

Introduction to Deep Learning

The Team

Lecturer



Prof. Angela
Dai

PhDs



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Student Teaching Assistants



Dan Halperin



Wei Cao



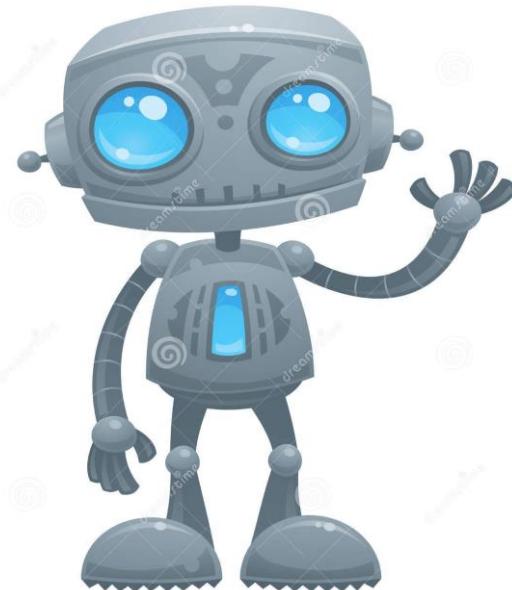
Haoxuan Li



Erik Traise

What is Computer Vision?

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



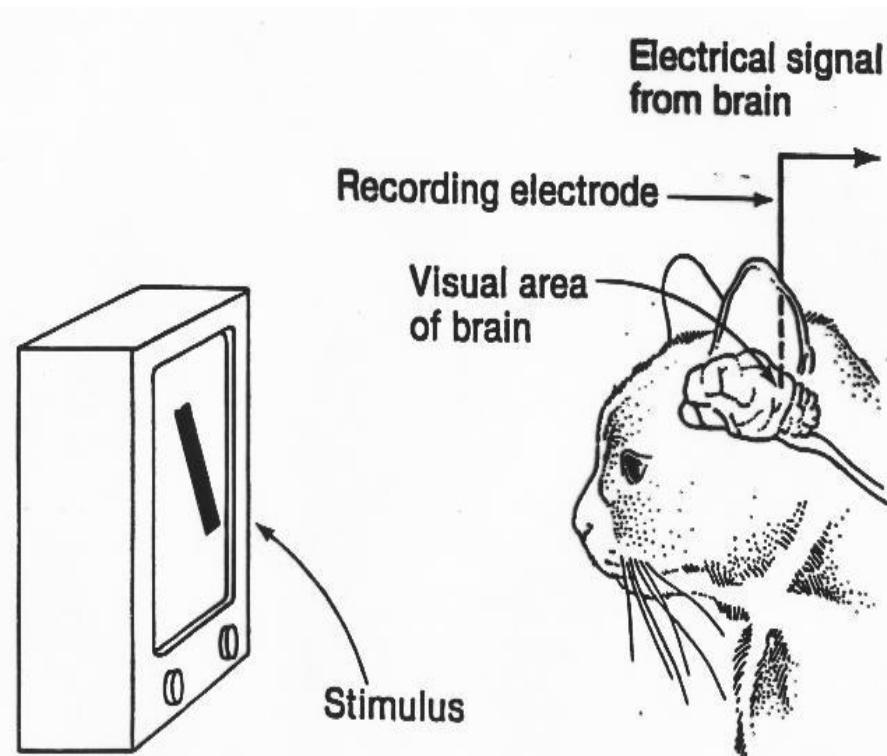
Hubel and Wiesel

- 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.

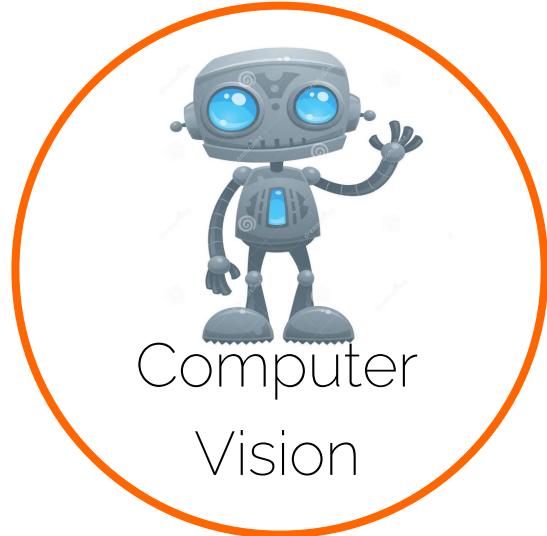
July 7, 1966

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...



Engineering

Mathematics

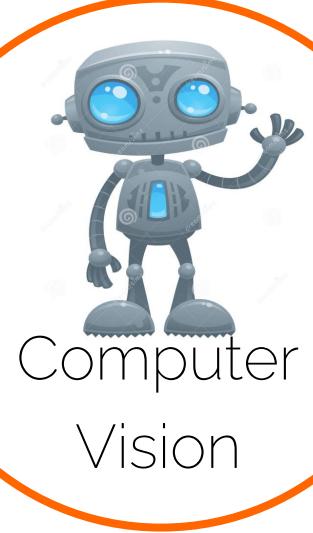
Computer
science

Robotics

NLP
Speech

Optics
Image
processing

Physics



Artificial
Intelligence
ML

Algorithms
Optimization

Neuroscience

Biology

Psychology

Image Classification

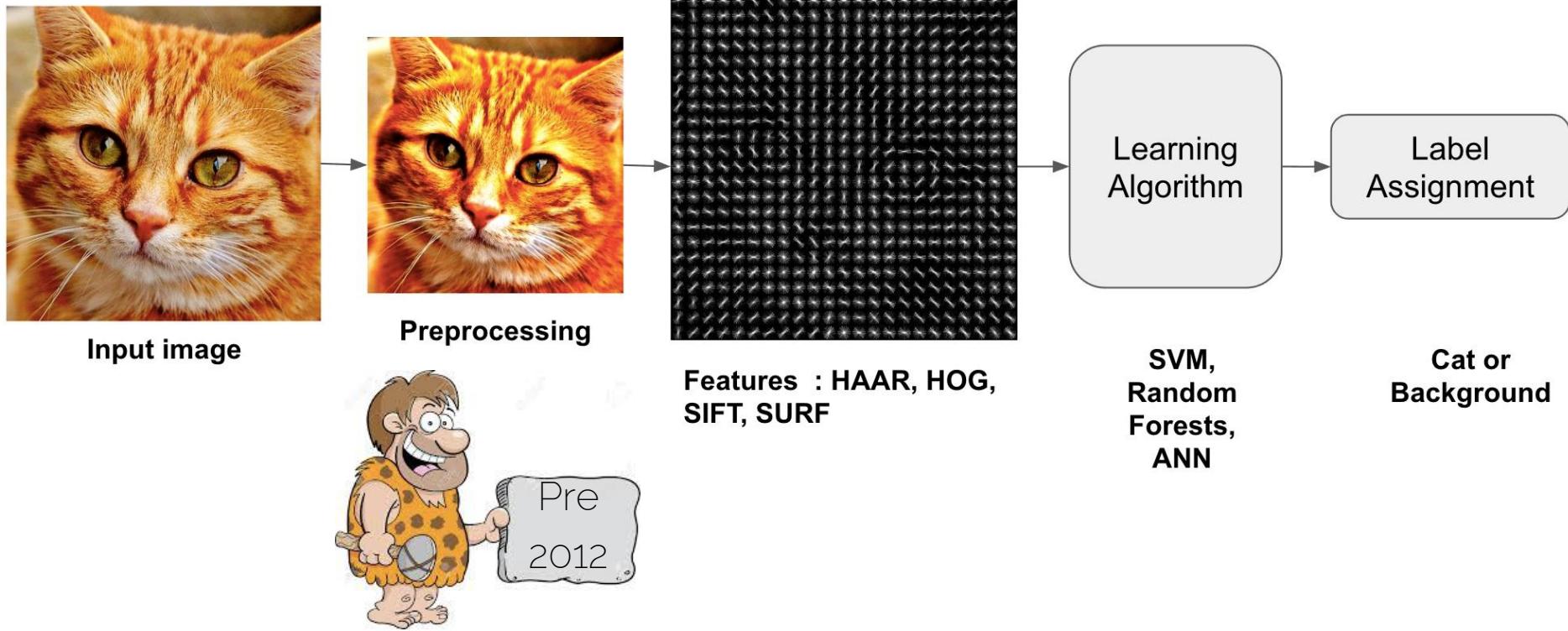


Image Classification



Input image



Awesome
magic box



Label
Assignment



Open the box

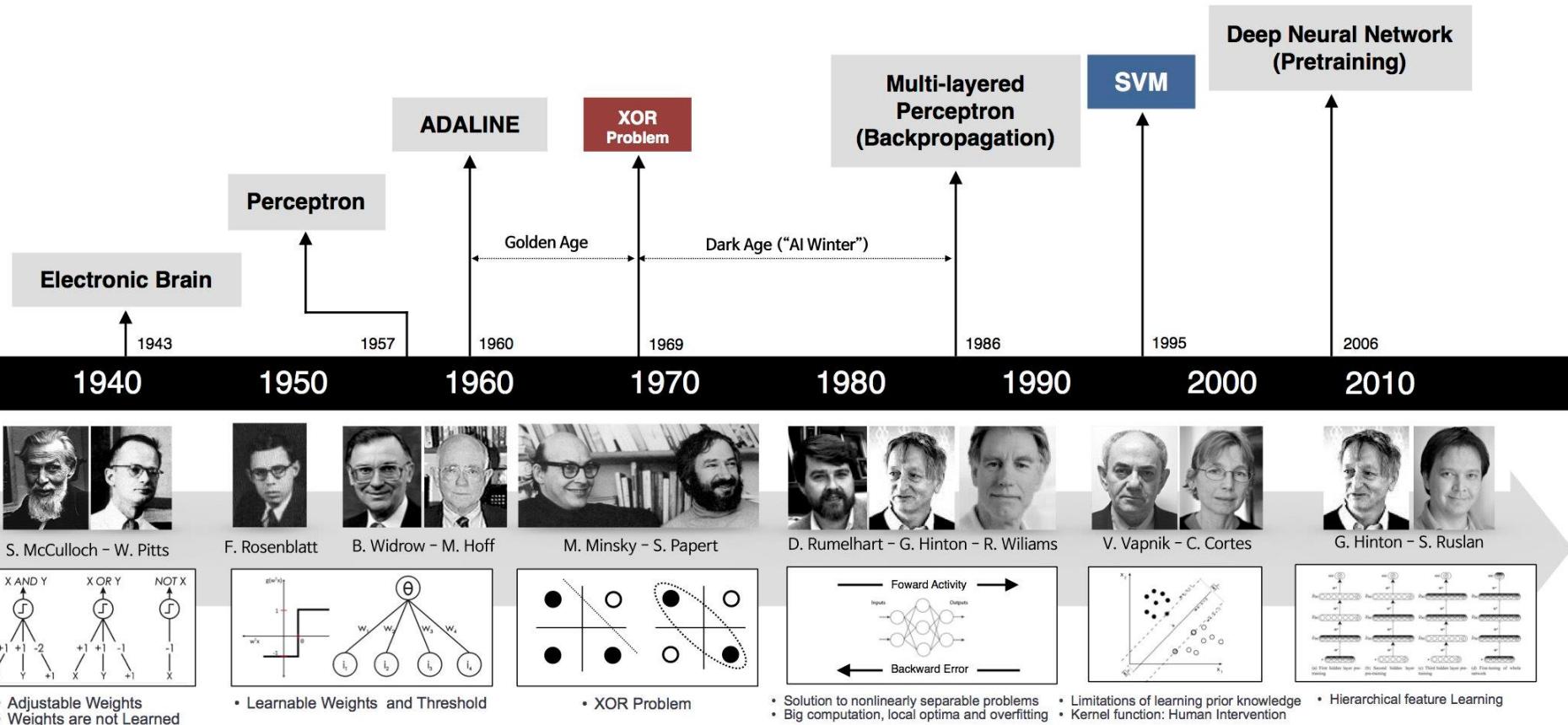


Become magicians

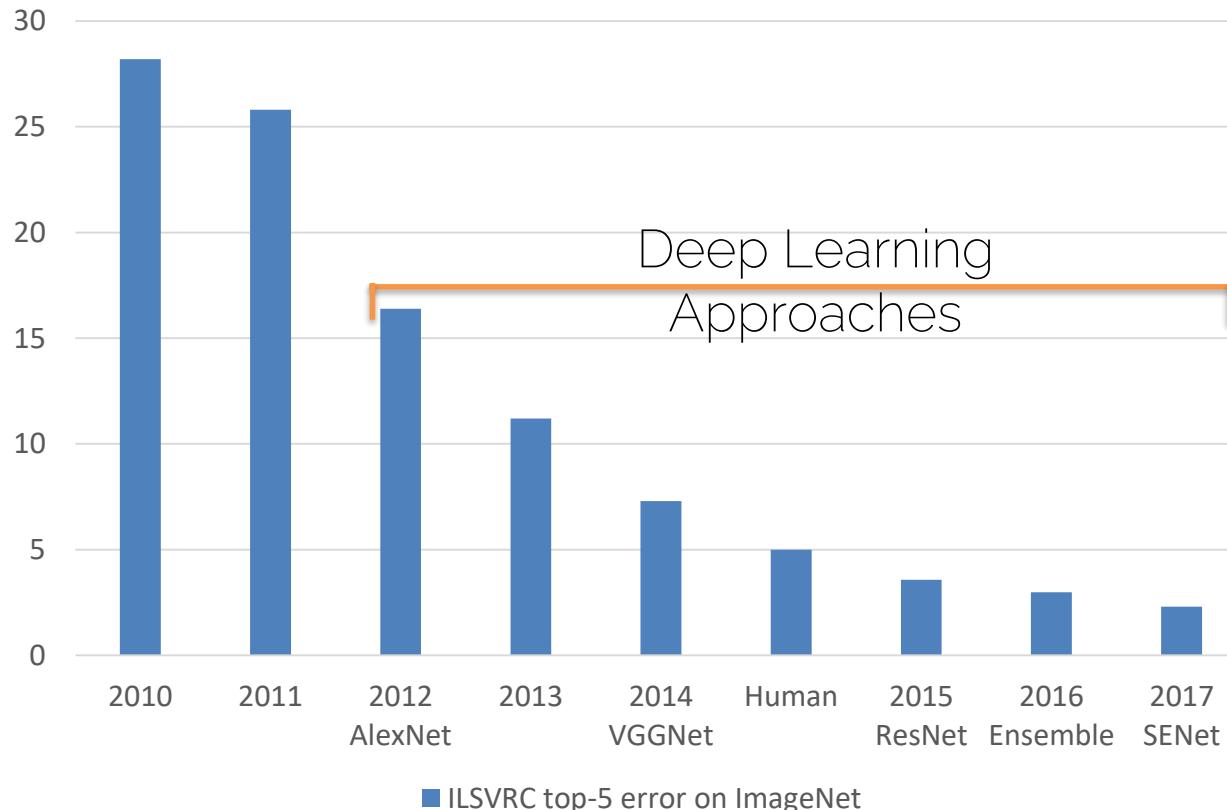
Cat or
Background

Why Deep Learning?

