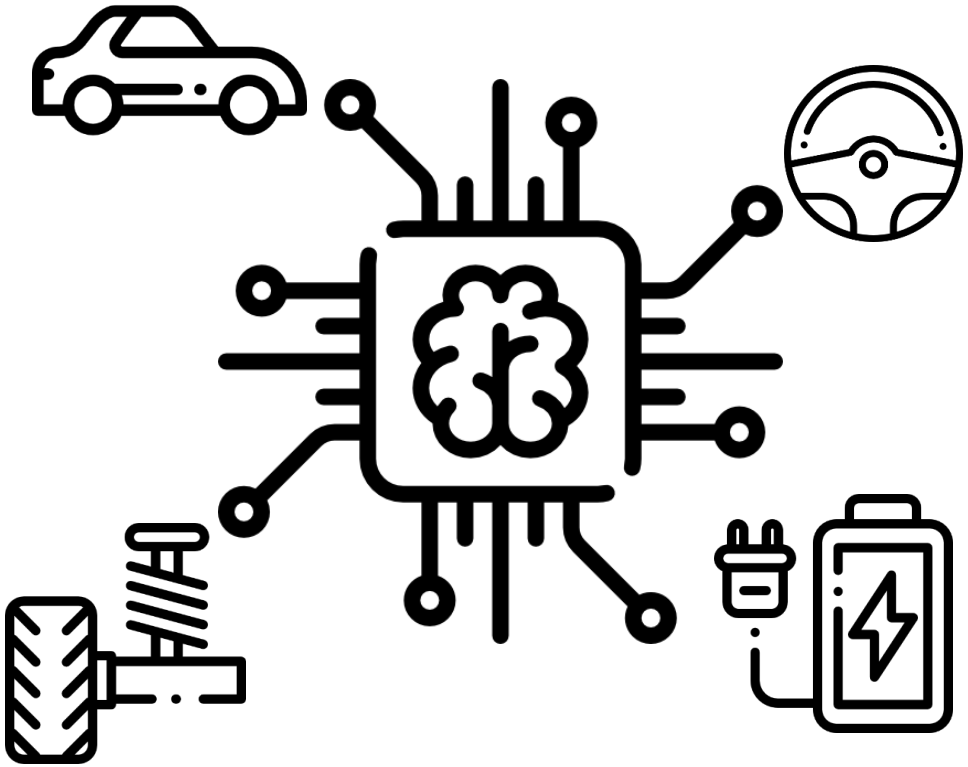
Institute of Automotive Technology
Faculty for Mechanical Engineering
Technical University of Munich

Artificial Intelligence in Automotive Technology

Maximilian Geißlinger / Fabian Netzler

Prof. Dr.-Ing. Markus Lienkamp



Lecture Overview

Lecture 16:15-17:45 | Practice 17:45-18:30	
1 Introduction: Artificial Intelligence	20.10.2022 – Maximilian Geißlinger
2 Perception	27.10.2022 – Sebastian Huber
3 Supervised Learning: Regression	03.11.2022 – Fabian Netzler
4 Supervised Learning: Classification	10.11.2022 – Andreas Schimpe
5 Unsupervised Learning: Clustering	17.11.2022 – Andreas Schimpe
6 Introduction: Artificial Neural Networks	24.11.2022 – Lennart Adenaw
7 Deep Neural Networks	08.12.2022 – Domagoj Majstorovic
8 Convolutional Neural Networks	15.12.2022 – Domagoj Majstorovic
9 Knowledge Graphs	12.01.2023 – Fabian Netzler
10 Recurrent Neural Networks	19.01.2023 – Matthias Rowold
11 Reinforcement Learning	26.01.2023 – Levent Ögretmen
12 AI-Development	02.02.2023 – Maximilian Geißlinger
13 Guest Lecture	09.02.2023 – driveblocks

General Information for the Exam

- The exam will be held on
  Wednesday, 08.03.2023, 14.15 – 15.45

- The exam will be held in various lecture rooms:
  - MI HS 1, Friedrich L. Bauer Hörsaal (5602.EG.001)
  - MW 2001 Rudolf-Diesel-Hörsaal (5510.02.001)

