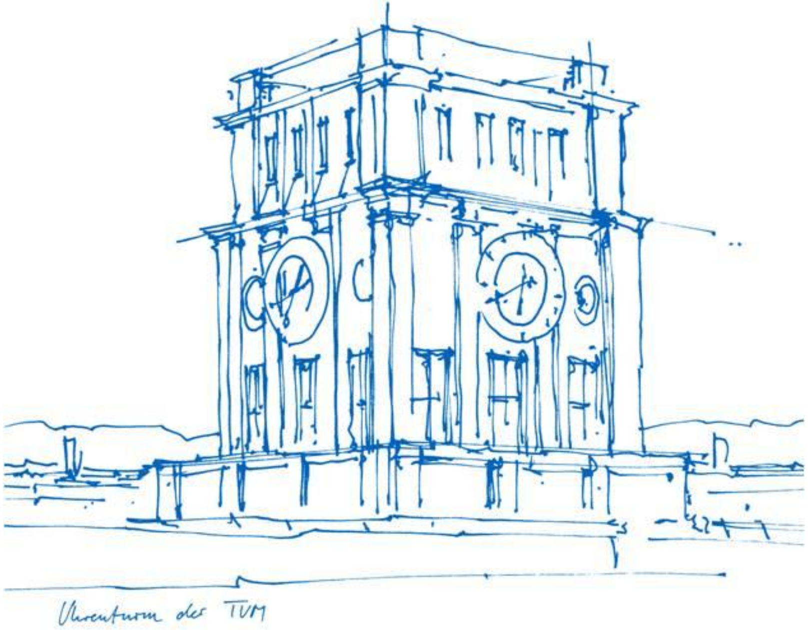
Beyond Deep Learning: Selected Topics

Christian Tomani, Yuesong Shen

Technical University of Munich

Chair of Computer Vision and Artificial Intelligence

Garching, July. 7th, 2021



Agenda

- What are the topics we will cover?
    - Layer and Architecture Designs
    - Alternatives to Neural Networks
    - Uncertainty Aware Models
    - Time Series and Sequence Models
- How is the course organized?
- How to apply?

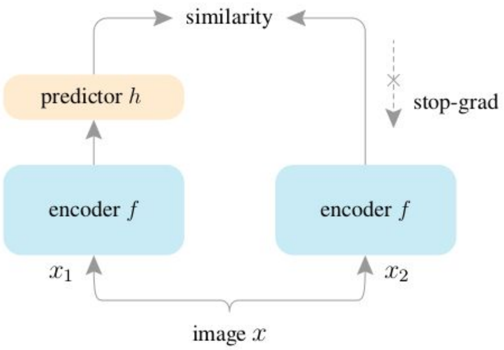
Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

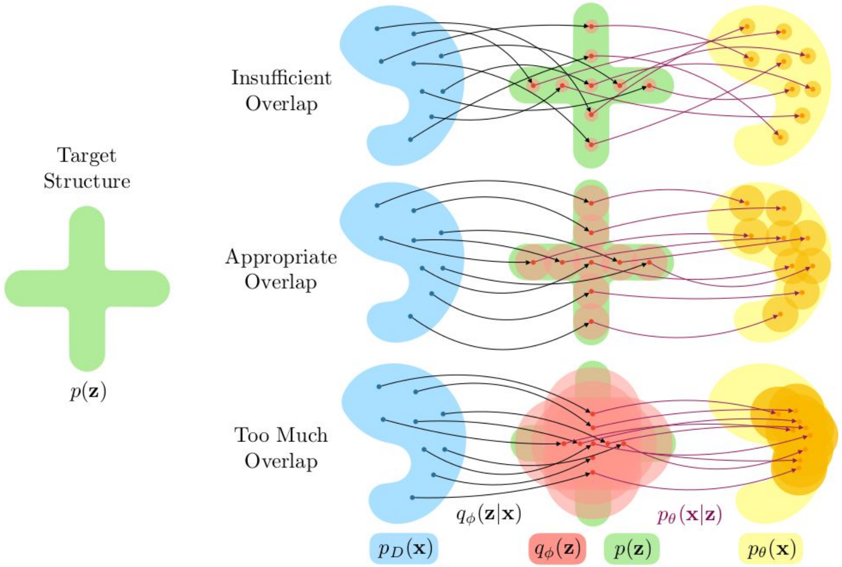
Layer and Architecture Design

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Self-supervised representation learning

