

# Introduction to Deep Learning

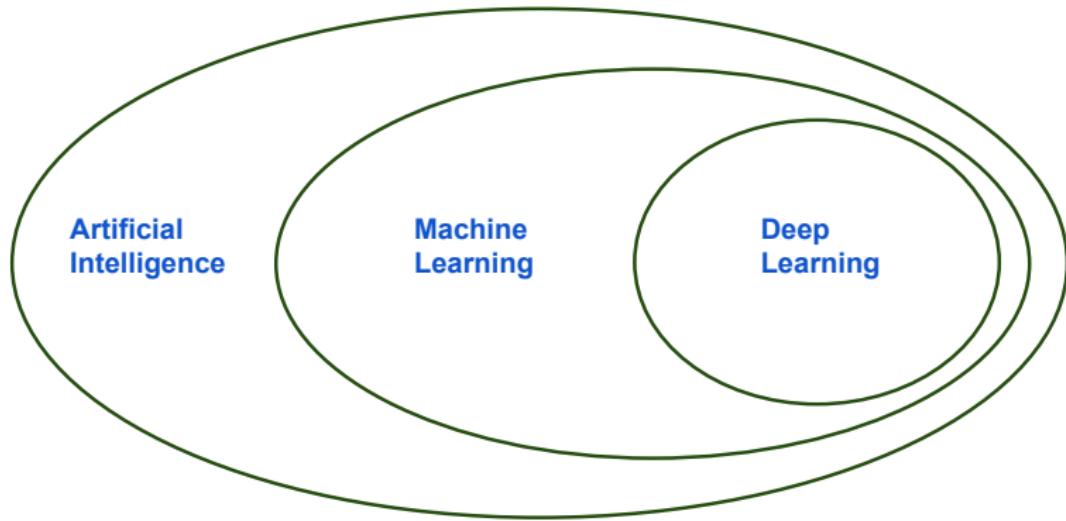
## Chapter 1: Introduction

**Bernd Bischl**

Department of Statistics – LMU Munich  
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# WHAT IS DEEP LEARNING



- Deep learning is the use of artificial neural networks to construct models on large amounts of (unstructured) data.

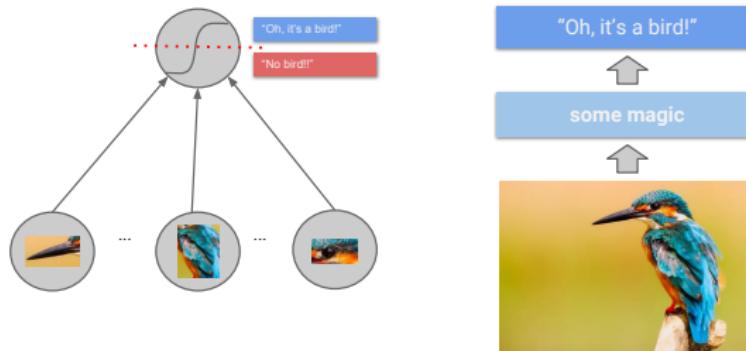
# DEEP LEARNING AND NEURAL NETWORKS

- Deep learning and neural networks are mostly equivalent.
- Deep learning itself is not *new*:
  - Neural networks have been around since the 70s
  - *Deep* neural networks, i.e., networks with multiple hidden layers, are not much younger.
- Why everybody is talking about deep learning now:
  - ❶ Specialized, powerful hardware allows training of huge neural networks to push the state-of-the-art on difficult problems.
  - ❷ Large amount of data is available.
  - ❸ Special network architectures for image/text data.
  - ❹ Better optimization and regularization strategies.