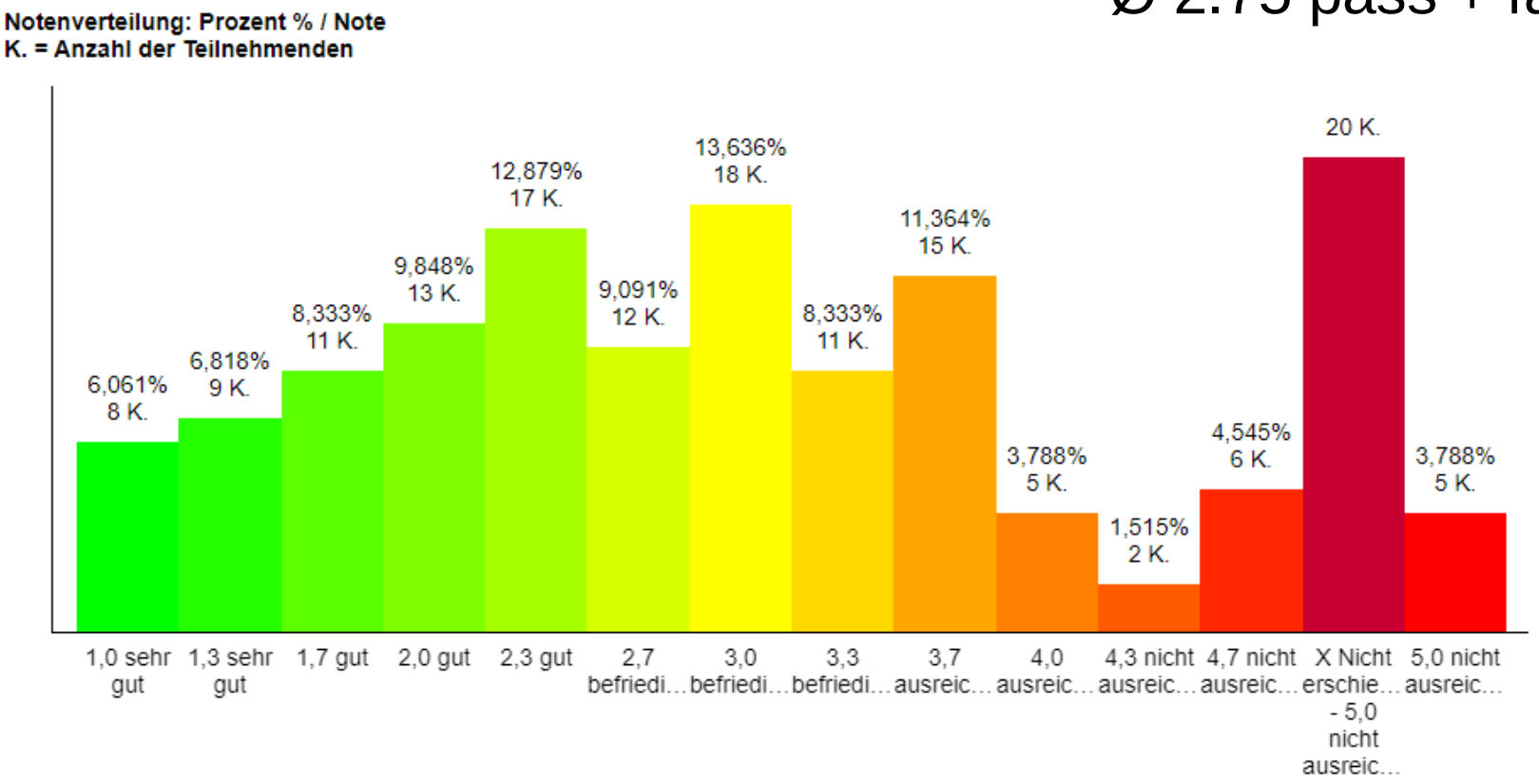
- The seat distribution will be published before
  Wednesday, 01.03.2023 via moodle

General Information for the Exam

Distribution of exam results WS 2021/2022

Ø 2.53 pass

Ø 2.75 pass + fail



Exam: Studying Advice

1. Have a close look at the **objectives** at the beginning of each lecture: Consider the required **depth of understanding**

2. Have a look at the **summary** at the end of each lecture

3. **Repeatable quiz:** Serves as a good exam preparation

4. Exemplary exam on moodle
   But be careful: topics may have changed over the years!

Exam: Style, Contents, Information

1. The majority of tasks in the exam is derived from **lecture documents** and **homework questions.** A small share of transfer questions can be expected

2. The exam consist of **knowledge questions**, **comprehension questions** and **application/analysis tasks** (calculator recommended)

3. **Standard** relationships and formulas should be known

4. We will **not ask** you to write or analyze any Python3 code in the exam

5. Exam has overhead: you do not need to answer all questions for the best grade

Exam: Things you do not need to know

- Any historic dates or information
- Knowledge regarding specific software (packages) e.g., "What is the difference between Matlab and OpenCV,‘
- Python Code
- Guest lecture contents

Example Questions – Knowledge

a) Wofür steht die Abkürzung „AI“? *(English translation: What does the abbreviation “AI” stand for?)*

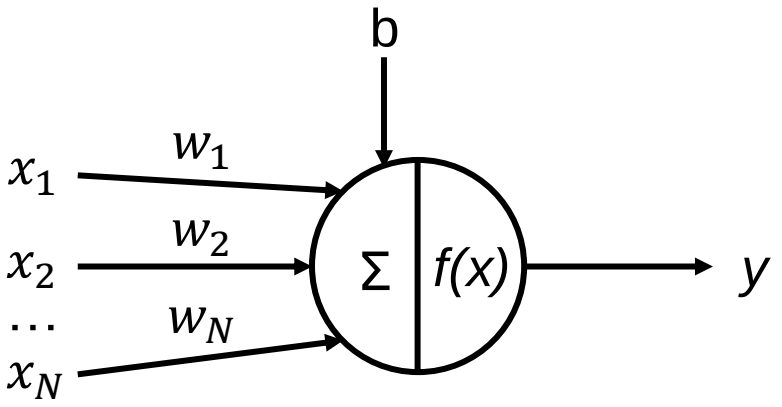
Gesamtpunktzahl: 1 Punkte

„Artifical Intelligence“

- Richtige Nennung des Begriffs (1 P)

Example Questions – Knowledge / Comprehension

a) Skizzieren Sie den Aufbau eines künstlichen Neurons mit allen wesentlichen Elementen. *(English translation: Draw the structure of an artificial neuron with all the essential elements.)*



