Exam Preparation and Summary of Topics
Introduction to Artificial Intelligence S. 5 Bachelor WS21/22
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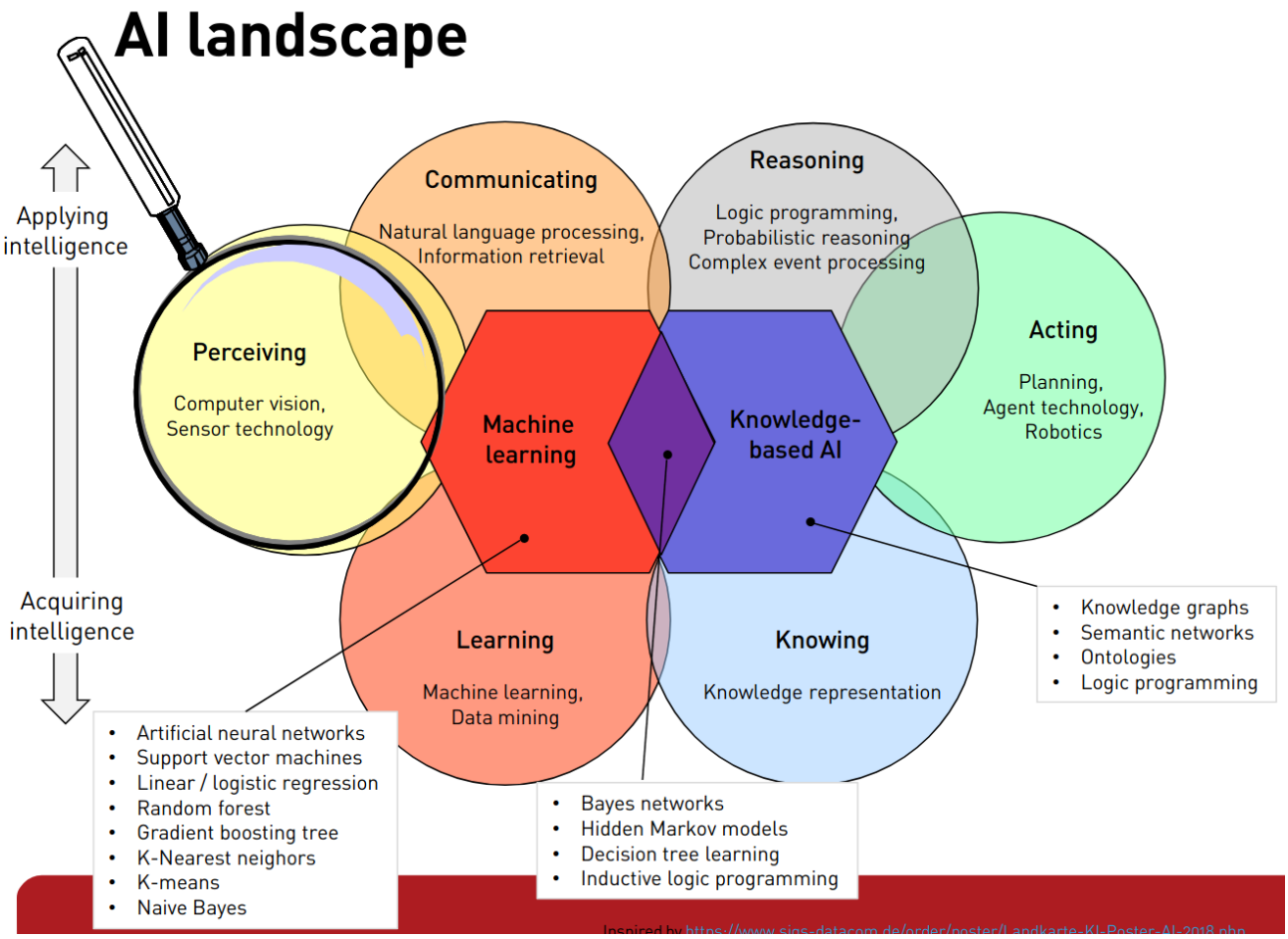
1 Regions of AI:



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 Preprocession

- 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 prediciton 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.