# IMAGE CLASSIFICATION WITH NEURAL NETWORKS

*“Machine learning algorithms, inspired by the brain, based on learning multiple levels of representation/abstraction.”*

Y. Bengio

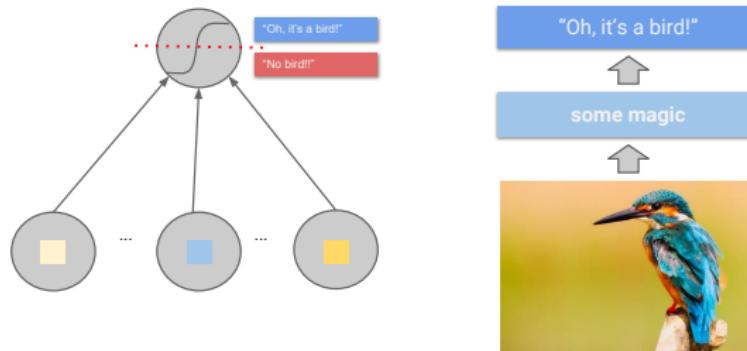


Caption 1

# IMAGE CLASSIFICATION WITH NEURAL NETWORKS

*“Machine learning algorithms, inspired by the brain, based on learning multiple levels of representation/abstraction.”*

Y. Bengio

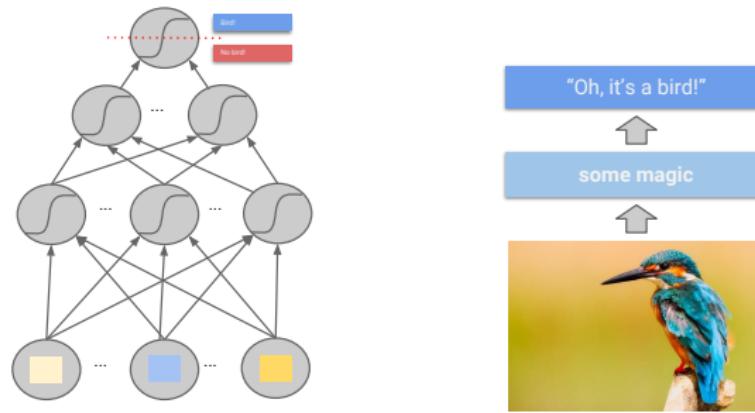


Caption 2

# IMAGE CLASSIFICATION WITH NEURAL NETWORKS

*“Machine learning algorithms, inspired by the brain, based on learning multiple levels of representation/abstraction.”*

Y. Bengio

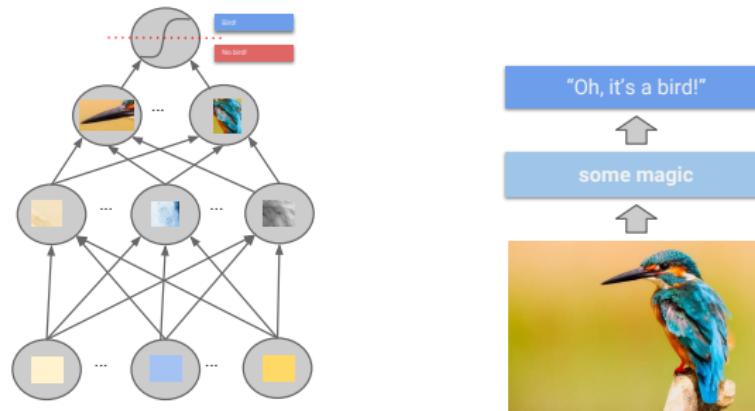


Caption 3

# IMAGE CLASSIFICATION WITH NEURAL NETWORKS

*“Machine learning algorithms, inspired by the brain, based on learning multiple levels of representation/abstraction.”*

Y. Bengio



Caption 4

# POSSIBLE USE-CASES

**Deep learning can be extremely valuable if the data has these properties:**

- It is high dimensional.
- Each single feature itself is not very informative but only a combination of them might be.
- There is a large amount of training data.

