INTRODUCTION TO BIG DATA AND ARTIFICIAL INTELLIGENCE

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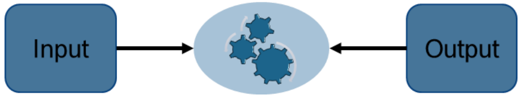
Introduction
Learning objectives

BD & AI:
What and why?

- Basic definitions
- Why AI and why now?
- Real world applications
- Bosch use cases

Data as an asset:
Value creation

- Relevance of data
- Data mining
- Big Data handling



Technical foundations:
Machine Learning

- What is machine learning?
- Strategies and tasks
- Method focus on Deep Learning overview

Implementation:
Data mining in your BU

- Value of data
- Data-driven mind-set
- Roles and competences
- Trainings and platforms
- Discuss & exchange

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Introduction
Now it’s your turn!

1. Who are **you** and where do you work?

2. What is your **expectation** of this day?

3. What is your **connection to AI** and how do you feel about AI on a **scale from worried to enthusiastic**?

Poll:

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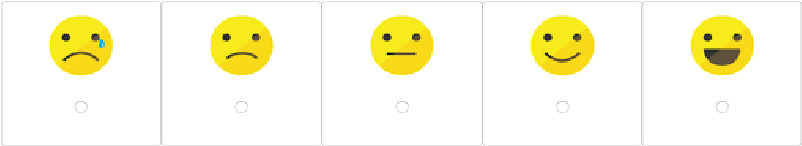

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INTRODUCTION

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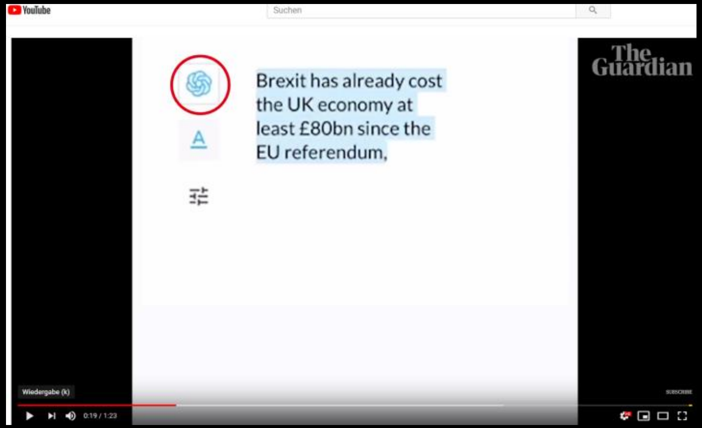
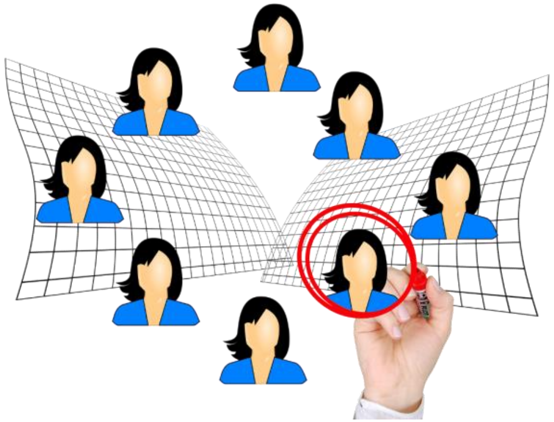
EXAMPLES

What AI demonstrates today



Introduction
Examples in everyday life



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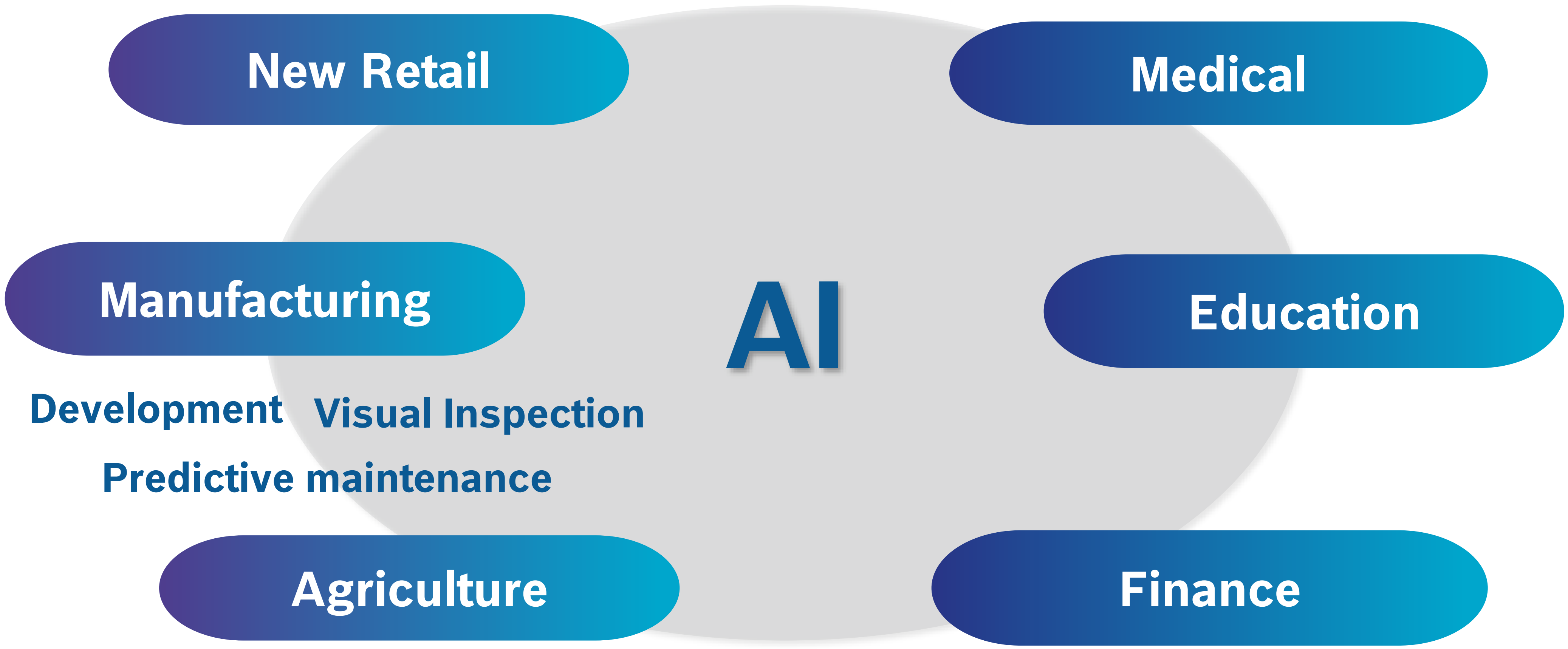
Introduction
AI application in major industries



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Introduction
Major application/technology

Computer Vision

Speech Recognition

Text Interpretation

Natural Language Process

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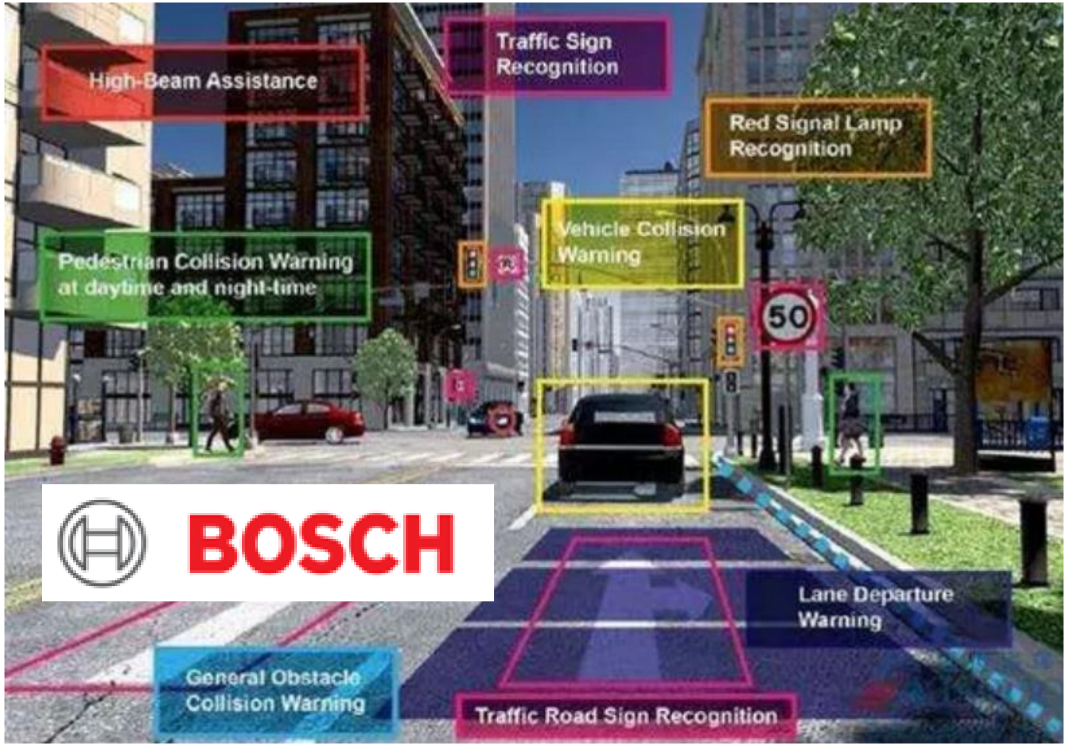
Introduction
Major application/technology

Computer Vision



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Introduction
Major application/technology

NLP-Speech Recognition

alexa

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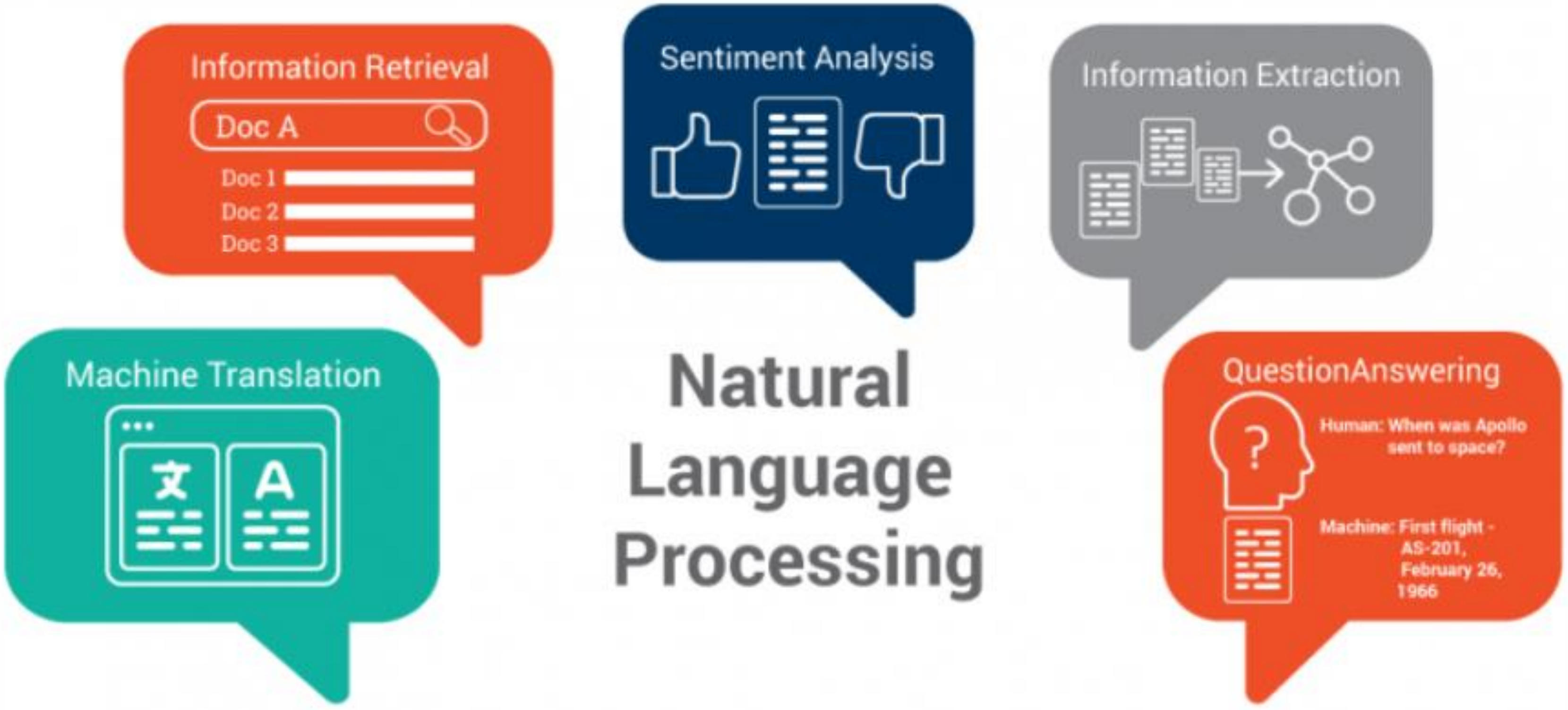
Introduction
Major application/technology

NLP-Text Interpretation



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Introduction
Examples at Bosch: Smart Agriculture Solution

Project Description

To develop a disease risk prediction model for tomato crops using data from greenhouse environmental conditions. The solution aims to protect farmers from yield loss and to optimize the use of chemical spray.

Goal of BCAI collaboration

The goal of this project is to establish collaboration with the FUJI team in Japan to develop smart AI-based solutions for the agricultural domain.

Impact

- Received cumulative orders of over 4,000 devices in Japan
- The solution is being extended to the Korean markets.

Data used

- Sensors installed inside the greenhouses are used to collect data at 10 minutes interval i.e. temperature and relative humidity.
- Metadata from the greenhouses such as crop stage, planting medium etc. are also used for model development
- Ground truth based on farmers' inputs on disease occurrence.

AI solution concept

- Raw Data from sensors is extracted and stored in a structured database.
- Agriculture domain and statistical based features are derived from raw data.
- ML model is developed using above mentioned features.
- To perform daily prediction, raw data coming from sensors is processed to get features and is fed to the ML model to get the prediction.
- The result is showcased on the Plantect App.

Pictures:

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Introduction

Examples at Bosch: Sales Forecasting

Context

Forecasting solution using an ensemble of 30+ state of the art models

User friendly interface via PowerBI. The solution is fully automated and applicable in all Bosch Business Units.

Monthly forecasts currently delivered to 7 GBs. Cloud onboarding Q4/19

Goal of project

Automatically generated sales forecast integrated into the new Bosch wide Finance Business Intelligence (FBI) platform.

Leverage domain knowledge of FBI team in controlling and BCAI in learning systems to create a scalable AI product.

Impact

Improved efficiency, objectivity, accuracy, and transparency

More frequent forecasts with higher or equivalent accuracy

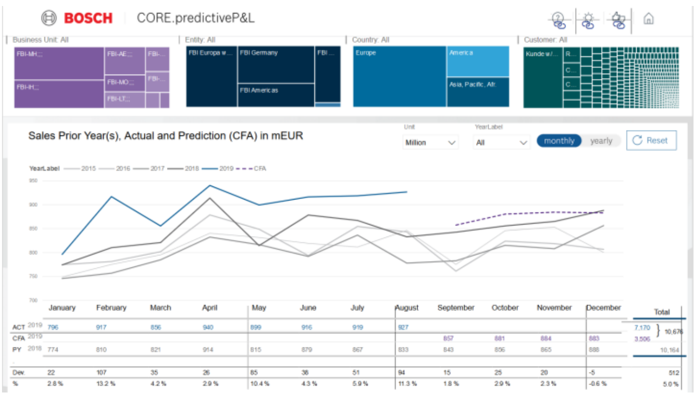
Data used

- Historical revenue data from GBs
- Business hierarchy data

AI solution concept

- 30+ forecasting models
- Feature-based model selection and combination using random forests
- Distributed computing using spark and kubernetes
- Hierarchical forecast based on business requirements
- Probabilistic forecasting (forecast distribution vs. point forecast)

Pictures



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DEFINITION AI

Introduction
Basic definition

Artificial intelligence is a subfield of computer science that models intelligent behaviour.

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What is Artificial Intelligence?
Definitions of AI

AI addresses problems which can be solved by humans, but for which we don't have good algorithms for solving.

AI is a moving target; once a task solved by algorithms, it's no longer perceived as AI!

Defining artificial intelligence isn't just difficult; it's impossible, not the least because we don't really understand human intelligence.

Artificial intelligence is the science of making machines do things that would require intelligence if done by men.

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Introduction
A bold assumption

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Dartmouth Conference (1956):

"Every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."

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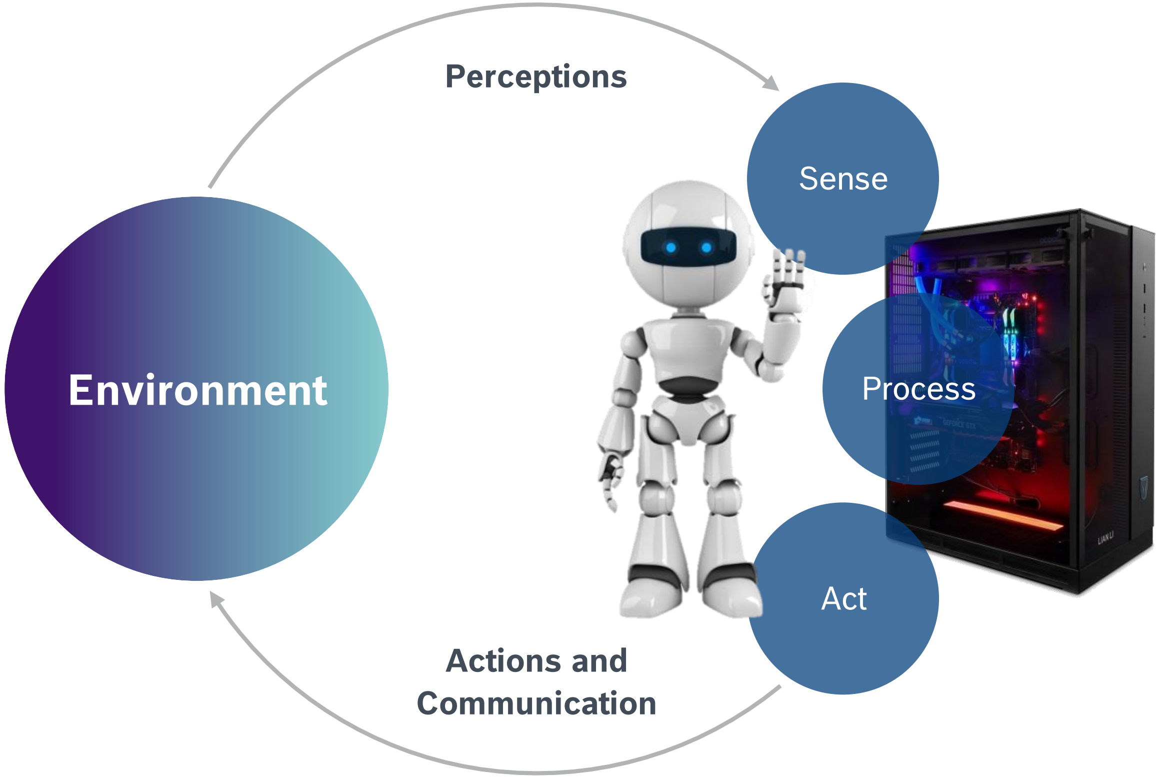
Introduction
What is necessary for Artificial Intelligence?

Poll:
"Which skills make humans intelligent?"

Which tasks do we have to model to make machines behave intelligently?



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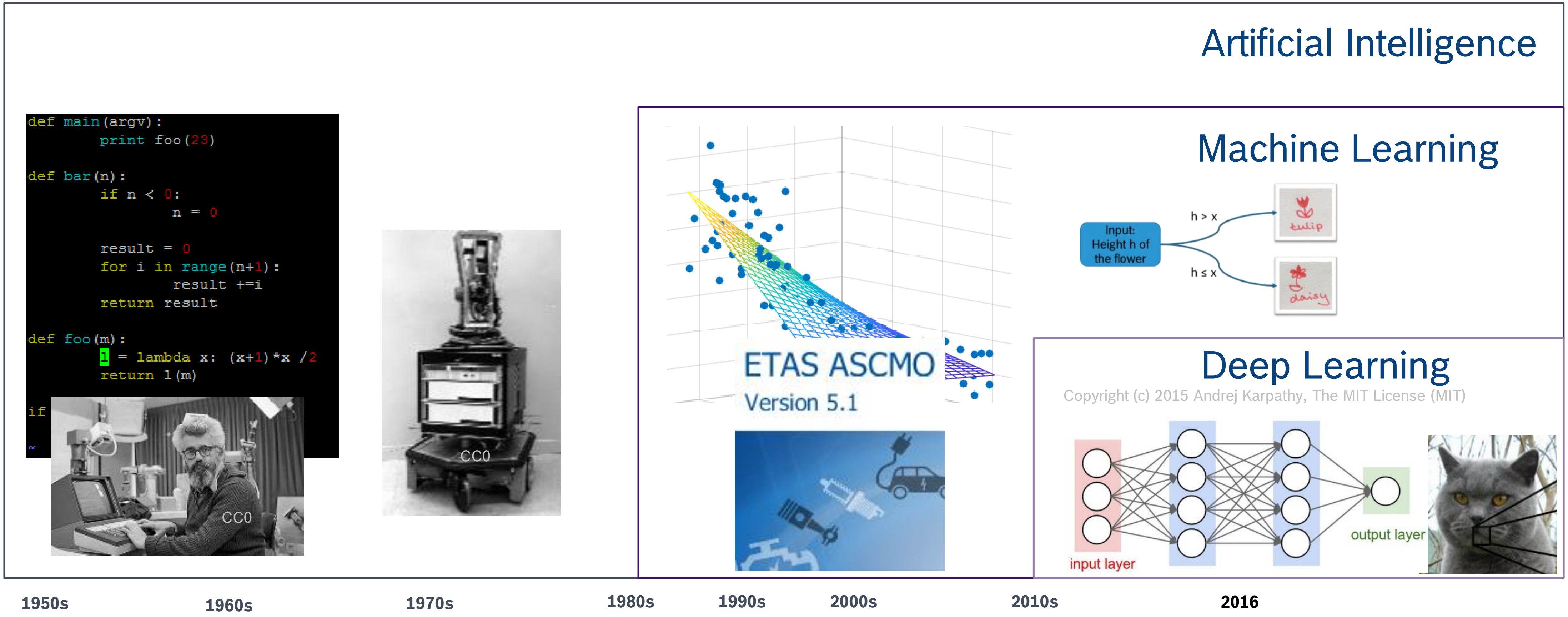
Introduction
A brief look at history



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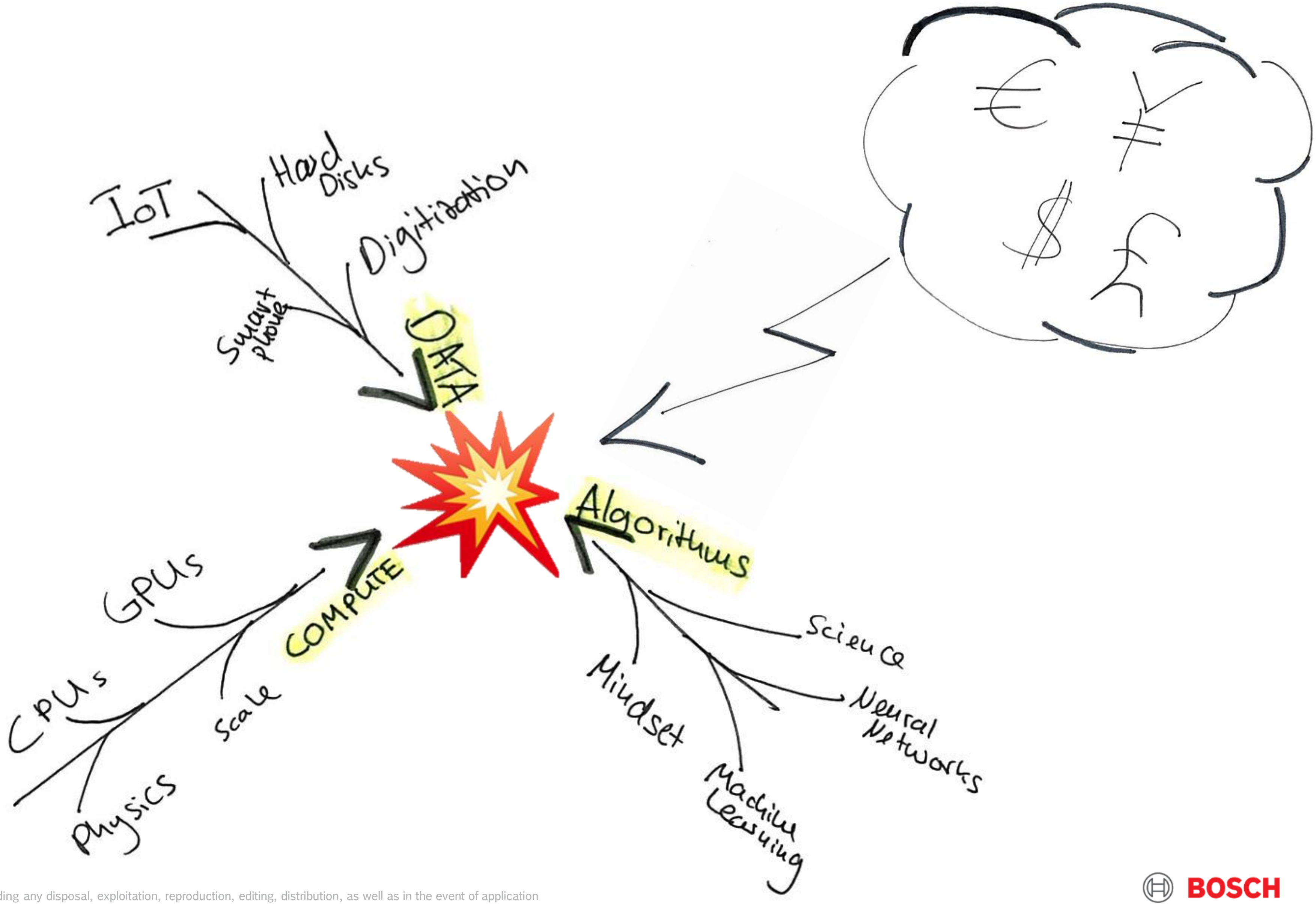
WHY NOW?

Introduction
Why now?



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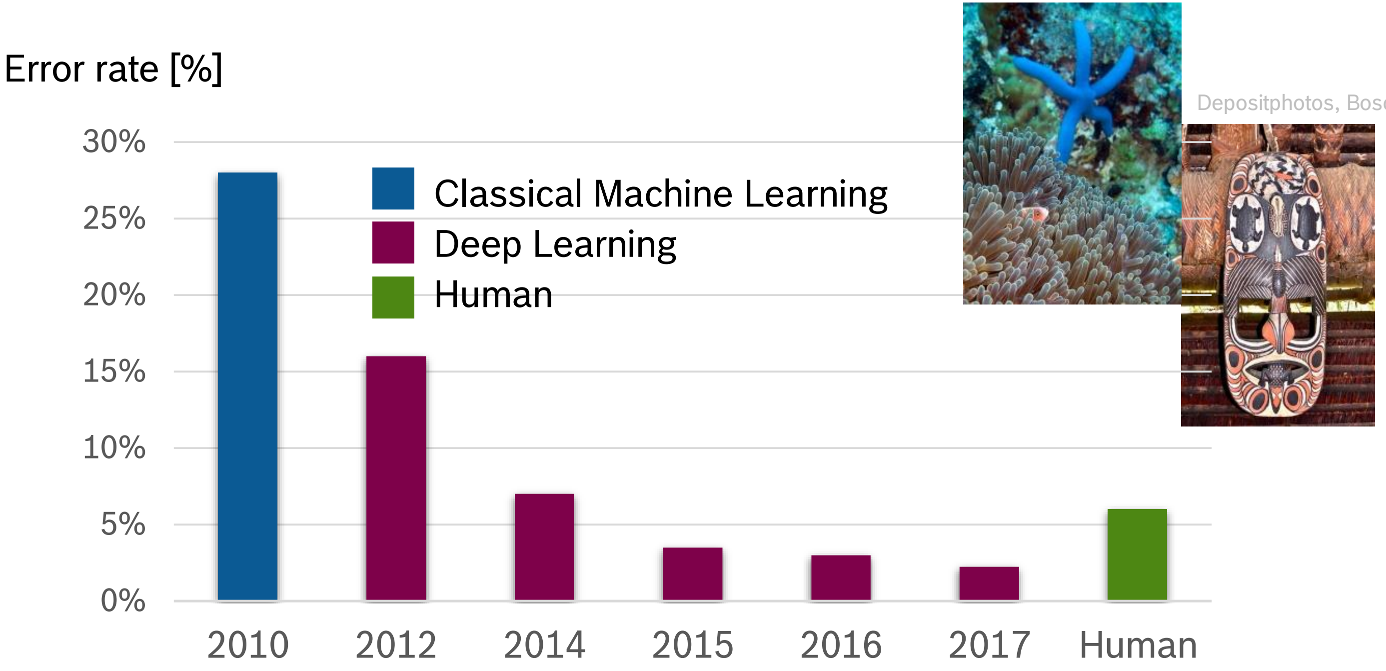
Introduction

Why now? – Improved algorithms

1. Algorithmic advances, especially in the area of deep learning



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➢ Error rate of image recognition “imagenet challenge”. In 2015, algorithms surpassed human image recognition error rate.

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Introduction
Why now? – Improved algorithms

1. Algorithmic advances, especially in the area of deep learning

From https://medium.freecodecamp.org/chihuahua-or-muffin-my-search-for-the-best-computer-vision-api-cbda4d6b425d

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Introduction
Why now? – More data

2. Tremendous growth of data – example: inauguration of the pope

Luca Bruno, AP

2005

Michael Sohn, AP

2013

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Introduction
Why now? – Cheaper computing power

3. Technological advancements lead to cheaper computing power, storage and memory

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1985, Cray-2
~ $ 32,000,000
(2011 dollars)

=

2010, iPhone 4
~ $ 600

=

2016, Apple Watch
~ $ 300

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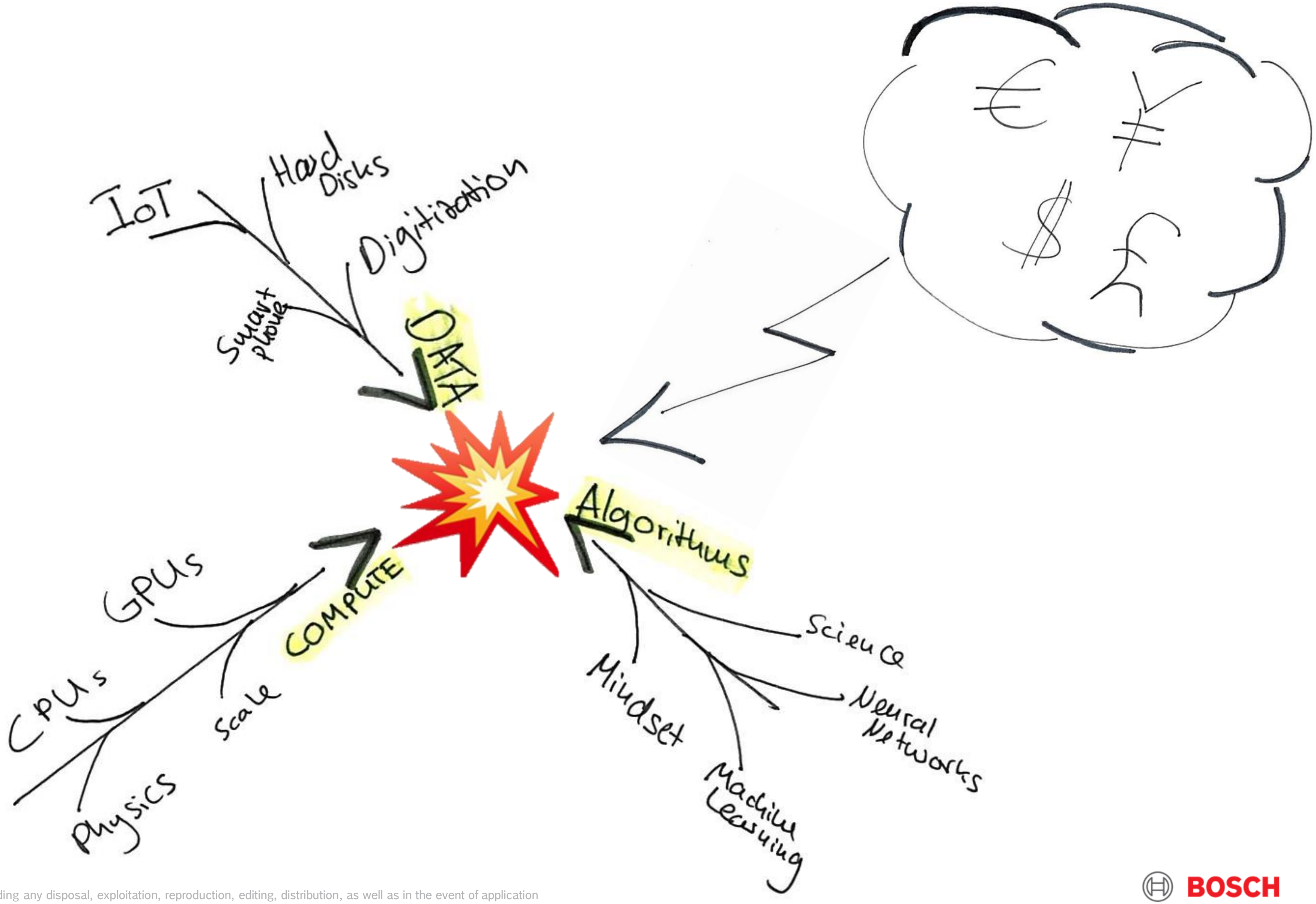
Introduction
Why now?



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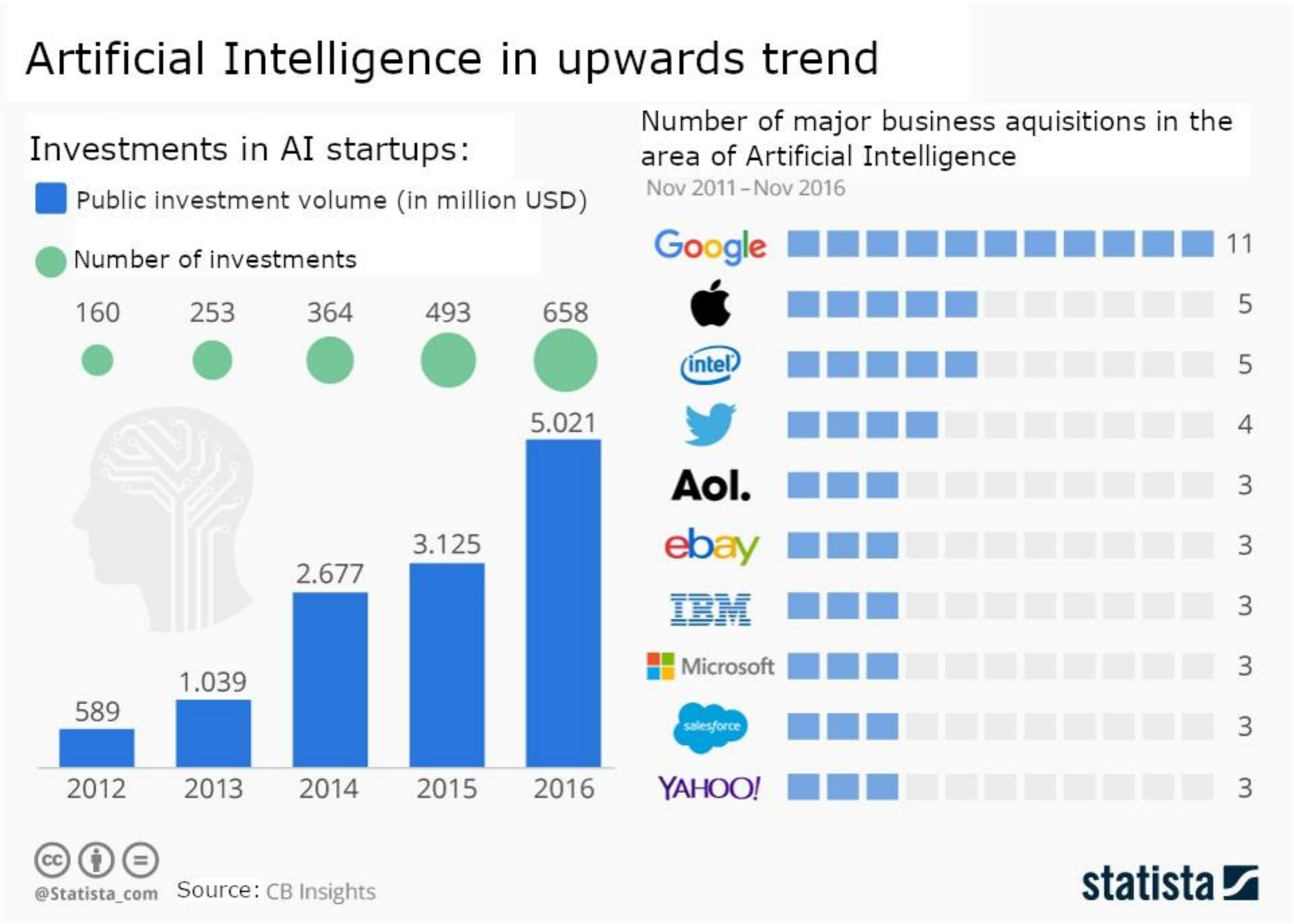
Introduction
Investments



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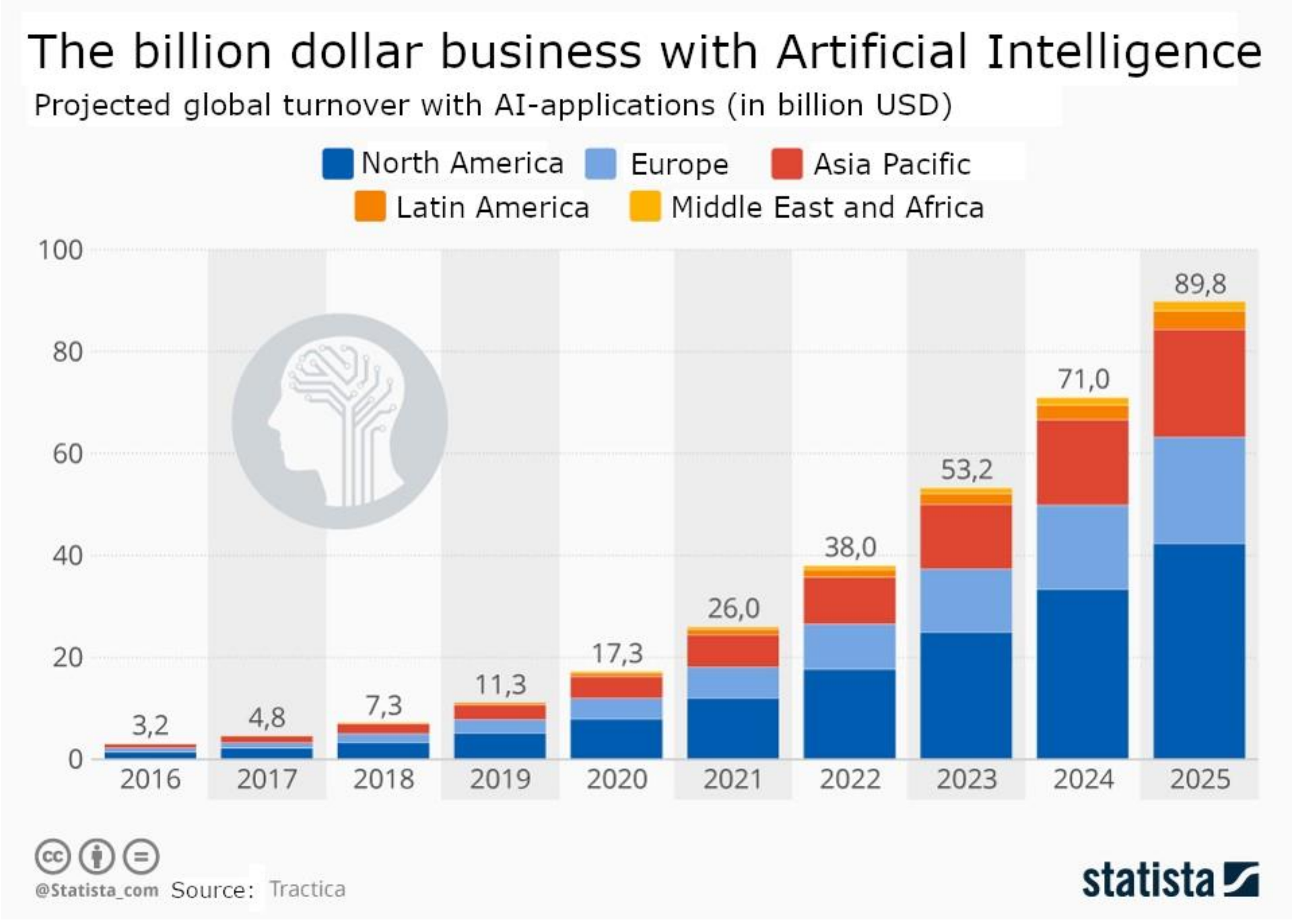
Introduction
Projected turnover



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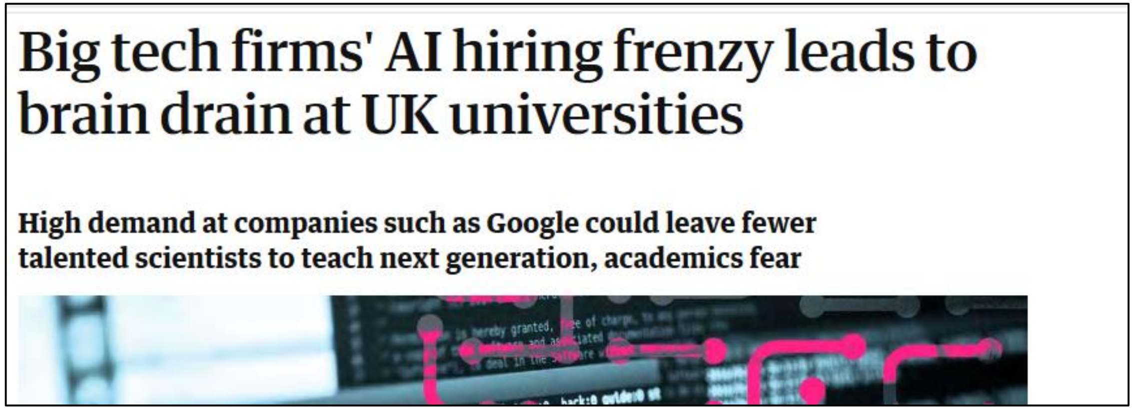
Introduction
AI researcher is the new soccer player

Skysports.com


Big tech firms' AI hiring frenzy leads to brain drain at UK universities

High demand at companies such as Google could leave fewer talented scientists to teach next generation, academics fear

The Guardian

- **AI** talent is scarce
- Experts expect another intensification in the „war for talent“ in the AI field
- Median income at Facebook $ 240,000 (Economist)

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DATA

Data
Why do we need data?

Big data is to AI what fuel is to engines: If the tank is empty, the engine comes to a halt.

Max Welling (Amsterdam Machine Learning Lab)

https://www.bosch.com/de/explore-and-experience/thought-leader-max-welling/

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Data
Types of data acquisition

no
data acquisition

passive
data acquisition
(digitization)

active
data acquisition
(business case driven)

strategic
data acquisition
(foresight based)

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Data
Example: Big Data at Waymo

- 32M km (20M miles) driven (as of 01/20)
- 10B miles in simulator (as of 09/19)
- Hand-over to driver every 21,151 km (disengagement report for 2019)
- 82,000 vehicles ordered for robo cab fleet
- Around 2/3 of Waymo’s valuation are because of their their test miles

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Poll:
“How much data did Bosch produce each day in 2016?”

