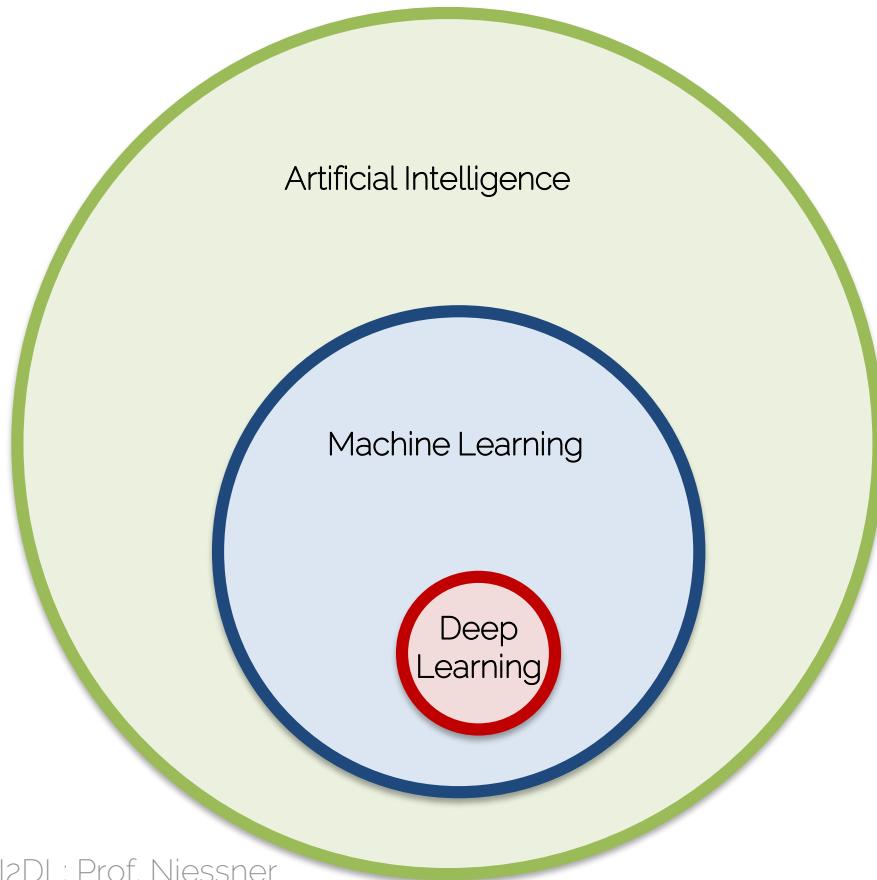
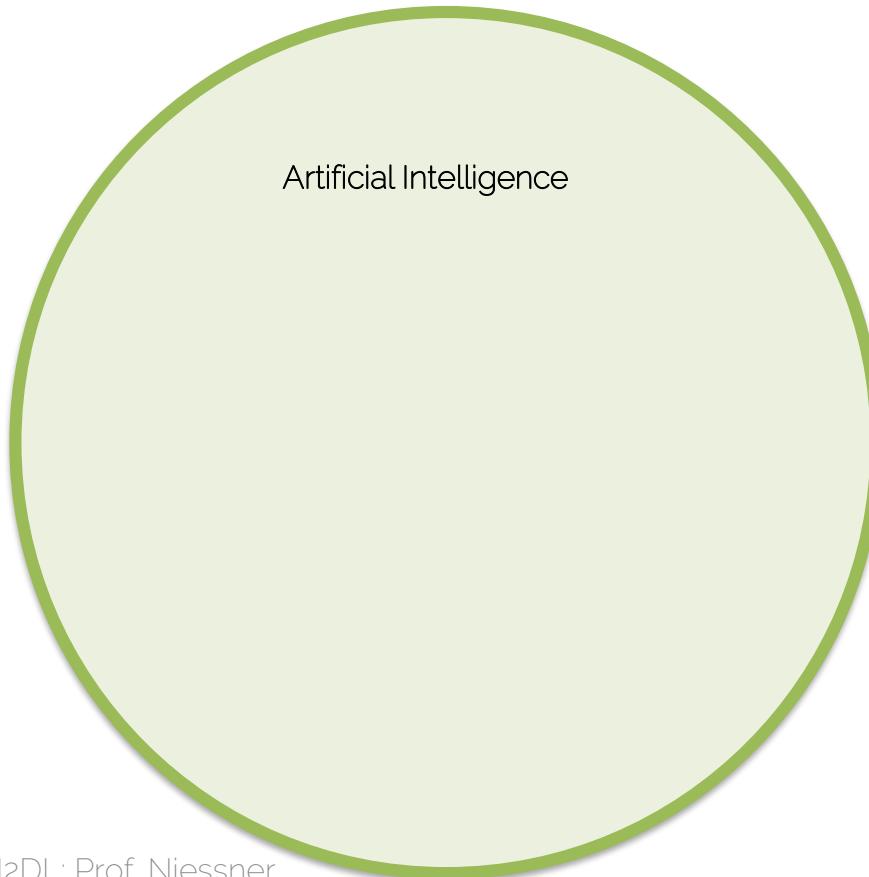


# Introduction to Deep Learning

# What is this Lecture about?



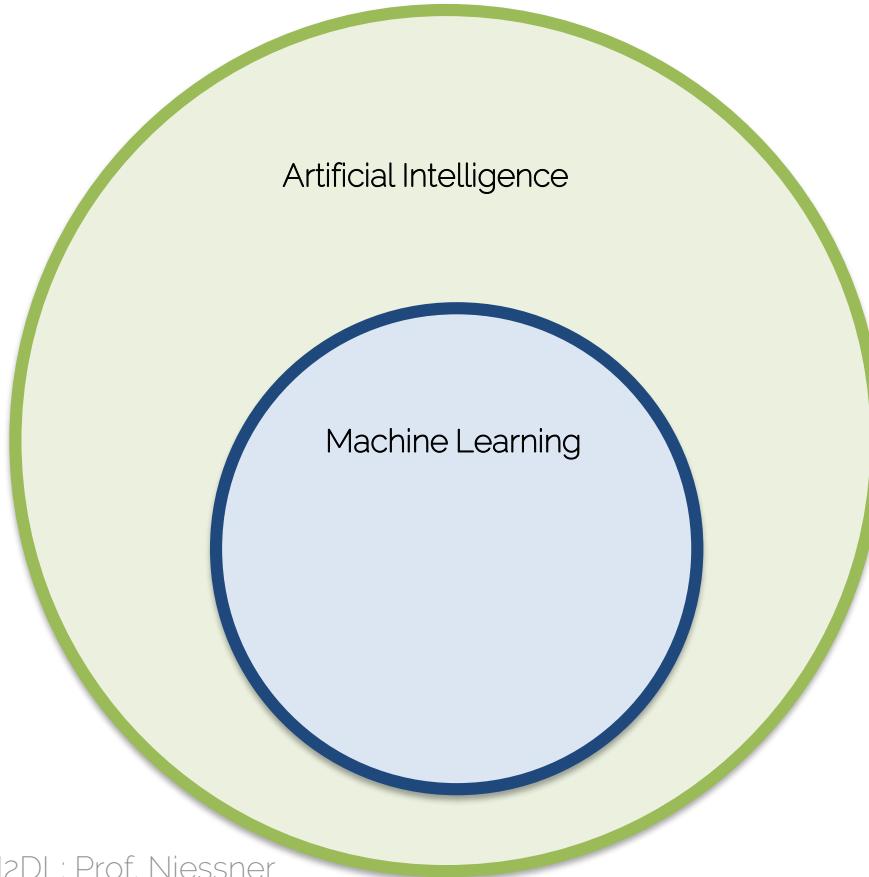
# What is this Lecture about?



- AI Methods
  - Broad definition!
    - "if" statements

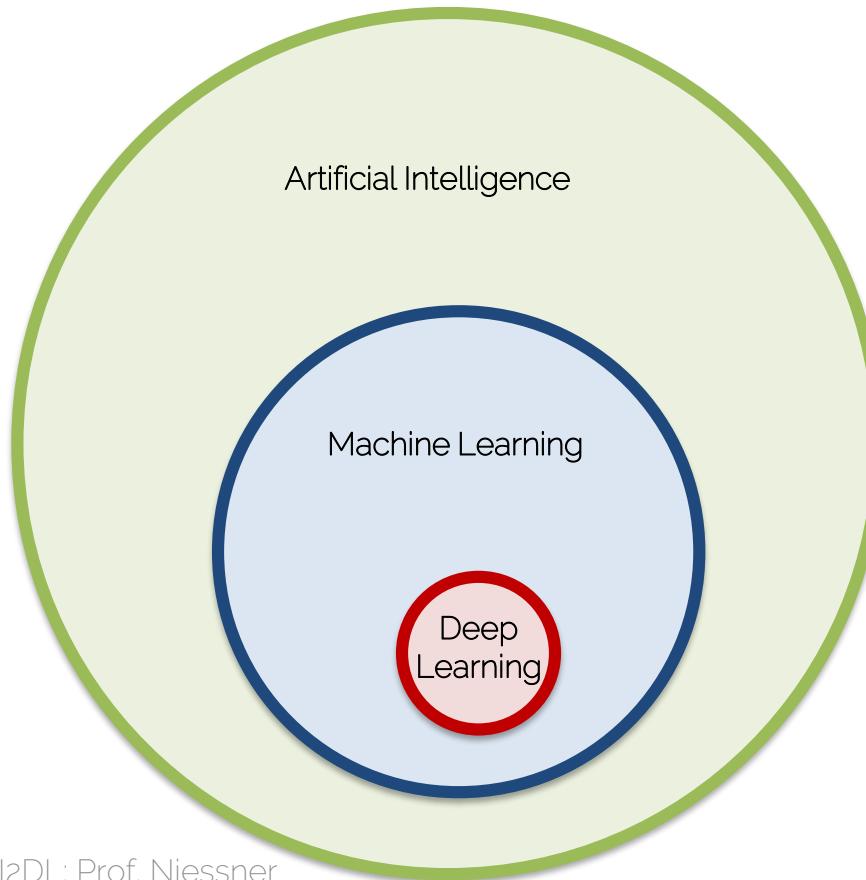
```
if (cold)
    turn_up_heat();
```
    - Binary Search
    - Dijkstra, A\*, ...
    - Prime, Kurskal, ...
    - Logic algorithms, etc.

# What is this Lecture about?



- ML Methods
  - Linear/logistic regression
  - Support Vector Machines
  - Random Decision Trees, Forests, Jungles, ...
  - ...

# What is this Lecture about?



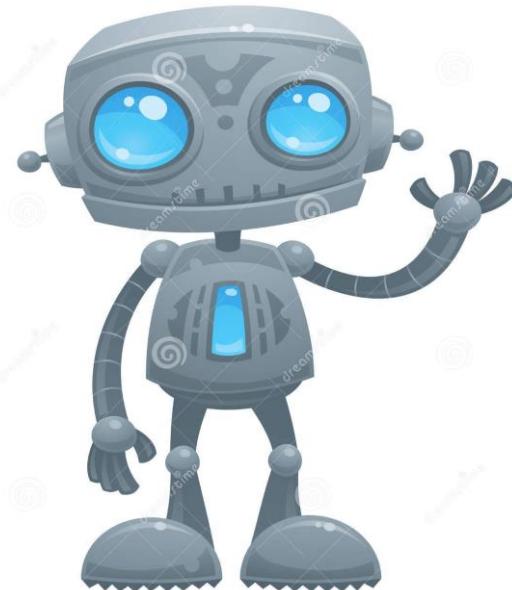
- Deep Learning
  - ML-methods leveraging neural networks
    - Multi-layer perceptrons
    - Convolutional neural networks
    - Recurrent neural networks
    - Transformers
    - Generative models, etc...

# Application Areas

- Computer Vision
  - Medical Imaging
  - Robotics
  - Natural Language Processing (NLP)
  - Computer Graphics
- + many more ☺

# What is Computer Vision?

- First defined in the 60s in artificial intelligence groups
- "Mimic the human visual system"
- Center block of robotic intelligence



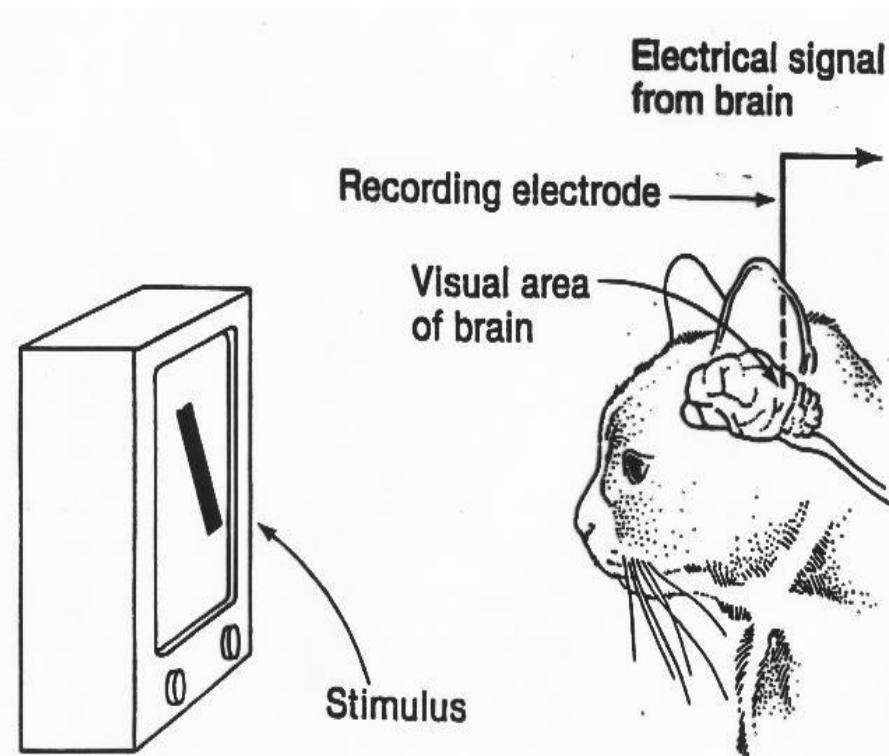
# Hubel and Wiesel

- David Hubel and Torsten Wiesel were neurobiologists from Harvard Medical School
- Experiment revealed several secrets of the human vision system
- Won 2 Nobel prizes



# Hubel and Wiesel Experiment

- Recorded electrical activity from individual neurons in the brains of cats.
- Slide projector to show specific patterns to the cats noted specific patterns stimulated activity in specific parts of the brain.
- Results: Visual cortex cells are sensitive to the orientation of edges but insensitive to their position



MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
PROJECT MAC

Artificial Intelligence Group  
Vision Memo. No. 100.