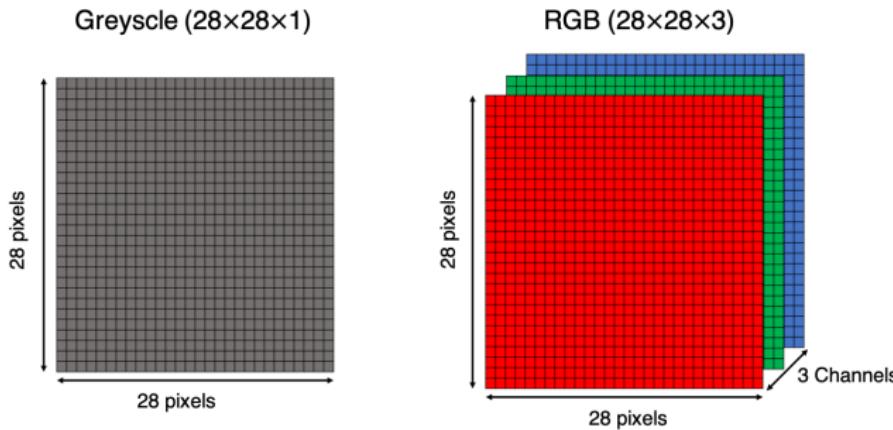
**This implies that for tabular data, deep learning is almost never the correct model choice.**

- Models like random forests or gradient boosting will outperform deep learning most of the time.
- One exception is data with categorical features with many levels.

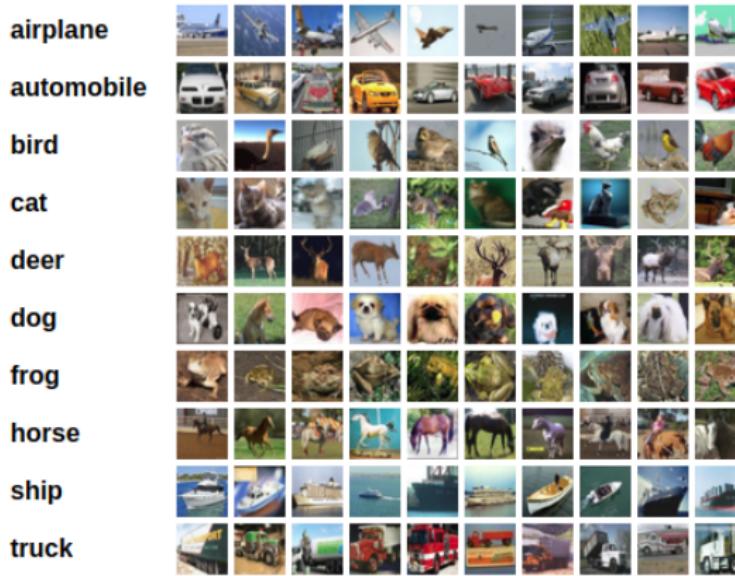
# POSSIBLE USE-CASE: IMAGES

- **High Dimensional:** A color image with  $255 \times 255$  (3 Colors) pixels already has 195075 features.
- **Informative:** A single pixel is not meaningful in itself.
- **Training Data:** Depending on applications huge amounts of data are available.