- Learning without labels
- Learn “good” representation efficiently

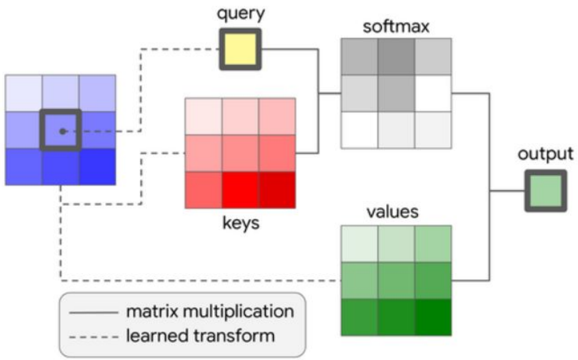


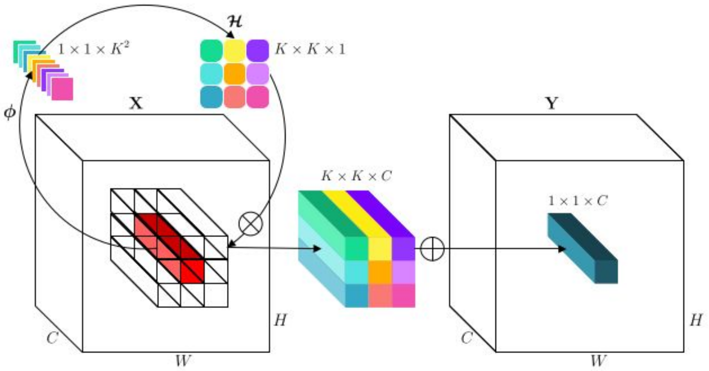


Original Images published in:
“Exploring Simple Siamese Representation Learning, Chen and He, 2020”; “Disentangling Disentanglement in Variational Autoencoders, Mathieu et al., 2019”

Learning in vision beyond CNNs

- New trend in CNN-dominated vision domain: attention
- Best of both Convolution and self attention?





Original Images published in:
“Stand-Alone Self-Attention in Vision Models, Ramachandran et al., 2019”; “Involution: Inverting the Inherence of Convolution for Visual Recognition, Lee et al., 2021”

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Alternatives to Neural Networks

Alternatives to Neural Networks: why?

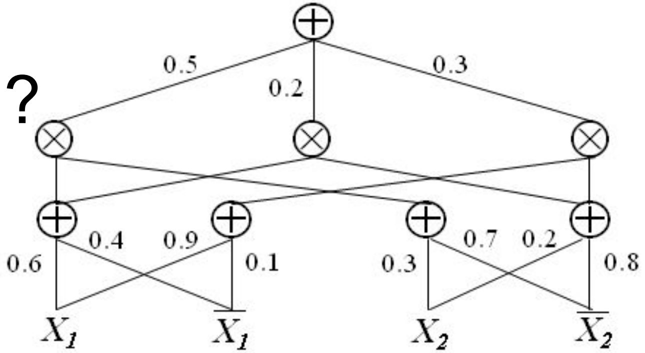
Neural network is currently the “star model” in the machine learning community

⇒ Why should we care about alternative ML models?

- NN does not offer solution to all problems
- Alternative solutions for generative modeling, unsupervised learning, uncertainty estimation ...
- Offer inspirations for improving NN / combination
- Better appreciate the strong / weak points of NN

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Alternatives to Neural Networks: which?



Some possible alternatives to neural network:

