

Introduction to Deep Learning

The Team

Lecturers



Prof. Dr. Laura
Leal-Taixé



Prof. Dr. Matthias
Niessner

PhDs



Patrick
Dendorfer



Andreas
Rössler

What is Computer Vision?

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



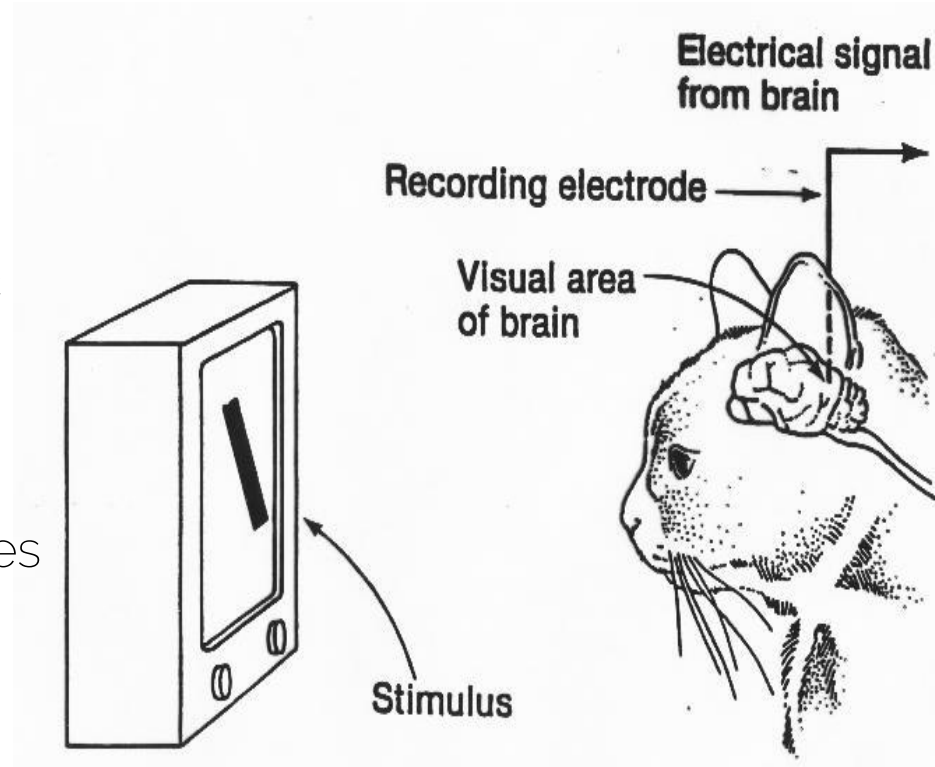
Hubel and Wiesel

- 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



Artificial Intelligence Group
Vision Memo. No. 100.

July 7, 1966

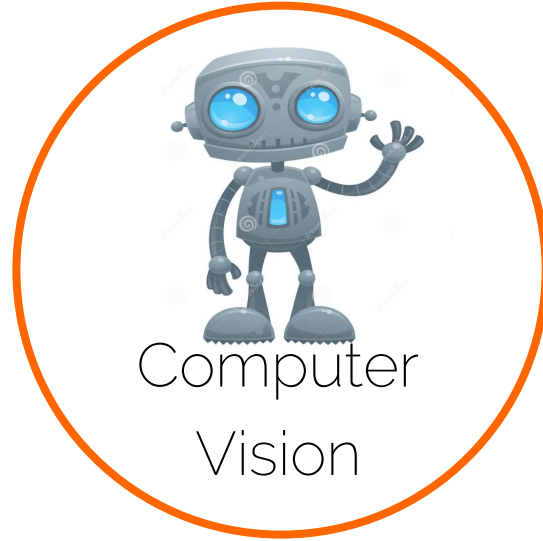
THE SUMMER VISION PROJECT

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".

Few Decades Later...



Engineering

Mathematics

Computer
science

Robotics

Artificial
Intelligence
ML

NLP
Speech

Algorithms
Optimization

Optics
Image
processing

Computer
Vision

Neuroscience

Physics

Biology

Psychology



Image Classification

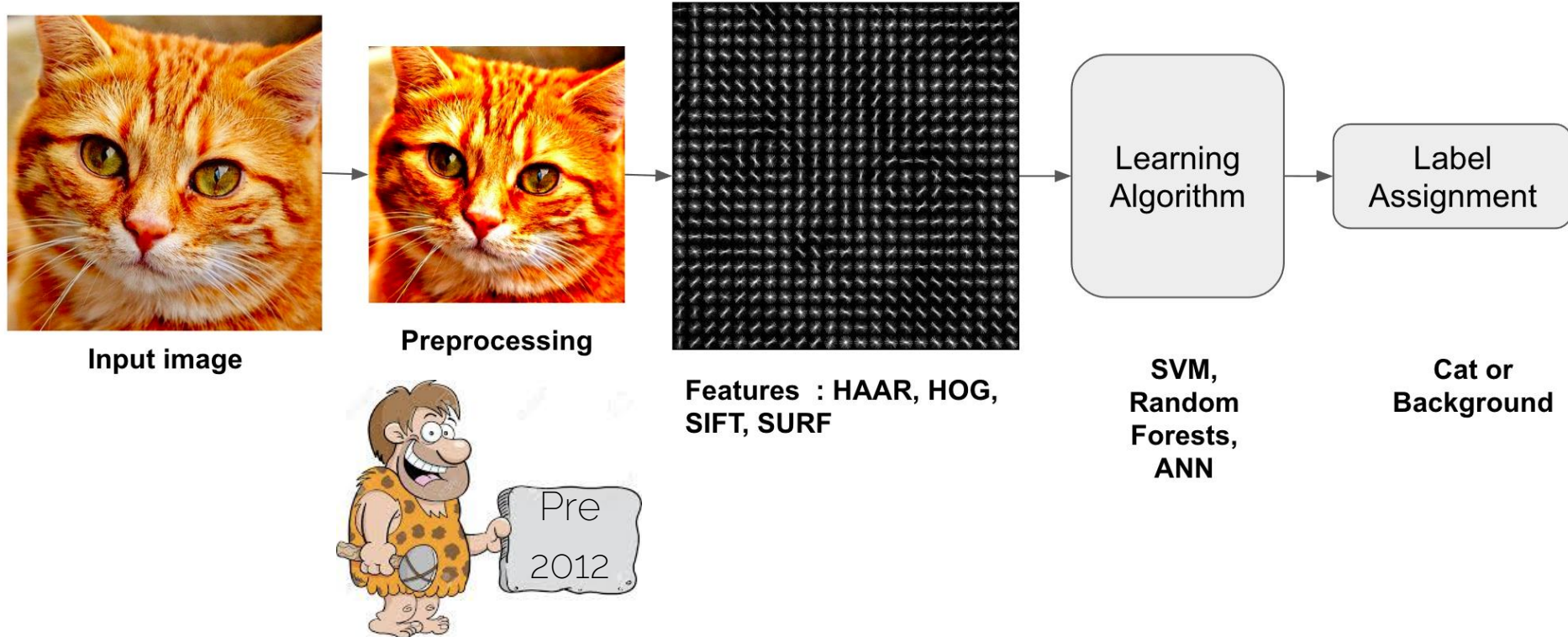


Image Classification



Input image



Awesome
magic box



Label
Assignment



Open the box



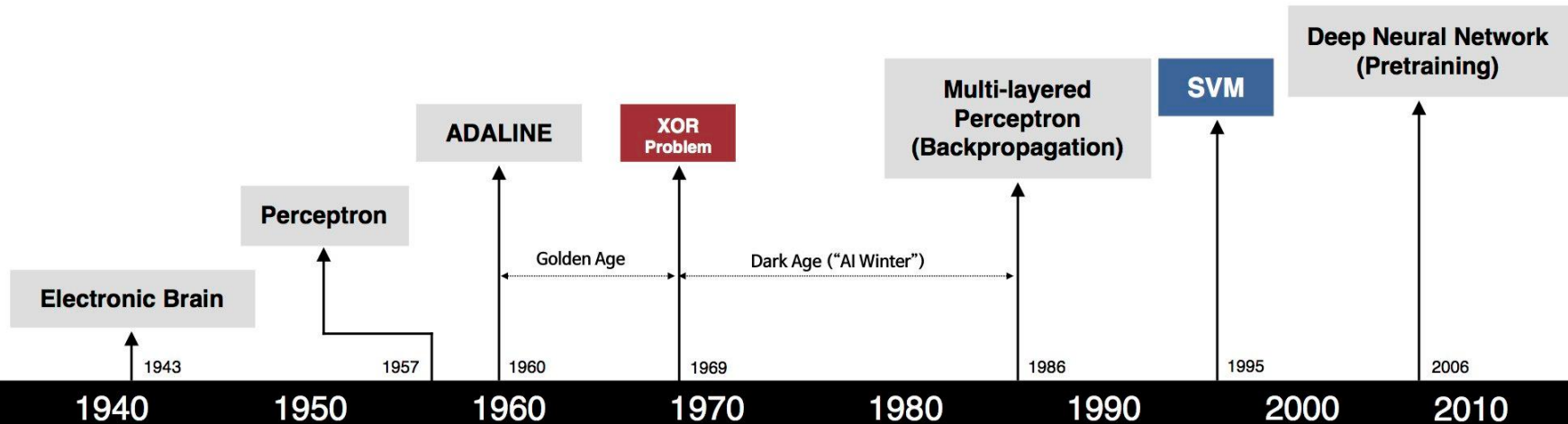
Become magicians

**Cat or
Background**

Post 2012

Why Deep Learning?