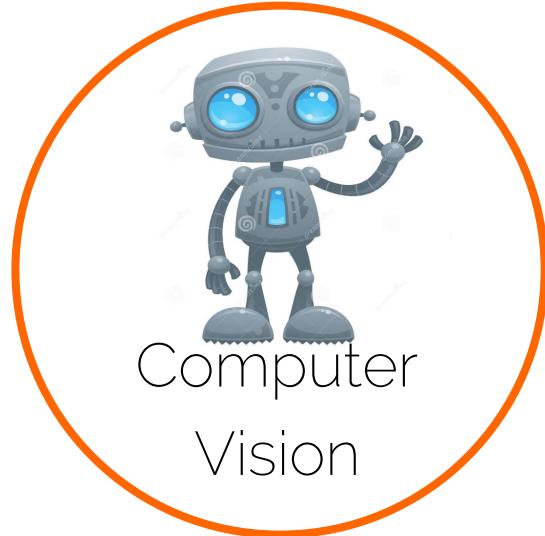
July 7, 1966

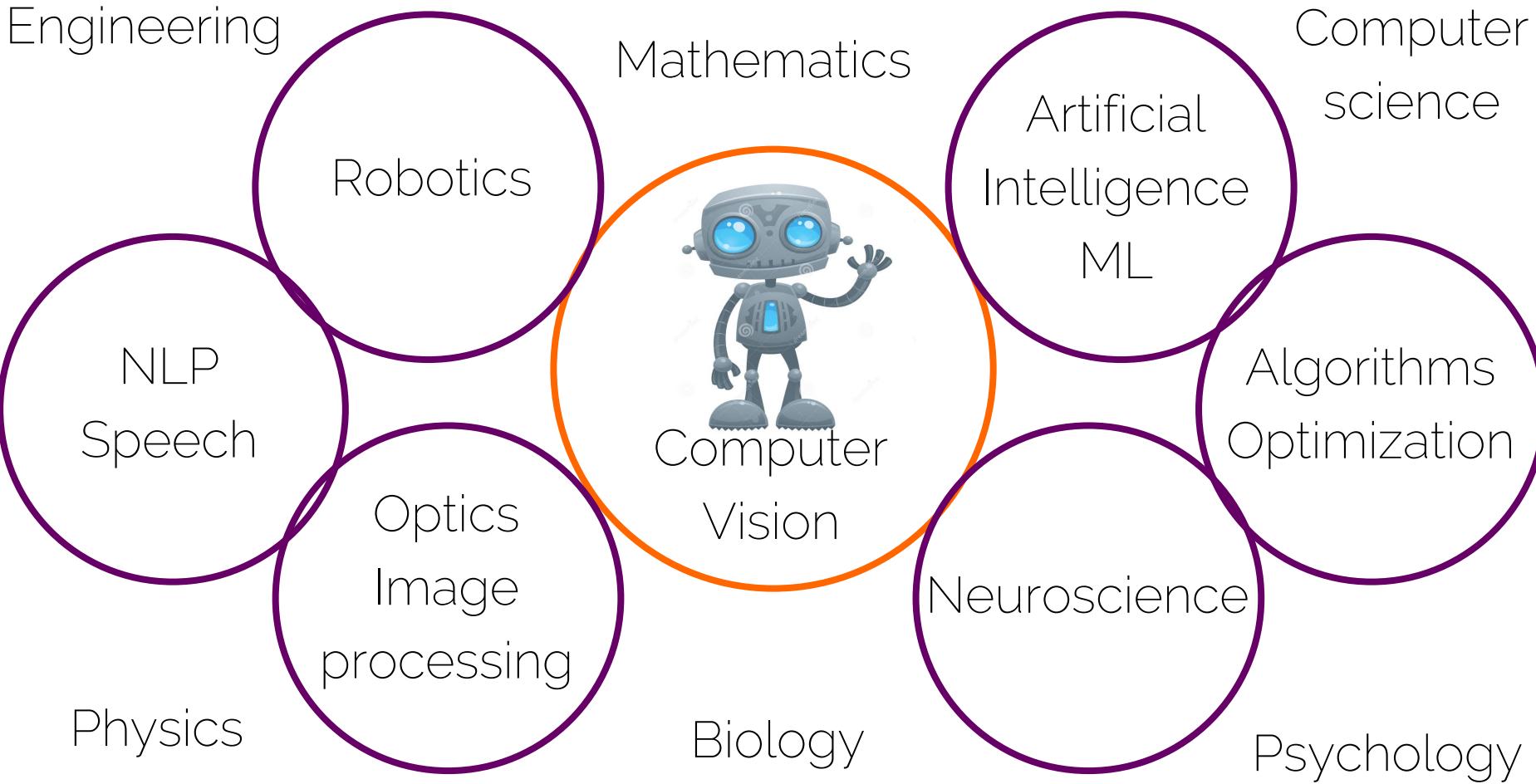
THE SUMMER VISION PROJECT

Seymour Papert

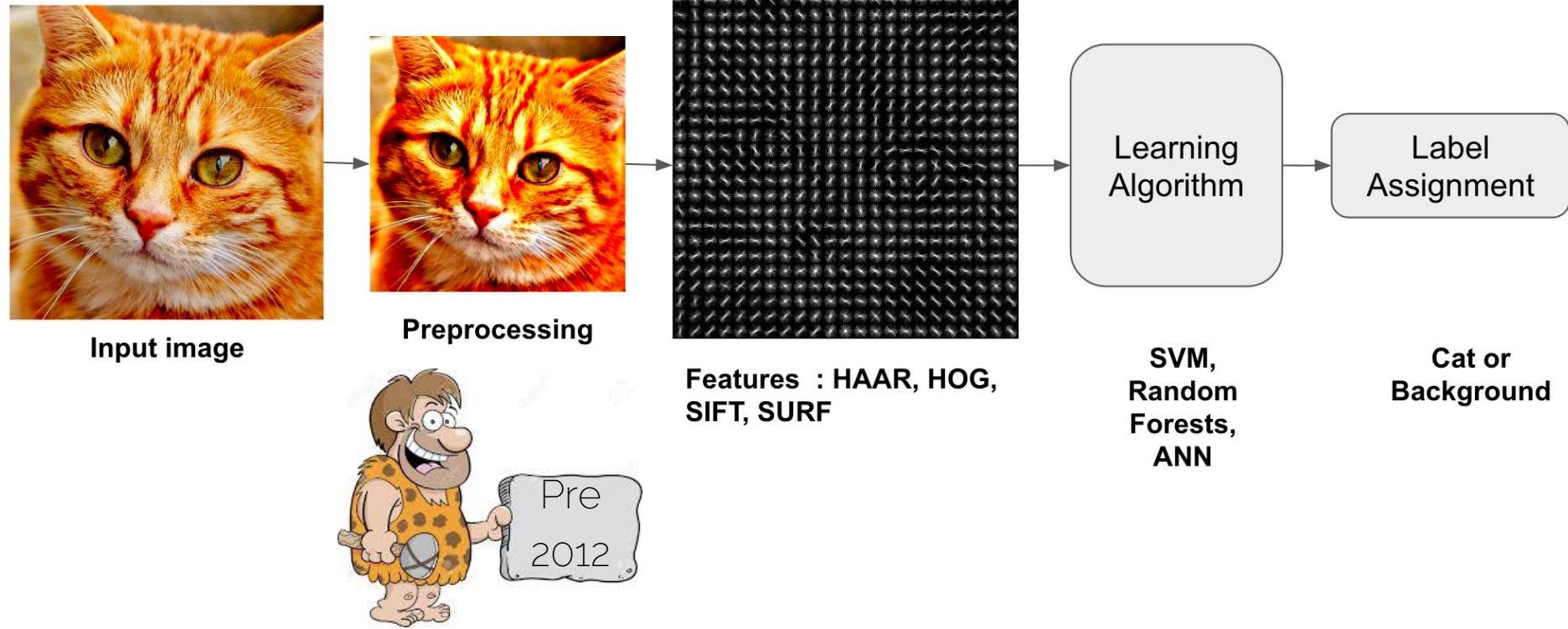
The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

