50.039 Theory and Practice of Deep Learning
W13S1 – End and Review

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Some admin stuff

Final exam

- Content will be everything from W1 to W12 included.

- Similar format as MidTerm.

- Details for exam (location, assignments, etc.) to be sent via email.

Big project

- **No extension will be given (have to give grades to OSA!)**

Some admin stuff

Conferences (to replace classes this week)

- **Paypal: Friday 22nd, 11.30am**

- **Gojek: Thursday 21st, 10am**

Over Zoom, links to be sent later.

Attendance is mandatory (unless you have clashes with other courses, in which case you will be excused).

So this is the end

What's next?

Develop a deeper understanding of…

Advanced attacks and Defense mechanisms (W8++)

Many more mechanisms when it comes to attacking and defending a Neural Network, e.g. new types of attacks, such as:

- Poisoning attacks (attempt to poison the dataset so the NN cannot re-train properly),

- Weights changes (attempt to change a small subset of the weights of the NN to prevent it from working in certain ways),

- Etc.

https://www.comp.nus.edu.sg/~reza/courses/cs6231/

Develop a deeper understanding of…

Advanced word embedding and NLP problems (W9++)

Many more mechanisms when it comes to embedding and language related problems.

- E.g. more advanced embeddings

- Typical tasks in NLP (chatbots, context propagation, sentiment analysis, translation, etc.)

- Go for the Term 8 NLP course!

https://istd.sutd.edu.sg/undergraduate/courses/50040-natural-language-processing

Develop a deeper understanding of…

Advanced Graph Neural Networks (W10++)

We barely scratched the surface of Graph Theory. If you need to study a new math theory, let it be graph theory!

• Good graph theory course here:

https://ocw.mit.edu/courses/mathematics/18-217-graph-theory-and-additive-combinatorics-fall-2019/

• More advanced problems and concepts on Graph Neural Networks in lectures 1-9 of course here:

https://www.cs.ox.ac.uk/teaching/courses/2020-2021/advml/

Develop a deeper understanding of…

Advanced Graph Neural Networks (W10++)

Also, keep in mind that Neural Networks are graphs…

- So technically, we could build a Neural Network, which receives another Neural Network as its input…!

- What could be the uses for such a technique?

- Meta-learning? (i.e. training an AI to train another AI?!) https://machinelearningmastery.com/meta-learning-in-machine-learning/

Develop a deeper understanding of…

Advanced Generative Models (W11++)

- Advanced GANs, operating on other types of data than just images (sound, text, etc.)

- Very good online course here:

https://cs236g.stanford.edu/

Develop a deeper understanding of…

Advanced Reinforcement Learning (W12++)

Barely scratched the surface about Reinforcement Learning.

- Currently considering to create a RL course at SUTD for Term 8. Thoughts?

- Otherwise, the reference course on RL is the one from David **Sliver** (the man behind AlphaGo!)

https://deepmind.com/learning-resources/-introduction-reinforcement-learning-david-silver

And https://www.davidsilver.uk/teaching/

Develop a deeper understanding of…

Advanced Interpretability (W12++)

- Rather an ongoing field in research at the moment.
- Not that many course out there, but worth keeping an eye out…

On top of everything we have seen…

More concepts, problems and architectures on Computer Vision

Ask for the course materials of the Computer Vision Term 7 course for more advanced concepts on CV, such as:

- More advanced loss functions like triplet loss,

- Advanced architectures like siamese networks,

- Video data models,

- Etc.

https://istd.sutd.edu.sg/undergraduate/courses/50035-computer-vision

On top of everything we have seen…

More concepts, problems and architectures on Computer Vision

- Also, always good to go for an image processing course to understand typical image transformation and problems out there.

https://www.coursera.org/learn/image-processing?ranMID=40328&ranEAID=*GqSdLGGurk&ranSiteID=.GqSdLGGurk-GV4LxEnPMuMd1.8y4AurRA&siteID=.GqSdLGGurk-GV4LxEnPMuMd1.8y4AurRA&utm_content=10&utm_medium=partners&utm_source=linkshare&utm_campaign=*GqSdLGGurk

On top of everything we have seen…

Bayesian and Statistical Learning (Variational AutoEncoders were 101).

• A good entry point for Bayesian Deep Learning

https://medium.com/@ODSC/introduction-to-bayesian-deep-learning-f7568f524c90

• Lectures 10-End

https://www.cs.ox.ac.uk/teaching/courses/2020-2021/advml/

On top of everything we have seen…

A bit of advanced optimization and game theory never hurts…

- Especially when trying to optimize two cooperating or competing neural networks! (GANs, actor-critic, etc.)

- Great courses here:

https://oyc.yale.edu/economics/econ-159

And

https://online.stanford.edu/courses/soe-ycs0002-game-theory

On top of everything we have seen…

CUDA masters are the king of the world these days…

- BigTech companies are looking for experts that can help with machine learning and custom GPU implementations

- The most obvious way to learn is from Nvidia courses themselves, some give certifications, but it is an investment...

https://developer.nvidia.com/cuda-education-training

CUDA Education & Training

Accelerate Your Applications

Learn using step-by-step instructions, video tutorials and code samples.

