Workshop: Building your first Convolutional Neural Network

Domen Rački, Andraž Mehle | Ljubljana, December 2018

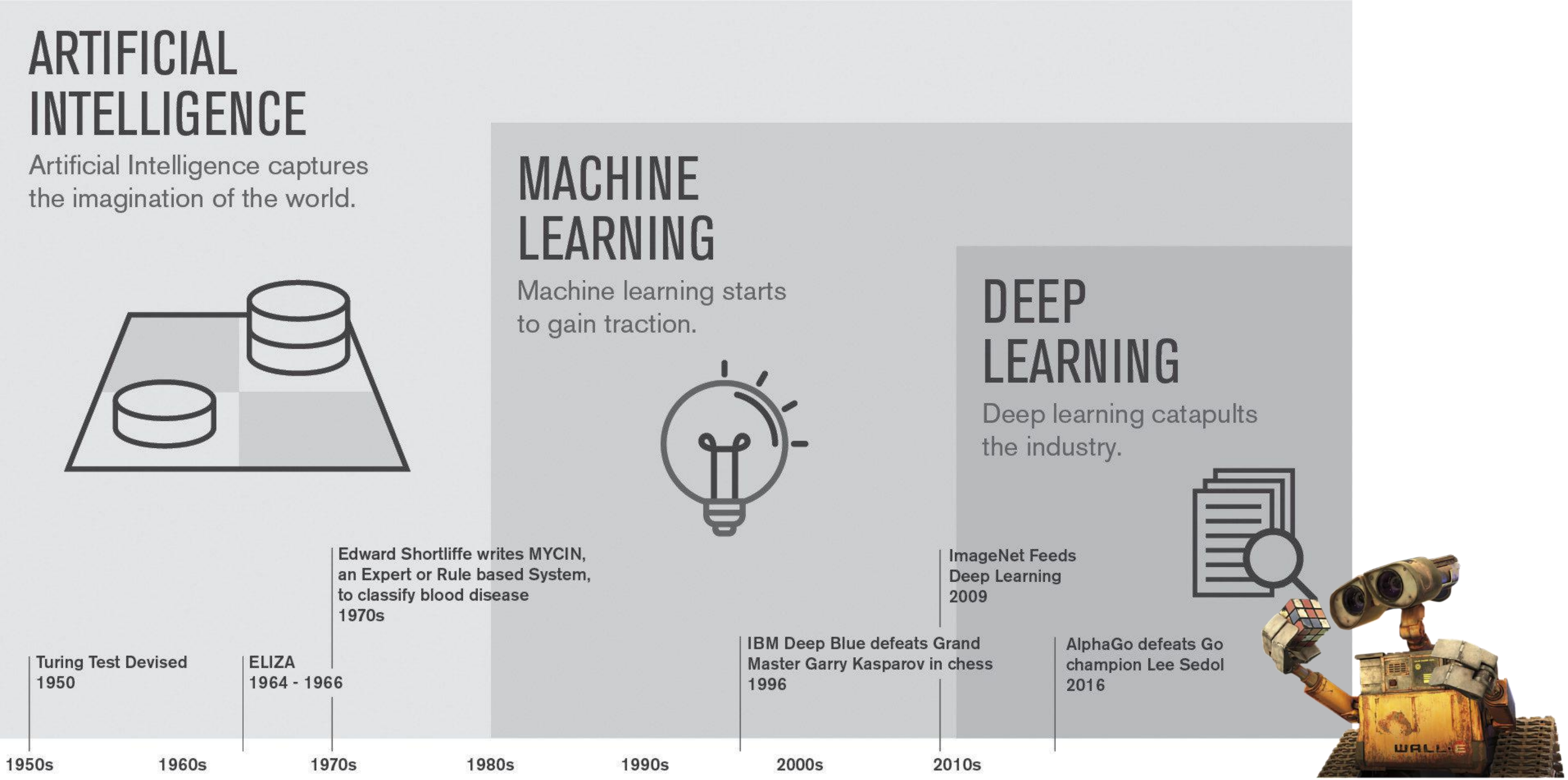
Foreword

- 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

What is deep learning?