Deep Learning History



S. McCulloch – W. Pitts



F. Rosenblatt



B. Widrow – M. Hoff



M. Minsky – S. Papert



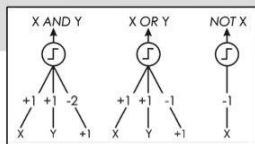
D. Rumelhart – G. Hinton – R. Williams



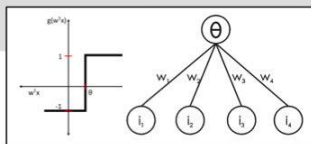
V. Vapnik – C. Cortes



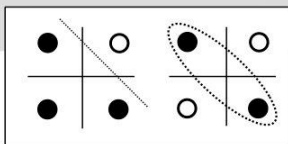
G. Hinton – S. Ruslan



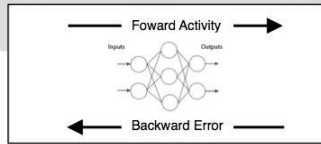
- Adjustable Weights
- Weights are not Learned



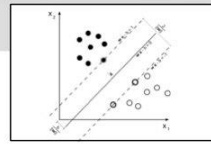
- Learnable Weights and Threshold



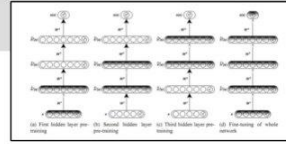
- XOR Problem



- Solution to nonlinearly separable problems
- Big computation, local optima and overfitting

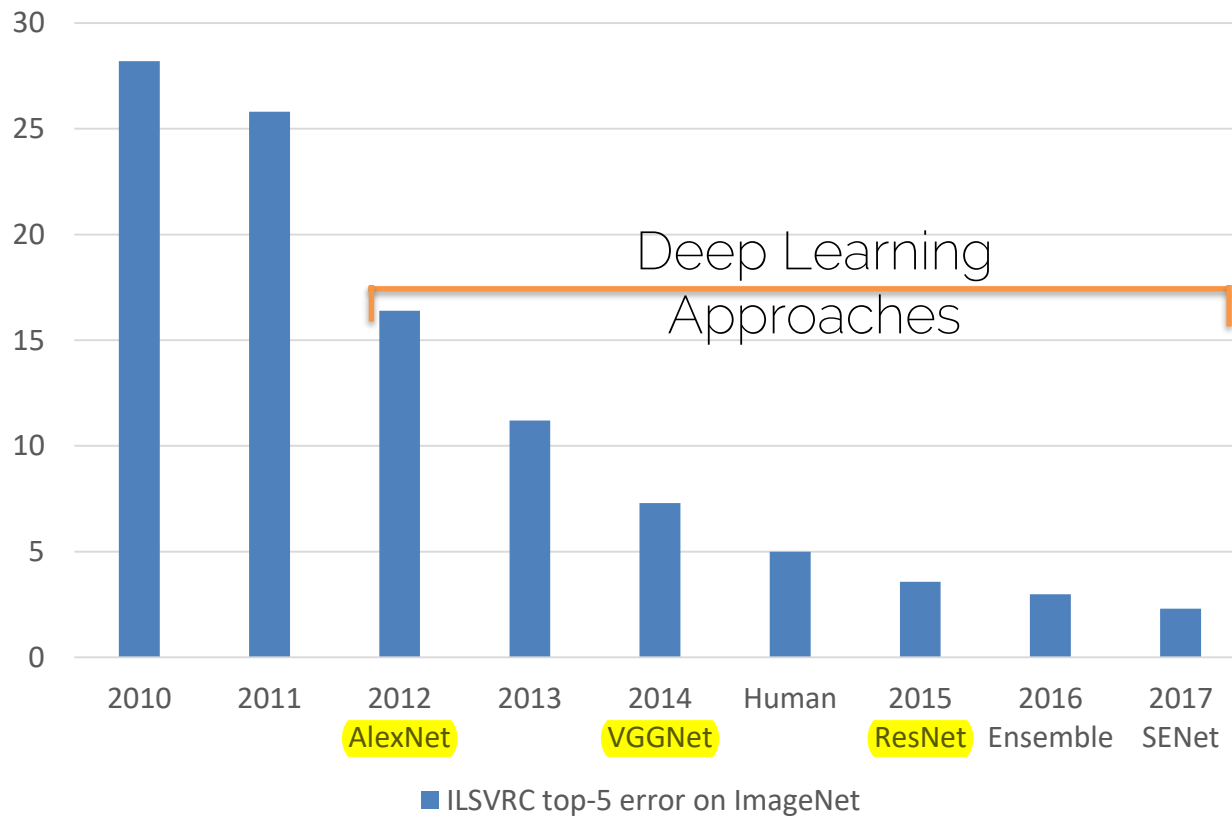


- Limitations of learning prior knowledge
- Kernel function: Human Intervention



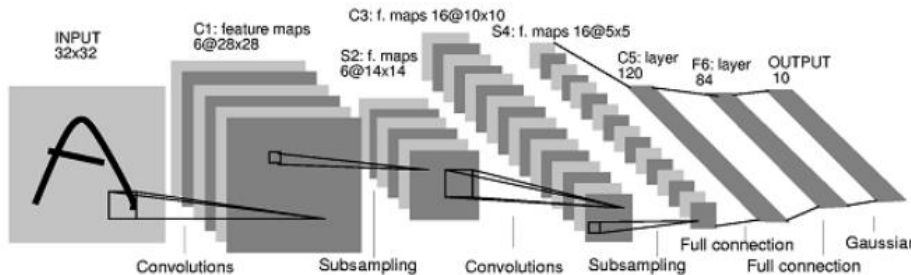
- Hierarchical feature Learning

The Empire Strikes Back



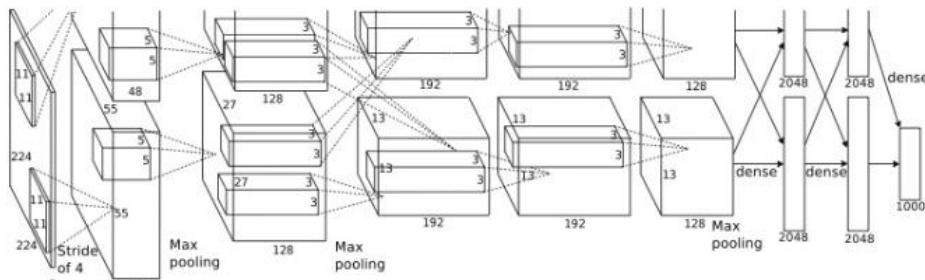
What Has Changed?

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?



Big Data

Models know
where to learn from



Hardware

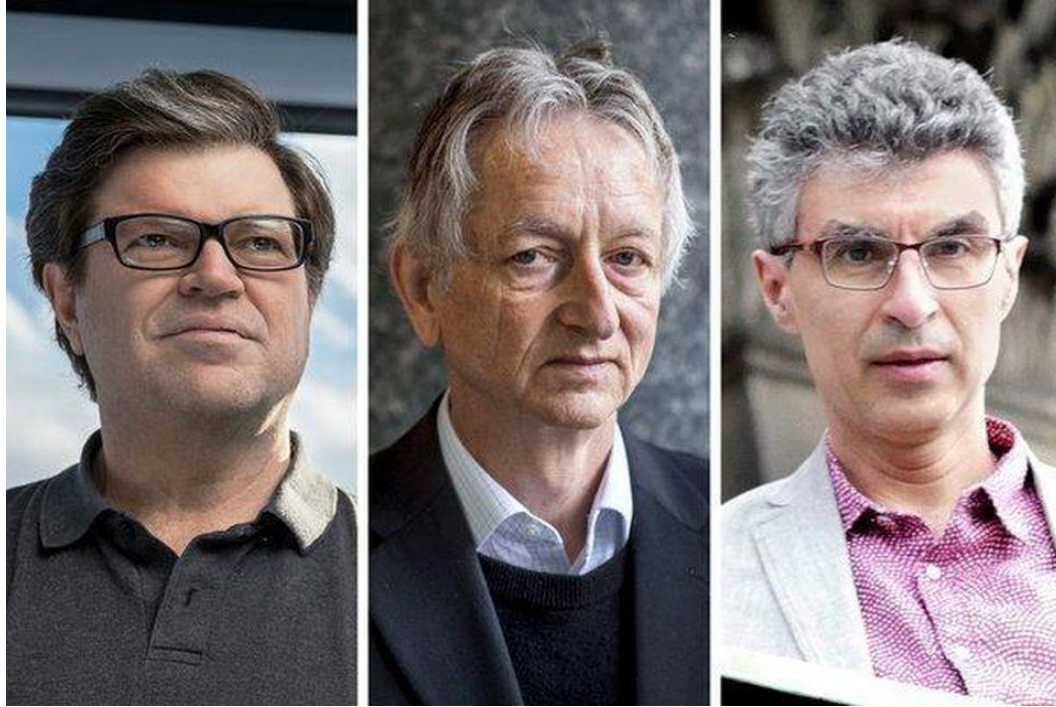
Models are
trainable



Deep

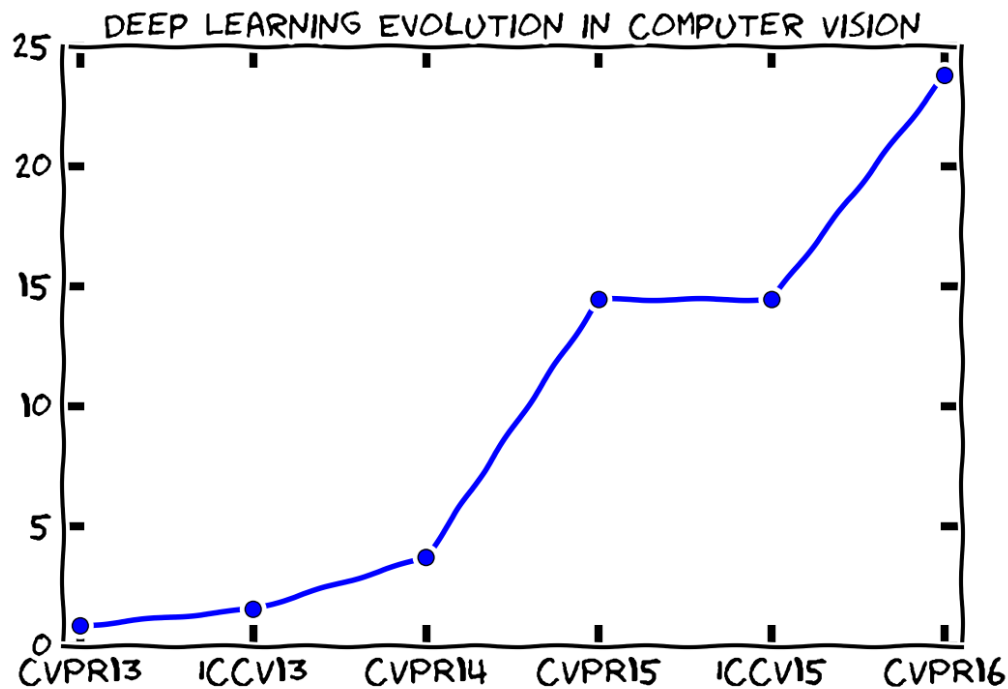
Models are
complex

Deep Learning Recognition



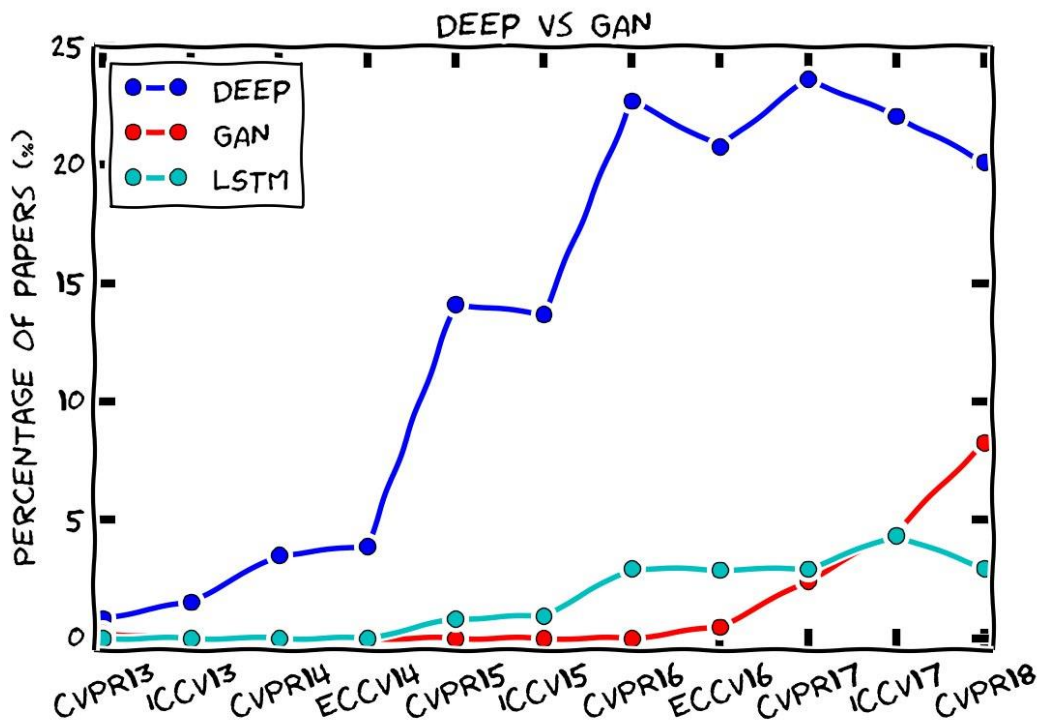
ACM Turing Award 2019 (Nobel Prize of Computing)
Yann LeCun, Geoffrey Hinton, and Yoshua Bengio