Architecture: **Convolutional Neural Networks (CNN)**



# POSSIBLE USE-CASE: IMAGES

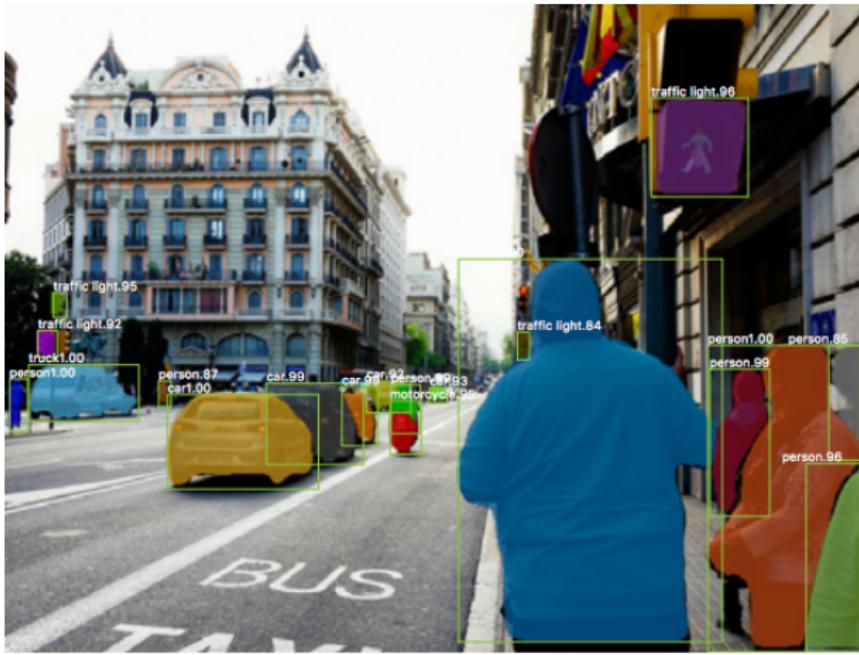


Credit: Alex Krizhevsky (2009)

**Image classification** tries to predict a single label for each image.

CIFAR-10 is a well-known dataset used for image classification. It consists of 60,000 32x32 color images containing one of 10 object classes, with 6000 images per class.

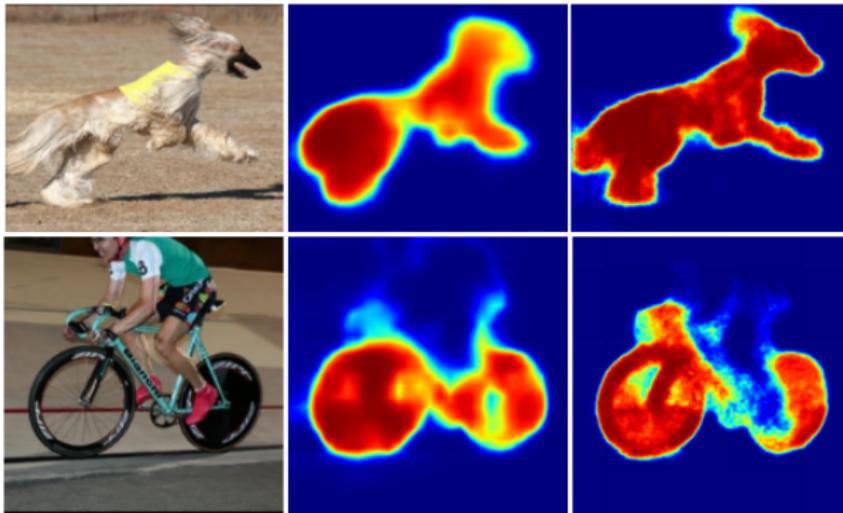
# POSSIBLE USE-CASE: IMAGES



Credit: Kaiming He (2017)

**Object Detection** Mask R-CNN is a general framework for instance segmentation, which efficiently detects objects in an image while simultaneously generating a high-quality segmentation mask for each instance.

# POSSIBLE USE-CASE: IMAGES



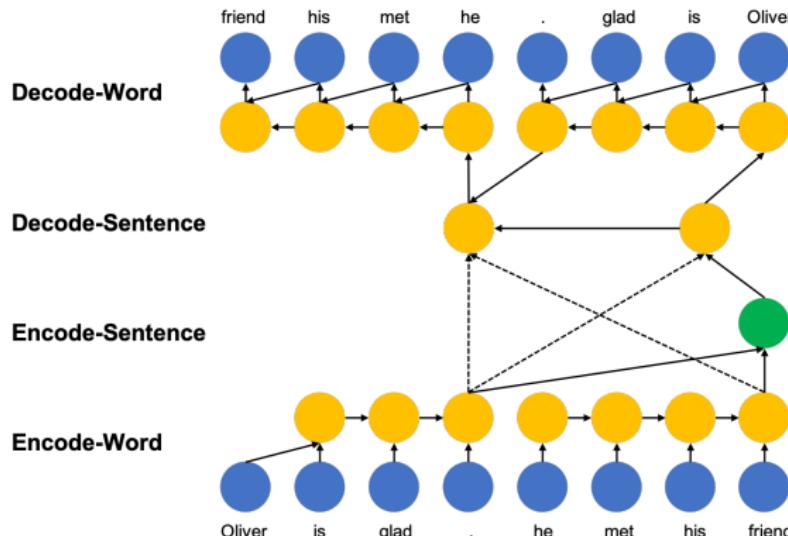
Credit: Hyeonwoo Noh (2015)

**Image segmentation** partitions the image into (multiple) segments.

# POSSIBLE USE-CASE: TEXT

- **High Dimensional:** Each word can be a single feature ( 300000 words in the German language).
- **Informative:** A single word does not provide much context.
- **Training Data:** Huge amounts of text data available.