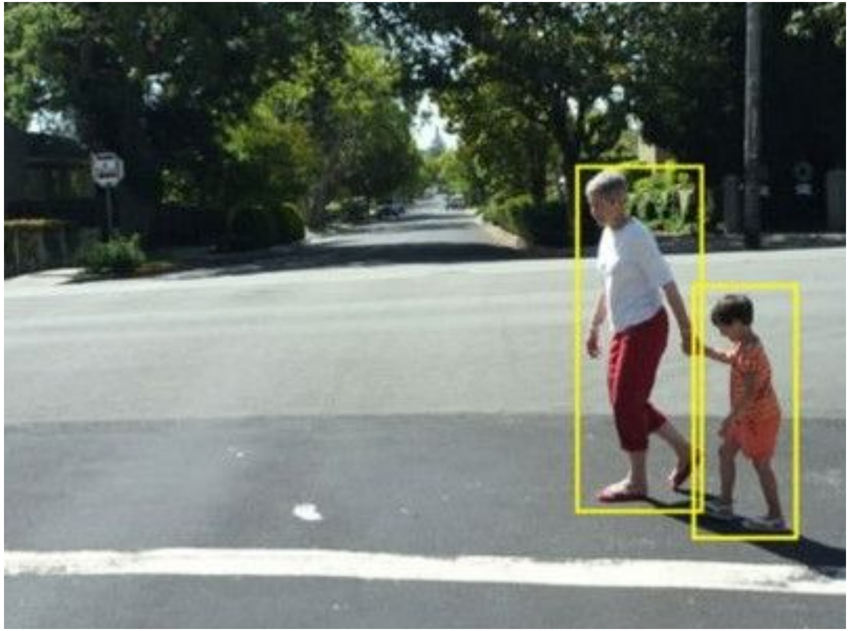
- (Deep) Gaussian process
- Deep belief network
- Deep Boltzmann machine
- Sigmoid belief network
- Sum-product network
- ...

Original Image published in:
"Sum-Product Networks: A New Deep Architecture, Poon and Domingos, 2011"

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Uncertainty Aware Models

Safety critical applications

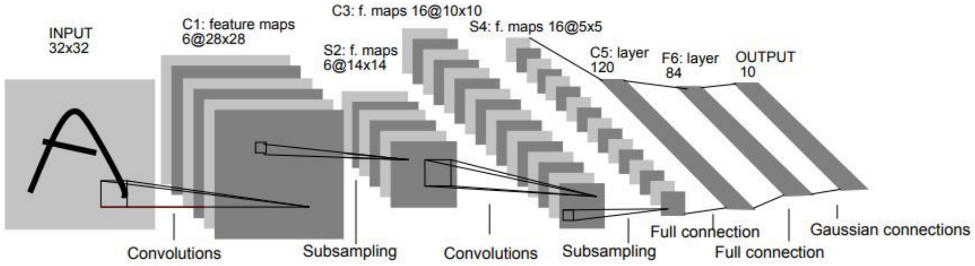


https://www.paperswithcode.com, 03/01/2020

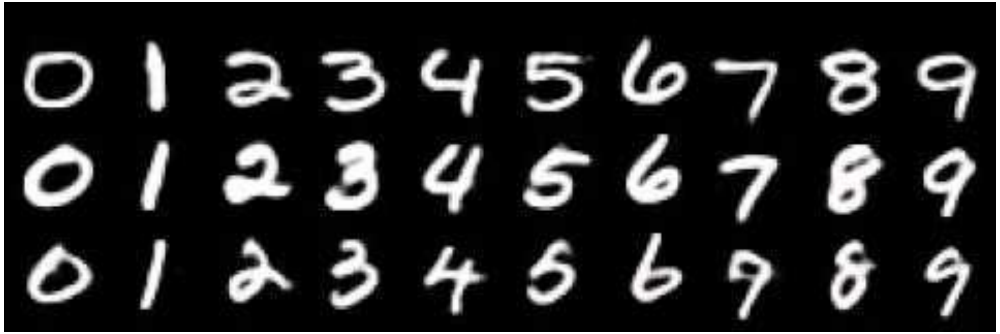
The issue with Deep Learning - Can we trust the model?