Deep Learning and Computer Vision



Credits: Dr. Pont-Tuset, ETH Zurich

Deep Learning and Computer Vision



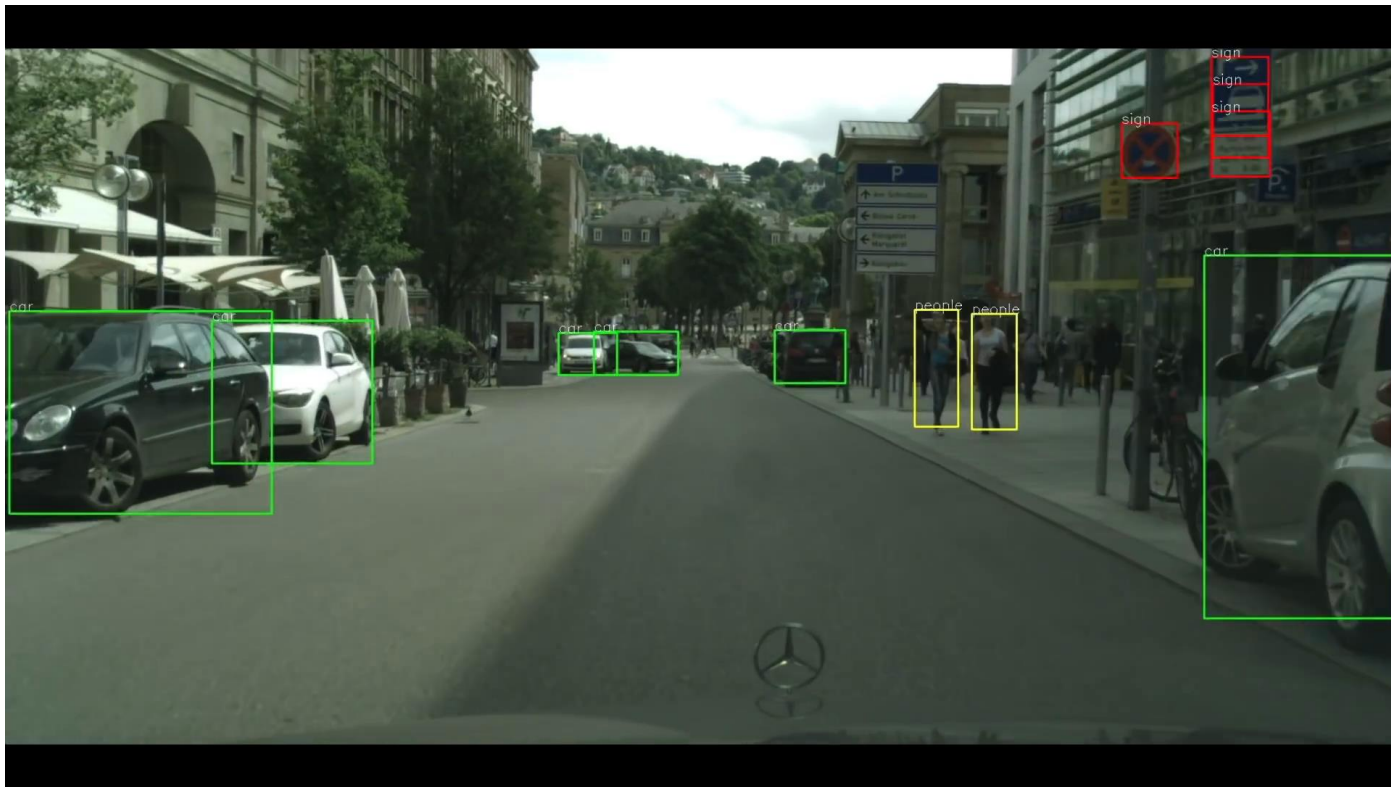
Credits: Dr. Pont-Tuset, ETH Zurich

Deep Learning Today



Object Detection

Deep Learning Today



Self-driving cars

Deep Learning Today

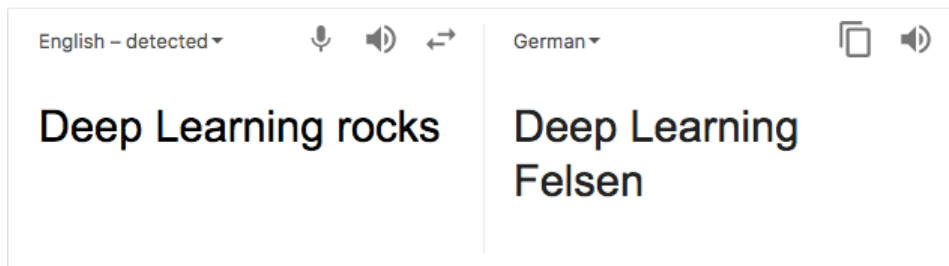


AlphaGo

ever punch a cactus?

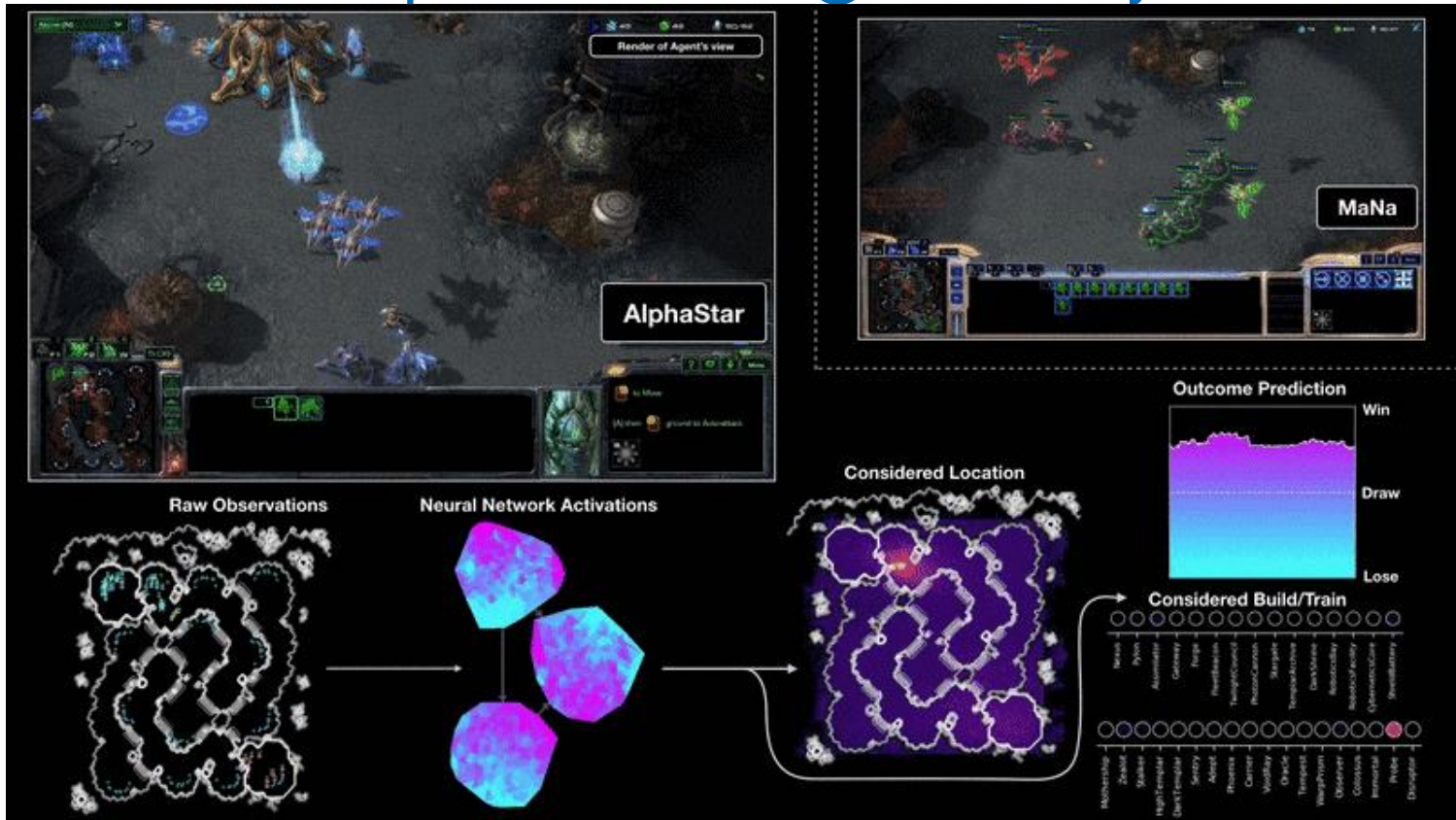


Emoticon suggestion



Machine translation

Deep Learning Today



Deep Learning Today

PANDARUS:

Alas, I think he shall be come approached and the day
When little strain would be attain'd into being never fed,
And who is but a chain and subjects of his death,
I should not sleep.

Second Senator:

They are away this miseries, produced upon my soul,
Breaking and strongly should be buried, when I perish
The earth and thoughts of many states.

DUKE VINCENTIO:

Well, your wit is in the care of side and that.

Second Lord:

They would be ruled after this chamber, and
my fair nuns begun out of the fact, to be conveyed,
Whose noble souls I'll have the heart of the wars.

