Friedrich-Alexander-Universität
Technische Fakultät

FAU

Advanced Deep Learning

Introduction

K. Breininger, V. Christlein

Artificial Intelligence in Medical Imaging + Pattern Recognition Lab, Friedrich-Alexander-Universität Erlangen-Nürnberg SoSe 2023

1. Getting to know each other
2. Why “advanced” deep learning?
3. Organization of this lecture
4. Topics

1. Getting to know each other
2. Why “advanced” deep learning?
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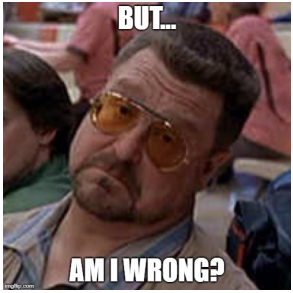
Who are we not!

Prof. Vasileios Belagiannis



Course: Advanced Deep Learning **Topics**

Sources:
https://www.tf.fau.de/2022/10/allgemein/neu-an-der-technischen-fakultaet-prof-dr-vasileios-belagiannis/
https://imgflip.com/i/2pn8yk

Who are we?

Katharina Breininger

Head of AI in Medical Imaging
(AIMI @ FAU)
Department AIBE

Vincent Christlein

Head of Computer Vision
Group at PRL
Department CS

Jonas Utz

Member of AIMI
Department AIBE

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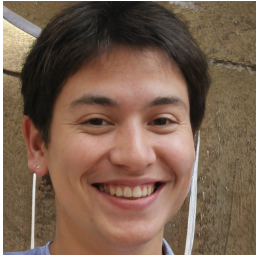
The power of CNNs



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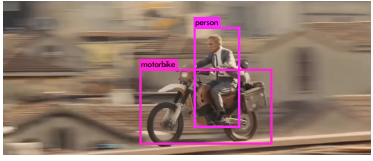
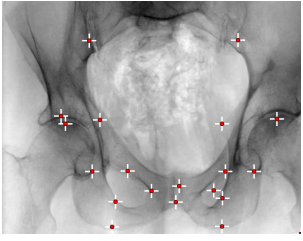
does not exist





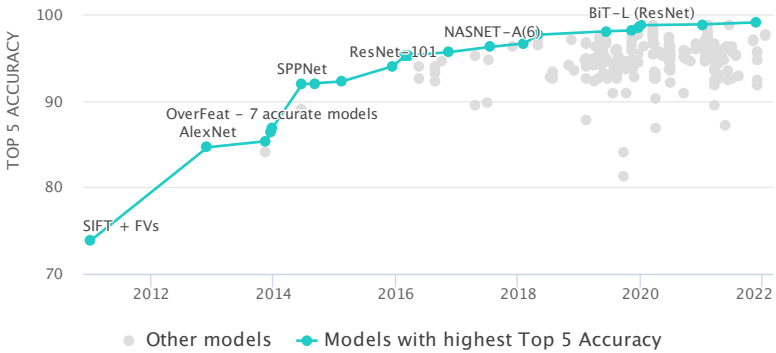
HEALTH

AI Is Better at Diagnosing Skin Cancer Than Your Doctor, Study Finds

By EMILY PRICE
May 30, 2018 8:20 PM GMT+2

Source: face: https://thispersondoesnotexist.com/, YOLO: www.youtube.com, Skin cancer: fortune.com, pelvis: Bier et al. 2018.

Why “advanced" deep learning?



Source: https://paperswithcode.com/sota/image-classification-on-imagenet

Current challenges and beyond CNNs

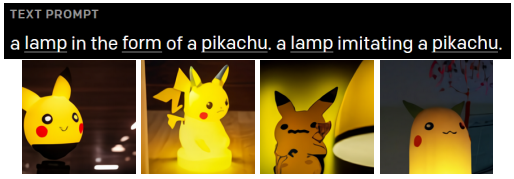
Artificial intelligence / Machine learning

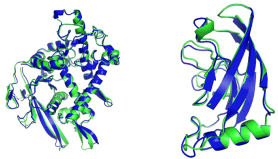
Google's medical AI was super accurate in a lab. Real life was a different story.