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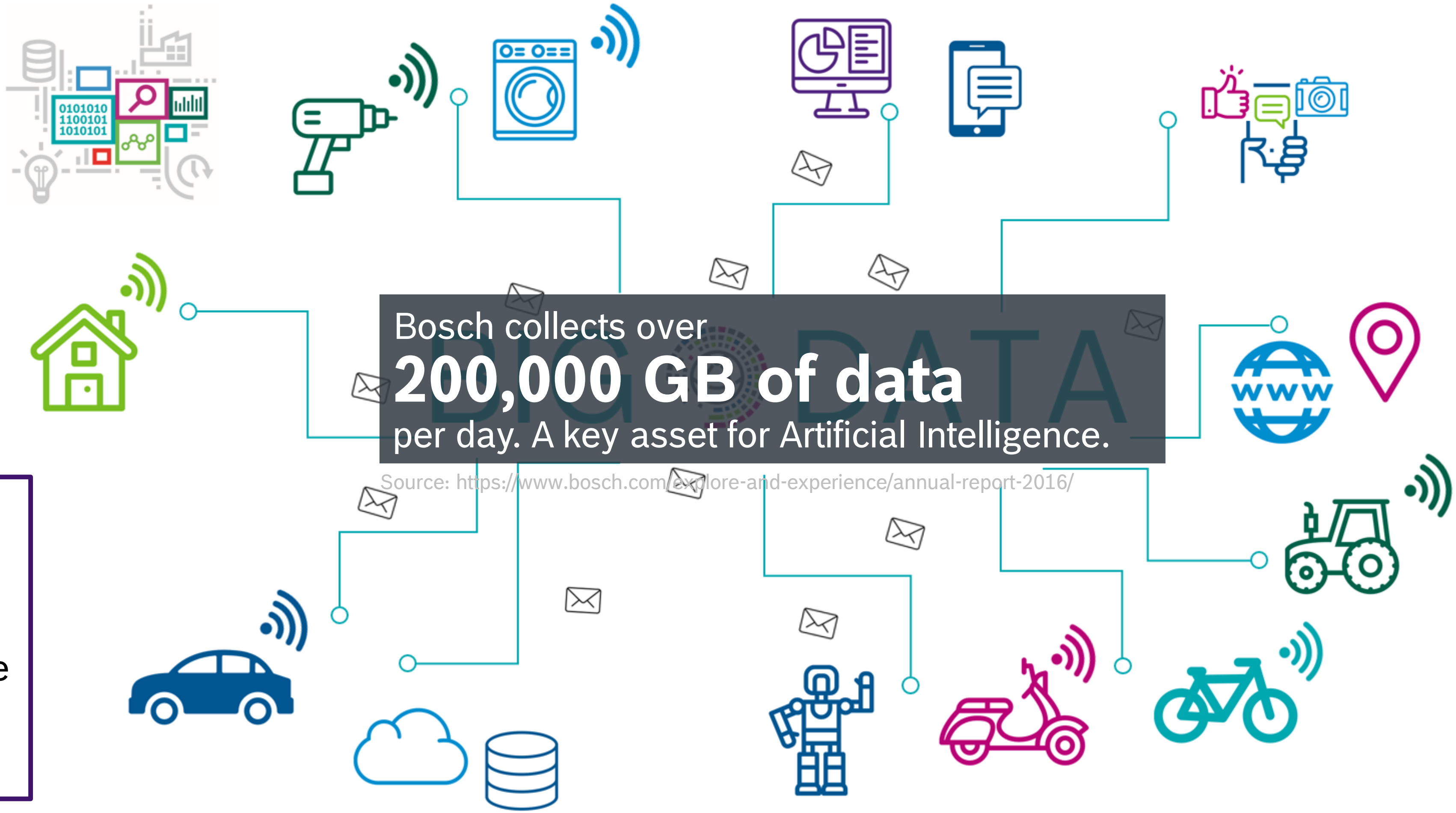
Data
Data at Bosch



Which data do you already or could you use for your business?

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Data Based Value Creation
Data Mining

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Data mining is the process of discovering hidden, previously unknown and usable information from a large amount of data.

(ISO/IEC JTC1/SC32 WG4 SQL/MM Part 6 WD, 2000)

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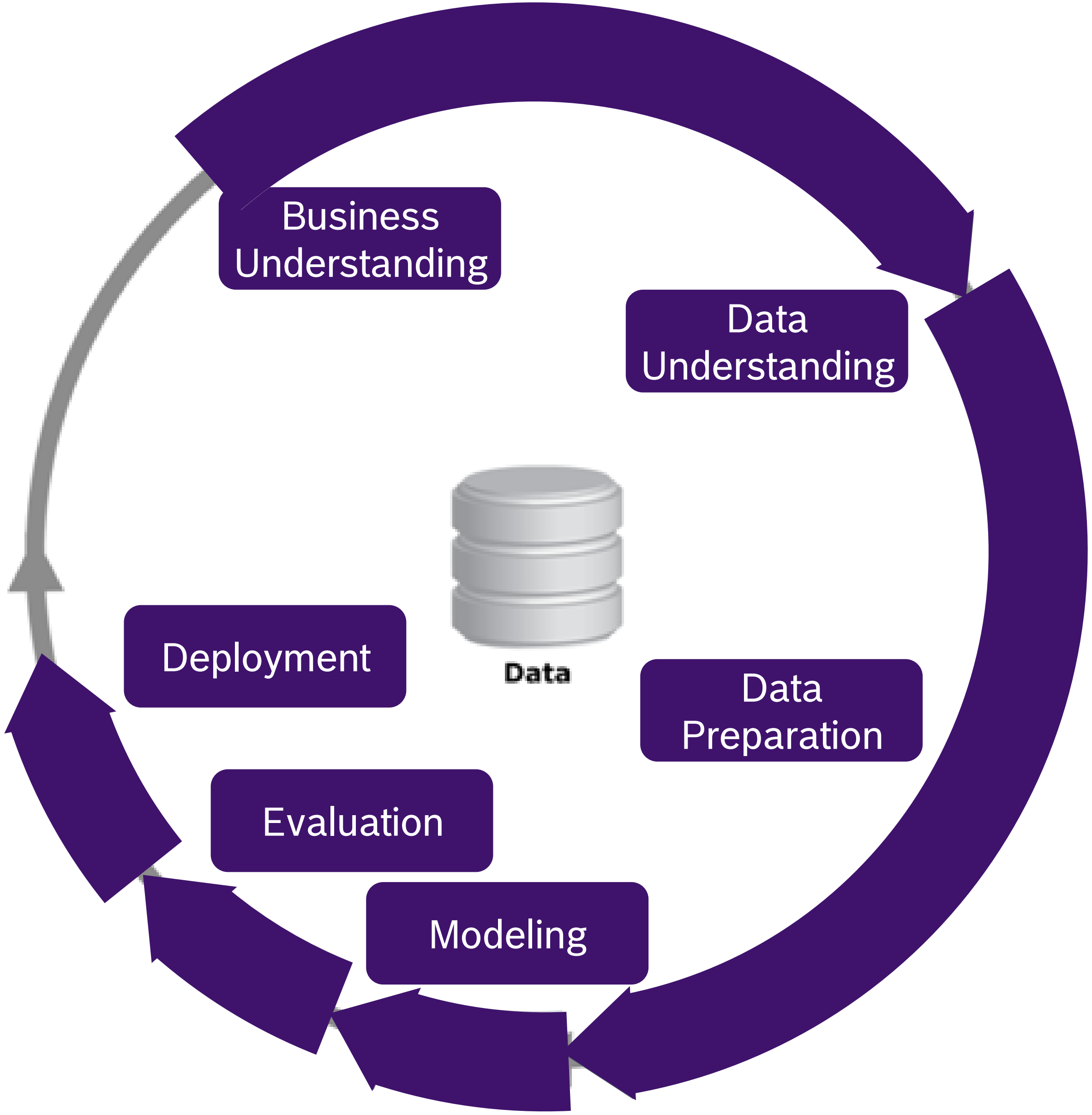
Data Based Value Creation
CRISP-DM

The standard data based value creation process is called CRISP-DM:

Cross-Industry
Standard Process
for Data Mining



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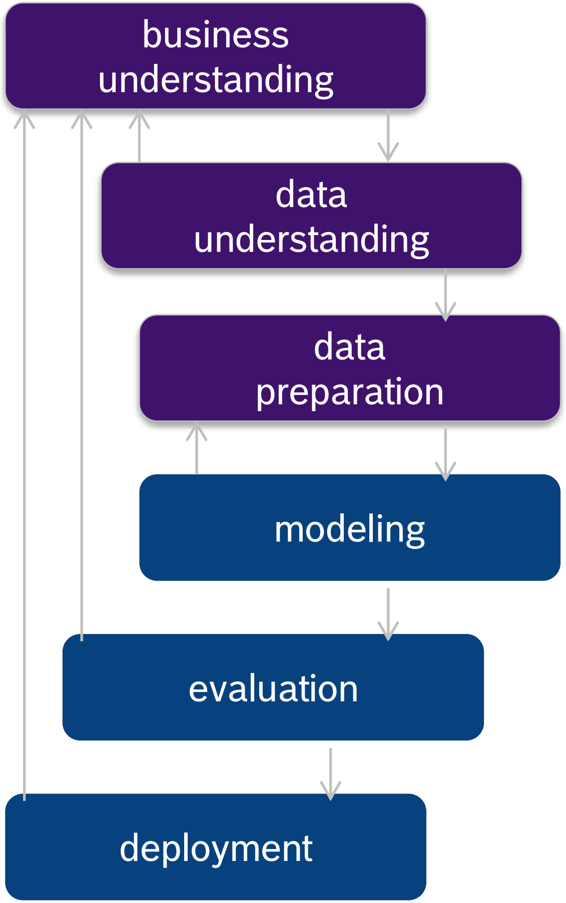
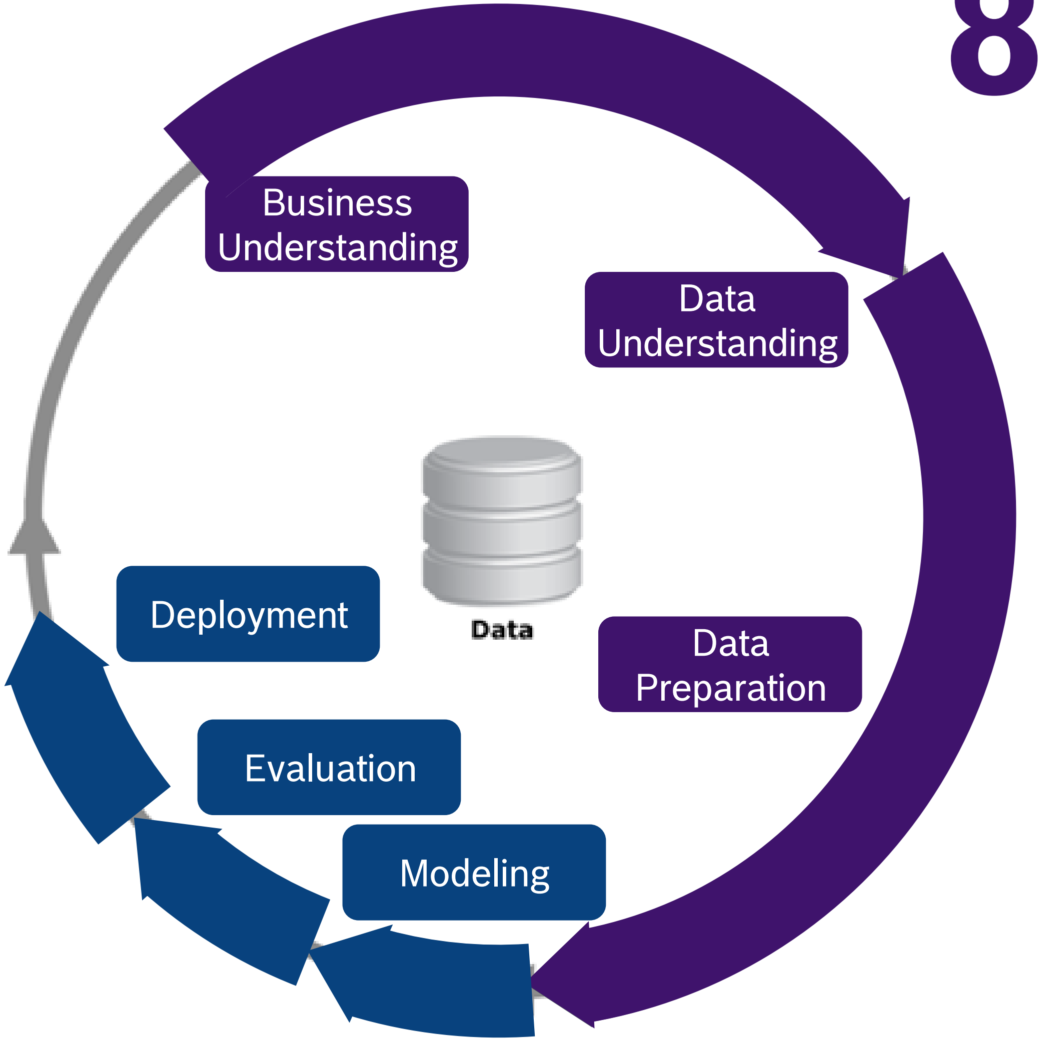
Data Based Value Creation
CRISP-DM



80%



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Data Based Value Creation
Excursion: Data quality

Schema Level

- Illegal values 1
- Violated attribute dependencies
- Uniqueness
- Referential integrity 2
- …

Instance Level

- Missing values 3
- Misspellings
- Redundancy/duplicates
- Contradictory values
- Wrong references 4
- …

Schema Level

- Structural conflicts 5
- Naming conflicts
- …

Instance Level

- Inconsistent representations 6
- Inconsistent timing
- …

1 Not allowed (for convention: DD.MM.YYYY)

2 Department not defined

Name	First Name	SSN	Date of Birth	Department
Müller	Maria	12345	01.13.1988	127
Müller	Maria	12345	01.03.1988	

4 contradiction

3 missing

Source 1

Name	Street	City	Sex
Müller	Amalienstraße	Munich	F

5 Structure differs

6 Representations differ

Name	Address	Sex
Müller	Amalienstraße, Munich	1

Source 2

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Data Based Value Creation
Excursion: Data quality 2

exactness
Are exact numeric values available?
Are different objects identifiable?

completeness
Are there missing attributes or values?

reliability
Is there a Standard Operating Procedure (SOP) that describes the provision of source data?

NEW

correctness
Do data and metadata provide an exact picture of the reality?

Data Quality
There are even more aspects to think about
…

NEW

understandability
Does a description for the data and coded values exist?

NEW

consistency
Are there contradictions in data or metadata?

relevance
Does the data contribute to the purpose of the use case?

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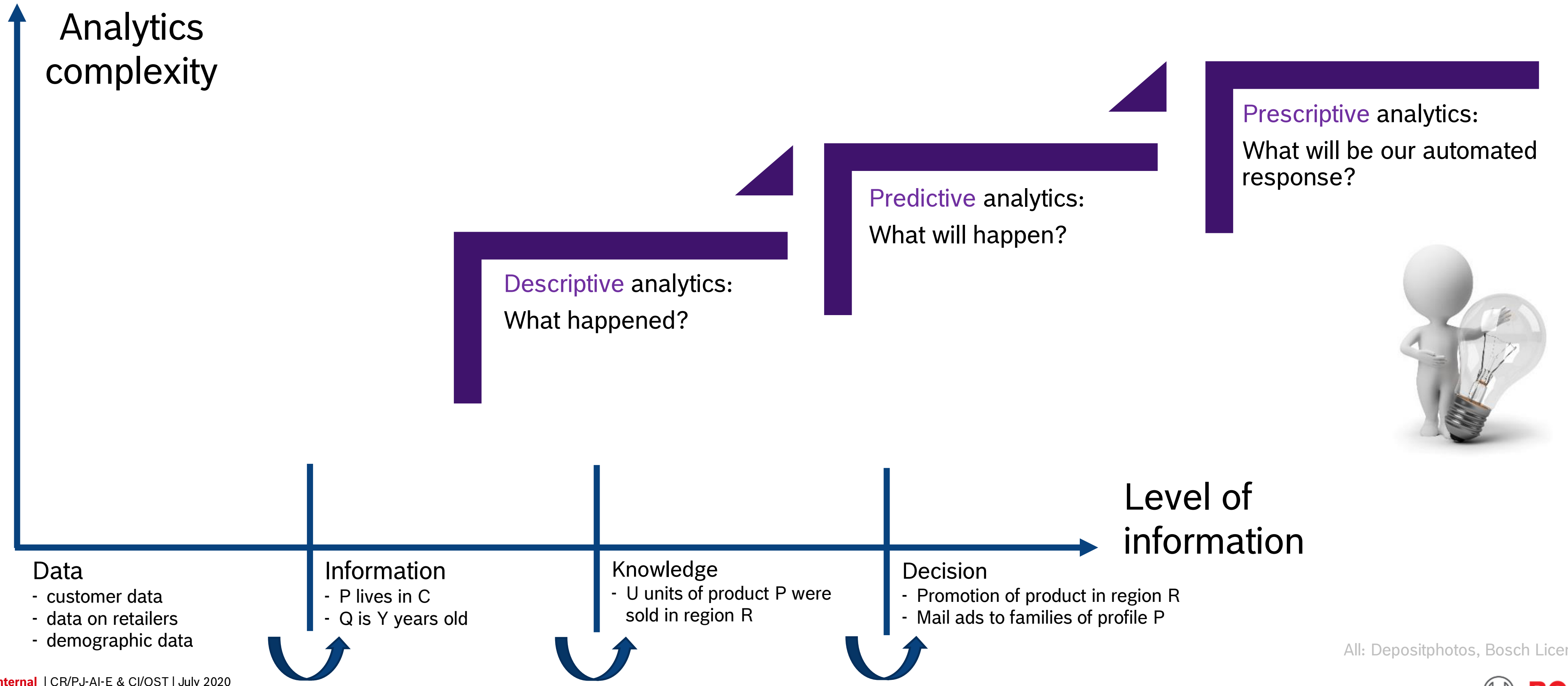
Data Based Value Creation
Levels of Data Mining



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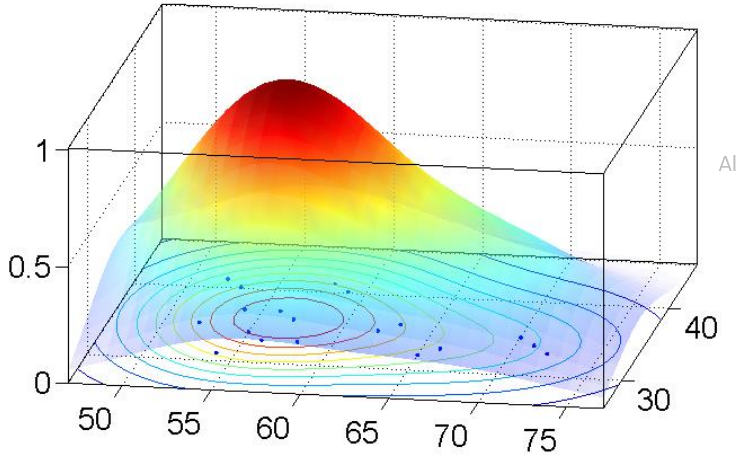
Data Based Value Creation
Descriptive analytics

We can gain data understanding by the use of descriptive analytics:



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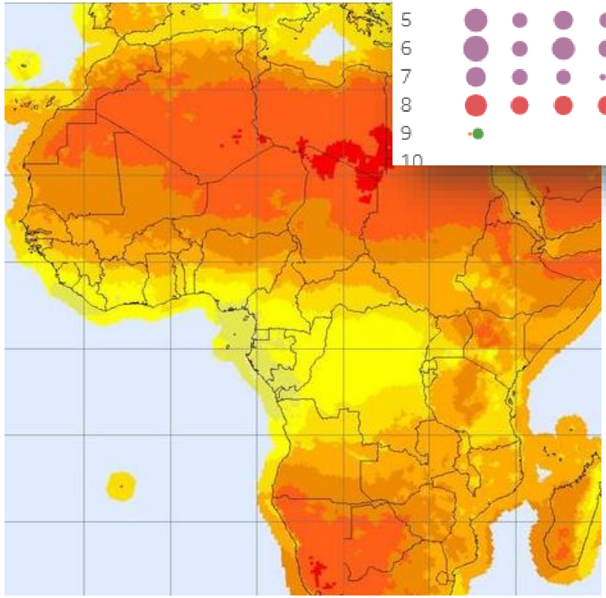

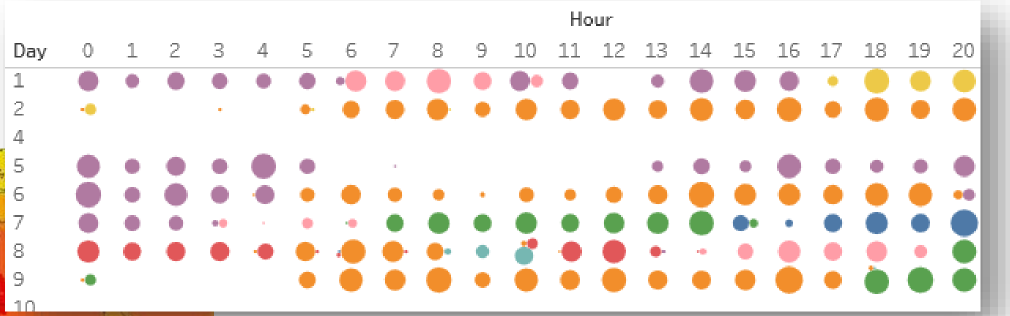

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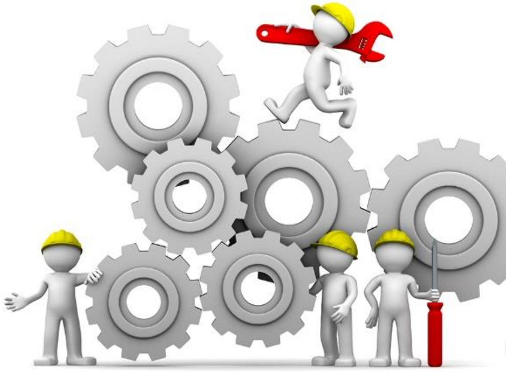
Data Based Value Creation
Predictive analytics

If we really understand the mechanisms behind our data,



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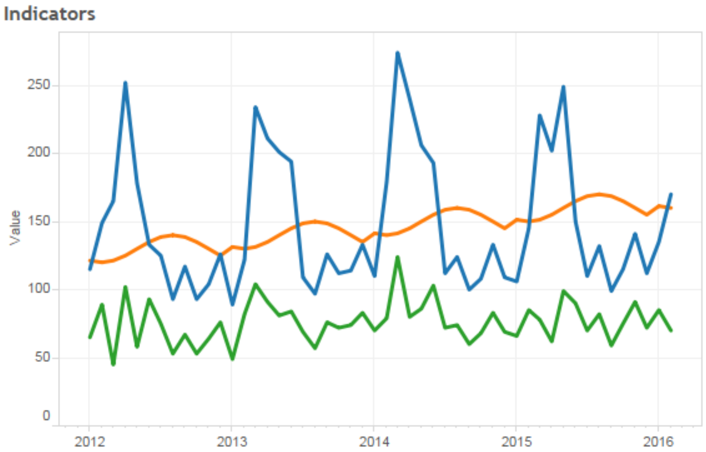
Example: Sales forecasting



we can make predictions for the future.

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Data Based Value Creation
Use case: Predictive Analytics Toolbox for Finance

A **forecasting toolbox** for Bosch which can answer questions such as the following:

- How many sales is a BU expected to generate in the short and mid-term future?
- Are there **regular sales patterns** in the past from which we are able to **predict future sales** developments?
- What drives **irregularities** and what can I learn for future predictions?

https://pixabay.com/de/wahrsagen-zukunft-magie-astrologie-1989579/, CC0

- Part of **G2/PJ-FCE** in close collaboration with BCAI and CI

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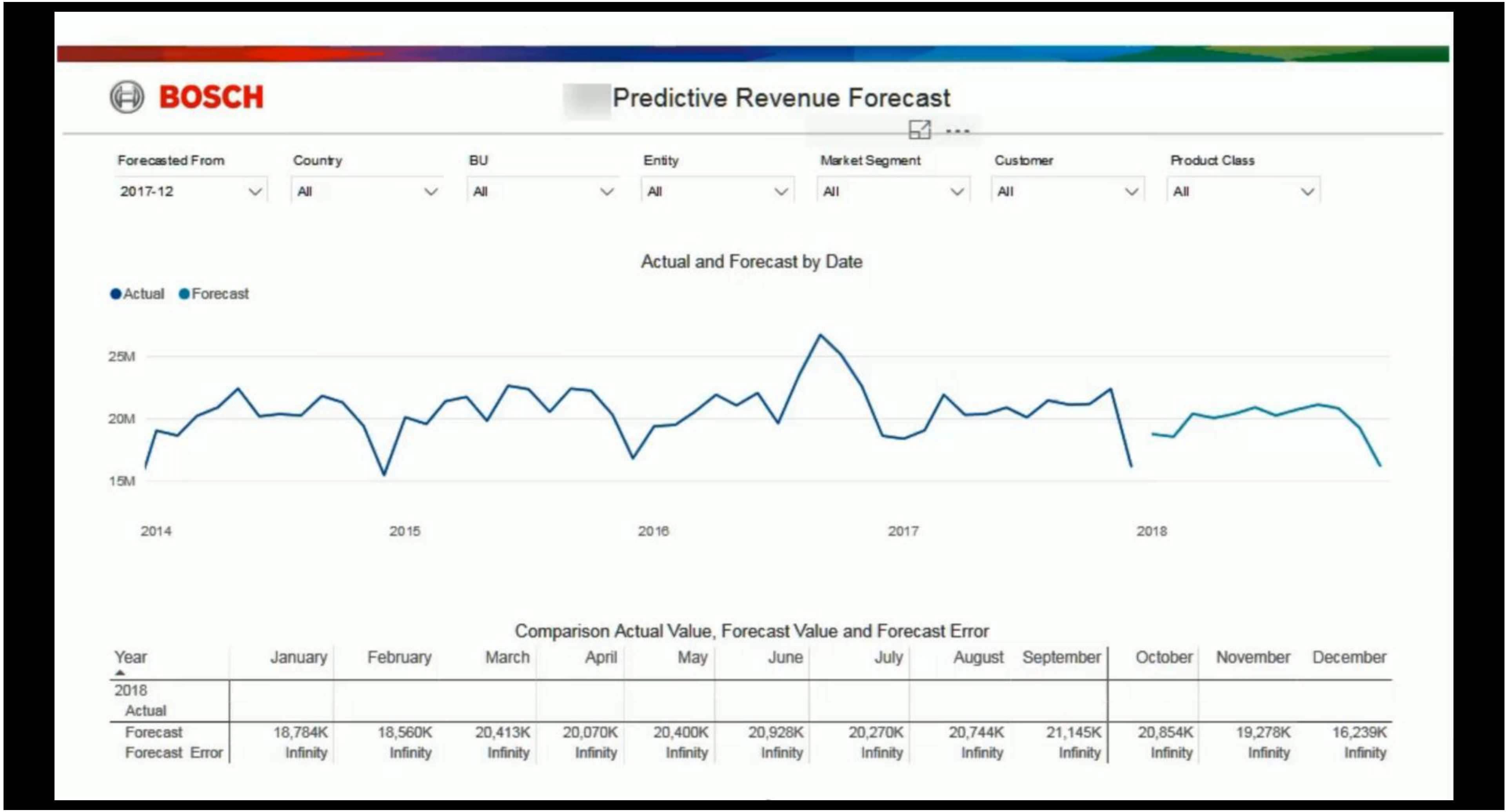
Video: Predictive Analytics Toolbox for Finance



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Data Based Value Creation
Use case: Predictive Analytics Toolbox for Finance

- Tremendous **speed-up** of and more accurate forecast (for regular patterns in the data)
  - Less bottom-up, **hand-tuned** aggregation and consolidation

  „ 90% of time required for number crunching and consolidation, getting it from BUs and sending it to Schillerhöhe“

  - More time for **strategic decision support**

- A tool to **understand the past**
  - Controllers can find out which **extraordinary factors influenced the business**

- Manual forecasts often have a **political component**
  - Data Mining is an objective resource and **adjustments have to be justified**

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Data Based Value Creation

Poll

Poll:
“On what level of data mining is forecasting?”

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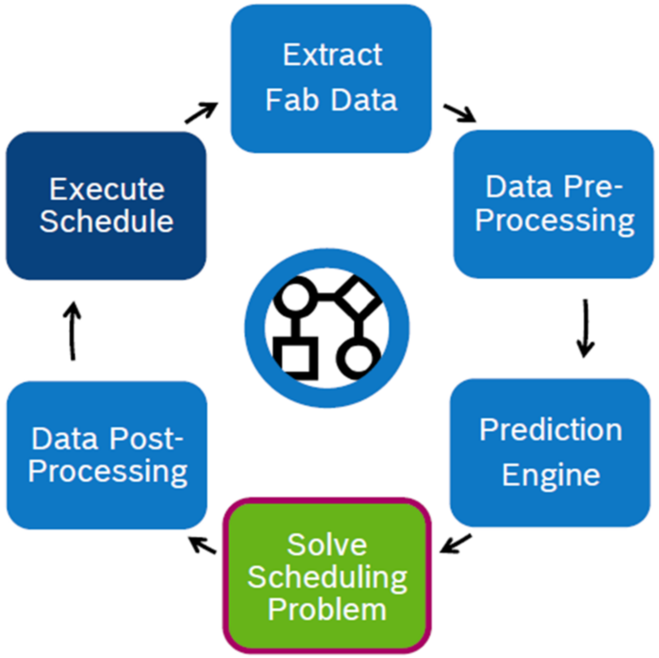
Data Based Value Creation
Prescriptive analytics

Example: Production Scheduling
@ Bosch plant in Reutlingen

We can expand predictive analytics to prescriptive analytics by automated reactions.



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Data Based Value Creation
Use case: Production Scheduling

Target:

Optimal production plan

also in varying conditions!

RtP1 project requirement:

New optimum production plan

within 5 minutes!

Changing job deadlines/priorities

Bicycle production line by clement127, CC0

Changing input provision

Changing output requirements

Machine stalls

Machine/job-dependent process times

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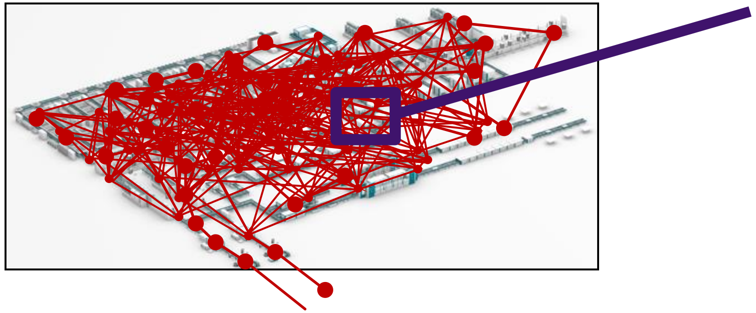
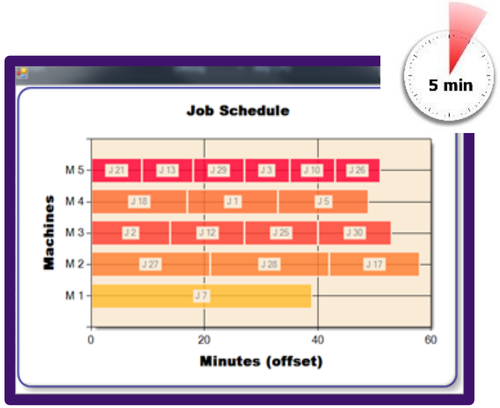
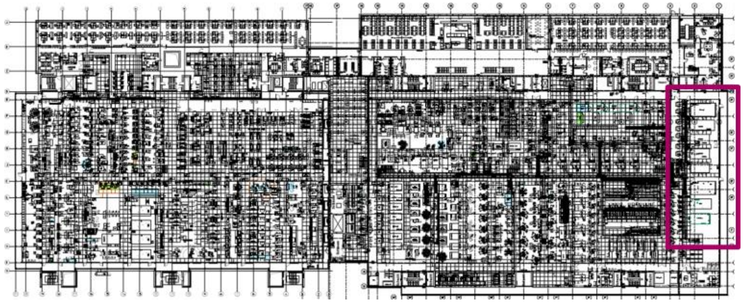
Data Based Value Creation
Use case: Production Scheduling





200mm Implant Workcenter



8 tools + 2 robots for (un-)loading

Rule-Based Dispatching

Status quo is production control using rule-based dispatching

Scheduling with Optimization (Solver)

First scheduling solution deployed in RtP1 production after 6 months (BCAI cooperation)

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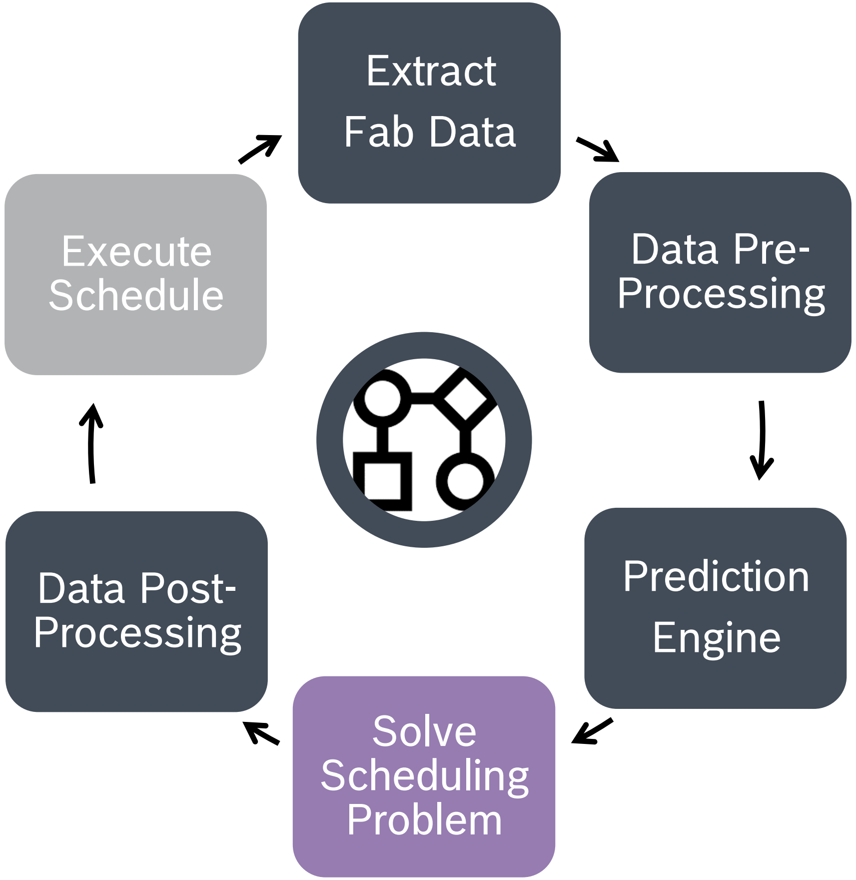
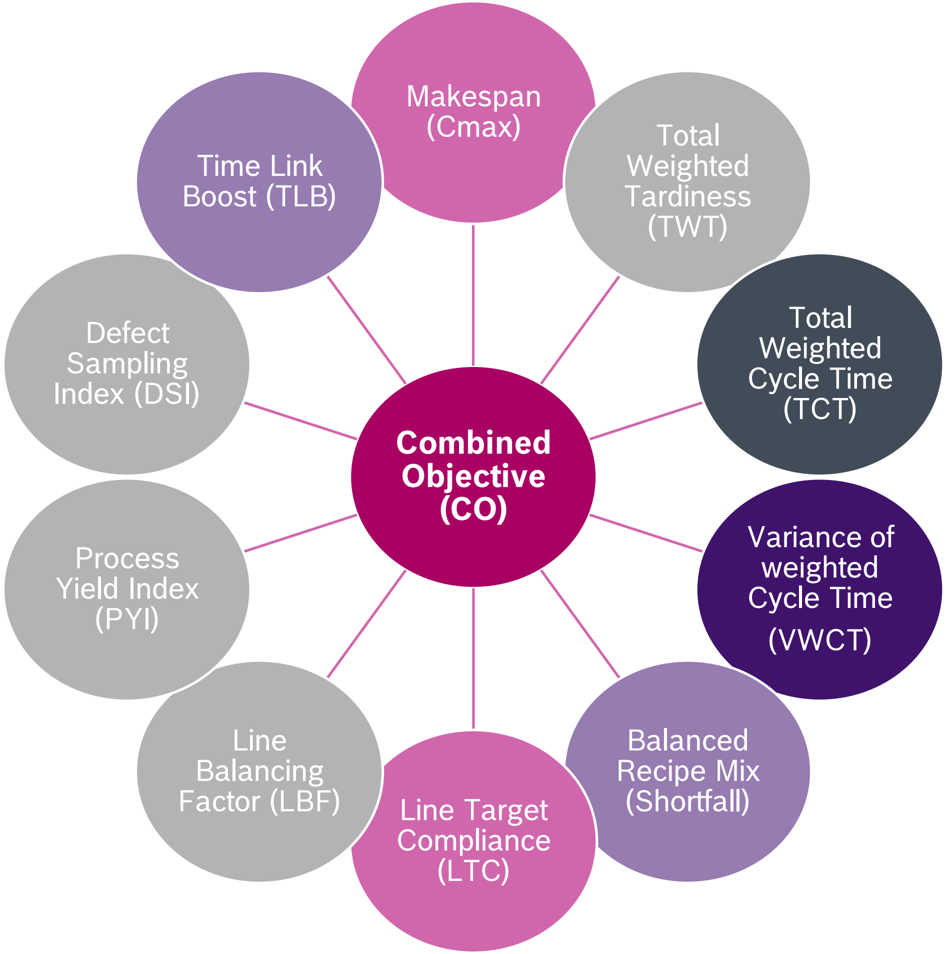
Data Based Value Creation
Use case: Production Scheduling





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Data Based Value Creation
Use case: Production Scheduling

“Nobody would intuitively do it like that, but it is actually better!”

Minus ~45% StandBy-With-WIP

>5% more throughput with all-times high record

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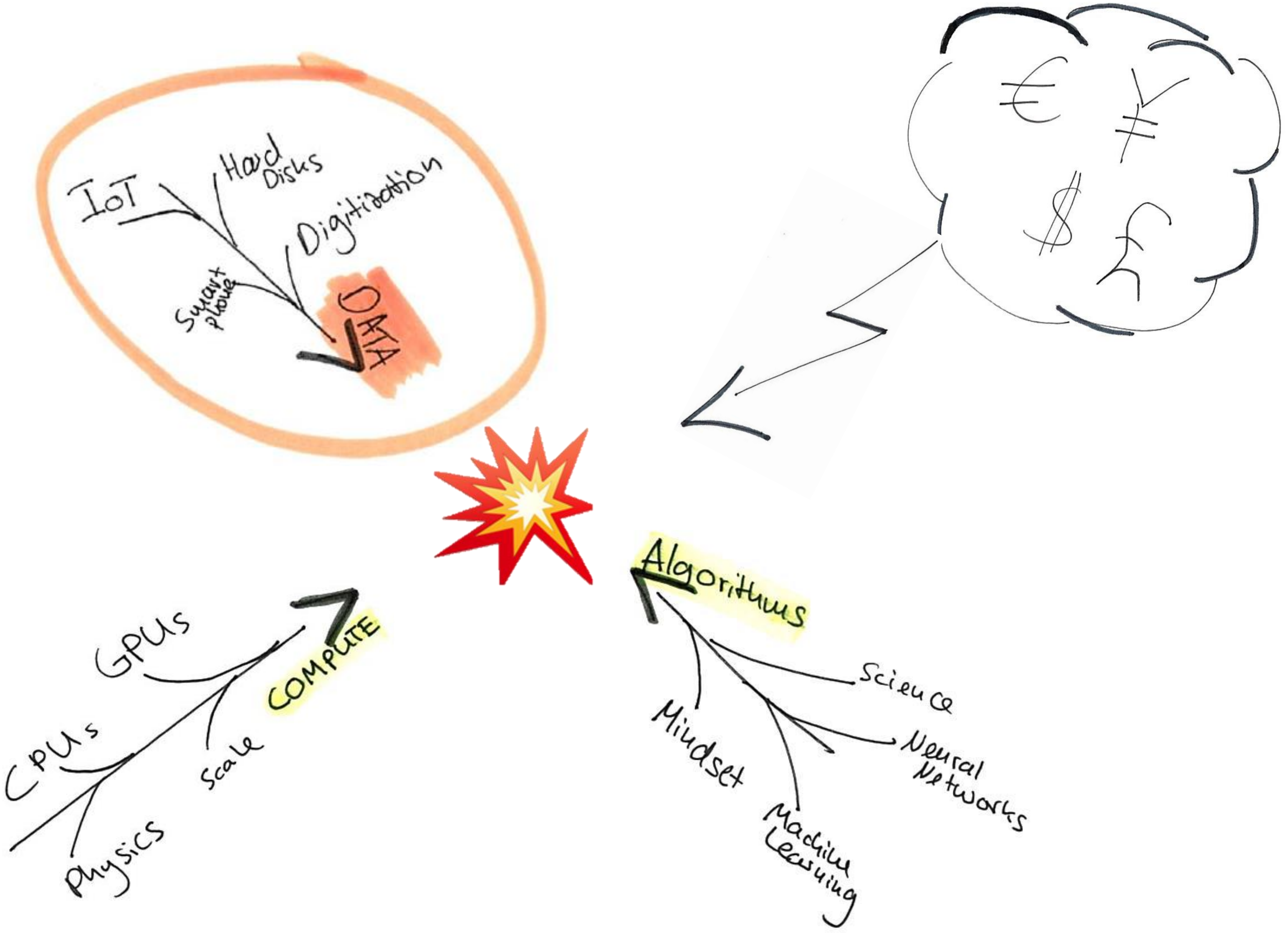
Big Data
The data dimension



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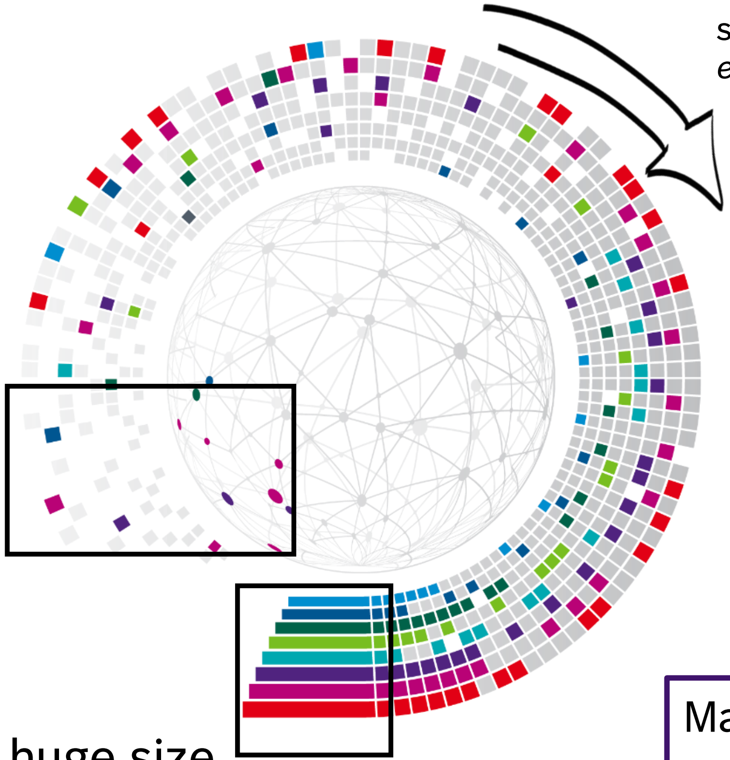
Big Data
The 3 V's

Velocity – data in motion

streaming data (msec to sec to respond)
e.g.: near real-time business data



Variety – data in many forms

e.g. text, video, images;
structured and unstructured
For example: self-driving car's cameras and sensors

Volume – data of huge size

large amounts of historical data (TBs or more)
e.g.: Connected Industry production lines

Matching **one of these criteria** already indicates that Big Data technologies may be beneficial.

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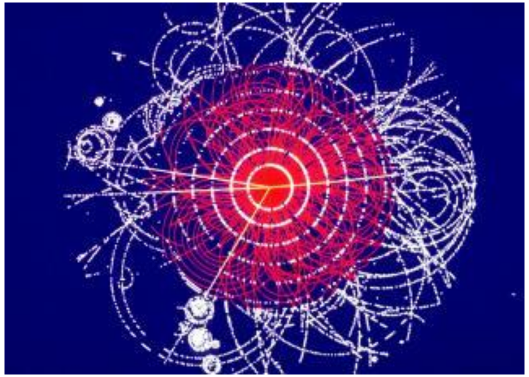
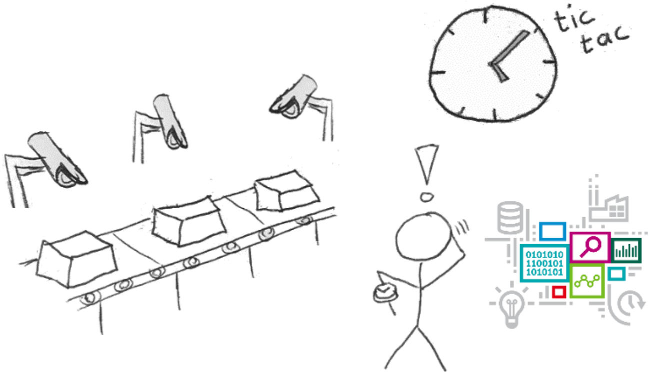
Big Data
What is Big Data? Volume

- Amount of data so large that we need new methods to process



CERN LHC data totaling 200 PB in 2017

Each day 4 PB are newly generated on Facebook



Cycle Time Reduction needs a large corpus of historical data to reveal patterns

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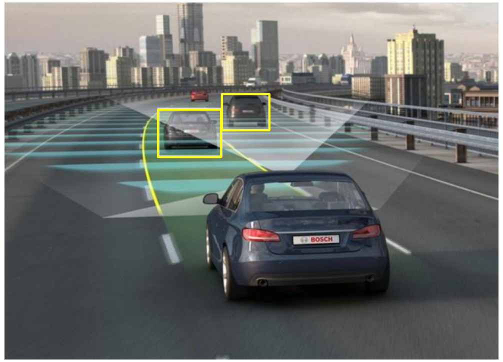
Big Data
What is Big Data? Velocity

- Data needs to be processed quickly for fast decision-making

High-frequency trading requires **seconds to milliseconds** reaction times



Autonomous driving needs to **process sensor, image, map data** rapidly to steer the car safely

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Big Data
What is Big Data? Variety

- Beyond tables: all sorts of data can now be analyzed

Voice data is analyzed for speech recognition

Pictures/Videos can be used for image recognition tasks

Natural language / text data can be analyzed to extract information

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Big Data
When do we speak about big volume data?