Gesamtpunktzahl: 3 Punkte

- Ein Punkt für die Berücksichtigung von gewichteten Eingängen und Bias (1 P)
- Ein Punkt für die Summierung (1 P)
- Ein Punkt für die Aktivierungsfunktion mit Ausgang (1 P)

Example Questions – Comprehension / Analysis

a) Die rote Linie in der Grafik zeigt die Position eines Querschnitts, für den die zugehörige Intensitätsverteilung gegeben ist. Einige Positionen auf der Intensitätskurve sind mit Buchstaben markiert (A,B,C,D,E,F). Nennen Sie die Positionen aus der Menge A-F, an denen Sie **starke** Kanten erwarten können. *(English translation: The red line in the graph shows the position of a cross-section for which the corresponding intensity distribution is given. Some positions on the intensity curve are marked with letters (A,B,C,D,E,F). Name the positions from the set A-F where you can expect **strong** edges.)*

Example Questions – Comprehension / Analysis

Gesamtpunktzahl: 6 Punkte

Richtige Antwort: A, C, E (je 2 P)

→ Richtige Punkte sind an den stark fallenden/steigenden Flanken der Intensität zu erkennen

Example Questions – Analysis / Application

a) Sie haben ein Regressionsmodell erstellt und stellen fest, dass es einen Modellfehler enthält. Berechnen Sie mithilfe der gegebenen Abweichungen ($y_i - \hat{y}_i$) den mittleren L1-Verlust nach der in der Vorlesung angegebenen Formel. Geben Sie das Ergebnis mit zweistelliger Genauigkeit an. (*English Translation: You have created a regression model and find that it contains a model error. Using the given errors* ($y_i - \hat{y}_i$), *calculate the mean L1 loss with the formula given in the lecture. Specify the result with two-digit precision.)*

Datapoint	Error ($y_i - \hat{y}_i$)
i=1	+2.6
i=2	-2.7
i=3	-8.7
i=4	-6.3
i=5	+5.0

Example Questions – Analysis / Application

Formel:

$$L = \frac{1}{N} \sum_{i=1}^{N} | \, y_i - \hat{y}_i \, |$$

Einsetzen (N=5): $L = \frac{1}{5} \cdot (|+2.6| + |-2.7| + |-8.7| + |-6.3| + |+5.0|)$

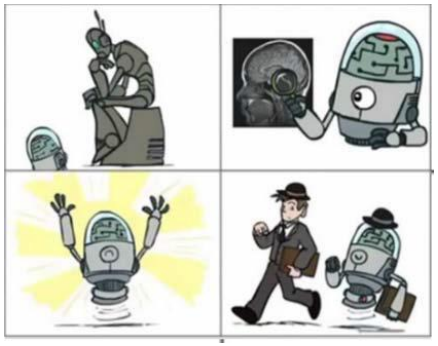
L1-Verlust = 5.06

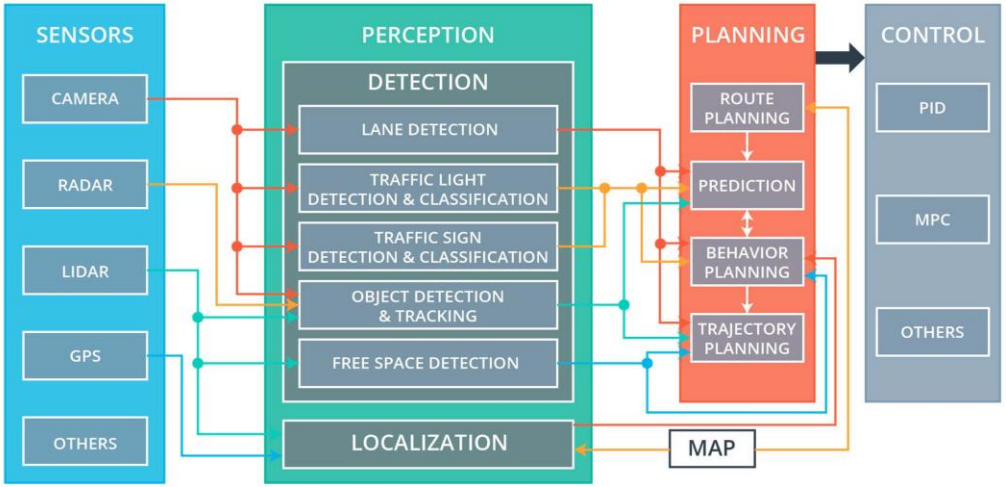
Gesamtpunktzahl: 3 Punkte

- Richtige Angabe der Formel (2P)
- Richtiges Ergebnis (1P)

Summary – Lecture 1: Introduction to AI

- What is intelligence?
- What is artificial intelligence?
- 9 AI sub-problems
- AI applications
- Autonomous driving

