

50.039 Theory and Practice of Deep Learning

W12S3 – 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 (W6++)

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 (W5++ and W8++)

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 (W9++)

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 (W9++)

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 (W10++)

- 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 (W11++)

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, more on diffusion models).

- 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...

Cloud computing is also very valuable...

- Similarly, a certification in AWS or Microsoft Azure or 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 with 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...

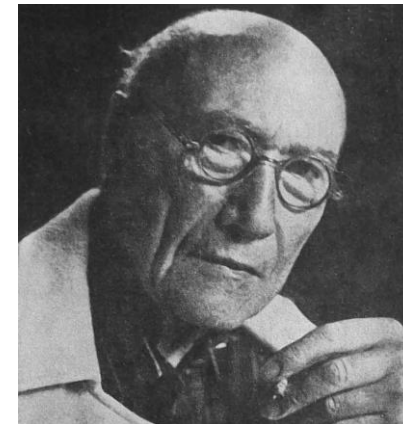
So, good luck on your continuing studies!

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 groups to your watchlist

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

Add these researchers, companies and research group 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 group to your watchlist

- **Trevor Hastie**: Professor at Stanford, co-author 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-author of the Bible of Statistical Learning. Inventor of the LASSO algorithm.
https://scholar.google.ca/citations?user=ZpG_cJwAAAAAJ&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=vtegaJgAAAAAJ&hl=fr>

Add these researchers, companies and research groupes to your watchlist

- **Fred Cummins**: Professor at **University College Dublin**, contributions to **LSTMs** and **NLP**.
<https://scholar.google.com/citations?user=E-vg2zQAAAAJ&hl=fr>
- **Andrej Karpathy**: Former 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=rDfyQnIAAAAAJ&hl=fr>
- **Pieter Abbeel**: Professor at **UC Berkeley**, and a leading researcher in reinforcement learning and robotics.
<https://scholar.google.com/citations?user=vtwH6GkAAAAJ&hl=en>

Add these researchers, companies and research groups 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 **InSight**, some cool **courses on Coursera**, she might be the co-founder of Coursera (?).
<https://scholar.google.com/citations?user=5lqe53IAAAAAJ&hl=en>

Add these researchers, companies and research group 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>