Deep Learning History

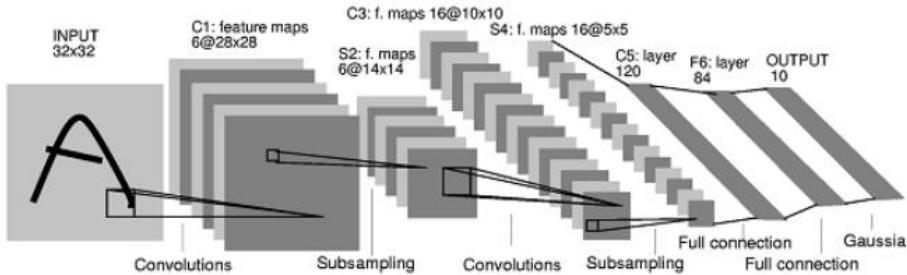


The Empire Strikes Back



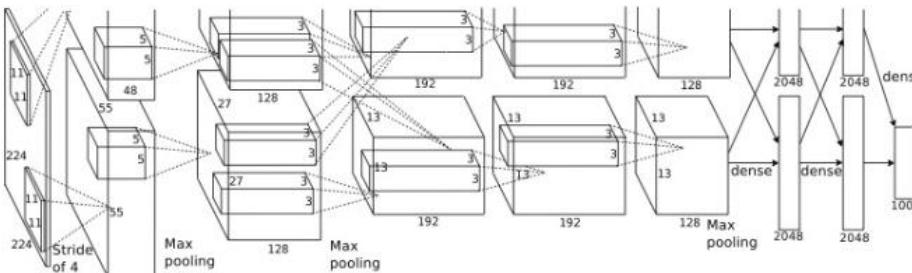
What Has Changed?

1998
LeCun
et al.



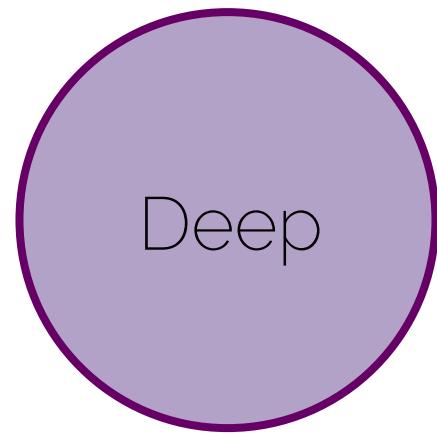
- MNIST digit recognition dataset
- 10^7 pixels used in training

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

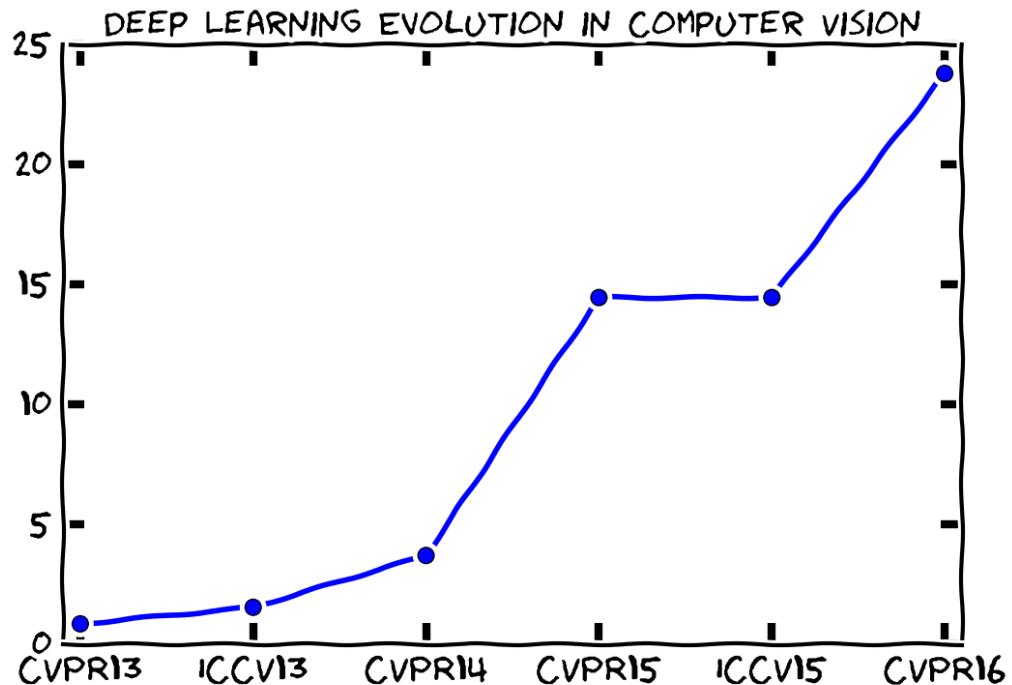
Models are
complex

Deep Learning Recognition



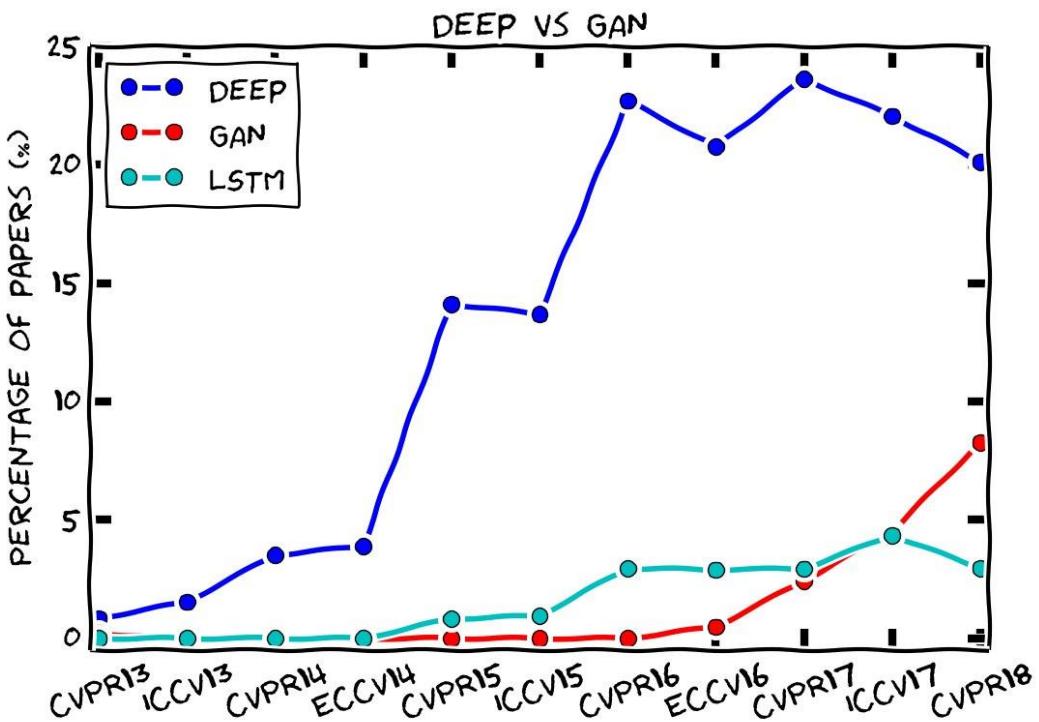
ACM Turing Award 2019 (Nobel Prize of Computing)
Yann LeCun, Geoffrey Hinton, and Yoshua Bengio