# A Few Decades Later...





# Image Classification



# Image Classification



Input image



Awesome  
magic box



Label  
Assignment



Open the box

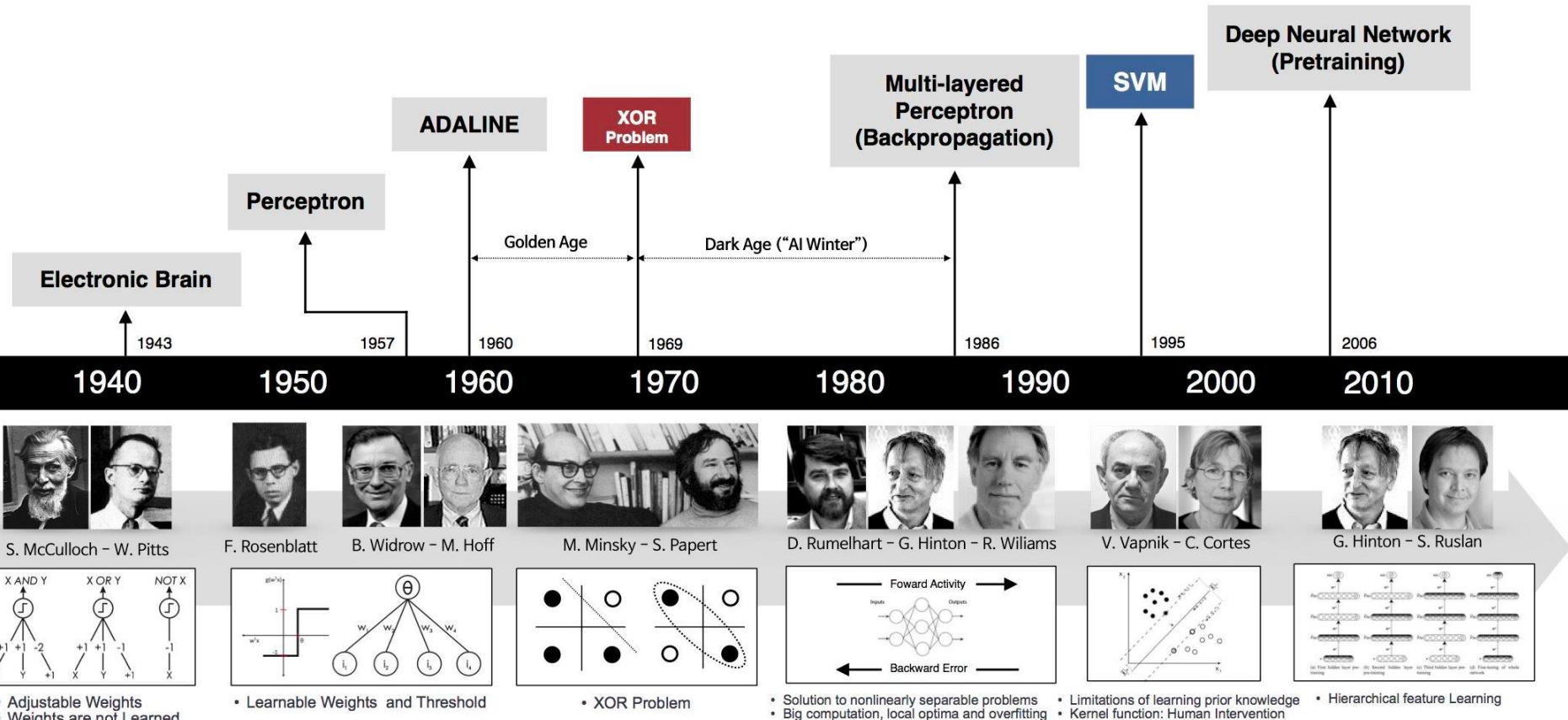


Become magicians

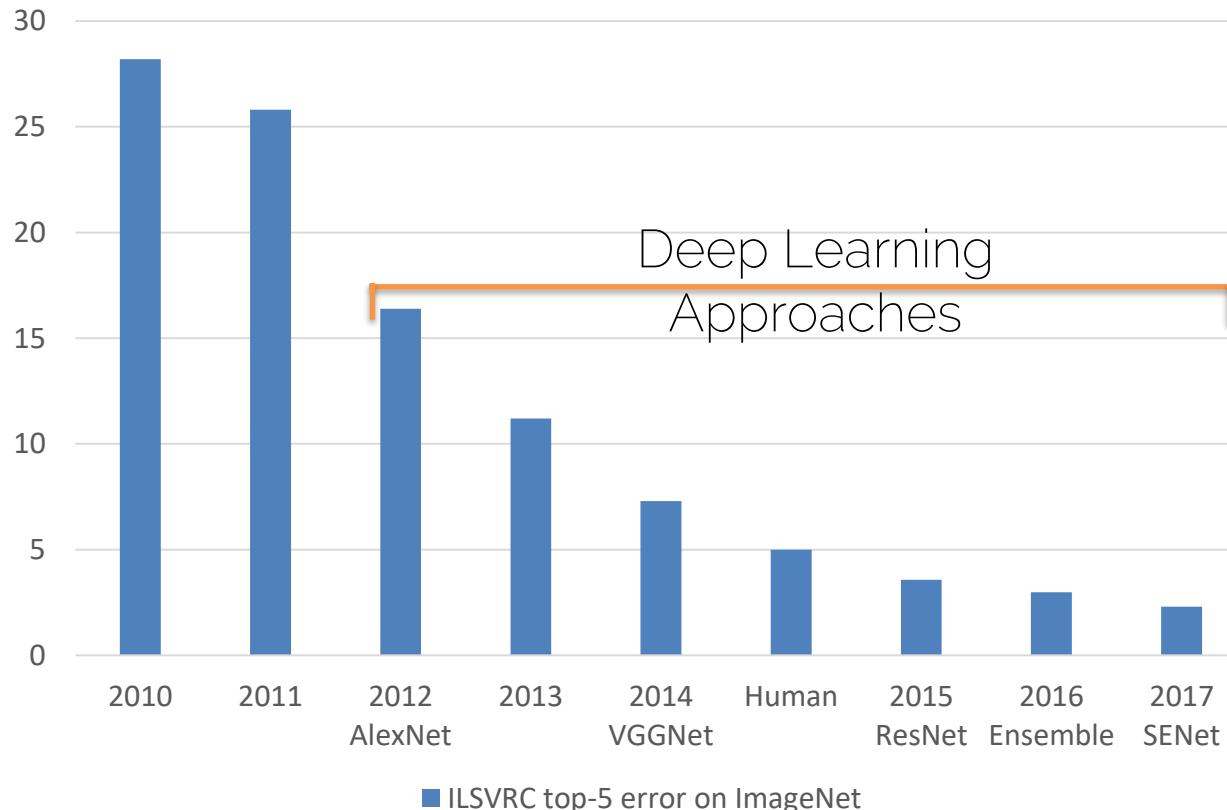
Cat or  
Background

# Why Deep Learning?

# Deep Learning History

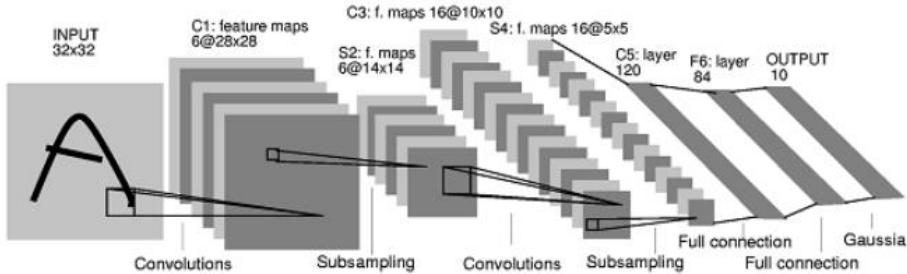


# The Empire strikes Back



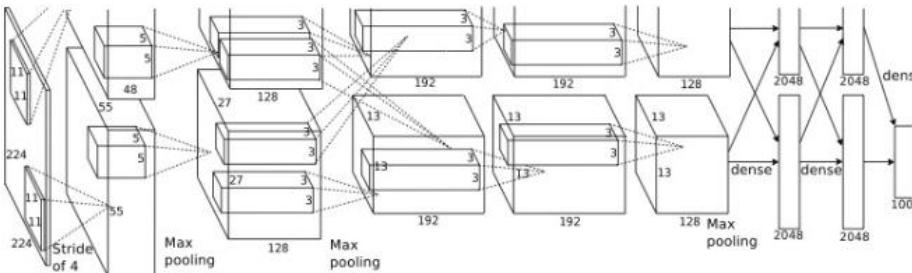
# What has Changed?

1998  
LeCun  
et al.



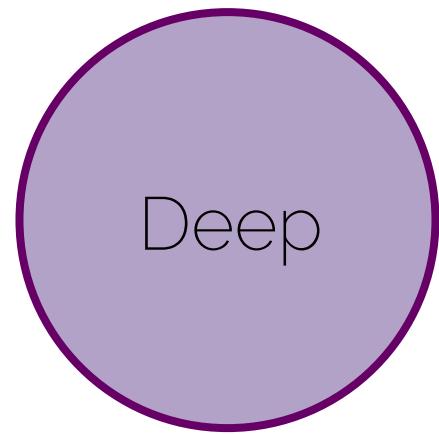
- MNIST digit recognition dataset
- $10^7$  pixels used in training

2012  
Krizhevsky  
et al.



- ImageNet image recognition dataset
- $10^{14}$  pixels used in training

# What Made this Possible?



Models know  
where to learn from

Models are  
trainable

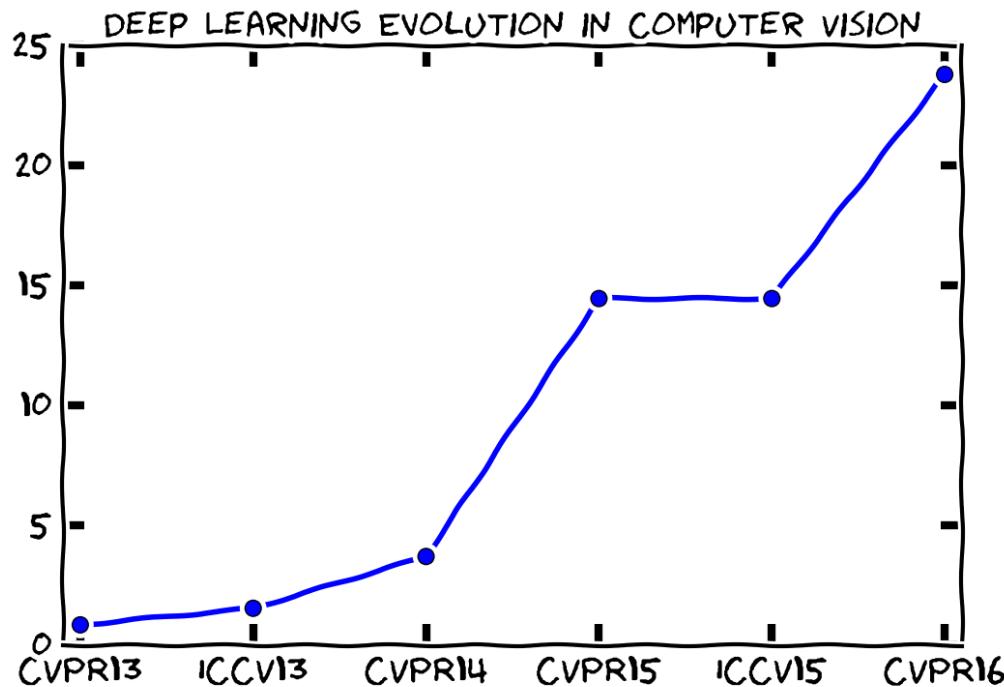
Models are  
complex

# Deep Learning Recognition



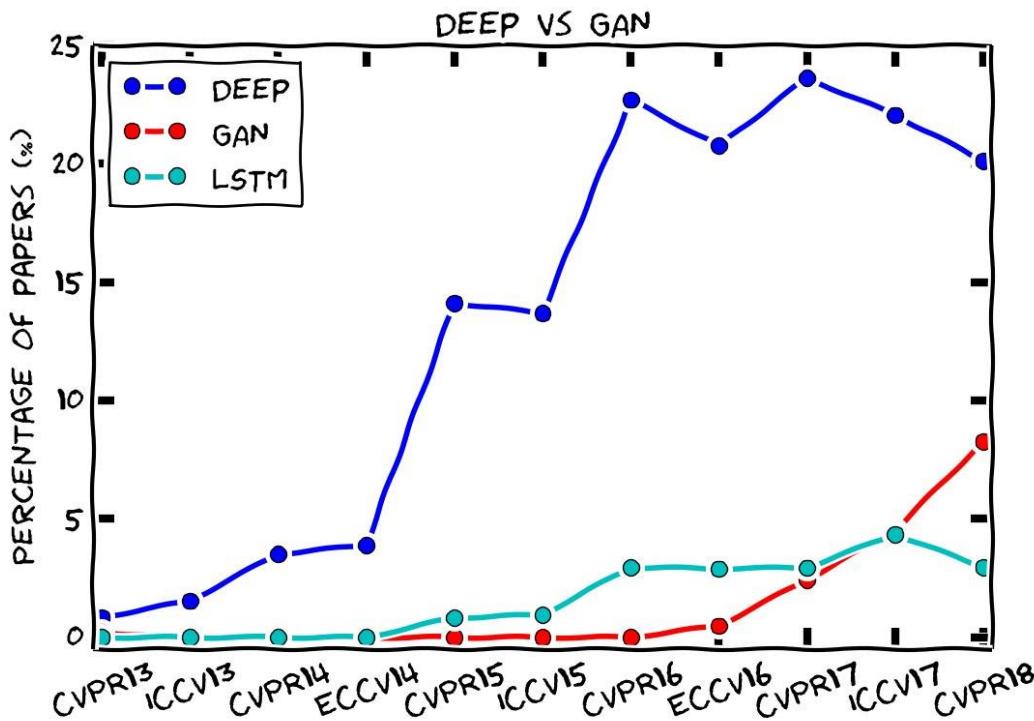
ACM Turing Award 2019 (Nobel Prize of Computing)  
Yann LeCun, Geoffrey Hinton, and Yoshua Bengio