- When we have > 100 GB of data which need to be processed continuously
- When the working memory of our PC is not sufficient anymore
- When the amount of data is rising in GBs on a monthly basis
- When relational databases, Excel etc. do not work efficiently anymore

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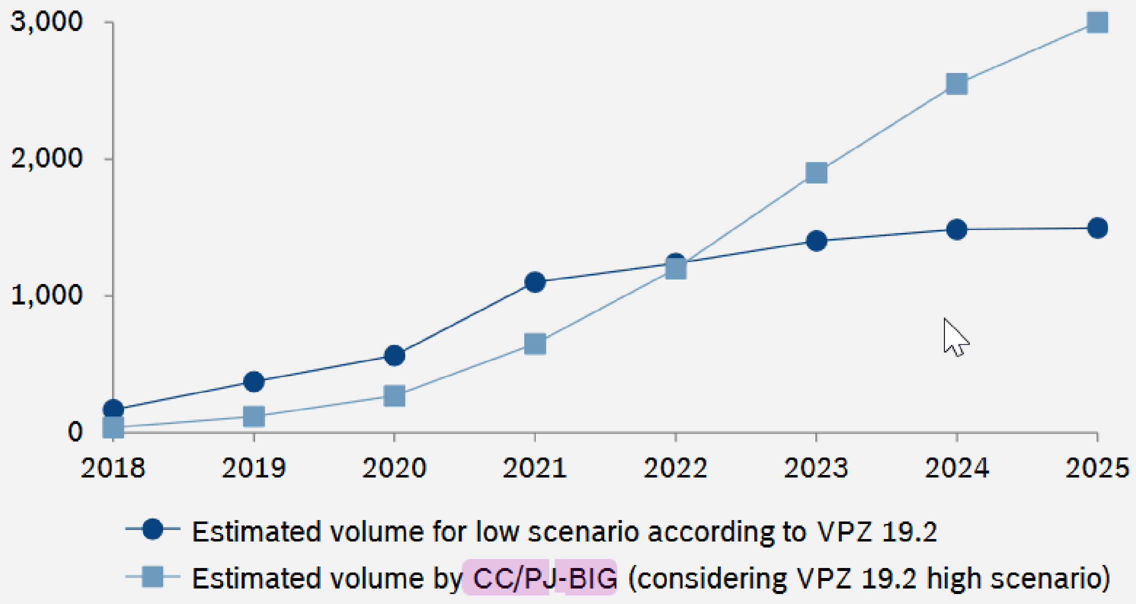
Big Data @ Bosch
Example: CC Data Lake

Expected data volume for CC in Petabyte (PB)



Total volume expected to rise up to 3,000 PB until 2025 with majority video data

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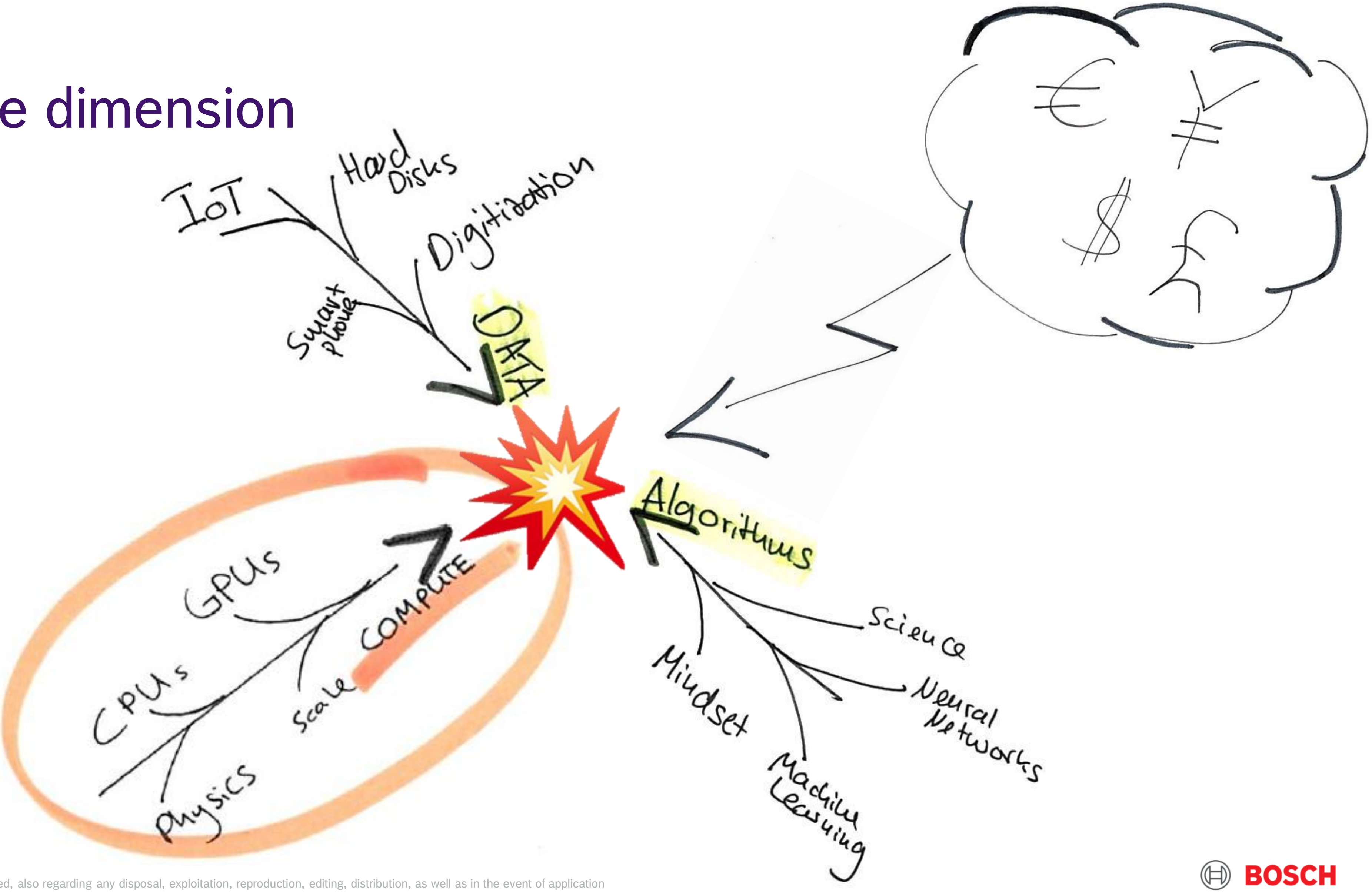
Big Data
The compute dimension



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Big Data
Big Data computation – the idea of batch processing

- Goal: process very large amounts of (historic) data

- Idea: Divide and conquer algorithm

- How-to: Bring "processing to the data"

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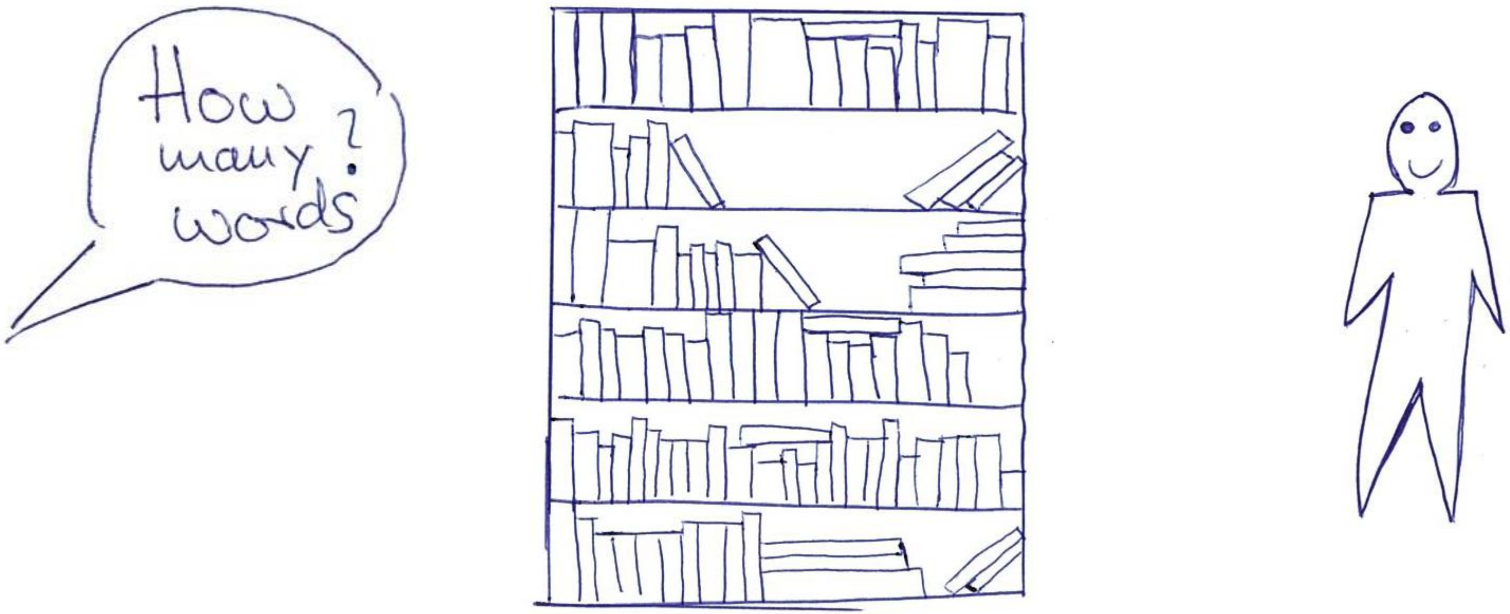
Big Data
How Big Data computation works – counting words



Challenging Task: count number of words in the whole bookshelf.

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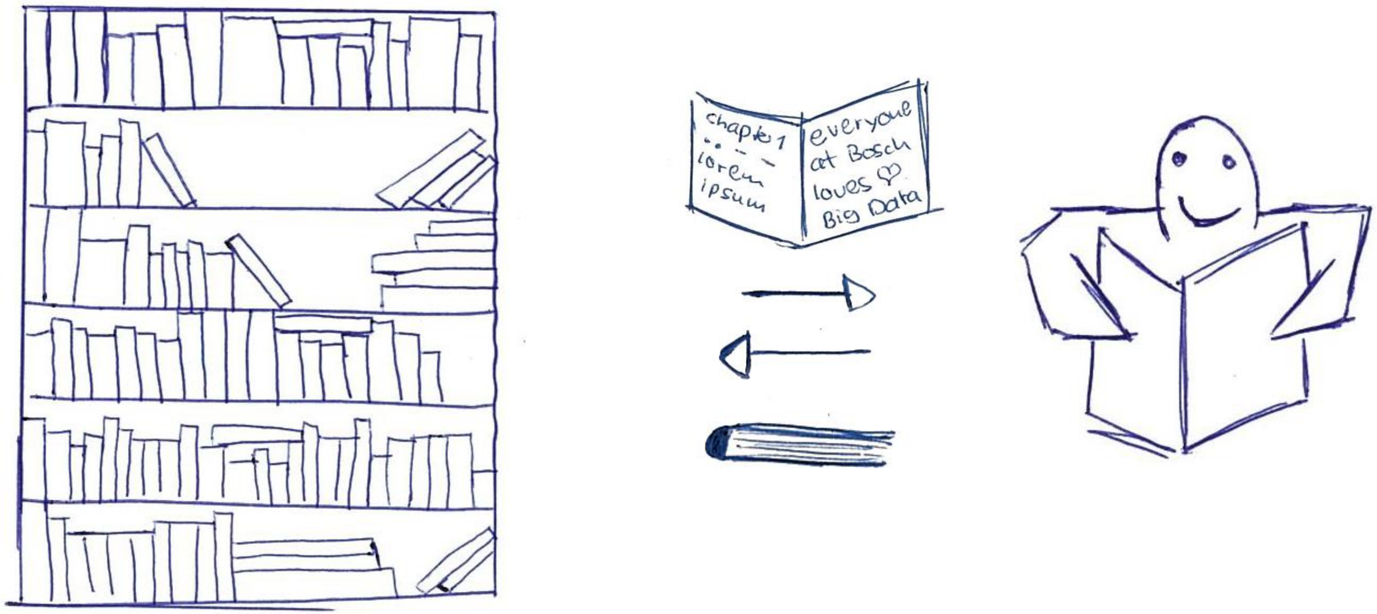
Big Data
How Big Data computation works – counting words



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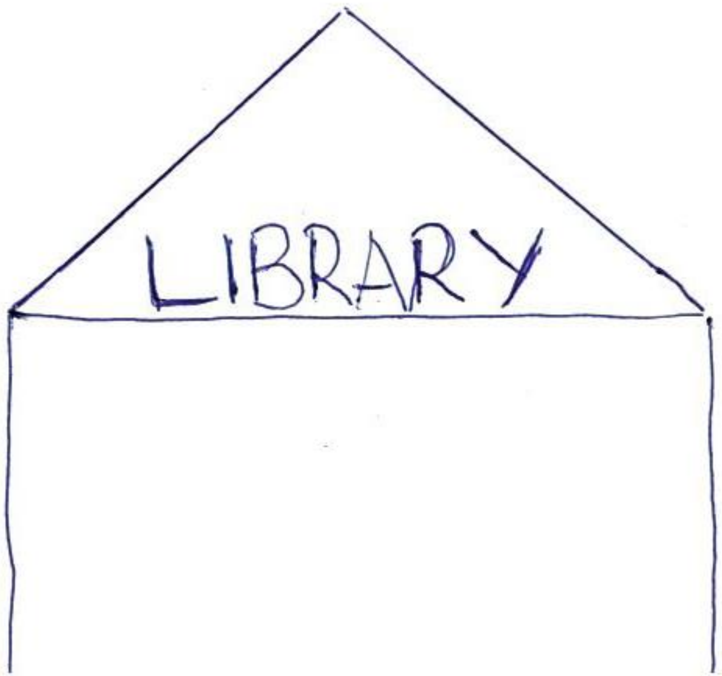
Big Data
How Big Data computation works – counting words



Sometimes you have a library to process ...

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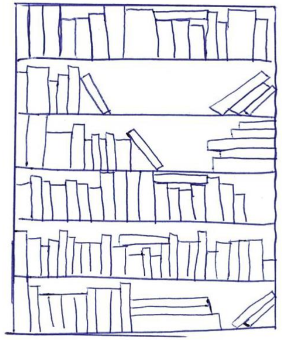
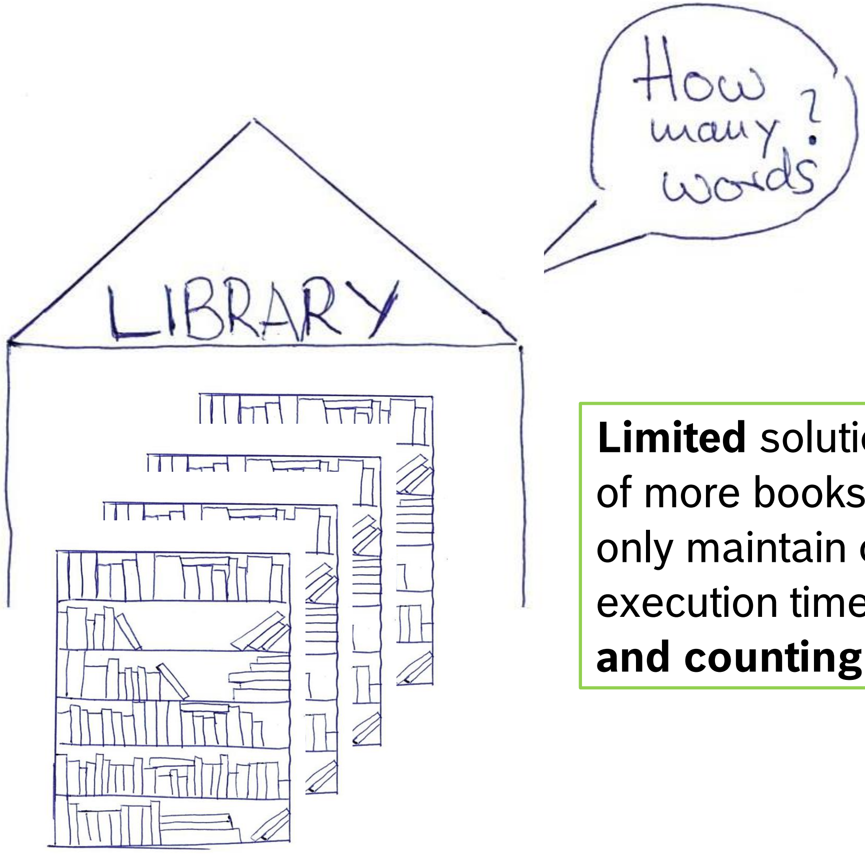
Big Data

How Big Data computation works – counting words



= same time



Limited solution: in the case of more bookshelves we can only maintain overall execution time by **reading and counting faster**!

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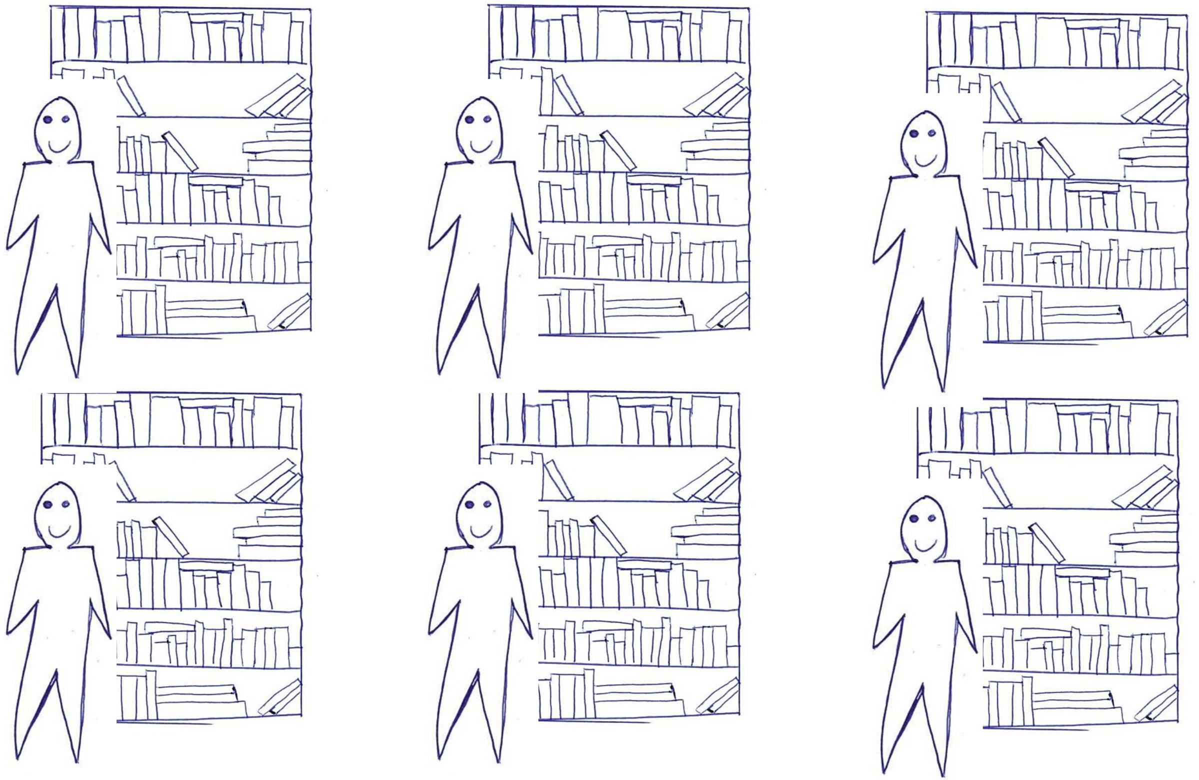
Big Data
How Big Data computation works – counting words



We move the workers close to data to minimize overhead: The **computation comes to the data**.

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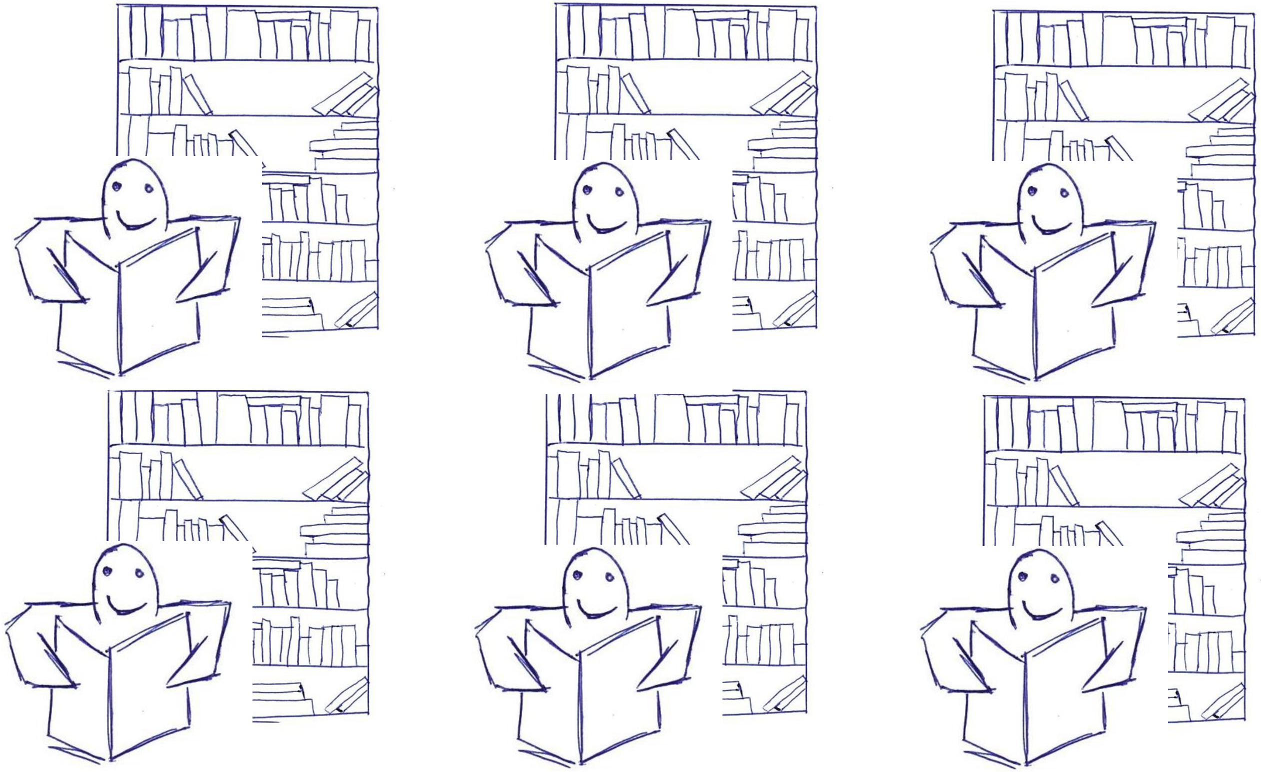
Big Data
How Big Data computation works – counting words



The **Big Data** approach is to find a **parallel description** of the task to **process more data in the time**.

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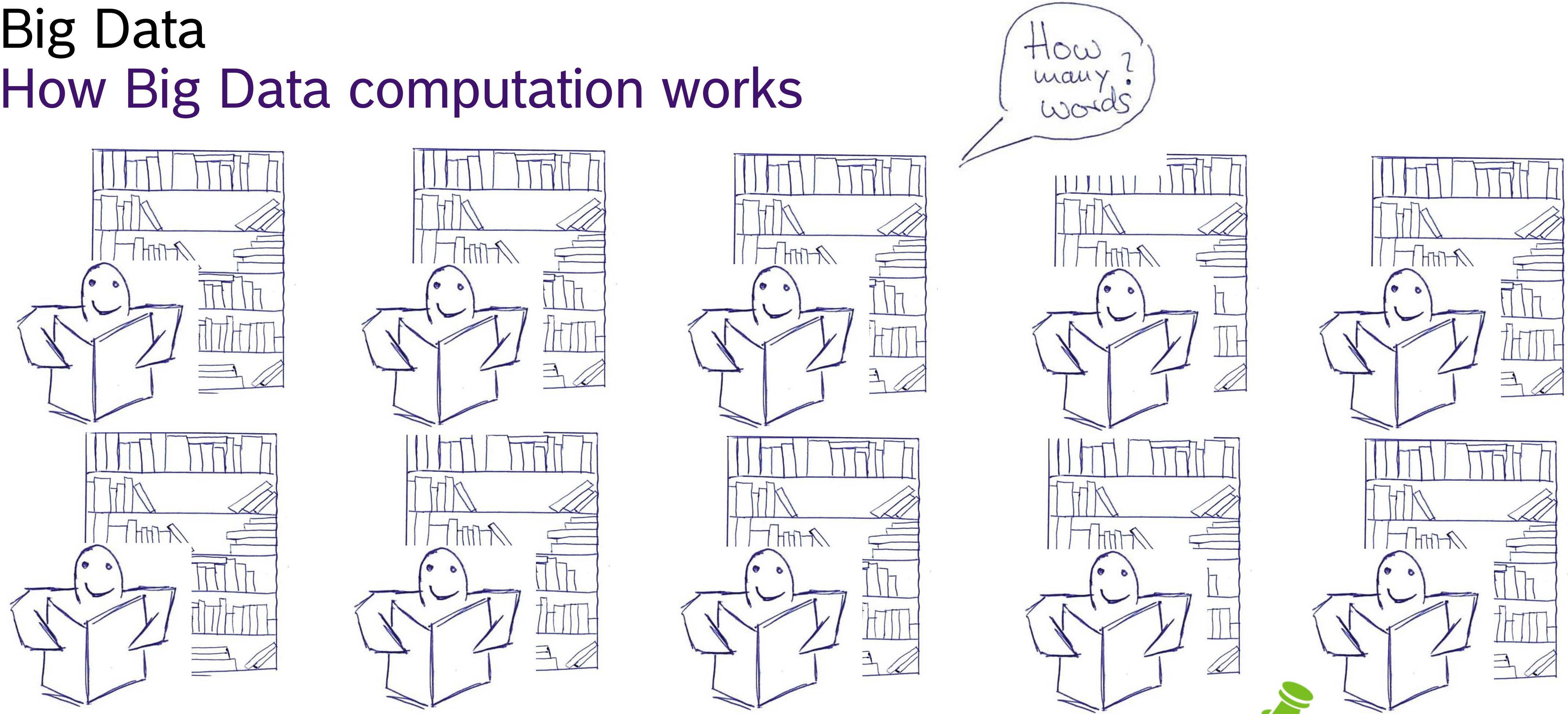
Big Data
How Big Data computation works



As **data volume grows**, workers can be added simply. The solution is highly **scalable.**

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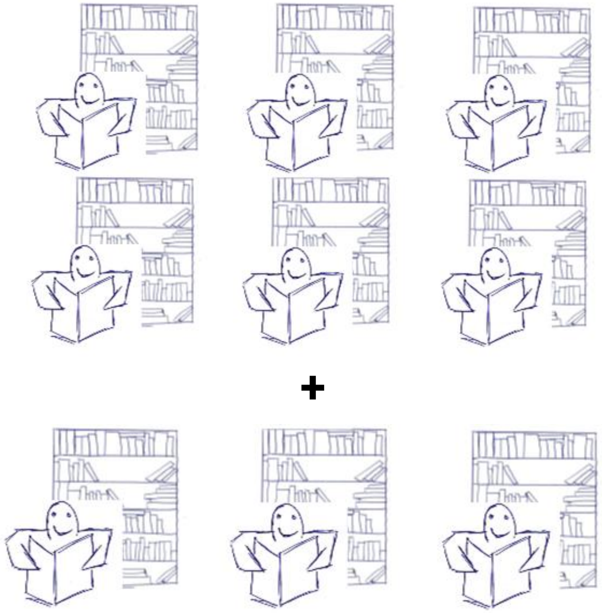
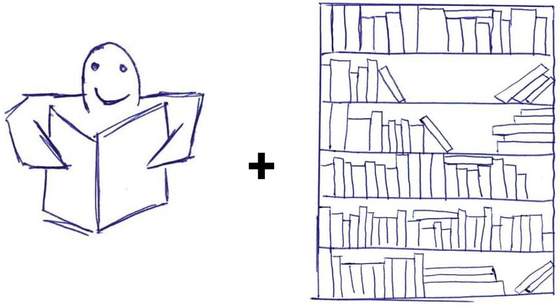
Big Data
Big Data computation – key benefits



Scalable solution that can grow dynamically with volume



Computation and data are always **bundled** in order make data processable

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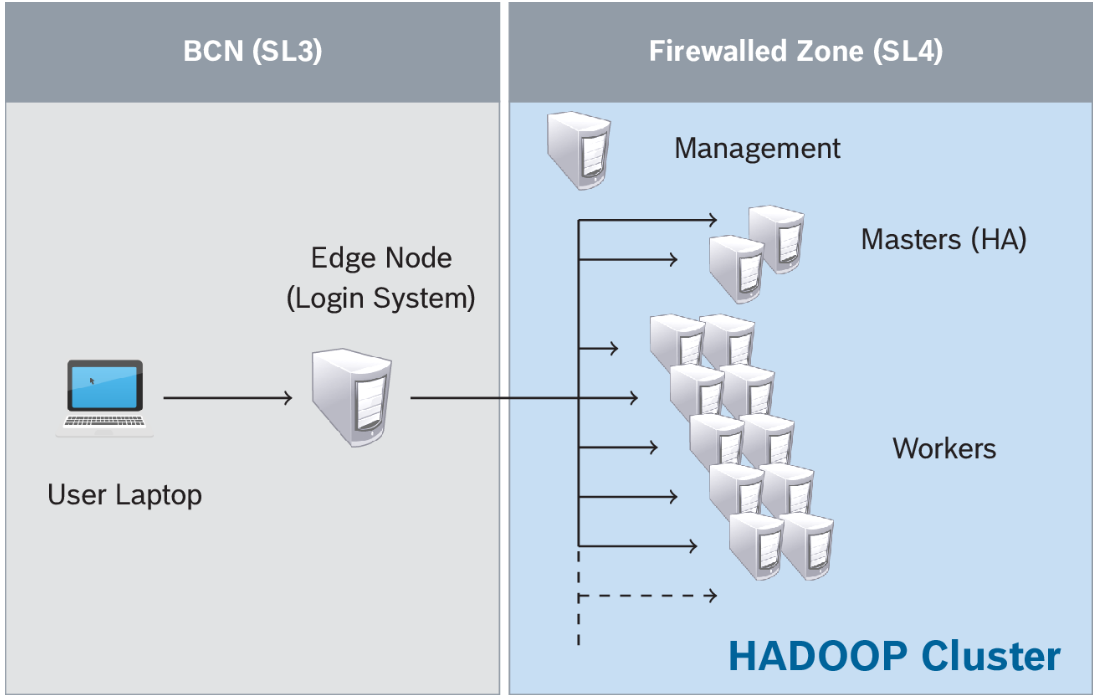
Big Data
A typical Hadoop cluster



Example configuration:

- Total net storage (10 Worker Nodes): **160 TB**
- Total working memory: **2560 GB**
- Total compute: **240 cores (480 with HT)**

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Big Data

Hadoop ecosystem – tools for many situations

Search framework for large amounts of data

In-memory analytics for immediate access

Processing of **quickly incoming data** (velocity)

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Data
Poll

Poll:
"What are the essential ideas of Hadoop clusters?"

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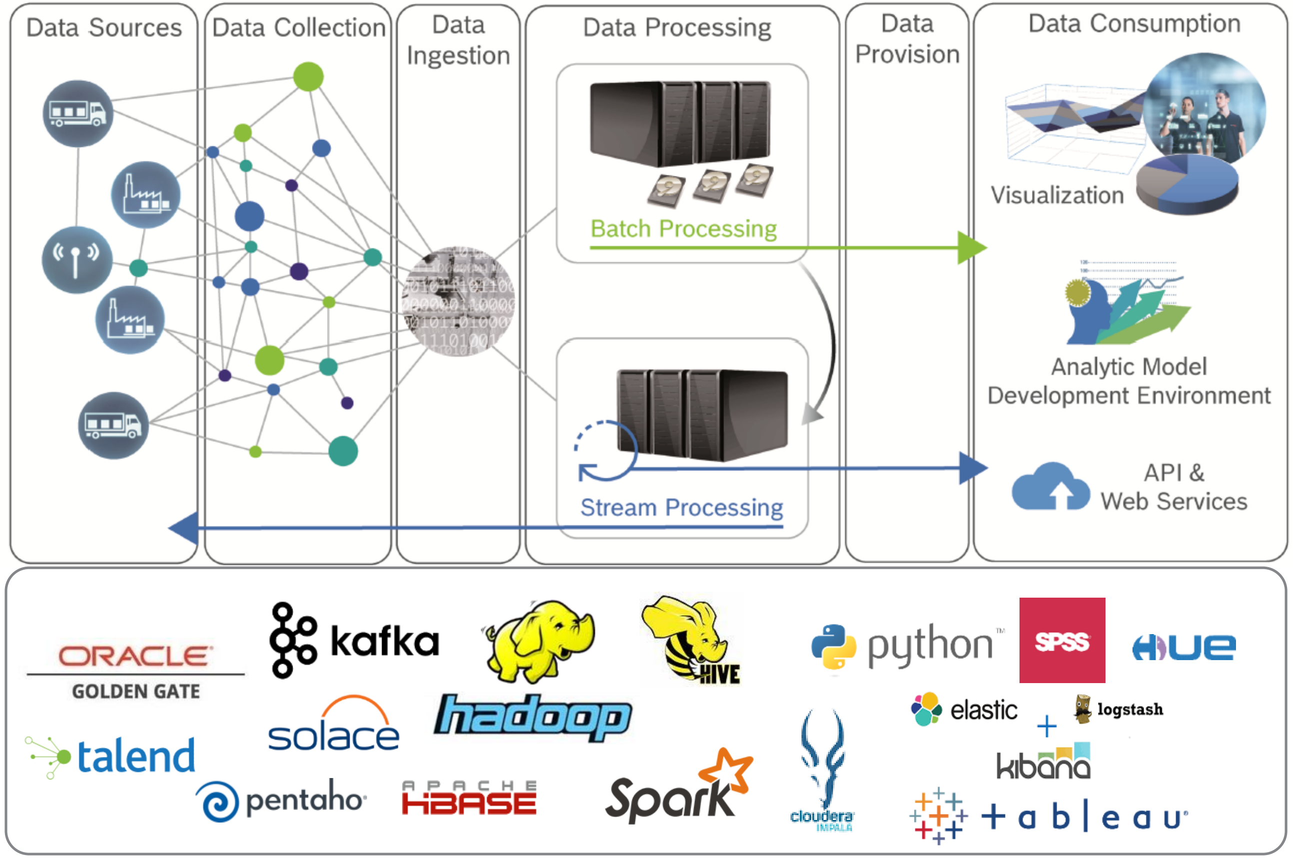
Big Data
RB Analytics Platform



The RB Analytics Platform is the implementation of Hadoop for Bosch needs.

It is a modular toolstack based on Big Data framework **Hadoop** with many state-of-the-art tools available.

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Big Data
Use Case: Big Data platform for PS/PJ-DT Xelerator

- At PS there is a 20-worker-node computer cluster (320 TB net storage) for analytics in production

- **Collect production data** from production systems of an injector
  - Access to production data bases without interruption
  - Unified schemas and datatypes
  - Data understanding of machine outputs and labels

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Big Data
Use Case: Big Data platform for PS/PJ-DT Xelerator

- Make data accessible to be **analyzed**
  - Build up of a common truth with production data
  - Dashboard for visual analytics
  - “What took weeks before we can now do in minutes”

- First use case: data-driven **reduction of test points**

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MACHINE LEARNING

Machine Learning
Machine Learning strategies

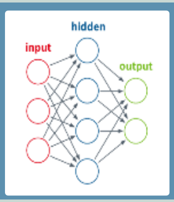
Tasks

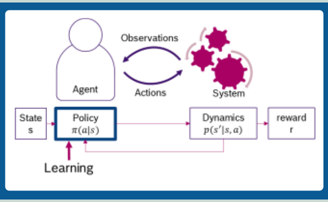
Strategies

Methods

Machine Learning Strategies

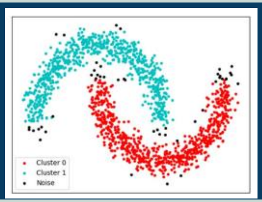
Supervised Learning





Reinforcement Learning

Unsupervised Learning



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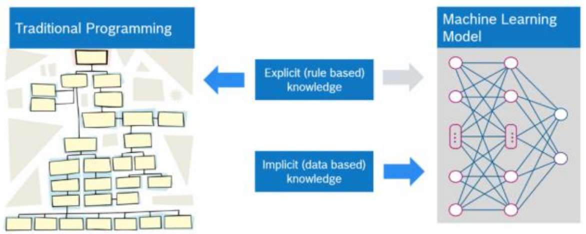
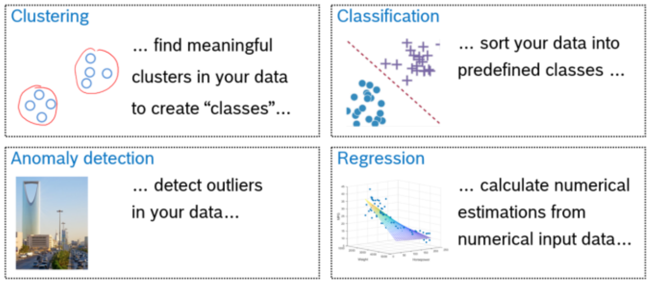
Machine Learning

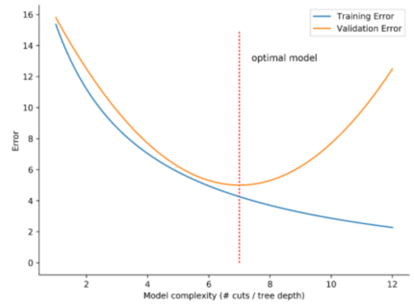
What will you learn in this section?



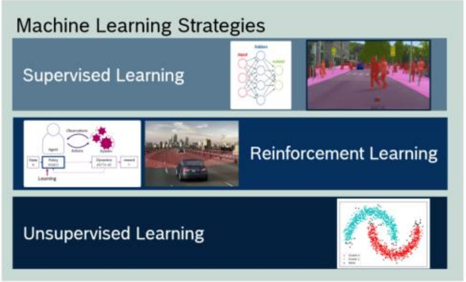
What makes ML revolutionary?



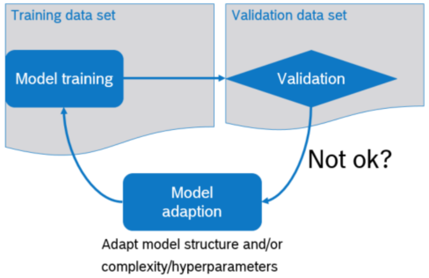
Tasks to solve



Model complexity



Types of ML strategies



How to train a model

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Machine Learning
Definition

Definition by Prof. Tom M. Mitchell:

A computer program is said to learn

from experience E

w.r.t. a task T and measure P,

if its performance P on T,

improves with experience E.

http://bzo.bosch.com/bzo/de/article_page_37325.html (Bosch Zünder Online)

Example

Your e-mail program improves its

spam filter mechanism by watching

you marking e-mails as spam or not.

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Machine Learning
Learning from experience

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Learning...

- To say “car”
- To distinguish cars from trucks
- To drive a car ...

all requires experience!

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Machine Learning
Example: a daisy vs tulip model (supervised learning)

In your garden, there are daisies and tulips. Your mom tells you to pick daisies for her.

We want to solve your daisy picking task by building a model, i.e. a system that helps you to distinguish daisies and tulips!

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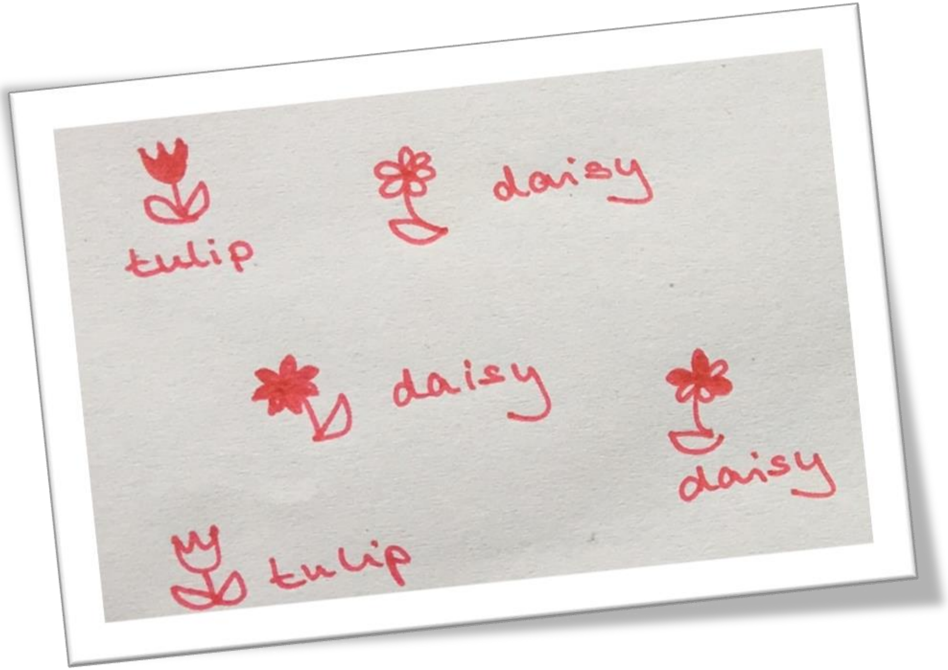
Machine Learning
Features as a basis for the model

Now choose features,

i.e. criteria that help you and the model

to decide if a flower is a daisy or a tulip.



Examples features:

- Number of leaves
- Height
- Color

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Machine Learning
Model building

1. Choose a feature (height)

2. Take measurements

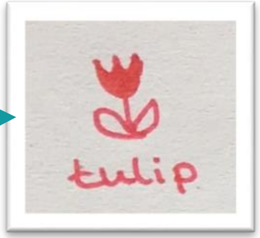
Type	Height (cm)
Daisy	8
Tulip	16
Tulip	20
Daisy	4
Tulip	9
Daisy	5
Daisy	10

3. Build a model

Output:
Type of
the flower

Input:
Height h of
the flower

$h > x$



$h \leq x$

This model has one parameter: x.

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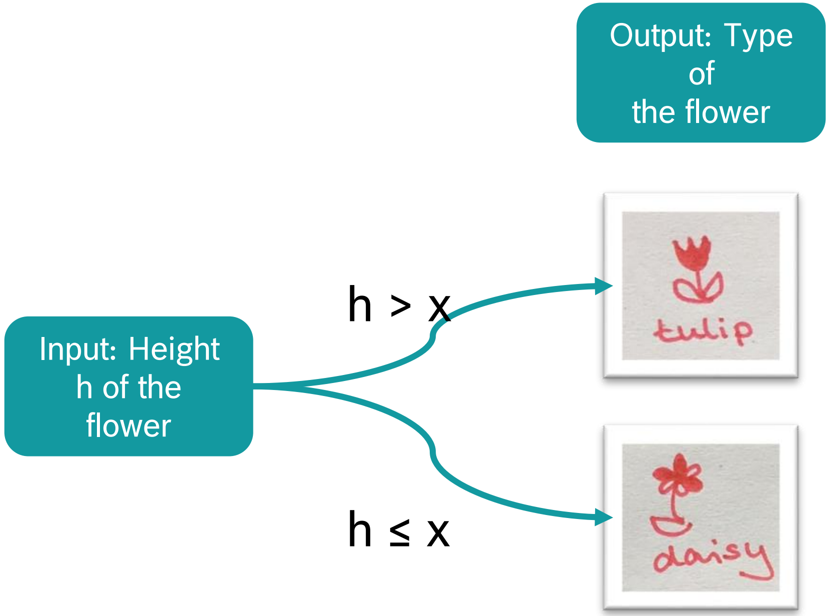
Machine Learning
Model training



Type	Height (cm)
Daisy	8
Tulip	16
Tulip	20
Daisy	4
Tulip	9
Daisy	5
Daisy	10

Model training means to optimize the parameter x such that it makes the least errors.

We learn the parameter of the model from data!

Exercise: Optimize x!