Deep Learning and Computer Vision



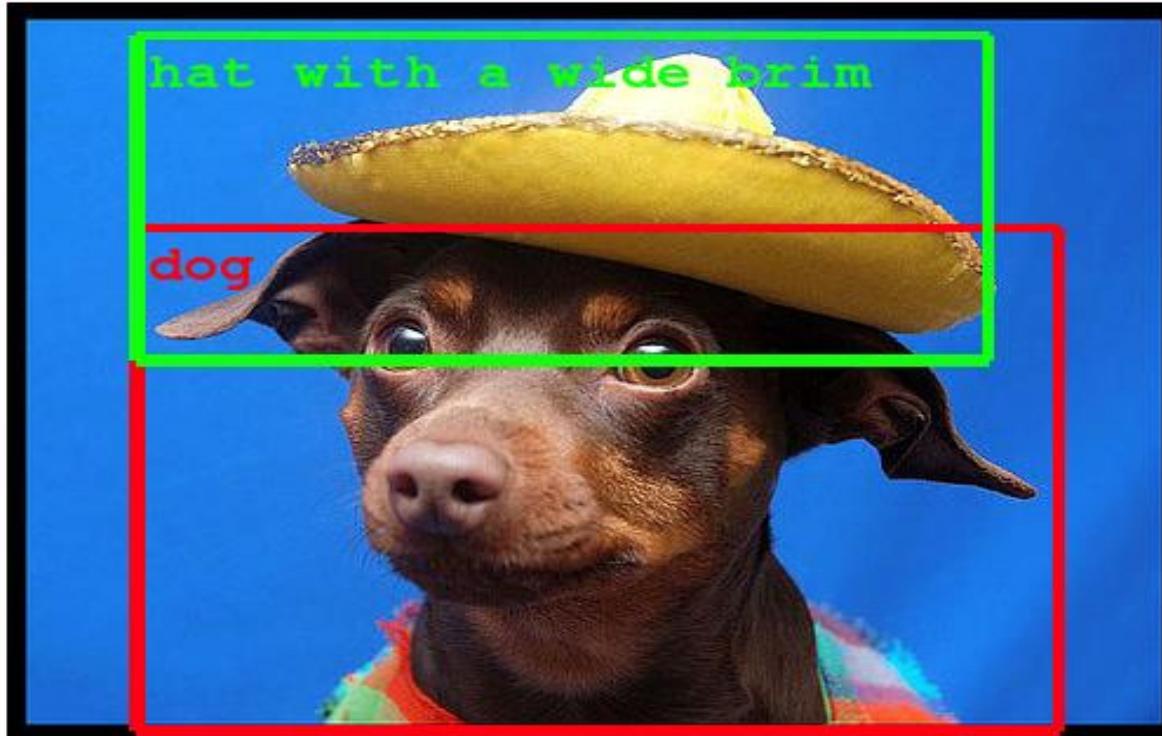
Credits: Dr. Pont-Tuset, ETH Zurich

Deep Learning and Computer Vision



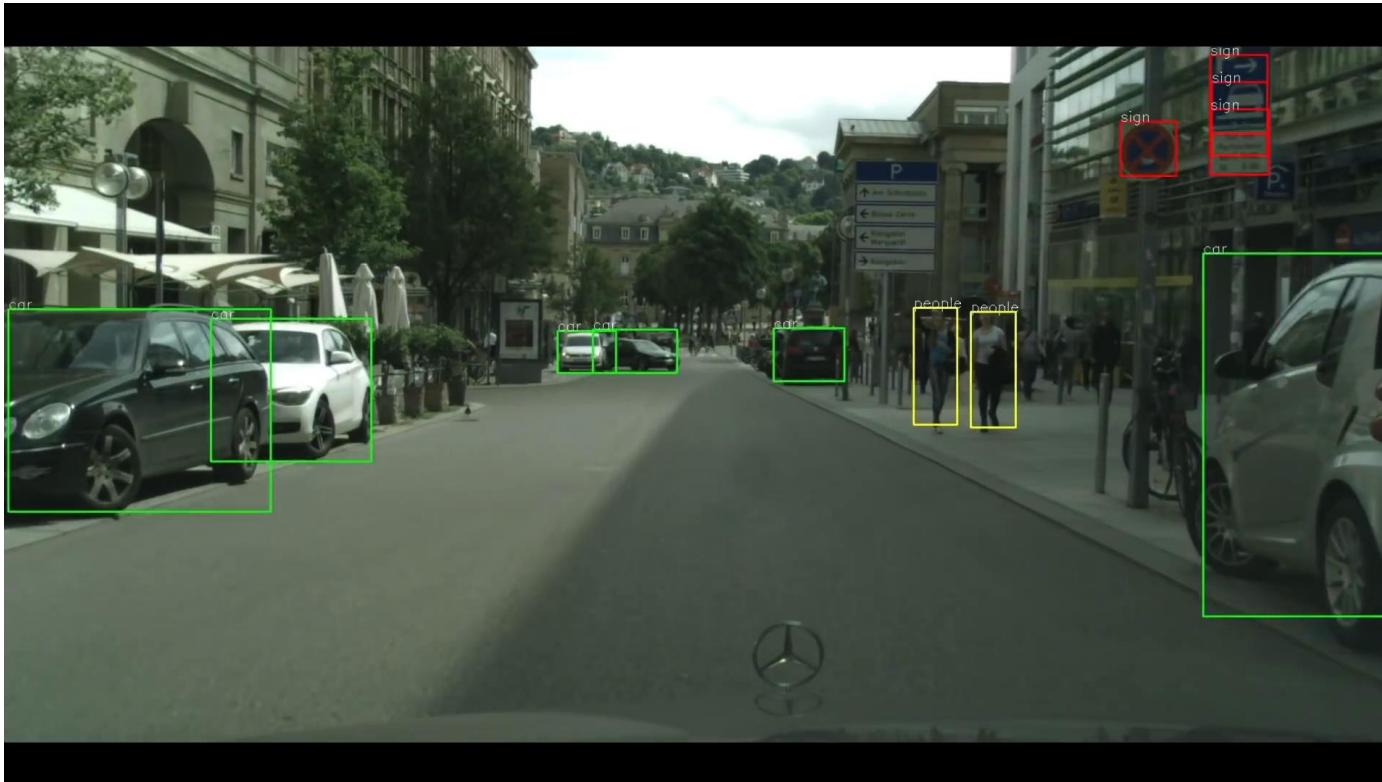
Credits: Dr. Pont-Tuset, ETH Zurich

Deep Learning Today



Object Detection

Deep Learning Today



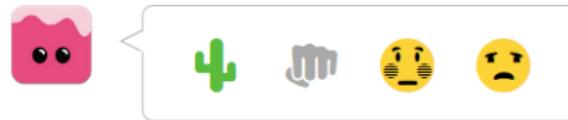
Self-driving cars

Deep Learning Today



AlphaGo

ever punch a cactus?

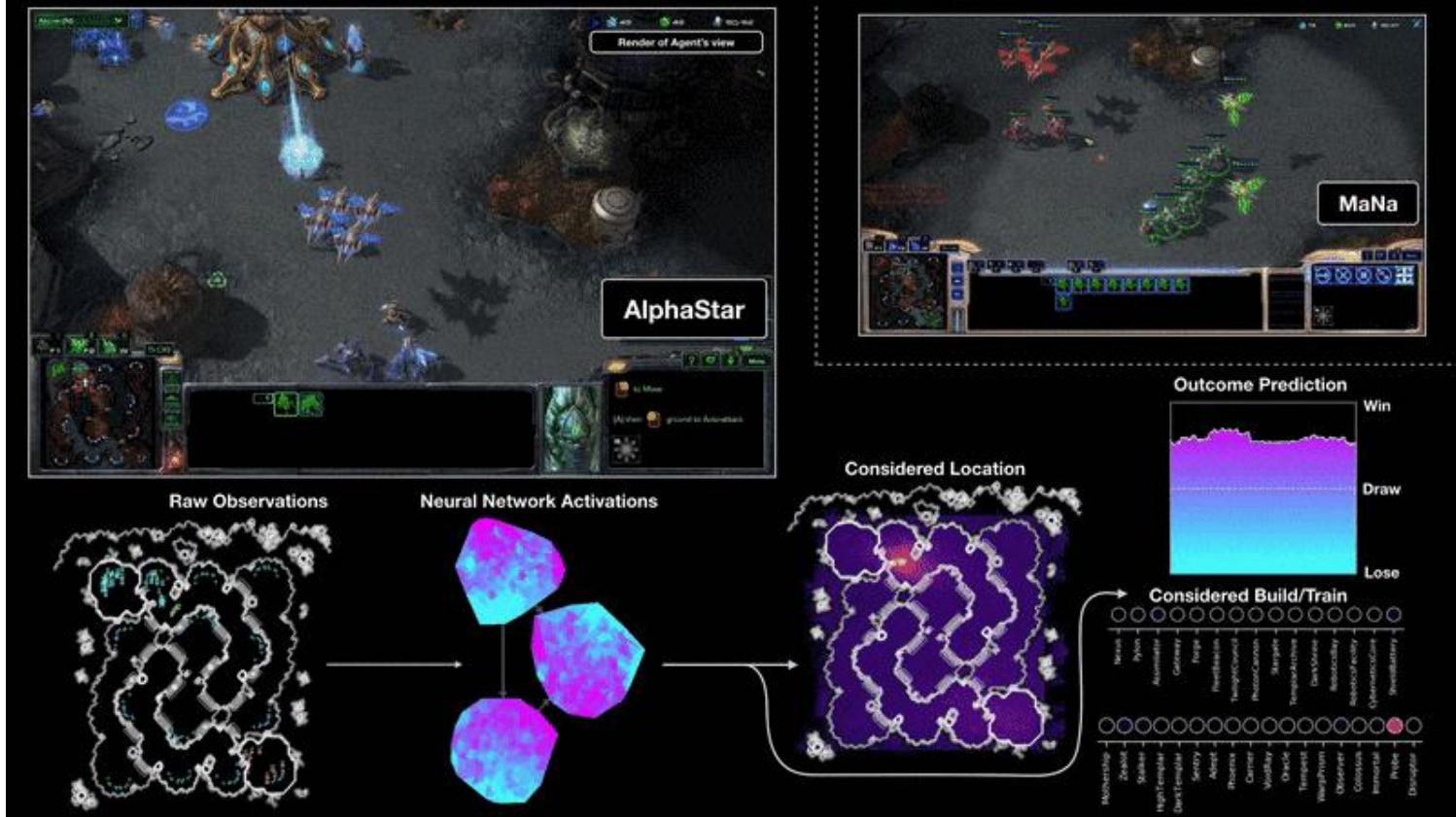


Emoticon suggestion

A screenshot of a machine translation interface. On the left, the English input "Deep Learning rocks" is shown with a "detected" status, a microphone icon, a speaker icon, and a refresh icon. On the right, the German output "Deep Learning Felsen" is shown with a speaker icon. Both inputs and outputs have a small square icon above them.

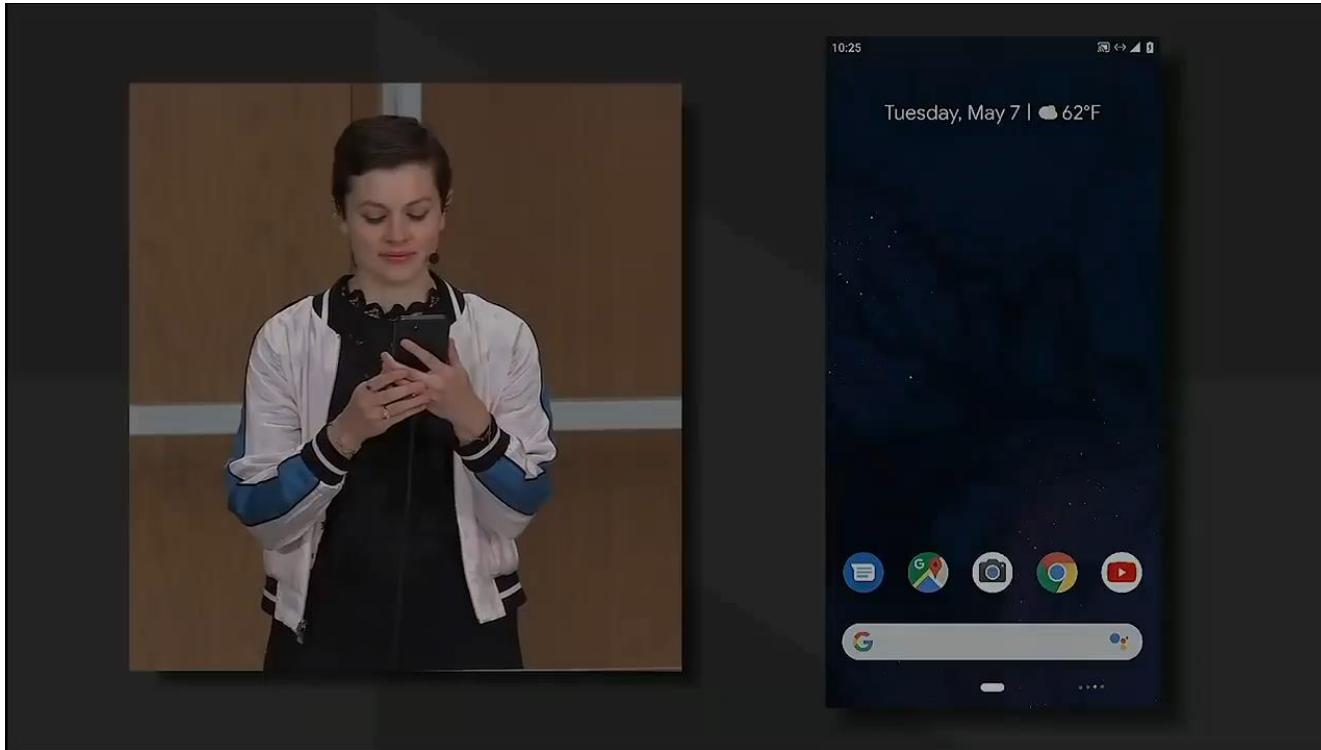
Machine translation

Deep Learning Today



Alpha Star

Deep Learning Today



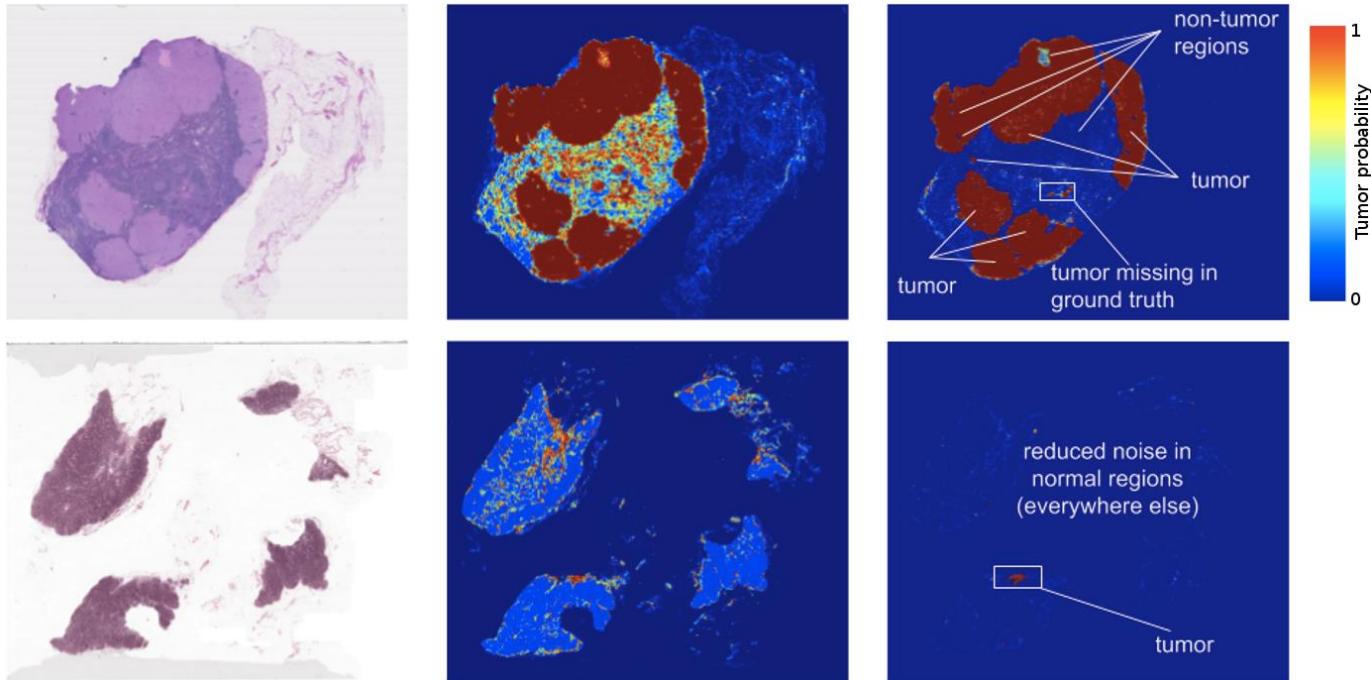
Google Assistant (Google IO'19)

Deep Learning Today



Google LaMDA (Google IO'22)