# Deep Learning and Computer Vision



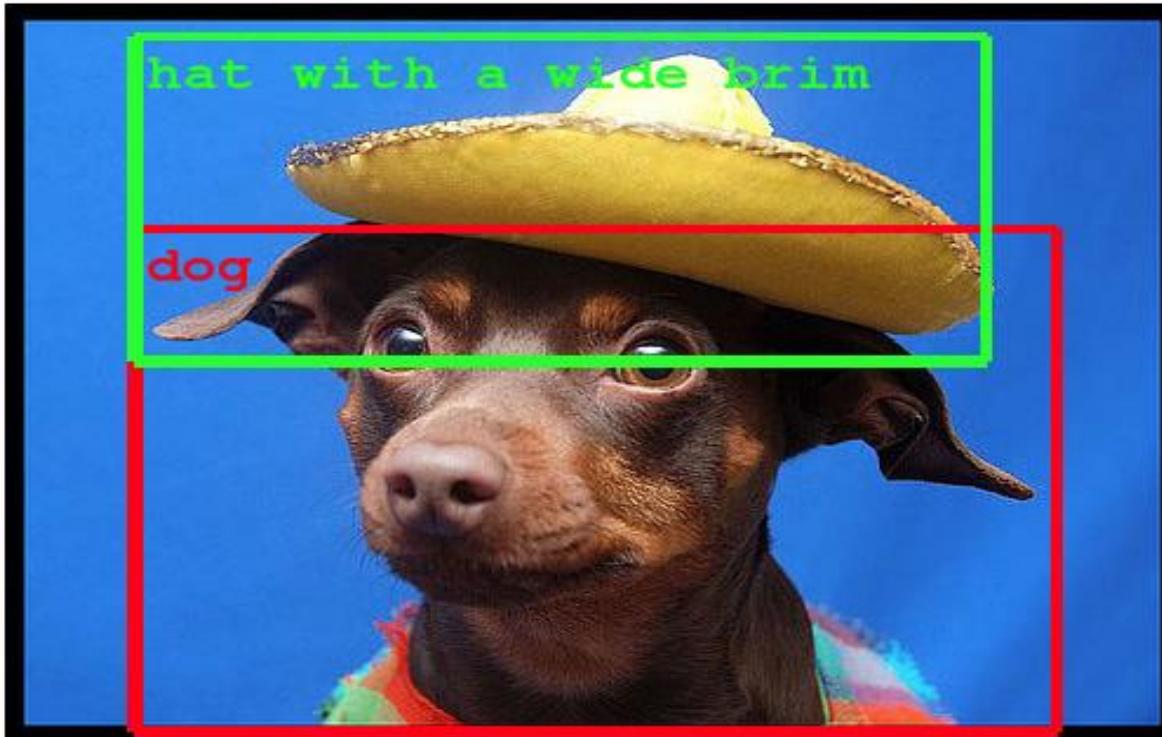
Credits: Dr. Pont-Tuset, ETH Zurich

# Deep Learning and Computer Vision



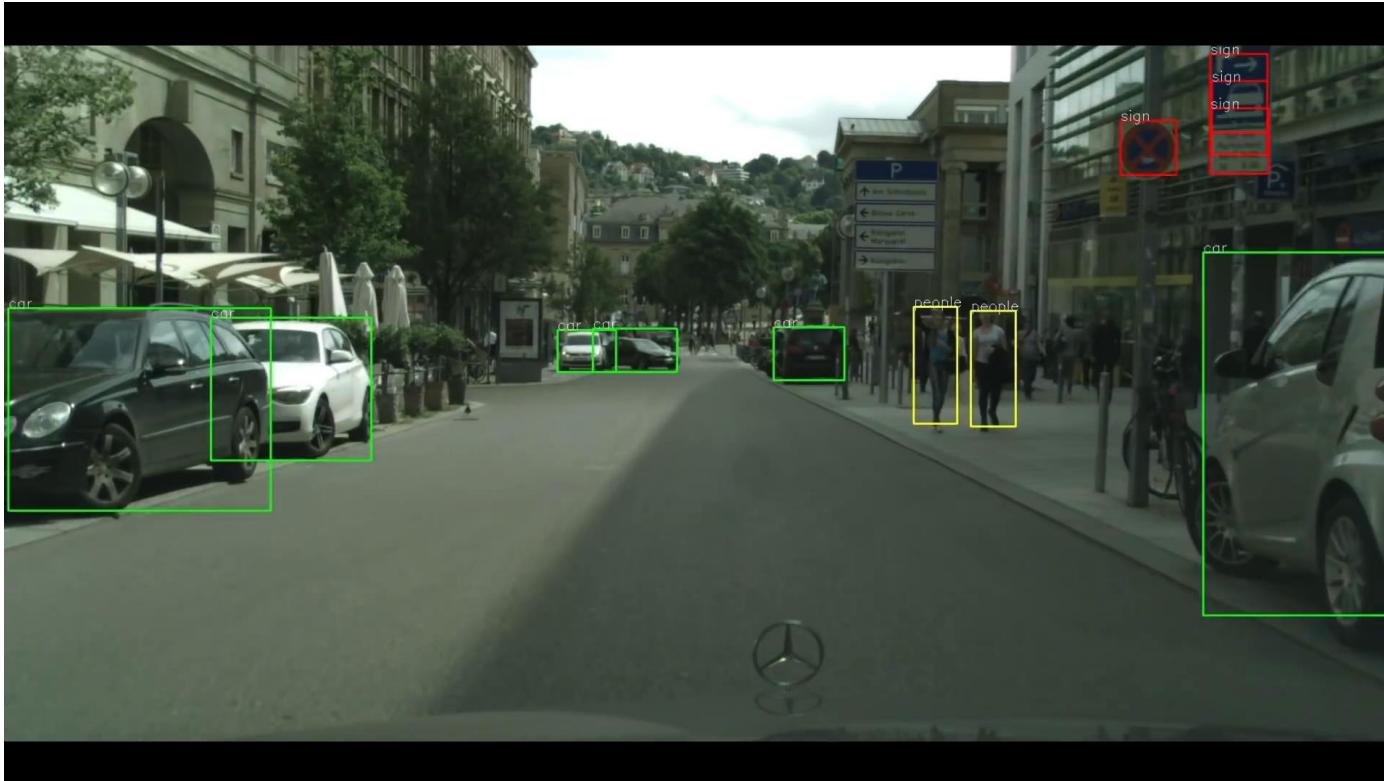
Credits: Dr. Pont-Tuset, ETH Zurich

# Deep Learning Today



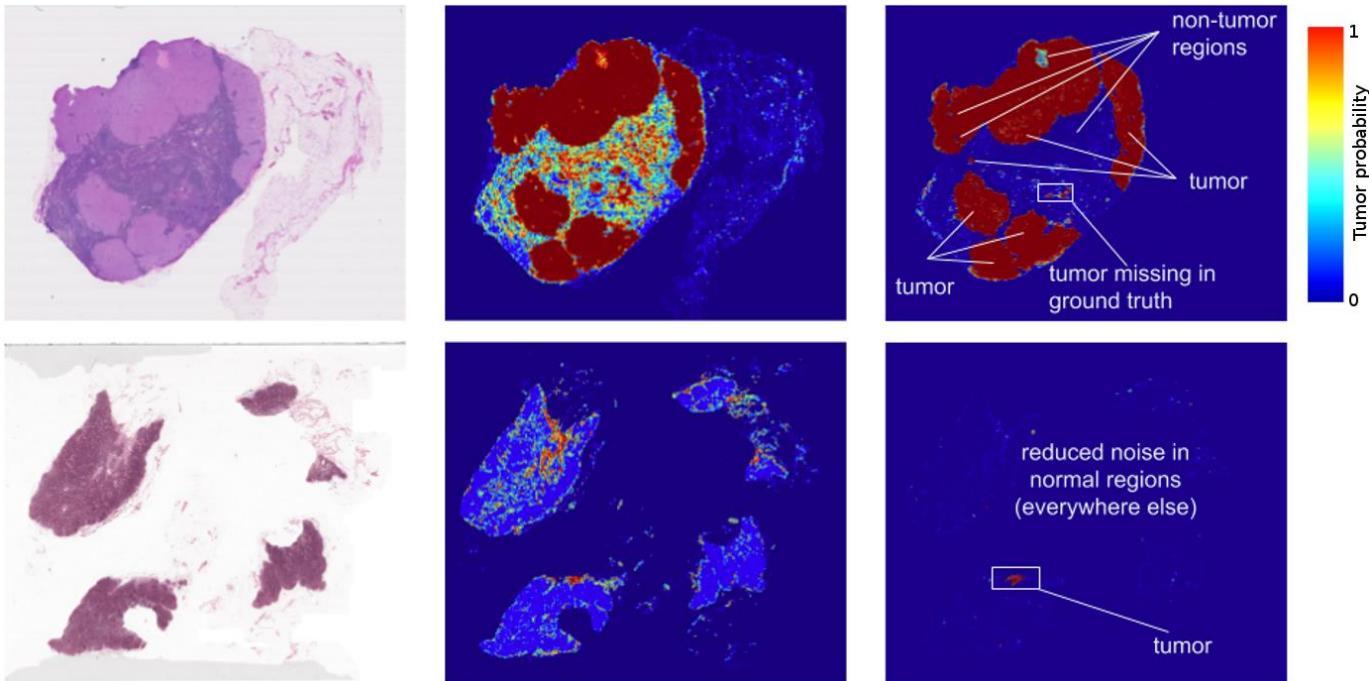
Object Detection

# Deep Learning Today



Self-driving cars

# Deep Learning Today



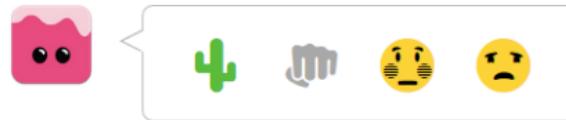
Healthcare, cancer detection

# Deep Learning Today



AlphaGo

ever punch a cactus?

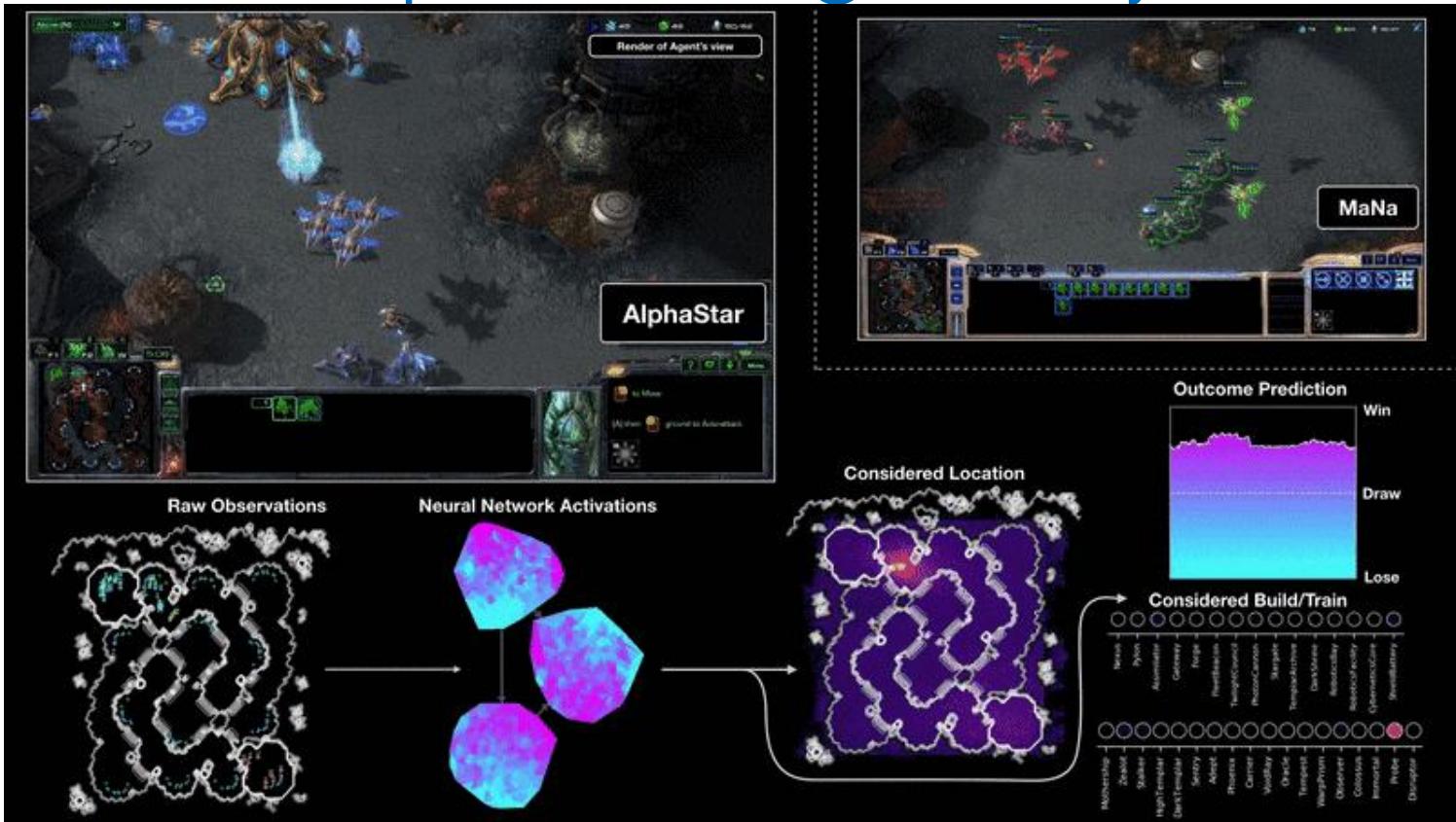


Emoticon suggestion

A screenshot of a machine translation interface. It shows two columns: English on the left and German on the right. The English input is "Deep Learning rocks" and the German output is "Deep Learning Felsen". The interface includes language selection dropdowns ("English – detected" and "German"), audio playback icons, and a copy icon.

Machine translation

# Deep Learning Today



Alpha Star

# Deep Learning Today



Google LaMDA (Google IO'22)

# Deep Learning Today

- Large Language Models (LLMs), e.g., Chat-GPT

NI

Tell me about deep learning and how I can teach it at TUM.



Deep learning is a subset of machine learning that involves training artificial neural networks to recognize patterns and make predictions or decisions based on input data. The term "deep" refers to the fact that these networks have many layers, which allows them to learn increasingly complex representations of the data as it moves through the network. thumb up thumb down

To teach deep learning at TUM, you could start with an introductory course that covers the basics of machine learning and neural networks. This could include topics such as:

1. Supervised learning: This involves training a model using labeled examples, so that it can make predictions on new, unseen data.
2. Unsupervised learning: This involves training a model to identify patterns in data without explicit labels.

# Deep Learning Today

## TEXT DESCRIPTION

An astronaut **Teddy bears** A bowl of soup

mixing sparkling chemicals as mad scientists **shopping for groceries** working on new AI research