[Image credit: Kingman Tang, Apttus]



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.

Turing Test Devised
1950

ELIZA
1964 - 1966

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

IBM Deep Blue defeats Grand Master Garry Kasparov in chess
1996

ImageNet Feeds Deep Learning
2009

AlphaGo defeats Go champion Lee Sedol
2016

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

[Slide credit: Techopedia, Forbes]

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)

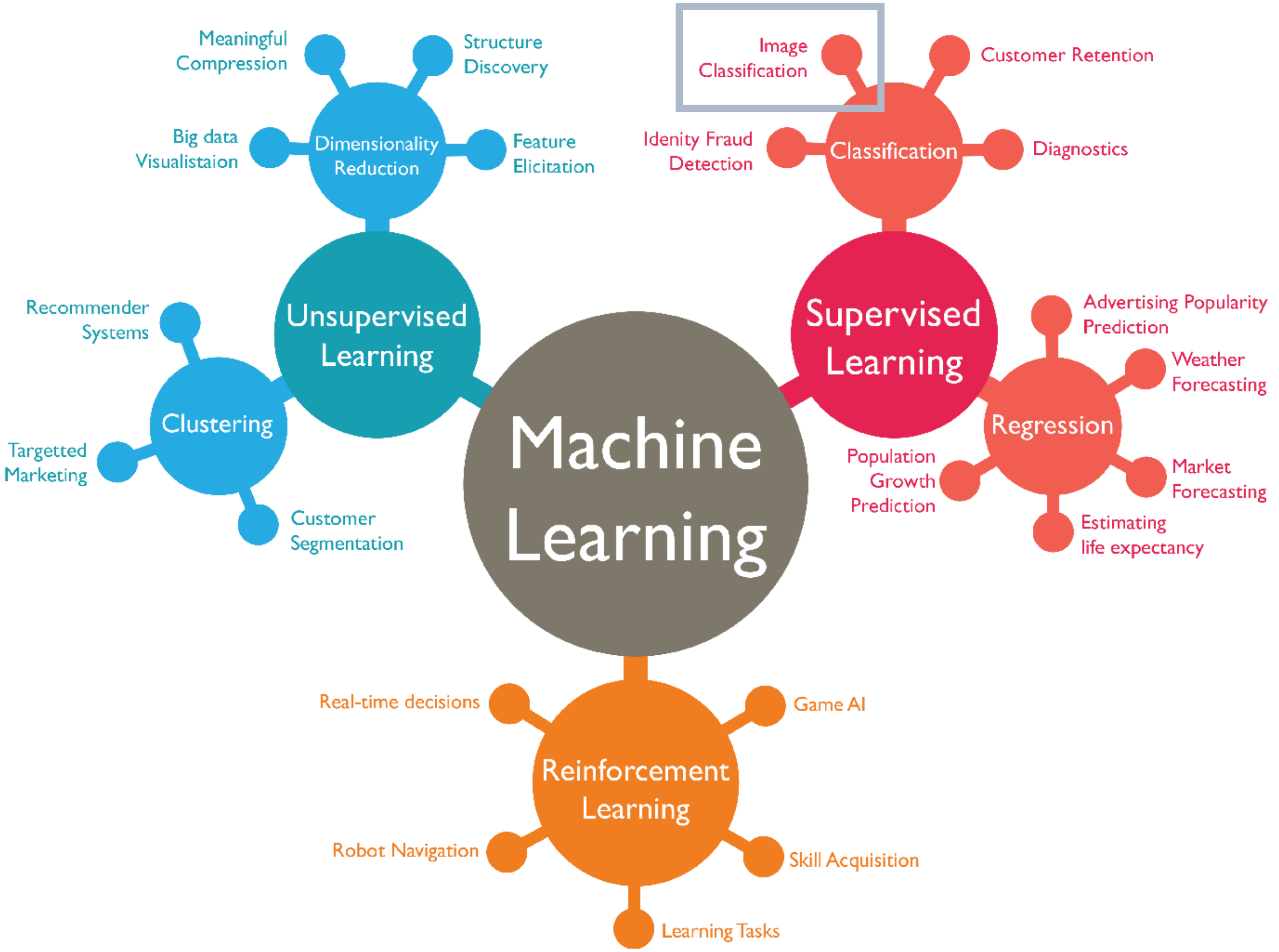
Deep learning model
(mapping function F)