Setup

LeNet-5 Model with weight decay



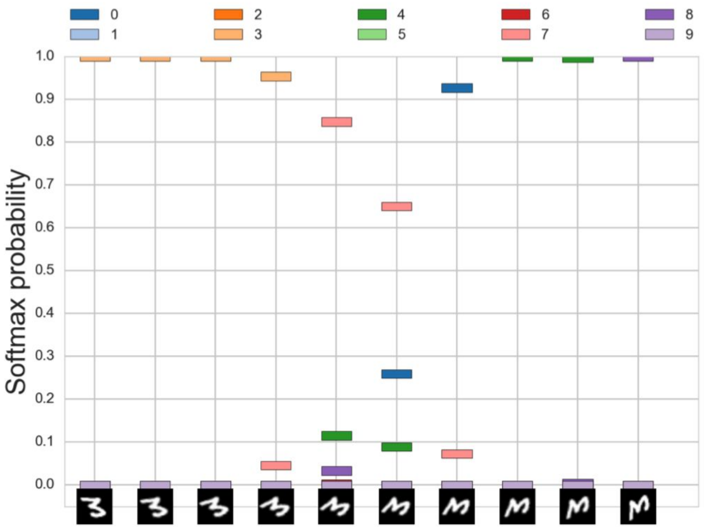
MNIST Dataset



LeCun et al. - Gradient Based Learning Applied to Document Recognition, 1998
https://github.com/cazala/mnist

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

The issue with Deep Learning - Can we trust the model?



Vanilla LeNet-5 Model on MNIST

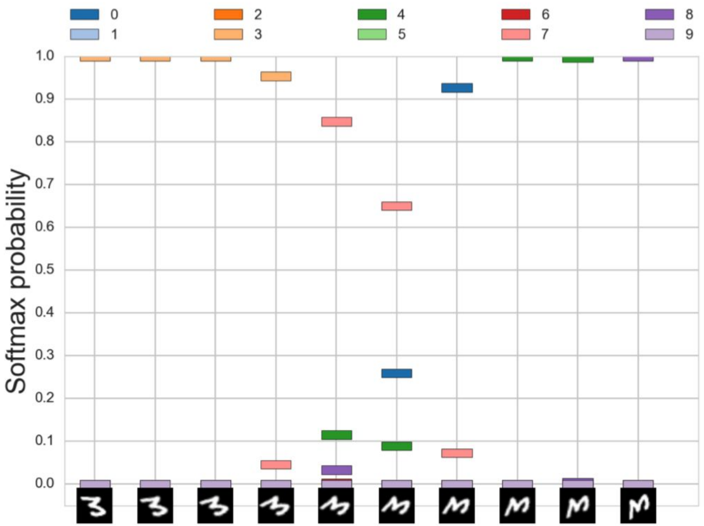
- Model is unreliable and not calibrated
- Gives totally wrong but highly confident predictions if data is perturbed
- wrong predictions cannot be distinguished from correct ones

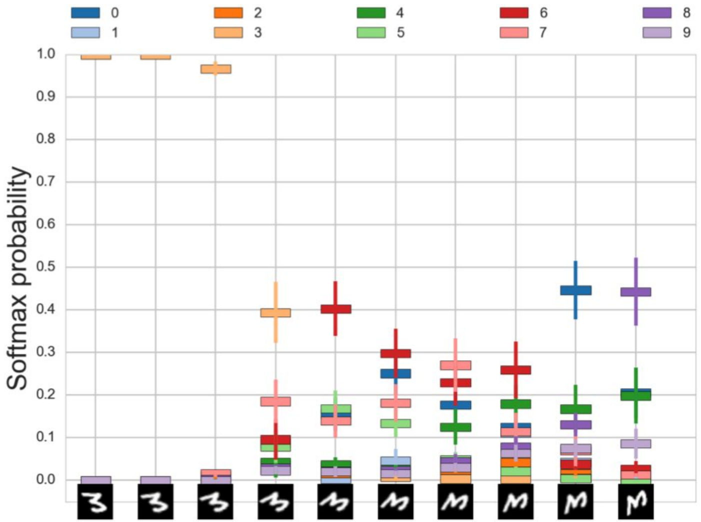
Softmax Probability $\neq$ Confidence

Christos Louizos - Multiplicative Normalizing Flows for Variational Bayesian Neural Networks, 2017

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

The issue with Deep Learning - Can we trust the model?





