Deep Learning - course schedule 2018

BME 595A, Eugenio Culurciello, Purdue University

Time and place: Tue/Thu 3-4.15pm, MJIS 1001

Recommended Books

- https://www.manning.com/books/grokking-deep-learning
- Deep Learning, http://www.deeplearningbook.org
- Neural Networks and Deep Learning, http://neuralnetworksanddeeplearning.com
- Data Science from Scratch, http://shop.oreilly.com/product/0636920033400.do
- Python Machine Learning, https://www.packtpub.com/big-data-and-business-intelligence/python-machine-learning
- http://machinelearningmastery.com/deep-learning-courses/
- Pytorch tutorials: https://drive.google.com/drive/folders/0B41Zbb4c8HVyUndGdGdJSXd5d3M and videos: https://www.youtube.com/playlist?list=PLlMkM4tgfjnJ3I-dbhO9JTw7gNty6o_2m

Recommended courses to follow

- https://documents.epfl.ch/users/f/fl/fleuret/www/dlc/ all in pytorch!
- CMU deep learning; https://www.youtube.com/channel/UC8hYZGEkI2dDO8scT8C5UQA/videos
- Oxford DeFreitas complements our course: https://www.cs.ox.ac.uk/people/nando.defreitas/machinelearning/, with Torch7 code, exercises: https://github.com/oxford-cs-ml-2015/
- Stanford FeiFei / Karphaty: excellent material and readings that complement our course: http://cs231n.stanford.edu/ , videos: https://www.youtube.com/playlist?list=PL3FW7Lu3i5JvHM8ljYj-zLfQRF3EO8sYv
- Deep Learning School 2016 Montreal: http://videolectures.net/deeplearning2016_montreal/
- Deep Learning School 2016: http://www.youtube.com/playlist?list=PLrAXtmErZgOfMuxkACrYnD2fTgbzk2THW
- Udacity Deep Learning nano-degree: https://www.udacity.com/course/deep-learning-nanodegree-foundation--nd101

Teaching assistants and help

- Eugenio Culurciello: lead instructor
- Dawood Sheik (dawood0), Abhishek Chaurasia (aabhish): assistant instructors
- Help: **(1)** work with you peers, **(2)** ask Gitter forum, **(3)** ask assistants in that order. If you need to send an email to any of the instructors, assistants, use `BME595-DeepLearning` at the beginning of your subject.
- Office hours: TBD, otherwise write on Piazza

Format

Please monitor the course page and follow the guidelines every week:

1. Monitor the class website and notifications,
2. Listen to video-lectures **before** class each week. Use the video numbers corresponding to each week, there will be questions in class about the material!
3. Read as much as possible before class each week, continue to read all suggested readings
4. Work on homework each week. Each homework is due on first class on following week. Work on homework individually, get help, suggestions, not solutions or copy code or snippets
5. Read as much as possible from suggested readings, additional material and search on your own. Remember: the more you learn, the more you can get from this course.
6. Class time is devoted to questions, problem-solving, in-depth reviews, but will not be a repetition of the materials listed here
7. Keep in mind that **your homework might be made public after due date**. In case you have any problem with that then you should notify your instructor/TA beforehand.

Forum and peer-help

Public chat room -> Purdue Blackboard Piazza: piazza.com/purdue/fall2017/bme595/home
This year we use PyTorch and python as framework. Please ignore any reference to old Torch7 and replace them with PyTorch. We are converting video and materials during the semester, so please be patient, and look for resources here.
More: https://github.com/ritchieng/the-incredible-pytorch
A good intro / playlist:
https://www.youtube.com/playlist?list=PLLHTzKZzVU9duBIJCVGRh3tiy39d7Iz1q

Computing resources:

The class homework can be performed on a laptop or standard PC. A modern > 2010 or so computer will be enough.
For students who want to run large jobs and projects, we can arrange access to Purdue Computing Cluster Scholar: https://www.rcac.purdue.edu/compute/scholar/

Content and timeline

Week 1: Introduction

Aug 21-23

- Introduction / applications / class format

- What is machine learning?

