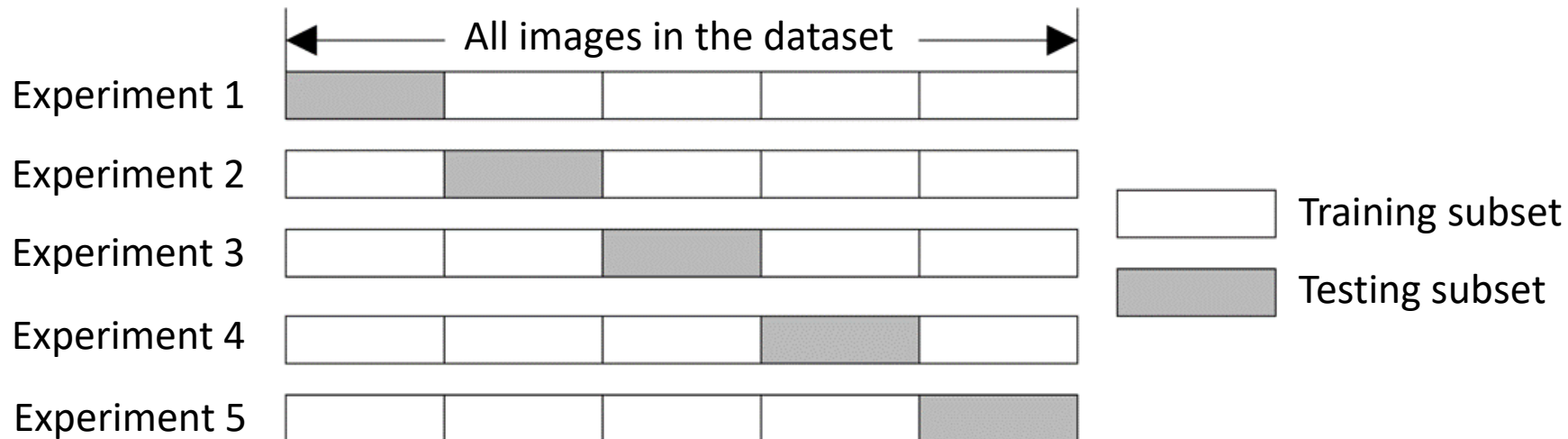
Split your data

- Split your data into a training and testing set
  - To see if your algorithm really learned anything

- Make sure that:
  - Your training and test sets do not overlap
  - Your sets are large enough to yield meaningful results
  - Your sets are representative of your problem

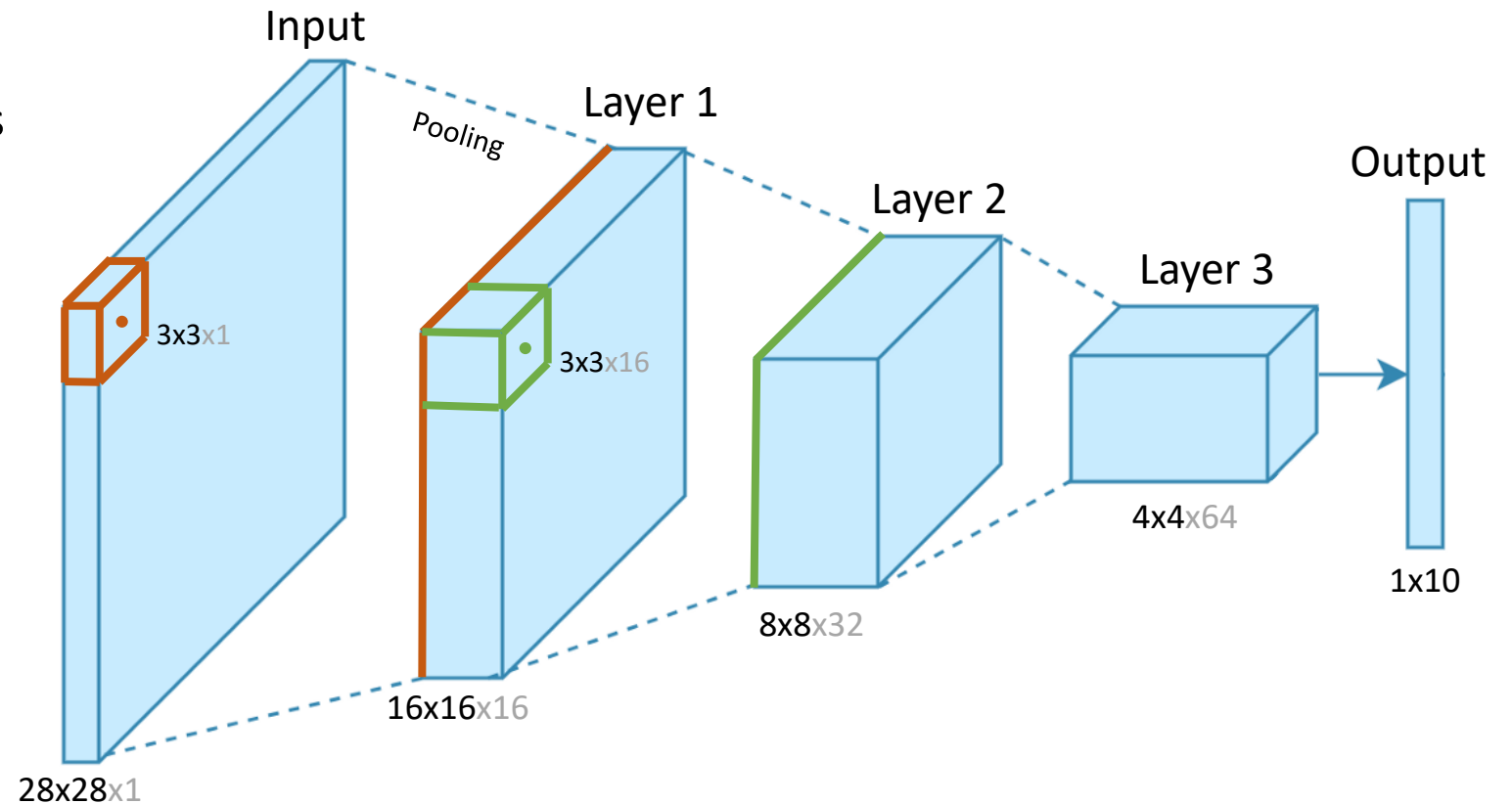- A less biased approach is k-fold cross validation