Deep Learning Today



Healthcare, cancer detection

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

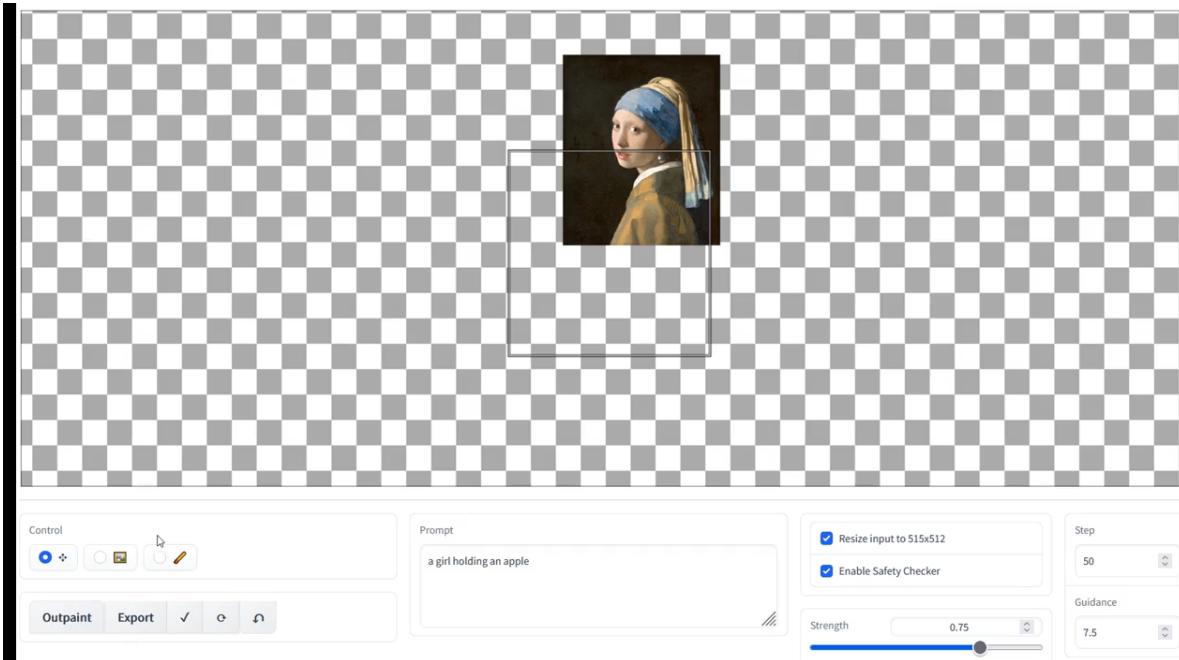
Generate image



StableDiffusion Image generation from text

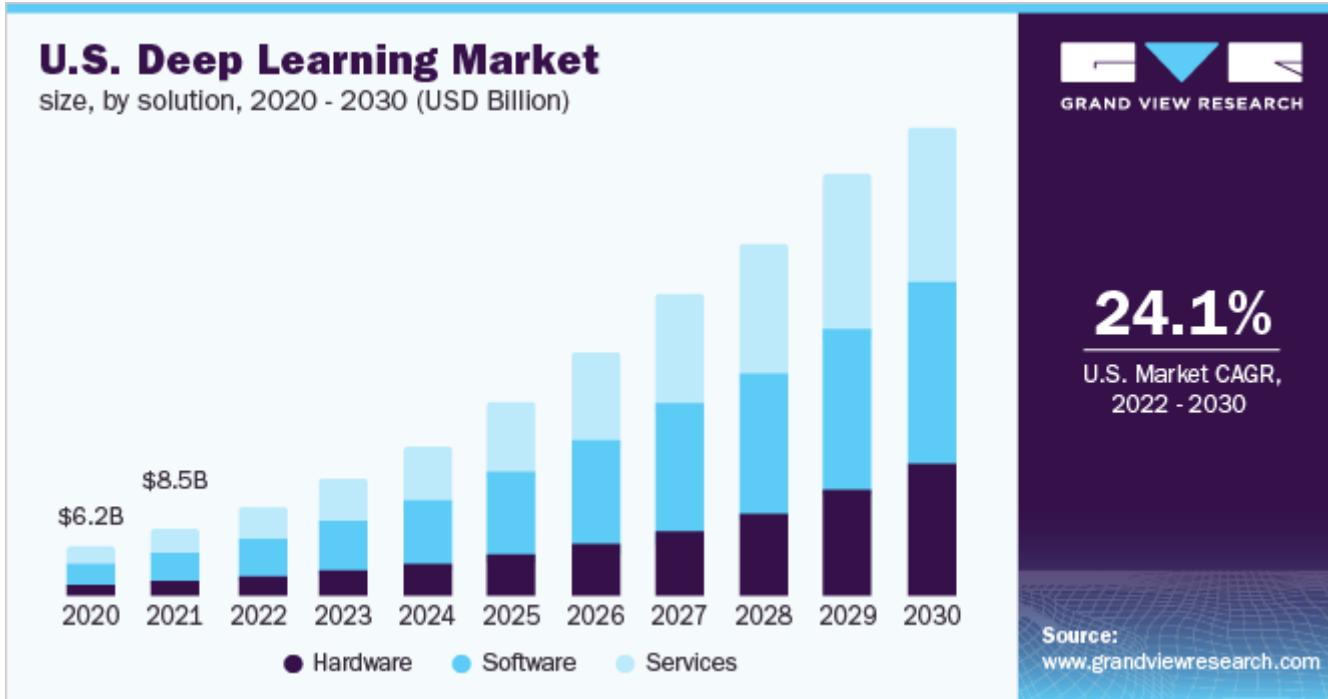
<https://huggingface.co/spaces/stabilityai/stable-diffusion>

Deep Learning Today



StableDiffusion Image Outpainting

Deep Learning 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

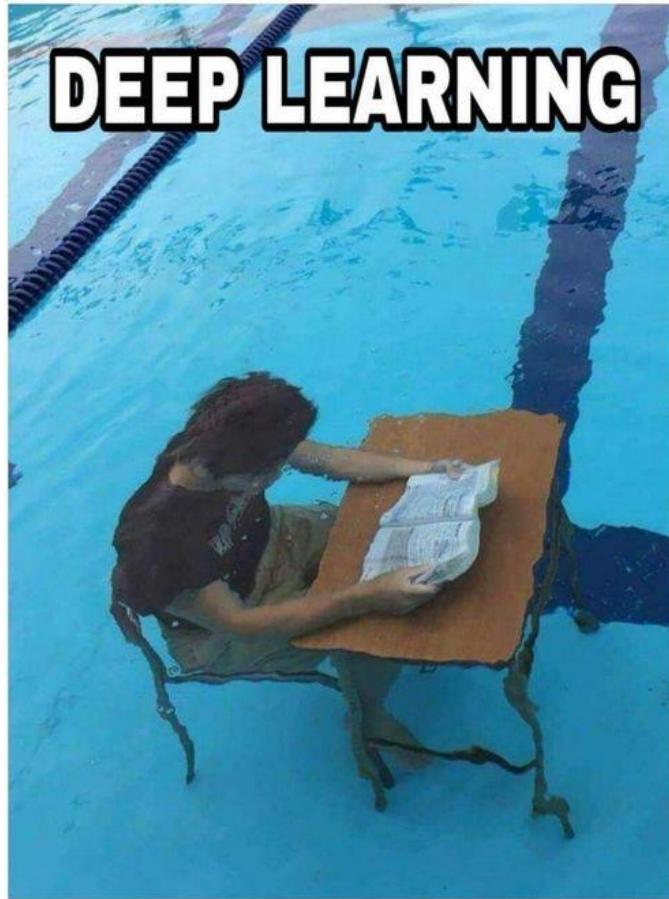
- Excellent Job Perspectives!
 - Automation requires ML/DL -> growth!
 - Top-notch companies will gladly hire you!
- Many industries now:
 - IT-Companies
 - Cars, Logistics, Health Care, etc...
 - Manufacturing / Robotics, etc...

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

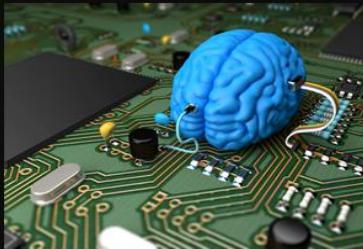


Deep Learning Memes

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

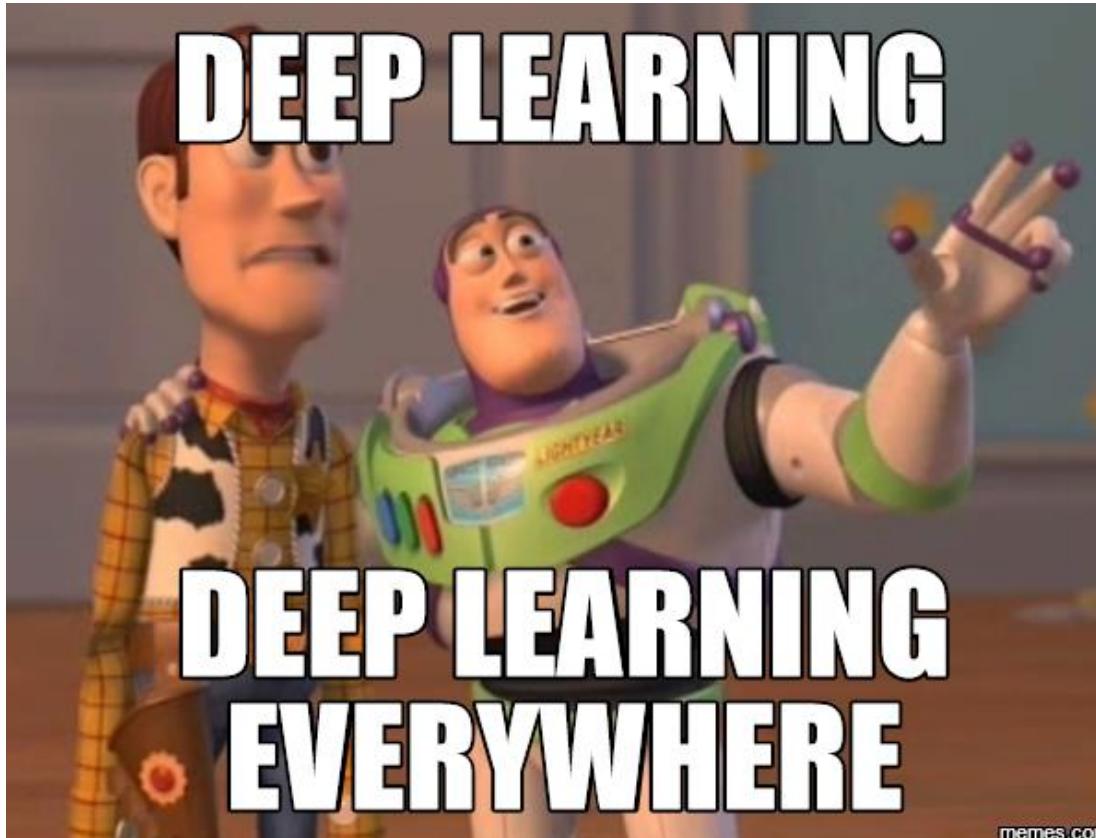


What I think I do

from theano import *

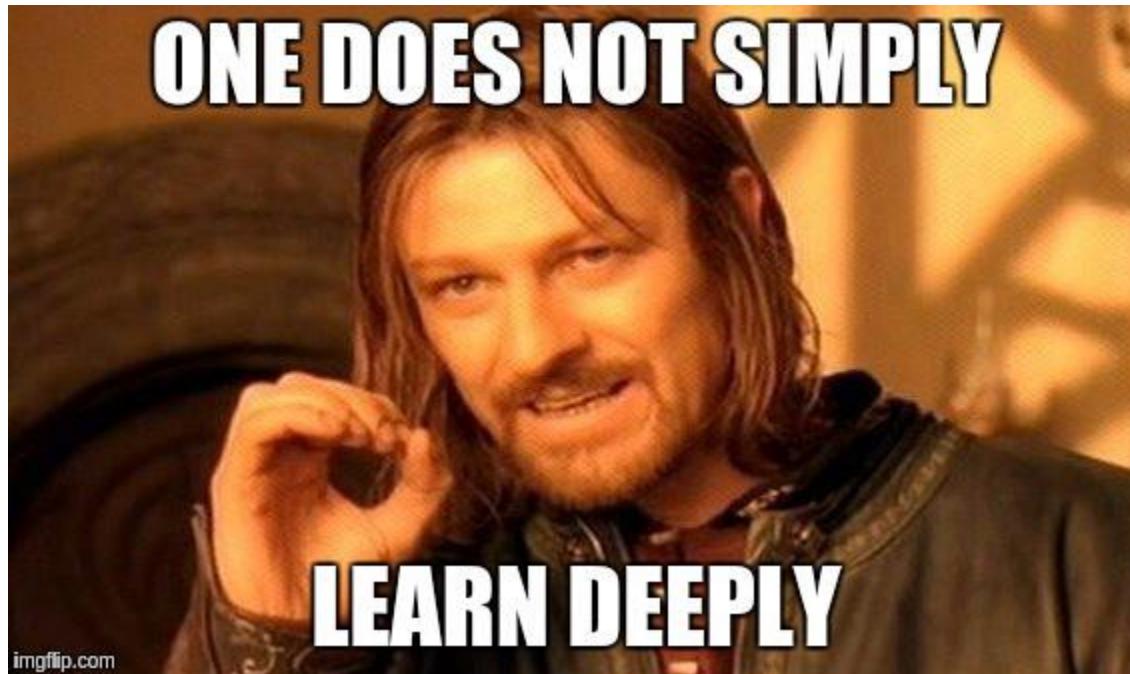
What I actually do

Deep Learning Memes



memes.com

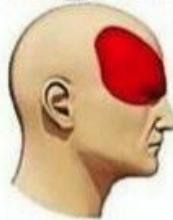
Deep Learning Memes



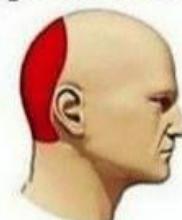
Deep Learning Memes

Types of Headaches

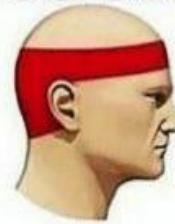
Migraine



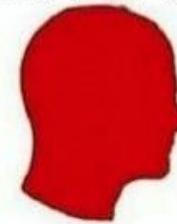
Hypertension



Stress



MATH BEHIND DL



Deep Learning at TUM

Many TUM Research Labs use DL

- 3D AI Lab (Prof. Dai)
 - Research in 3D perception, 3D scene understanding
- Visual Computing Lab (Prof. Niessner):
 - Research in computer vision, graphics, and machine learning
- 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 probably many more ☺