RETAIL OCTOBER 11, 2018 / 1:04 AM / UPDATED 2 YEARS AGO

Amazon scraps secret AI recruiting tool that showed bias against women

By Jeffrey Dastin 8 MIN READ





T1037 / 6vr4
90.7 GDT
(RNA polymerase domain)

T1049 / 6y4f
93.3 GDT
(adhesin tip)

Experimental result
Computational prediction

Source: Google lab: technologyreview.com, Reuters: reuters.com, Pikachu lamp: https://openai.com/blog/dall-e/, protein: deepmind.com

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What do we want to achieve?

- Teach you advanced deep learning topics
- Practice your DL programming skills
- Engage in scientific discussions

Source: https://kidscodecs.com/memes-for-programmers/

What do we expect from you?

- Commitment
- Preparation & participation
- Communication – let us know if there are problems!

  Important: Let us know early if you want to drop the course!

Prerequisites

- Advanced master level course (!)
- Good understanding of deep learning and machine learning in general
- Sound mathematical background
- Willingness to “dig deeper” and look into complex topics

Final grade

- Oral exam in the lecture-free period
- Regular active participation in the lecture is expected
- We will ask some questions about the exercises

Exercises

Coding

1. Attention
2. Diffusion models
3. Energy-based models
4. Bonus: Competition about representation learning

➔ It will be challenging! There are typically no unit-tests

Presentations

- Prepare a 5 minute video lecture about a paper (in teams of 2)

Source: http://edisonwritingcenter.blogspot.com/2014/04/11-presentation-tips-ft-memes.html

Lecture organization

- 5 min Recap about last lecture
- 10 min (pre-recorded) paper presentations by 4 students
- 5 min Q & A
- 60 min lecture of new topic
- 10 min Discussion/Q & A

Last but not least: in-person lecture

- Room 08801.00.020 (Seminarraum ZMPT 00.020)
- **Do not** attend a session if you feel sick or have flu-like symptoms

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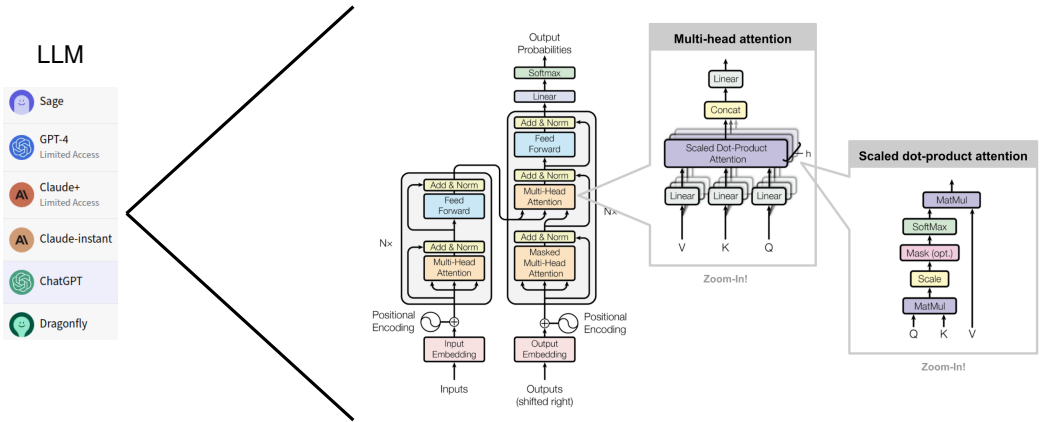
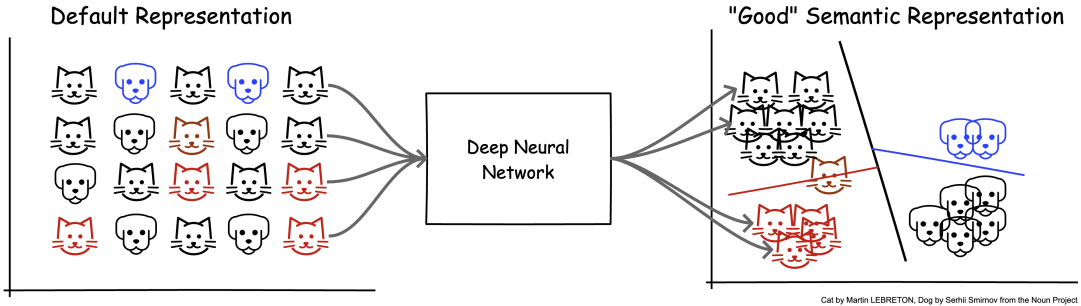
Attention, Transformers, LLM