Clothing category
(space B)

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

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

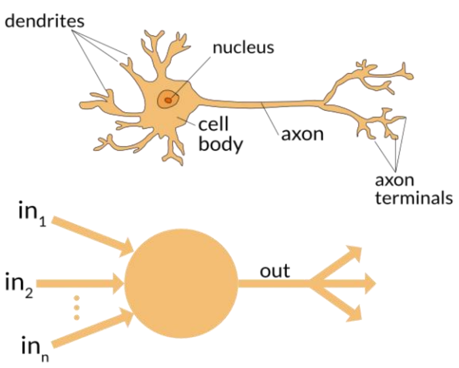
Different types of learning

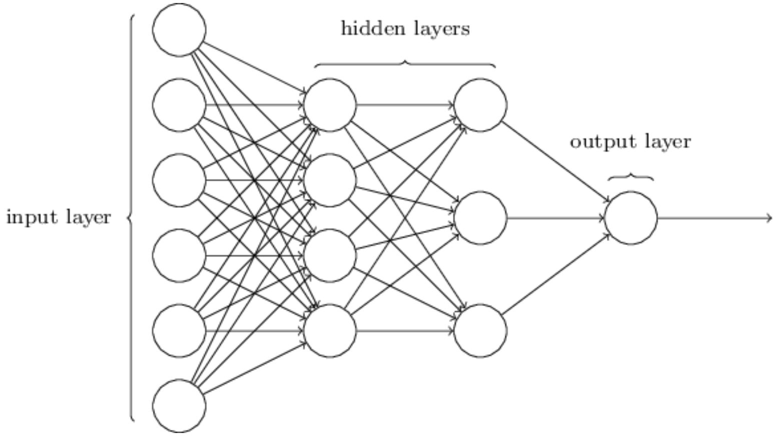


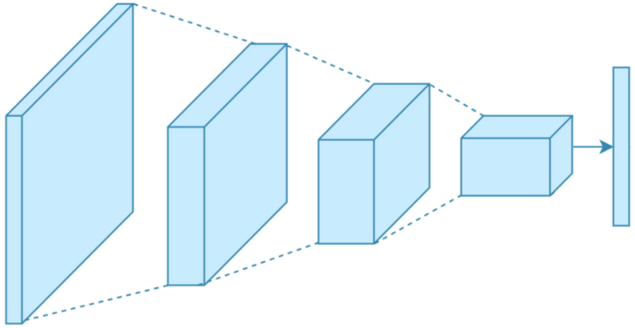
[Image credit: kisspng.com]