- Accelerated Computing with C/C++
- Accelerate Applications on GPUs with OpenACC Directives
- Accelerated Numerical Analysis Tools with GPUs
- Drop-in Acceleration on GPUs with Libraries
- GPU Accelerated Computing with Python

On top of everything we have seen…

Could computing is also very valuable…

- Similarly, a certification in AWS or Microsoft Azure of Google Cloud for cloud computing machine/deep learning is of high value these days!

On top of everything we have seen…

Quantum is the next best thing?

Quantum computers are expected to be the next big thing in Computer Science in general.

- This will also apply to AI/ML/DL…

- This means we will get to train larger networks, faster. (This is currently a limit for many applications these days).

- Picking up on quantum computing is never a bad idea (but careful, possibly the most difficult topic out there!)

https://towardsdatascience.com/dont-ask-what-quantum-computing-can-do-for-machine-learning-cc44feeb51e8

https://pennylane.ai/qml/whatisqml.html

On top of everything we have seen…

More stuff

- Advanced Probability and Statistics (a.k.a. Statistical Learning) is always a great plus…
https://www.statlearning.com/

- Neuroscience should probably be part of any serious AI curriculum… [NeuroAI] Barron et al., "What insects can tell us about the origins of consciousness", 2015.

- Etc.

On top of everything we have seen…

More stuff

- Using DL to solve complex differential equations. https://medium.com/swlh/artificial-intelligence-can-now-solve-a-mathematical-problem-that-can-make-researchers-life-easier-9602c869128

- General AI, i.e. designing an AI will full human cognitive capabilities (vision, hearing, speech, movement, etc.). https://www.forbes.com/sites/forbestechcouncil/2021/07/16/the-future-of-artificial-general-intelligence/?sh=c9223323ba99

- Etc.

The important message is…

Your learning should not stop after SUTD…

Keep learning to stay up to date, this is a very fast evolving field…

So, good luck on your continuing studies!

More importantly

DL/AI is a very active and fast-paced field.

- Keep your watchlist of papers and authors up to date.

- I have mentioned researchers, which I believe are among the most notable influencers of the Deep Learning community.

- Will be adding some more on the next slides.

"A good professor should have this constant concern: teaching his students how to continue without him."
– André Gide, Nobel Prize of Literature in 1947
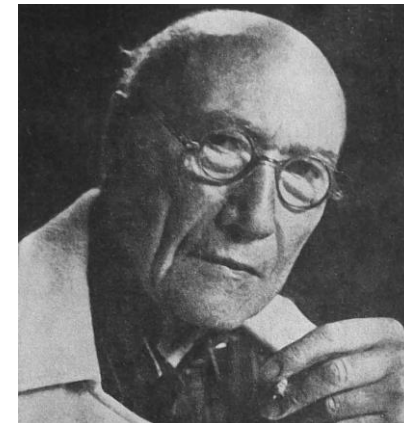
Add these researchers, companies and research groupes to your watchlist

- **Yann LeCun: Chief AI Scientist** at **Facebook AI**, **Professor** at **New York University**, inventor of **CNNs**, creator of **MNIST** dataset, **third one** of the **three GodFathers of Deep Learning**.
  https://scholar.google.com/citations?user=WLN3QrAAAAAJ&hl=fr

- **Demis Hassabis**: Co-founder of **DeepMind**, **AlphaGo**. Several contributions in **Reinforcement Learning**.
  https://scholar.google.com/citations?hl=en&user=dYpPMQEAAAAJ

- **Alex Graves**: **Professor** at **University of Toronto**. Several contributions in **Reinforcement Learning**.
  https://scholar.google.co.uk/citations?user=DaFHynwAAAAJ&hl=en

- **Michael I. Jordan**: Professor at **UC Berkeley**, co-inventor of LDA.
  https://scholar.google.com/citations?user=yxUduqMAAAAJ&hl=fr

Add these researchers, companies and research groupes to your watchlist

- **Christian Szegedy: Research Scientist** at **Google Research, many contributions including** Inception BatchNorm, Attacks, etc. https://scholar.google.com/citations?user=3QeF7mAAAAAJ&hl=en

- **Leon Bottou**: **Researcher** at **Facebook AI**, co-inventor of **Wasserstein GANs** and many contributions to NLP. https://scholar.google.fr/citations?user=kbN88gsAAAAJ&hl=fr

- **Dzmitry Bahdanau**: **Researcher** at **ServiceNow**, several contribution to NLP including attention models. https://scholar.google.de/citations?user=Nq0dVMcAAAAJ&hl=en

- **Kyunghyun Cho**: **Professor** at **New York University**, with many contributions to NLP and Computer Vision. https://scholar.google.co.uk/citations?user=0RAmmIAAAAAJ&hl=en