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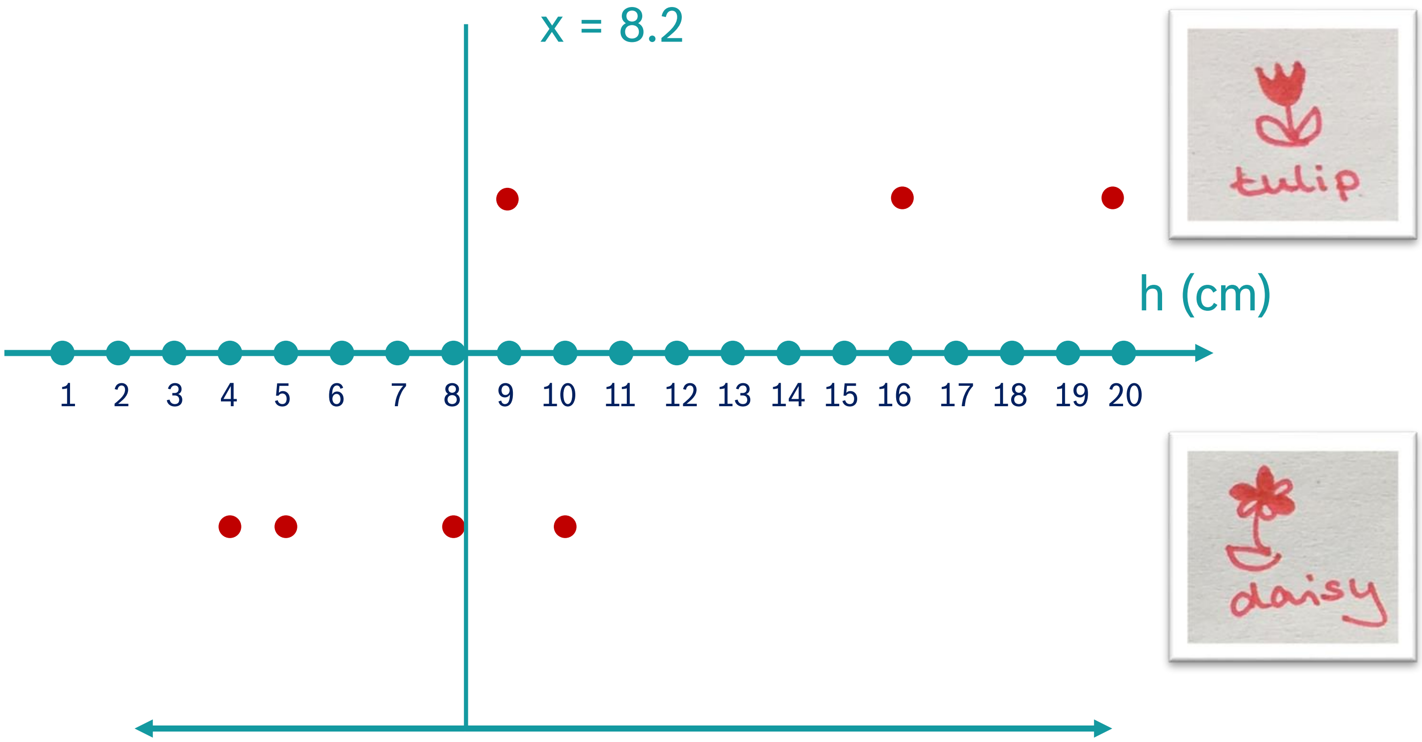
Machine Learning
Optimized model 1

Type	Height (cm)
Daisy	8
Tulip	16
Tulip	20
Daisy	4
Tulip	9
Daisy	5
Daisy	10



Guess: daisy
All of them are daisies

Guess: tulip
One daisy misclassified
As tulip

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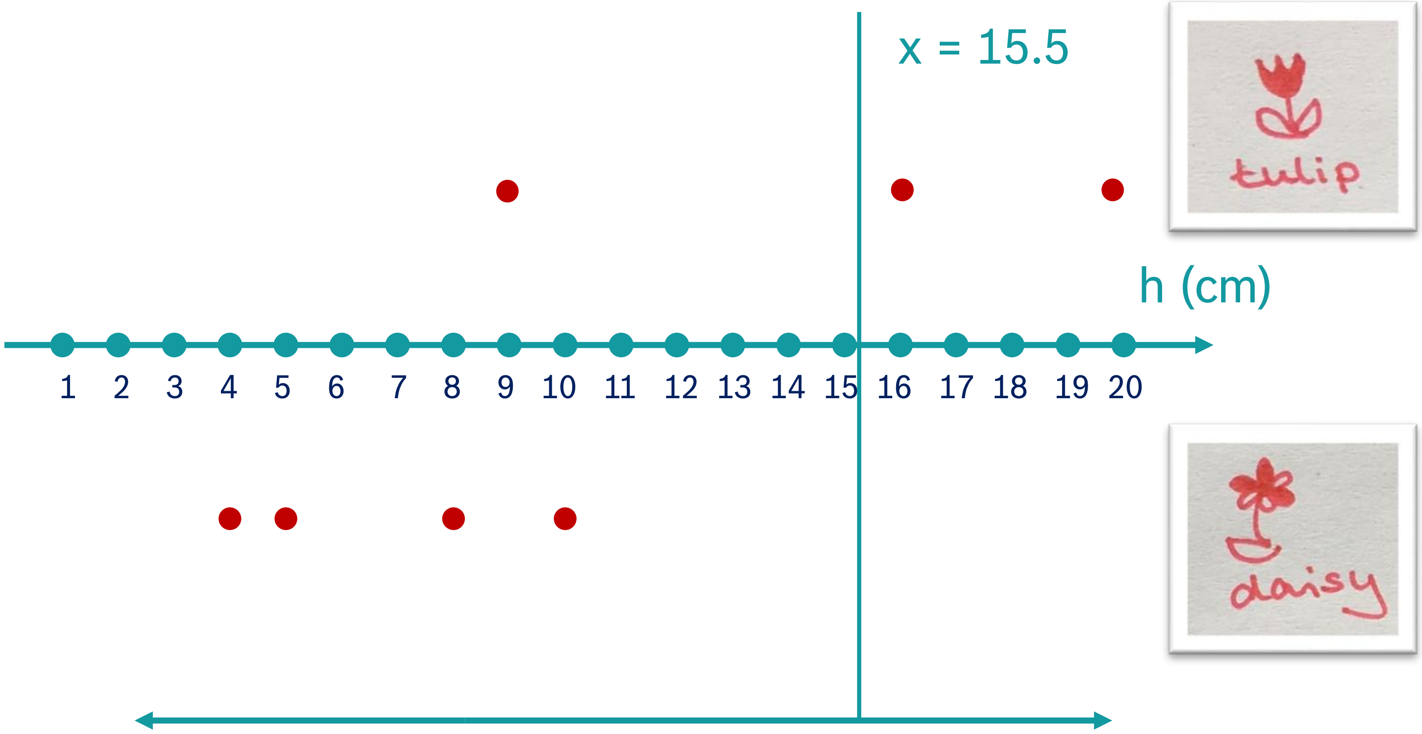
Machine Learning
Optimized model 2

Type	Height (cm)
Daisy	8
Tulip	16
Tulip	20
Daisy	4
Tulip	9
Daisy	5
Daisy	10



Guess: daisy
One tulip misclassified
As daisy

Guess: tulip
All of them are tulips

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Machine Learning
Model performance

How good is our model and our parameter choice?

Different ways to measure model performance

Accuracy:

$$\frac{\#\ \text{correct predictions}}{\#\ \text{total predictions}}$$

Confusion matrix:

Prediction Reality		
	OK	Error 1
	Error 2	OK

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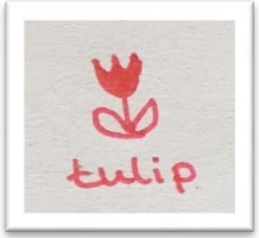
Machine Learning

Training strategy: supervised learning

Model training
in 3 steps:



Predict

Estimate output of your model based on new input

Error check

Evaluate the error between prediction and target output

modify x

Learn

Update model parameters to minimize error

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Machine Learning
Do machines learn from experience?

Traditional software development

- Task described by formal specification
- Implemented with an unambiguous set of instructions

```
def bar(n):
        if n < 0:
                n = 0

        result = 0
        for i in range(n+1):
                result +=i
        return result

def foo(m):
        l = lambda x: (x+1)*x /2
        return l(m)

if __name__ == "__main__":
        main(sys.argv)
```

Job of the programmer:

- Find out the logics to solve the task
- Implement path to solution step by step

Job of the program:

- Execute step by step what the programmer implemented
- No changes from experience
- Explicit process steps implemented

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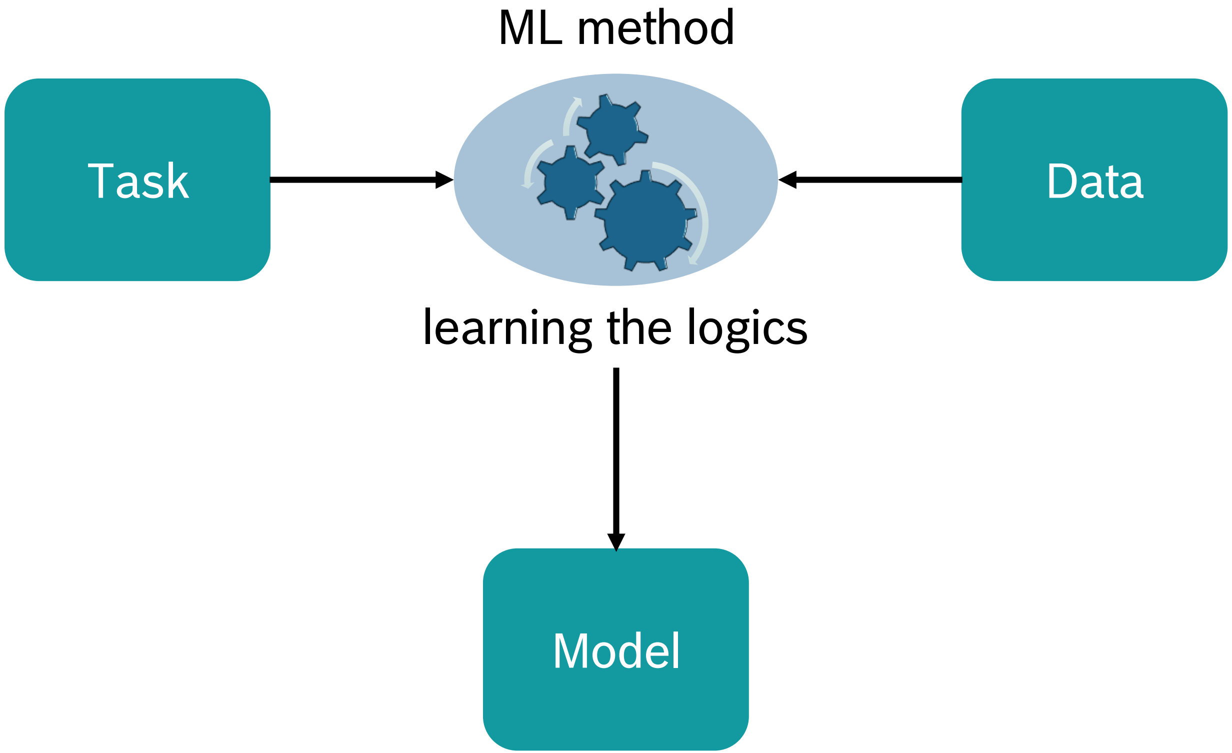
Machine Learning
Machine Learning (ML) as a new software development paradigm



Job of the ML engineer:

- ❖ Find the right ML method
- ❖ Feed it with the right data according to the task to solve

Job of the ML method:

- ❖ Learn the logic to solve the task
- ❖ Optimize iteratively by learning from data describing the right behavior

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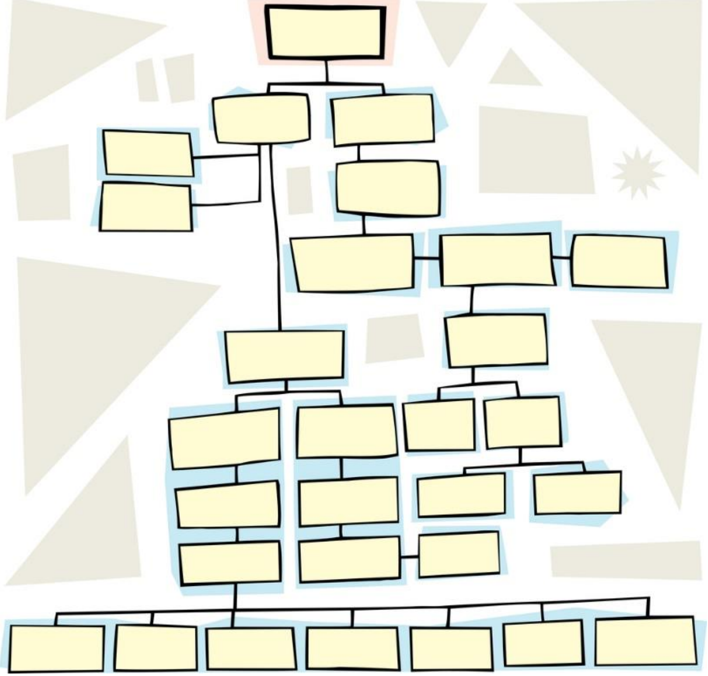
Machine Learning
Explicit vs. implicit knowledge

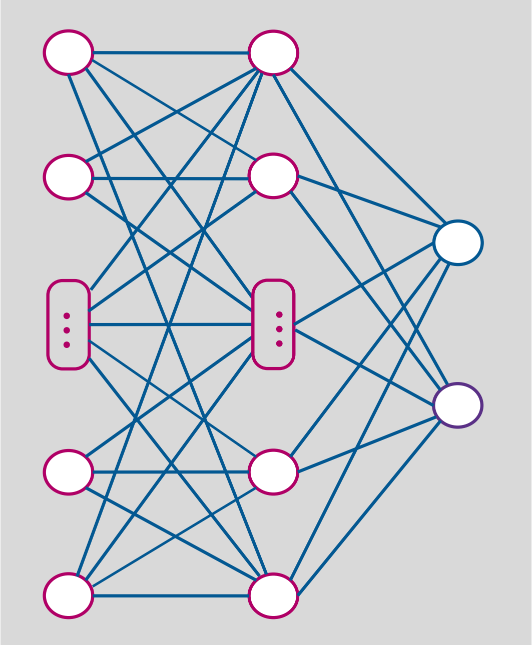
Traditional Programming



Explicit (rule based) knowledge

Implicit (data based) knowledge

Machine Learning Model



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Machine Learning
Second example: pool data set

Which house has a pool?

Price	Pool (0=no, 1=yes)
200k	0
405k	1
230k	0
357k	1
189k	0
171k	1
...	...

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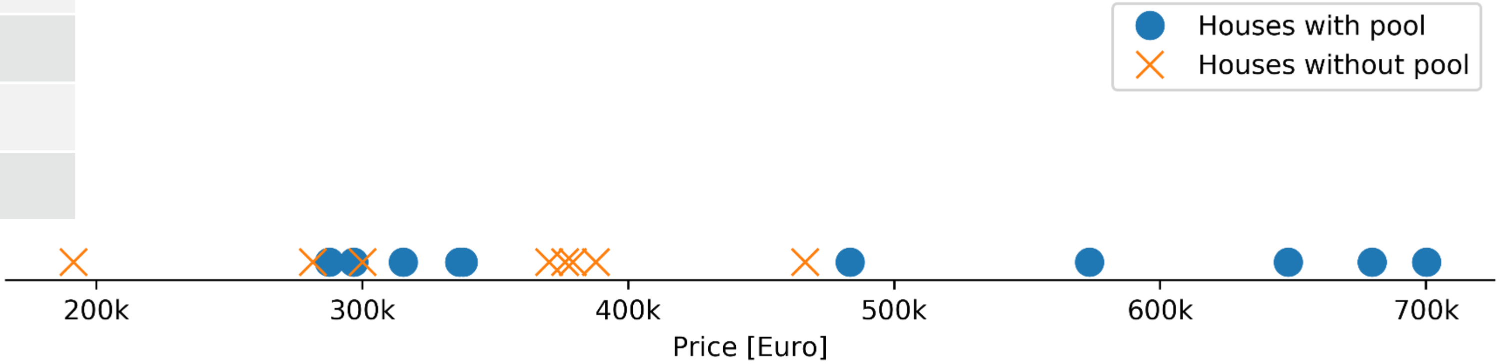

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Machine Learning
Simple cut-based model

Definition:

$$\text{Accuracy} = \frac{\#\ \text{correctly classified data samples}}{\#\ \text{total data samples}}$$

Input:
Price of the house

price ≤ x

price > x

Output:
Pool or no pool

Bauernhaus im Innviertel by Werner100359, CC BY-SA 3.0

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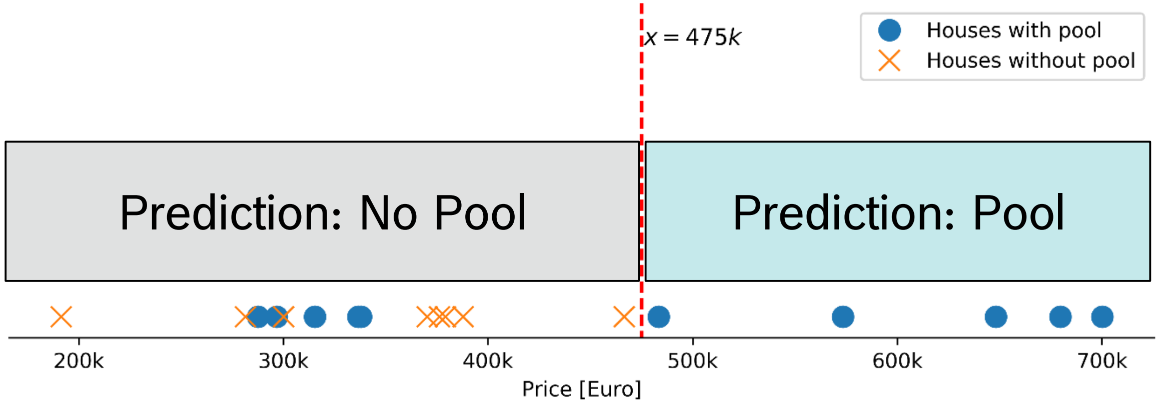

Performance on training data

4 misclassifications: $\text{Accuracy} = \frac{14}{18} = 77.8\%$

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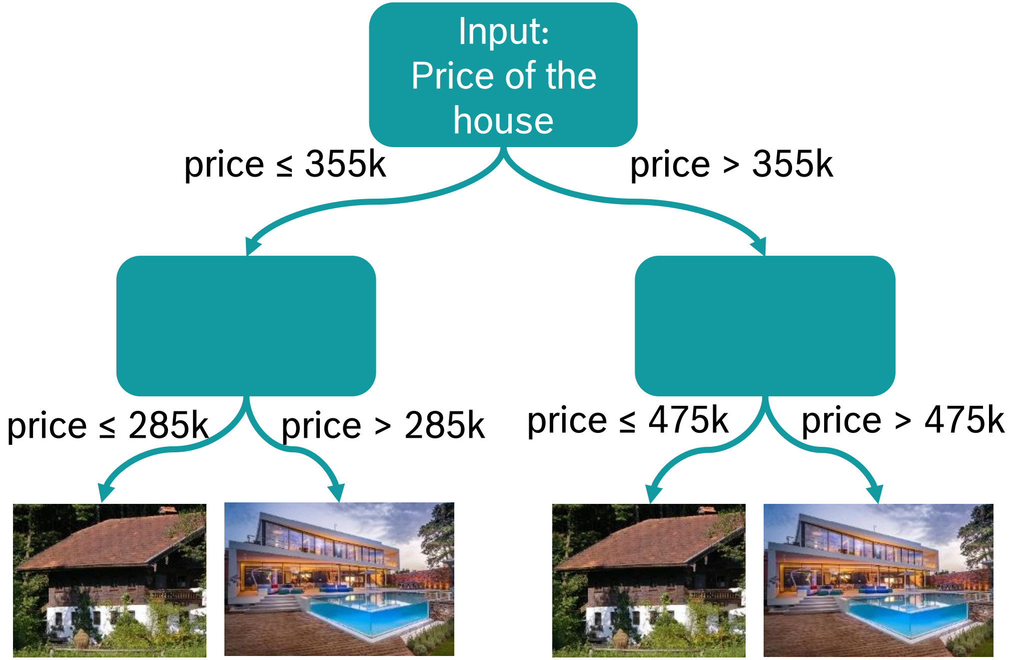
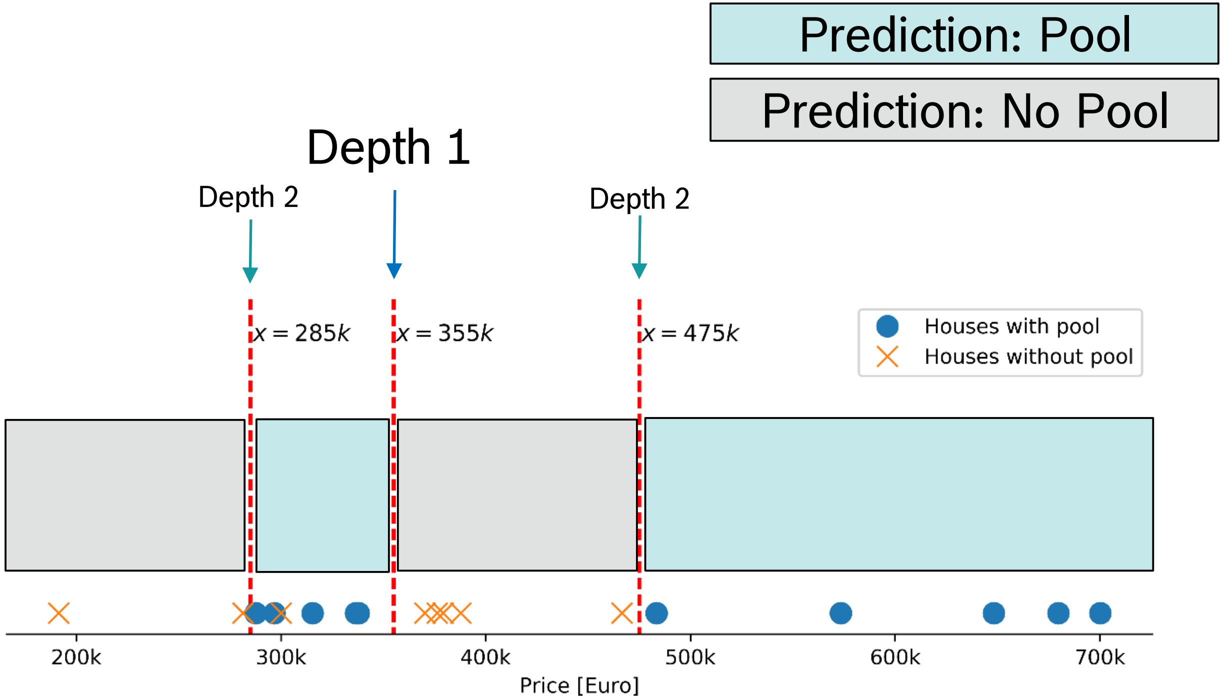
Machine Learning
Model with depth 2





Performance on training data

1 misclassification: $\text{Accuracy} = \frac{17}{18} = 94.4\%$

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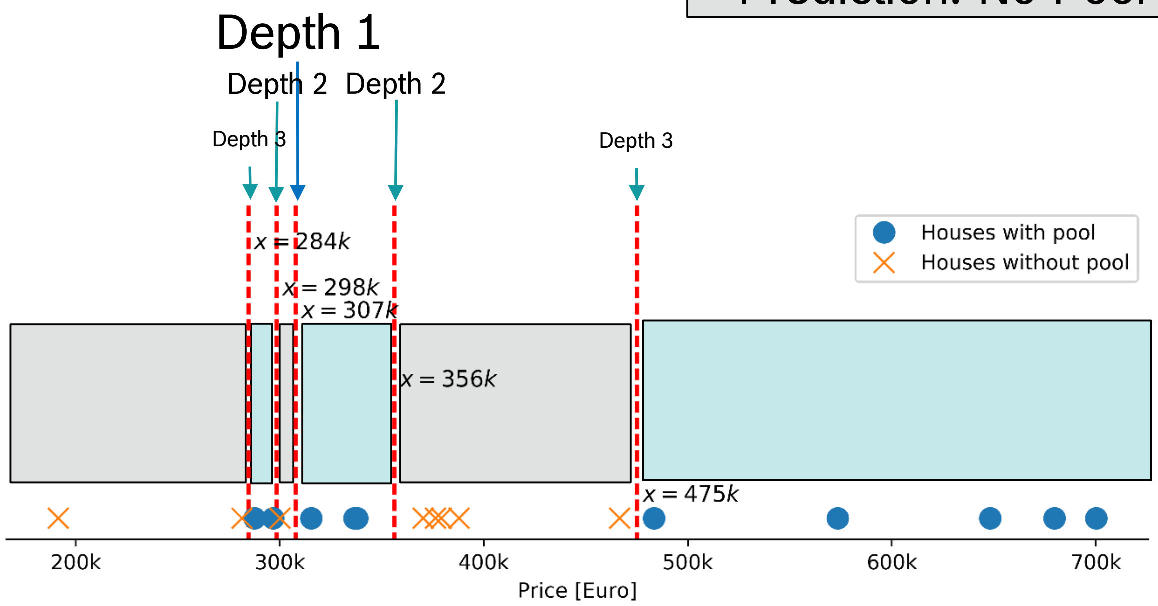
Machine Learning
Model with depth 3

Prediction: Pool

Prediction: No Pool



Performance on training data

0 misclassifications: $\text{Accuracy} = \frac{18}{18} = 100\%$

Poll:
„Would you use this model for new data?"

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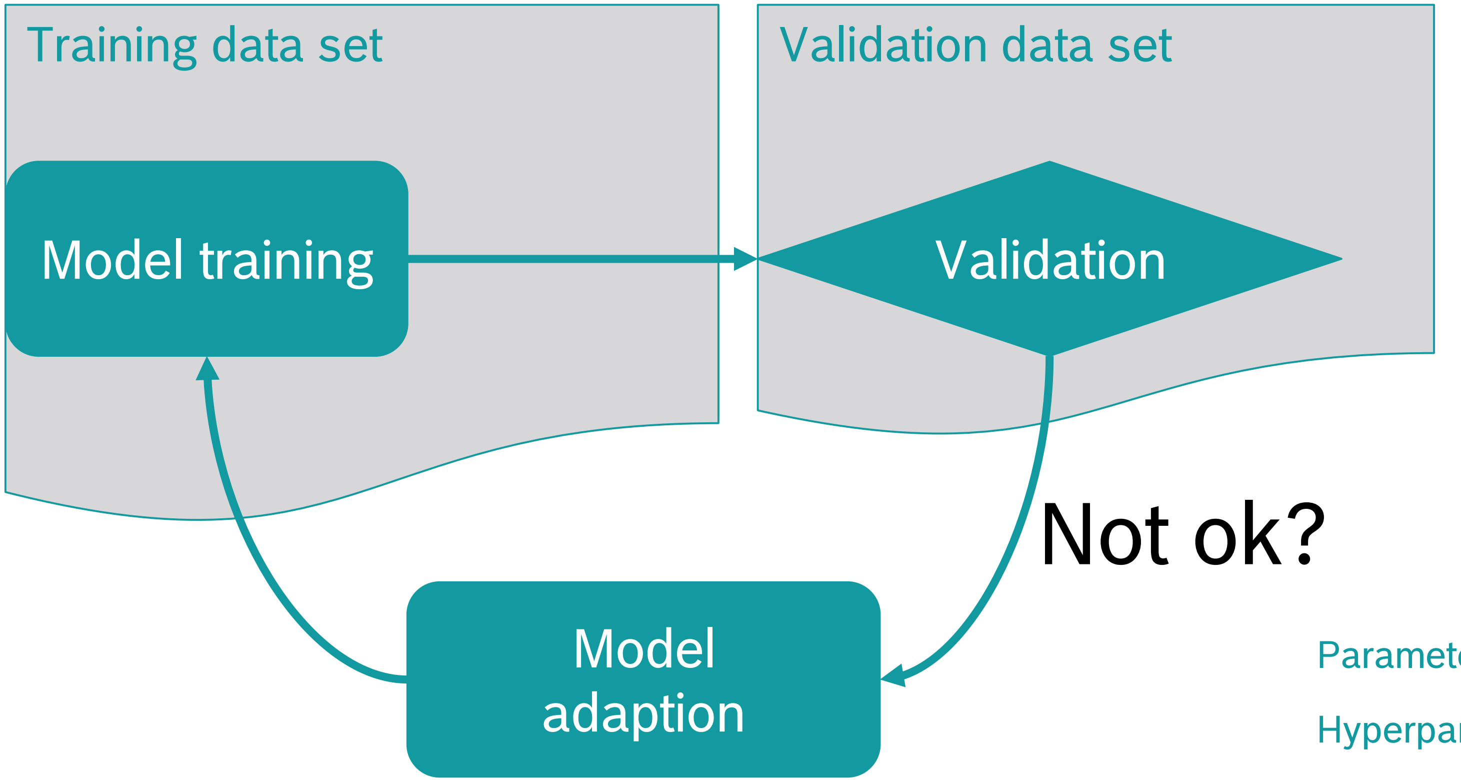
Machine Learning
Model validation & adaption



Adapt model structure and/or complexity/hyperparameters

Accuracy:

$$\frac{\#\ \text{correct predictions}}{\#\ \text{predictions}}$$

Parameters: learned by the training of the model

Hyperparameters: have to be set by the Data scientist, will not be trained by the model (examples: tree depth)

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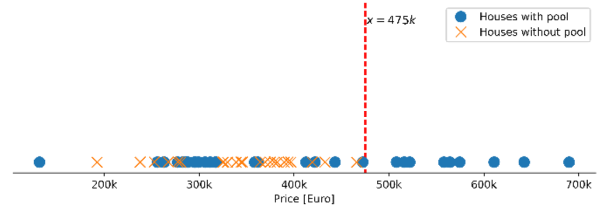
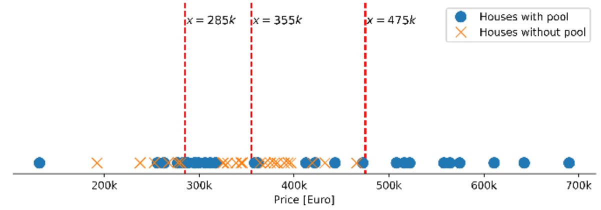
Machine Learning
Model validation

Apply trained model to houses not used for training (validation data)



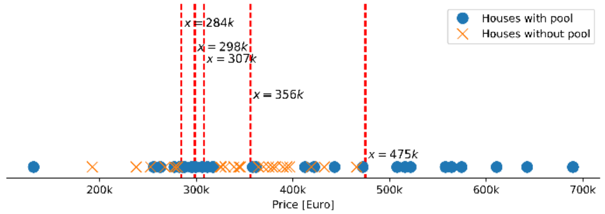
Training accuracy: 77.8%

Validation accuracy: 61.1%



Training accuracy: 94.4%

Validation accuracy: 66.7%



Training accuracy: 100%

Validation accuracy: 62.9%

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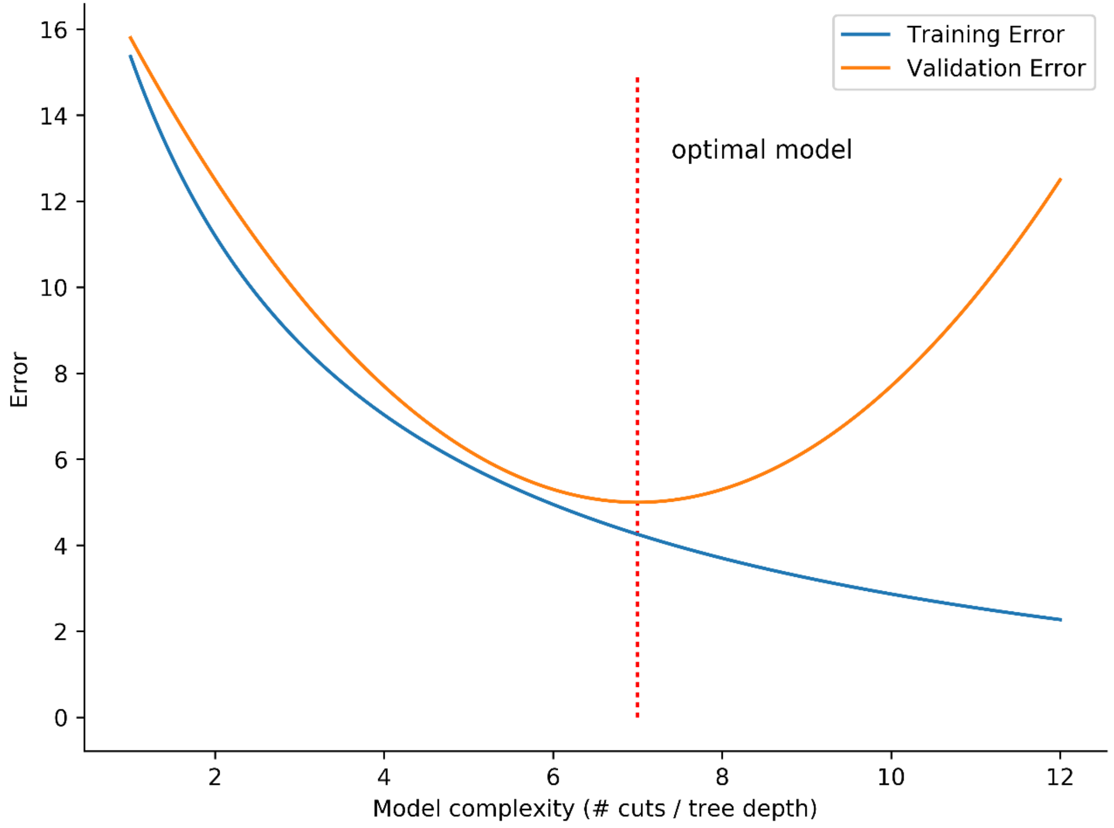
Machine Learning
Training vs validation error



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Machine Learning
Poll

Poll:
"Why do we need a validation data set?"

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Machine Learning
Task: classification

The task in the examples is called classification.

Target: sort data into predefined classes

Examples: scrap (yes/no)

driver types (sporty, economic, …)

image recognition (car, tree, pedestrian)

choosing the right type of “gummy bear”

Swedish Fish, gummi bears and gummi worms by ChildofMidnight, CC BY-SA 3.0

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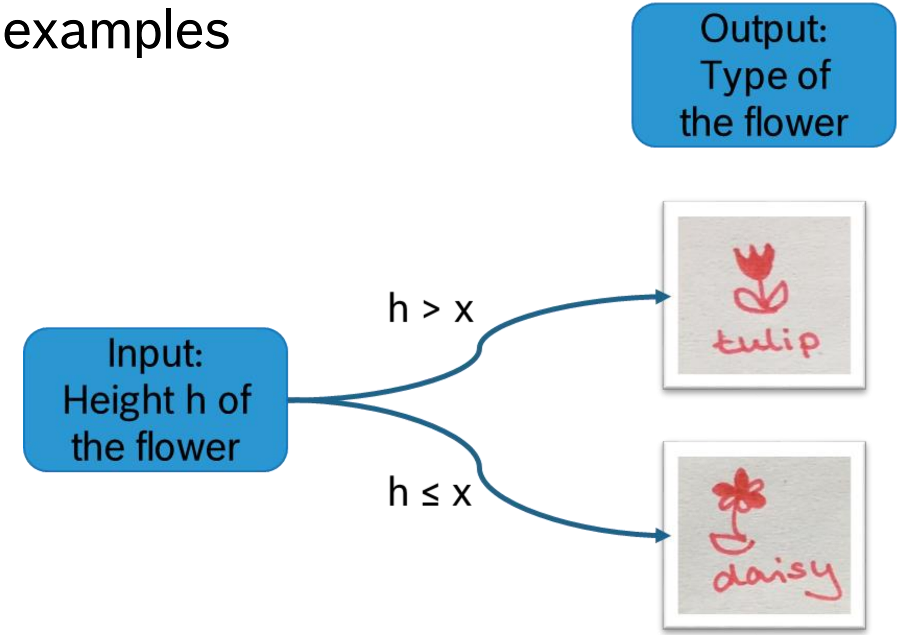
Machine Learning
Classification methods

The task of classification is often solved by

- Decision trees as in the daisy/tulip, pool/no pool examples



- Deep learning (later)

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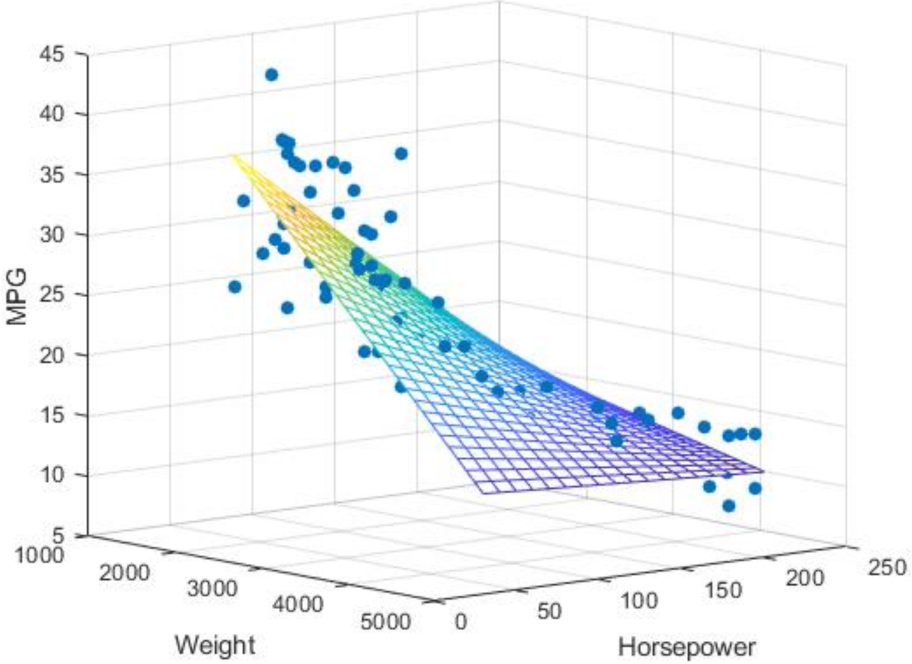
Machine Learning
Task: regression

Target: numerical estimation of a variable due to certain input variables

Example: vehicle range (MGP)

depending on vehicle

weight and horsepower



Multiple linear regression graphic by MathWorks

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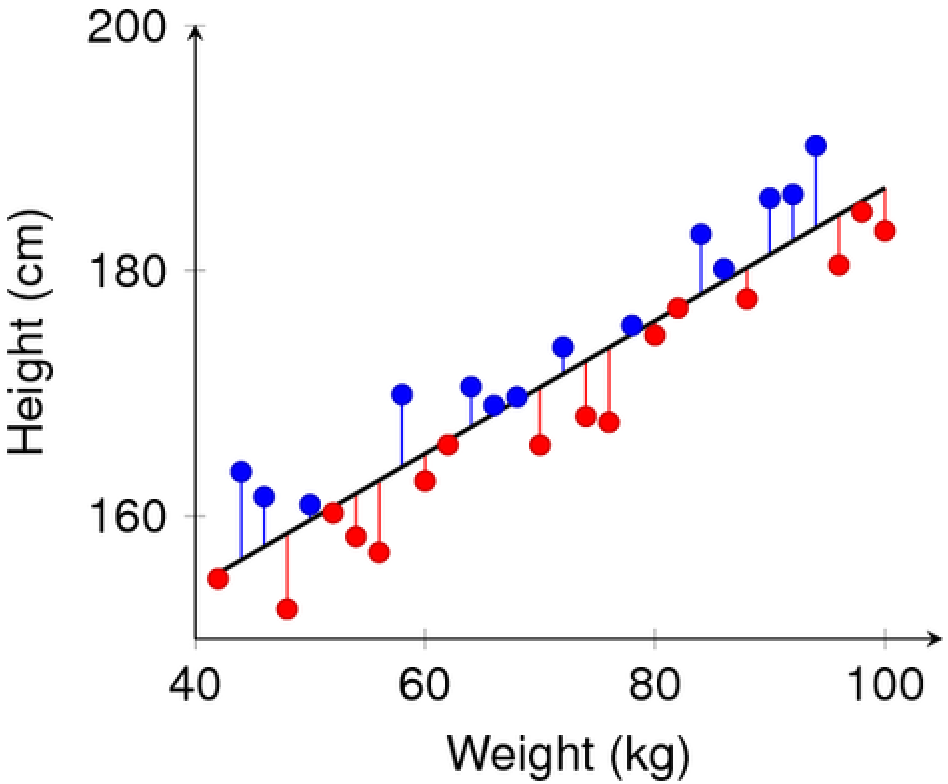
Machine Learning
Regression methods

- ❖ Polynomial regression
- ❖ Deep learning (later)



Regression with Residuals by Jake, CC BY 2.5

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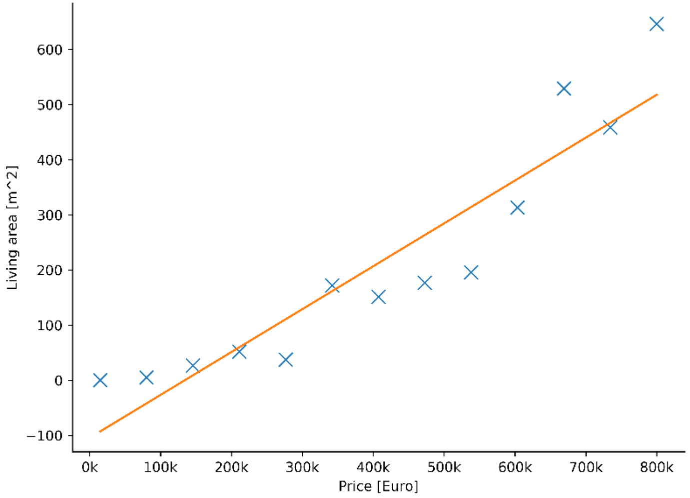
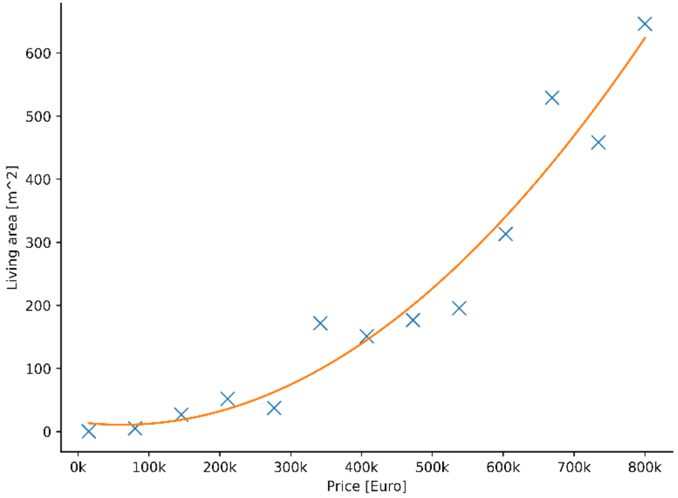
Machine Learning
Training vs validation error for polynomial regression

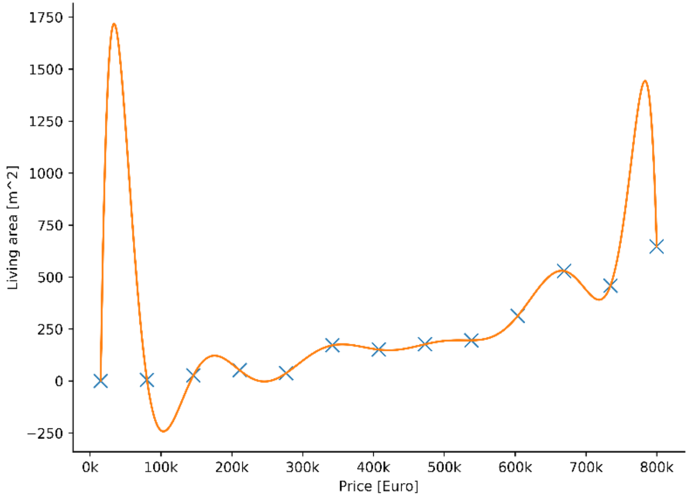
Poll:
„What can we learn from these plots?"

- Here we see an example for model complexity in regression tasks.

Linear regression	Quadratic regression	Polynomial regression ^10
→ High training error	→ Lower training error	→ Low training error
→ High validation error	→ Low validation error	→ High validation error







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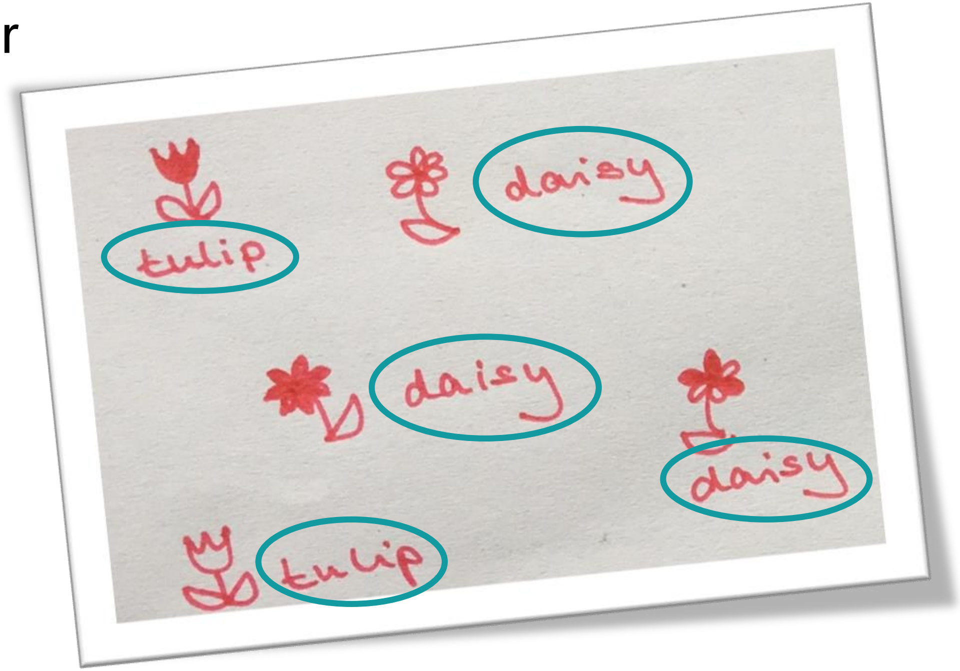
Machine Learning
Labeled data

Supervised learning need labeled or tagged data which provide the piece of information you are searching for and the model shall provide.

The problem with supervised learning is:
- Often there is not enough labelled data available
- Labelling of data sets can be very time and cost intensive
- Bosch has hundreds of people working on data labelling – located in India



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Machine Learning

Labeled data – a billion $ business

The Future of AI Depends on a Huge Workforce of Human Teachers

VCs are investing heavily in startups that tap people to make artificial intelligence better at speaking, seeing, and driving.

