

Exam Preparation and Summary of Topics  
Introduction to Artificial Intelligence S. 5 Bachelor WS21/22  
h\_da Darmstadt

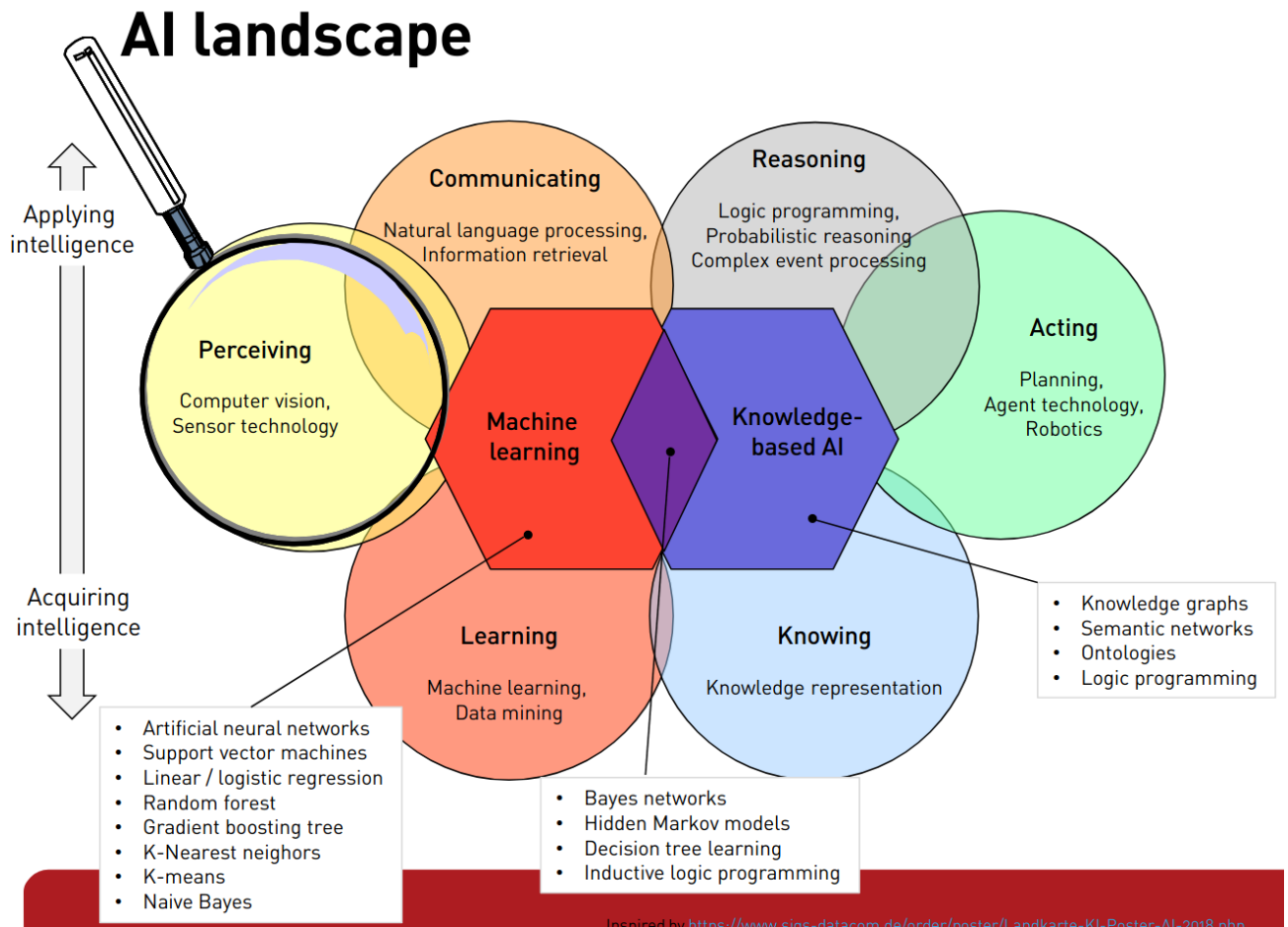
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February 23, 2022

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## 1 Regions of AI:



## 2 Machine Learning

### 2.1 Definition

Machine learning is the approach of generating a model based on inputs (training) and using it for making predictions (productive application) instead of programming instructions explicitly. It is therefore a data-driven approach to finding solutions to problems.