Our Research Lab

3D AI Lab (Prof. Dai):

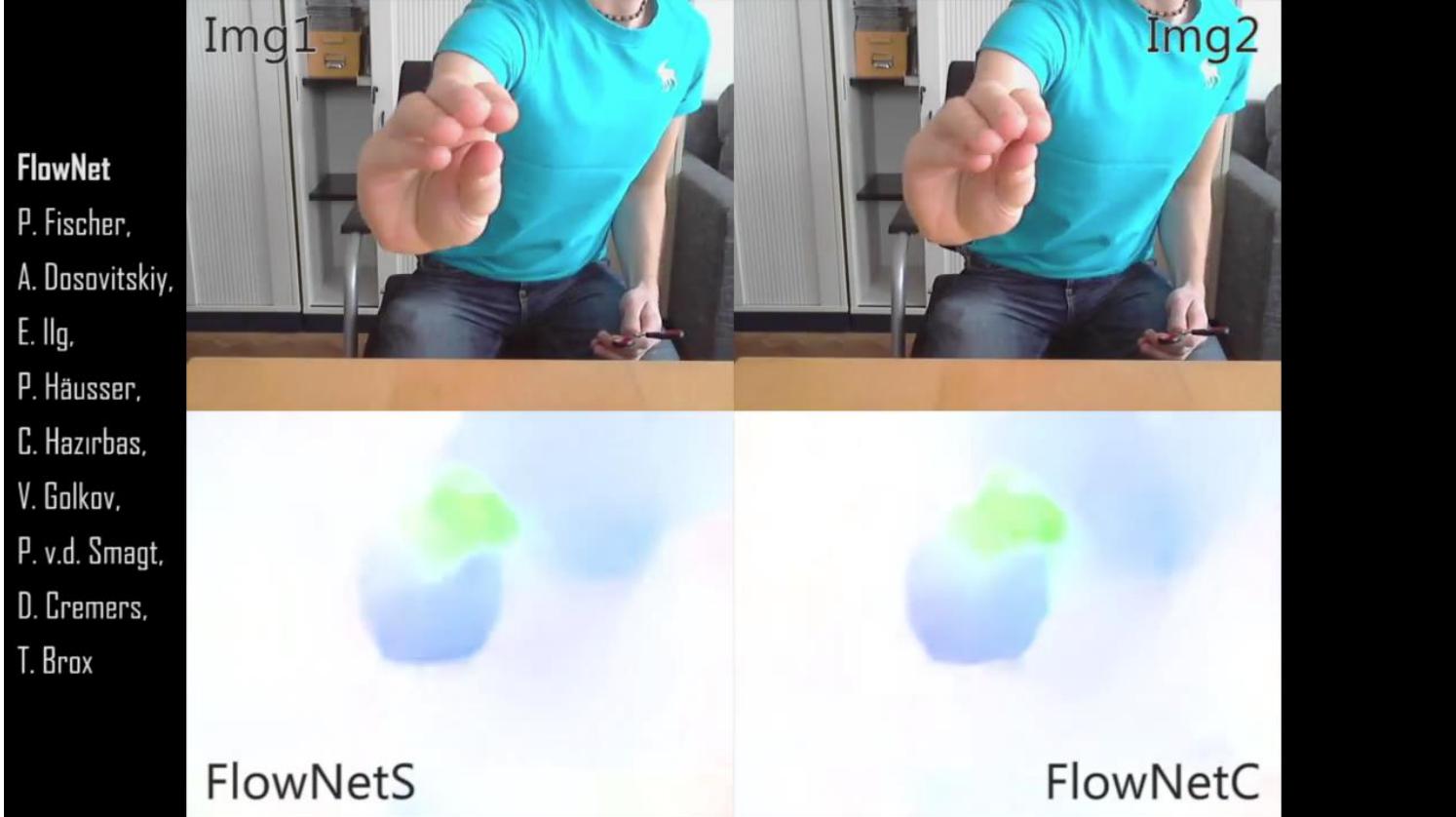
<https://www.3dunderstanding.org/publications.html>

- Twitter: <https://twitter.com/angelaqdai>
- Youtube:
<https://www.youtube.com/channel/UC71pxwyTLVK1HopuMmN7pRw>

Deep Learning at TUM



Deep Learning at TUM

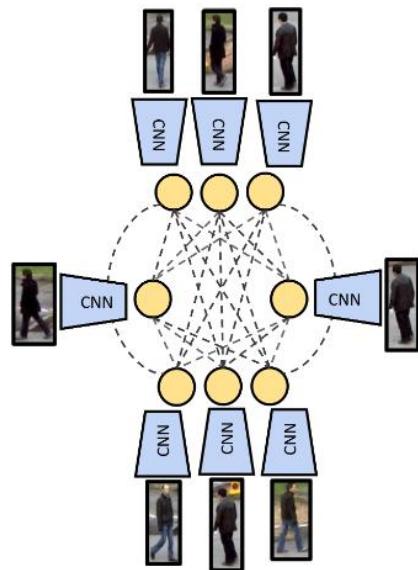


Deep Learning at TUM

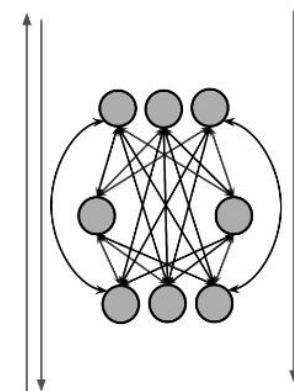
- Multiple object tracking with graph neural networks



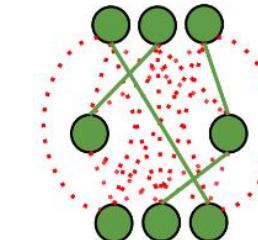
(a) Input



(b) Graph Construction + Feature Encoding



(c) Neural Message Passing



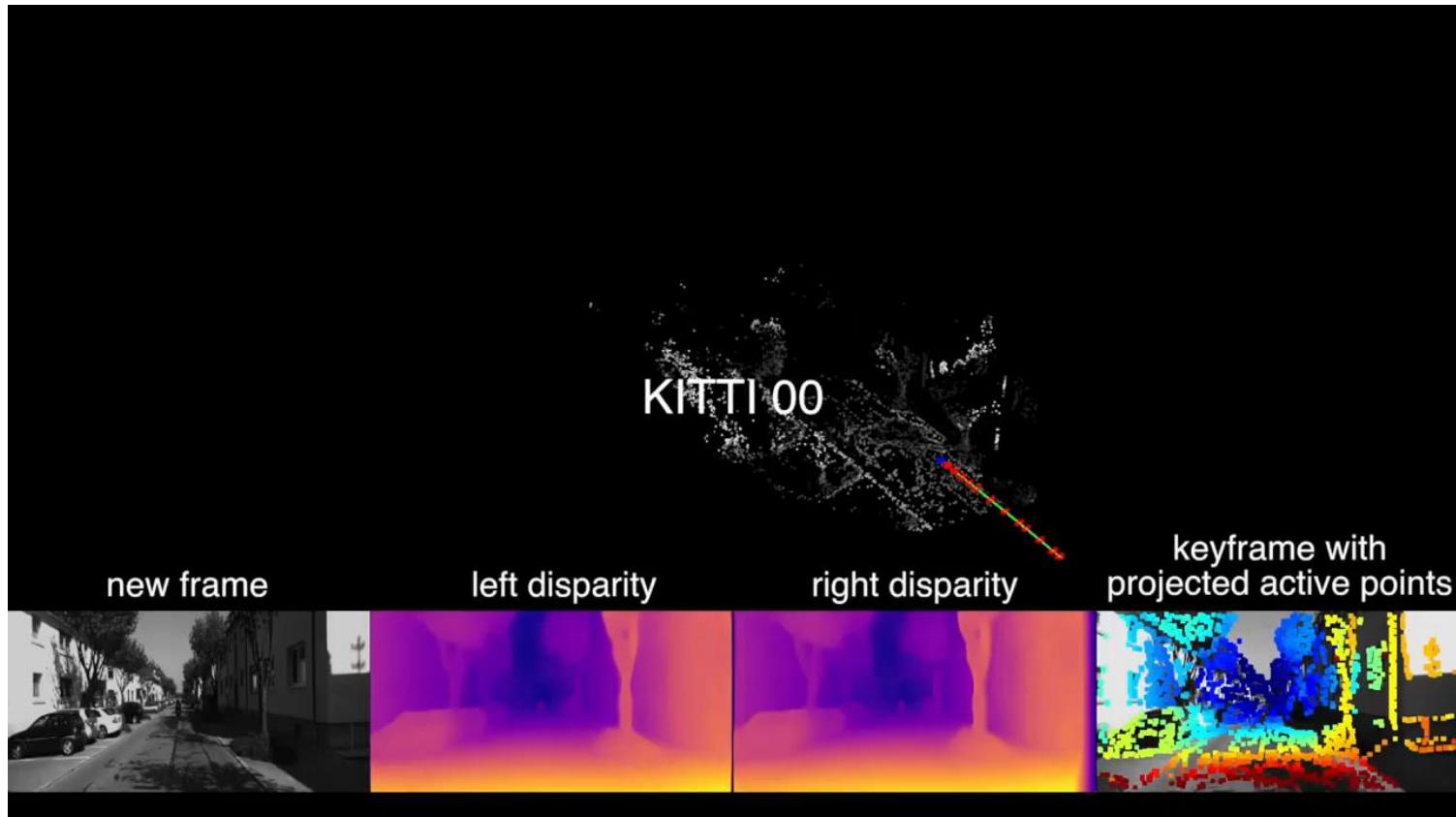
(d) Edge Classification



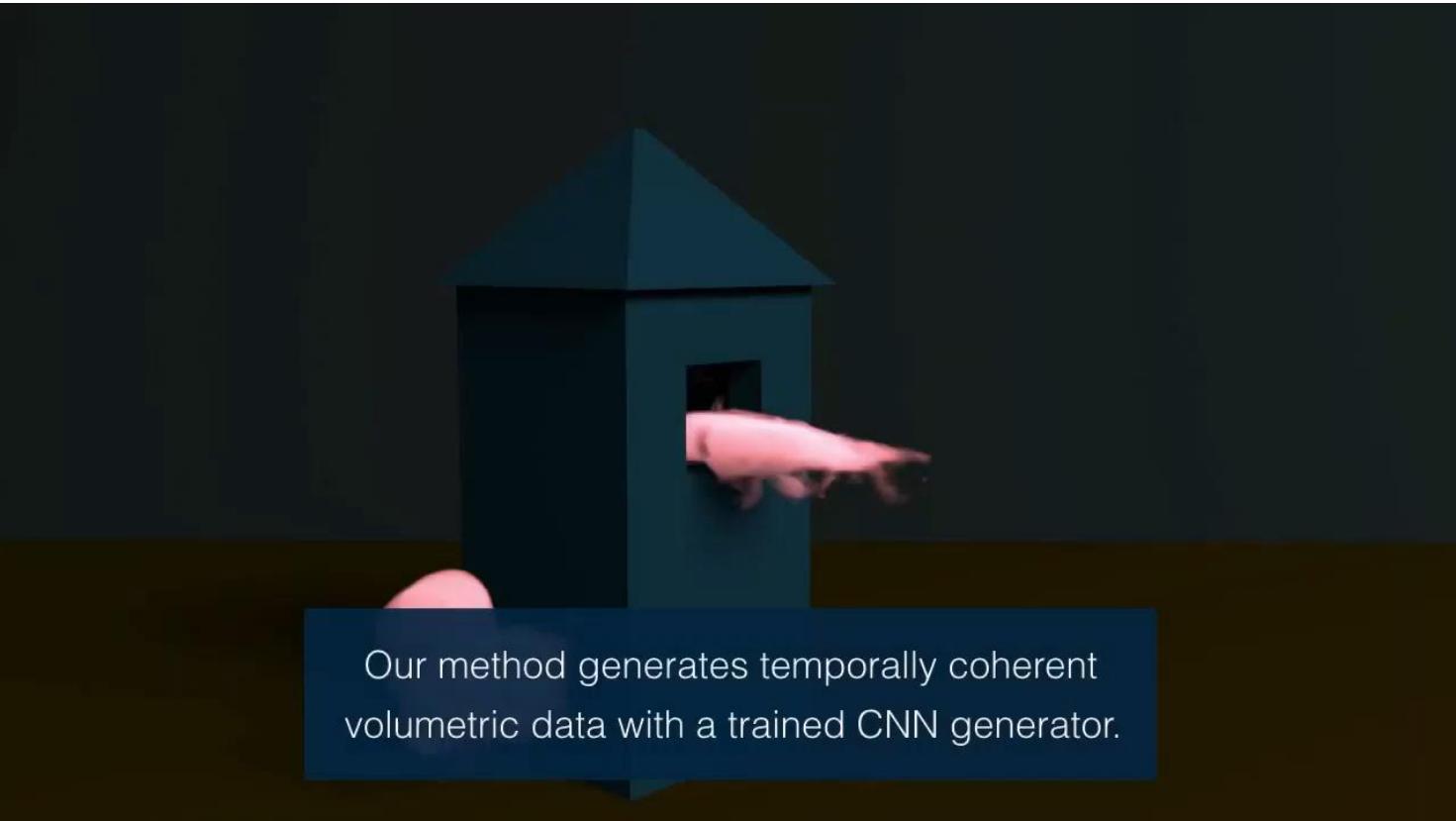
(e) Output

[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.