Clown:

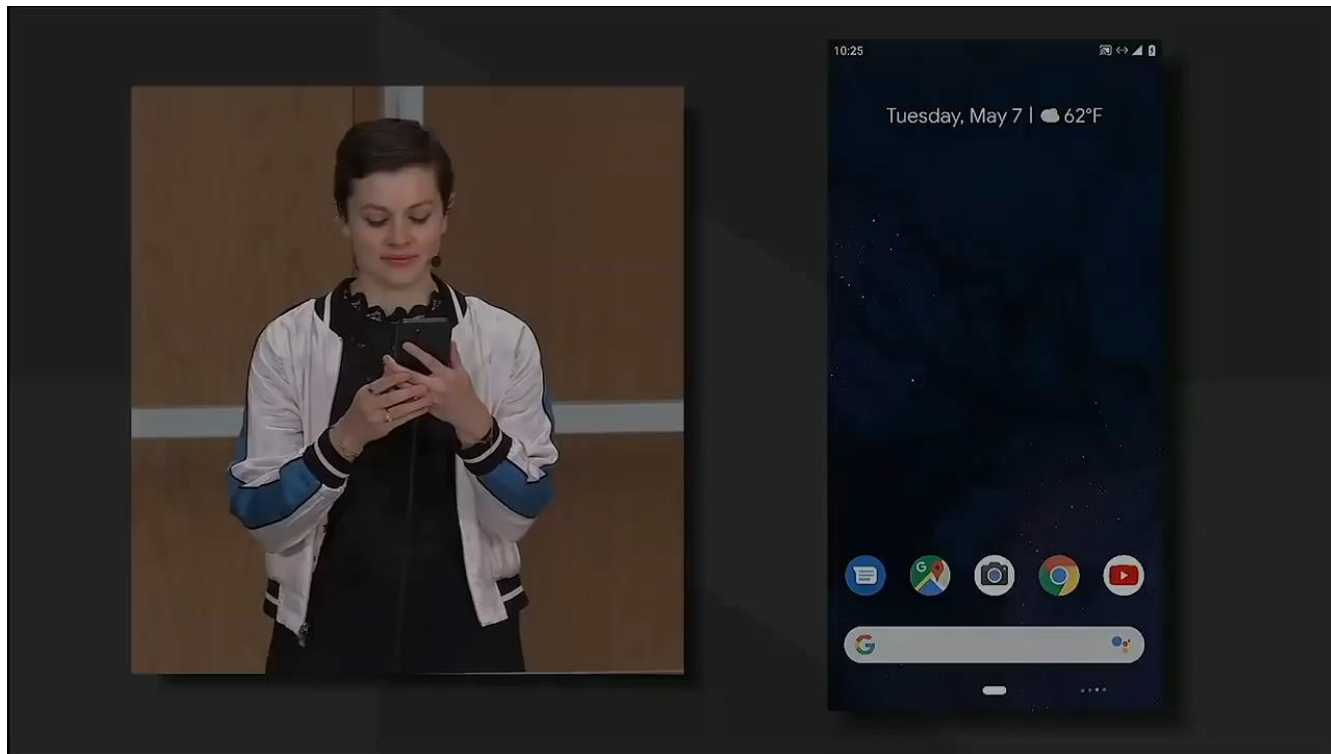
Come, sir, I will make did behold your worship.

VIOLA:

I'll drink it.

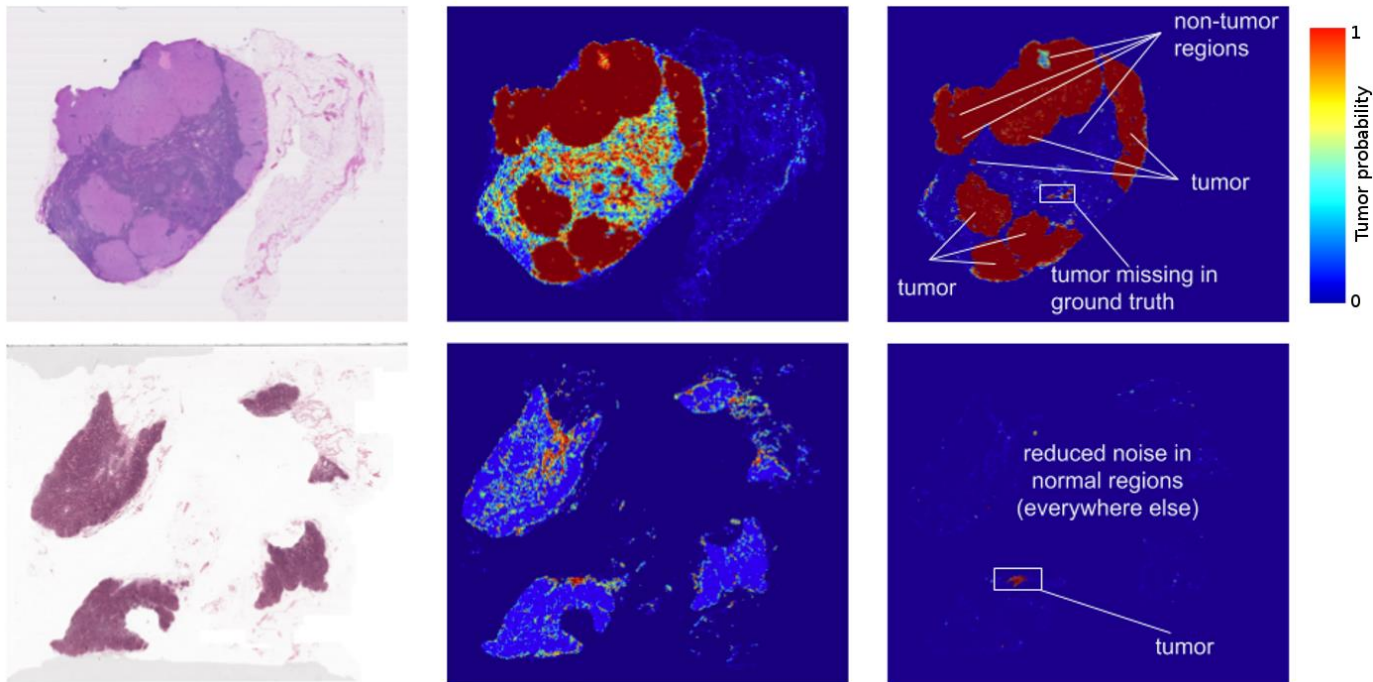
Automated Text Generation [Karpathy et al.]

Deep Learning Today



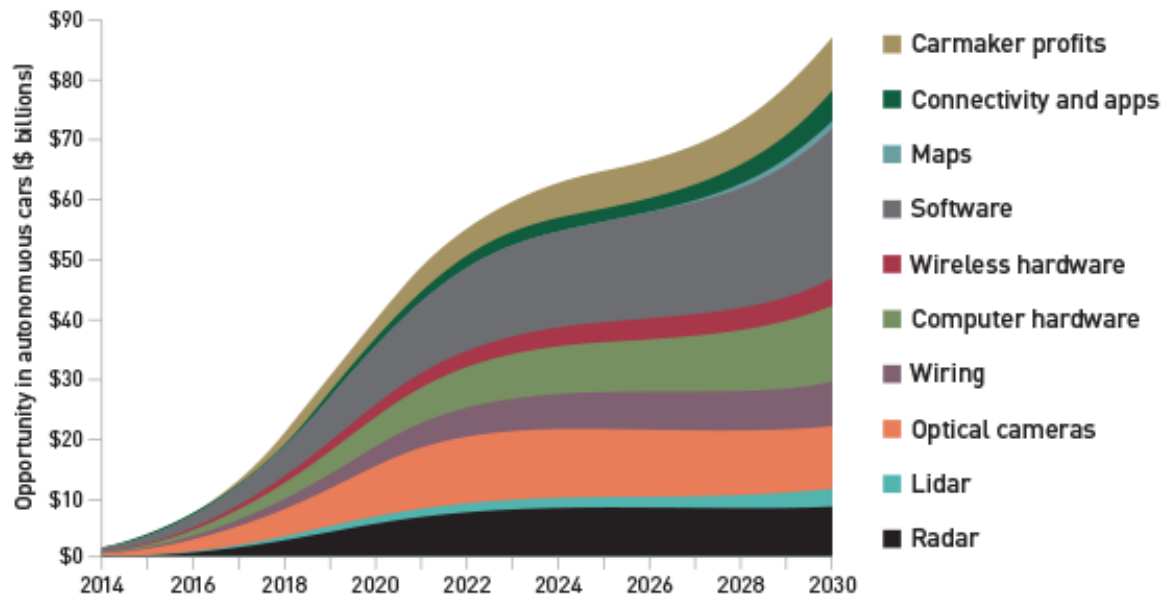
Google Assistant (Google IO'19)

Deep Learning Today



Healthcare, cancer detection

Deep Learning Market



[...] market research report Deep Learning Market [...] " the deep learning market is expected to be worth **USD 1,722.9 Million by 2022.**

Deep Learning Job Perspective

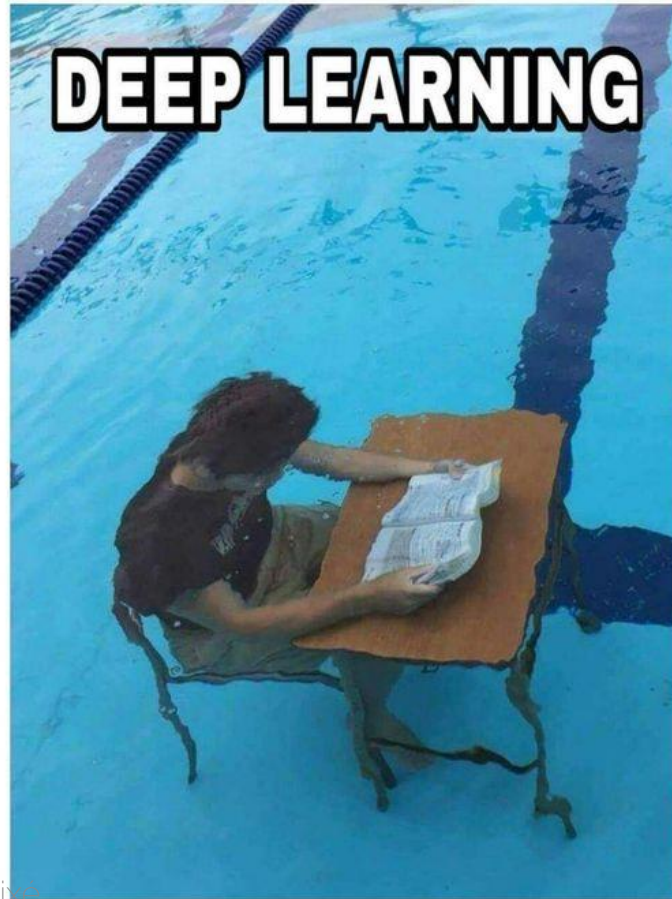
- Excellent Job Perspectives!
 - Automation requires ML/DL -> growth!
 - Top-notch companies will gladly hire you!
- Many industries now:
 - IT-Companies
 - Cars, Logistic, Health Care, etc...
 - Manufacturing / Robotics, etc...