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



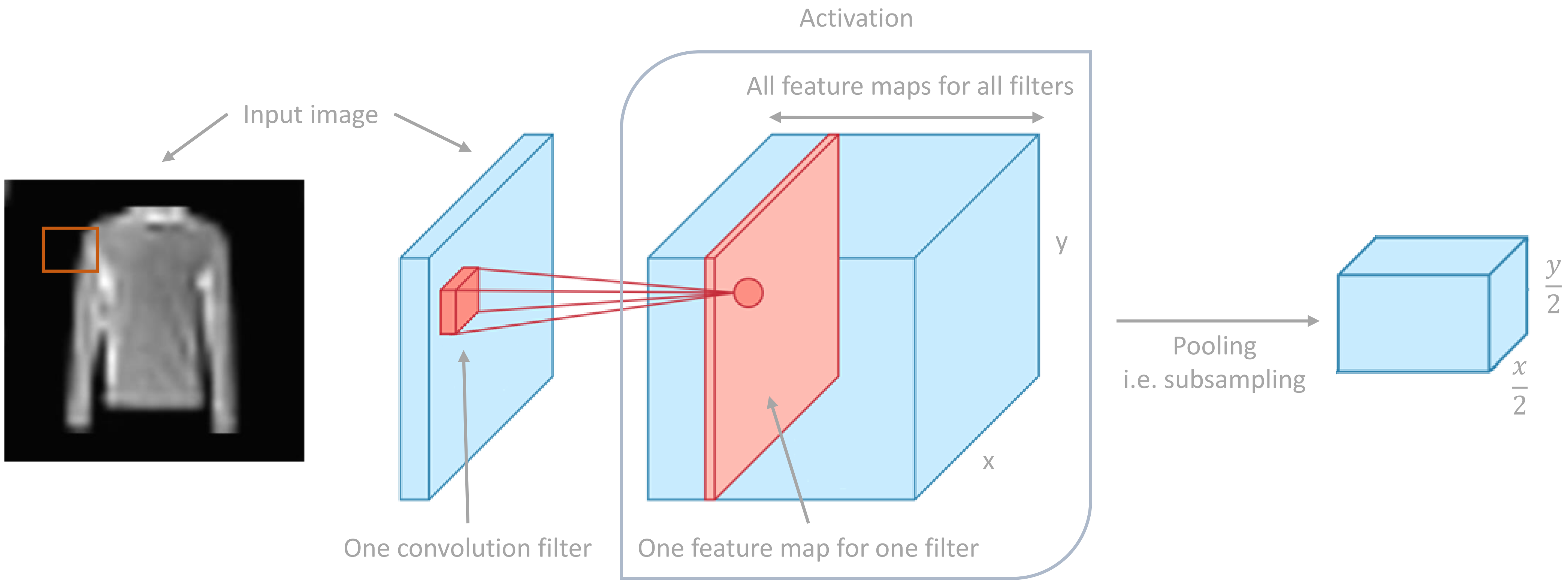




[Image credit: analyticsvidhya.com, neuralnetworksanddeeplearning.com, Applied Deep Learning]

How does a CNN work?

- Convolution, activation, pooling, repeat



[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

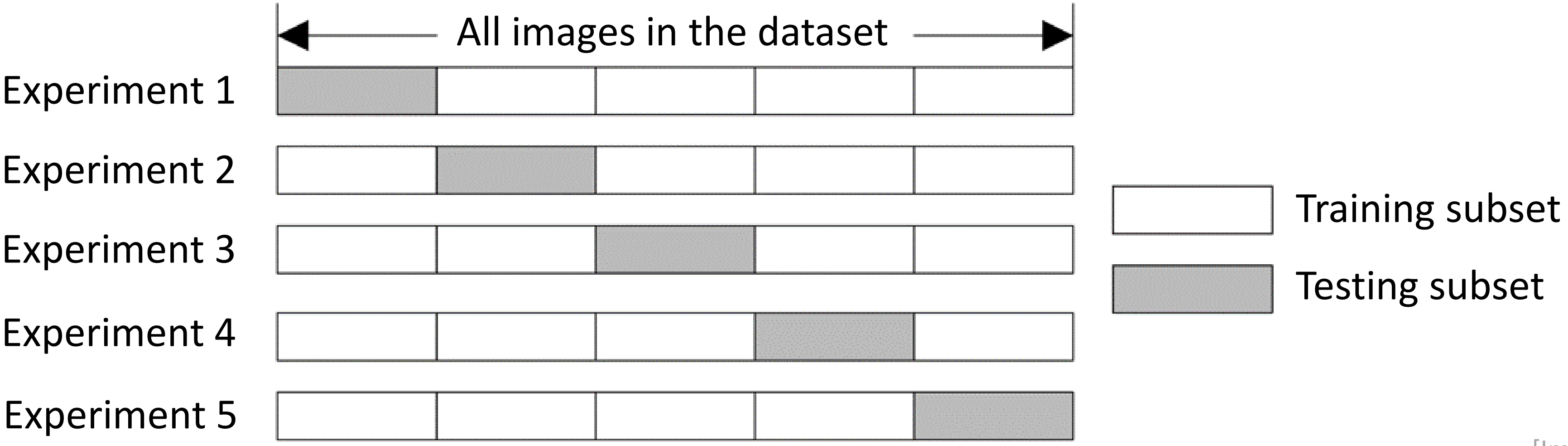
- Step 1: Download and Install Anaconda 3.7
  - https://www.anaconda.com/download/
- Step 2: Set up Anaconda environment
  - Open console and create anaconda environment:
    ```
    conda create -n tfenv python=3.5 anaconda
    ```
- Step 3: Install Tensorflow
  - Activate anaconda environment: `activate 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