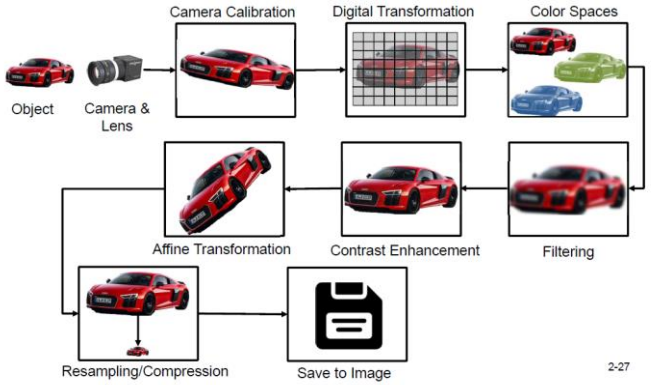




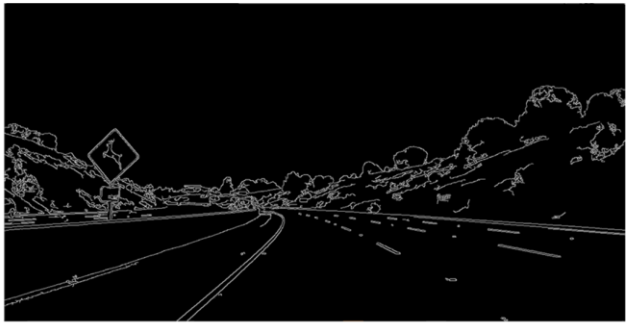
Summary – Lecture 2: Perception

- What is Computer Vision and why do we need it?

- Image processing:
  - Color Spaces
  - Filtering
  - Contrast Enhancement
  - Resampling



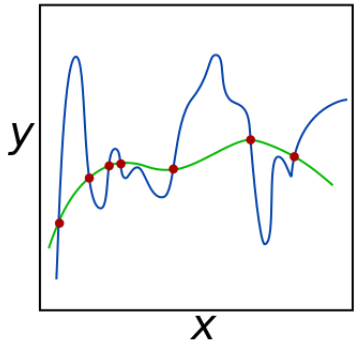
- Feature Extraction:
  - Canny Edge Detection
  - Hough Transform

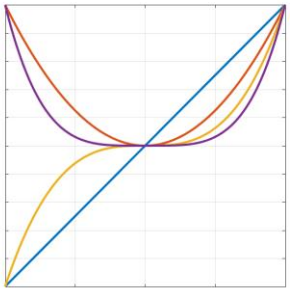


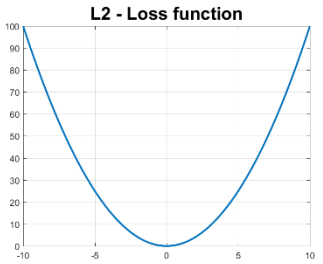
- Video Analysis

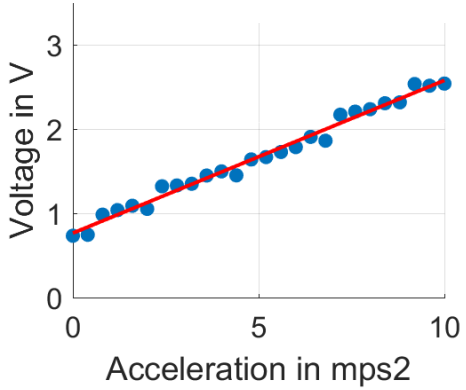
Summary – Lecture 3: Regression

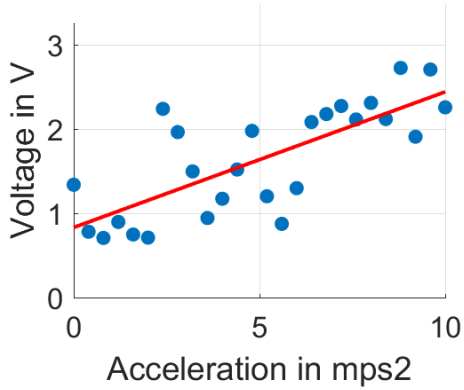
- Supervised learning
- Prediction of continuous outcome
- Linear basis function model
- Loss functions
- Regularization





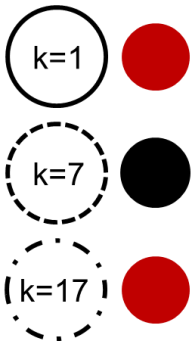


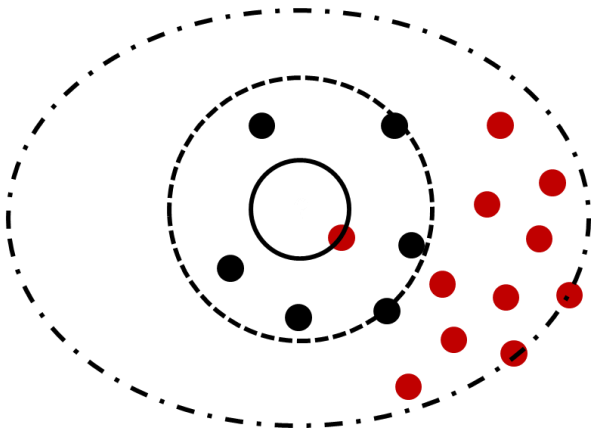


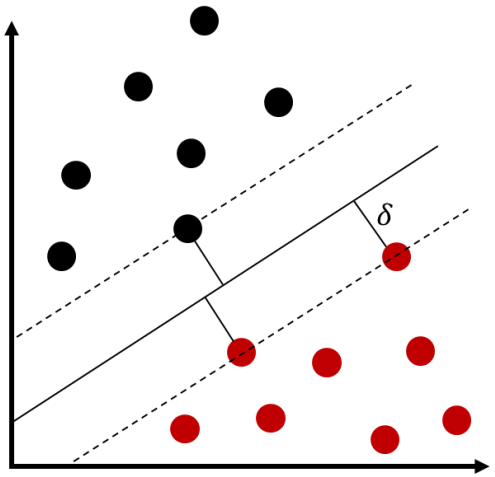


Summary – Lecture 4: Classification

- Supervised learning
- Prediction of discrete outcome
- KPIs, e.g., Recall / Precision / Specifity
- Methods, e.g., kNN classifier and Support Vector Machine