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 Culture

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

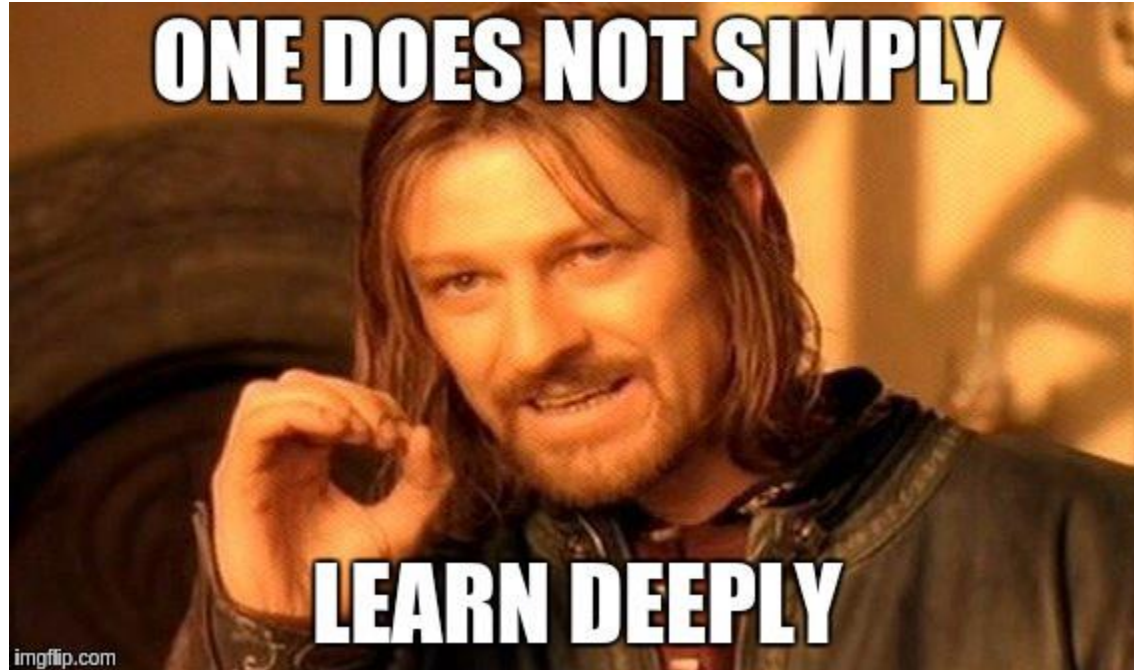
```
from theano import *
```

What I actually do

Deep Learning Memes



Deep Learning Memes



Deep Learning Memes

Types of Headaches

Migraine



Hypertension



Stress

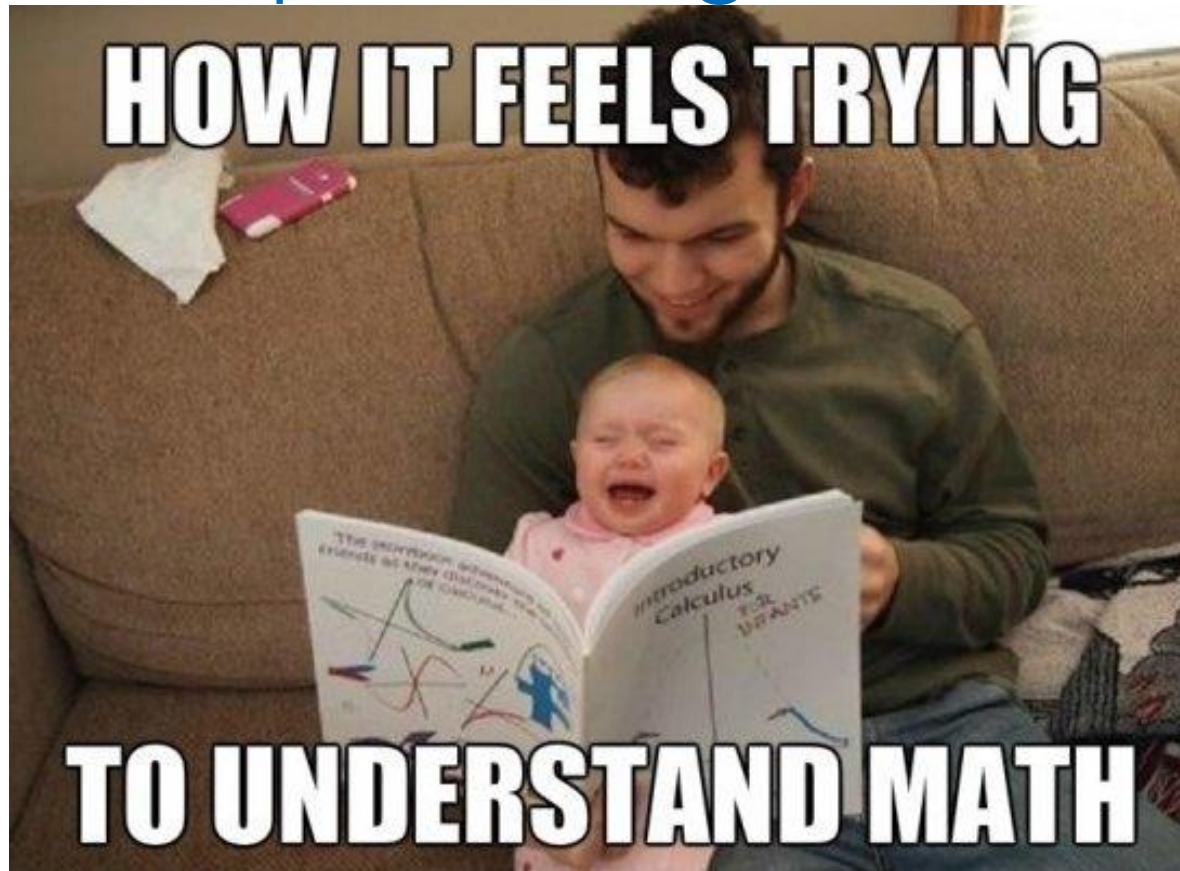


MATH BEHIND DL



imgflip.com

Deep Learning Memes



Deep Learning at TUM

Many TUM Research Labs use DL

- Visual Computing Lab (Prof. Niessner):
 - Research in computer vision, graphics, and machine learning
- Dynamic Vision and Learning Group (Prof. Leal-Taixe)
 - Research on Computer Vision; e.g., video editing/segmentation etc.
- 3D Understanding Lab (Dr. Dai):
 - Research in 3D scenes and its semantics.
- 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 😊

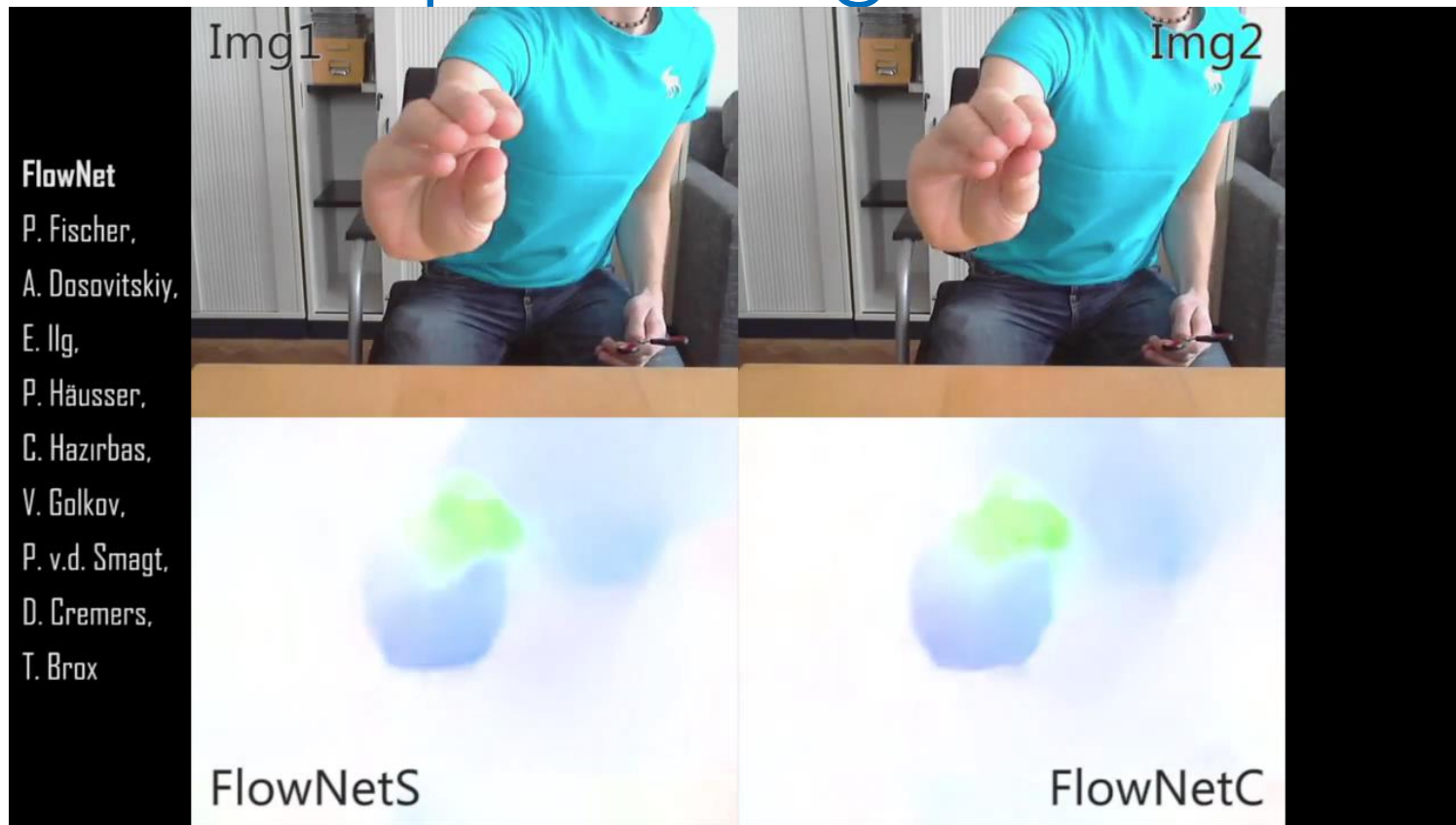
Our Research Labs

- Visual Computing Lab (Prof. Niessner):
<https://niessnerlab.org/publications.html>
 - Twitter: <https://twitter.com/MattNiessner>
 - Youtube: <https://www.youtube.com/channel/UCXN2nYjVTocR9G61RPEzK5Q>
 - Facebook: <https://www.facebook.com/matthias.niessner>
- Dynamic Vision and Learning Lab (Prof. Leal-Taixé):
<https://dvl.in.tum.de/publications.html>
 - Twitter: <https://twitter.com/lealtaixe>
 - Youtube: <https://www.youtube.com/channel/UCQVCsX1CcZQrooUMZg6szlQ>