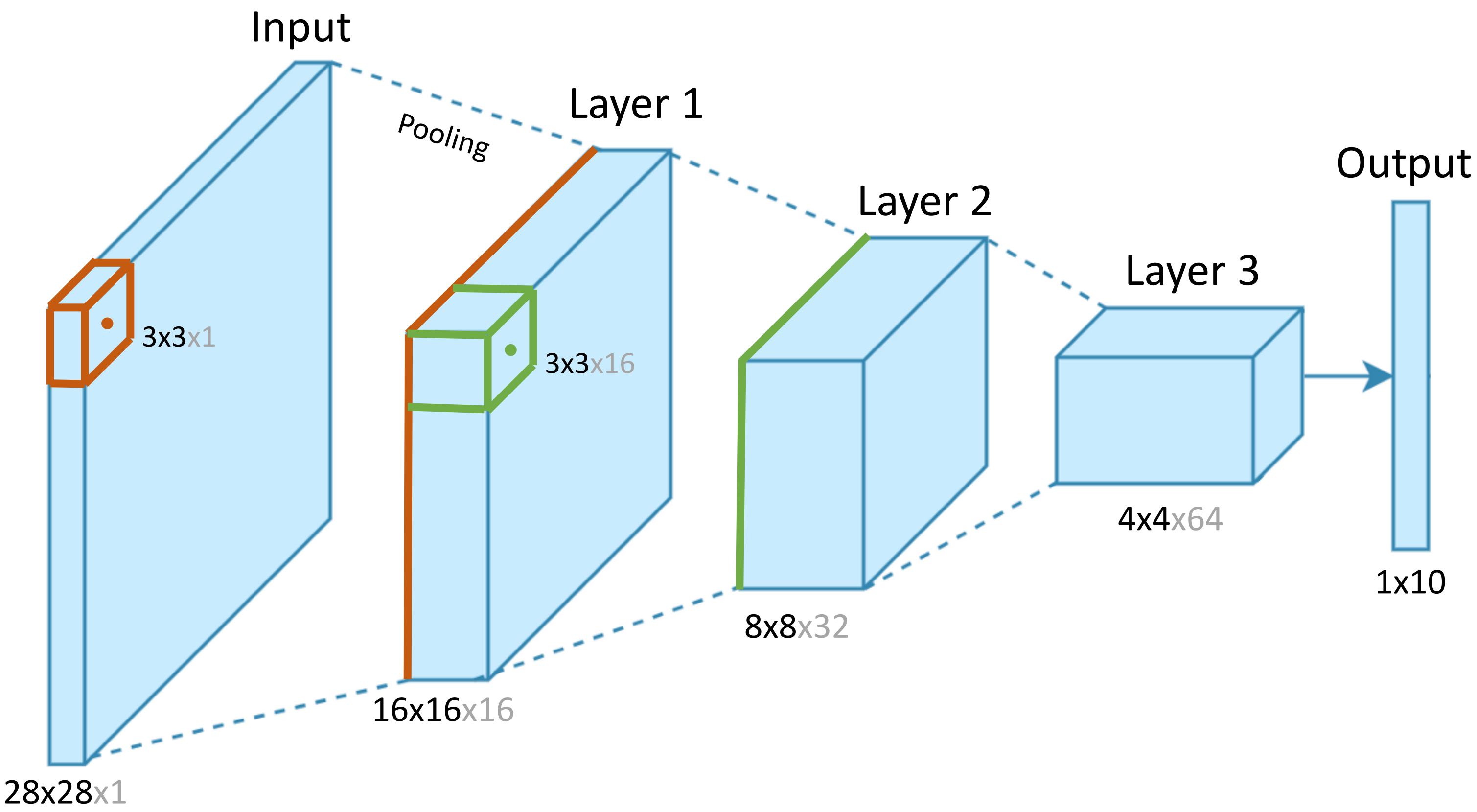
Testing set



[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

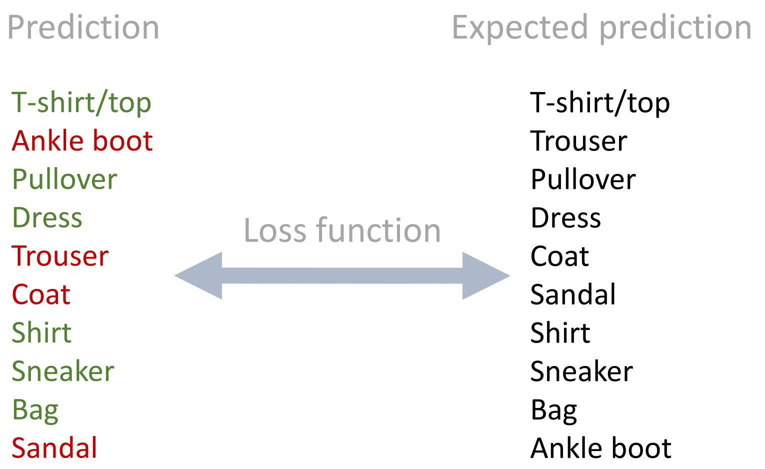


Choose a loss function

- 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