By Matthew Hutson

For an autonomous car to recognize pedestrians and stop signs, it's typically fed thousands or millions of photos, all hand-labeled. To nail a conversation, a digital assistant needs to be told over and over when it's failed. And so Rubin spends 10 to 30 hours a week on her phone or computer evaluating search results and chat retorts through a site called Clickworker. Her income, generally $10 to $14 an hour, pays for part of her college commute from New Jersey and some of her

Bloomberg

Jacques Bughin, a director of the McKinsey Global Institute, speculates that the nine-figure market could hit $5 billion in five years... A radiologist tagging a medical image can cost up to $2000.

Providers of data labelling service

amazon mechanical turk beta

ALEGION

Mighty Ai

defined crowd

cloudfactory

CrowdFlower

clickworker

Reducing labelling efforts significantly is an ongoing research topic.

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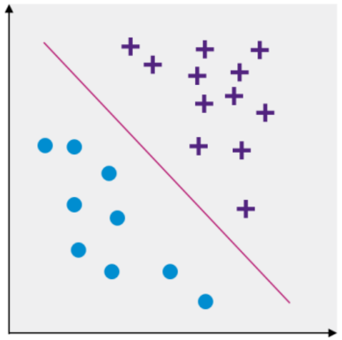
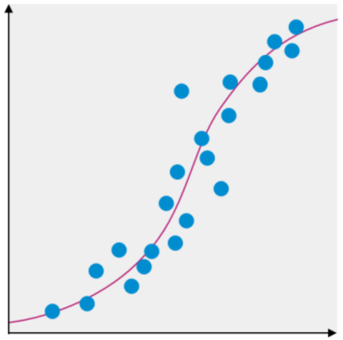
Machine Learning
Supervised vs. unsupervised learning

Supervised Learning

Build a predictive model using training data with known output (labels)



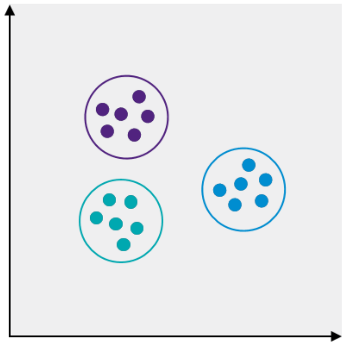
Classification



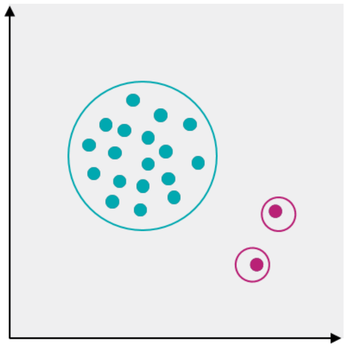
Regression

Unsupervised Learning

Describe “hidden” structure in unlabeled data



Clustering



Anomaly Detection

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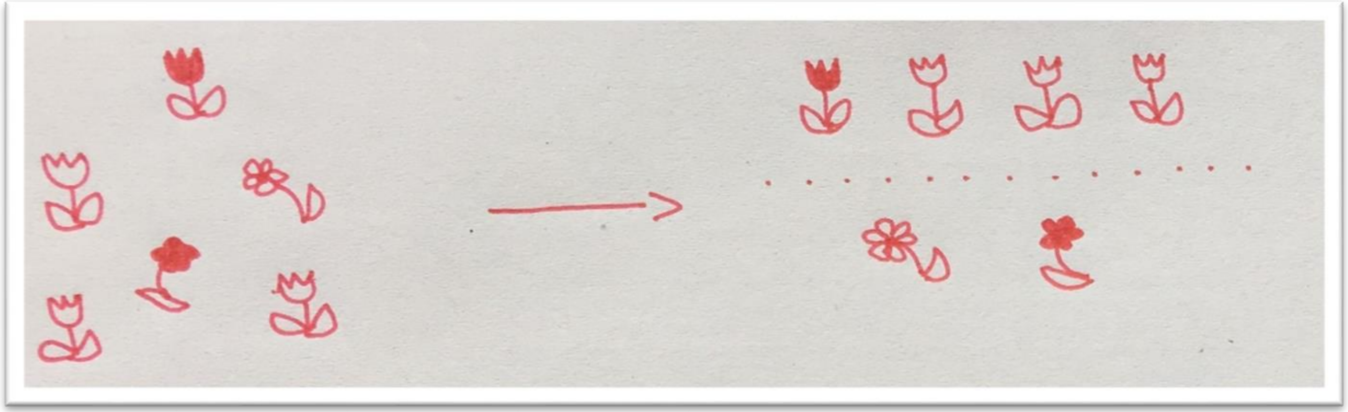
Machine Learning
Unsupervised learning task: clustering

Target: find meaningful groups in your data and create “classes”

- Discover patterns in data
- Replace high-dimensional data by representatives
- Data labelling
- Outlier detection

Height (cm)
8
16
20
4
9
5
10



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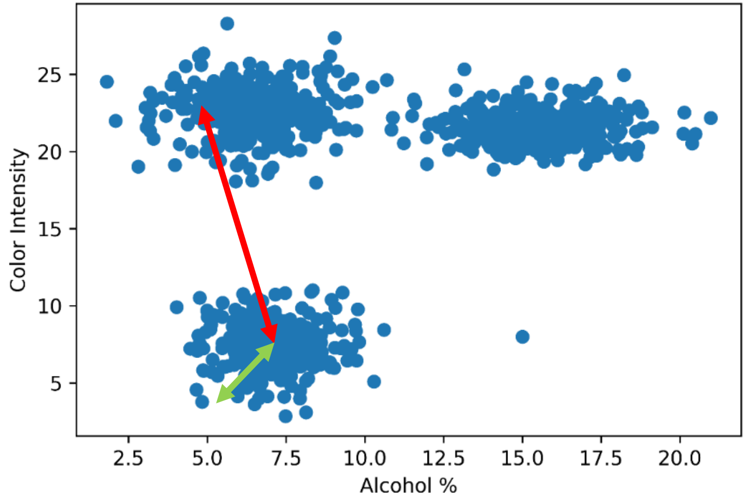
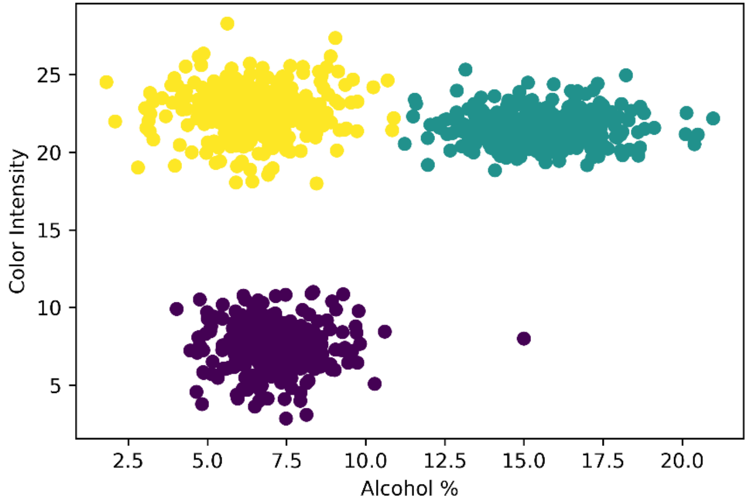
Machine Learning
Distance based clustering

Strategy: data in the same group are “closer” to each other than to data in other groups





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Machine Learning
K-means algorithm

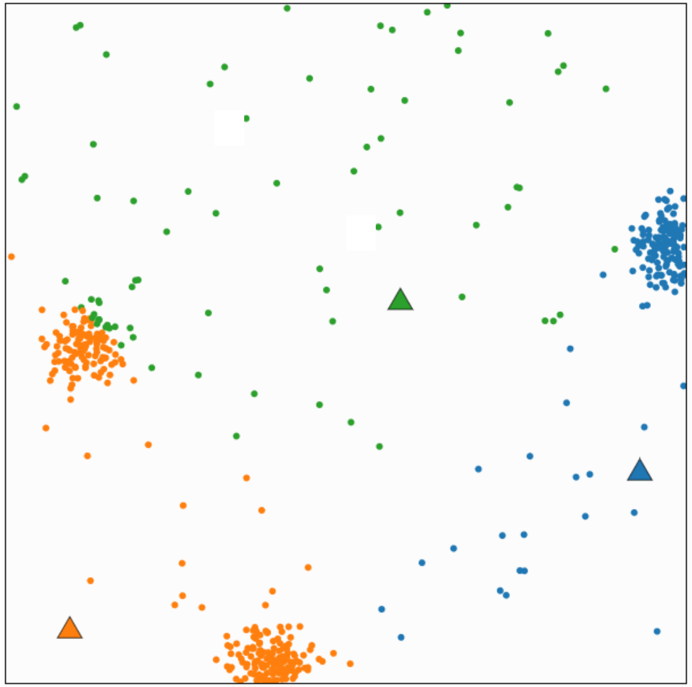
1. **Input:** *N* data points

2. **Initialize k centroids randomly**

3. **Repeat until converged:**

   - **Assign** each data point to the closest centroid:

   - **Recompute** new centroids as the mean of the newly assigned cluster members



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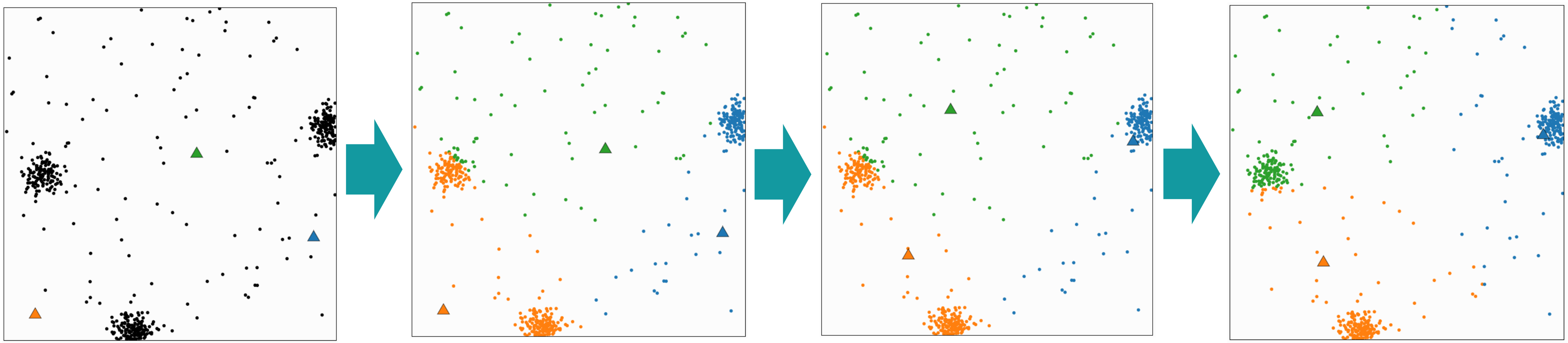
Machine Learning
K-means algorithm



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http://stanford.edu/class/ee103/visualizations/kmeans/kmeans.html

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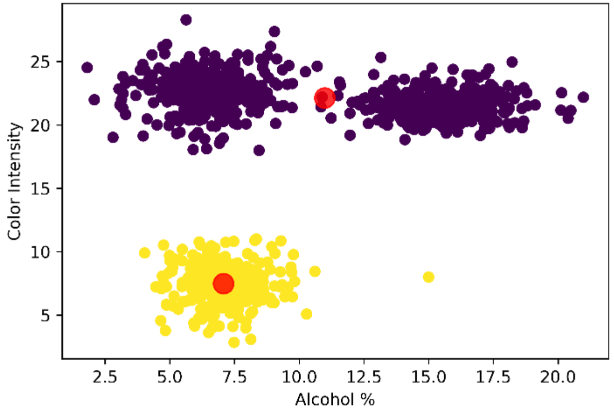
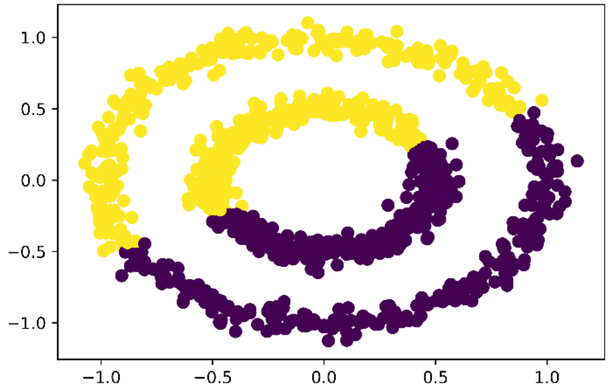
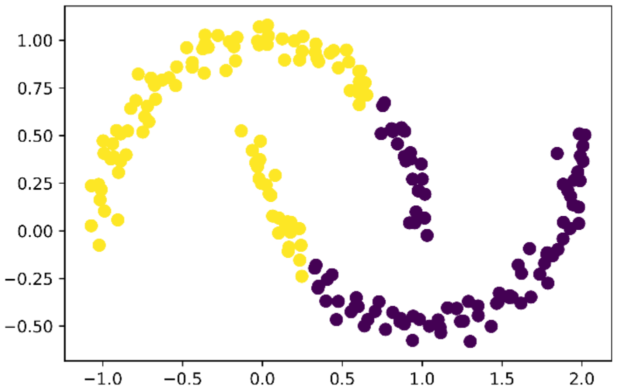
Machine Learning
Problems with K-means

1. Wrong number of clusters



2. Non-spherical distribution





3. k-means is very sensitive to outliers

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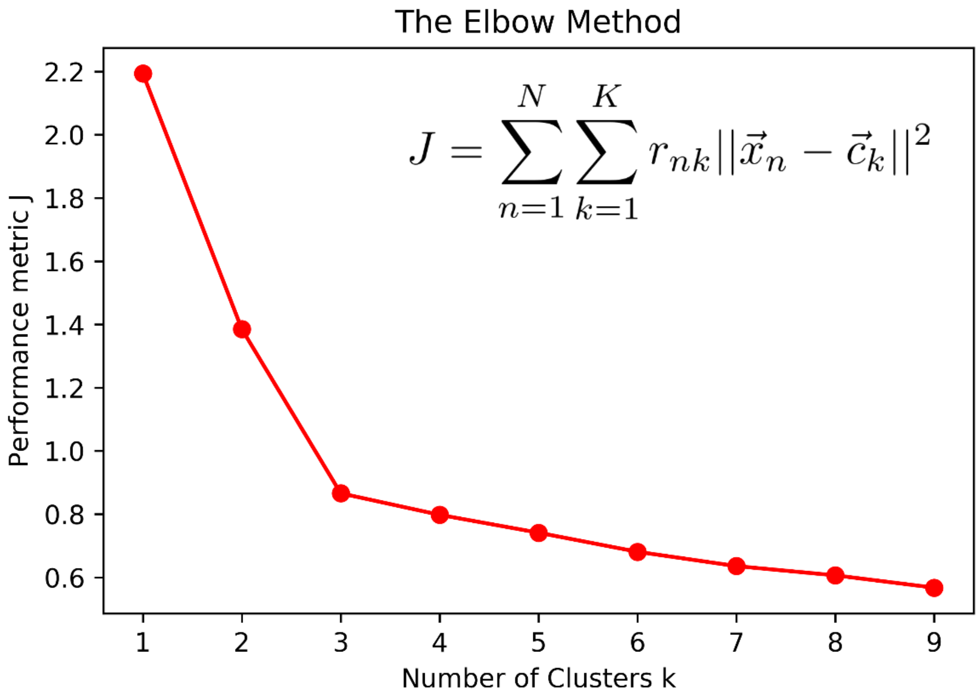
Machine Learning
Elbow method

How many clusters to choose?



$\vec{x}_n$: data points

$\vec{c}_k$: cluster centers (centroids)

$$r_{nk} = \begin{cases} 1 \text{ if point n belongs to centroid k} \\ 0 \text{ otherwise} \end{cases}$$

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Poll:
“How do you use the elbow criterium to determine the number of clusters in K-means?”

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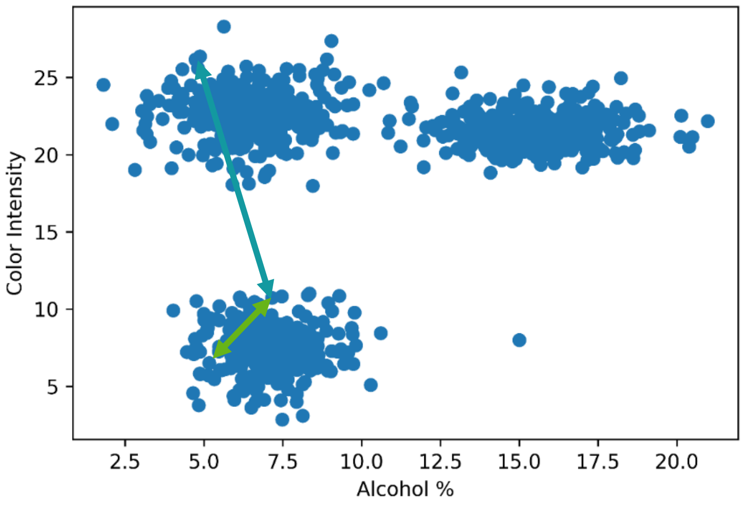
Machine Learning
Clustering

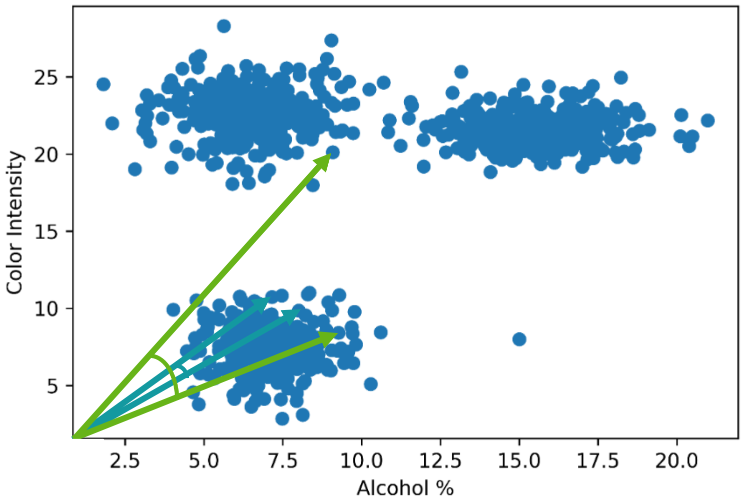
Euclidean distance as a similarity measure:

$$\mathrm{dist}(\vec{x},\vec{y}) = \sqrt{\|\vec{x}-\vec{y}\|^2}$$



Cosine similarity works better in higher dimensions:

$$\mathrm{dist}(\vec{x},\vec{y}) = \cos\theta = \frac{\vec{x}\cdot\vec{y}}{\|\vec{x}\|\,\|\vec{y}\|}$$



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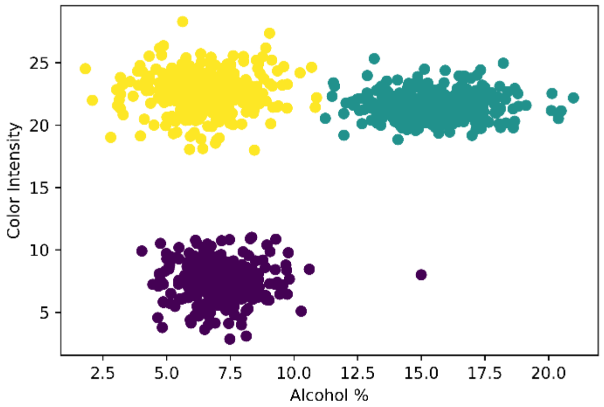
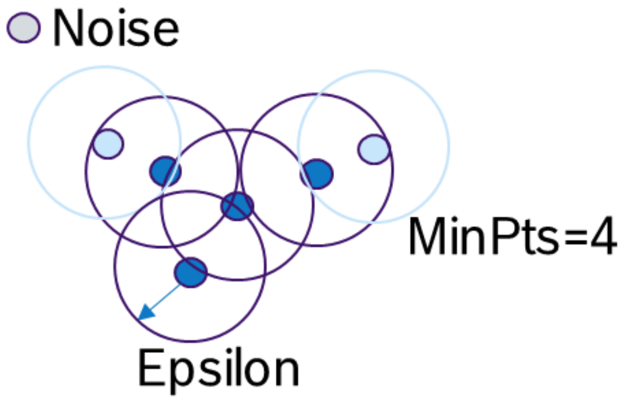
Clustering
Overview of methods

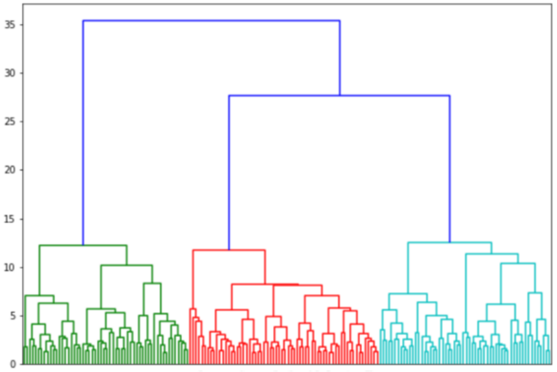
Partitioning Methods



Density-Based Methods



Hierarchical Methods



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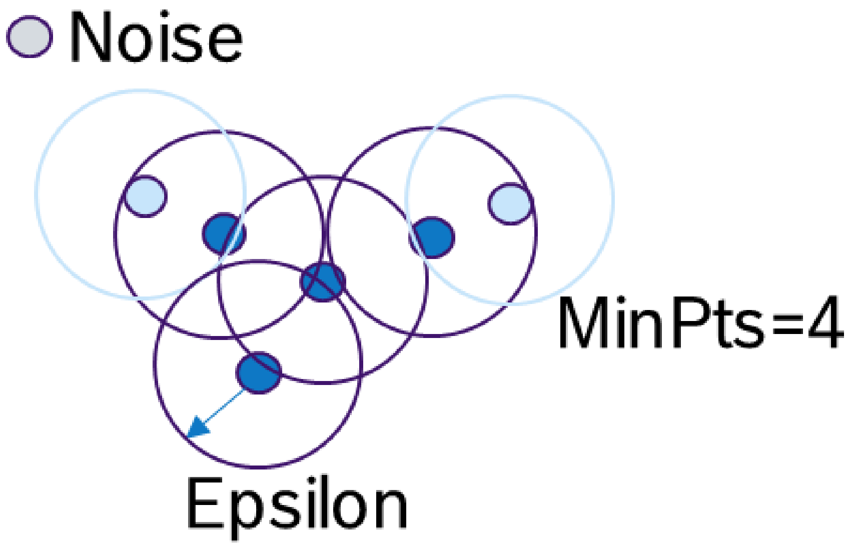
Machine Learning
Density-based clustering

- *p* is a core point if
  ≥ minPts points are within distance ε
- *q* is directly reachable from a core point *p* if point *q* is within distance ε from *p*
- *q* is reachable from *p* if there is a “chain” of directly reachable points connecting p and q

- Reachable points form a cluster
- All other points are outliers



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Machine Learning
Clustering application

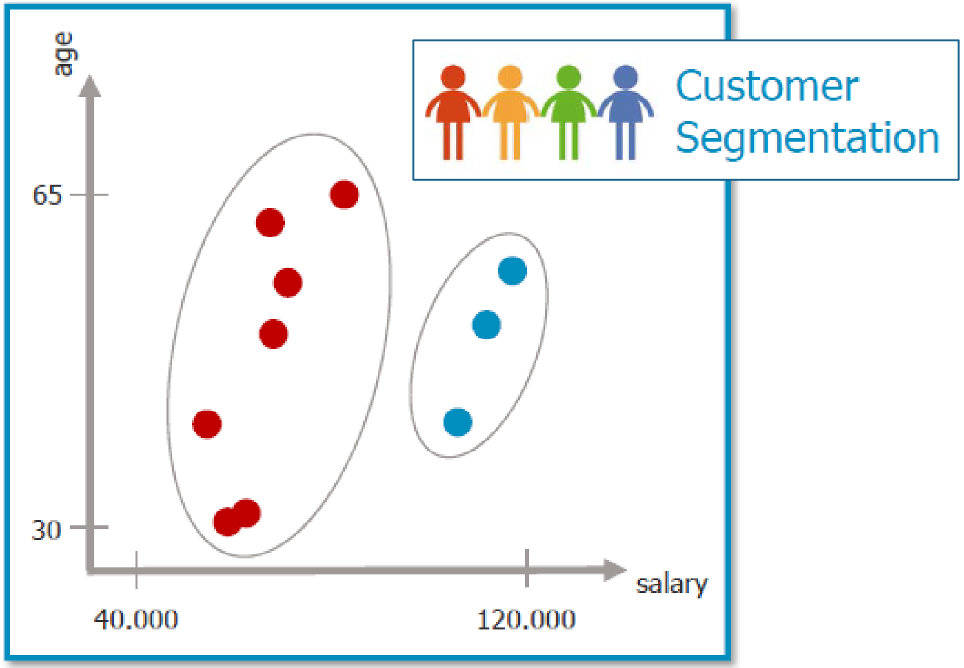
Example: customer segmentation

customer data

ID	Age	Salary	Address (Town)	
1	30	55.000	Stuttgart	…
2	31	57.000	Frankfurt	…
3	56	120.000	Munich	…
4	55	65.000	Stuttgart	…
5	47	66.000	Hamburg	…
6	65	76.000	Hamburg	…
7	48	105.000	Berlin	…
8	42	49.000	Köln	…
9	42	99.000	Munich	…
10	63	62.000	Berlin	…
…	…		…	…

cluster algorithm

customer segments



Customer Segmentation by Prof. Mitschnang, Universität Stuttgart, IVPS

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Machine Learning
Unsupervised learning task: anomaly detection

Depositphotos, Bosch License

Target: detect outliers in your data

Examples:
- unrealistic sensor data
- technical problems in production
- fraud detection
- cyber security

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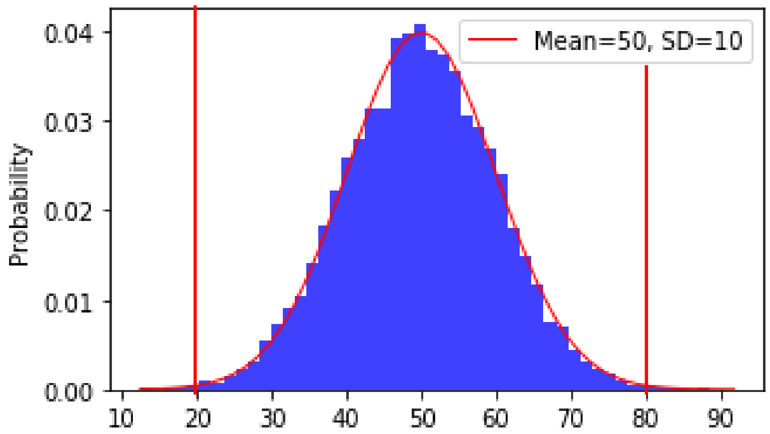
Machine Learning
Anomaly detection methods

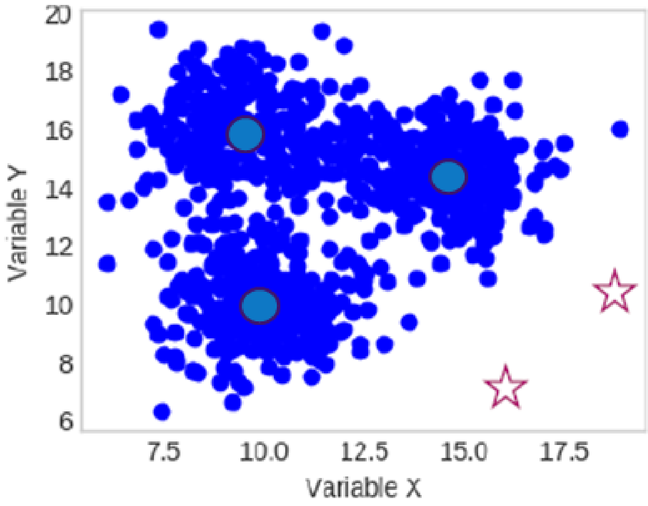
Statistical Methods

Outliers are points with a certain deviation from the mean value, often 3σ (standard deviation)



K-Means

Outliers are clusters with very few points and points far away from the cluster centers



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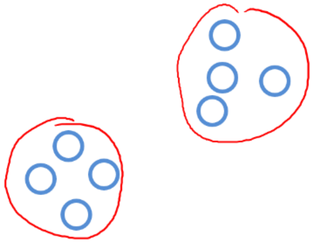
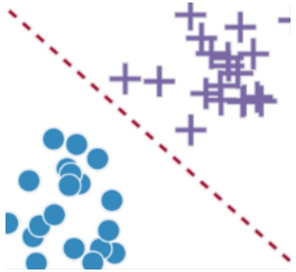
Machine Learning
Overview of 4 important ML tasks

Clustering



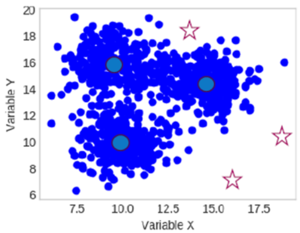
... find meaningful clusters in your data to create “classes”...

Classification



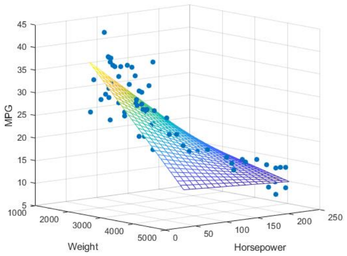
... sort your data into predefined classes ...

Anomaly detection



... detect outliers in your data...

Regression



... calculate numerical estimations from numerical input data...

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Machine Learning
ML tasks: exercise 1


Bosch Media Space

Robert is a line manager.

In order to detect scrap earlier, he wants to predict whether a part will pass or fail at the end of line test based on measurements in previous parts of the production cycle.

Poll: „Which task will he solve?"

Classification, Clustering, Regression, or Anomaly detection?

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Machine Learning
ML tasks: exercise 2

Bosch Media Space

Andrew is a logistics manager.

His plant uses 500 different packaging materials.

He would like to reduce it to 20 standardized boxes based on product type, form and dimensions.

Poll: „Which task will he solve?"

Classification, $\boxed{\text{Clustering,}}$ Regression, or Anomaly detection?

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Machine Learning
Sweet spot of Machine Learning

Work on data based machine learning

if you have ...

- ❖ A clear business case
- ❖ Sufficient amounts of data
  carrying the relevant information
- ❖ Sufficient computational resources
- ❖ Knowledge, experience, and/or partners that help you get started
- ❖ Patience to go through trial and error process

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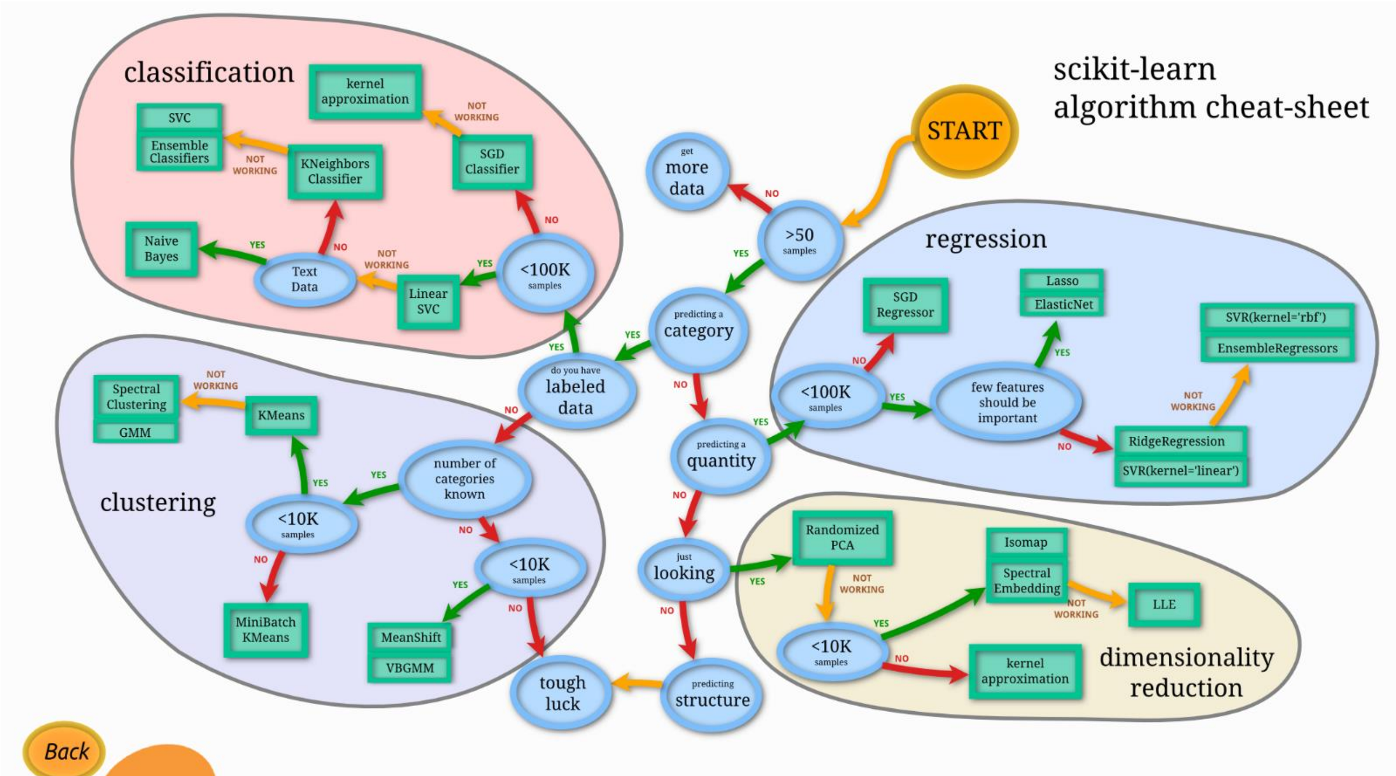
Machine Learning
Helpful resources for Machine Learning

❖ Frameworks, libraries & tutorials

- Scitkit-learn
- H2O
- TensorFlow
- Microsoft CNTK

❖ Guidelines:

- ML decision tree (Scikit-learn)
- Method pros & cons (recast.ai)



Scikit-learn algorithm cheat-sheet by scikit-learn developers, BSD License
http://scikit-learn.org/stable/tutorial/machine_learning_map/

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Poll:
“Which of these are unsupervised learning methods?”

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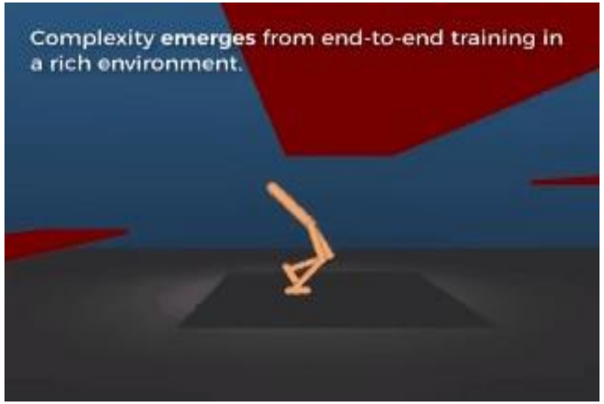
Machine Learning
What is reinforcement learning?

- Reinforcement learning is the field of sequential decision making under uncertainty
- Goal: maximize the long-term cumulative reward

Atari video games

Robotics



Learning to walk

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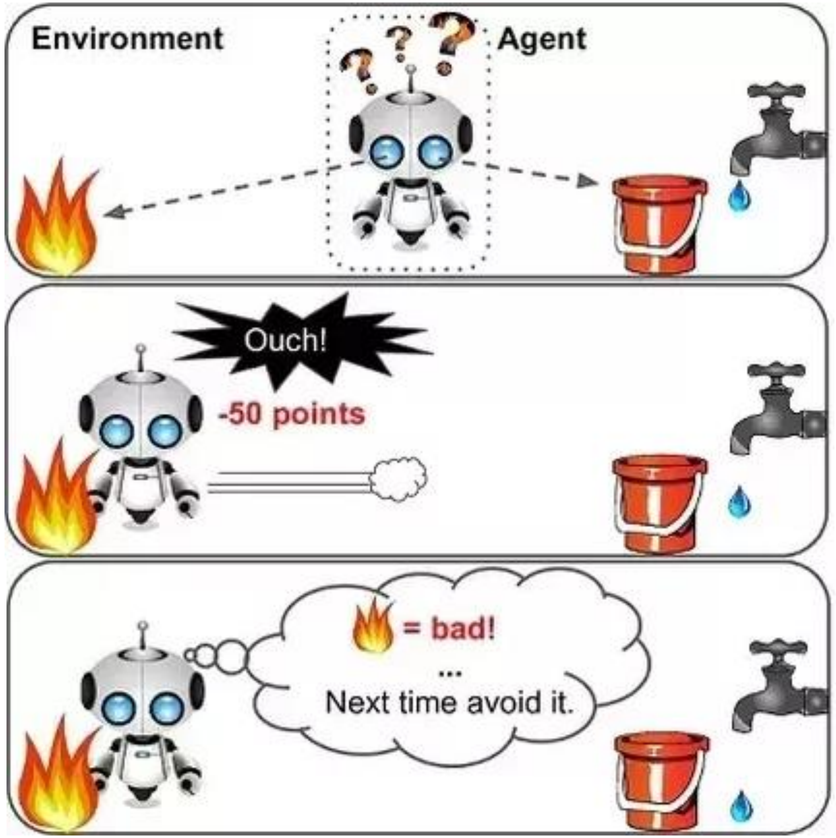
Machine Learning
ML strategy: reinforcement learning



- ❖ System perceives environment
- ❖ Decides what to do according to its policy

- ❖ System interacts with environment
- ❖ Gets a penalty or reward

- ❖ System learns = changes its policy

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Machine Learning
ML strategy: reinforcement learning

Solved in classical way:

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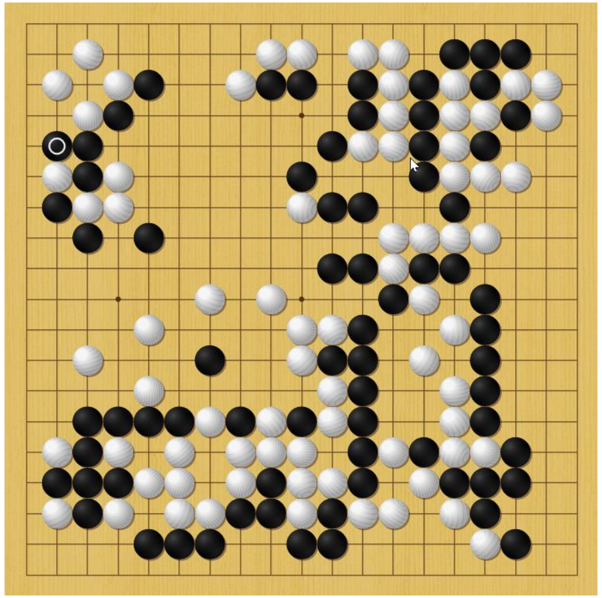
Only solved with RL:



- ❖ Not every action provokes reactions in the environment that provide information about how successful the policy is!
- ❖ Example: Games like chess, Go
- ❖ Reinforcement learning always needs interaction with the environment and/or simulation!

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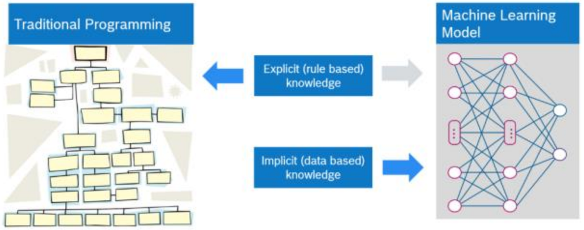
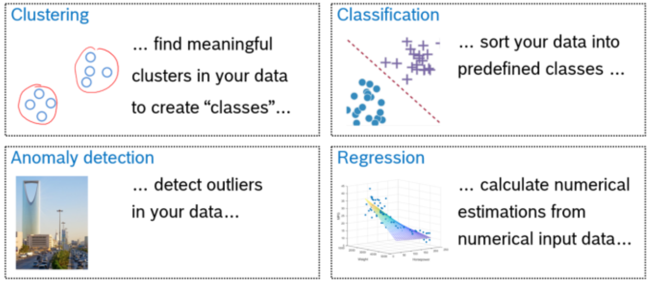
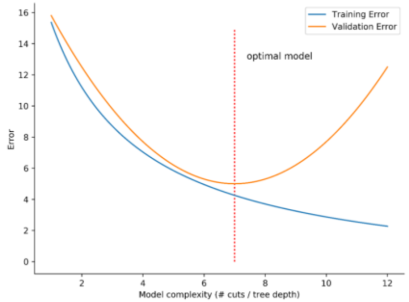
Machine Learning
Summary



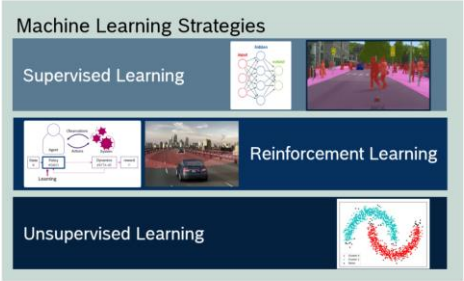
What makes ML revolutionary?



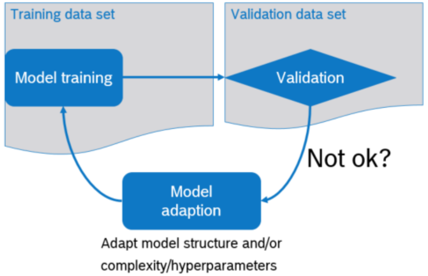
Tasks to solve



Model complexity



Types of ML strategies



How to train a model

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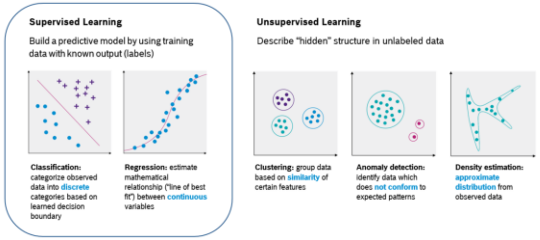
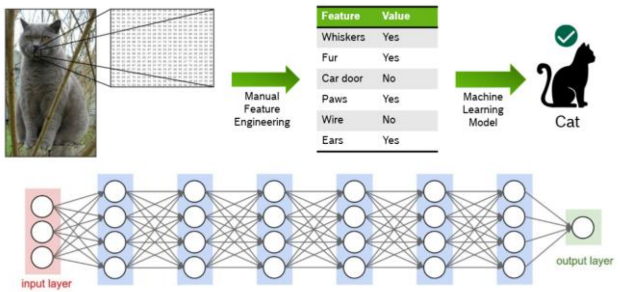
DEEP LEARNING

Deep Learning
What will you learn in this section?

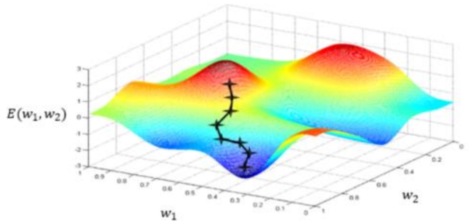


What tasks can DL solve?

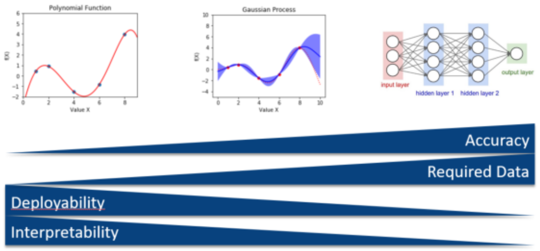


Classical ML vs DL

Why CNNs?



Training of DL Models



When to use DL

Intern | CR/PJ-AI-E | July 2020
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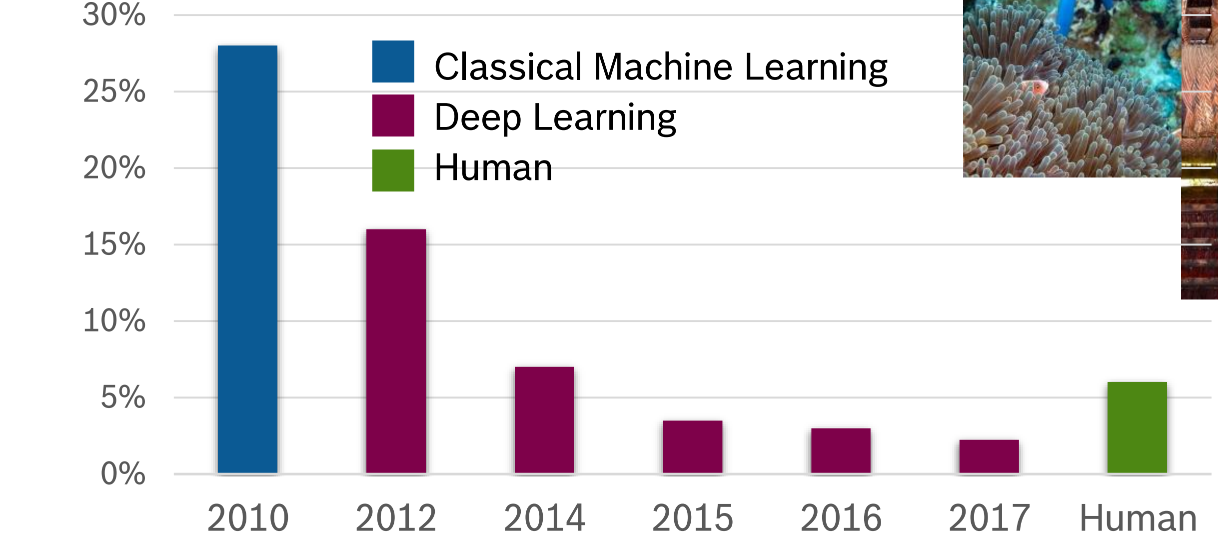
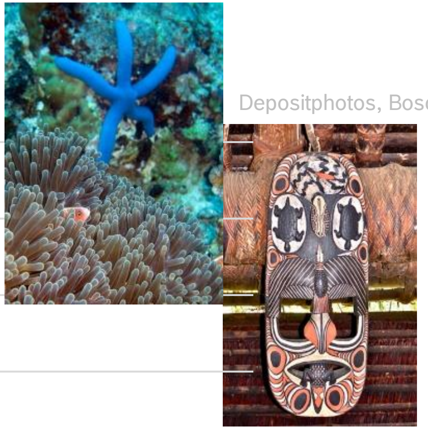
Deep Learning
The Deep Learning revolution

Algorithmic advances, especially in the area of deep learning





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Error rate of image recognition “Imagenet” challenge. In 2015, algorithms surpassed human image recognition error rate.