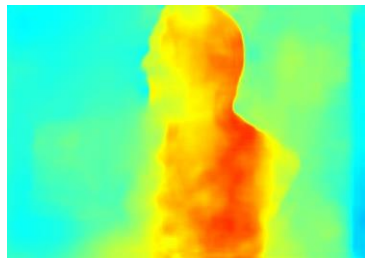
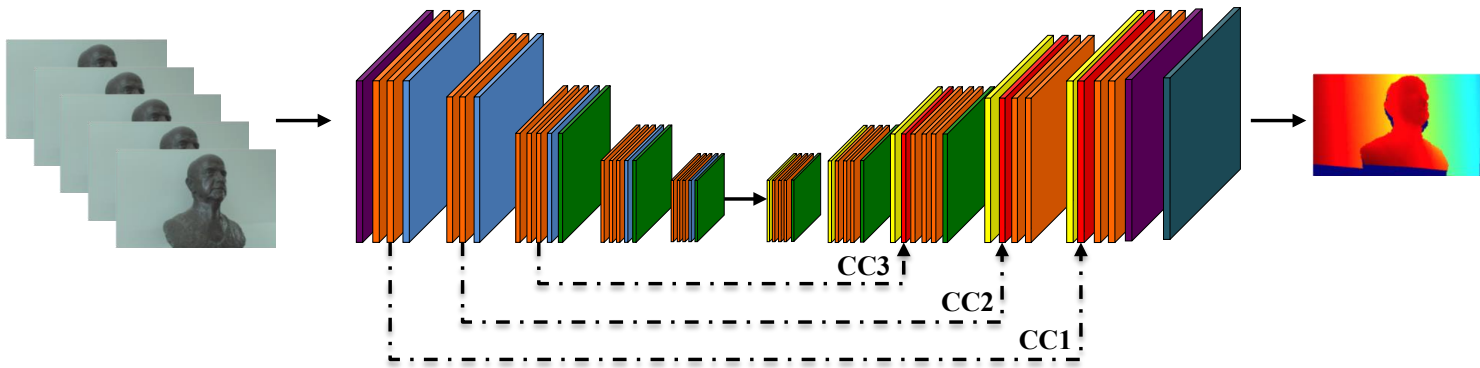
Deep Learning at TUM



Deep Learning at TUM



Deep Learning at TUM



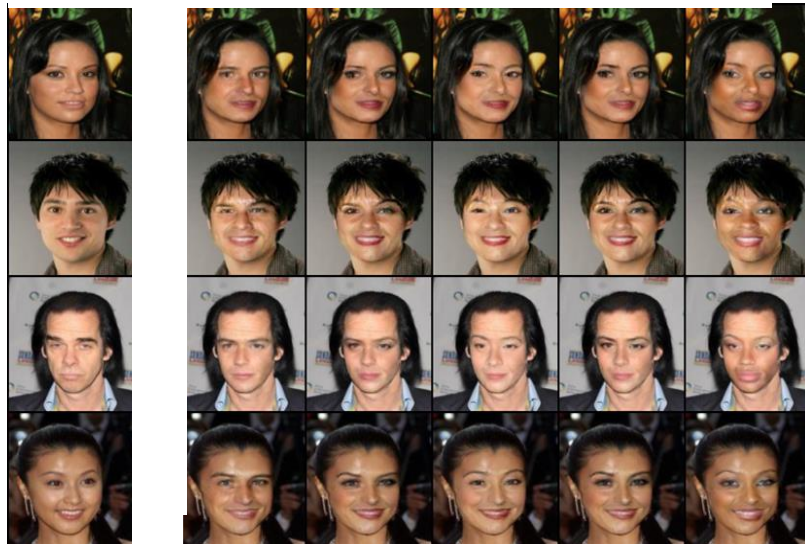
Deep Learning at TUM

- Video anonymization



Control
identity

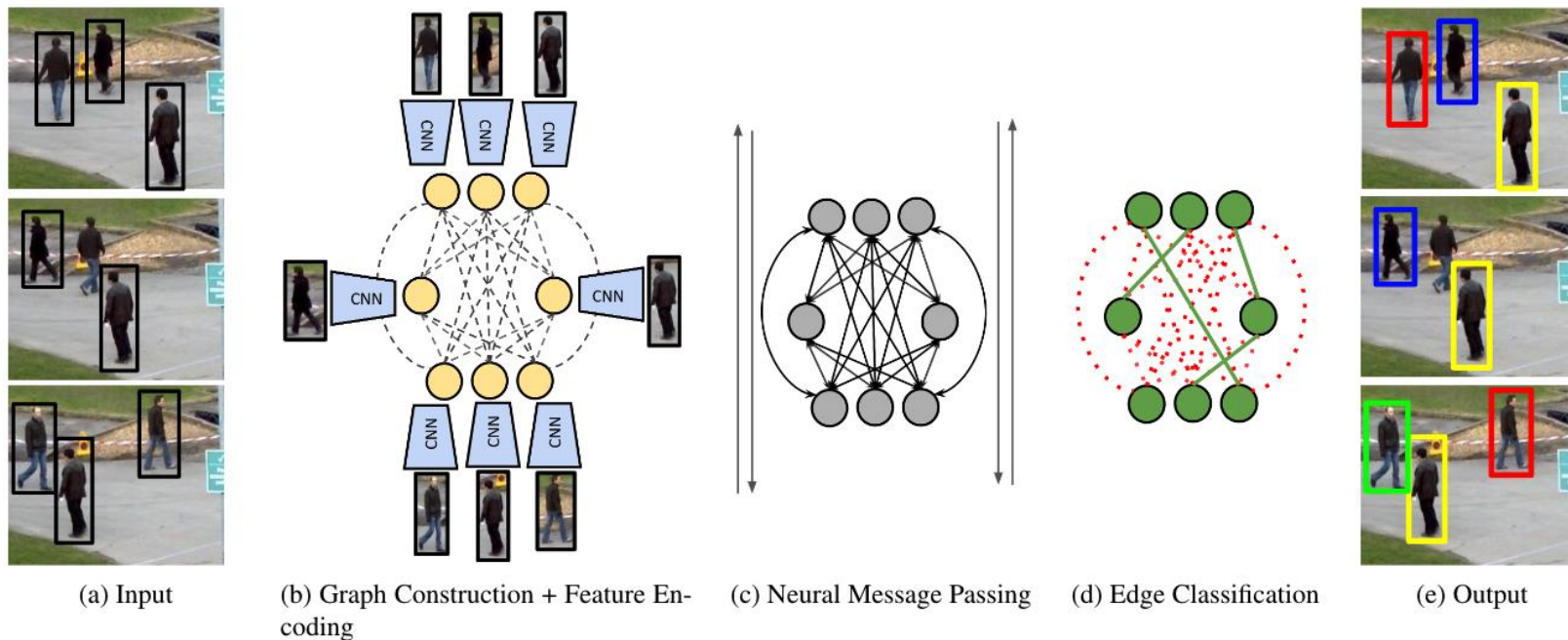
Source



[Maximov et al., CVPR 2020] CIAGAN: Conditional identity
anonymization generative adversarial networks.