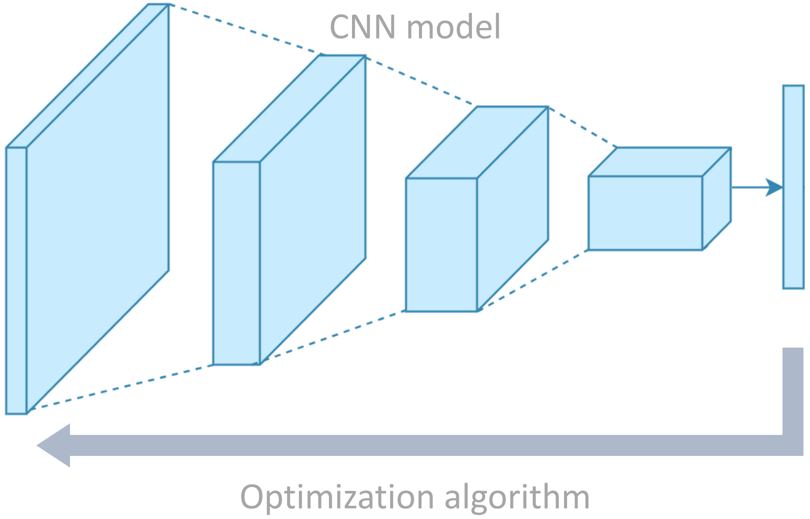
Prediction	Expected prediction
T-shirt/top	T-shirt/top
Ankle boot	Trouser
Pullover	Pullover
Dress	Dress
Trouser	Coat
Coat	Sandal
Shirt	Shirt
Sneaker	Sneaker
Bag	Bag
Sandal	Ankle boot