Christos Louizos - Multiplicative Normalizing Flows for Variational Bayesian Neural Networks, 2017

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Time Series and Sequence Models

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

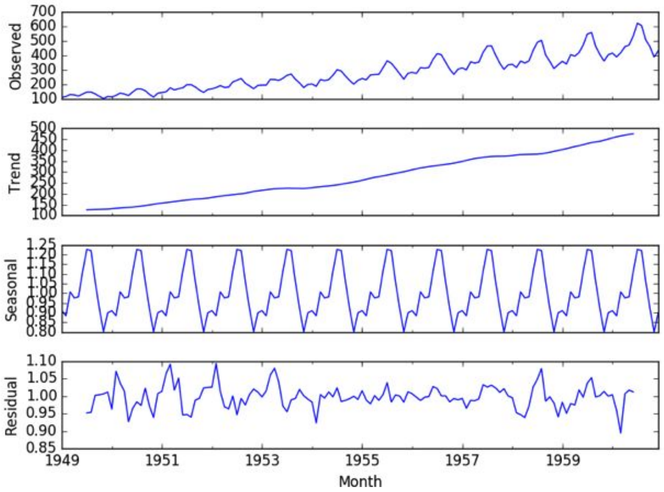
Time Series Basics

2 Types of time series:

- univariate time series
- multivariate time series

Decomposition of time series:

- d_t trend component (deterministic)
- c_t cyclical component (deterministic, periodic)
- s_t seasonal component (deterministic, periodic)
- ε_t irregular component (stochastic, stationary)



$$y_t = d_t + c_t + s_t + \epsilon_t$$

https://machinelearningmastery.com/decompose-time-series-data-trend-seasonality/

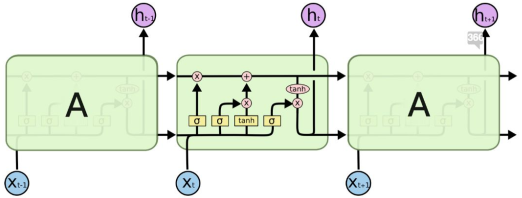
Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Time Series Models

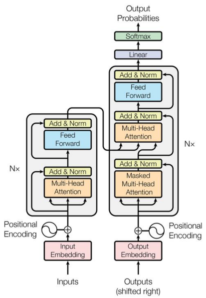
Autoregressive Model:

$$X_t = c + \sum_{i=1}^{p} \varphi_i X_{t-i} + \varepsilon_t$$

Long Short Term Memory Model (LSTM):



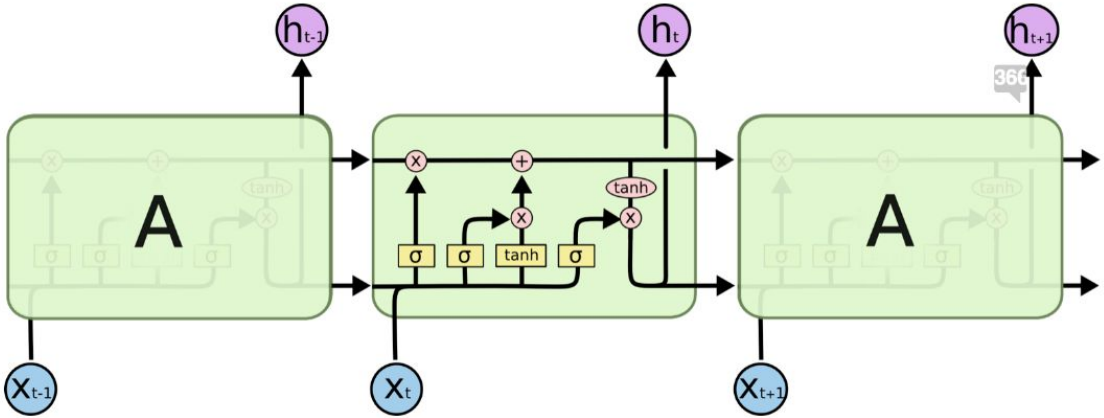
Transformer Models:



https://colah.github.io/posts/2015-08-Understanding-LSTMs/
Vasvani et al.: Attention is all you need, 2017