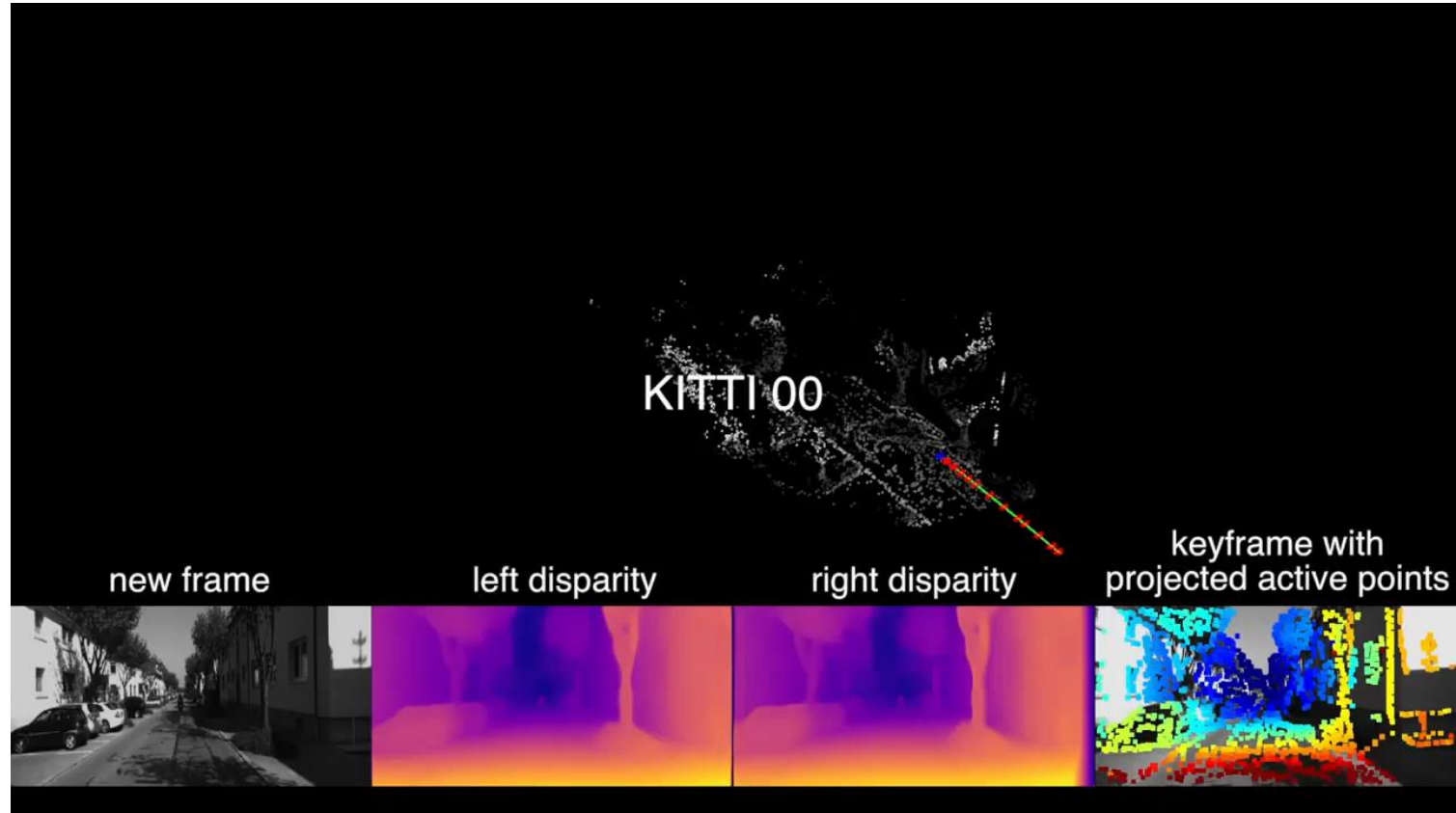
Deep Learning at TUM

- Multiple object tracking with graph neural networks

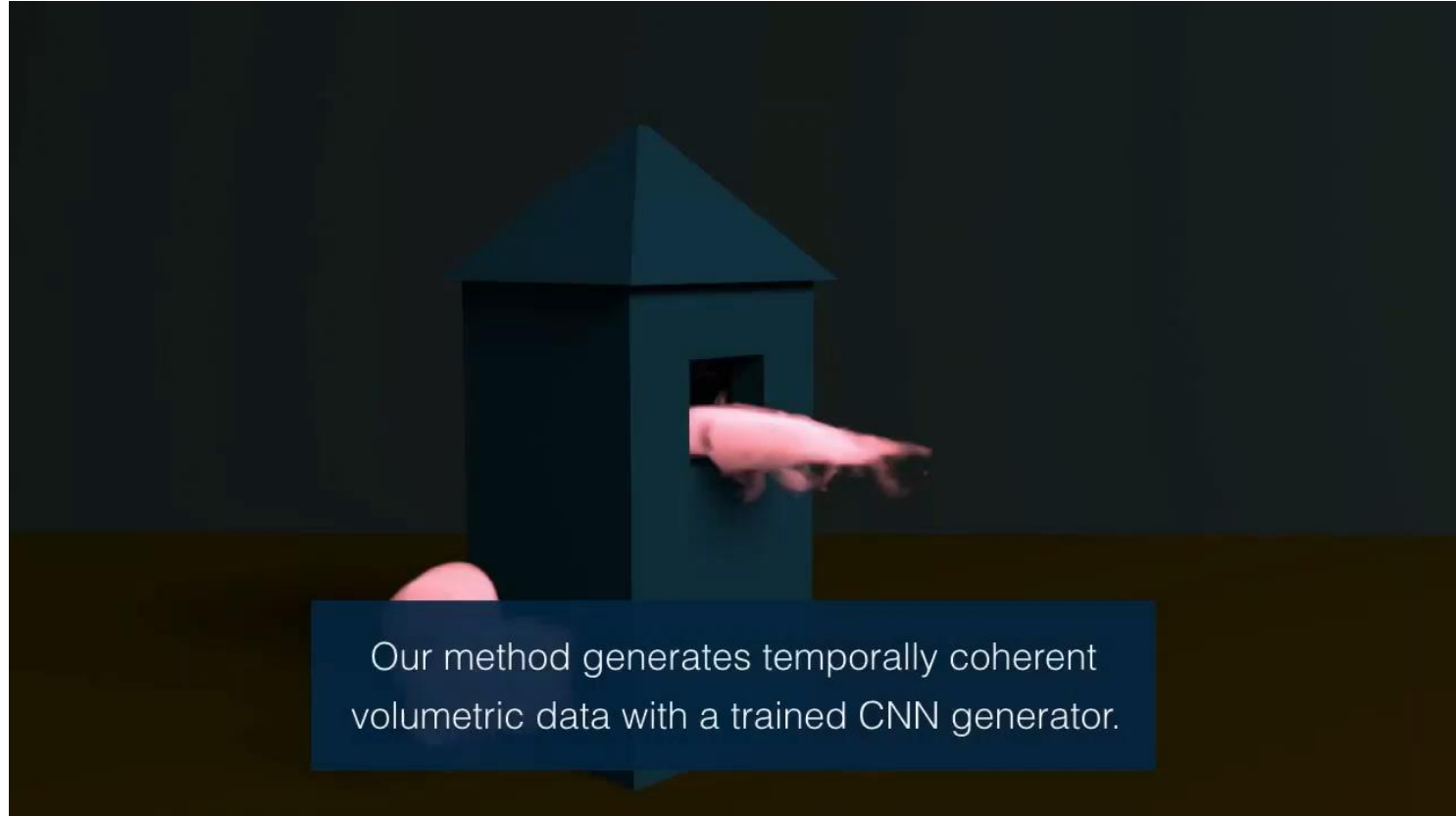


[Brasó and Leal-Taixé, CVPR 2020] Learning a Neural Solver for Multiple Object Tracking.