Add these researchers, companies and research groupes to your watchlist

- **Juergen Schmidhuber**: **Professor** at **King Abdullah University of Science and Technology**, co-inventor of **LSTMs**.
https://scholar.google.com/citations?user=gLnCTgIAAAAJ&hl=fr

- **Sepp Hochreiter**: **Professor** at **Johannes Kepler University Linz** , co-inventor of **LSTMs**.
https://scholar.google.at/citations?user=tvUH3WMAAAAJ&hl=en

- **Fred Cummins**: **Professor** at **University College Dublin**, contributions to **LSTMs** and **NLP**.
https://scholar.google.com/citations?user=E-vg2zQAAAAJ&hl=fr

- **Terrence Sejnowski**: **Professor** at **UC San Diego**, **Boltzmann machines**.
https://scholar.google.ca/citations?user=m1qAiOUAAAAJ&hl=en

Add these researchers, companies and research groupes to your watchlist

- **Peter Norvig**: **Director of Research** at **Google**, co-author of the other Bible of Deep Learning
  https://scholar.google.com/citations?user=Ol0vcWgAAAAJ&hl=en
  http://aima.cs.berkeley.edu/

- **Stuart Russell**: **Professor** at **UC Berkely**, co-author of the other Bible of Deep Learning
  https://scholar.google.com/citations?user=2oy3OXYAAAAJ&hl=en

- **Francois Chollet**: **Researcher** at **Google**. The man behind the **Keras** framework and **Xception**.
  https://scholar.google.com/citations?user=VfYhf2wAAAAJ&hl=en

Add these researchers, companies and research groupes to your watchlist

- **Trevor Hastie**: **Professor** at **Stanford**, co-autor of the Bible of Statistical Learning.
  https://scholar.google.ca/citations?user=tQVe-fAAAAAJ&hl=en
  https://hastie.su.domains/ElemStatLearn/download.html

- **Robert Tibshirani**: **Professor** at **Stanford**, co-autor of the Bible of Statistical Learning. Inventor of the LASSO algorithm.
  https://scholar.google.ca/citations?user=ZpG_cJwAAAAJ&hl=en

- **Vladimir Vapnik: Retired Professor**, inventor of **SVMs** and many other concepts. Worked with **Yann LeCun** at **Facebook AI**.
  https://scholar.google.com/citations?user=vtegaJgAAAAJ&hl=fr

Add these researchers, companies and research groupes to your watchlist

- **Andrej Karpathy**: **Director of AI** at **Tesla**. Many contributions to Computer Vision (**Imagenet**) and NLP (**RNNs**).
  (Probably better to follow him than Elon Musk.)
  https://scholar.google.com/citations?user=l8WuQJgAAAAJ&hl=fr

- **Li Fei-Fei**: **Professor** at **Stanford**. Many contributions to Computer Vision (**Imagenet**).
  https://scholar.google.com/citations?user=rDfyQnIAAAAJ&hl=fr

- **Ilya Sutskever**: **Co-founder** of **OpenAI**.
  Many contributions to Computer Vision (**Imagenet**) and **Reinforcement Learning**.
  Co-inventor of Dropout layers and **Tensorflow**.
  https://scholar.google.com/citations?user=x04W_mMAAAAJ&hl=fr

Add these researchers, companies and research groupes to your watchlist

- **Anil K. Jain**: **Professor** at **Michigan State University**. Many contributions to Computer Vision and Statistical Learning. https://scholar.google.com/citations?user=g-_ZXGsAAAAJ&hl=fr

- **Jitendra Malik**: **Professor** at **UC Berkeley**. Many contributions to Computer Vision and Statistical Learning. https://scholar.google.com/citations?user=oY9R5YQAAAAJ&hl=fr

- **Sebastian Thrun**: **Stanford**, cool stuff on **robotics**. https://scholar.google.com/citations?user=7K34d7cAAAAJ&hl=fr

- **Daphne Koller**: **CEO** at **InSitro**, some cool **courses on Coursera**, she might be the co-founder of Coursera (?). https://scholar.google.com/citations?user=5Iqe53IAAAAJ&hl=en

Add these researchers, companies and research groupes to your watchlist

- **Andrew Ng**: **Professor** at **Stanford**, co-creator of **Coursera**. Has one of the best online courses on Deep Learning.
https://scholar.google.com/citations?user=mG4imMEAAAAJ&hl=en

- **Jeremy Howard**: **Research Scientist** at **University of San Francisco**, a good scout for notable research papers on Twitter and **TED talks**.
https://scholar.google.com/citations?user=ZWdEJ54AAAAJ&hl=en

- **Yaser S. Abu-Mostafa**: **Professor** at **CalTech**, one of the best professors for Deep Learning out there.
https://dblp.org/pid/69/3008.html

- **Rachel L. Thomas**: **University** of **San Francisco**, **FastAI**, some great TED conferences on AI and Deep Learning.
https://scholar.google.com/citations?user=BDsAYUsAAAAJ&hl=en