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

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 todoay?"
- **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.

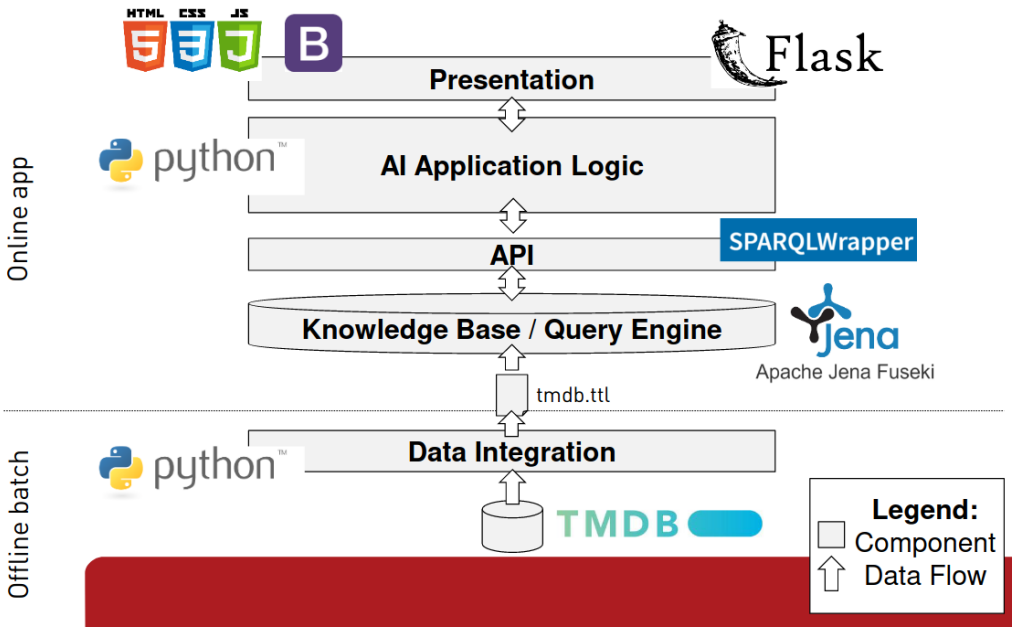
5 Computer Vision

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

Hype

There was a hype around artificial intelligence which lead to exaggerated opinions and crazy movies:

- Marvin Minsky 1970: "Within 10 years computers won't even keep us as pets."
- Ray Kurzweil 2005: "Artificial Intelligence will reach human levels by around 2029. Follow that out further to, say, 2045 we will have multiplied the intelligence the human biological machine intelligence of our civilization a billion-fold."

Reality

In reality AI applications are ambiguous and used in a lot of day to day situations. However, they are specialized in certain areas and are not even close to being as intelligent as humans.

Cyborg - Technological enhancement of human body

- Neil Harbisson with an Antenna allowing him to perceive colors that go beyond human perception.
- Amanda Kitts with an arm prosthesis
- Hearing aid
- Heart pacemaker

Industry 4.0 replacing human labor

In fact there have been multiple industrial revolutions before. Now we are at the point that machine learning applications are capable of replacing some human labor. This has positive and negative effects on society. People will loose their jobs. But this also means that there is less labor needed, which is a good thing and can lead to an overall increasing standard of living.

Biased Machine Learning

Machine Learning models can not be better than the data they are trained on. That means if we have biased data supporting stereotypes, then we will face the problem that machine learning models decisions are also driven by those stereotypes.

Decision Making

Is it ethically correct to let machine learning models take decisions even if it has been shown that the divisions are more accurate than human decisions in some cases?
Examples are:

- Autonomous driving and accidents
- Choosing employees for a company based on features of the applicants
- High frequency trading

8 CEP - Complex Event Processing

Complex Event Processing ist ein Themengebiet der Informatik, das sich mit der Erkennung, Analyse und Verarbeitung voneinander abhängiger Ereignisse beschäftigt.