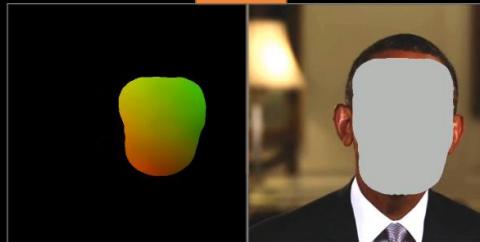
Deep Learning at TUM

Animation Synthesis

Source Actor



Target UV-Map

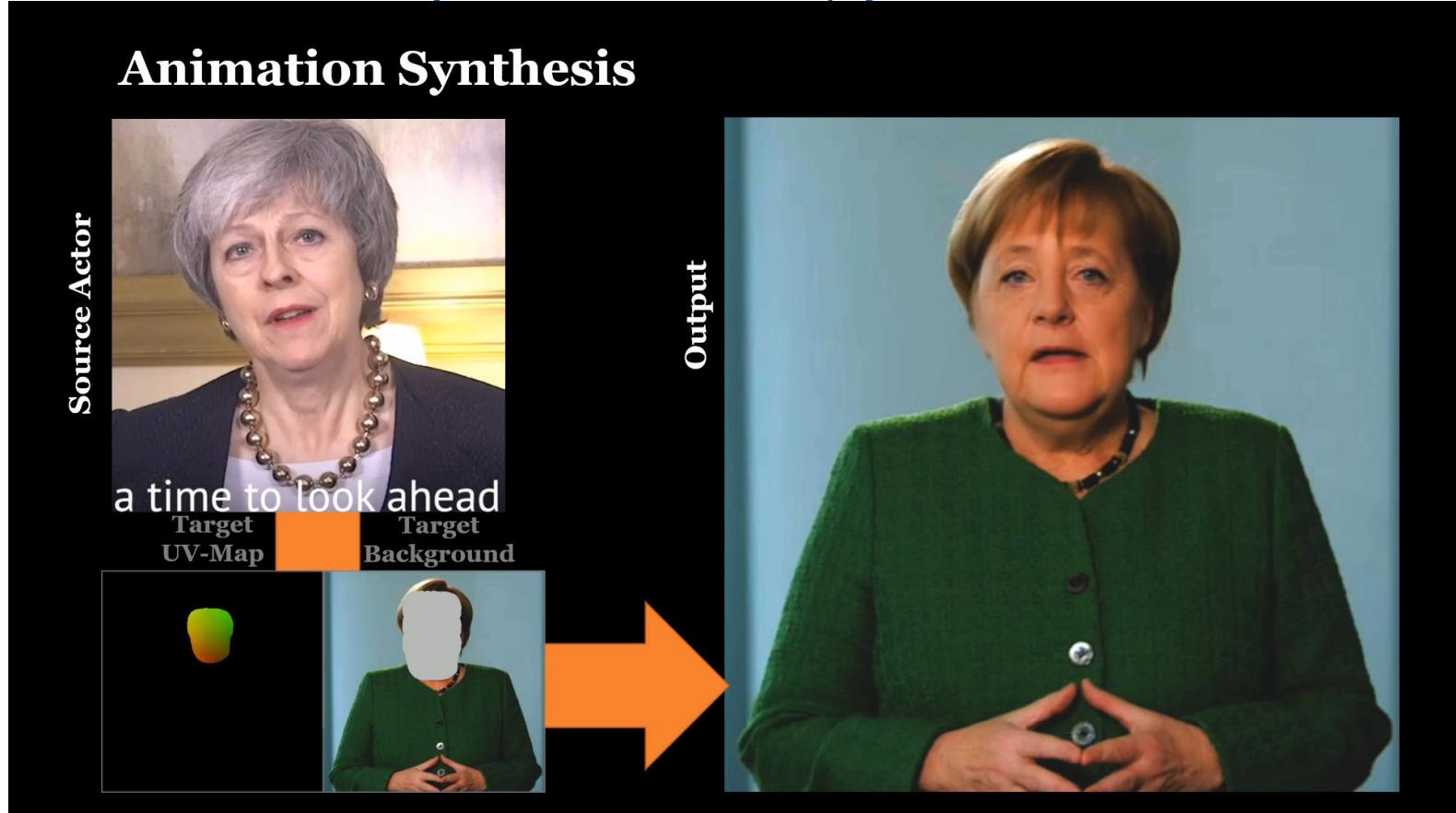


Output

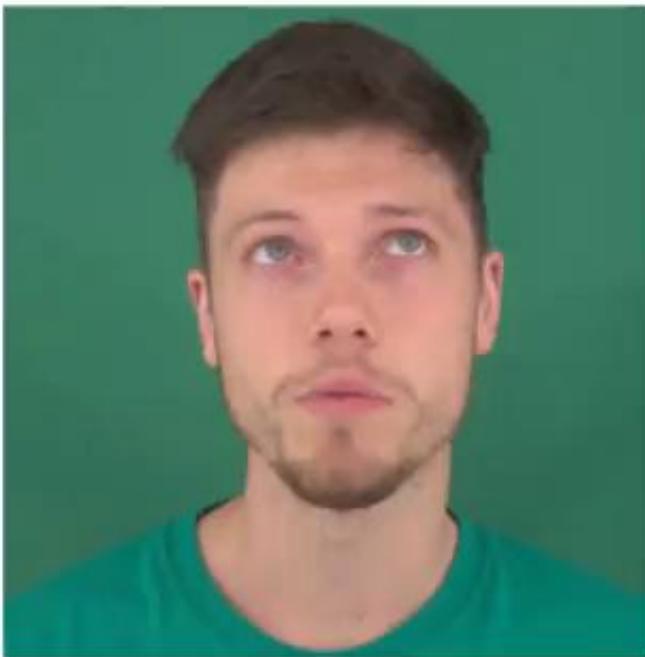


Deep Learning at TUM

Animation Synthesis



Deep Learning at TUM



Input Video



4D Head Avatar

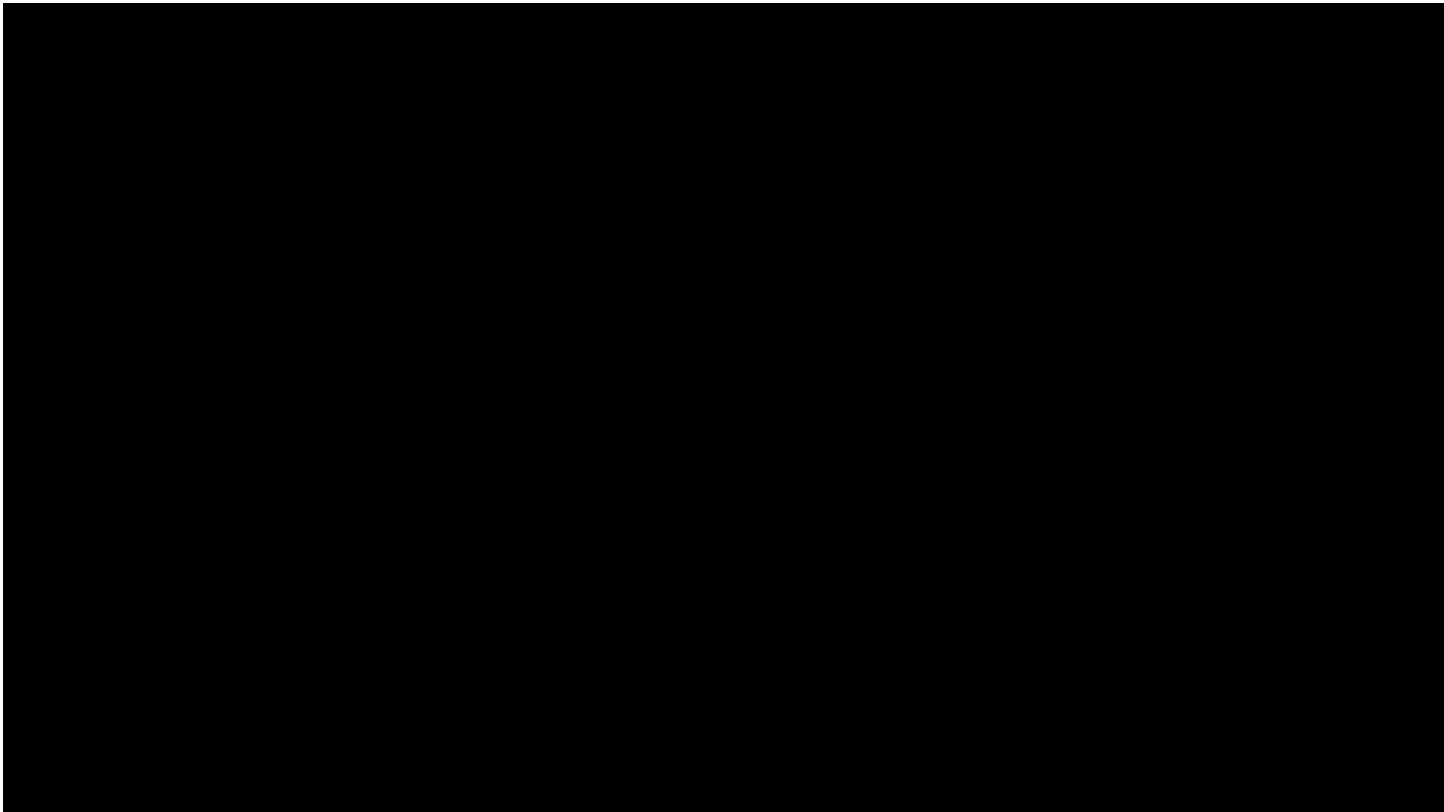
Deep Learning at TUM

Single RGB Image \Leftrightarrow Scene Reconstruction



Only single-view training samples

Deep Learning at TUM



Deep Learning at TUM

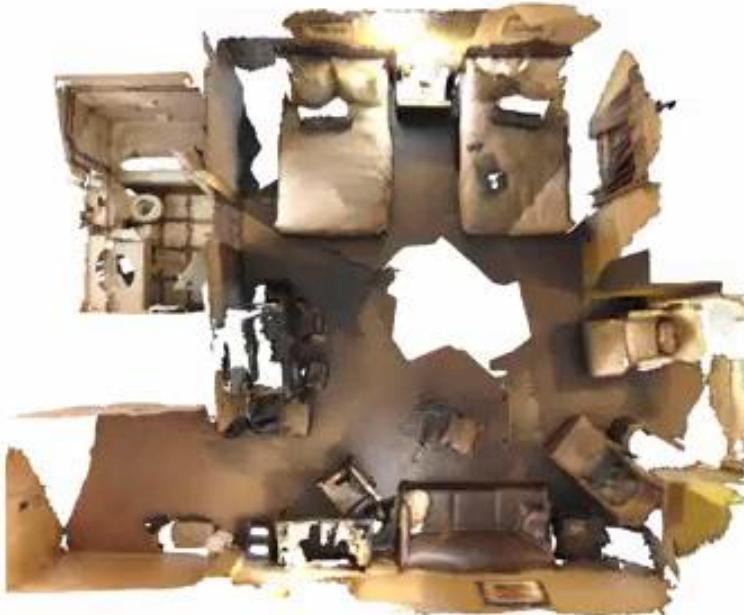


ScanNet Stats:

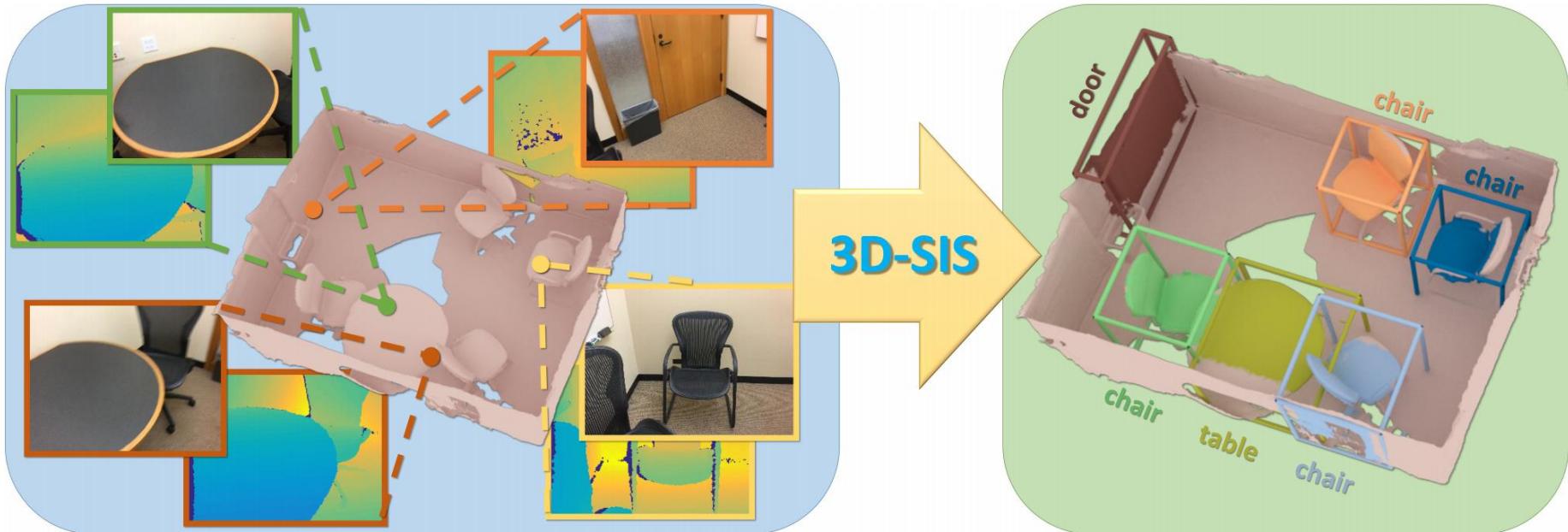
- Kinect-style RGB-D sensors
- 1513 scans of 3D environments
- 2.5 Mio RGB-D frames
- Dense 3D, crowd-source MTurk labels
- Annotations projected to 2D frames

Deep Learning at TUM

Learning 3D Using Language



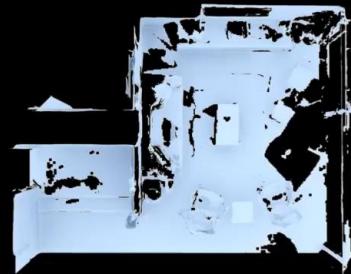
Deep Learning at TUM



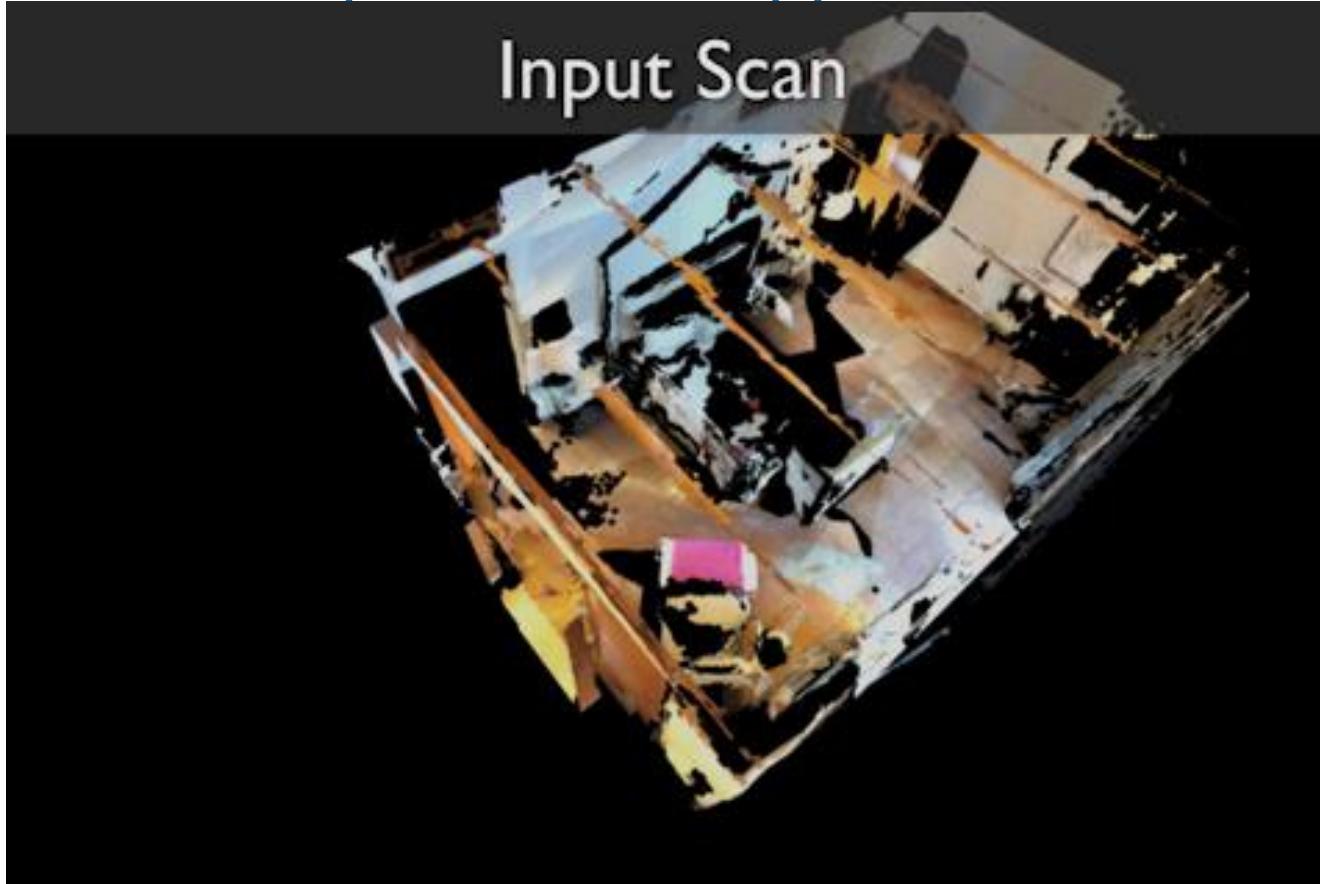
[Hou et al., CVPR'19] 3D Semantic Instance Segmentation

Deep Learning at TUM

Input Scan

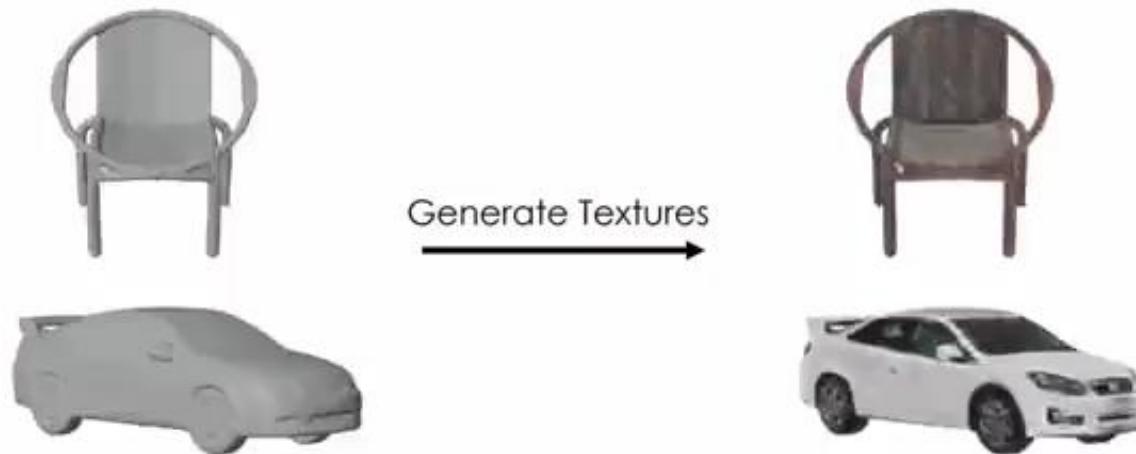


Deep Learning at TUM

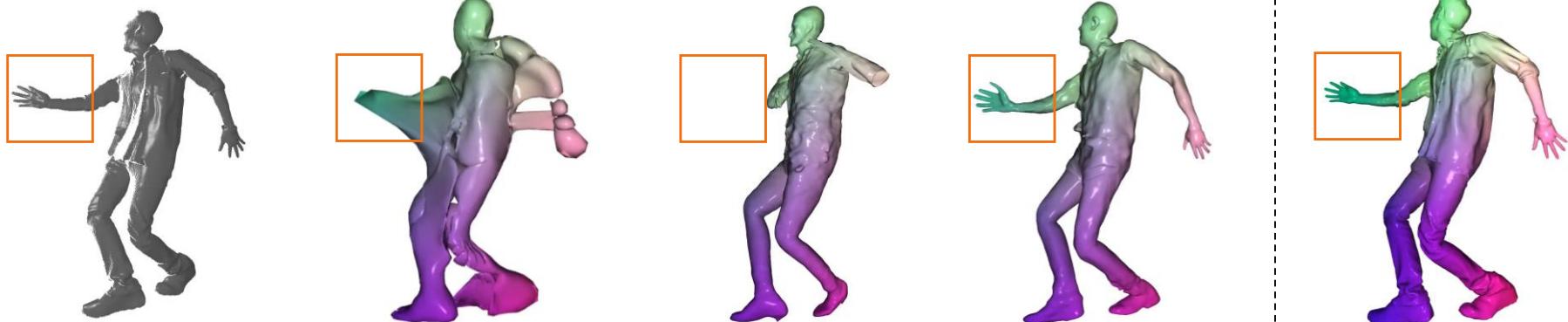


Deep Learning at TUM

Texturify



Deep Learning at TUM



Depth Input
(lateral view)

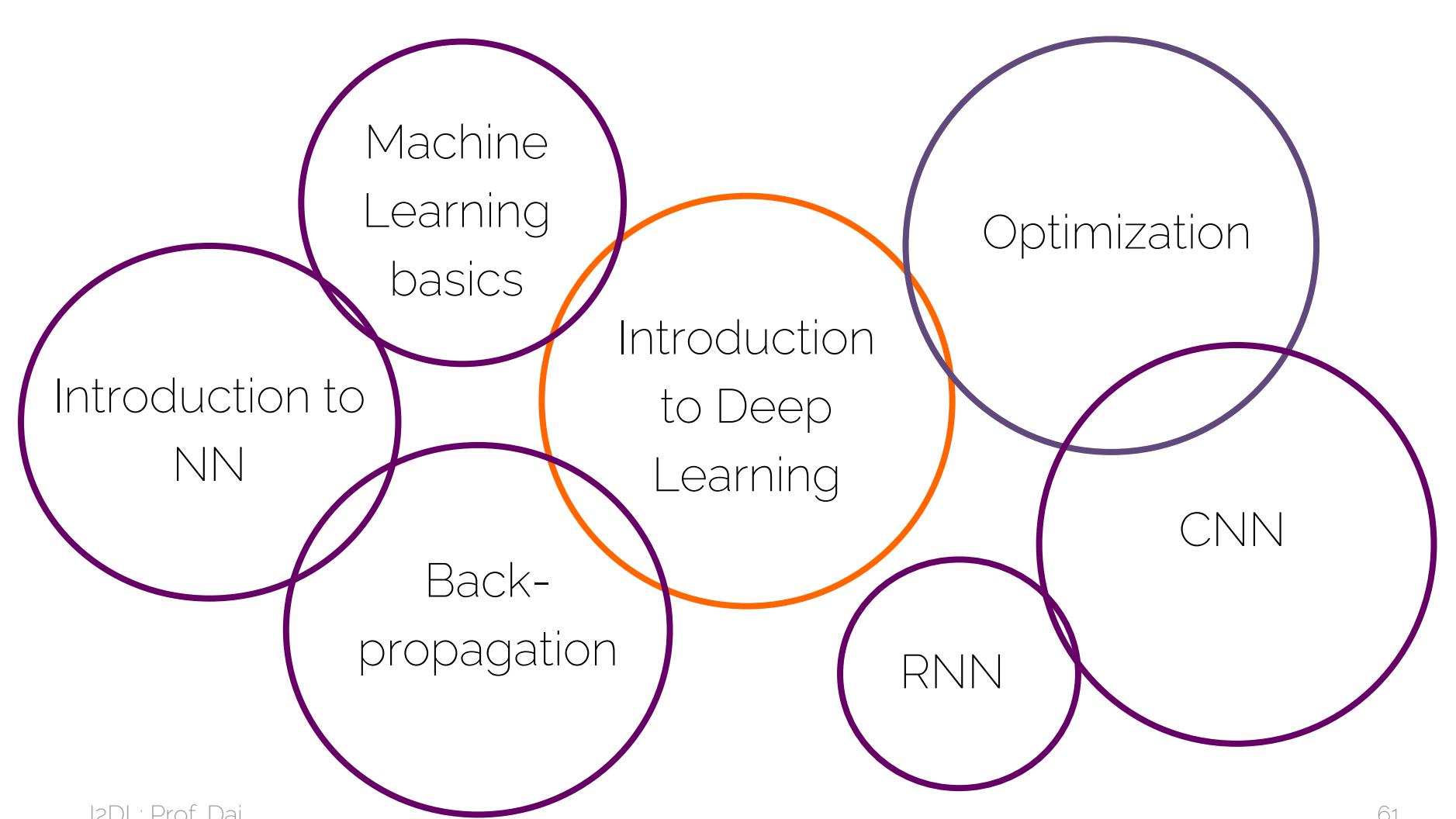
IPNet
[Bhatnagar et al. 2020]

NPMs*
[Palafox et al. 2021]