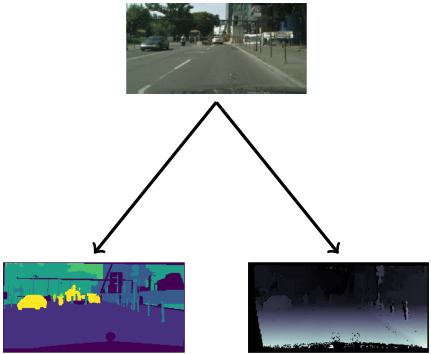
Source: poe.com | Vaswani et al. 2017 [1], https://lilianweng.github.io/posts/2018-06-24-attention/

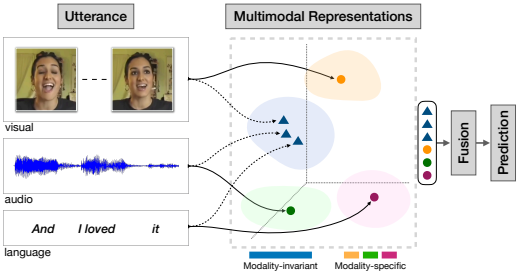
Representation learning



Source: https://blog.fastforwardlabs.com/2020/11/15/representation-learning-101-for-software-engineers.html

Multi-task & multi-modal learning





Source: Liu et al. 2019 [2] | Hazarika et al. 2020 [3]

Diffusion Modeling

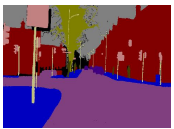
Text prompt

medium-full off-center shot,
35 mm Kodachrome film still,
capturing a Japanese woman peacing out and waving down a taxi,
wearing a gingham print dress made of silk,
blue/white palette,
accessorized by sleek pearl earrings,
another moody late-night in Tokyo
–ar 1:1

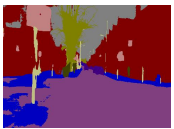
Generate

Source: https://twitter.com/nickfloats/status/1645522764084772875

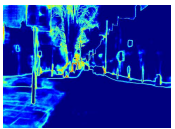
Bayesian deep learning



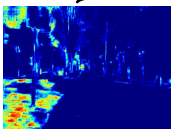
Ground Truth



Output



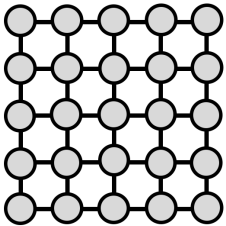
Data uncertainty



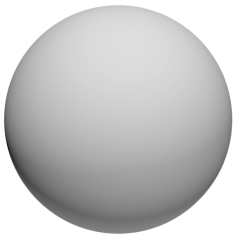
Model uncertainty

Source: Kendall & Gal 2017 [4]

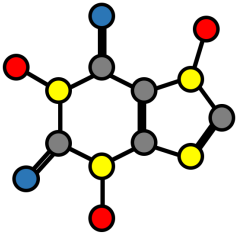
Geometric deep learning



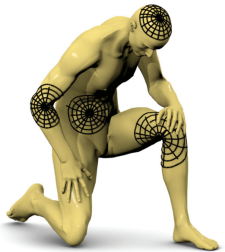
Grids



Groups



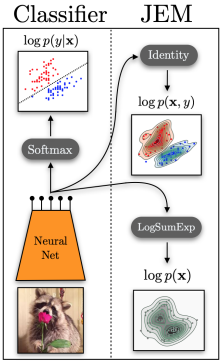
Graphs



Geodesics & Gauges

Source: Bronstein et al. [5]