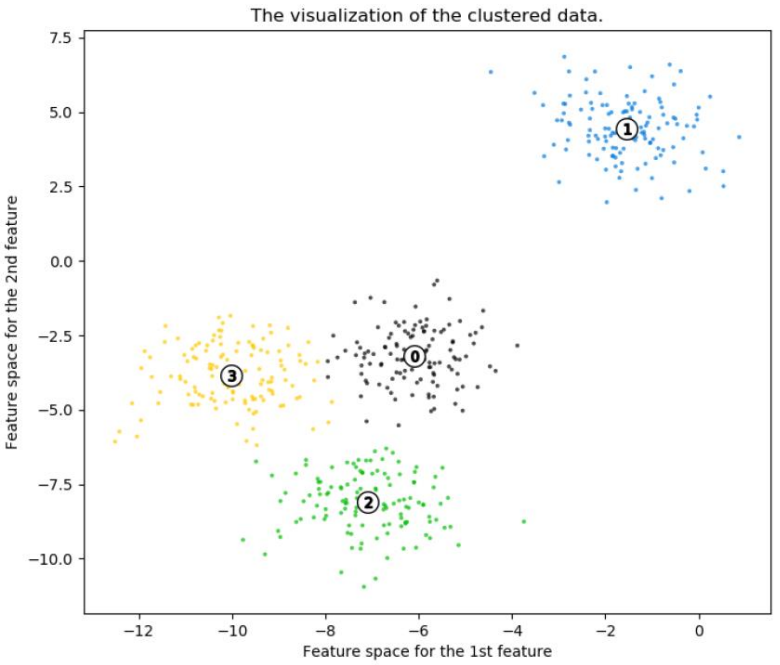


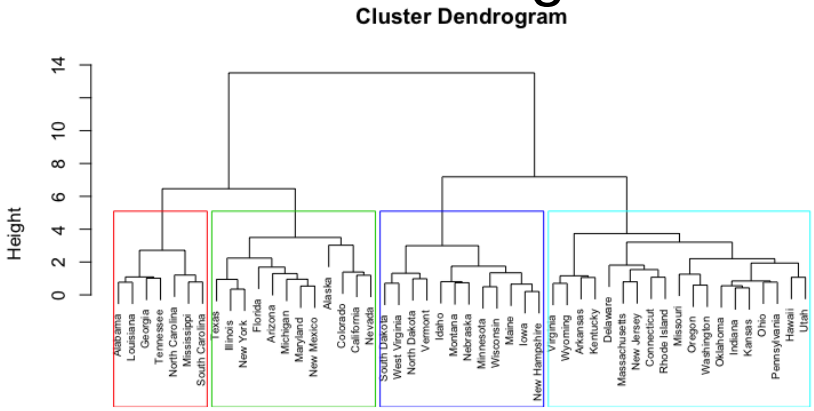




Summary – Lecture 5: Clustering

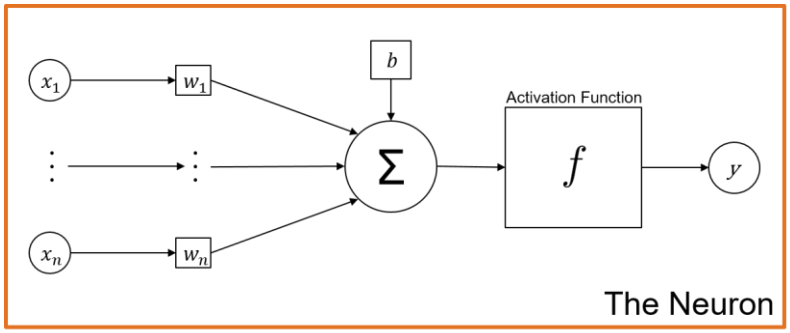
- Unsupervised learning
- Prediction of discrete outcome
- K-means
- Hierarchical clustering

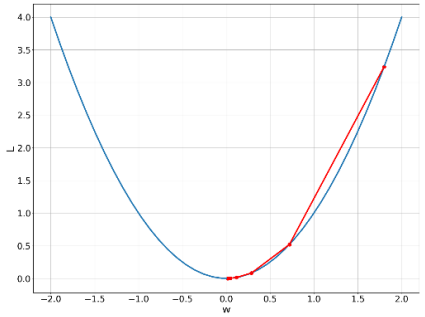


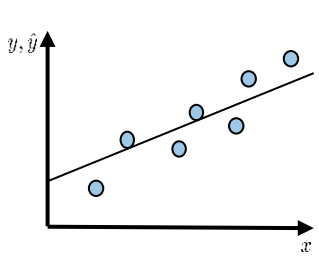


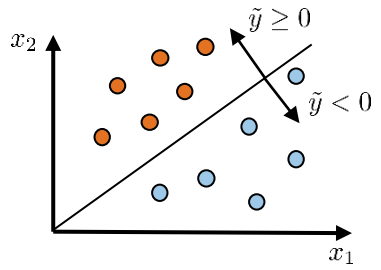
Summary – Lecture 6: Neural Networks

- From linear regression to artificial neurons
- Gradient descent
- Activation function
- Regression / classification
- Difference single neuron / multilayer networks