**in the style of ukiyo-e** as a one-line drawing in ancient Egypt



## DALL-E 2



Dall-E 2 Image generation from text

# Deep Learning Today

A high tech solarpunk utopia in the Amazon rainforest

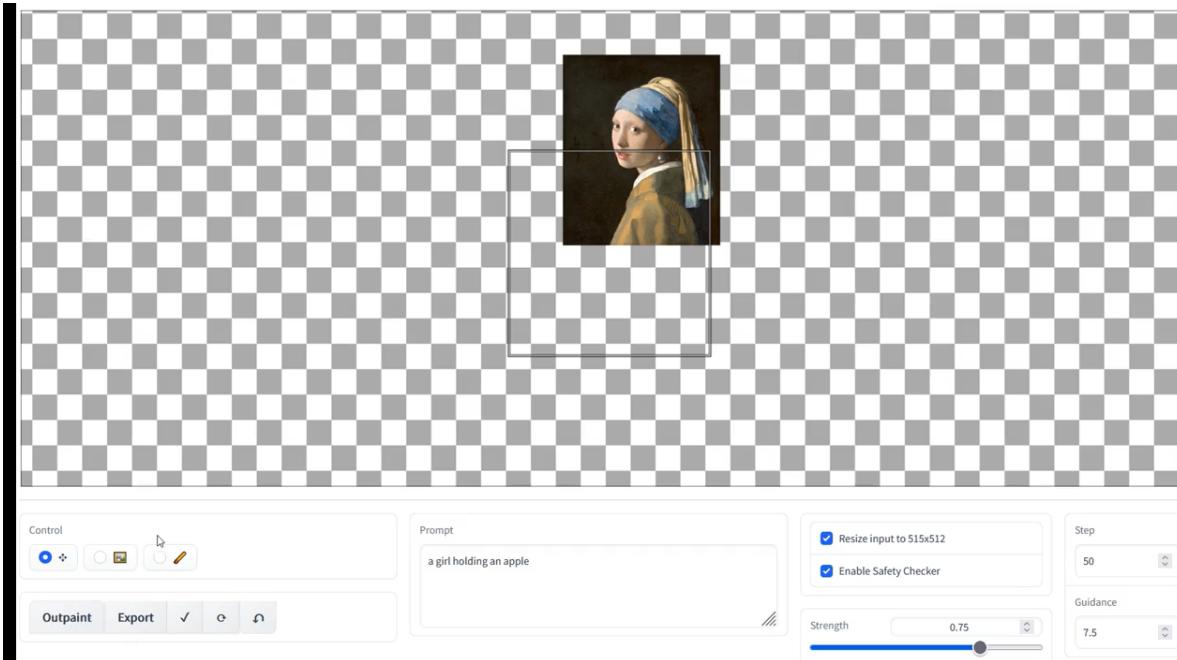
**Generate image**



StableDiffusion Image generation from text

<https://huggingface.co/spaces/stabilityai/stable-diffusion>

# Deep Learning Today



StableDiffusion Image Outpainting

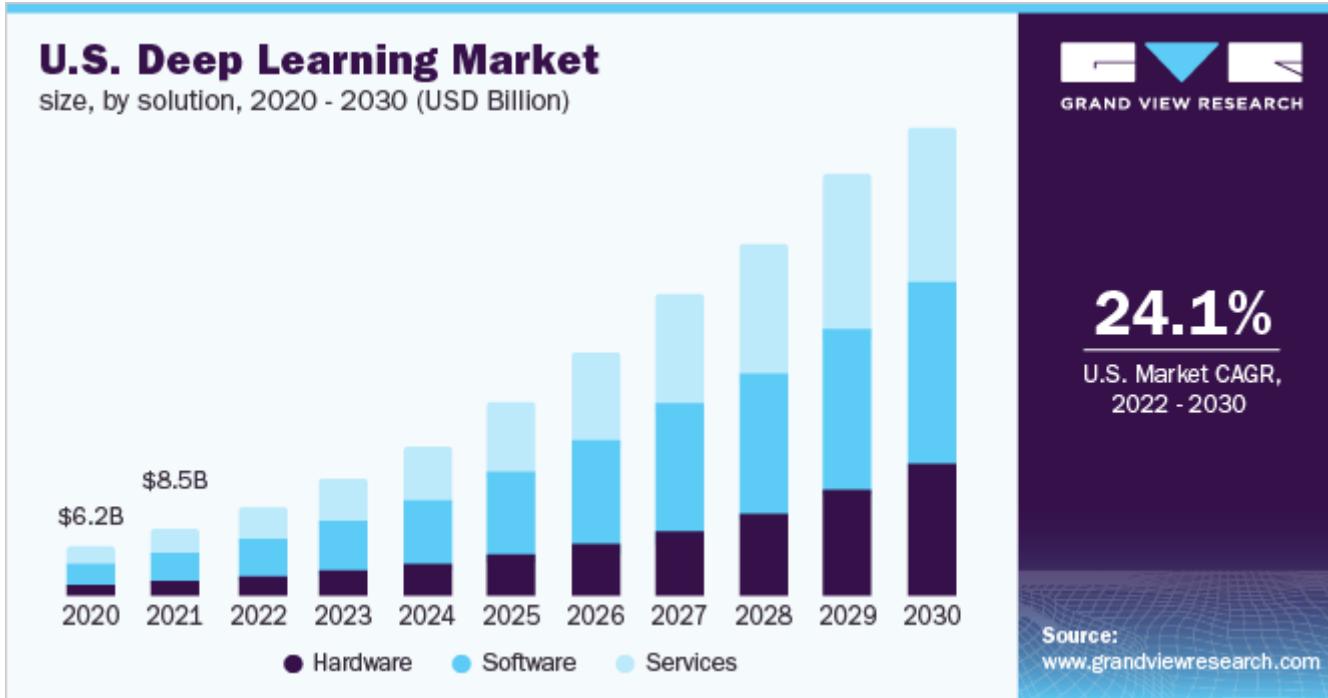
# Deep Learning Today



# Deep Learning Today



# Deep Learning Market



[...] market research report Deep Learning Market [...] " the deep learning market is expected to be worth **USD 415 Billion by 2030**.

# Deep Learning Job Perspective

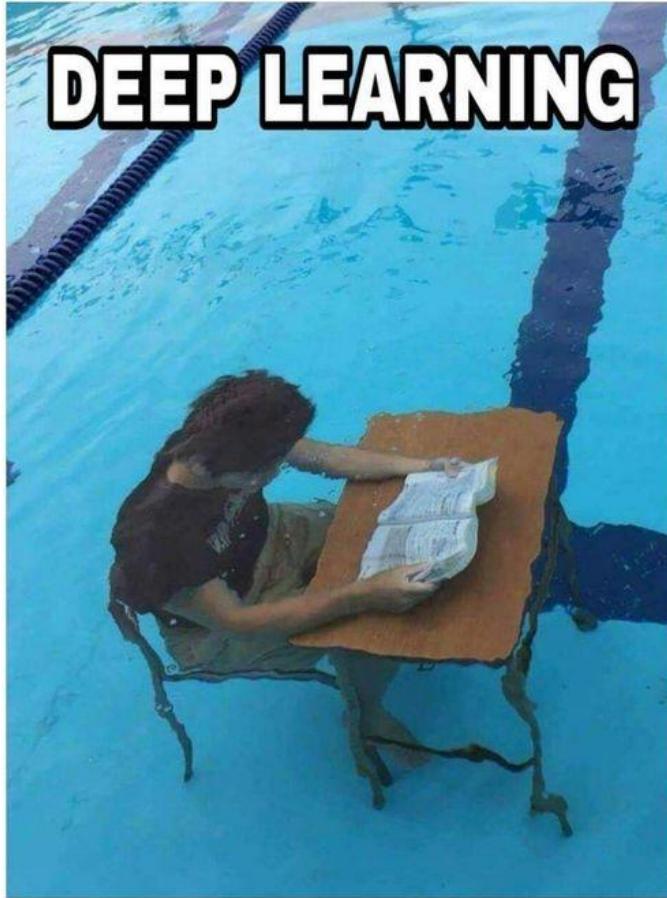
- Excellent Job Perspectives!
  - Automation requires ML/DL -> growth!
  - Top-notch companies will gladly hire you!
- Many industries now:
  - IT-Companies
  - Cars, Logistics, Health Care, etc...
  - Manufacturing / Robotics, etc...

# But: Also Challenging!

- High-level understanding is not enough
  - Need proper theory background
  - Need proper practical skillsets
- Can be competitive!
  - Many good people
  - Downloading scripts / running code not enough ☺
  - Deeper understanding often requires PhDs

# Deep Learning on the Internet

# Deep Learning Memes

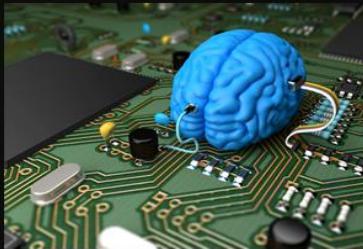


# Deep Learning Memes

## Deep Learning



What society thinks I do



What my friends think I do



What other computer  
scientists think I do



What mathematicians think I do

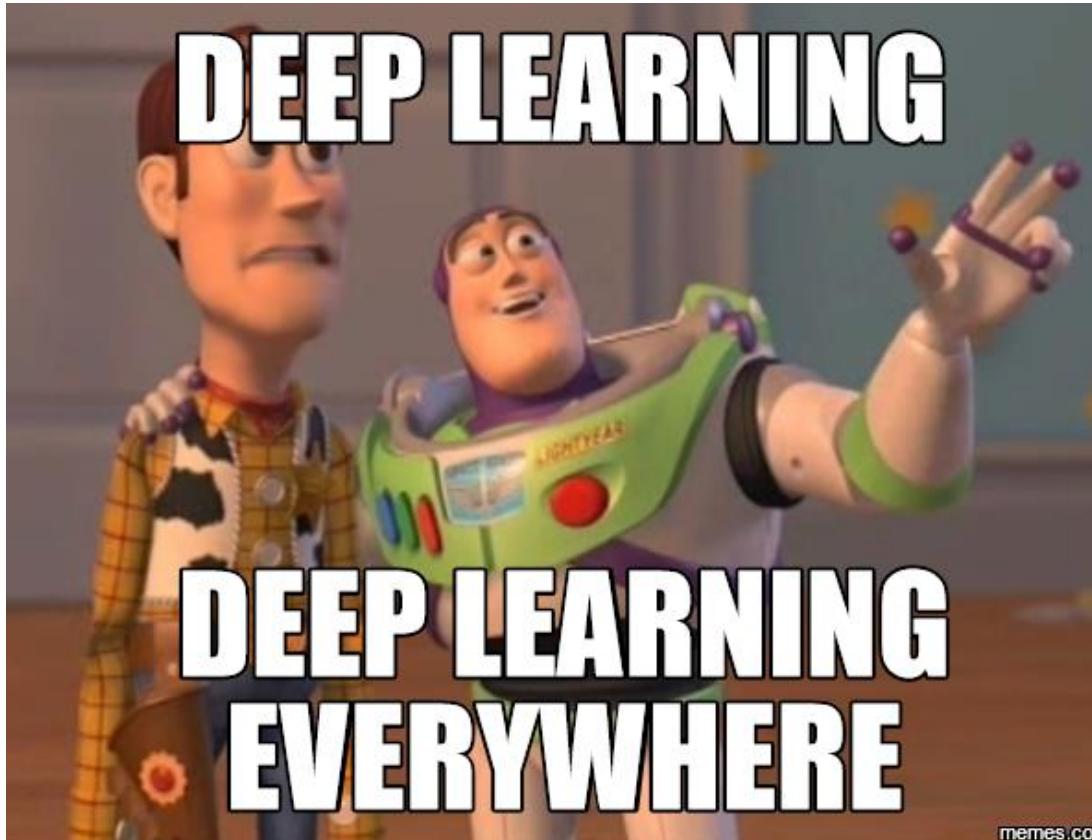


What I think I do

from theano import \*

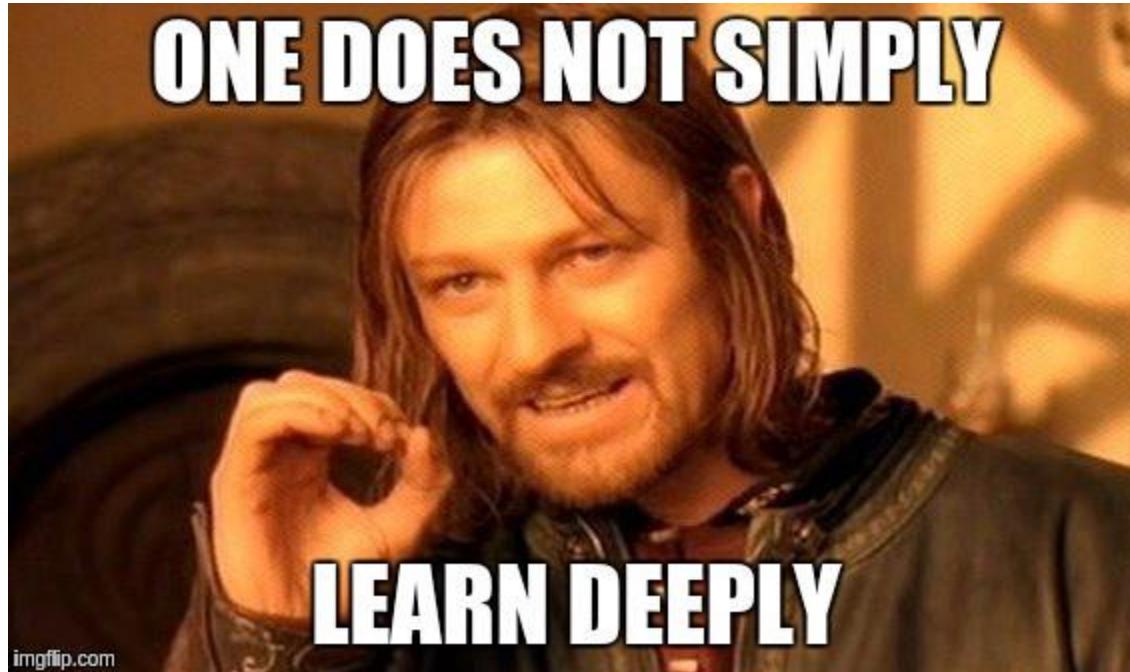
What I actually do

# Deep Learning Memes



memes.com

# Deep Learning Memes

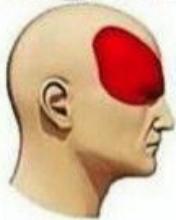


imgflip.com

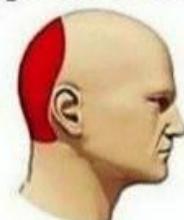
# Deep Learning Memes

## Types of Headaches

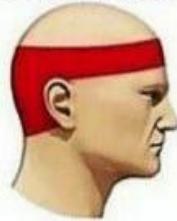
**Migraine**



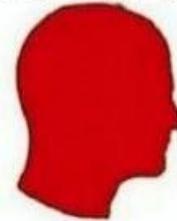
**Hypertension**



**Stress**



**MATH BEHIND DL**



[imgflip.com](http://imgflip.com)

# Deep Learning at TUM

# Many TUM Research Labs use DL

- Visual Computing Lab (Prof. Niessner):
  - Research in computer vision, graphics, and machine learning
- 3D AI Lab (Prof. Dai)
  - Research in 3D perception, 3D scene understanding
- Computer Vision Group (Prof. Cremers)
  - Research in computer vision and pattern recognition
- Data Mining and Analytics Lab (Prof. Günnemann)
  - Research methods for robust machine learning
- Computer Aided Medical Procedures (Prof. Navab)
  - Research in machine learning for medical applications
- And many more ☺

# Our Research Lab

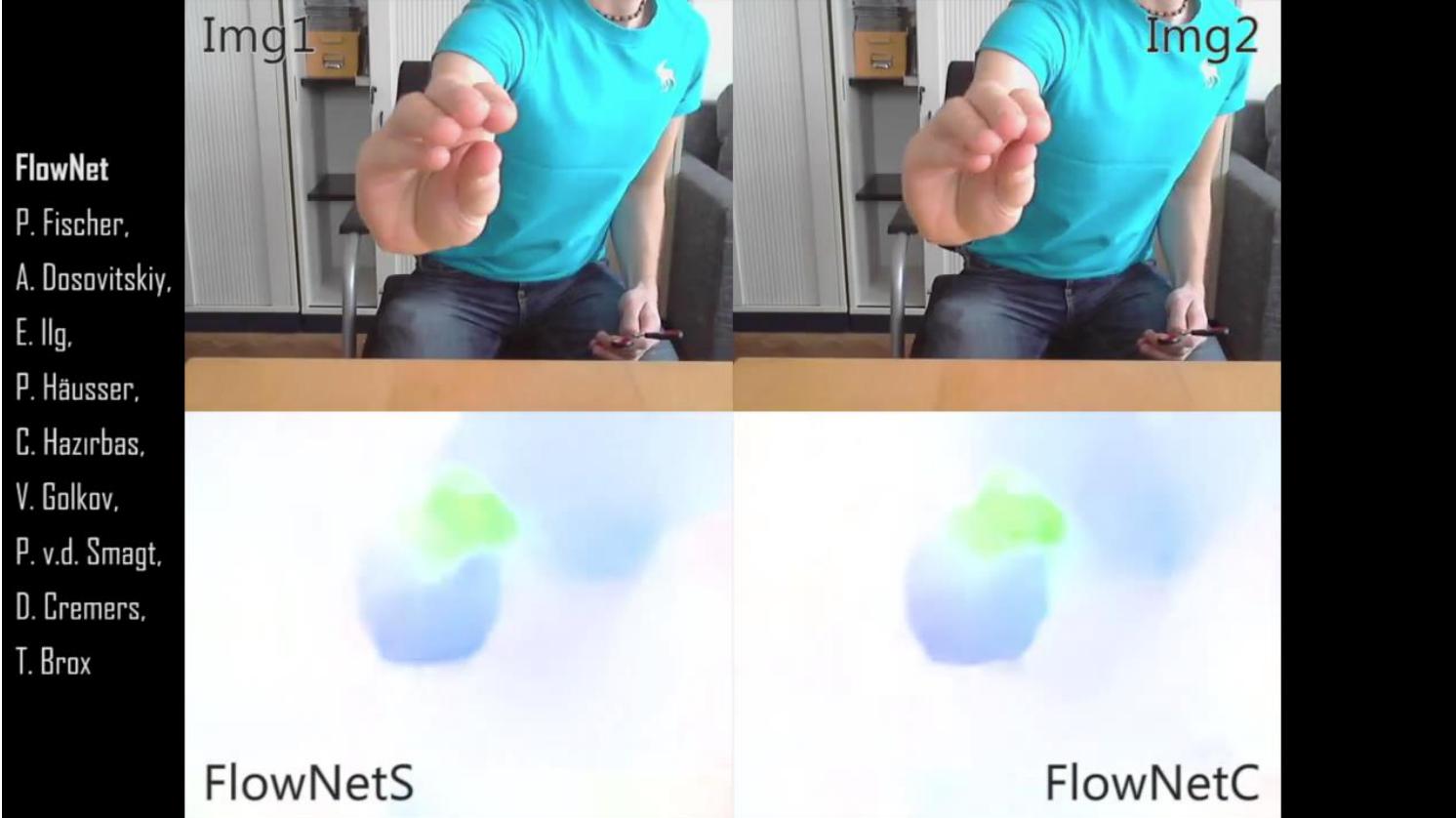
Visual Computing & Artificial Intelligence (Prof. Niessner):