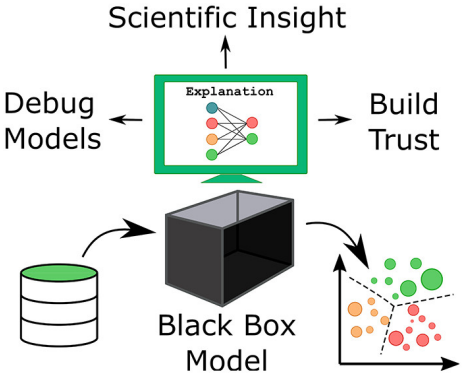
Joint energy-based models



- Calibration
- Generation
- Out-of-distribution classification
- ...

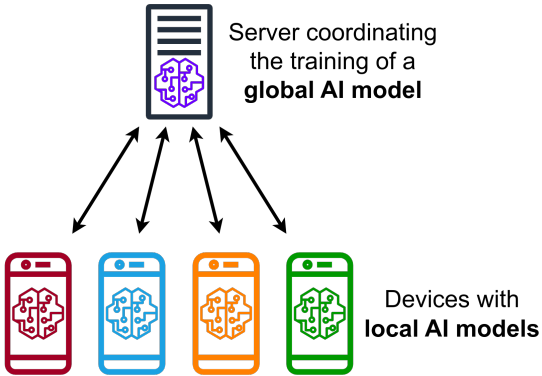
Source: Grathwohl et al. 2020 [9]

Interpretable DL & causal DL



Source: Oviedo et al. 22 [6]

Federated and privacy-preserving DL

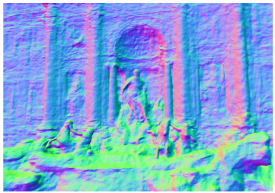


Source: https://en.wikipedia.org/wiki/Federated_learning (CC-BY-SA)

Neural rendering

Training image

Reconstruction



Normals

Diffuse Albedo

Illumination

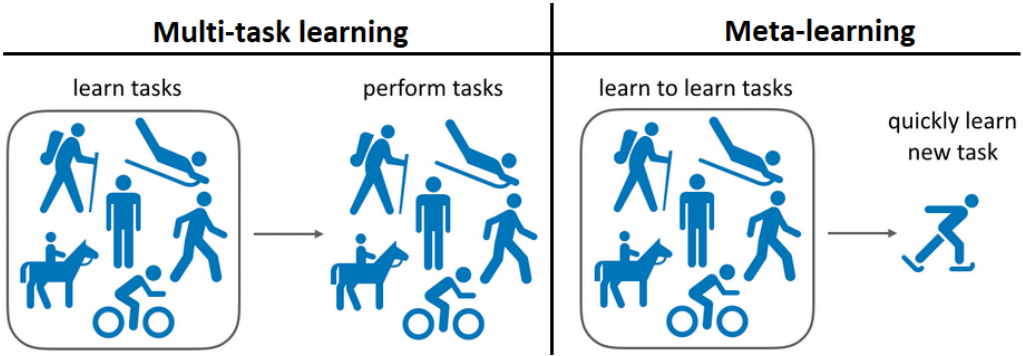
Shadows

Novel Lighting

Novel Lighting and Viewpoint

Source: Rudnev et al. 2022 [7]

Meta learning & knowledge distillation



Source: Huisman et al. 2021 [8]