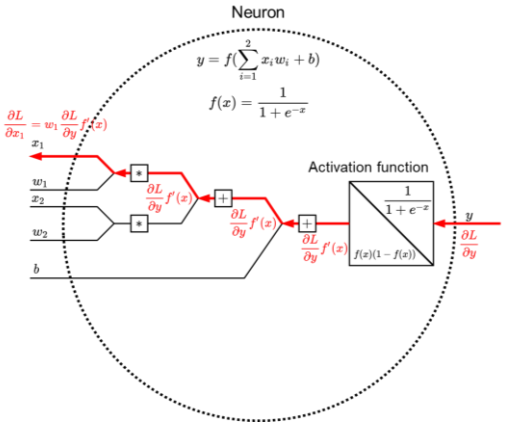


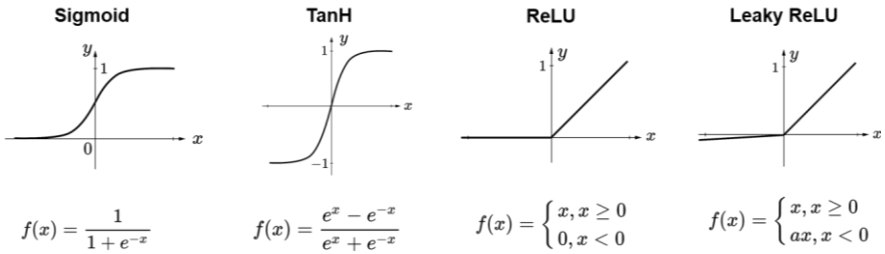


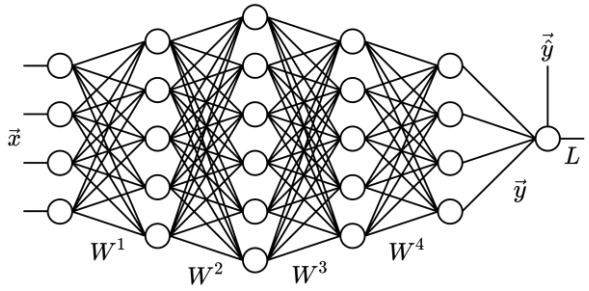


Summary – Lecture 7: Deep Neural Networks

- Backpropagation
- Activation functions
- Fully-connected layers
- Batches
- Weight initialization

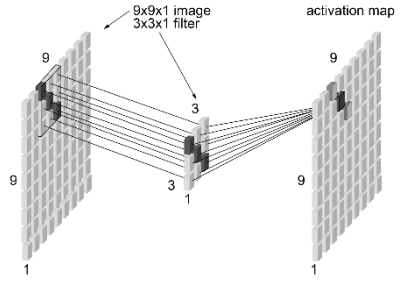


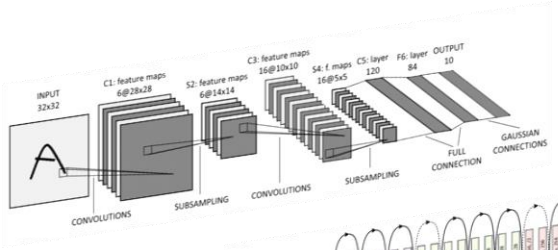


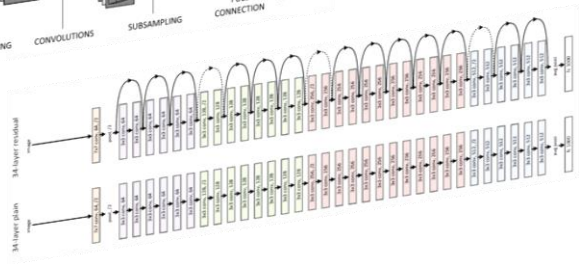


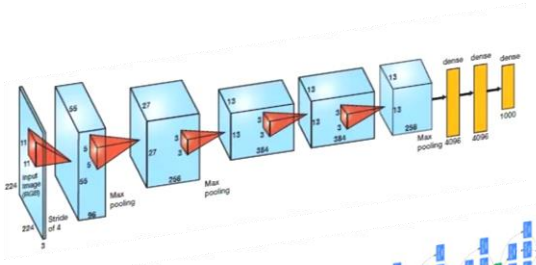
Summary – Lecture 8: Convolutional Neural Networks

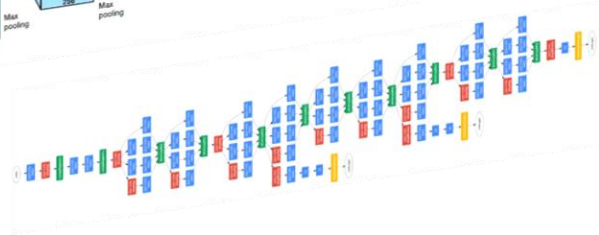
- Convolution
- CNN-specific Hyperparameters
- (Un-)Pooling
- Architectures, applications and performance