8.1 CEP Application Examples

- **Fraud Detection:**
  Input: Stream of Credit Card Transactions
  Output: Fraud alert triggering a human interview
- **Predictive Maintenance:**
  Input: Stream of Sensor inputs from machinery in factory
  Analysis: Check for patterns that indicate deterioration of machine e.g. vibration
  Output: Warning triggering soon replacement of the machine part
- **Logistics:**
  Input: Stream of RFID signals
  Analysis: Check for conditions that require certain actions
  Output: Trigger actions such as inform logistic partners, inform customers about delivery, alert
- **Stock Market Trading:**
  Input: Stream of stock market data
  Output: Sell or buy decision

8.2 Terminology

Definition CEP

Processing streams of event data and deriving conclusions from them.

Definition Event

Something notable that happens in real life.

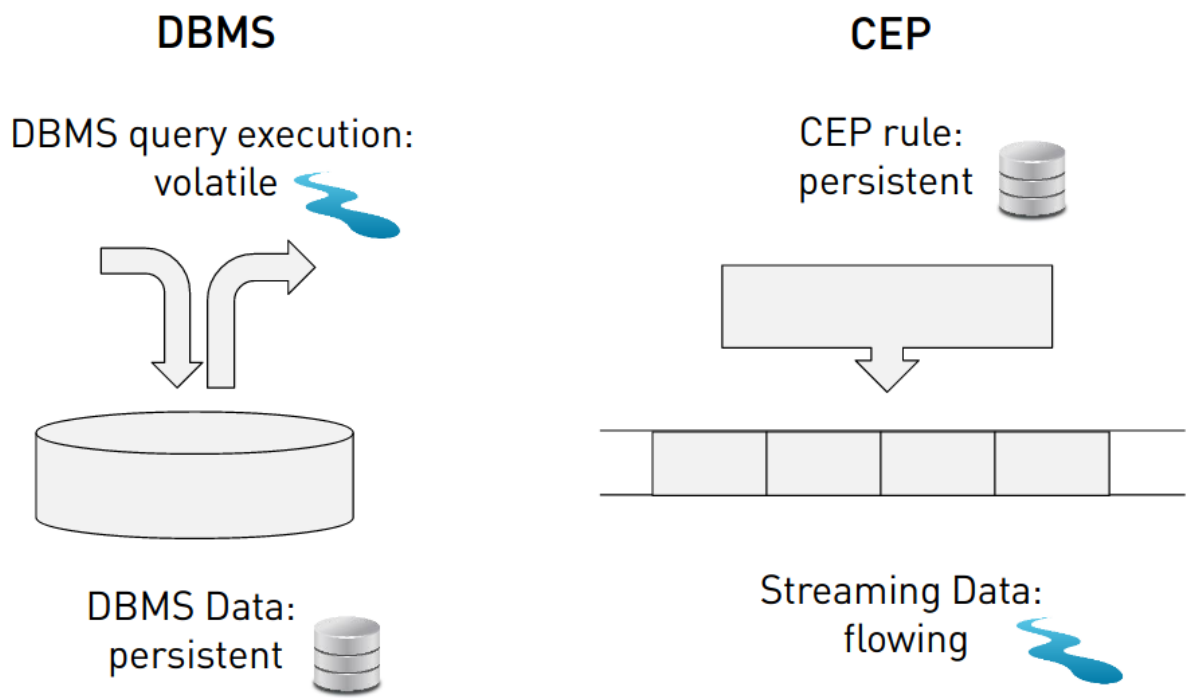
Definition Event Object

A data record representing a single event.

Event Type

Specifies the common structure for event objects such as their attributes and data types. Therefore it is a class and event objects are instances of it.

DBMS vs CEP



8.3 Sliding Window

A sliding window is a method for repeatedly capturing sequences of information from an event data stream from the near past. We define a window with duration/size n (captures all data in the last n seconds) and a windowing frequency m (captures the last n seconds every m seconds).

8.4 CEP Technology

- Apache Kafka
- Apache Flink
- Apache Spark
- Drools Fusion
- MS Azure Stream Analytics
- Oracle Stream Analytics
- SAG Apama
- SAP ESP
- TIBCO
- IBM WebSphere Business Events