Architecture: Recurrent Neural Networks (RNN)



# POSSIBLE USE-CASE: TEXT CLASSIFICATION



**Positive**



**Neutral**



**Negative**

Great job! Your customer support is fantastic.

Not bad, but it should be improved in the future.

The worst customer service I have ever seen.

**Sentiment Analysis** is the application of natural language processing to systematically identify the emotional and subjective information in texts.

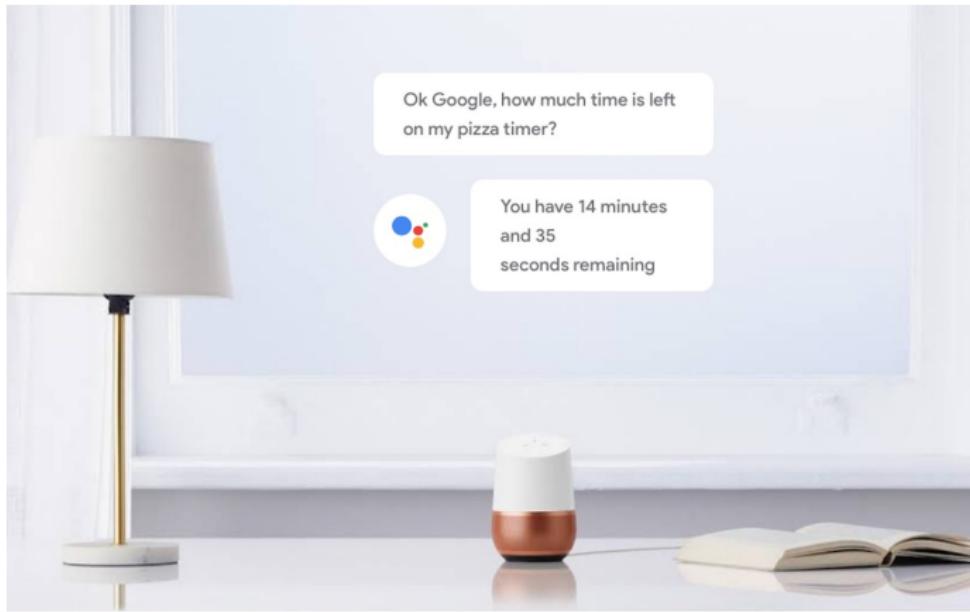
# POSSIBLE USE-CASE: TEXT

The screenshot shows a translation interface with two panels. The left panel has "English – detected" at the top, followed by the sentence "He loves to eat" with an "Edit" link. The right panel has "German" at the top, followed by the translated sentence "Er liebt es zu essen". Between the two panels are standard translation controls: a microphone icon, a speaker icon, and a double-headed arrow icon.

The screenshot shows another translation interface with two panels. The left panel has "Norwegian" at the top, followed by the sentence "Butikken er stengt" with an "Edit" link. The right panel has "English" at the top, followed by the translated sentence "The store is closed". Between the two panels are standard translation controls: a speaker icon, a double-headed arrow icon, and a refresh/circular arrow icon.

**Machine Translation** (e.g. google translate) Neural machine translation exploits neural networks to predict the likelihood of a sequence of words, typically modeling entire sentences in a single integrated model.

# APPLICATIONS OF DEEP LEARNING: SPEECH



**Speech Recognition and Generation** (e.g. google assistant) Neural network extracts features from audio data for downstream tasks, e.g., to classify emotions in speech.