

# 50.039 Theory and Practice of Deep Learning

## W13S1 – End and Review

Matthieu De Mari, Berrak Sisman



# 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 22<sup>nd</sup>, 11.30am**
- **Gojek: Thursday 21<sup>st</sup>, 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
- Lectures 1-9 of course here

<https://www.cs.ox.ac.uk/teaching/courses/2020-2021/advm/>

# 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.
- 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](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 Deep 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 of both time and money...

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

- 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.

# More importantly

- 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.
- Adding some more on the next slides

# 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!

# Add these researchers, companies and research groups 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 groups 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 groups 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=tvUH3WMMAAAAJ&hl=en>
- **Fred Cummins**: Professor at University College Dublin, contributions to LSTMs and NLP.  
<https://scholar.google.com/citations?user=E-vg2zQAAAAAJ&hl=fr>
- **Terrence Sejnowski**: Professor at UC San Diego, **Boltzmann machines**.  
<https://scholar.google.ca/citations?user=m1qAiOUAAAAAJ&hl=en>



# Add these researchers, companies and research groups 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 groups 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](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 groups 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](https://scholar.google.com/citations?user=x04W_mMAAAAJ&hl=fr)

# 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](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 groups 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=mG4imMEAAAJ&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>