Training set

Testing set

All images in the dataset

Experiment 1

Experiment 2

Experiment 3

Experiment 4

Experiment 5
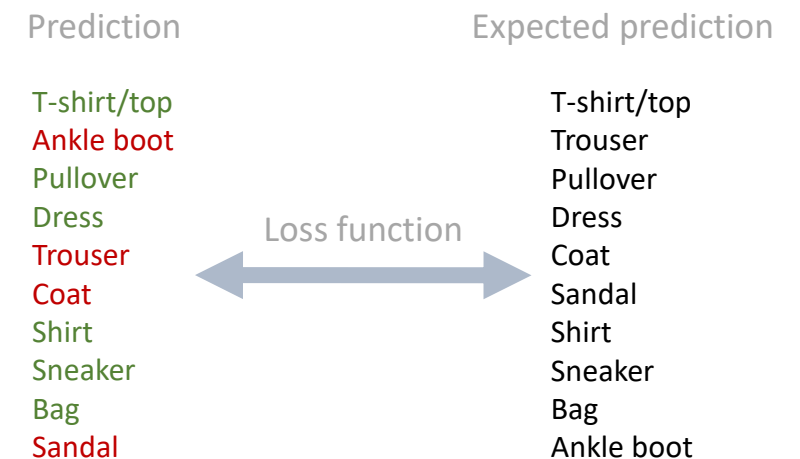
Training subset

Testing subset

[Image credit: DanB, kaggle.com]

Construct a model

- My inputs are grayscale images of size 28x28x1 pixels

- My model will have 3 layers with 16, 32 and 64 filters

- My filters will be 3x3 pixels and I will subsample by a factor of 2 in each layer

- I want to classify my image into one of 10 categories

Input

Layer 1

Pooling

Layer 2

Layer 3

Output

3x3x1

3x3x16

4x4x64

1x10

8x8x32

16x16x16

28x28x1

Choose a loss function

- **What does a loss function do?**
  - It shows you how 'wrong' your predictions are form your expected predictions

- **Which loss function should I pick?**
  - This depends on your specific problem
  - Generally the one that works best

- **Classification problem**
  - You want to predict a discrete category
  - Cross-entropy is preferred

- **Regression problem**
  - You want to predict a continuous number
  - Mean squared error is preferred

Prediction

T-shirt/top
Ankle boot
Pullover
Dress
Trouser
Coat
Shirt
Sneaker
Bag
Sandal

Loss function

Expected prediction

T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot

Choose an optimization algorithm

- **What does an optimization algorithm do?**
  - It 'adjusts' your model so that next time around the predicted accuracy improves

- **Which optimization algorithm should I pick?**
  - This depends on your specific problem
  - Generally the one that works best

- **Usually the Adam optimizer is used**

- **What does a learning rate do?**
  - It controls how much your model is 'adjusted'
  - Usually a learning rate around 0.001 is a good choice