- Website:  
<https://niessnerlab.org/publications.html>
- Twitter:  
<https://twitter.com/MattNiessner>
- Youtube:  
<https://www.youtube.com/channel/UCXN2nYjVTocRgG61RPEzK5Q>

# Deep Learning at TUM



# Deep Learning at TUM

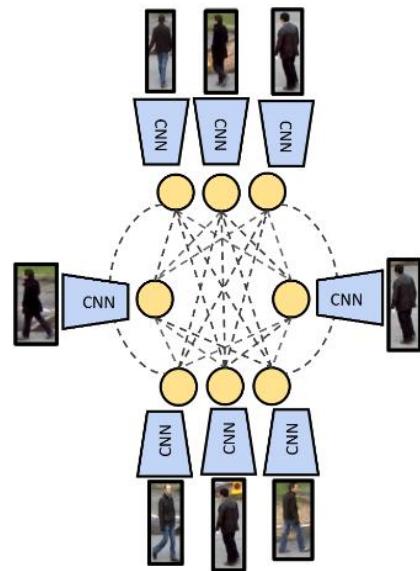


# Deep Learning at TUM

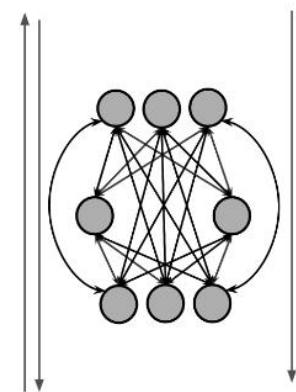
- Multiple object tracking with graph neural networks



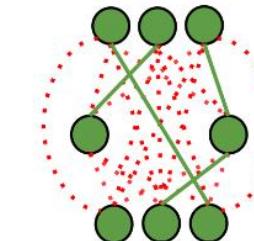
(a) Input



(b) Graph Construction + Feature Encoding



(c) Neural Message Passing



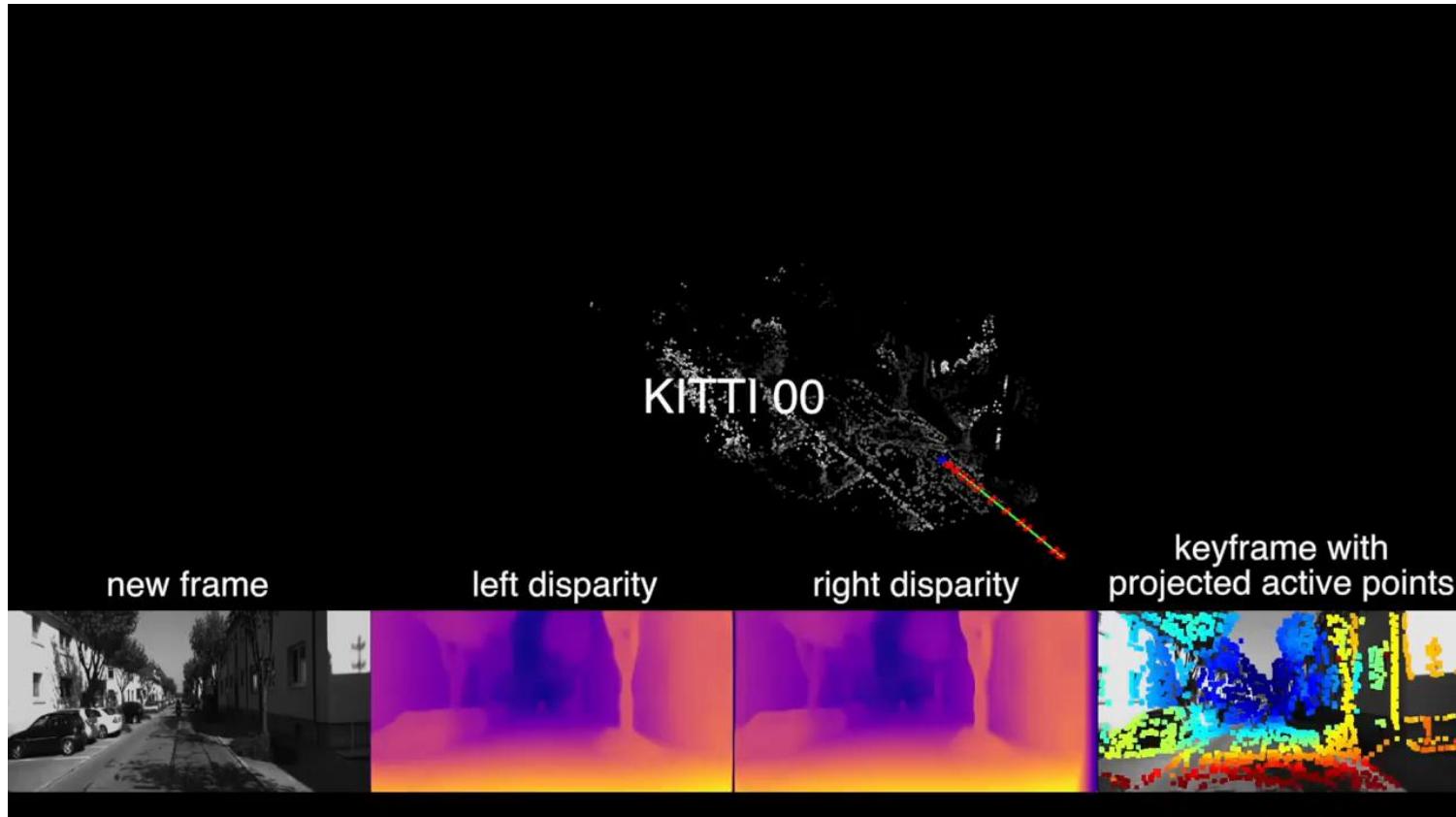
(d) Edge Classification



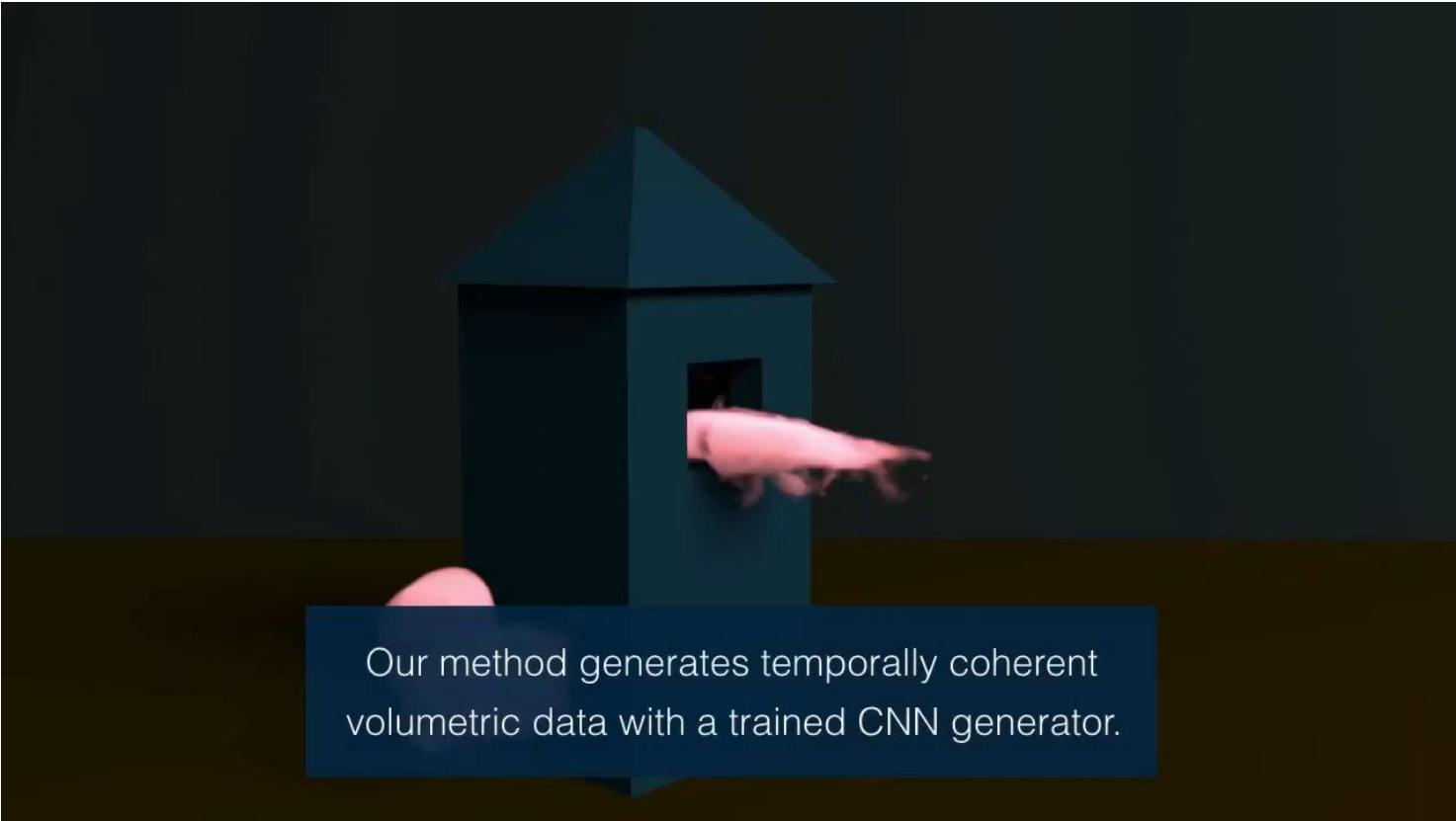
(e) Output

[Brasó and Leal-Taixé, CVPR 2020] Learning a Neural Solver for  
Multiple Object Tracking.

# Deep Learning at TUM



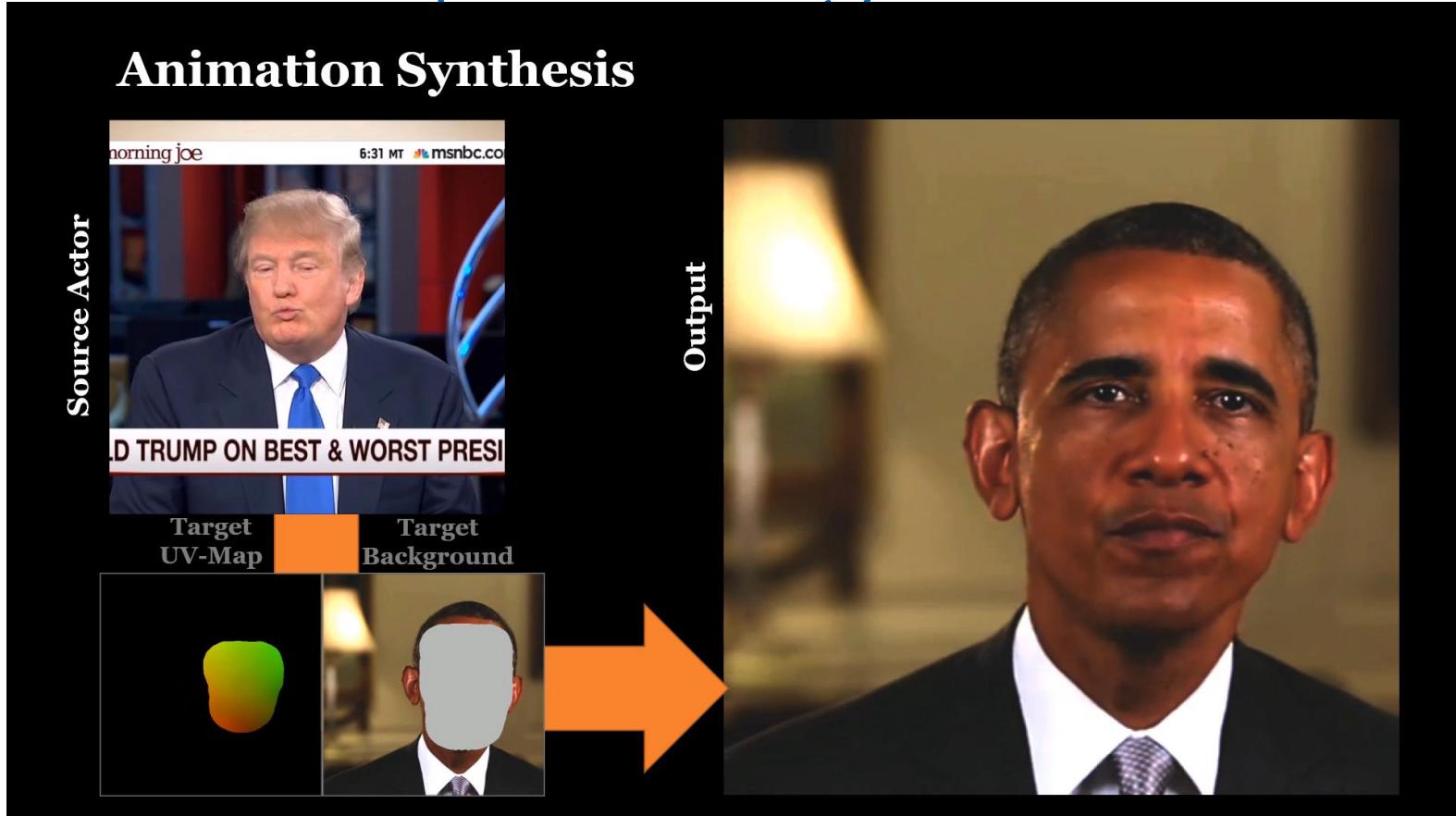
# Deep Learning at TUM



Our method generates temporally coherent  
volumetric data with a trained CNN generator.