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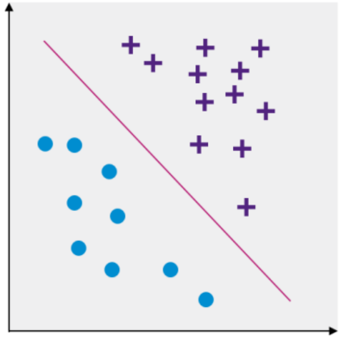
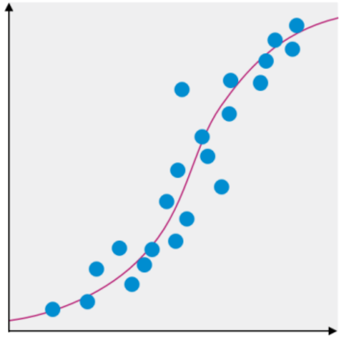
Deep Learning
Supervised Learning vs. Unsupervised Learning

Supervised Learning

Build a predictive model by using training data with known output (labels)



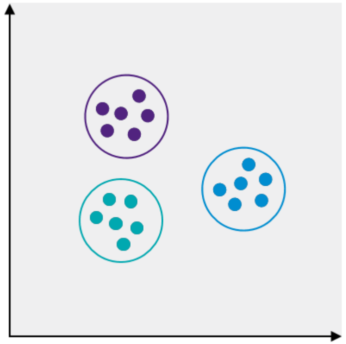


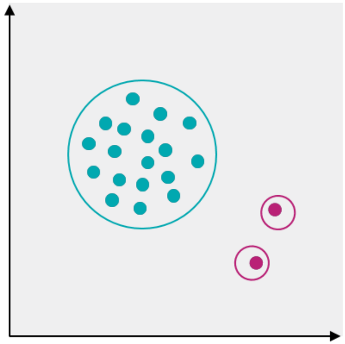
Classification: categorize observed data into **discrete** categories based on learned decision boundary

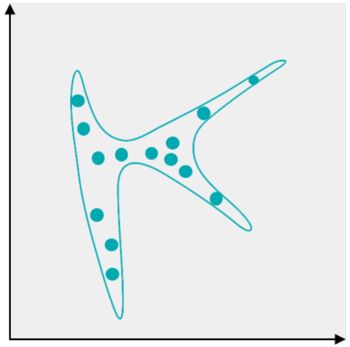
Regression: estimate mathematical relationship ("line of best fit") between **continuous** variables

Unsupervised Learning

Describe "hidden" structure in unlabeled data







Clustering: group data based on **similarity** of certain features

Anomaly detection: identify data which does **not conform** to expected patterns

Density estimation: **approximate distribution** from observed data

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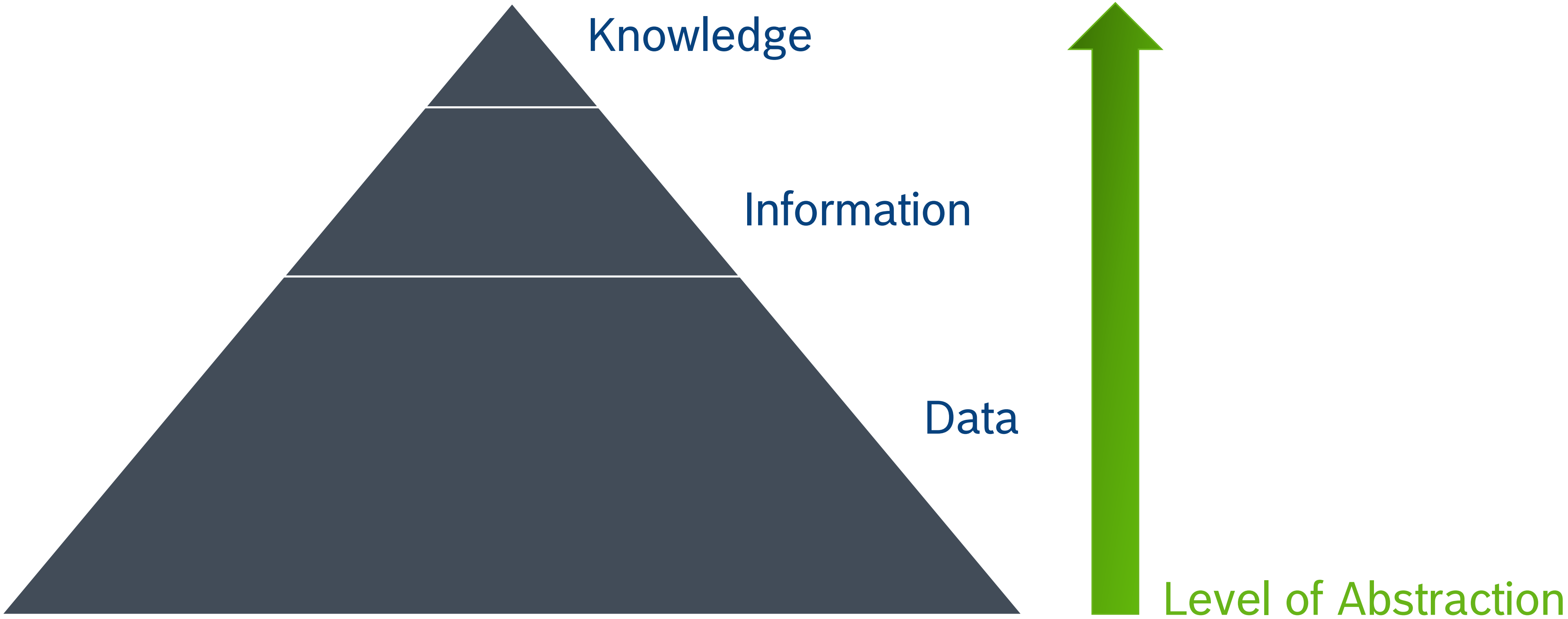
Deep Learning
Learning more levels of abstraction



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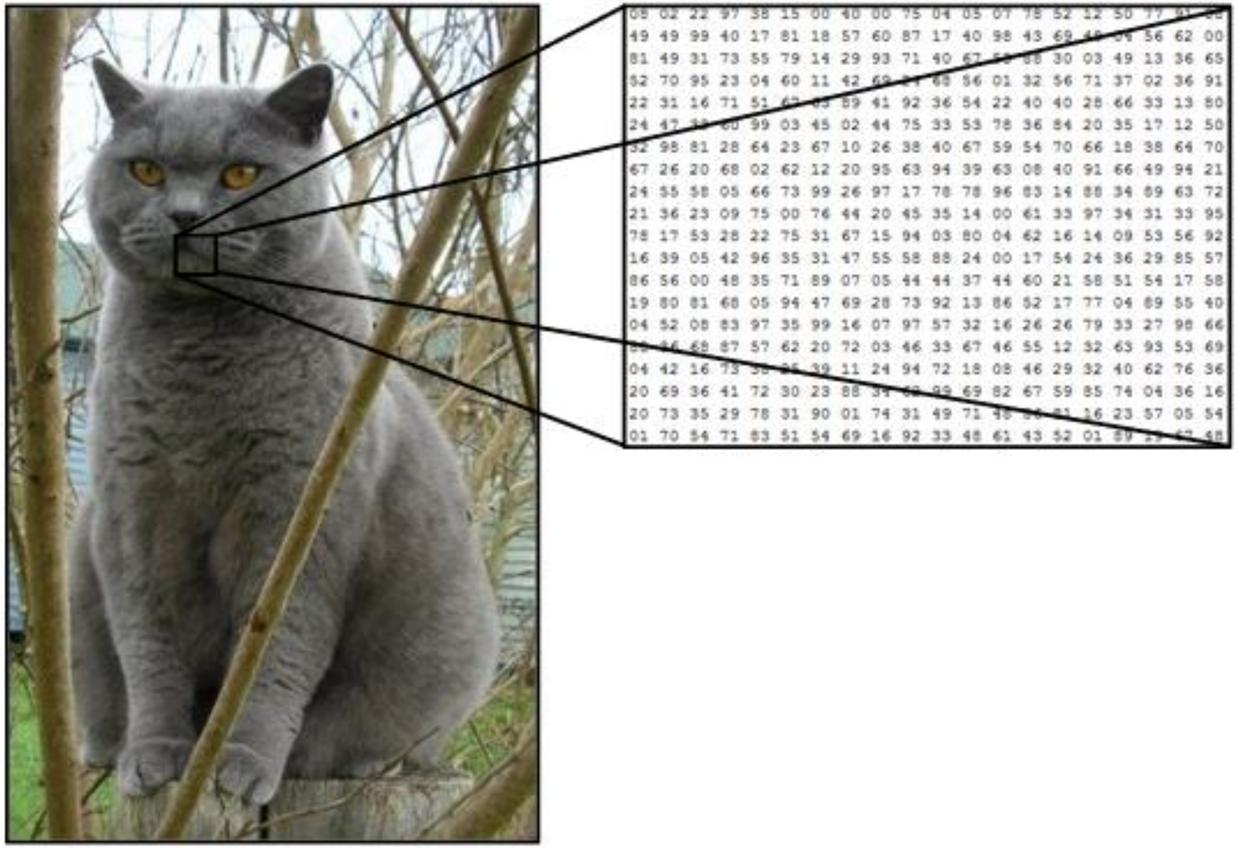
Deep Learning
Distilling knowledge from data



Feature	Value
Whiskers	Yes
Fur	Yes
Car door	No
Paws	Yes
Wire	No
Ears	Yes

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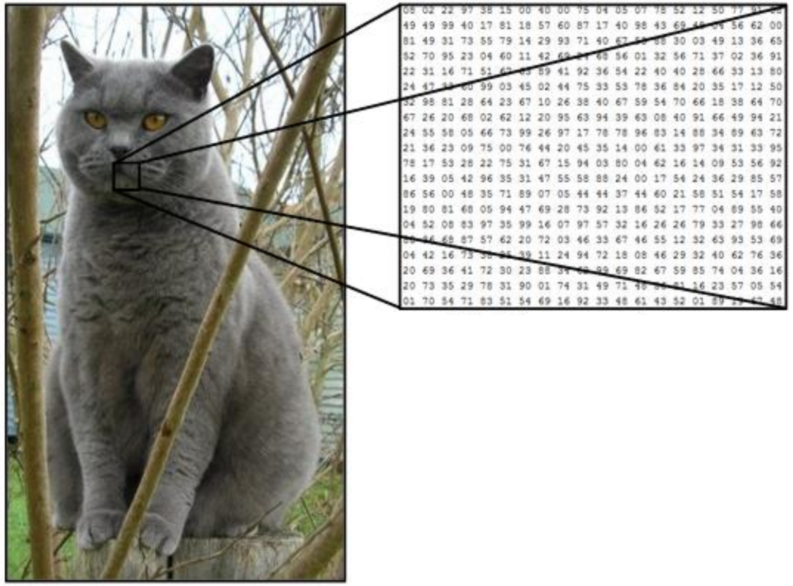
Deep Learning
Classical Machine Learning



Manual Feature Engineering

Feature	Value
Whiskers	Yes
Fur	Yes
Car door	No
Paws	Yes
Wire	No
Ears	Yes

Machine Learning Model

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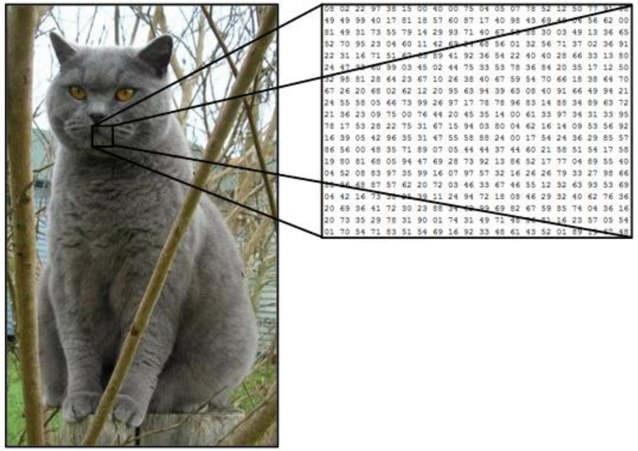
Deep Learning
Deep Learning

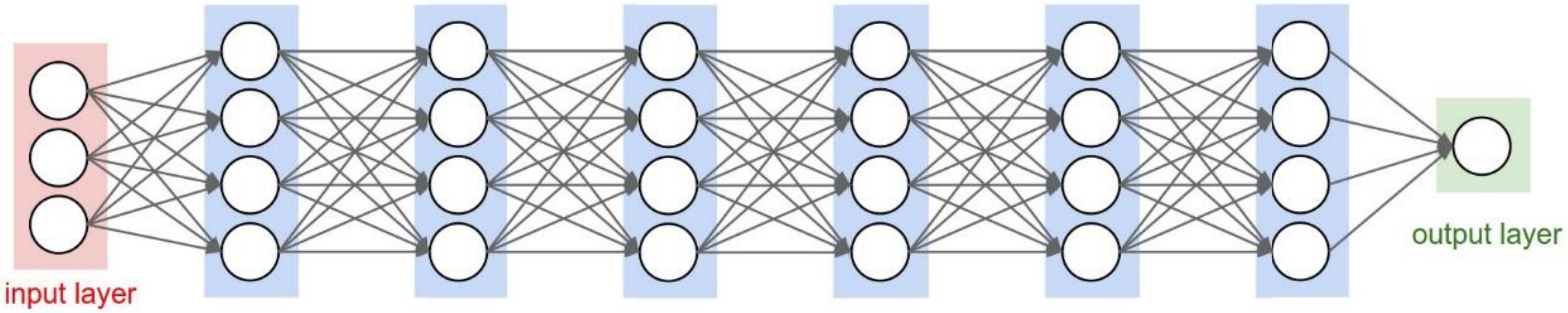


Manual Feature Engineering

Feature	Value
Whiskers	Yes
Fur	Yes
Car door	No
Paws	Yes
Wire	No
Ears	Yes

Machine Learning Model

Cat



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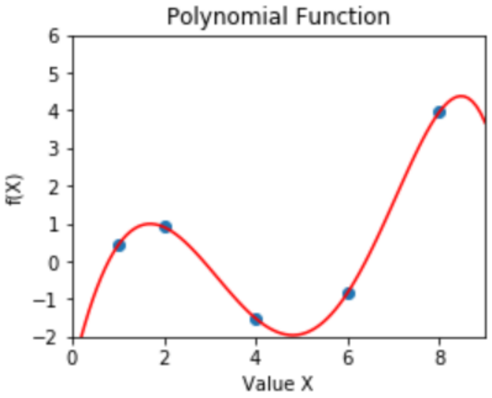
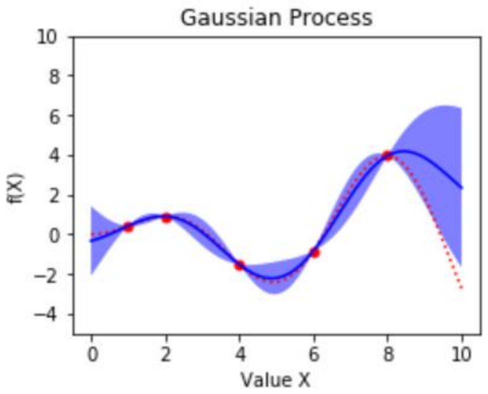
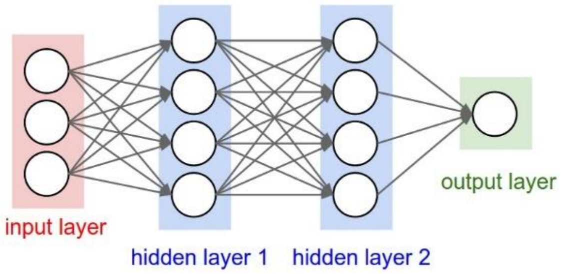
Deep Learning
When should I use Deep Learning?







Accuracy

Required Data

Deployability

Interpretability

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Poll:
“What is the relationship between Deep Learning and Machine Learning?”

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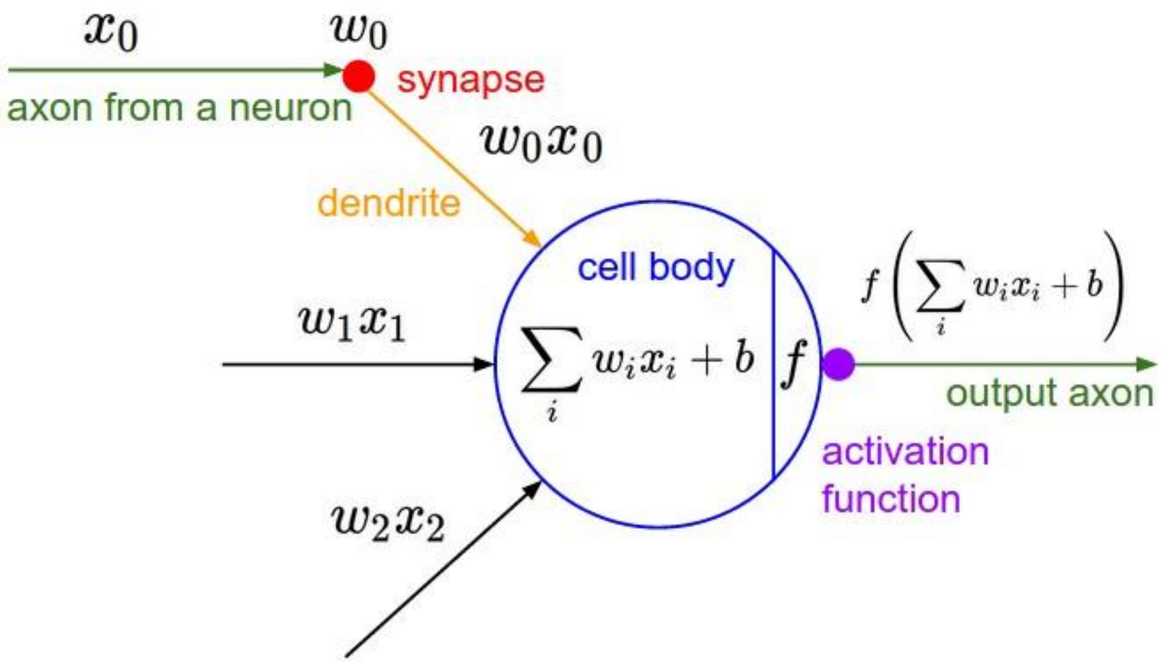
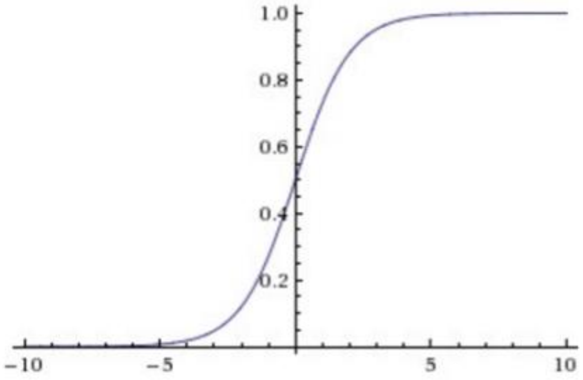
How does it work?

Deep Learning
Artificial neurons



Non-linear activation function f(x):



e.g. Sigmoid

Image: Single neuron in neural network using c++ by Stackoverflow,, CC BY-SA 3.0

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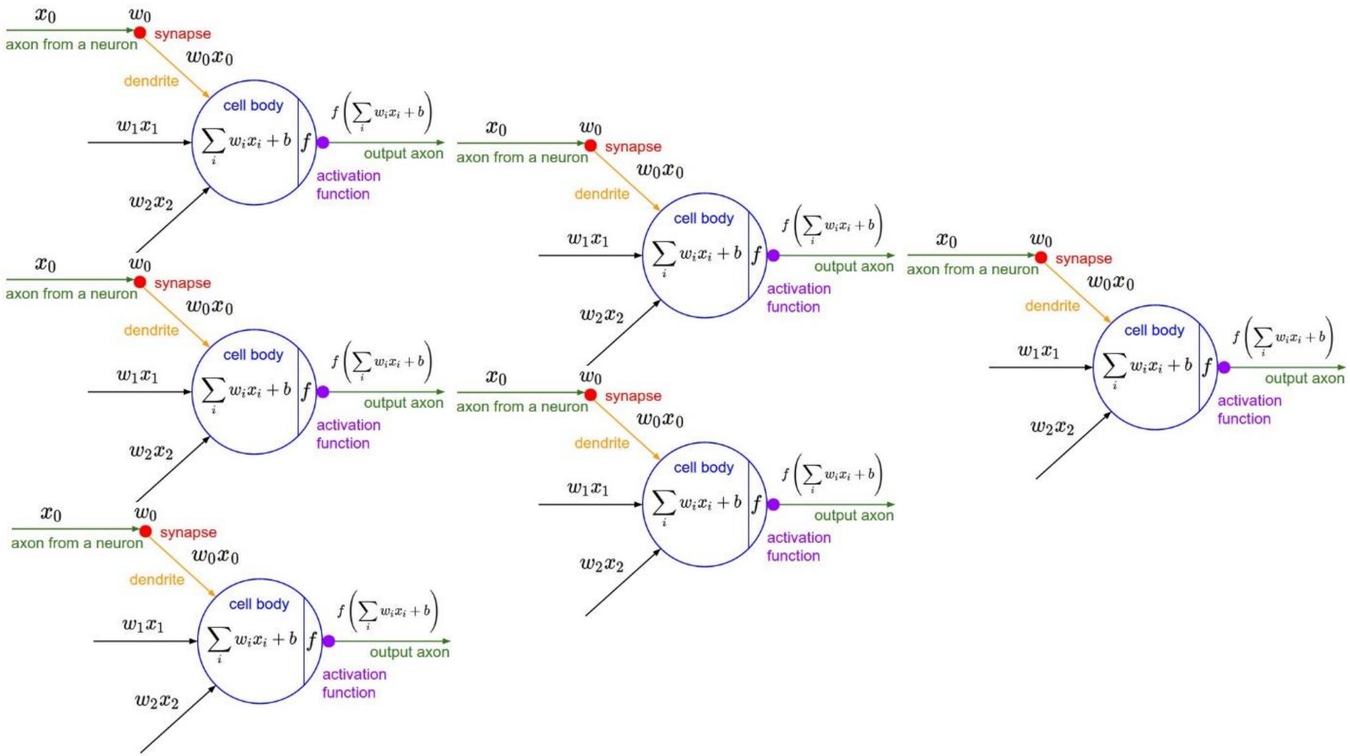
Deep Learning
Artificial neurons



The number of neurons and their connections are defined by the **Network Architecture**

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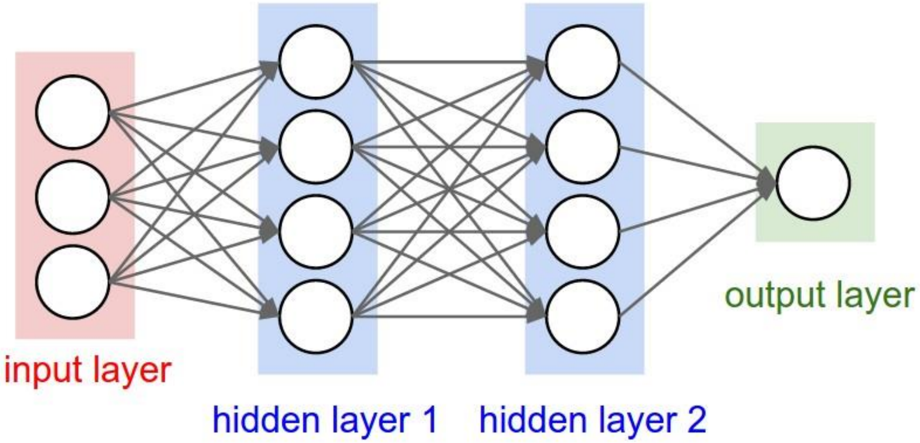
Deep Learning
Layered structure



Modern artificial neural networks combine artificial neurons in layers with:

- No connections between neurons of the same layer
- Typically no connections skipping a layer

→ Why is this structure of layers so powerful?

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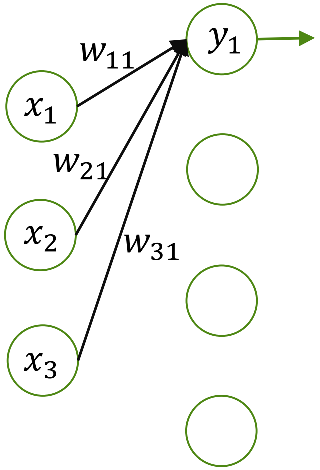
Deep Learning
Layered structure

1. It's computationally efficient



$$y_1 = f(w_{11}x_1 + w_{21}x_2 + w_{31}x_3)$$

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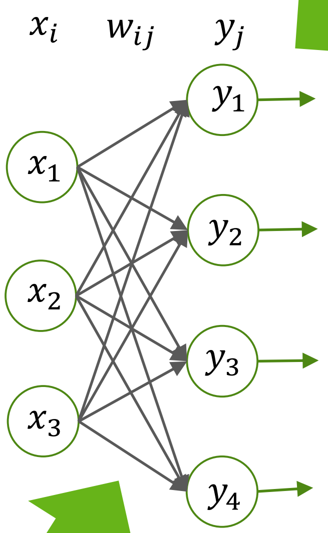
Deep Learning
Layered structure

$$\vec{y} = \begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{pmatrix}$$

$$\vec{x} = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$



$$y_j = f\left(\sum_i w_{ij} x_i\right)$$

$$W = \begin{pmatrix} w_{11} & w_{21} & w_{31} \\ w_{12} & w_{22} & w_{32} \\ w_{13} & w_{23} & w_{33} \\ w_{14} & w_{24} & w_{34} \end{pmatrix}$$

$$\vec{y} = f\left(W\vec{x}\right)$$

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Deep Learning
Layered structure

GPUs are designed precisely for the task of fast, parallelized matrix multiplication.

Image: Evan Amos, Public domain

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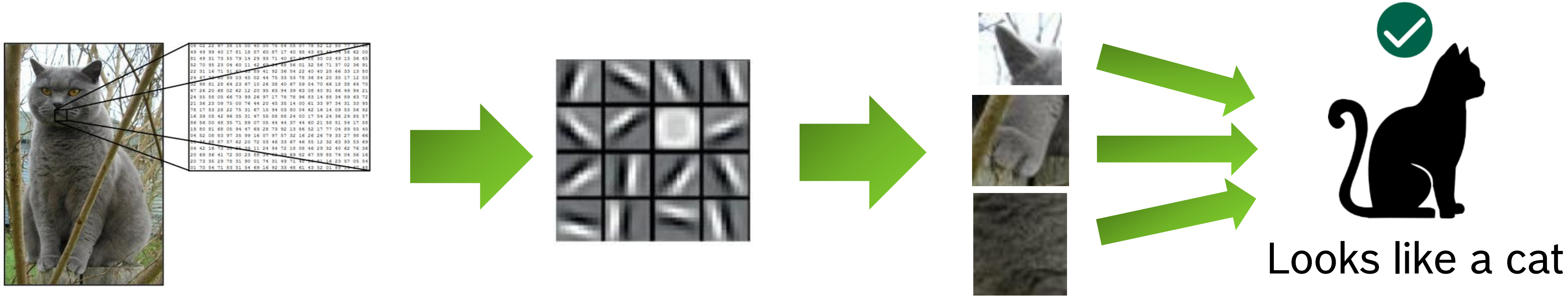
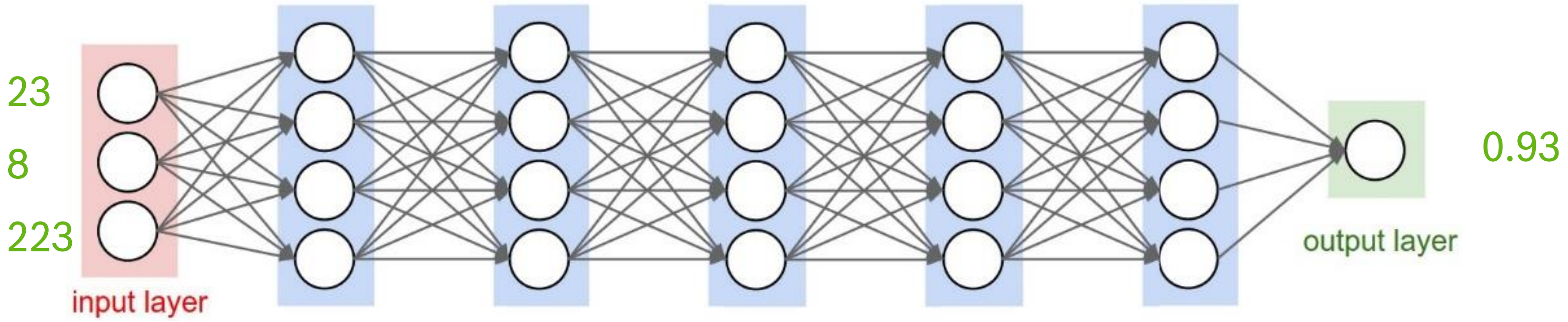
Deep Learning
The power of representation learning

2. A layered structure encapsulates the hierarchical structure of the world





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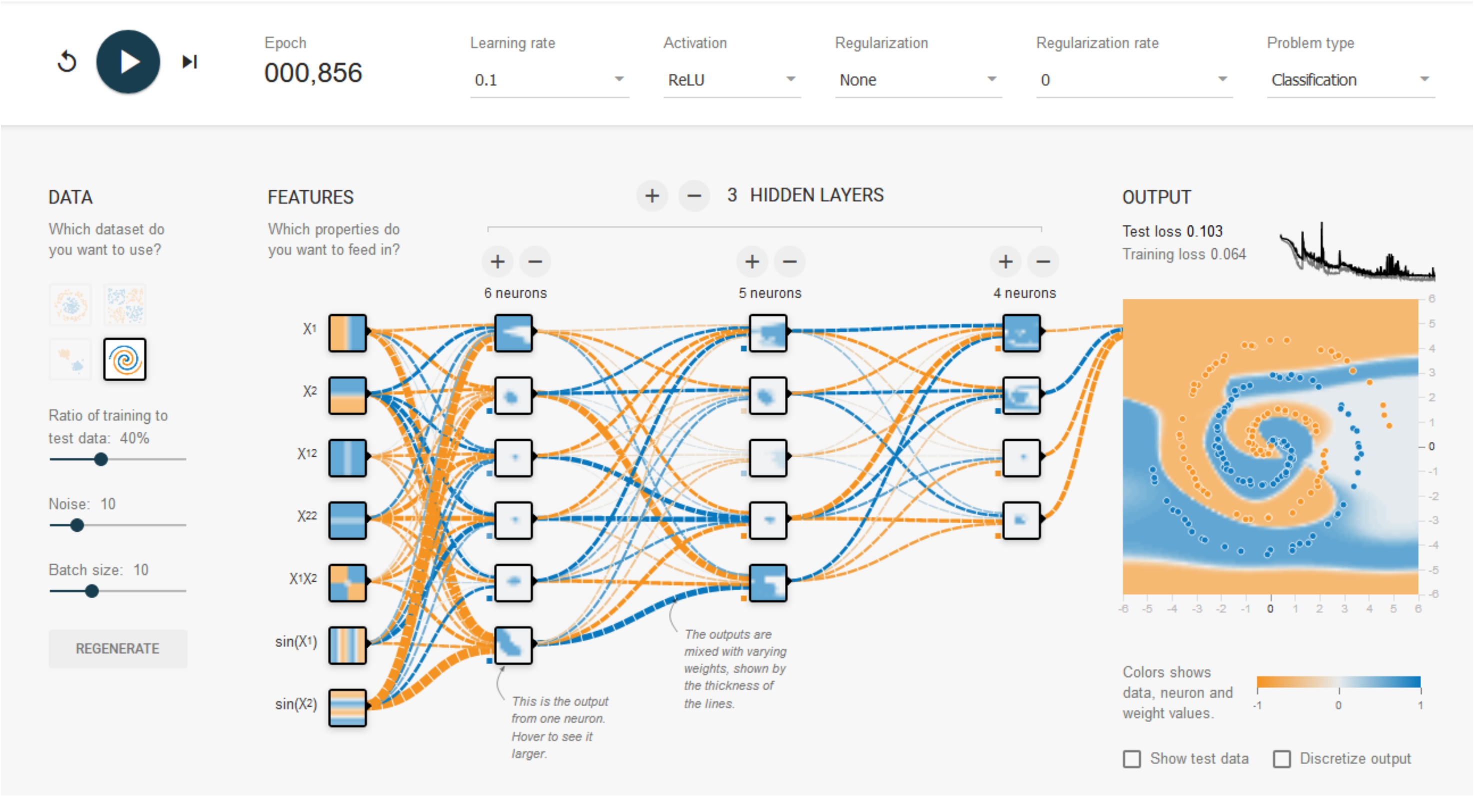
Deep Learning
Tensorflow Playground

Nice website to get an intuitive feeling for neural networks. Click picture for link.



playground.tensorflow.org

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Poll

Poll:

“What is the purpose of the activation function?”

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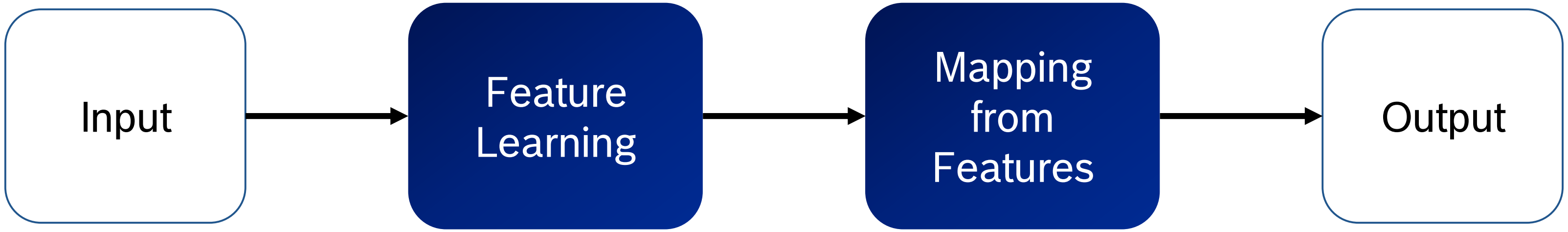
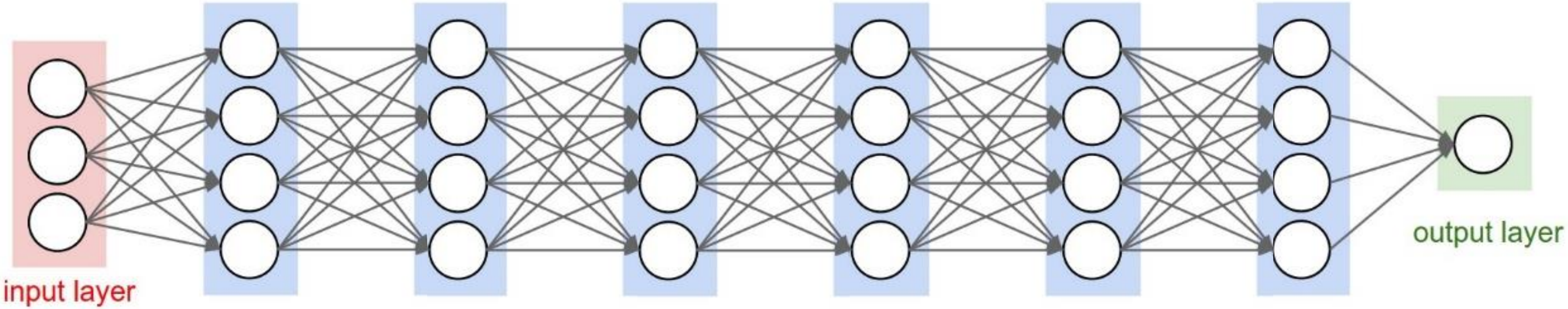
Deep Learning
The power of representation learning





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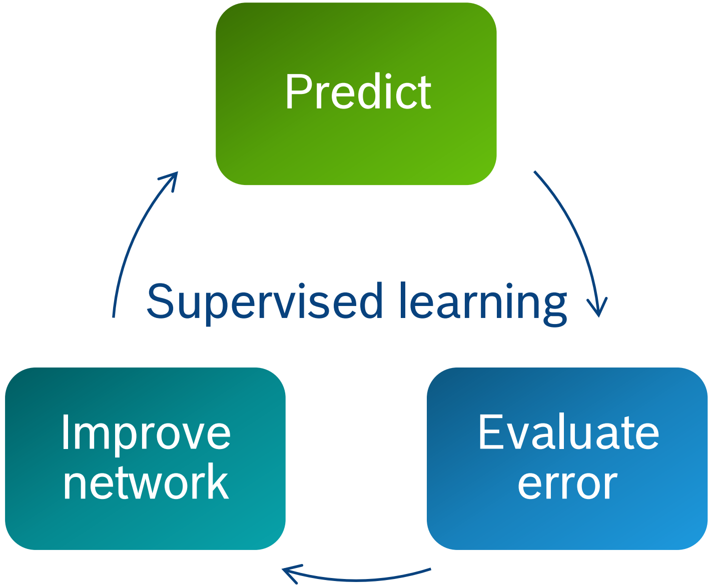
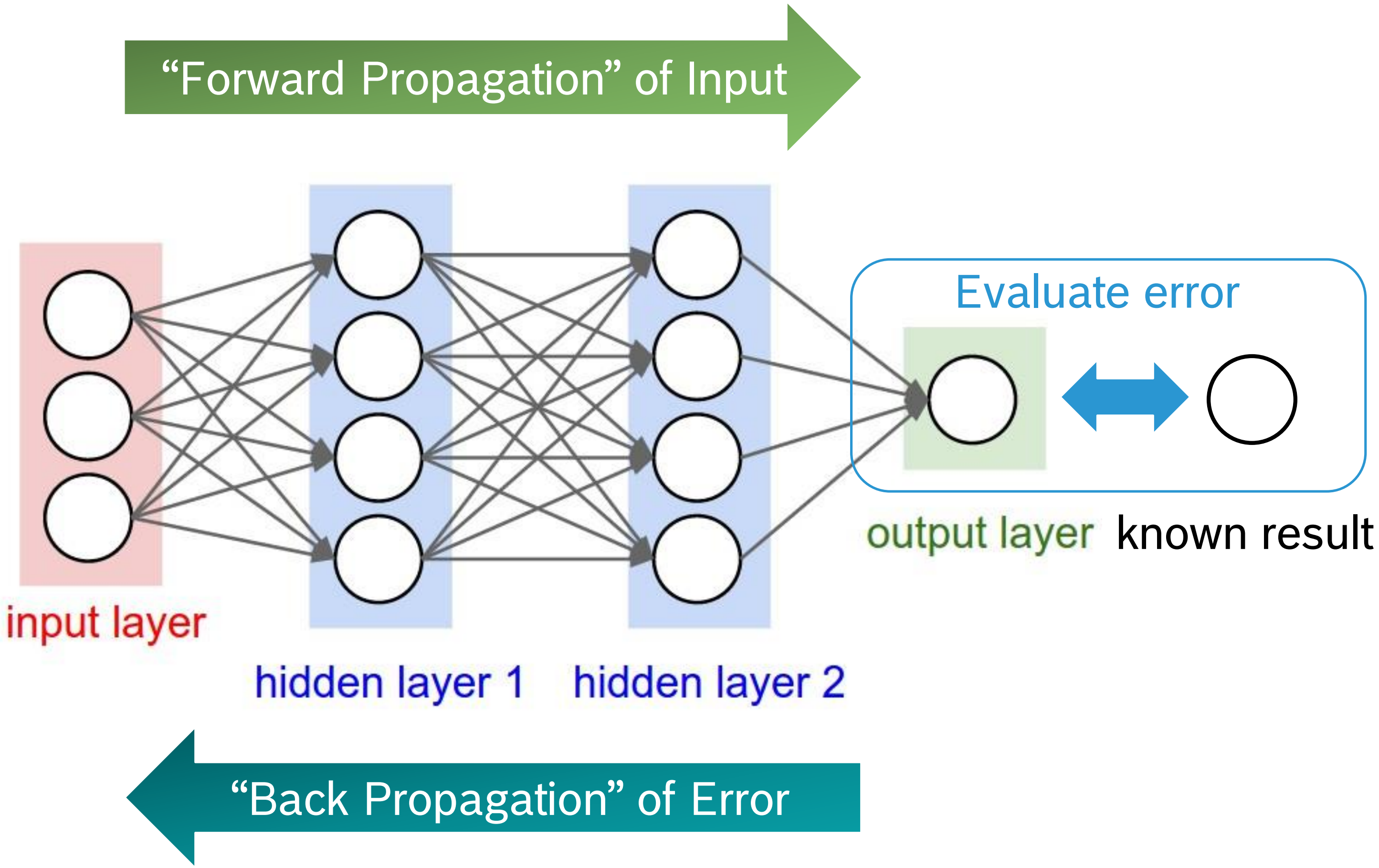
The actual learning

Deep Learning
Network training





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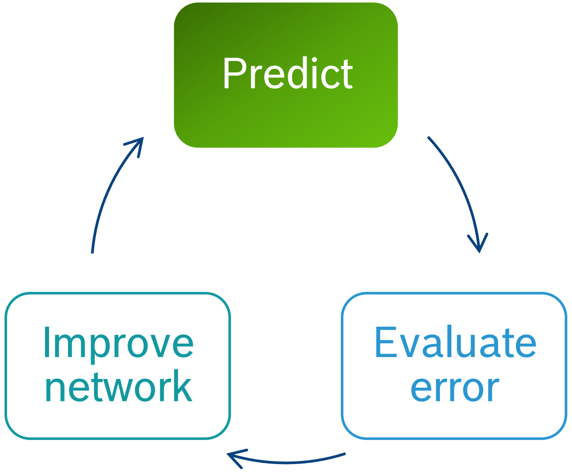
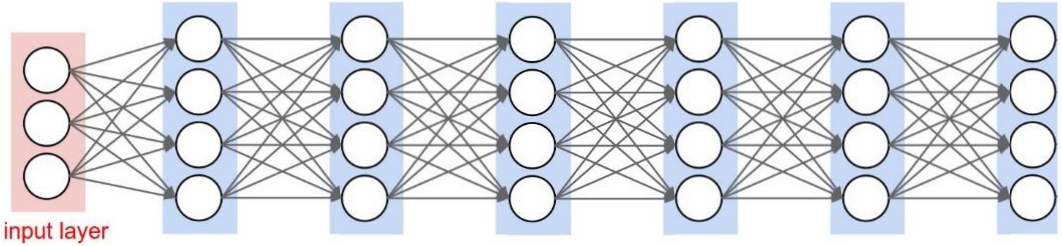
Deep Learning

1st Step: Forward propagation



"Forward Propagation" of Input



Class	Prediction
Car	0.649
Sock	0.001
Dog	0.15
Cat	0.2

Output: Class "Car"

Image: CC0

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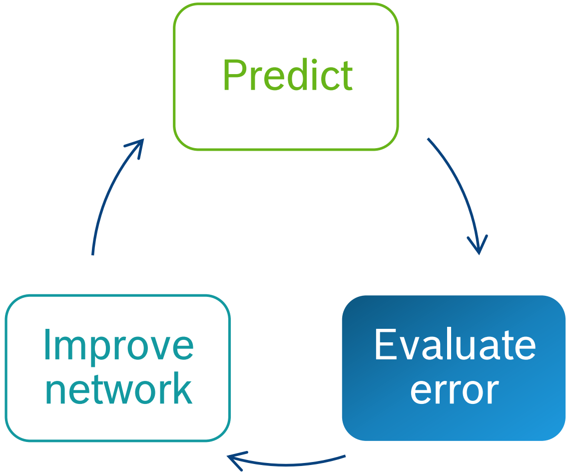
Deep Learning