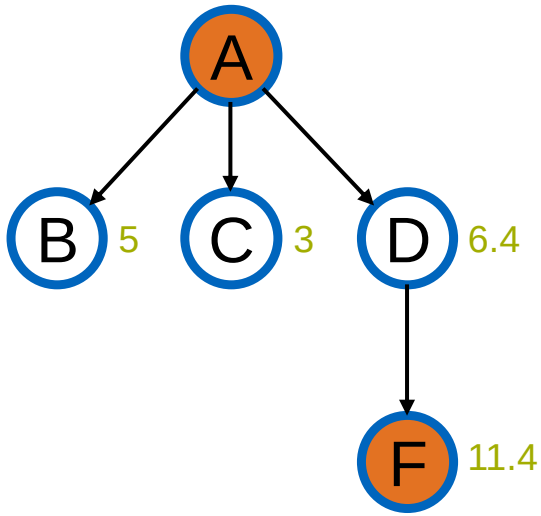


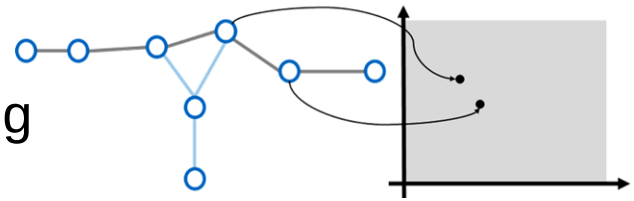


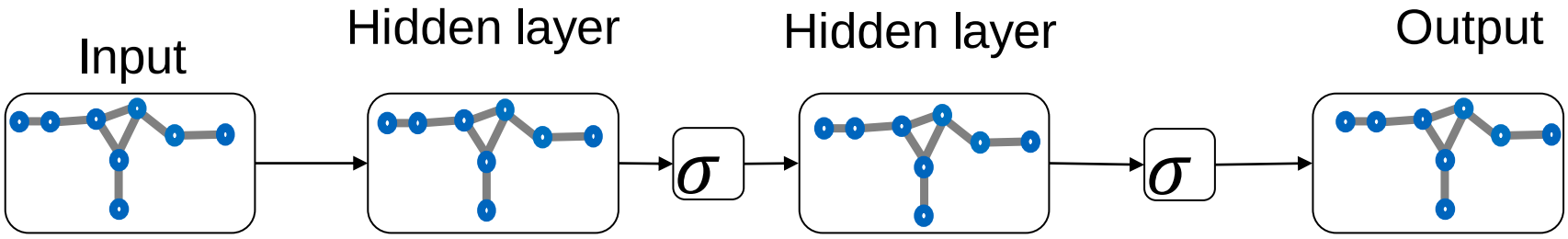


Summary – Lecture 9: Knowledge Graphs

- Pathfinding, general and optimal
- Basic, labelled and property graphs
- Graph Embedding (adjacency, random walk)
- Graph Neural Networks and Message Passing