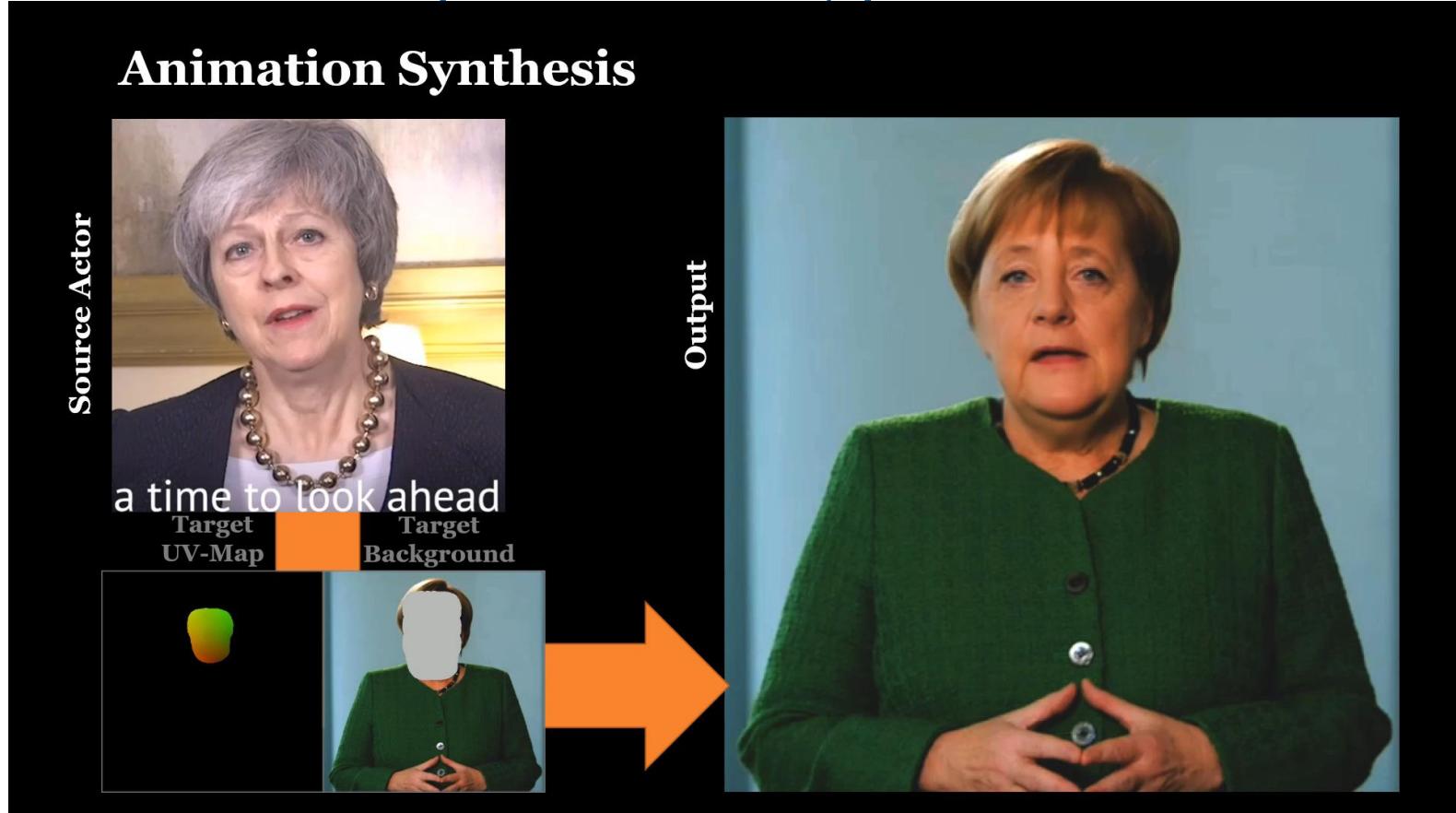
# Deep Learning at TUM

## Animation Synthesis



# Deep Learning at TUM

## Animation Synthesis



# Deep Learning at TUM



Input Video



4D Head Avatar

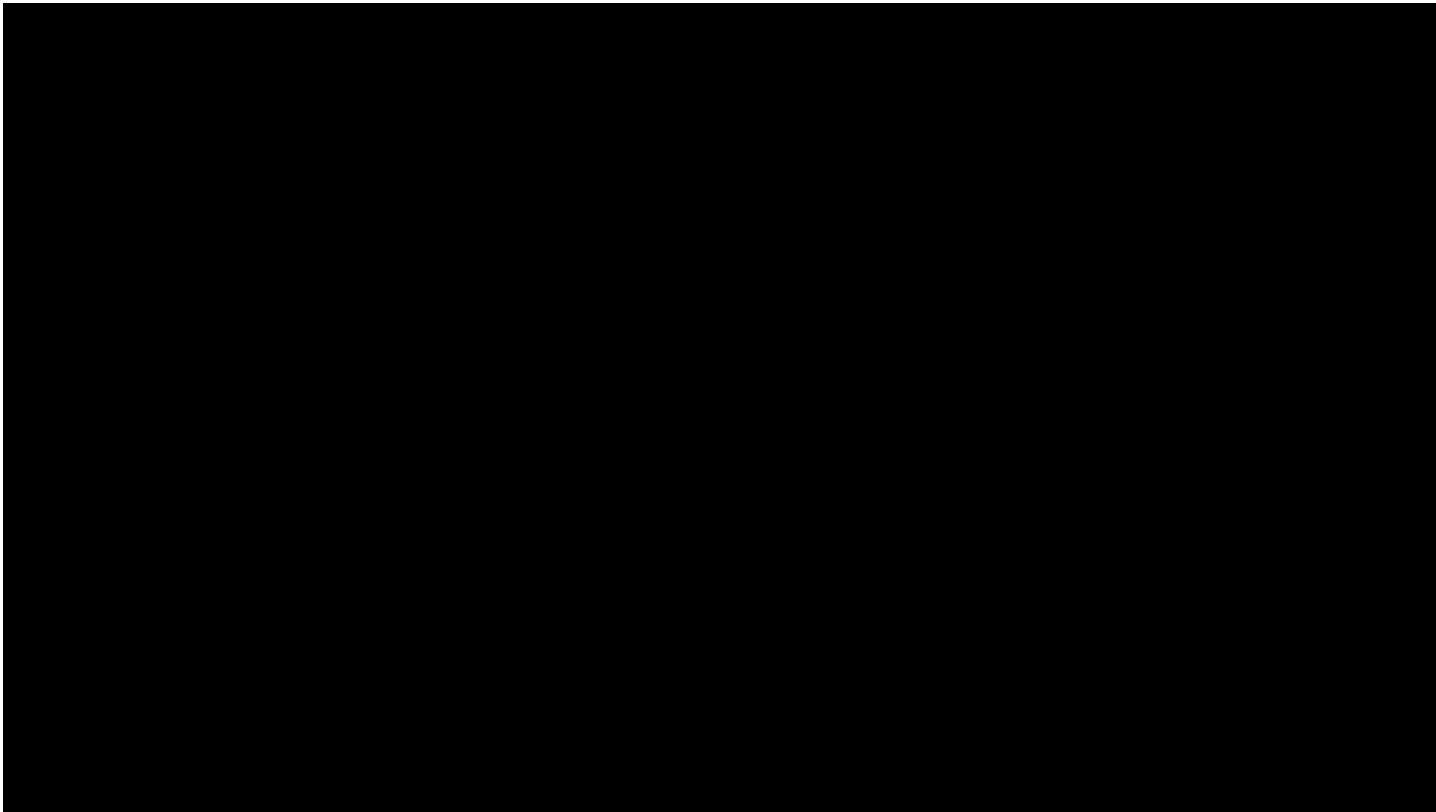
# Deep Learning at TUM

Single RGB Image  $\Leftrightarrow$  Scene Reconstruction



Only single-view training samples

# Deep Learning at TUM



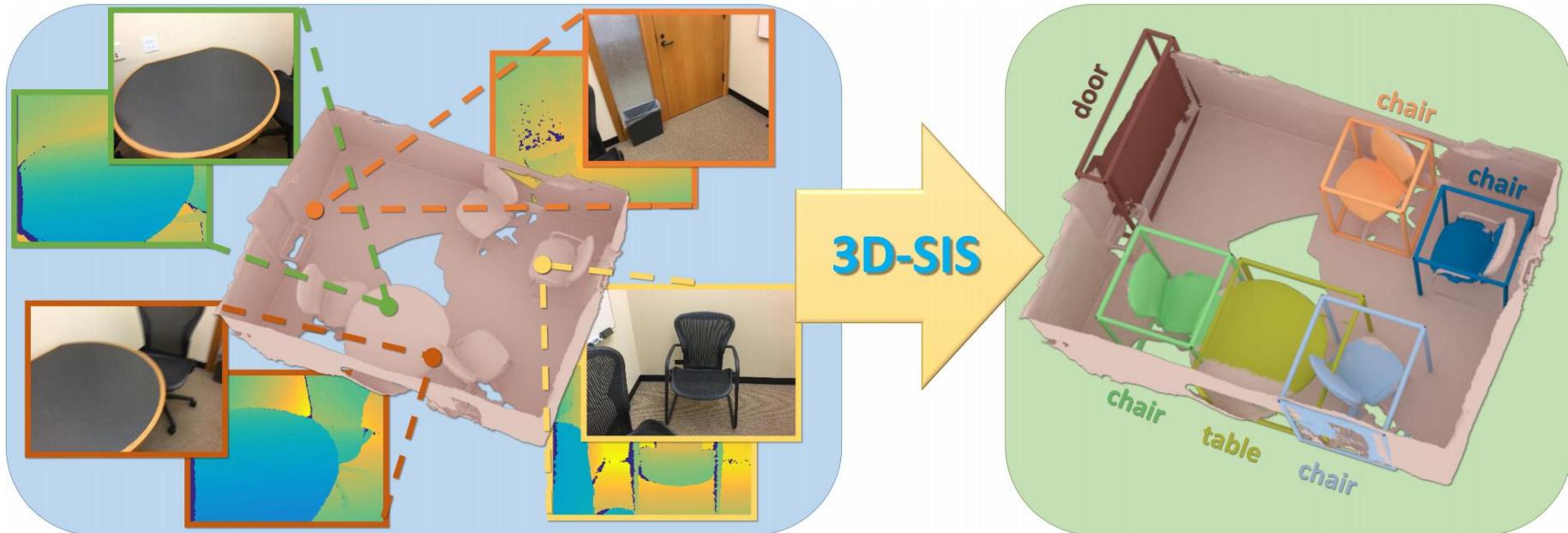
# Deep Learning at TUM



ScanNet Stats:

- Kinect-style RGB-D sensors
- 1513 scans of 3D environments
- 2.5 Mio RGB-D frames
- Dense 3D, crowd-source MTurk labels
- Annotations projected to 2D frames