### 2.2 Examples of ML tasks

- Spam Filter: Classify emails as spam and not spam
- Stock market analysis: Make recommendations on buying or selling stocks
- Loyal Customer Detection: Given Data about a customer, classify him/her as loyal or non-loyal customer for the future

### 2.3 Categories of ML tasks

- Supervised Learning
  - Classification
  - Regression
- Unsupervised Learning

- Clustering
- Feature selection
- Feature extraction
- Reinforcement Learning: Try and error mit nach Belohnungsprinzip

### 2.3.1 Preproccession

- Extracting relevant columns →
  - Faster learning process
  - better results
- Filling missing values
  - Deleting rows with missing values
  - Mean
  - Median
  - Use Algorithm that supports missing values

### 2.3.2 Error functions

- Mean absolute error (MAE)
- Mean squared error (MSE)
- Rooted MSE (RMSE)

### 2.3.3 Metrics

#### Accuracy

Accuracy answers the question "What is the probability that a predicition is correct?".

$$Acc = \frac{TP + TN}{TP + TN + FP + FN}$$

It is only good, if the real distribution of positive and negatives in the data is close to symmetric.

#### Precision

Precision answers the question "If we classify something as positive, how probable is it that it is actually positive?".

$$Precision = \frac{TP}{TP + FP}$$

#### Recall

Recall a.k.a. sensitivity answers the question "If a sample is positive, what is the probability we also label it as positive?".

$$Recall = \frac{TP}{TP + FN}$$

## F1 Score

The F1-score divides the true positives by the sum of the true positives and the mean of the false positives and false negatives. This a high F1-score requires the model to make not few false predictions in either direction. Therefore F1-score is better than accuracy if the real distribution of positive and negative values in the dataset is uneven.

$$F1 = 2 \cdot \frac{Precision \cdot Recall}{Precision + Recall} = \frac{TP}{TP + \frac{1}{2} \cdot (FP + FN)}$$

## Validation

### 2.3.4 K-fold cross validation

- split dataset into k subsets
- Perform k trainings on k-1 subsets and use the one remaining set for validation such that each subset has been used for validation exactly once
- calculate the mean of all k iterations

## 3 Knowledge Representation

### 3.1 Knowledge Graphs

A knowledge graph a.k.a. semantic net or ontology is a data structure linking different entities to each other. A common type of knowledge graph is one that consists of triples [subject, predicate, object]. Linked Open Data (LOD) refers to all publicly available data in the internet that can be found using URIs and HTTP.

RDF (Resource Description Framework) is a system for describing such data in nets of triples. SPARQL is a query language that can be used to retrieve data from a database which is using the RDF format. A popular free SPARQL server is Apache Jena Fuseki.

In the following we can see how to extract tuples (name, country) of city names and country names for which the city is the capital of the country and the country is located in Africa. `es` is the prefix for all classes used in this example. `cityname`, `isCapitalOf`, `country` and `isInContinent` are classes of predicates. All identifiers starting with a question mark are variables.

```
1 PREFIX ex: <http://example.com/exampleOntology#>
2 SELECT ?capital
3        ?country
4 WHERE
5 {
6     # match every city here, assign them to variable ?x and
7     # their name and the countries it is a capital for to
8     # variables ?capital and ?y
9     ?x ex:cityname      ?capital    ;
10      ex:isCapitalOf    ?y          .
11     # For all those countries which have capitals,
12     # filter those who are in located in Africa and extract their names
13     ?y ex:countryname  ?country    ;
14      ex:isInContinent ex:Africa    .
15 }
```

## 4 Natural Language Processing (NLP)

### 4.1 Areas of NLP

- **Information retrieval:** Retrieving relevant information from documents e.g. by using SPARQL-queries.

- **Text classification**
- **Information Extraction:** Building knowledge graphs from natural language texts
- **Question Answering:** Answering natural language questions like "What is the weather today?"
- **Machine Translation:** translating a text into a different language
- **Text Generation:** Generate natural language texts e.g. answers to natural language questions for a voice assistant.