Choose an optimization algorithm

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

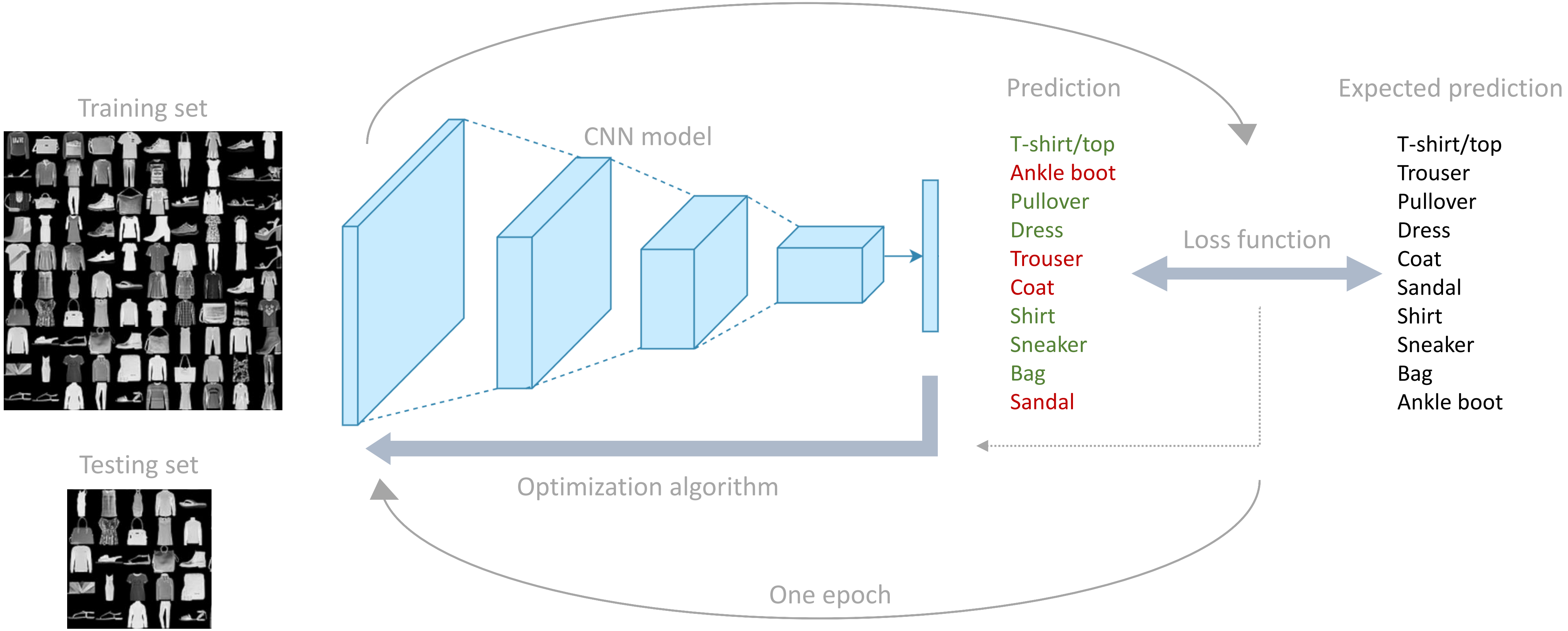
- Which optimization algorithm should I pick?
  - This depends on your specific problem
  - Generally the one that works best
  - Usually the Adam optimizer is used

- What does a learning rate do?
  - It controls how much your model is 'adjusted'
  - How do I choose a learning?
  - Generally by trial-and-error
  - Usually a learning rate around 0.001 is a good choice



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



Training set

Testing set

CNN model

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

Loss function

Optimization algorithm

One epoch

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