2^{nd} Step: Error evaluation



Prediction

Class	Prediction	Label
Car	0.649	0
Sock	0.001	0
Dog	0.15	0
Cat	0.2	1

$$Error = \sqrt{(0-0.649)^2 + (0-0.001)^2 + (0-0.15)^2 + (1-0.2)^2} = 1.041$$

Prediction

Class	Prediction	Label
Car	0.05	0
Sock	0.6	1
Dog	0.01	0
Cat	0.34	0

$$Error = \sqrt{(0-0.05)^2 + (1-0.6)^2 + (0-0.01)^2 + (0-0.34)^2} = 0.536$$

Images: CC0

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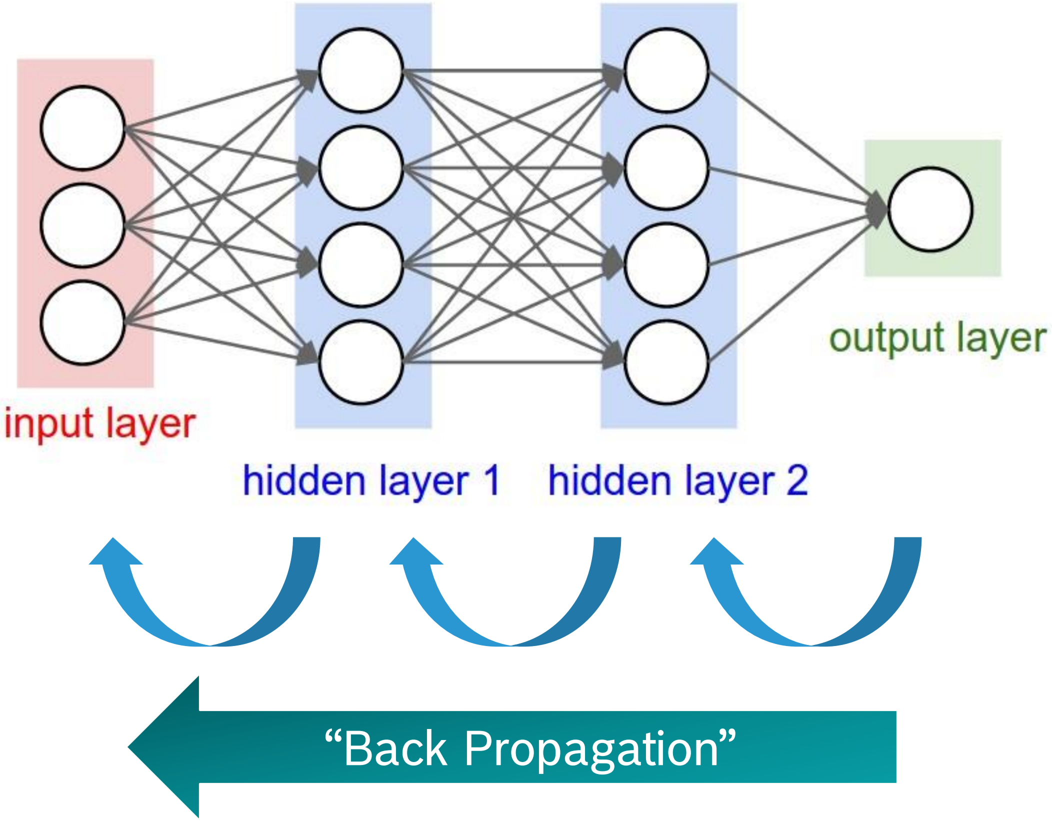
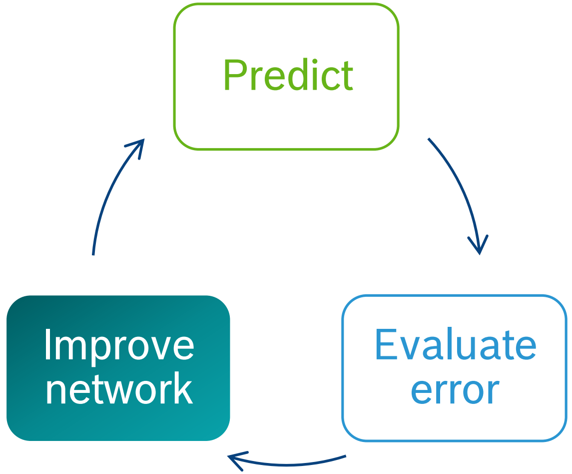
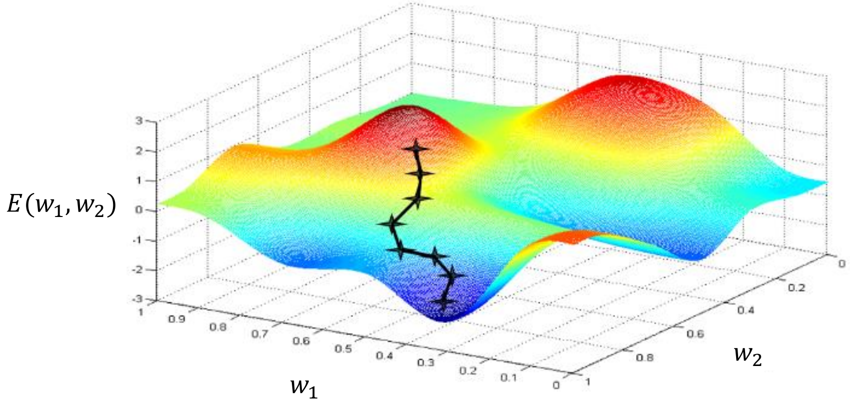
Deep Learning
3rd Step: Back propagation





The error is a function of the network's weights



Minimize error using Gradient Descent

Images: Gradient Descent by StackOverflow, CC-BY 3.0, Copyright (c) 2015 Andrej Karpathy, The MIT License (MIT)

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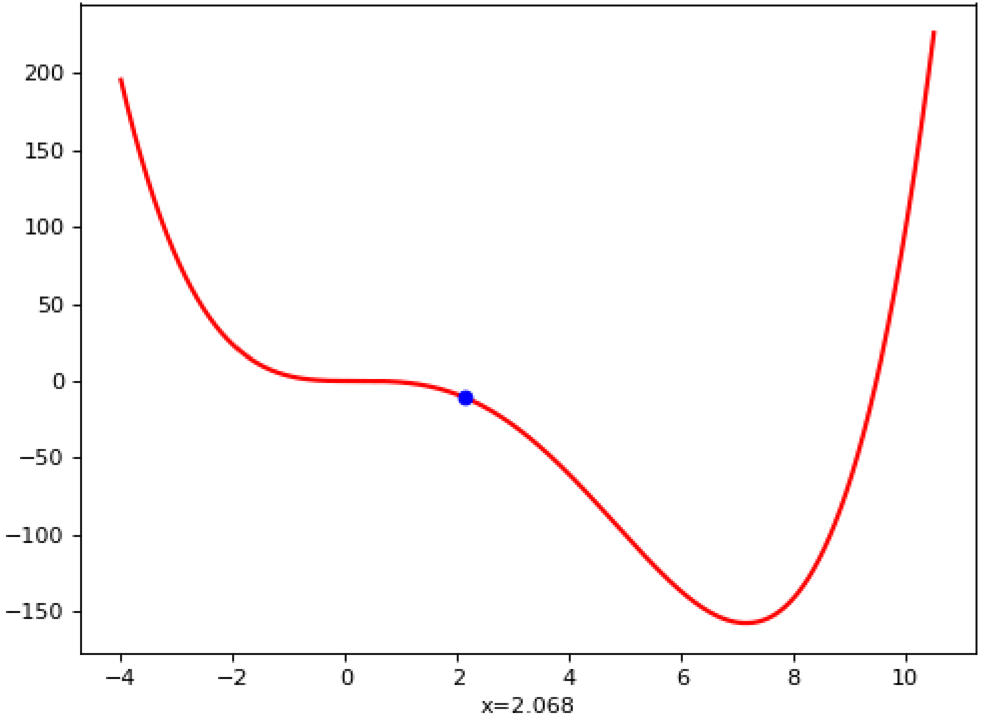
Deep Learning
Gradient descent

Weight update:

$$w^{(k+1)} = w^{(k)} - \eta \frac{\partial E}{\partial w}$$



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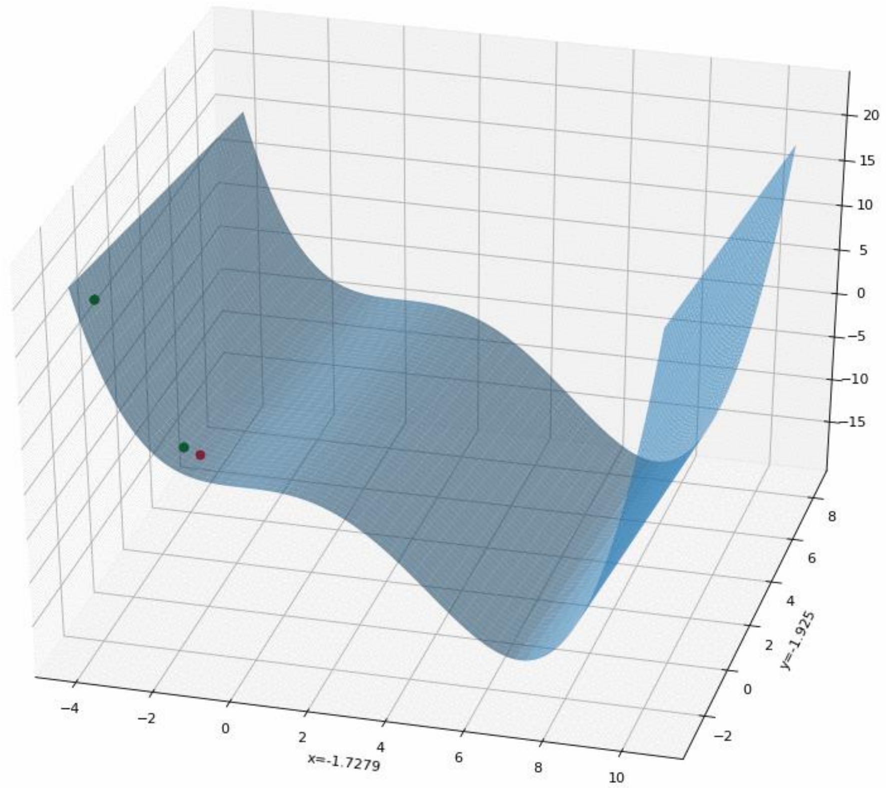
Deep Learning
Gradient descent

Weight update in 2D:

$$\vec{w}^{(k+1)} = \vec{w}^{(k)} - \eta \nabla E$$



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Poll:
“What is the idea of gradient descent?”

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Advanced Architectures

Deep Learning
Convolutional Neural Networks (CNNs)

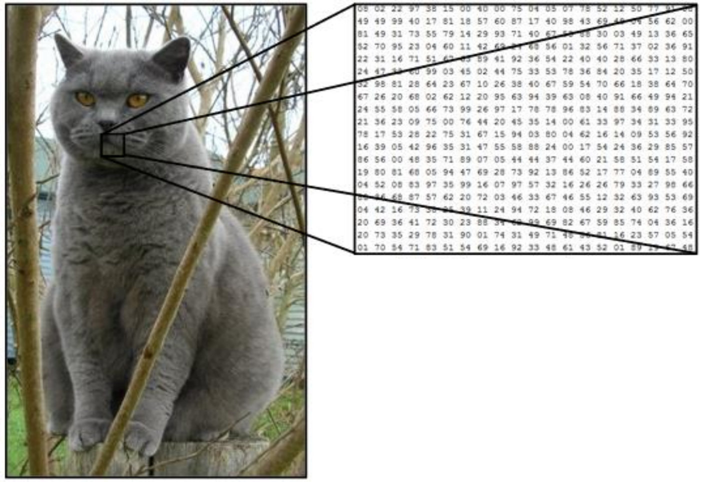
Challenge:

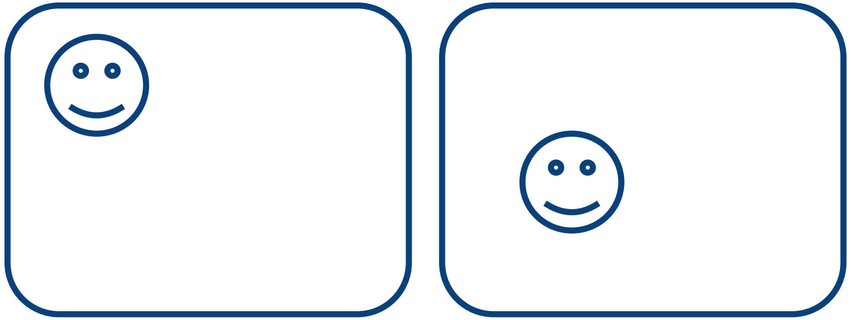
- Vision involves a large number of input neurons (e.g. 1000x1000 pixel values)

→ 10^6 x 10^6 neurons = 10^{12} weights!
Connecting all neurons entirely unfeasible

Solution:

- Take advantage of symmetries and locality





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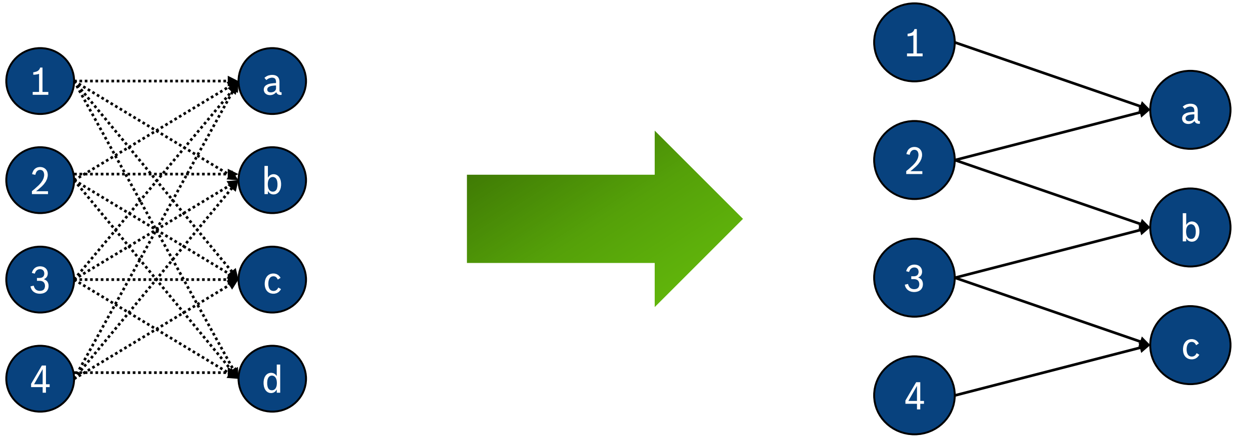
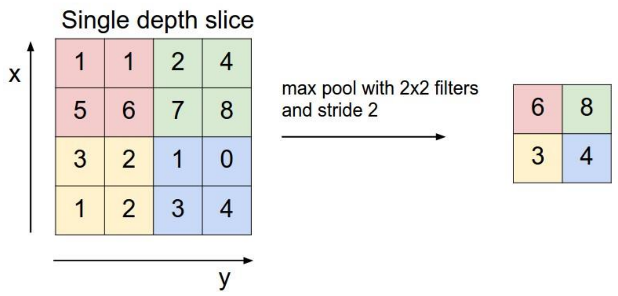
Deep Learning
Convolutional Neural Networks (CNNs)





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Poll

Poll:

“Why would you use a convolutional neural network over a standard fully connected network?”

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When to use deep learning (and when not to)

Deep Learning
Poll

Poll:
“Which of these increase as we move from classical methods to neural networks?”

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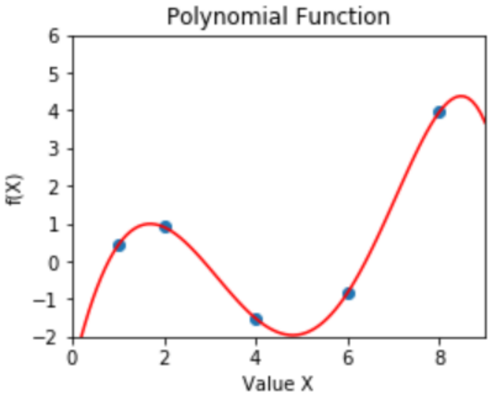
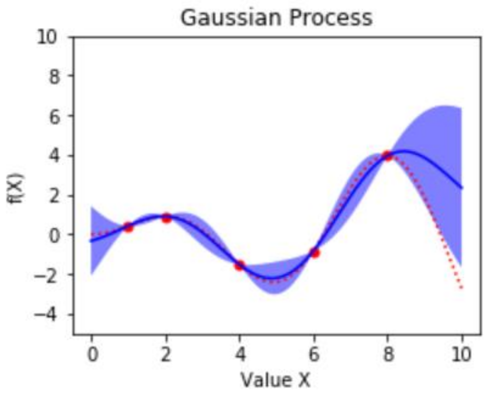
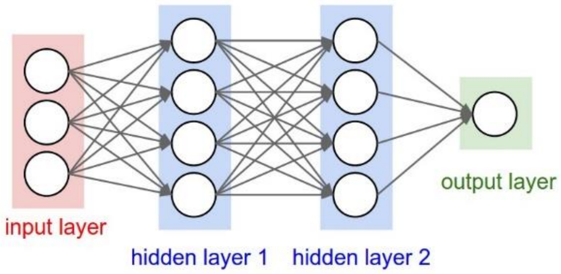
Deep Learning
When should I use Deep Learning?







Accuracy

Required Data

Deployability

Interpretability

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Deep Learning
Deep Learning model complexity

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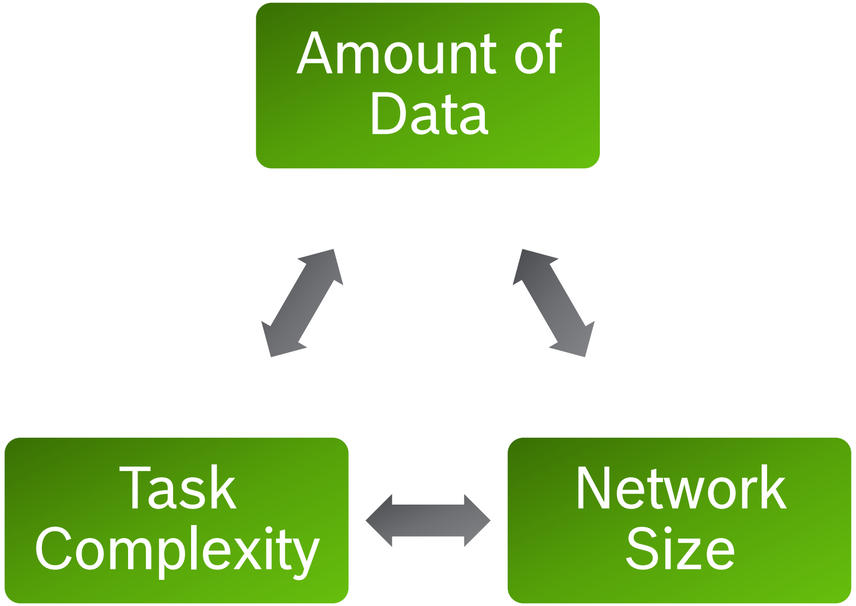

	Image Net Image Classification	MNIST Digit Classification
# features	270 000	784
# outputs	1000	10
# model parameters	~50 000 000	< 50 000
# data samples	14 000 000	42 000
Training time on 1 GPU	1-2 weeks	2 minutes

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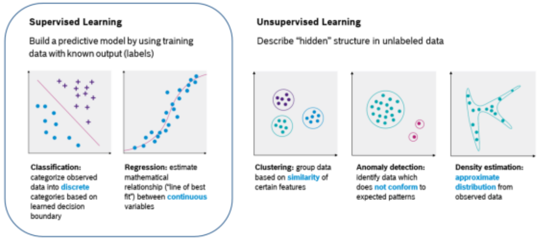
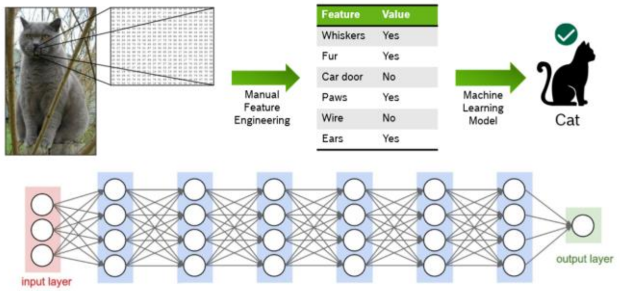
Deep Learning
Summary

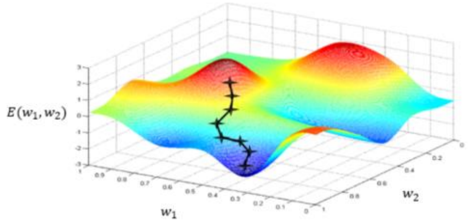


What tasks can DL solve?

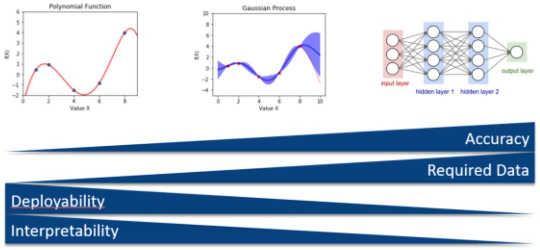


Classical ML vs DL

Why CNNs?



Training of DL Models



When to use DL

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IMPLEMENTATION– ROLES, TRAINING AND CONSULTING

Roles, Training and Consulting
AI Roles and Competencies

Executive
Understands strategic relevance of data, has tools overview, knows staff requirements

Data Analyst
Has a data-driven mind-set, expert in visualizing data from various sources, knows basics of statistical data analysis

Data Scientist
Expert in statistics, machine learning, artificial intelligence and big data technologies and methodologies

Data Engineer
Builds links to big data systems, provides clean data, develops deployment strategies and drives IT enhancement

Existing training portfolio available

Concept phase
Pilot in Q2 2020

DAX
Data Analytics Expert Program

DSX
Data Science Expert Program

Concept phase
Pilot in Q1 2020

DEX
Data Engineering Expert Program

Create AI Awareness in Executives and set standards of qualification for AI expert roles

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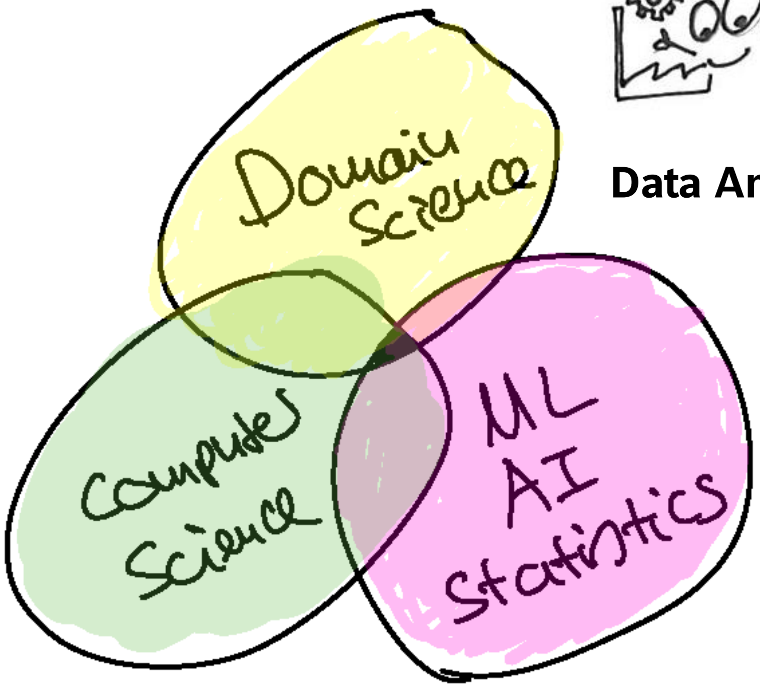
Roles, Training and Consulting
Data Analyst, Data Scientist and Data Engineer

Data Analyst



Data Scientist

Data Engineer

Data-driven projects are a team effort where **domain experience**, **analytical skills** and **technological expertise** go hand in hand.

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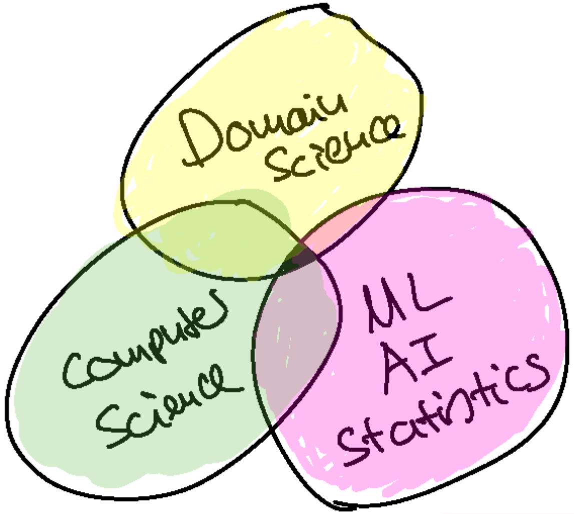
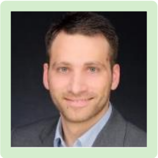
Roles, Training and Consulting
Interplay at controlling use case

Michael Binder (G2/PJ-FCE-IT)
Background: Controlling
Project topics: Product lead



Phil Gaudreau (CR/PJ-AI-S1)
Background: Mathematics
Project topics: Design of prediction algorithm



Dominik Mayer
Background: Hadoop and Linux administration

Cinar Goktug (CR/PJ-AI-S1)
Background: PhD in Machine Learning
Project topics: Design and implementation of prediction algorithm

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Data Engineering Expert Program (DEX)
Expert in building reliable data infrastructure

	Junior Expert			Senior Expert	
	Basics	**Methodical Overview**	**Project 1**	**Specialization**	**Project 2**
Content	• Required programming languages • Collaborative Software Design	• Data sources and architectures, data warehouse/lake • Designing of reliable data pipelines	• Project ideation and proposal • Execution with BCAI mentoring	• Deployment and continuous X • Operation and maintenance • Security and resource management	• Project ideation and proposal • Execution with BCAI mentoring
Duration	3 months	4 months	3 months	4 months	6 months
Grading	Certificate	Certificate	Final presentation	Assignment grading	Final presentation & FEBER
Trainee Effort	~100 h	~150 h	~ 120 h	~ 150 h	~ 230 h
Provider	Coursera	BCAI, Udacity, Coursera	BCAI	BCAI, Udacity, Coursera	BCAI

DEX: Expert in distributed data-intensive applications based on profound Software Engineering expertise

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Data Science Expert Program (DSX)

Expert in functionality and application of ML methods

	Junior Expert			Senior Expert	
	Basics	Methodical Overview	Project 1	Specialization	Project 2
Content	• Python for Data Science • Visualization • Linux basics • Version control • SQL	• Classroom Trainings on basics of Data Science, Statistics and Machine Learning • Exercises in Python	• Project ideation and proposal • Execution with BCAI mentoring	Options: • Deep Learning • Embedded • NLP • DevOps • Autonomous vehicles	• Project ideation and proposal • Execution with BCAI mentoring
Duration	2 months	2 months	4 months	4 months	6 months
Grading	Certificate	Assignment grading	Final presentation	Certificate	Final presentation & FEBER
Trainee Effort	~ 100 h	~ 90 h	~ 180 h	~ 200 - 400 h	~ 270 h
Provider	Coursera	BCAI	BCAI	Depends on specialization	BCAI

DSX: Expert in Statistics, Machine Learning and implementing advanced algorithms

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Data Analytics Expert Program (DAX)
Expert in data analysis & visualization

	Expert		
	Basics	**Advanced**	**Project**
Content	• Introduction to Python and Jupyter Notebooks • Python at Bosch • Python for Data Science • Visualization • SQL	• Basics of Statistical Data Analysis • Tableau • Power BI	• Project ideation and proposal • Execution with BCAI mentoring
Duration	6 weeks	6 weeks	3 months
Grading	Certificate	Assignment grading	Final presentation
Trainee Effort	~ 80 h	~ 80 h	~ 140 h
Provider	Coursera, BCAI	Coursera, BCAI, CI	BCAI

DAX: Expert in Data Analytics & Visualization

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BCAI Classroom Training Portfolio

	Executives, Managers, Project Leaders		Also covered in [FT-AI-ML-01]	Engineers, Experts	
	[EDT-AI-100] Introduction to Big Data and Artificial Intelligence	[FT-AI-DDP-01] Leading Data-Driven Projects	[FT-AI-DL-01] Deep Learning Deep Dive	[FT-AI-STL-01] Statistical Learning and Gaussian Processes	[FT-AI-ML-01] Machine Learning and Deep Learning
Summary	AI Introduction	Short methodical introduction	Introduction to deep neural networks	Basics of statistics and Gaussian models	Classical machine learning, deep learning
Prerequisites	None	General understanding of AI	General understanding of AI	Basic Python skills recommended	Basic understanding of statistics, Python skills
Content	General overview of AI and data value Ability to see data-driven opportunities in the area of expertise	Overview of basic methods for regression, clustering and classification with a focus on model validation for AI project leads	Basics of deep neural networks, architectures for image classification and object detection, hands-on workshop	Introduction to statistics, Bayesian statistics, hypothesis tests, regression analysis, Gaussian mixture models, Gaussian processes	Data Science workflow, machine learning tasks, concepts and models, data-preprocessing, time series analysis, deep neural networks, CNNs
Duration Price (Germany)	1 day 750 EUR	1 day 750 EUR	1 day 750 EUR	2 days 1450 EUR	3 days 2175 EUR
Next Dates (Germany)	Online Format: 28th - 29th Jul 2020	To be added	To be added	Online Format: 7th - 10th Jul 2020	Online Format: 14th - 22th Jul 2020
	Link for more details	Link for more details	Link for more details	Link for more details	Link for more details

Recommended: [FT-AI-STL-01] → [FT-AI-ML-01]

Info Online Format: Training days split up in double amount of half-days

Alternative:
free web-based training [EDT-AI-100_WBT]

In case of questions/remarks please contact Jennifer.Thompson2@de.bosch.com

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Demonstrators
Experience AI in a hands-on tutorial

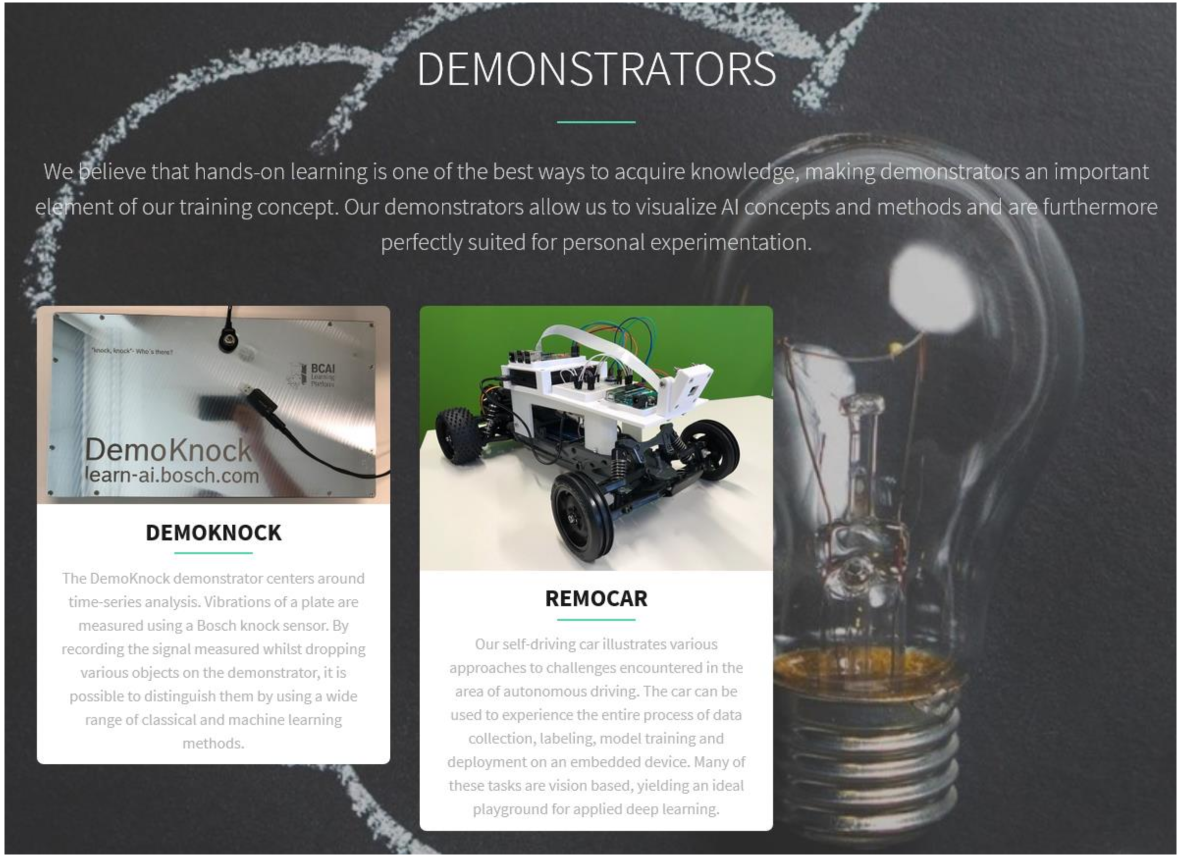
Philosophy

- Growing palette

→ as the next one a catapult for
Bayesian Optimization

- Purposes
  - Part of trainings
  - Keynotes, conferences
- Can be used as demonstration material for groups to get excited about AI

- See instructions for assembly below:
  - DemoKnock
  - RemoCar



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Train the Trainer
Scaling concept for class room trainings

Trainers

- Requirements for candidates
  - Skills/Background (ML/AI)
  - Motivation
  - Strong recommendation: team of min. two trainers
- Participate in 3 trainings (6 training days) to be certified for full portfolio:
  - EDT-AI-100, FT-AI-STL-01, FT-AI-ML-01
- Proposed workload: 5-10 training days/year

Benefits

- Profit by local organizations:
  - Direct local trainings in the right language
  - Additional local business context (use cases can be added)
  - Cost reduction

Process

Local manager:
- suggest candidates

Candidates:
- participate in trainings in Germany
- get materials and additional training by BCAI trainers

BCAI with local BTC and manager:
- clarify training conditions (fee, dates, ...)
- clarify license fee process

Candidates → Local trainers:
- conduct pilot training
- evaluate the feedback with BCAI

Local trainers and BTC:
- schedule and conduct trainings

Training

- Already up and running/in development in Turkey, Portugal & Spain, US, Mexico, France, China, Japan, Brazil
- Types of training
  - General AI awareness
  - Deep methodical knowledge
- We start with the awareness training to establish the processes

Price Structure

- BCAI: license fee 150 Euro/Participant per day (materials, infrastructure, support, quality meetings)
- Local: trainer cost defined by local manager with BTC/HR
- Local: organizational costs (training, organization, room, catering, etc…)

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Training: Intro to Big Data and Artificial Intelligence

Training duration: 1 day

Max. 15 participants

BD & AI:

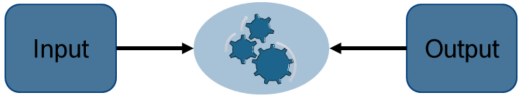
What and why?

- Basic definitions
- Why AI and why now?
- Real world applications
- Bosch Use Cases

Data as an asset:

Value creation

- Relevance of data
- Big Data handling
- Data mining
- Roles and processes



Technical foundations:

Machine Learning

- What is machine learning?
- Strategies
- Tasks
- Methods

Get started:

Data mining in your BU

- Interactive session
- Find business opportunities
- Learn how to tackle them
- Discuss & exchange

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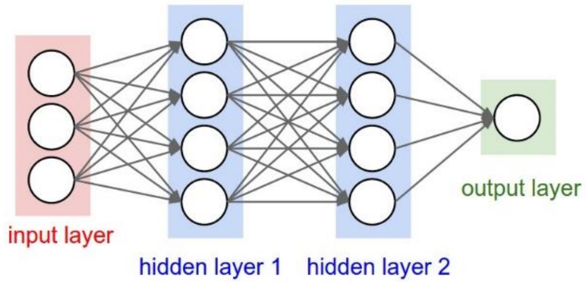
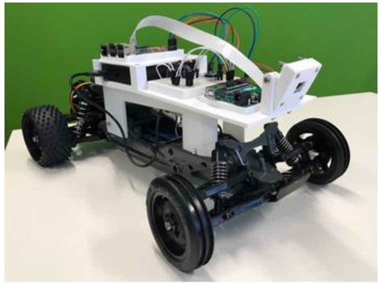
Training: Deep Learning Deep Dive

Training duration: 1 day

Max. 15 participants





LO1: Understand Deep Learning Functionality

- Basic structure
- Terminology
- Training and inference
- Important architectures

LO2: Identify Deep Learning Applications

- Image Classification
- Object Detection
- Natural Language Processing

LO3: Know Project Requirements

- Data
- Infrastructure
- Algorithms

LO4: Work on a Real Deep Learning Problem

- Incrementally learn to develop a neural network for autonomous lane keeping
- Deploy your network on a model car and see it in action

Leftmost image: http://cs231n.github.io (MIT license)

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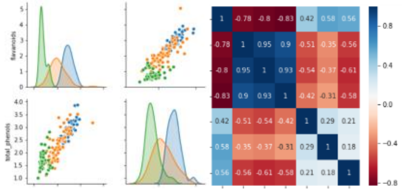
Training: Leading Data-Driven Projects

Training duration: 1 day

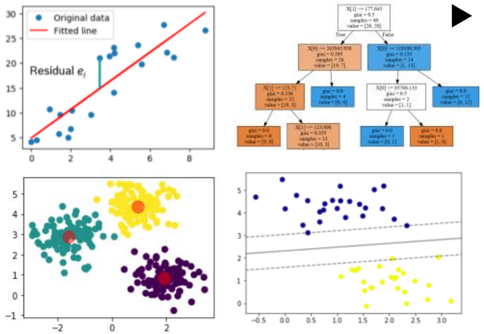
Max. 15 participants

Data Exploration



- Exploratory analysis
- Visualization

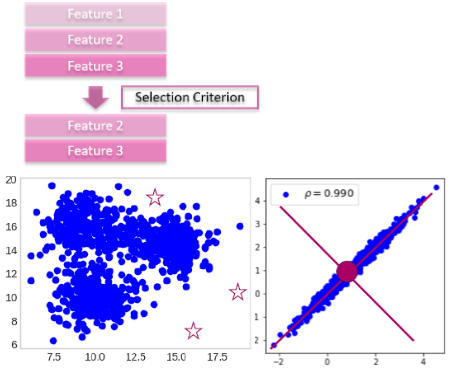
Modelling



- Train an appropriate model
  - Regression
  - Clustering
  - Classification

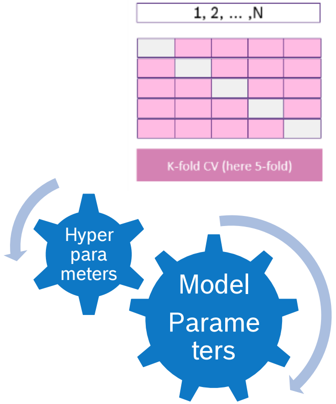
Deployment

- Implement your model in a production system



Data pre-processing

- Feature (predictor) selection
- Outlier treatment
- Dimensionality reduction
- Model-specific processing



Validation

- Cross-validation
- Test model on an independent dataset
- Tune hyperparameters

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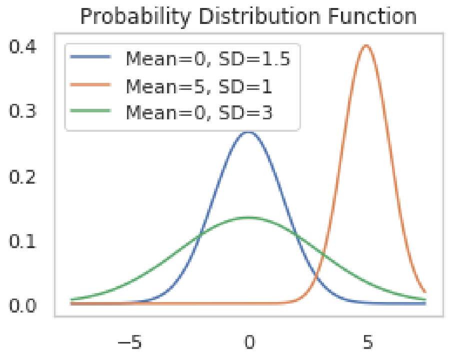
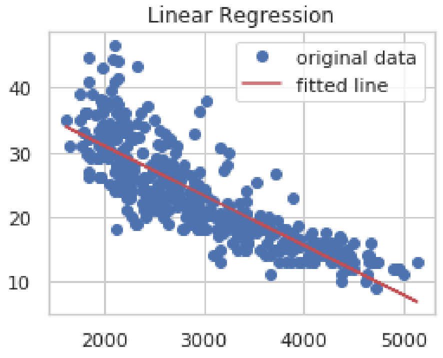
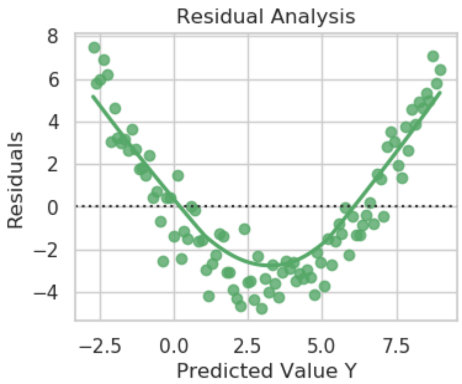
Training: Statistical Learning & Gaussian Processes

Training duration: 2 day
Max. 15 participants





	The Null Hypothesis	
Decision	True	False
Accept H_0	(1-α)	β
Reject H_0	α	(1-β)



LO1: Understand Basic Statistical Terminology

- (Conditional) probabilities
- Location and distribution parameters
- Common distributions

LO2: Correlation and Linear Regression

- Correlation
- Linear regression
- Parameter interpretation

LO3: Parameter Estimation and Statistical Tests

- Parameter estimation
- Hypothesis tests
- Confidence intervals

LO4: Linear Regression Assumptions and Diagnostics

- Basic assumptions, tests and remedies against assumption violation
- Residual analysis

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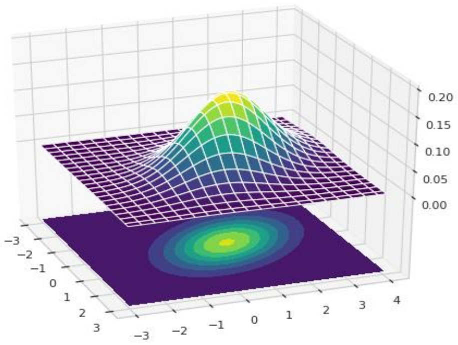
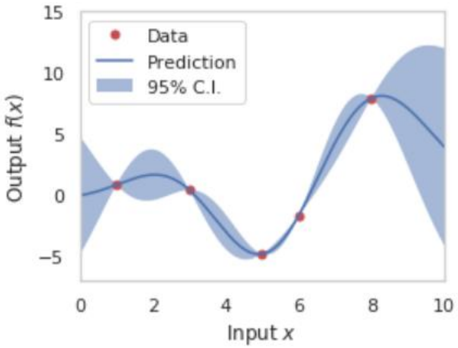
Training: Statistical Learning & Gaussian Processes

Training duration: 2 day
Max. 15 participants



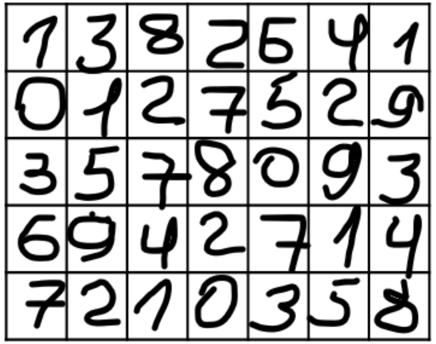
LO5: Gaussian Mixture Models

- Multivariate Gaussian distribution
- Gaussian mixture models
- Estimation by expectation maximization



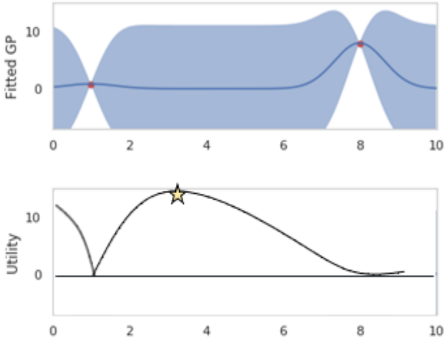
LO6: Understanding Gaussian Processes (GP)

- Covariance function
- Noise-free vs. noise case
- Hyperparameters (signal and noise variance, length-scale)



LO7: Advanced Topics and Applications of GP

- Types of covariance functions
- Regression and classification with GP
- Model estimation and selection



LO8: Bayesian Optimization (for Hyperparameters)

- General purpose
- Acquisition functions
- Exploration vs. Exploitation
- Application for GP

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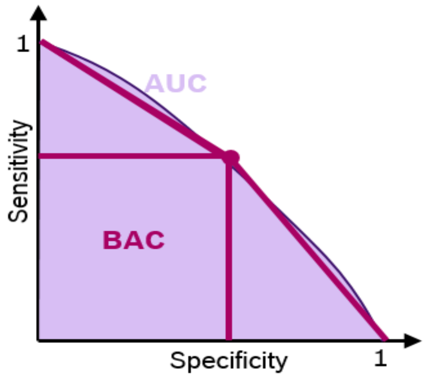
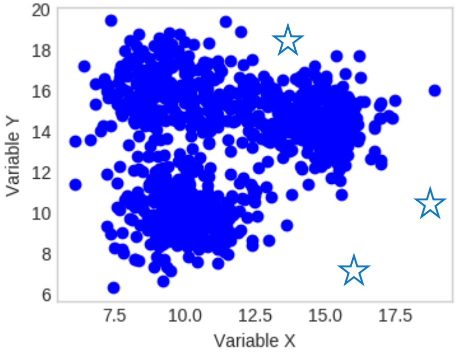
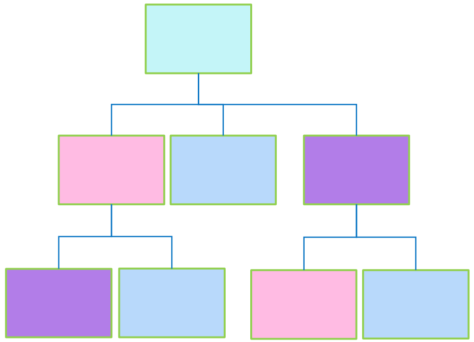
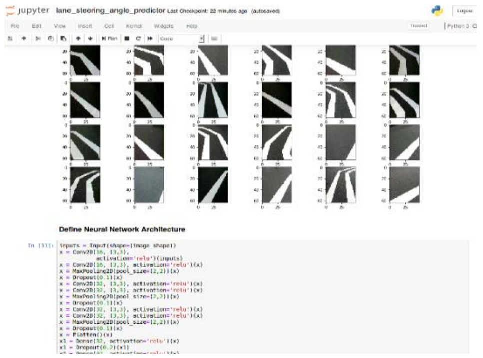
Training: Machine Learning & Deep Learning

Training duration: 3 day
Max. 15 participants









LO1: Machine Learning (ML) Concepts

- ML workflow
- Model complexity
- Regularization
- Ensembles

LO2: Data Science Workflow

- Data exploration and dimensionality reduction
- Outlier detection
- Model validation and selction

LO3: Algorithms and Methods

- Clustering
- Decision trees
- Support vector machines
- Time series analysis

LO4: Application of Learned Concepts using Python

- Implementing the models
- Performance comparison
- Use cases at Bosch and potential in BUs

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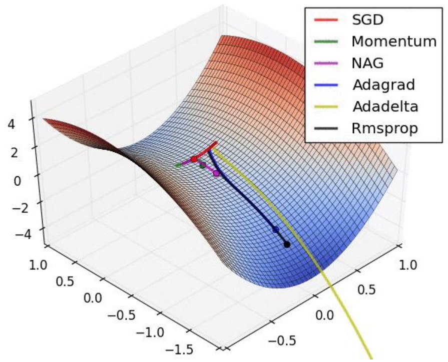
Training: Machine Learning & Deep Learning

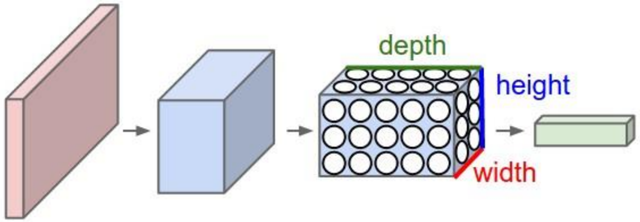
Training duration: 3 day

Max. 15 participants



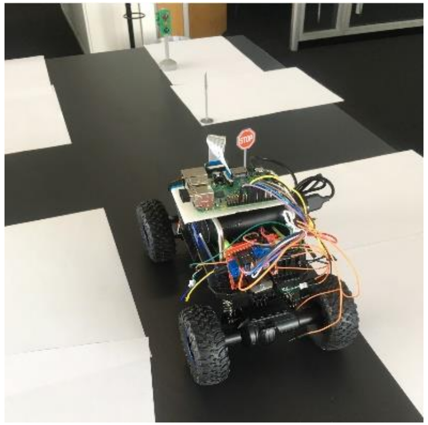
LO5: Basics of Neural Networks

- Training and inference
- Optimization
- Activation and loss functions
- Weight initialization
- Transfer learning



LO6: Deep Learning

- Vanishing gradient problem
- Convolutional Neural Networks (CNN)
- Word embeddings
- Bosch use cases



LO7: Work on a real Deep Learning Problem

- Incrementally learn to develop a neural network for autonomous lane keeping
- Deploy your network on a model car and see it in action

Images: http://cs231n.github.io (MIT), A. Radford https://imgur.com/a/Hqolp

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AI Roles and Competencies
Learning journey for executives

If you need more methodical knowledge in machine learning and/or deep learning you have the opportunity to have a one-day methodical deep dive

Before:

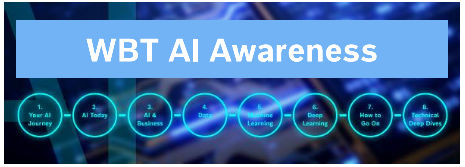
No AI Background

You have been hearing Artificial Intelligence on every corner but except for the utopic picture of machines taking over you have no further ideas about it?