## 4.2 SpaCy - NLP library

- **Tokenization:** Segmenting a text into single words punctuation marks etc.
- **Part-of-speech (POS) tagging:** Assigning word types to tokens like verb, noun, adjective...
- **Dependency Parsing:** Assigning dependency syntactic labels describing the relations between tokens e.g. subject, object, predicate
- **Lemmatization:** Finding the base form of words e.g. drives *rightarrow* drive
- **Sentence Boundary Detection (SBD):** Splitting text by sentences. This is not Trivial as full stops can also appear mid-sentence e.g. when writing acronyms.
- **Named Entity Recognition (NER):** Labelling real world objects like persons, companies or locations
- **Entity Linking (EL):** Linking tokens or groups of tokens in a text to unambiguous entries in a knowledge base e.g. a knowledge graph.
- **Similarity:** Calculating similarity of words or text spans
- **Classification:** Assigning categories or labels to a whole document or parts of a document
- **Rule-based Matching:** Finding sequences of tokens based on their linguistic annotations similar to regular expressions.
- **Training:** Updating and improving a statistical model's prediction
- **Serialization:** Saving objects to files or byte strings

### A simple idea for implementing Question Answering with SpaCy:

If we already have a database with questions and their answers we can answer new questions by returning the answer to the most similar question in our database.

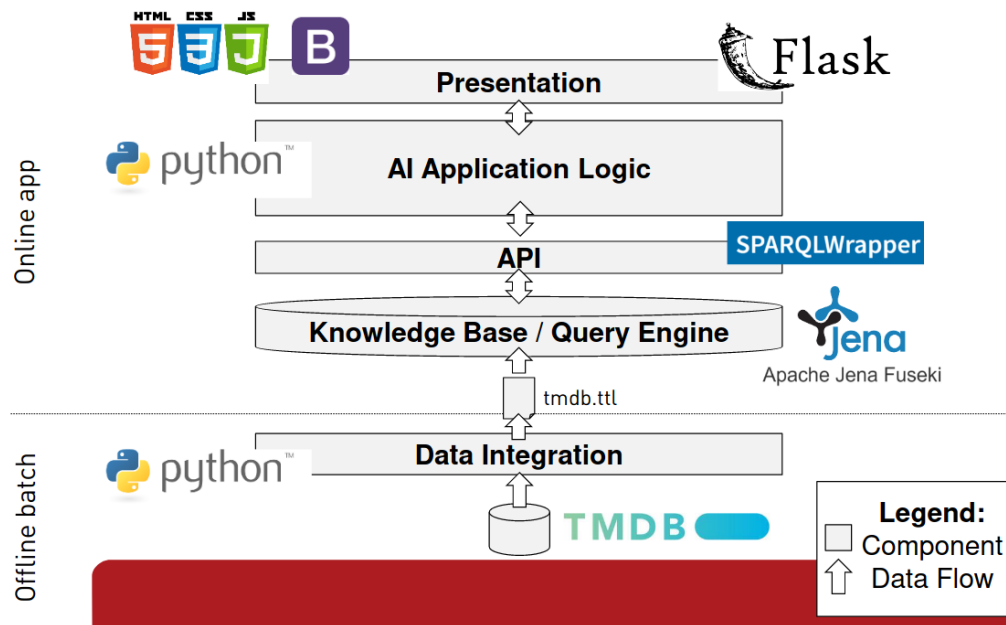
## 5 Computer Vision

### 5.1 Common Types of Applications

- **Optical Character Recognition (OCR):**  
Input: Image of handwritten or typewritten text.  
Output: Text Document
  - Digitalization of documents
  - Scanning addresses on letters
  - Evaluating forms
- **Face Recognition:**  
Input: Image  
Output: Information about face: position and maybe building on top of that further information in form of classification
  - Autotagging camera images

- Image search
- Detecting people on security cameras
- **Medical Applications:** Detecting anomalies in CT/ MRI / Ultrasound images
- **Industrial / Agricultural Applications:**
  - Sorting fruits in agriculture
  - Quality management
  - Automation of manufacturing process using robots with computer vision technologies
- **Military Applications:**
  - Detection of enemies
  - Missile guidance
  - Autonomous drones and vehicles
- **Automotive Applications:**
  - Collision warning
  - Parking aid
  - Road sign detection
  - Autonomous driving
- **Cinema:**
  - Motion Capturing: translating real world motion into the motions of animated movie characters

## 6 AI application development



In the following we will list some common tools for application development:

- **Flask:** Micro web framework written in Python.

- **Jinja:** Web template engine for Python. Similar to Django but provides Python-like expressions while ensuring that templates are evaluated in a sandbox. In essence it evaluates HTML with embedded Python.
- **Bootstrap:** CSS-Framework mit SCC und HTML Gestaltungsvorlagen, die durch anhängen von Tags and das HTML des Benutzers verwendet werden können.

## 7 Ethical Aspects of AI