CNN model

Optimization algorithm
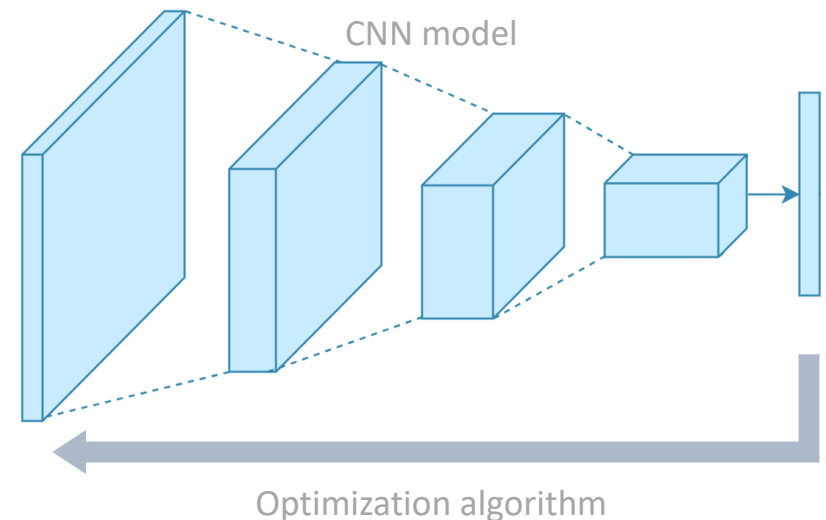
Train and evaluate your network

- Show the training set to the network 100 times and show the testing set only once
  - Train my network for 100 epochs on the training set and evaluate it on the test set
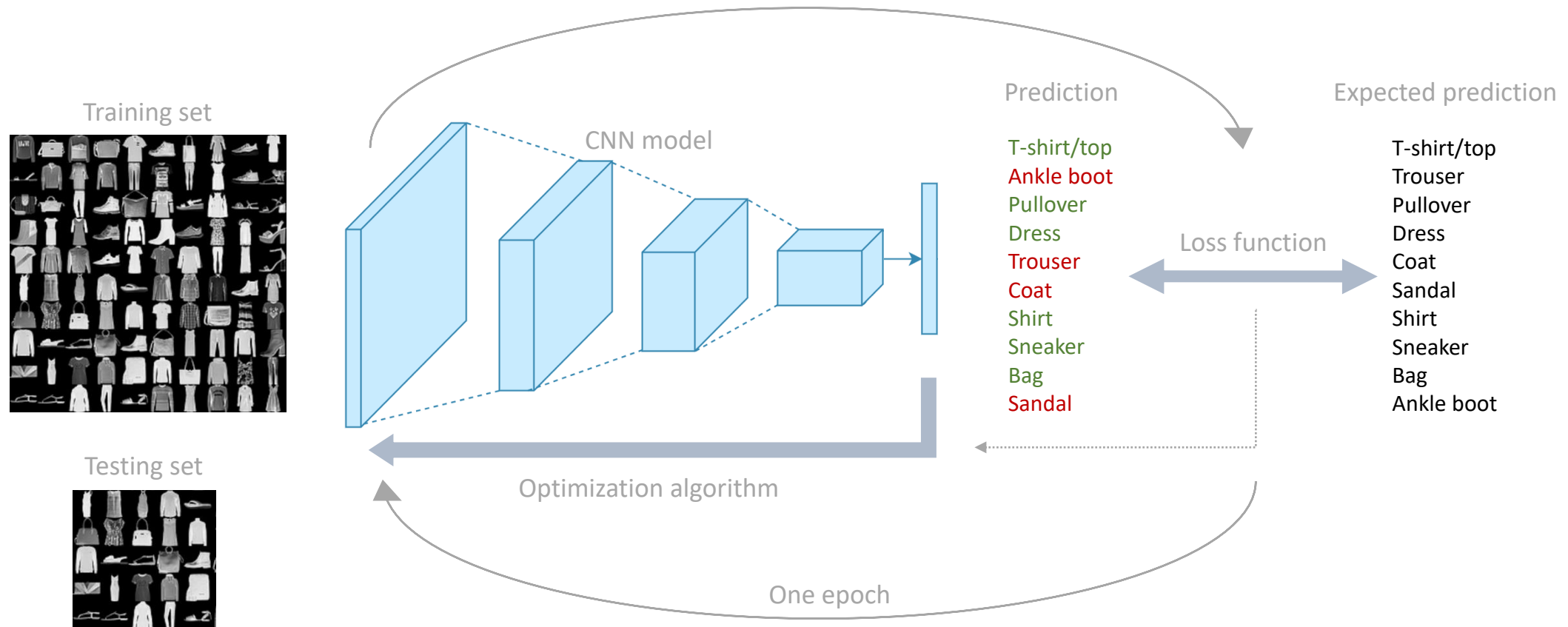
Takeaways

- Deep learning removes the manual identification of features in data

- Split your data to ensure unbiased model performance evaluation

- Choosing a suitable loss function is crucial

- Choosing a suitable optimization algorithm and learning rate is crucial

- Want more? Just google:
  - Stanford University CS231n
  - MIT Deep Learning Book