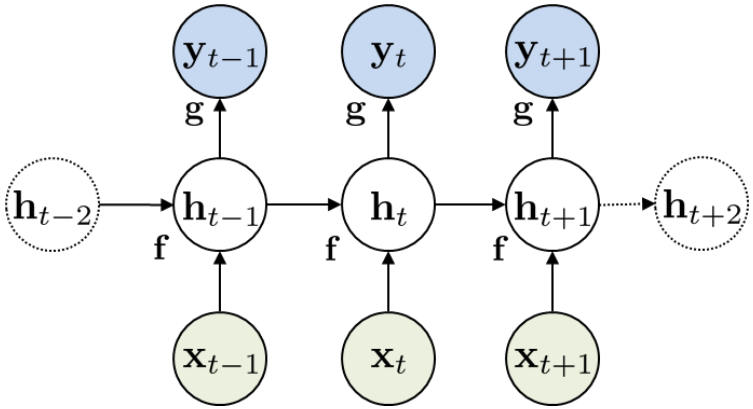


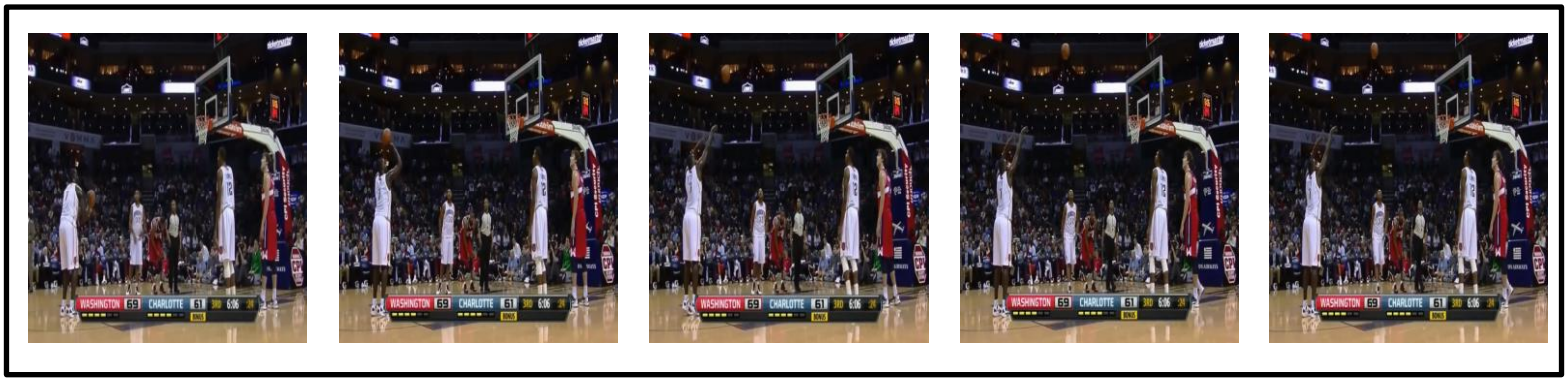




Summary – Lecture 10: Recurrent Neural Networks

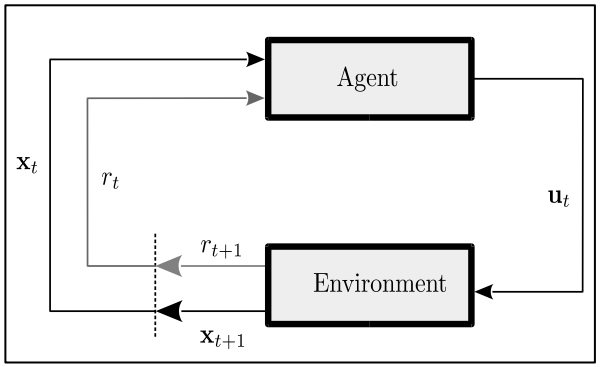
- Usage of sequential data
- Definition of RNNs
- LSTM networks

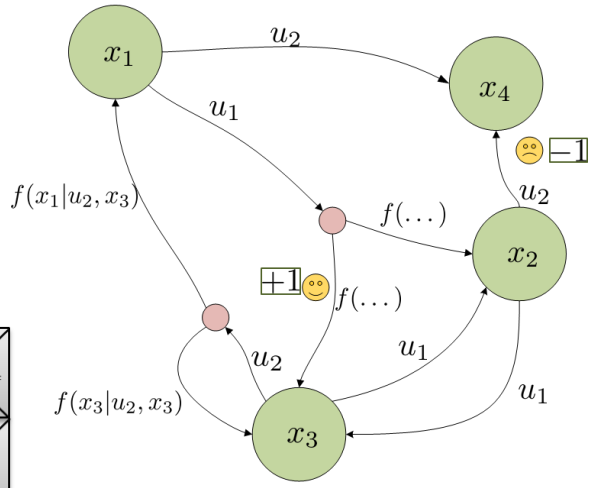


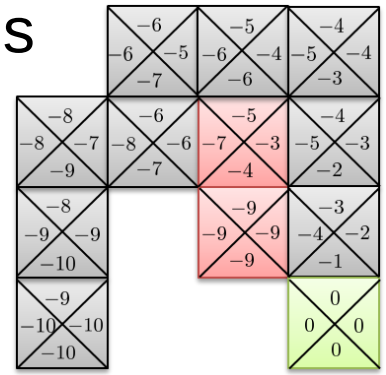


Summary – Lecture 11: Reinforcement Learning

- Agent, environment, state, action
- Actions of the agent are rewarded (or punished)
- Learning to make good decisions by repeating tasks
- Markov decision process
- Q-Learning

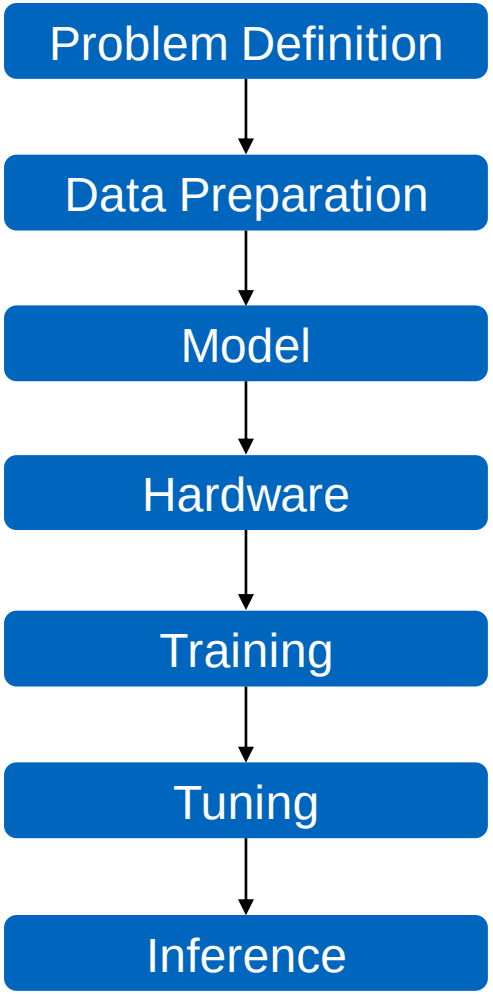






Summary – Lecture 12: AI Development

- AI development pipeline
- The importance of data
- Hardware
- Hyperparameter tuning
- Evaluation of DL algorithms



On backpropagation:

"My view is throw it all away and start again."

"The future depends on some graduate student who is deeply suspicious of everything I have said."

Geoffrey Hinton

"Godfather of Deep Learning"