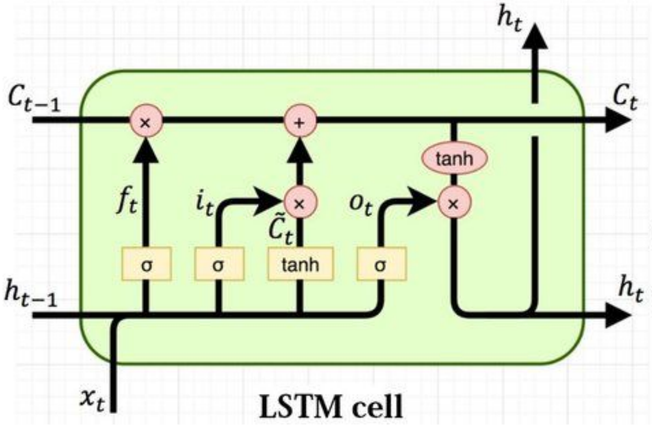
Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Long Short Term Memory Model (LSTM)



https://colah.github.io/posts/2015-08-Understanding-LSTMs/

Long Short Time Model (LSTM)



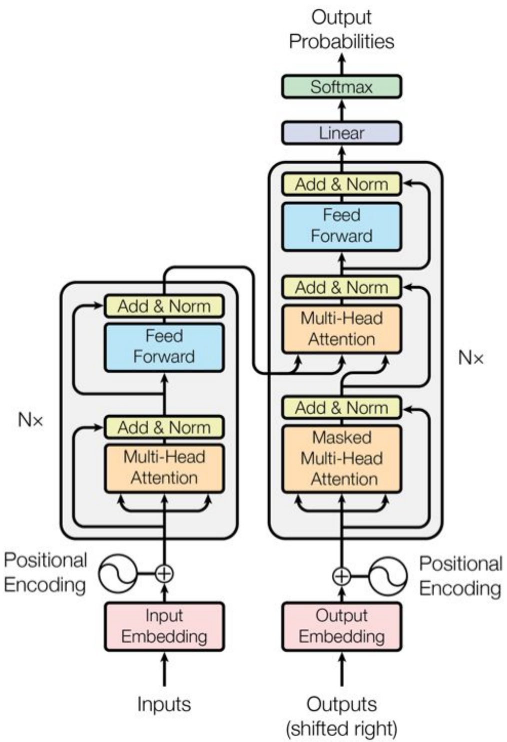
$$i_t = \sigma\left(x_t U^i + h_{t-1} W^i\right)$$
$$f_t = \sigma\left(x_t U^f + h_{t-1} W^f\right)$$
$$o_t = \sigma\left(x_t U^o + h_{t-1} W^o\right)$$
$$\tilde{C}_t = \tanh\left(x_t U^g + h_{t-1} W^g\right)$$
$$C_t = \sigma\left(f_t * C_{t-1} + i_t * \tilde{C}_t\right)$$
$$h_t = \tanh(C_t) * o_t$$

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

Transformer Models

- Encoder and decoder stacks
- Attention
- No recurrent neural network
- Applications:
  - Sequence modeling
  - Language translation
  - Text processing

Attention is all you need
vs.
Hopfield Networks is All You Need



Vasvani et al.: Attention is all you need, 2017

Course logistics

Course Organization

Course website: https://vision.in.tum.de/teaching/ws2021/bdlstnc_ws2021

Course email: bdlstnc-ws21@vision.in.tum.de

Course structure:

- Kick-Off Meeting with all the topics (default date: October 20th)
- Matching to the topics
- Read the papers and do a literature search and elaborate on the topic you are provided with
- Get optional help, if you did not understand the paper
- Send a first draft of the presentation and get optional feedback
- Presentations take place on January 18th-19th 2022
- Final report will be due after the presentations

Prerequisites

- Machine learning & deep learning knowledge:

  Basic ML concepts and ML/DL models

  Min. Requirement: passed one ML/DL related course (I2ML, I2DL, ADL4CV, PGM ...)

- Soft skills:

  Manage regular workflow and communicate with tutors efficiently

- We also value:
  - solid basis & interest for maths
  - prior experience with ML/DL projects

Chair of Computer Vision & Artificial Intelligence
Department of Informatics
Technical University of Munich

How to apply

1. Apply via the **TUM Matching system** (July 15th - 20th, 2021)
    - If you like our course, make sure to give it a high priority :)
2. **Send us an email** to show your interest and fulfillment of prerequisites
    - Crucial for us to give you a priority

- The email should be sent to bdlstnc-ws21@vision.in.tum.de **latest July 20th** with the title "[Application] <Firstname> <Lastname>" and contain
    - Filled information form (template on course website, rename to "firstname_lastname.xlsx")
    - Transcript
    - CV

Thank you! Questions?