Topics and preliminary lecture schedule

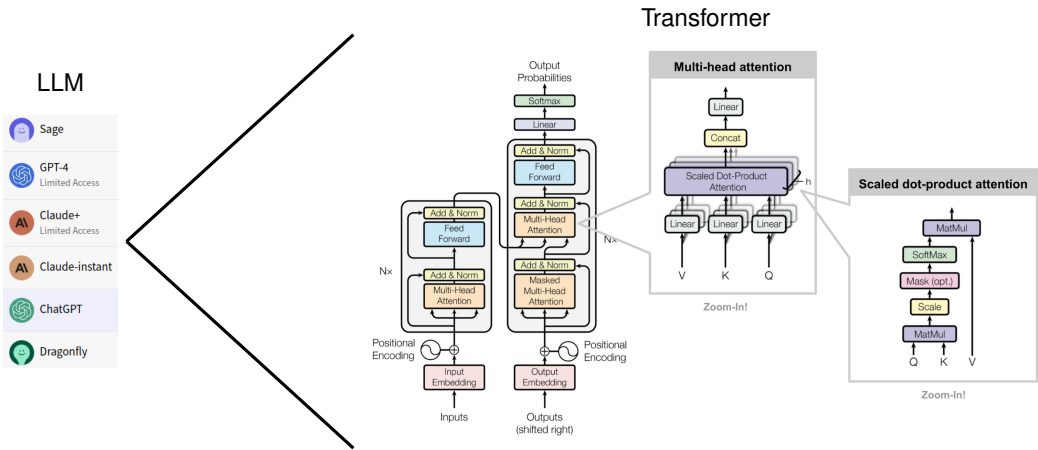
1. Intro
2. Attention, transformers, large-language models
3. Representation learning, metric learning
4. Multi-task learning, multi-modal learning
5. Diffusion models
6. Bayesian DL
7. Geometric DL
8. Joint energy-based models
9. Interpretable DL, causal DL
10. Federated DL, privacy-precerving DL
11. Neural rendering
12. Meta learning, knowledge distillation
13. Tricks of the trade
14. Q & A, exam preparation

NEXT TIME

ADVANCED

ON DEEP LEARNING

Coming up: attention, transformers, LLM



Source: poe.com | Vaswani et al. 2017 [1], https://lilianweng.github.io/posts/2018-06-24-attention/

References

References I

[1] Ashish Vaswani, Noam Shazeer, Niki Parmar, et al. “Attention is All you Need”. In: Advances in Neural Information Processing Systems. Vol. 30. Curran Associates, Inc., 2017.

[2] Shikun Liu, Edward Johns, and Andrew J. Davison. “End-To-End Multi-Task Learning With Attention”. In: 2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR). June 2019, pp. 1871–1880.

[3] Devamanyu Hazarika, Roger Zimmermann, and Soujanya Poria. “MISA: Modality-Invariant and -Specific Representations for Multimodal Sentiment Analysis”. In: Proceedings of the 28th ACM International Conference on Multimedia. MM ’20. Seattle, WA, USA: Association for Computing Machinery, 2020, pp. 1122–1131.

[4] Alex Kendall and Yarin Gal. “What Uncertainties Do We Need in Bayesian Deep Learning for Computer Vision?” In: Advances in Neural Information Processing Systems. Vol. 30. Curran Associates, Inc., 2017.

References II

[5] Michael M. Bronstein, Joan Bruna, Taco Cohen, et al. Geometric Deep Learning: Grids, Groups, Graphs, Geodesics, and Gauges. 2021. arXiv: 2104.13478 [cs.LG].

[6] Felipe Oviedo, Juan Lavista Ferres, Tonio Buonassisi, et al. "Interpretable and Explainable Machine Learning for Materials Science and Chemistry". In: Accounts of Materials Research 3.6 (2022), pp. 597–607. eprint: https://doi.org/10.1021/accountsmr.1c00244.

[7] Viktor Rudnev, Mohamed Elgharib, William Smith, et al. "NeRF for Outdoor Scene Relighting". In: Computer Vision – ECCV 2022. Cham: Springer Nature Switzerland, 2022, pp. 615–631.

[8] Mike Huisman, Jan N. van Rijn, and Aske Plaat. "A survey of deep meta-learning". In: Artificial Intelligence Review 54.6 (Aug. 2021), pp. 4483–4541.

[9] Will Grathwohl, Kuan-Chieh Wang, Joern-Henrik Jacobsen, et al. "Your classifier is secretly an energy based model and you should treat it like one". In: International Conference on Learning Representations. 2020.