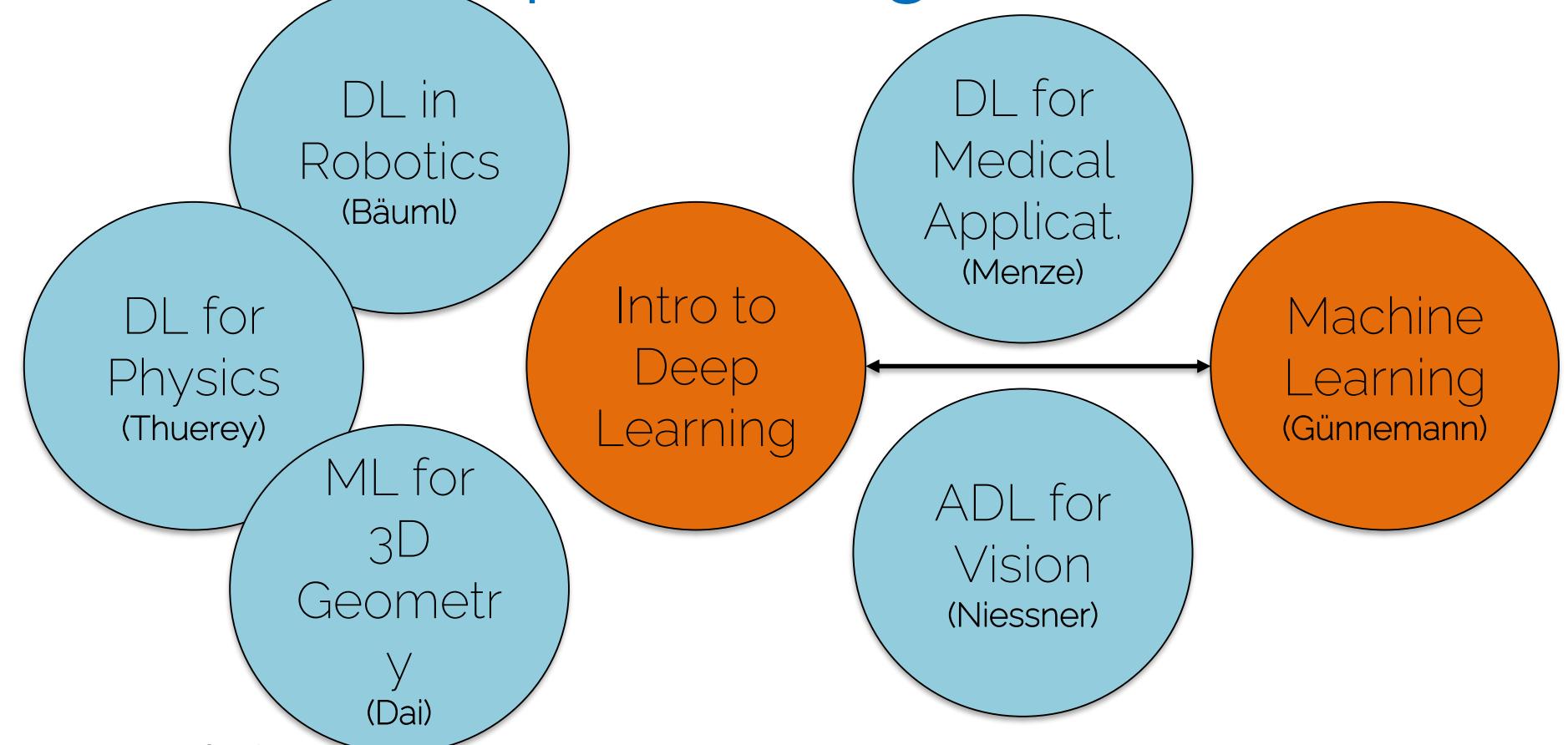
SPAM (Ours)

Ground Truth

Context of 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

About the Lecture

- Theory lectures
- Every Tuesday 14:00-16:00
 - Lectures are on-site and will be streamed to RGB Live:
<https://live.rgb.tum.de/course/2022/W/i2dl>
- Practical exercises (see later slides)
 - Released every Thursday, 13:00
 - Tutorial: Online videos (uploaded to live.rgb.tum.de as well)
 - Programming exercises
- Guest lecture TBD

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 (TBD)

Moodle → Piazza

- Announcements via Piazza - **IMPORTANT!**
 - Sign up online for access: <http://piazza.com/tum.de>
 - Select "Winter 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

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

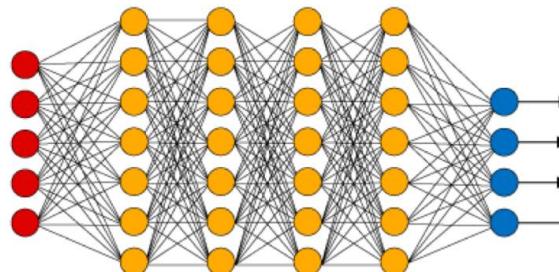
- We will have dedicated office hours regarding
 - Theoretical help (e.g., specific lecture questions)
 - Help on exercises
- Will be starting next week (24/10)
- Zoom links will be posted on Piazza

Website

- Links and slides will be shared on website



Introduction to Deep Learning (I2DL) (IN2346)



Welcome to the Introduction to Deep Learning course offered in WS22-23.

<https://www.3dunderstanding.org/i2dl-w22/>

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
- Lectures will be recorded and streamed on RGB Live
 - <https://live.rbg.tum.de/course/2022/W/i2dl>
- Again: check announcements on piazza

Practical Exercises

Exercise – Goal

- Hands-on programming experience (Learning by Doing)
- Reimplementations basic building blocks
- Introduction to common libraries
- (Get grade bonus)
- Ultimately: Gather enough experience to start your own individual (research) deep learning project

Exercise – Format

- Tutorial:
 - Video only
Posted on live.rbg.tum.de
Slides uploaded to piazza & website
 - Video length
Ex02: Full lecture with written exercise
Ex03-11: Short (~30min) video and coding exercises
 - Programming:
Interactive coding notebooks (~4h each)
- Start time: Thursdays 13:00 *
- Working Time: 1 week
- Deadline: Wednesdays, **15:59**
- Except for exercise 1:
- No video → this lecture
 - Starting time: Today
 - Working time: 2 weeks

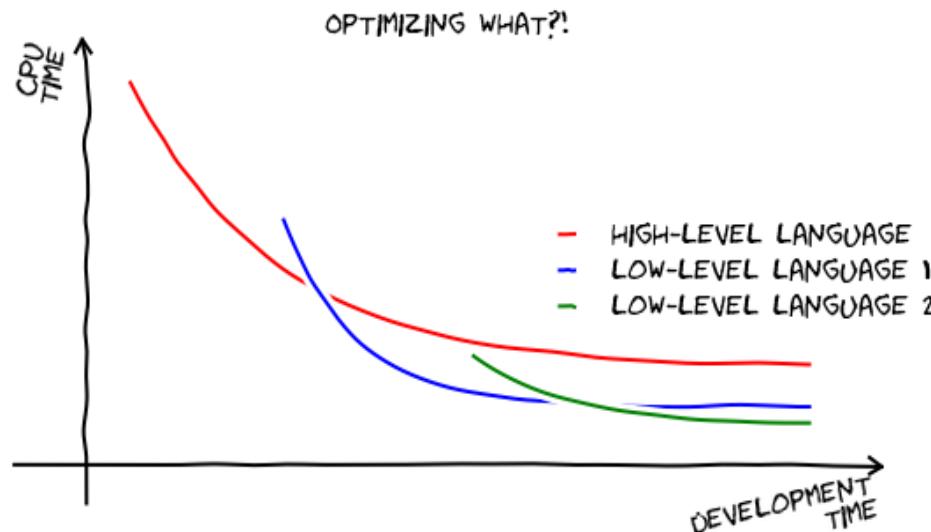
Exercises – Tech Stack

- Python
Jupyter notebooks
Numpy
- Deep Learning library
Pytorch
- Hardware requirements
 - Minimum: CPU
 - Preferred: Nvidia GPU
 - Alternative: Google Colab



Why Python?

- Very easy to write development code thanks to an intuitive syntax
- Biggest language used in deep learning research



Exercises – Content

Exercise 01: Organization
Exercise 02: Math Recap

Intro

Exercise 03: Dataset and Dataloader
Exercise 04: Solver and Linear Regression
Exercise 05: Neural Networks
Exercise 06: Hyperparameter Tuning

Numpy
(Reinvent the wheel)

Exercise 07: Introduction to Pytorch
Exercise 08: Autoencoder

Pytorch/Tensorboard

Exercise 09: Convolutional Neural Networks
Exercise 10: Semantic Segmentation
Exercise 11: Recurrent Neural Networks

Applications
(Hands-off)

Exercises – 9 Submissions

* Exercise 01: Organization

Exercise 02: Math Recap

Intro

- * Exercise 03: Dataset and Dataloader
- * Exercise 04: Solver and Linear Regression
- * Exercise 05: Neural Networks
- * Exercise 06: Hyperparameter Tuning

Numpy
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Exercise 07: Introduction to Pytorch

* Exercise 08: Autoencoder

Pytorch/Tensorboard

- * Exercise 09: Convolutional Neural Networks
- * Exercise 10: Semantic Segmentation
- * Exercise 11: Recurrent Neural Networks

Applications
(Hands-off)

Submission System

The screenshot shows the i2DL Submission System interface. At the top, there is a navigation bar with links for 'Home', 'Course Page', 'Forum', and 'Login'. Below the navigation bar, there are two main sections: 'Login' and 'Register'. The 'Login' section (marked with a red circle containing '2') contains fields for 'Username' (with a user icon) and 'Password' (with a lock icon), followed by a green 'Login' button. The 'Register' section (marked with a red circle containing '1') contains a field for 'Matriculation Number' (with a user icon), followed by a green 'Register' button.

1: Register with your enrolled Matriculation Number

2: Login with your credentials you get via email

<https://i2dl.vc.in.tum.de/>

Submission System

Exercise submission

Exercise 1 – Test the system	▼
Exercise 3 – Dataset and Dataloader	▼
Exercise 4 – Solver and Linear Regression	▼
Exercise 5 – Neural Networks	▼
Exercise 6 – Hyperparameter Tuning	▼
Exercise 7 – Intro to Pytorch [Optional]	▼
Exercise 8 – Autoencoder	▼
Exercise 9 – Convolutional Neural Networks	▼
Exercise 10 – Semantic Segmentation	▼
Exercise 11 – Recurrent Neural Networks	▼

Exercise 1 – Test the system

Info

- **Description:** Test the system
- **Start:** 2022-10-18 13:00:00
- **Deadline:** 2022-11-02 15:59:59
- **Requirement:** 60.0
- **Max Score:** 100.0
- **Submission:** Within the working period you can submit solutions as often as you want
- **Bonus:** The best score counts for the bonus
- **Evaluation Time:** The maximum evaluation time is 30min.
- **Issues:** In rare cases it can still happen that your submission will get stuck in "queued". If your submission is there for more than 10min, please submit again. - Sorry for the inconveniences.

Upload

Datei auswählen Keine ausgewählt

Upload

Your previous submissions

#	Date	Status	Passed?	Score	Download
1	2022/10/16 18:12:07	finished	✓	70.00	
2	2022/10/16 17:50:57	finished	✗	38.00	
3	2022/10/14 19:10:05	cancelled	✗	-	

Within the working time you can submit as often as you want!

Submission System

Bonus

1

Exercise 1	Exercise 3	Exercise 4	Exercise 5	Exercise 6	Exercise 8	Exercise 9	Exercise 10	Exercise 11
✓ (70.00)	✓ (90.00)	✓ (100.00)	✓ (100.00)	✓ (52.02)	✓ (78.00)	✗ 0	✓ (64.17)	✓ (84.38)

This table gives an overview over your current status regarding the grade bonus.

For each exercise only the best submission is displayed.

To be eligible for the grade bonus of 0.3 (on an already passed exam), you need to pass 8 of the 9 non-optional submissions.

Leaderboard

2

The leaderboard shows for each exercise the highest scoring submission from each user. Only valid submissions are displayed.

Exercise 1 **Exercise 3** Exercise 4 Exercise 5 Exercise 6 Exercise 8 Exercise 9 Exercise 10 Exercise 11

#	User	Score
1	a0001	90.00
2	a0006	90.00
3	a0007	90.00

Grade Bonus

- Solve **8 out of 9** submissions (bold ones)
 - Pass the required score
- Grade bonus:
 - 0.3 improvement on **passed** exam
 - Can be transferred from previous and future semesters

* **Exercise 01: Organization**

Exercise 02: Math Recap

* **Exercise 03: Dataset and Dataloader**

* **Exercise 04: Solver and Linear Regression**

* **Exercise 05: Neural Networks**

* **Exercise 06: Hyperparameter Tuning**

Exercise 07: Introduction to Pytorch

* **Exercise 08: Autoencoder**

* **Exercise 09: Convolutional Neural Networks**

* **Exercise 10: Semantic Segmentation**

* **Exercise 11: Recurrent Neural Networks**

Exercise 01 – Overview

- Starting time: Today, after the lecture (16:00)
- Deadline: Wednesday 02/11, 15:59 (in 2 weeks)
- Content
 - Get familiar with the exercise structure
 - Jupyter Notebook & Python setup (local / Google Colab)
 - Introduction to the submission system
 - Submission:
 - Implement 1 line of code

Upcoming Lecture

- No Lecture next week
- Next Lecture: Lecture 2: Machine Learning basics
- From today: Start of exercise 1

See you next time 😊