# Deep Learning at TUM



[Hou et al., CVPR'19] 3D Semantic Instance Segmentation

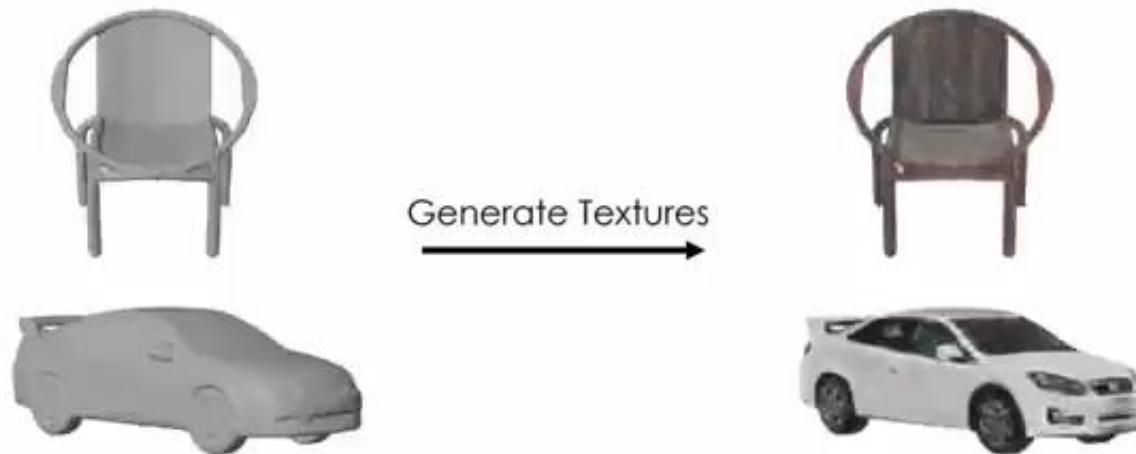
# Deep Learning at TUM

## Input Scan

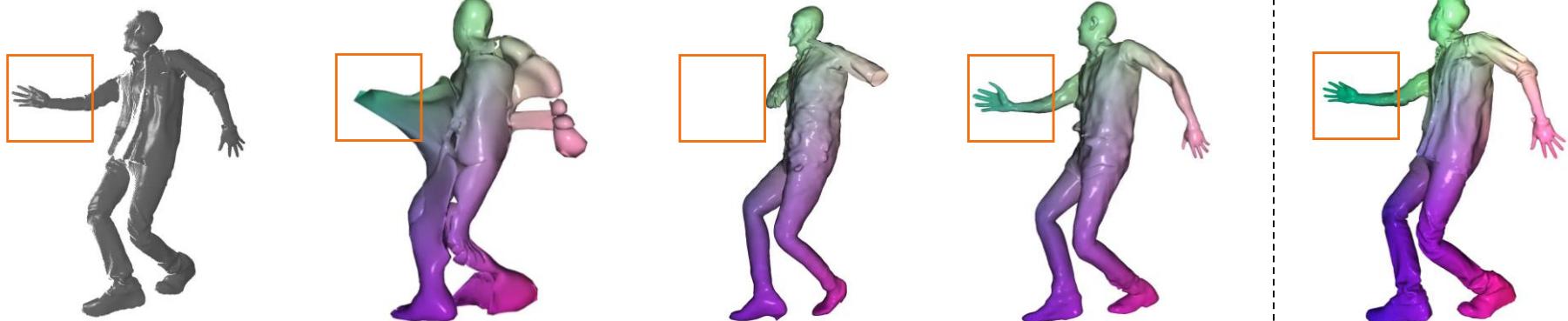


# Deep Learning at TUM

## Texturify



# Deep Learning at TUM



Depth Input  
(lateral view)

IPNet  
[Bhatnagar et al. 2020]

NPMs\*  
[Palafox et al. 2021]

SPAM (Ours)

Ground Truth

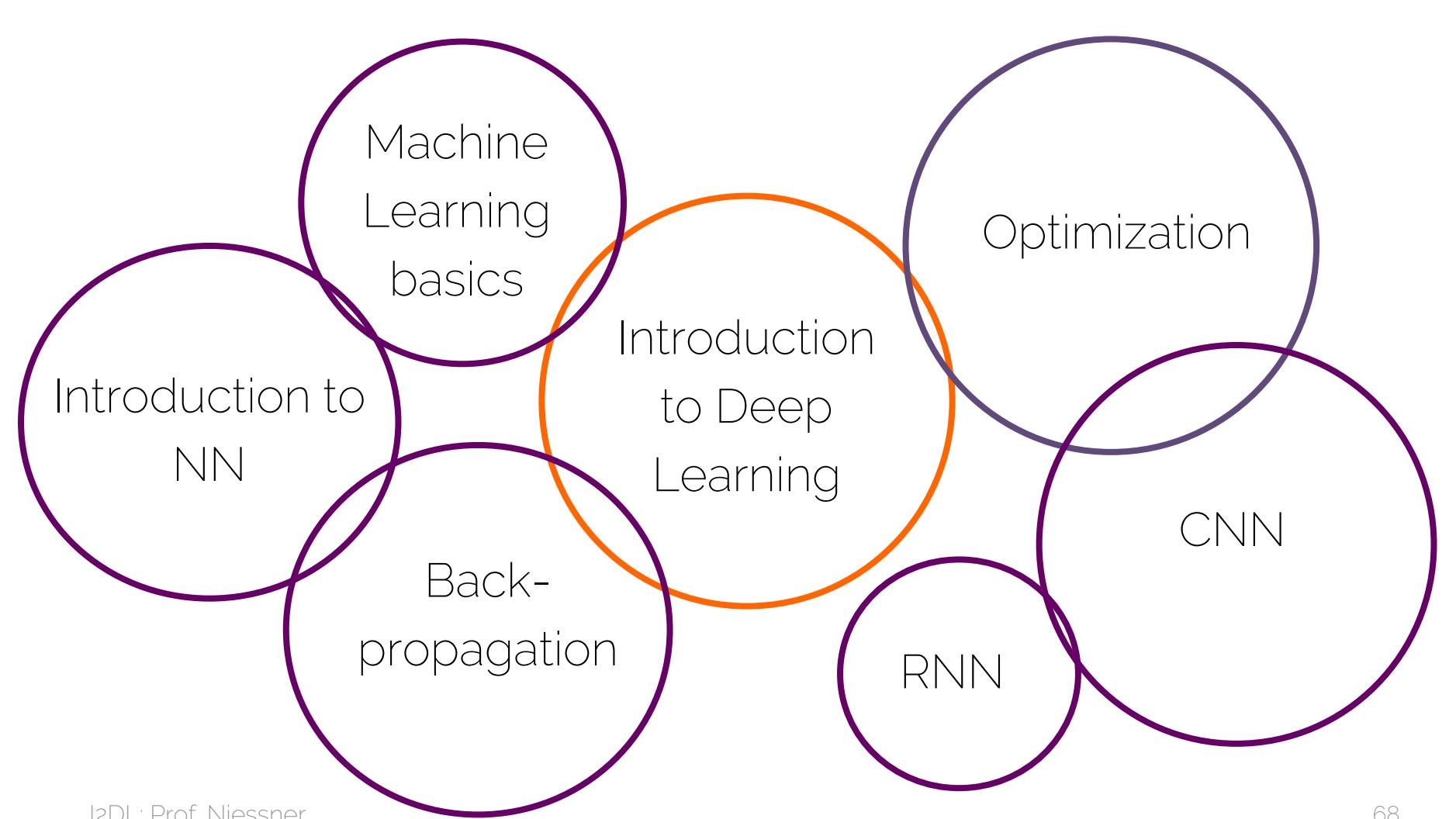
# Deep Learning at TUM

## Reconstruction of Human Heads

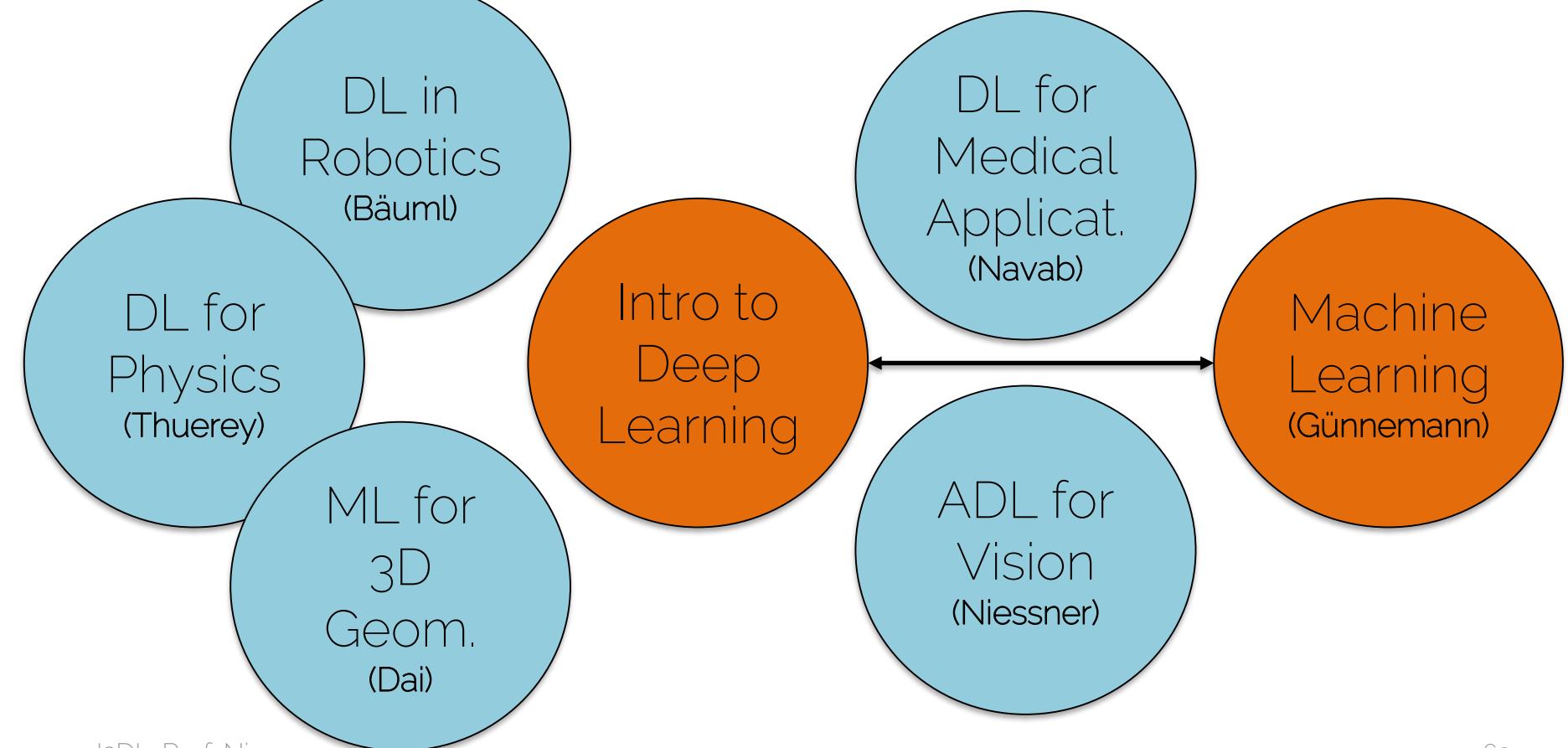


[Kirschstein et al., 23] NerSemble

# Relation to other Lectures at TUM



# Deep Learning at TUM



# Why is I2DL so Important?

- Many of the other lectures / practical require it!
  - Often only limited spots are available (e.g., in the Advanced Deep Learning for Computer Vision Class)
- Solid preparation for guided research / IDP
  - Most topics require it
  - For career in AI/DL these are the best ways to get into

# Introduction to Deep Learning

## Logistics

# The Team

Lecturer



Matthias  
Niessner

PhDs



Manuel Dahnert



Yujin Chen



Guy Gafni

# About the Lecture

- Theory lectures
- Lectures are online and will be released every Tuesday on Piazza and the lecture webpage  
<https://niessner.github.io/I2DL/>
- Practical exercises (see later slides)
  - Released every Thursday, 13:00
  - Tutorial: Online videos posted to Piazza and the webpage
  - Programming exercises
- Guest lecture!

# Preliminary Syllabus

Lecture 1: Introduction to the lecture, Deep Learning, Machine Learning.

Lecture 2: Machine Learning Basics, Linear regression, Maximum Likelihood

Lecture 3: Introduction to Neural Networks, Computational Graphs

Lecture 4: Optimization and Backpropagation

Lecture 5: Scaling Optimization to large Data, Stochastic Gradient Descent

Lecture 6: Training Neural Networks I

Lecture 7: Training Neural Networks II

Lecture 8: Training Neural Networks III

Lecture 9: Introduction to CNNs

Lecture 10: CNNs architectures;

Lecture 11: Recurrent Neural Networks (RNNs)

Lecture 12: Advanced Deep Learning architectures

Guest Lecture

# Moodle → Piazza

- Announcements via Piazza - **IMPORTANT!**
  - Sign up online for access: <http://piazza.com/tum.de>
    - Select “**Summer 2023**” term, search for IN2346
    - Use your @mytum.de email address
  - We will share common information (e.g., regarding exam)
- Forum
  - Ask and discuss questions
    - Tutors will monitor and answer questions
    - You are very welcome to actively participate
  - Please do not post solutions of the exercises
  - You can post private question visible only to the staff

# Website

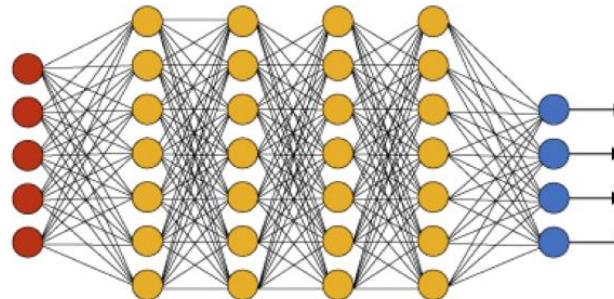
- Links and slides will be shared on website



Visual Computing Group  
Prof. Matthias Nießner

Home Publications Teaching Openings Team Contact

## Introduction to Deep Learning (I2DL) (IN2346)



Welcome to the Introduction to Deep Learning course offered in SoSe23.

<https://niessner.github.io/I2DL/>

# Email

- Email list:

i2dl@vc.in.tum.de

- Do NOT email us personally!
  - Cannot handle so many emails / hence will be ignored
- Email list for organizational questions only!
  - Content questions -> Piazza or Office Hours
  - Or post the question/issue in a private thread on Piazza

# (Virtual) Office Hours

- We will have dedicated office hours regarding
  - Theoretical help (e.g., specific lecture questions)
  - Help on exercises
- More info in the first tutorial session
- Zoom links will be posted on Piazza

# Exam FAQ

- Final Exam: TBA
- Content: Lecture & exercises
- Important: No retake exam (I2DL is taught every semester)
- Grade Bonus:
  - Solve 8 out of 9 “non-optional” practical exercises
  - Bonus 0.3 on a **passed** final exam
  - Bonus is transferable from previous and future semesters

# Other Administrative

- "External" students welcome (LMU, TUM PhD)
  - Fill out registration form and we will add you to the course
  - Will get Certificate / Schein at the end
- Again:
  - Check announcements on piazza
  - Check content on website:  
<https://niessner.github.io/I2DL/>

# Upcoming Lecture

- Next Lecture: Lecture 2: Machine Learning basics
- Thursday: Tutorial 1 and Exercise 1

See you next time 😊