Step 1:

AI Awareness Class Room

OR



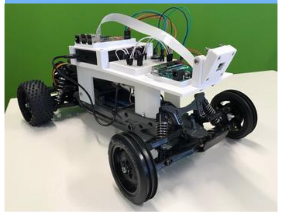
Use a series of eight episodes from our web-based training to get an initial overview over the most prominent AI topics, methods, and some of Bosch use cases

Step 2:

Leading Data-Driven Projects

AND/OR

Deep Learning Deep Dive



After:

You are aware of what the chances and risks of AI are, what words machine learning, deep learning mean, have seen some use cases and have decided how to proceed on your own

Training Bar

After you know what keyword to look for we can offer you a wide palette of further training offers (internal/external) in different formats (online vs. class room, priced vs. free).
If you want a practical implementation experience in Python in addition to a methodical introduction, see our landing page

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Web-based Training "Data & AI"

Target Groups

Executive

Understands strategic relevance of data & AI, has tools overview, knows staff requirements

Employee

Understands strategic relevance of data & AI, has tools overview, knows the basics of these topics

Learning Objectives

- Build a mindset for the importance and **value of data** and data mining
- Understand **the value proposition and the limitations** of (big) data and artificial intelligence
- Identify **commercial opportunities** of deploying (big) data and artificial intelligence in our products, services, and processes
- Prepare for the **chances and challenges** coming with the rise of artificial intelligence technologies
- Gather a **high-level understanding of the technologies** behind (big) data and artificial intelligence, including machine learning and deep learning

Cost	Time Effort	Requirements
Our web-based training is free of charge!	8 x 25 min of interactive web-based learning	Interest and willingness to dive into the topics of data & AI

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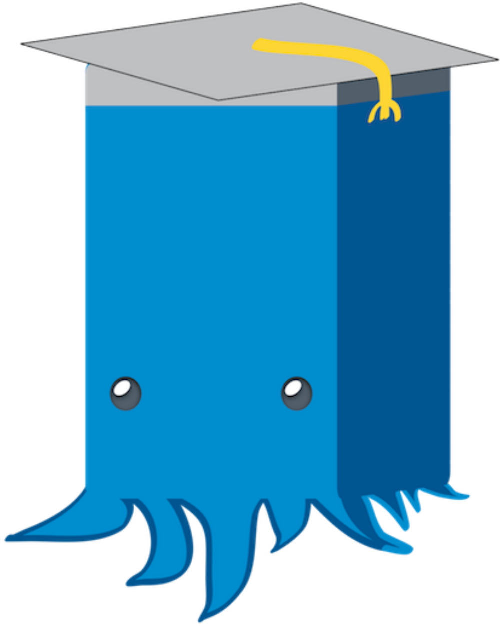
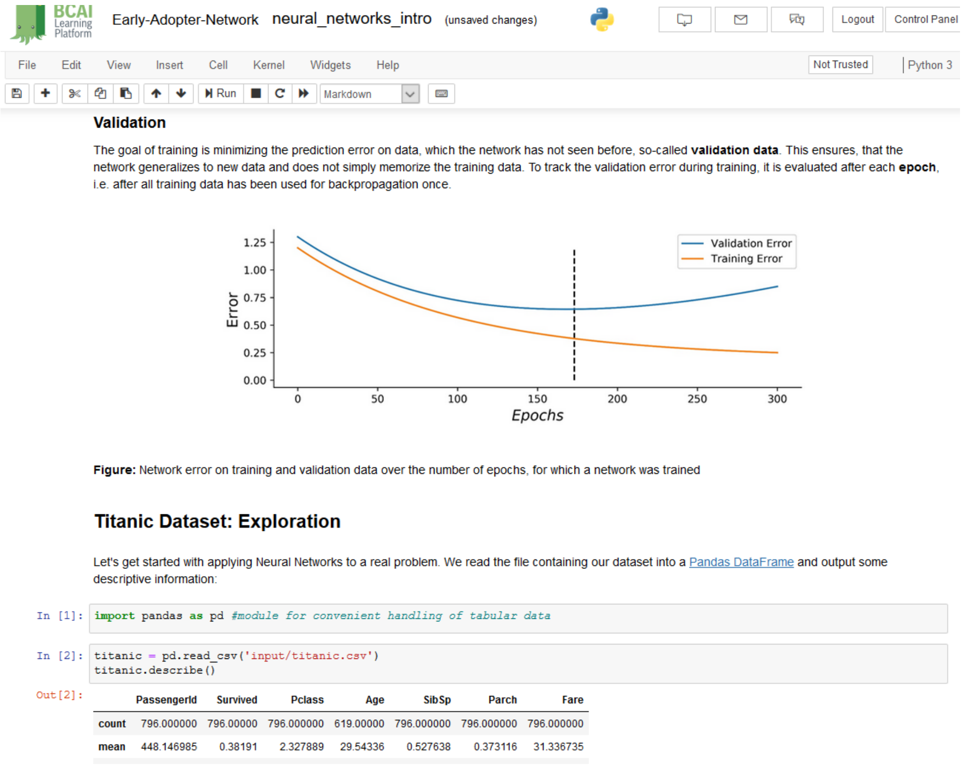
AI Learning Platform
Supporting AI enthusiasts

Target Group



- Motivated AI enthusiasts

Training Offers



- Self-paced learning on Jupyter notebooks
- Prerequisites:
  - Basic Python skills
- Linked with our community

Access Links

[Visit Our Learning Platform]

[Visit Our Community]

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AI Competitions on “Baggle” (Kaggle for Bosch)

Facts

- Pilot together with CC and hosted on the AI learning platform
- **5 challenges** online, 1 more to come based on real use cases and data
- Bosch Connect community
- About **200 registered participants** from 600 addressed in the keynote
- Over 100 submissions after approx. 3 weeks

Competitions (2019)

Highway Detection by Automated Driving - Perception
Classify if a car is driving on a highway
launched 17 days ago close in about 2 months
15 teams
16 submissions

Driver Fatigue Detection by Advanced Development Projects
Classify the awareness of a driver
launched 2 months ago close in about 2 months
11 teams
0 submissions

First Level Support by Engineering Software Coordination, Methods and Tools
Classify support tickets by tool
launched 2 months ago close in about 2 months
83 teams
234 submissions

Loose Wheel Detection by Engineering Software for Controllers
Predict a loose wheel from speed sensor data
launched 2 months ago close in about 2 months
35 teams
187 submissions

Noise prediction for ESP devices by Engineering Components and Hydraulic Functions
Generate what a driver hears from sensor data
launched 2 months ago close in about 2 months
30 teams
78 submissions

See this link for more details

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BCAI Organization & Contacts

CR/P

BCAI
CR/PJ-AI
Christoph Peylo

AI Research
gain best in class AI technology

- Generate technical differentiation
- Realize cutting-edge AI into lead application USP's
- Establish BCAI as a major player in the academic community
- **CR/PJ-AI-R**
  Alexander Müller

External Scientific Advisory Board

Consultancy Board

AI Enabling
accelerate digital business

- Build up AI competence in business units
- Drive data as an asset mindset
- Facilitate transfer of research results

See: learn-ai.bosch.com

- **CR/PJ-AI-E**
  Martin Thomas

AI Marketing
raise awareness of BCAI

- Drive internal and external communication
- Active Stakeholder Management
- Develop Market Intelligence
- **CR/PJ-AI-M**
  Christoph Röscher

AI Consulting
support project strategies

- AI project ideation and incubation
- AI project preparation and execution
- AI strategy support
- **CR/PJ-AI-C**
  Thomas Geiler

AI Services
drive commercialization

- Projects that apply state of the art AI to solve business problems for BUs
- AI platform to fast-track AI project and solution development
- **CR/PJ-AI-S**
  Rahul Kapoor

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Bringing your ideas to life with BCAI CONSULTING

SEND US YOUR USE CASE

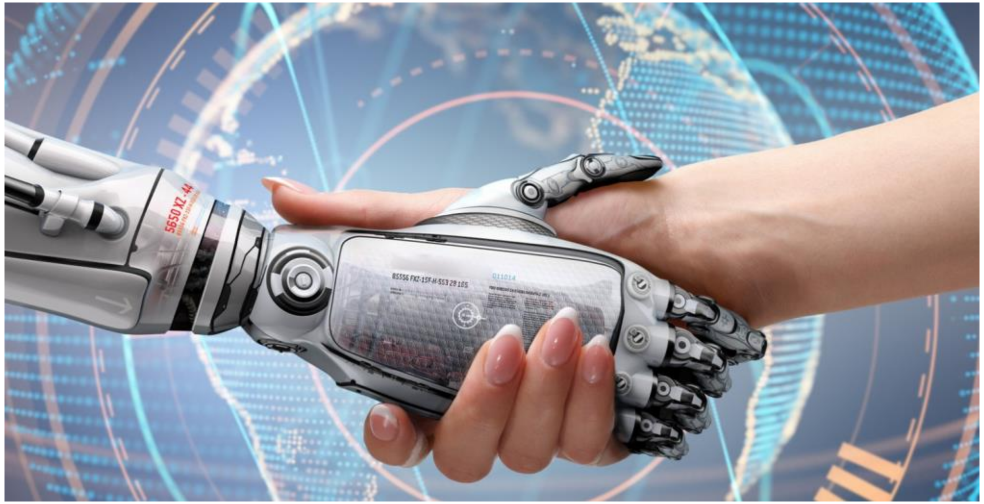
https://bcaic-ai-demo.learn-ai.bosch.com/contact/form/

BOSCH

AI code of ethics
Bosch sets company guidelines for the use of artificial intelligence

At a glance: guidelines in Bosch's AI code of ethics

- All Bosch AI products should reflect our "Invented for life" ethos, which combines a quest for innovation with a sense of social responsibility.
- AI decisions that affect people should not be made without a human arbiter. Instead, AI should be a tool for people.
- We want to develop safe, robust, and explainable AI products.
- Trust is one of our company's fundamental values. We want to develop trustworthy AI products.
- When developing AI products, we observe legal requirements and orient to ethical principles.



Bosch Zünder

Processes will be established to ensure that the AI codex stays a "living document".

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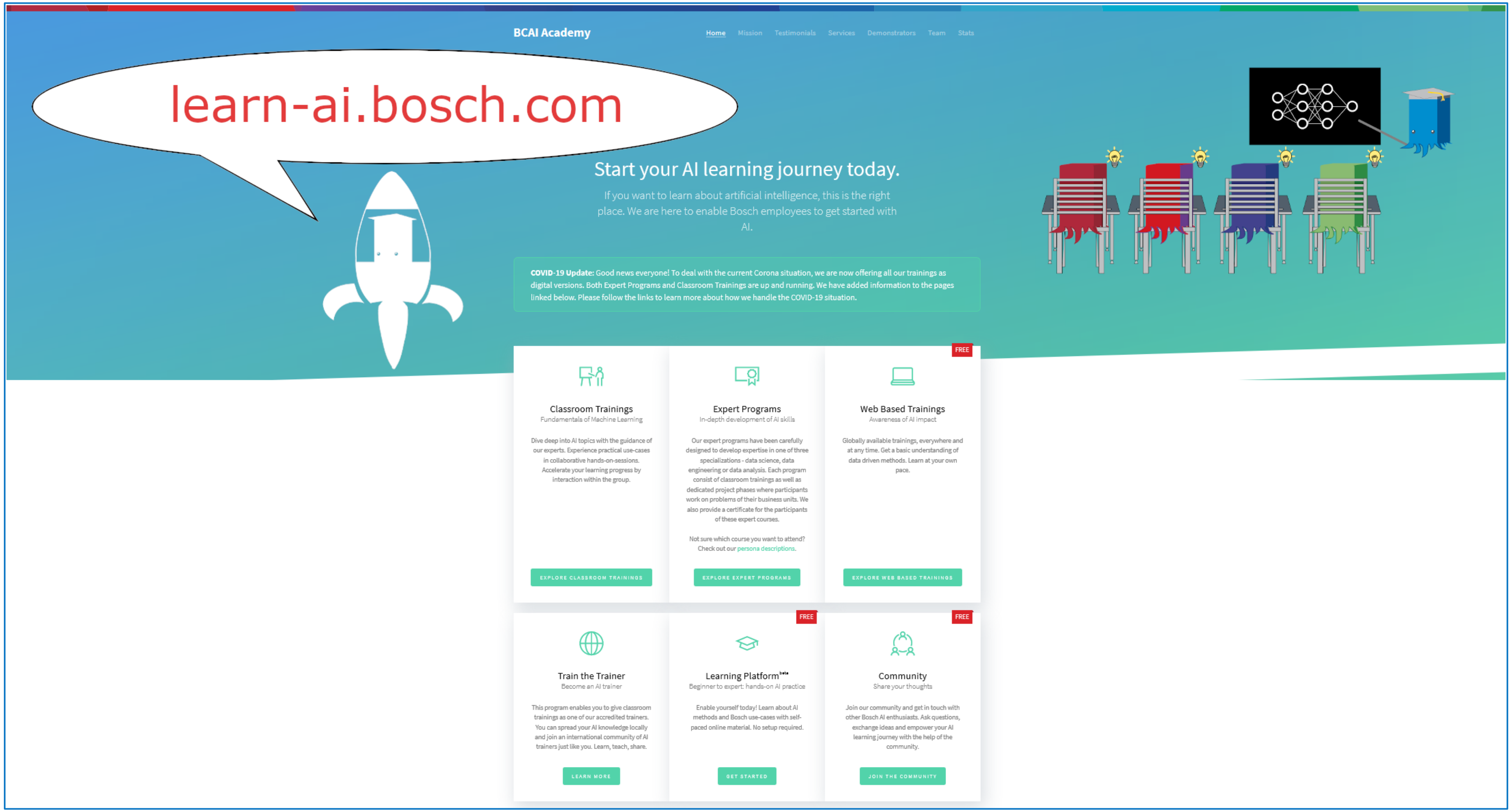
Check out our landing page for all our offers



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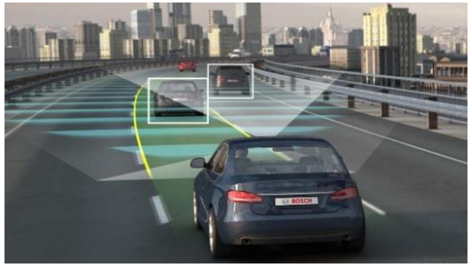
IMPLEMENTATION– PLATFORM PROVIDERS

Platform Providers
CI/OST – CoC Big Data platforms

Mobility Analytics



Autonomous Driving Platform for CC

Connected Industry

RB i4.0 Analytics Platform for AE, PS, CC, DC and CM

Cloud Operations

Big Data Platform capabilities making use of the cloud

Deep Learning

GPU Computing Platform for BCAI, CR and CC

- CoC Big Data Director: Dr. Michael Peters (CI/OST)
- Bosch Connect: https://connect.bosch.com/communities/community/**bigdata**

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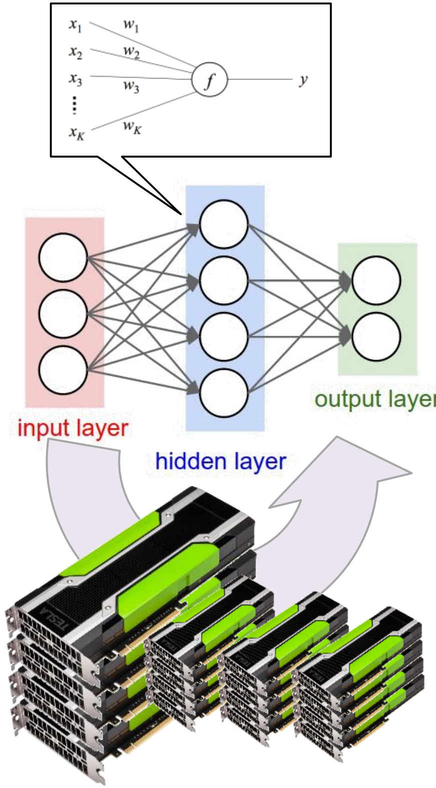
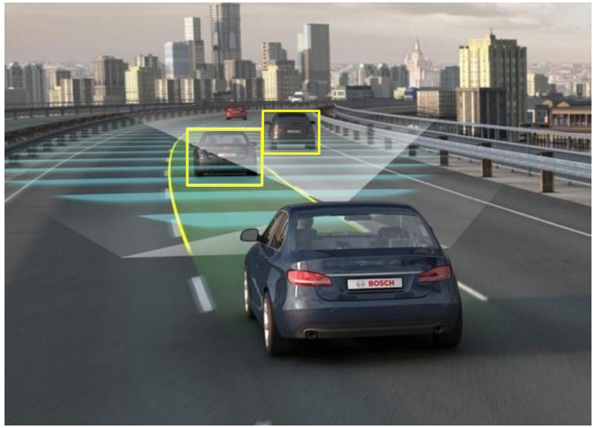
Platform Providers

GPU cluster: Infrastructure for Deep Learning applications

Data sets
for training and validation



GPU Cluster
to accelerate model training



Inference
Application of models
to unknown (e.g. live) data

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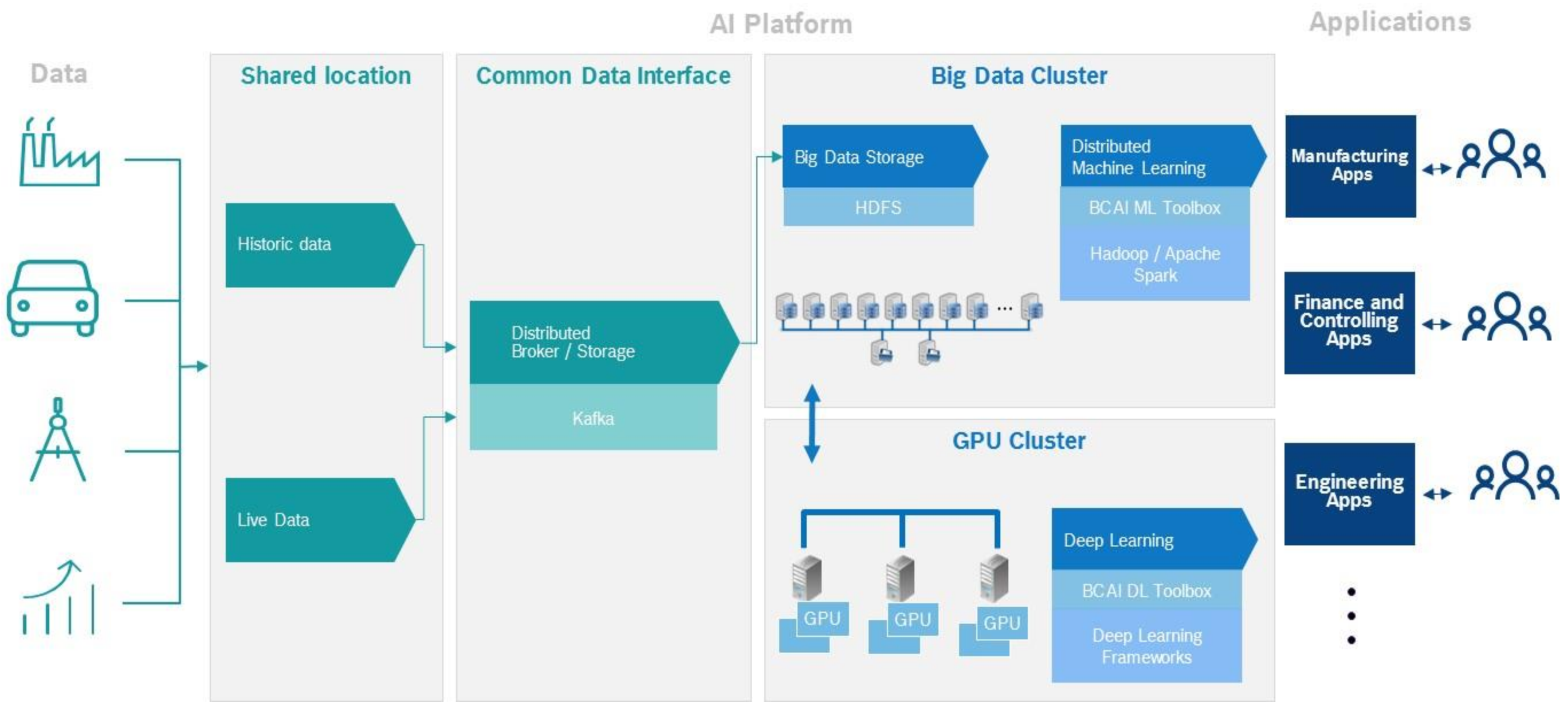
Platform Providers

AI platform: Bring key ingredients together to scale AI at Bosch



BCAI platform provides framework to accelerate AI deployment in BUs

- ✓ Adjacent, curated data sets speed up AI development and enable cross domain use cases
- ✓ Access for BU data scientists to state-of-the-art AI tools and Big data infrastructure minimizes lead time for own set-up and invest for BU.
- ✓ Domain-specific applications, pre-trained AI models unlock immediate value from data for BUs.

AI platform developed by integration of off-the-shelf components with in-house AI assets

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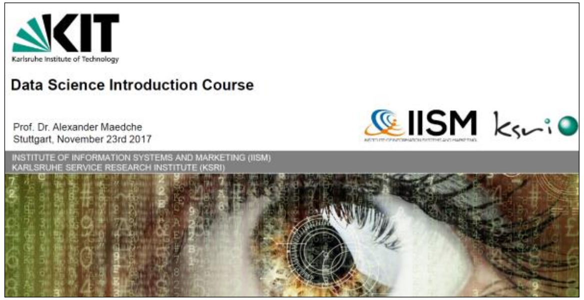
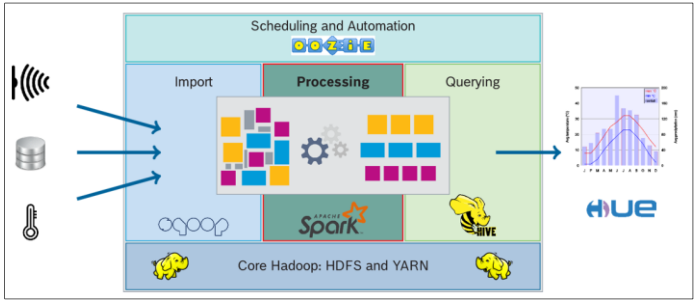
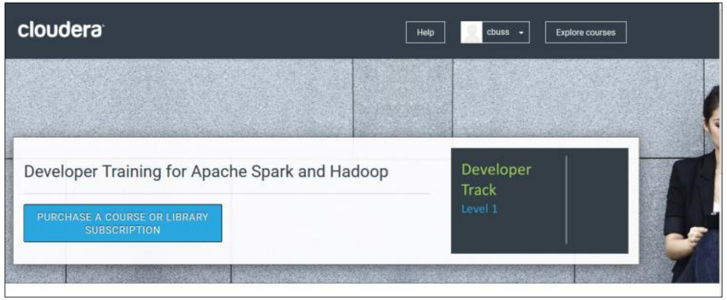
Roles, Training and Consulting
Big Data Analytics training portfolio



[IT-BD-120] Intro to Data Science



[IT-BD-110] Hadoop Hands-On Tutorial



[IT-BD-210-A] Hadoop and Spark Developer

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IMPLEMENTATION–
DATA-DRIVEN MINDSET

Data-Driven Mindset
Example: Data-driven mindset at Amazon

- Everything that can be **measured**, is measured: web design, product features, HR, finance, operations processes …
  - Example: impact of website load times on sales
- Prove the opportunities of a new idea with a **live test** and **result data**
- Everyone, regardless of seniority, has **access to data** and tools to test their ideas and intuitions

Source: https://www.entrepreneur.com/article/237326

Direct access to data and computing capabilites are of fundamental importance.

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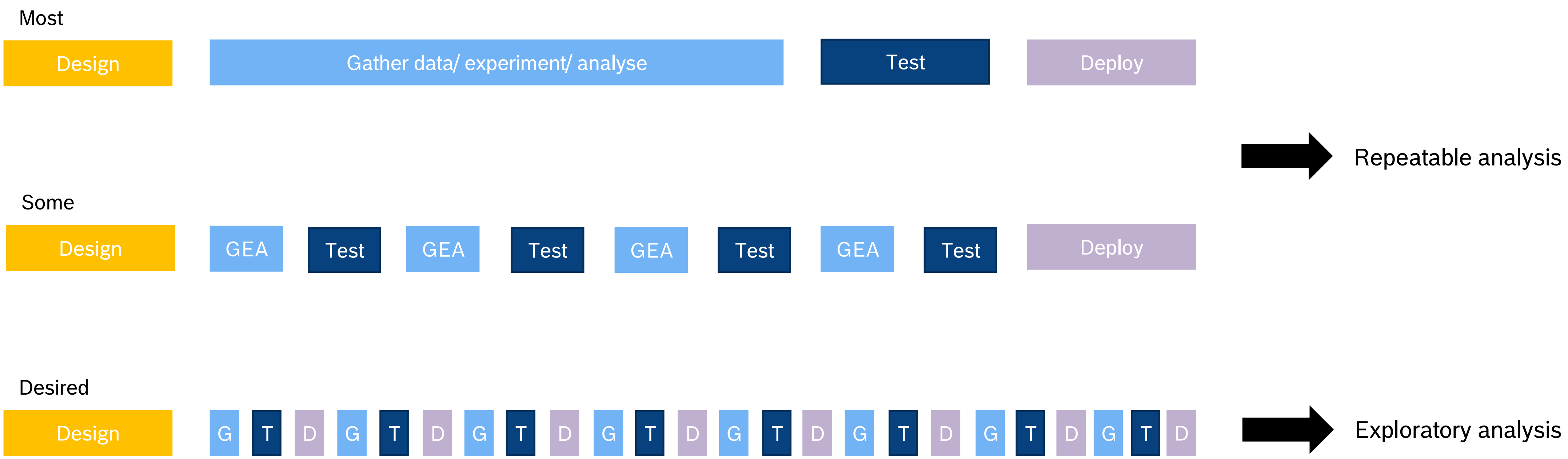
Data-Driven Mindset
Data worker process



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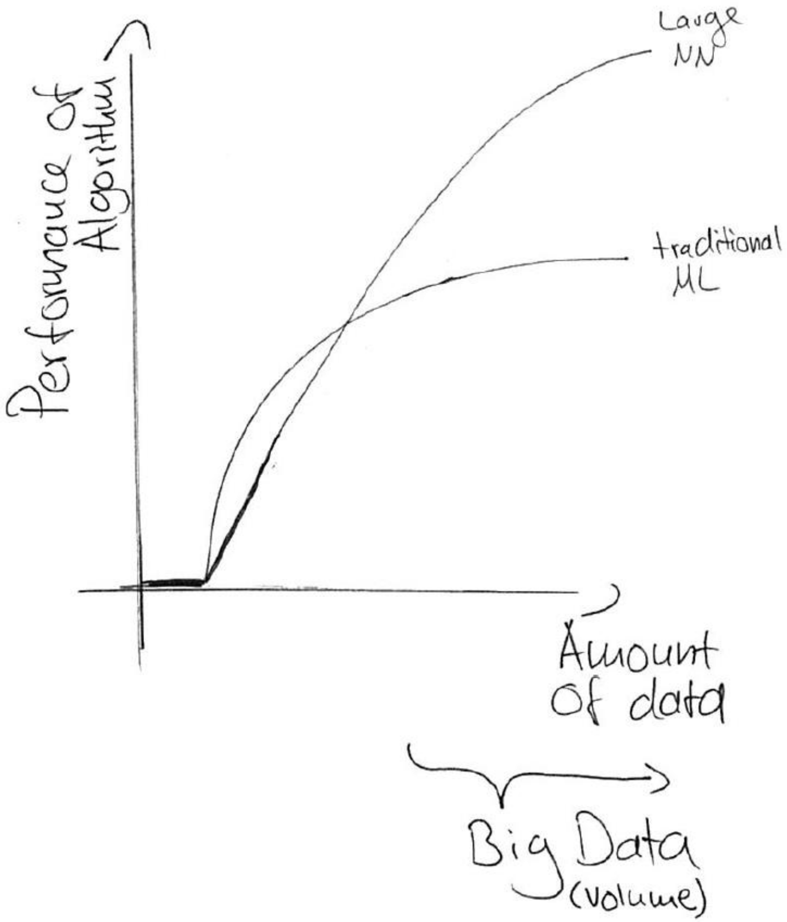
Data-Driven Mindset
The value of data



Not only algorithms **win the game** but also data.

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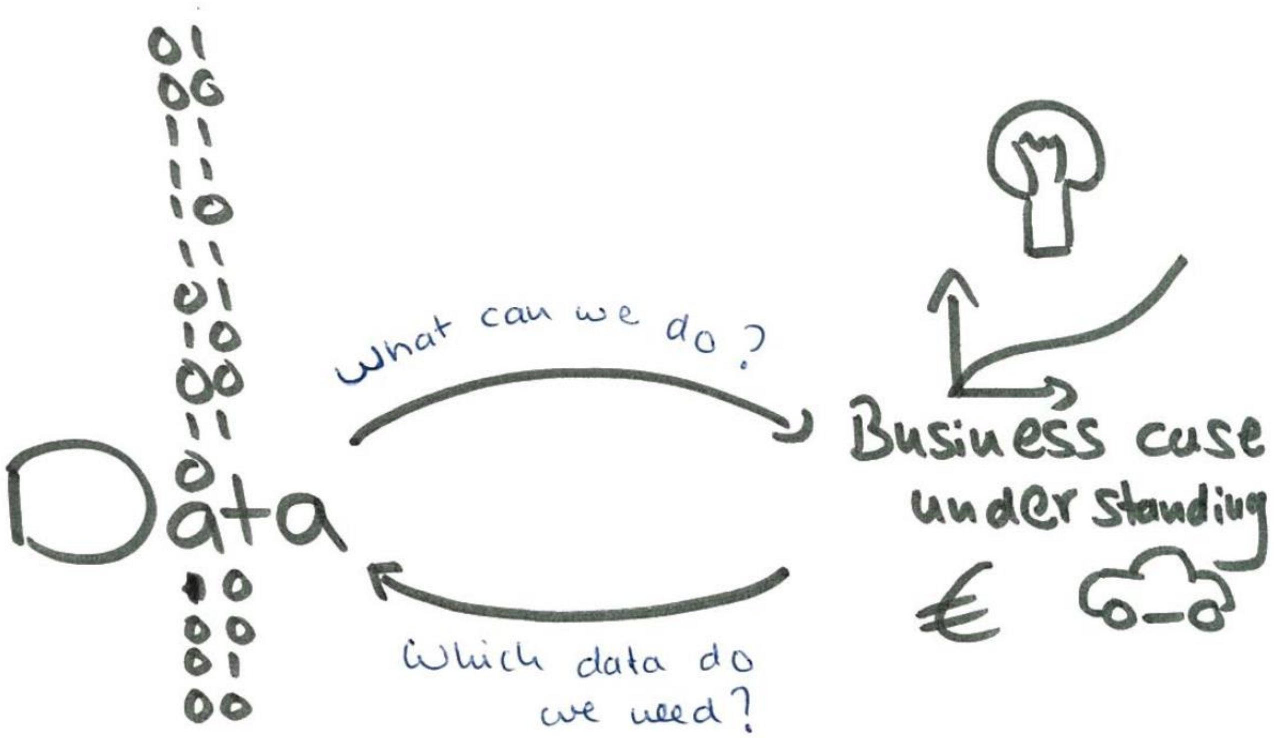
Data-Driven Mindset
What is first: data or the business case?



Data first: collecting data **early** is the start of **data strategy**.

Surely data can be collected before a fully defined business case. The earlier you start, the better.

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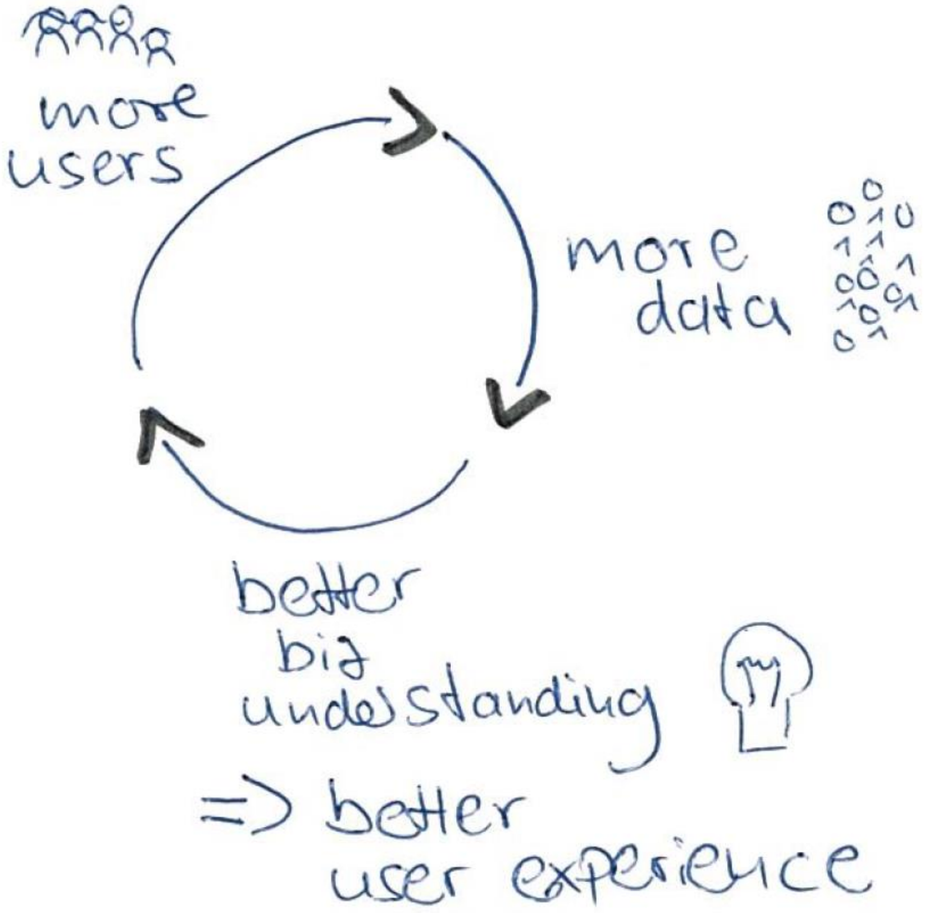
Data-Driven Mindset

The positive data feedback loop / data advantage



Data is the defensible barrier in data-driven business.

It may lead to a continuous self-enhancing improvement cycle.

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Data-Driven Mindset
Sensors: the data approach to vision ...

- Software defined camera with 16 lenses
- 10 pictures per lens at once from **small inexpensive photo sensors**
- Result are higher-quality, higher-resolution, and 3D pictures for a **fraction of the cost** of sophisticated sensors and lenses
- **51 Megapixel image** including depth map
- Possibly can be used instead of LiDAR and for smartphones
- Valuated with 147M$ in 2017

Light L16

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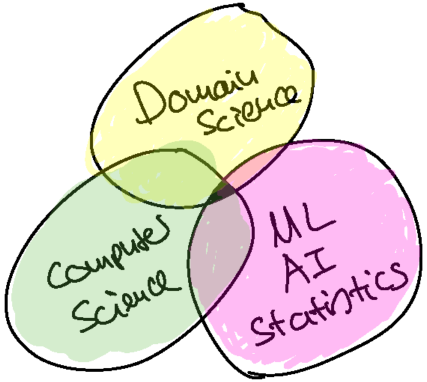
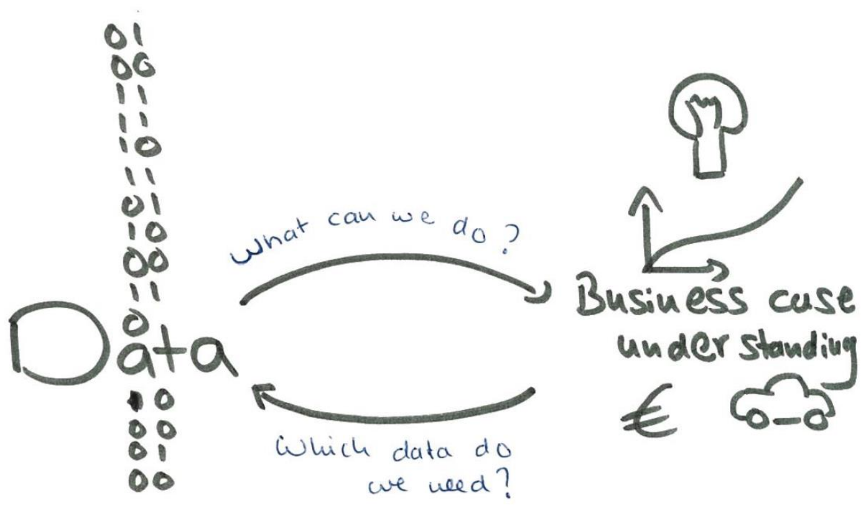
CLOSING

Retrospective
Closing remarks

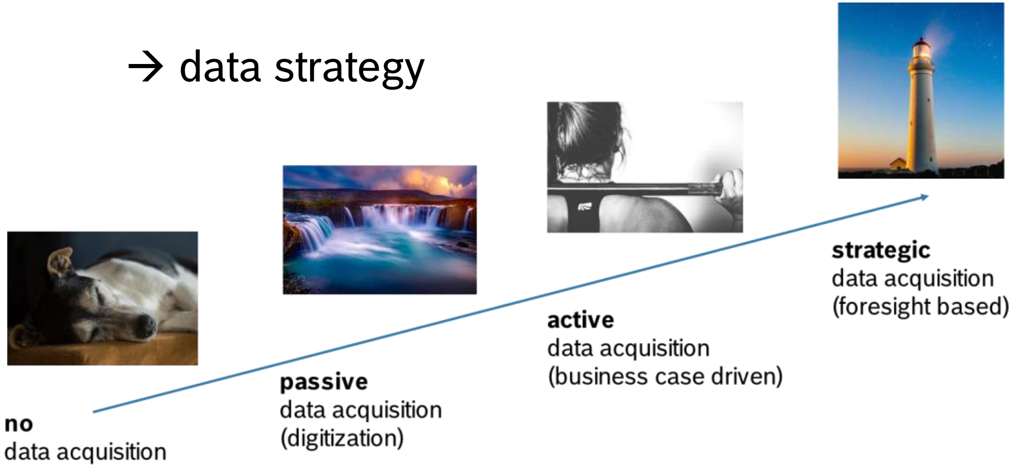
Data as an asset becomes more and more important!





→ competences in data science, data engineering, domain

→ data strategy



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Retrospective
Closing remarks

AI is neither a panacea nor work of the devil – it is a useful toolbox!

There are almost endless new possibilities to apply the new methods and technologies!

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Retrospective
Closing remarks

Bosch is in a very good position to be successful in data-driven innovations, too!

Start your journey and contact us any time with your questions, ideas, project proposals ...

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INTERACTIVE SESSION

Data-driven problem finding and solving

Objectives and scope

Introduction (5 min)

⇩ 3 groups

Idea brainstorming (10 min)

⇩ Discuss on ideas

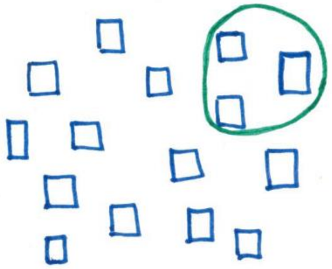
Decide on one idea (5 min)

⇩ Working on one idea

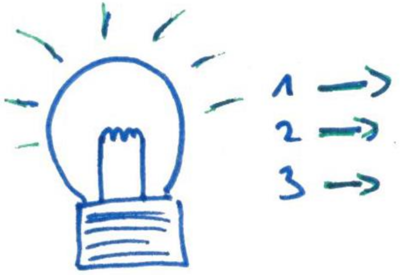
Detailed Solution (20 min)

⇩ Define further steps

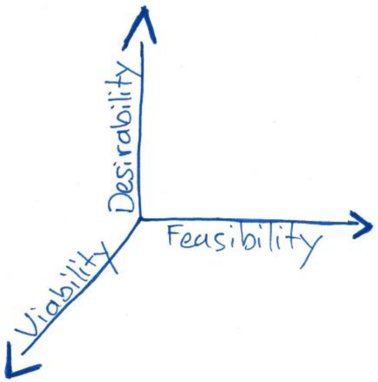
Final Presentation and Discussion (20 min)



Frame the challenge



Envision solutions



Formulate solutions

Decide on further actions

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Data-driven problem finding and solving (Online Version)

Objectives and scope

Introduction (5 min)

⇩ Everyone alone

Idea brainstorming (10 min)

⇩ Gather in 2-3 groups

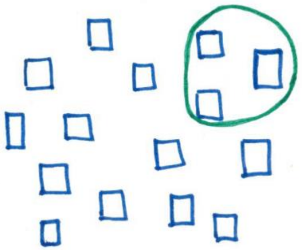
Discuss and decide on one idea (10 min)

⇩ Working on one idea

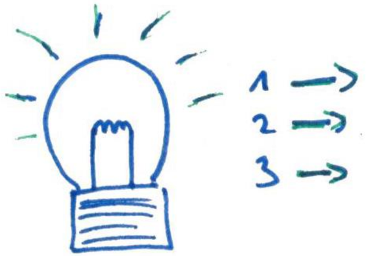
Detailed Solution (20 min)

⇩ Define further steps

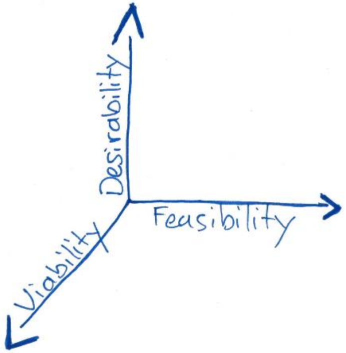
Final Presentation and Discussion (15 min)



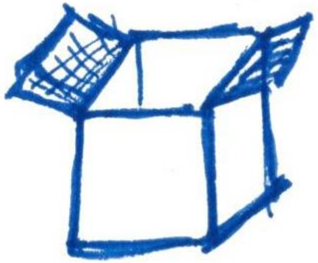
Frame the challenge



Envision solutions



Formulate solutions



Decide on further actions

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Data-driven problem finding and solving
Potential domains and dimensions

Frame the challenge

Envision solutions

Formulate solutions

Decide on further actions

Engineering

Example: Designing for data (capacity, data transfer, frequency, ...)?

Manufacturing

Example: Using sensors for early scrap reduction?

Field/Aftersales

Example: Reliability and revenue using predictive maintenance?

4 Dimensions: Product – Process – People – Profit

Potential interfaces and implications for other groups?

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