Deep Learning at TUM



Deep Learning at TUM



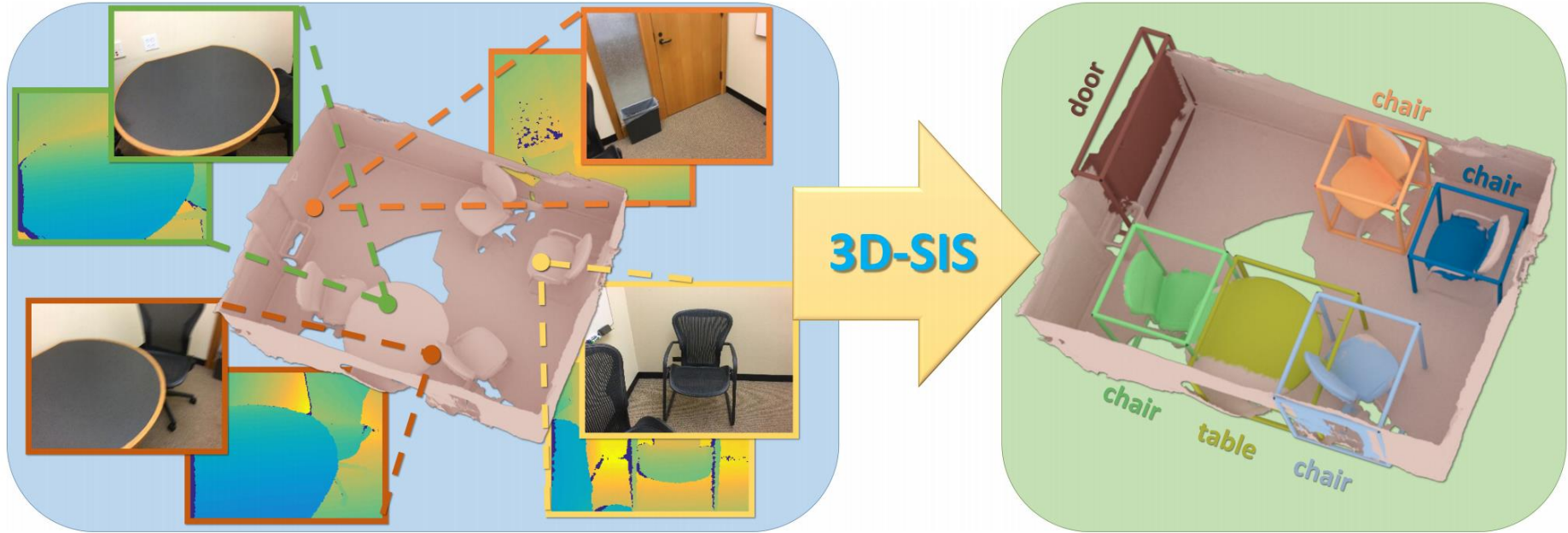
Deep Learning at TUM



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

Animation Synthesis

Source Actor



Target
UV-Map



Target
Background



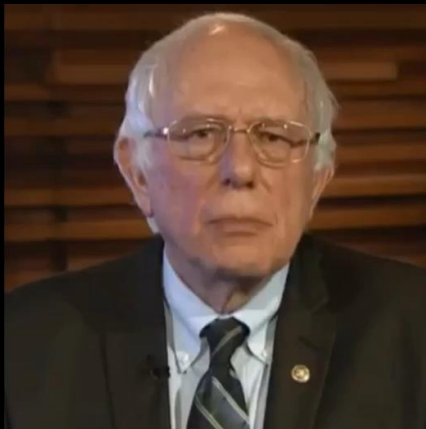
Output



Deep Learning at TUM

Animation Synthesis

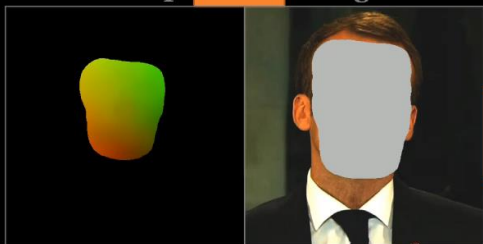
Source Actor



Target
UV-Map



Target
Background



Output



Deep Learning at TUM

Animation Synthesis

Source Actor



Target
UV-Map



Target
Background



Output



Deep Learning at TUM

Animation Synthesis

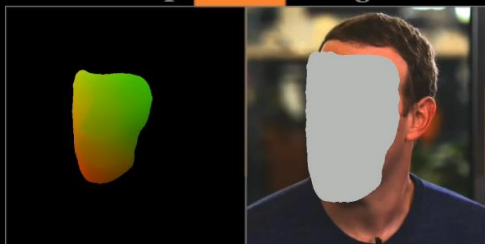
Source Actor



Target
UV-Map



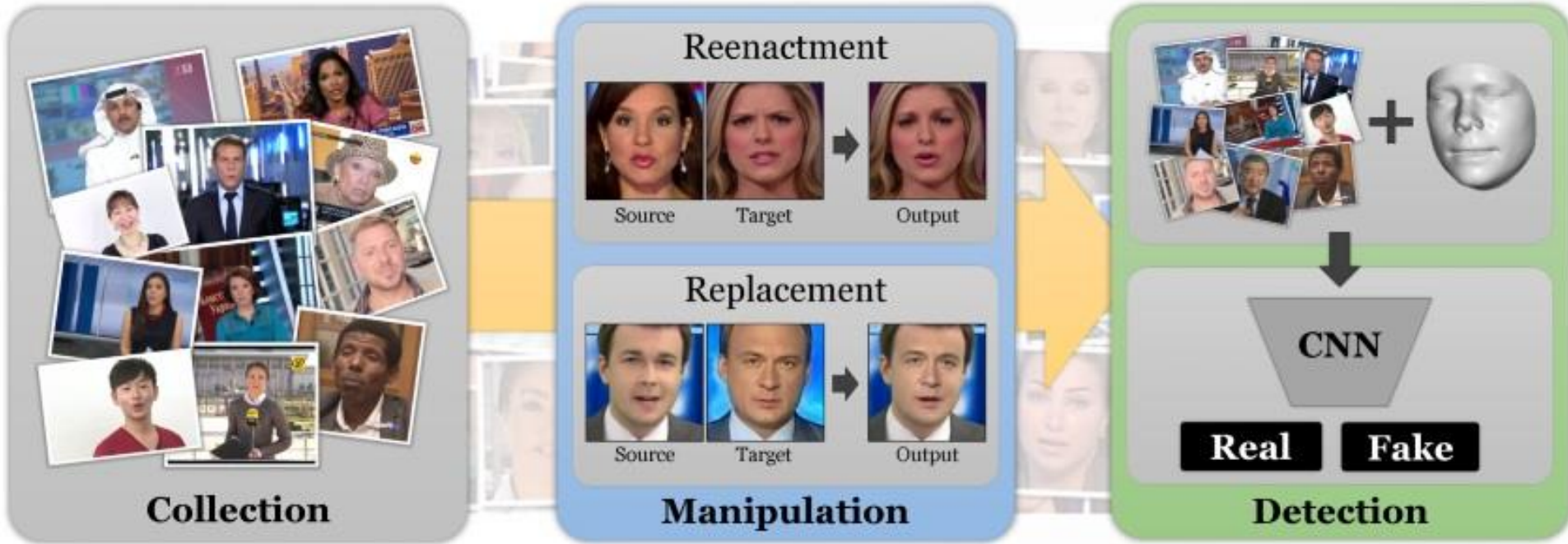
Target
Background



Output

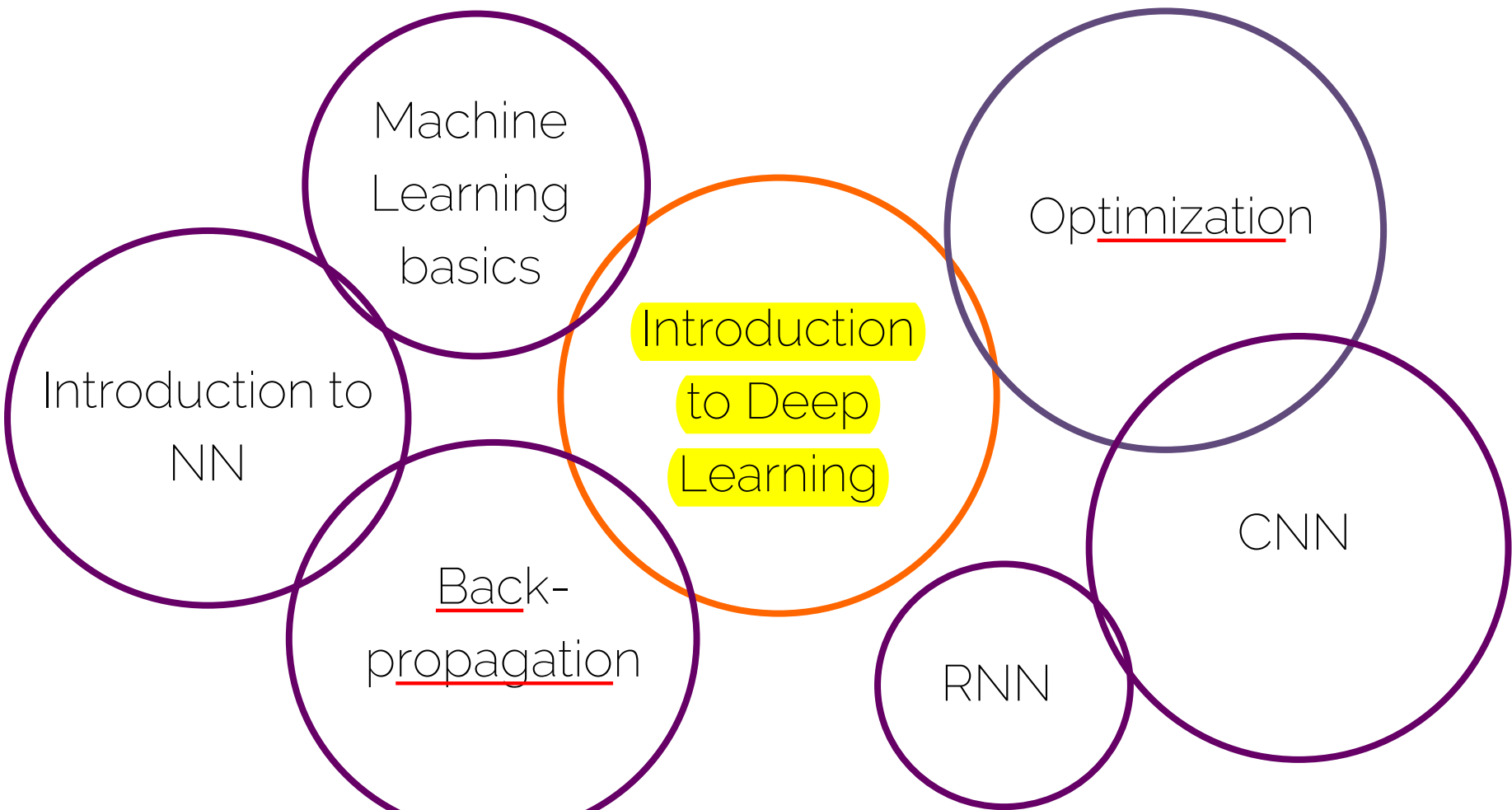


Deep Learning at TUM

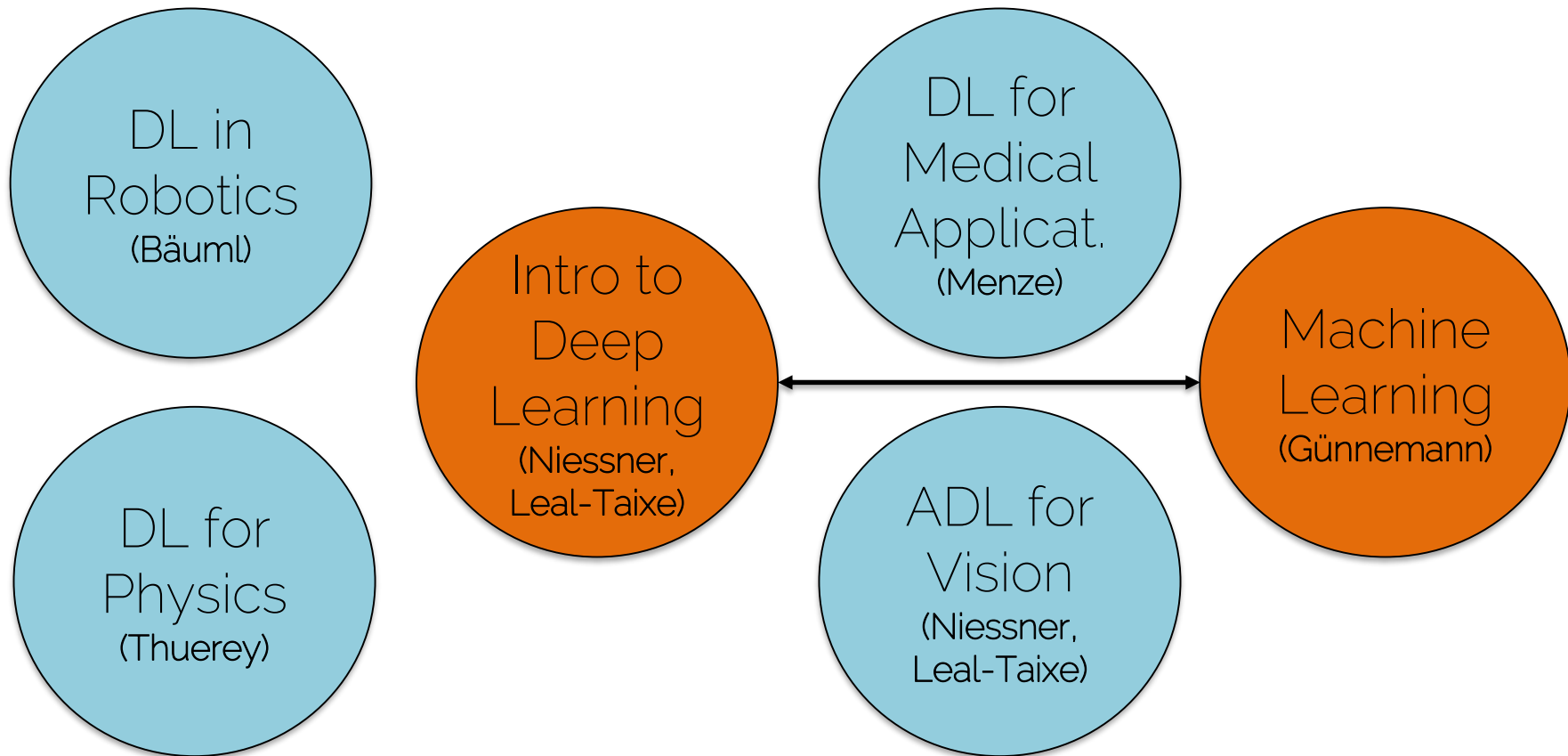


[Roessler et al., ICCV'19]: Face Forensics++

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 prestigious Advanced Deep Learning for Computer Vision Class)
- Always preparation for guided research / IDP
 - Most topics require it
 - For career in AI/DL these are the best ways to get into

What's New?

- Last semester:
 - Re-vamped content of slides / improved design
 - Re-organization of lecture structure
- This semester:
 - Re-vamping of the exercises (incl. sessions)
 - Earlier intro to pyTorch, more but smaller exercises

Introduction to Deep Learning

Moodle

- Announcements via Moodle - **IMPORTANT!**
 - Sign up in TUM online for access:
<https://www.moodle.tum.de/>
 - We will share common information (e.g., regarding exam)
 - Ask content questions online so others benefit
 - Don't post solutions
 - TAs will monitor Moodle (expect answers within hours)
 - We have a team of 11 TAs

Email

- Email list:

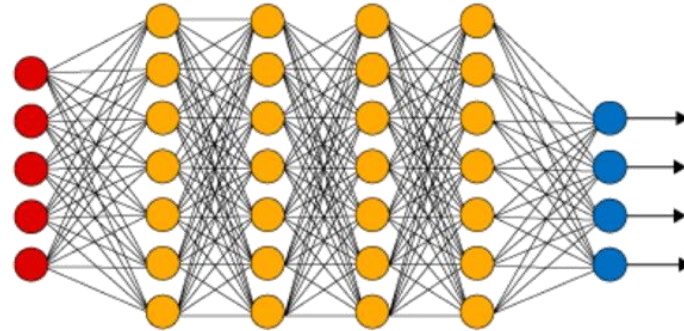
i2dl@vc.in.tum.de

- Do NOT email us personally!
 - Cannot handle so many emails / hence will be ignored
- Email list for organizational questions only!
 - Content questions -> Moodle or Office Hours

Website

- Links and slides will be shared on website

Introduction to Deep Learning (I2DL) (IN2346)



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

About the Lecture

- Theory lectures
- Every Monday 14:15-15:45
 - Lectures are virtual and will be uploaded to youtube:
<https://www.youtube.com/channel/UCXN2nYjVTocRgG61RPEzK5Q>
- Practical sessions
 - Every Thursday 8:30-10:00
 - There will be practical exercises
- Guest lecture TBD

Grading System

- Exam: TBA
- Review: TUM Exam
- Important: no retake exam
- Practice: More information on Thursday!
 - Bonus 0.3 + questions in the final exam
 - Do not miss the first practical session !!!

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; CNNs for object detection
- Lecture 11: Recurrent Neural Networks (RNNs)
- Lecture 12: Autoencoders, VAEs and GANs
- Lecture 13: Reinforcement Learning
- Lecture 14: Guest Lecture (TBD)

Other Administrative

- External students welcome
 - Will get Certificate / Schein at the end
 - Send email to list and we will add you to moodle
- Lectures will be recorded and put on youtube
 - <https://www.youtube.com/channel/UCXN2nYjVTocRgG61RPEzK5Q>
- Again: check announcements on moodle

Office Hours

- We will have dedicated office hours regarding
 - Theoretical help (e.g., specific lecture questions)
 - Help on exercises
- Will be announced with first tutorial session and on Moodle

Upcoming Lecture

- Next Lecture: Lecture 2: Machine Learning basics
- This Thursday: 1st Practical Session
 - if you want bonus, do not miss it!

See you next week 😊