Material

- Video lectures: 0.X,1.X, slides
- Pytorch website
- Pytorch tutorial
- Training neural networks: examples in pytorch

Assignment

- Redo Deep Learning with PyTorch: A 60 Minute Blitz till "Autograd: Automatic differentiation"
- Install pytorch (preferably using source)
- **Homework-01** (link) - Convolution, due by Thu August 30th

Week 2: Neural networks

Aug 28 - 30

- what is a neuron (AND, OR in class example)
- what is a neural net (EX-OR example)
- neural nets in real biology and in artificial
- Example forward pass: https://mattmazur.com/2015/03/17/a-step-by-step-backpropagation-example/

Material

- Video lectures: 2.X, slides
- **Practical 2.0** - Forward pass: https://youtu.be/hxA0wxibv8g
- [Advanced] NN, manifolds and topology: blog

Assignment

- **Homework-02** (link) - Forward propagation, due by Thu September 6th
- How would you write a program for the categorization of images? Discussion in class this week

Week 3: Back-propagation

Sept 4-6

Back-propagation explained, and in-class equations in simple terms

Material

- Video lectures: 3.X, slides
- **Practical 2.1** - Backward pass: https://youtu.be/VaQUx7m3oR4
- Great simple numerical example: https://medium.com/@14prakash/back-propagation-is-very-simple-who-made-it-com

plicated-97b794c97e5c and https://mattmazur.com/2015/03/17/a-step-by-step-backpropagation-example/ and https://sudeepraja.github.io/Neural/
- [Advanced] http://colah.github.io/posts/2015-08-Backprop/
- Linear classification loss visualization from Stanford and https://playground.tensorflow.org/

Assignment

- **Homework-03** (link) - Back-propagation, due by Thu September 13th

Week 4: Data sets, learning and regularisation

Sept 11-13

- What is a dataset? Examples of datasets, how to create datasets and labels
- How do we get to generalise well on unseen samples?
- Gradient checking!

Material

- Video lectures: 4.X, slides
- Bias, variance: https://people.cs.umass.edu/~domke/courses/sml2011/02overfitting.pdf
- Andrew Ng practical advice on machine learning: https://www.youtube.com/watch?v=F1ka6a13S9I, from minute 22
- Optimisation techniques: http://ruder.io/optimizing-gradient-descent/
- Regularisation for NNs (Abu-Mostafa): http://work.caltech.edu/slides/slides12.pdf
- Understanding neural nets: http://playground.tensorflow.org

Assignment

- **Homework-04** (link) - Back-propagation, due by Thu September 20th

Week 5: Training neural networks

Sept 18-20

How to train network using PyTorch script

Material

- Training network using PyTorch: (link)
  Look into mnist and then if you want, try imagenet
- Deep Learning with PyTorch: Deep Learning with PyTorch: A 60 Minute Blitz (Neural Networks and Training Classifier section)

- Troubleshooting: https://blog.slavv.com/37-reasons-why-your-neural-network-is-not-working-4020854bd607
- Training using Torch (link): try to do this in jupyter for pytorch
- Loss functions: http://pytorch.org/docs/master/nn.html#loss-functions, http://ml-cheatsheet.readthedocs.io/en/latest/loss_functions.html

Assignment

- Back propagation with nn
- **Homework-05** (link) - Back-prop using nn, due by Thu September 27th

Week 6: Convolutional neural networks

Sept 25-27

recent state of art CNN models / recent paper architectures
Tools for machine learning: TorchNet or else, Torch packages

Material

- Video lectures: 6.1, slides
- **Practical 3.0** - https://youtu.be/kwCbmx3tFwY
- **Practical 3.1** - https://youtu.be/BCensUz_gQ8
- **Practical 3.2** (LeNet-5 model only) - https://youtu.be/LYYwUr0vCjg
- Convolutional neural network tutorial: http://neuralnetworksanddeeplearning.com/chap6.html
- Study CNN model here: https://github.com/pytorch/vision/tree/master/torchvision/models
- Convolutions in neural networks: http://colah.github.io/posts/2014-07-Understanding-Convolutions/
- Details on convolution arithmetics: https://github.com/vdumoulin/conv_arithmetic
- Training tutorial: https://github.com/pytorch/examples/tree/master/imagenet
- Backprop in convolutions: https://grzegorzgwardys.wordpress.com/2016/04/22/8/ and https://www.slideshare.net/kuwajima/cnnbp
- Visualizing neural network

Articles

- Efficient backprop [original][my version]
- On the importance of initialization and momentum in deep learning [original]
- Gradient Based Learning Applied to Document Recognition [original]
- Batch Normalization: Accelerating Deep Network Training by Reducing Internal Covariate Shift [original]

Assignment

- **Homework-06** (link) - Train classifier of AlexNet, due by Thu October 11th. (Yes, 2 weeks for this homework)

Week 7: Advanced convolutional neural networks

Oct 2-4

Material

- Video lectures: 6.2, slides
- **Practical 3.2** - https://youtu.be/LYYwUr0vCjg
- **Practical 3.3** - https://youtu.be/kcOJEplX7i0
- Advanced models: https://medium.com/towards-data-science/neural-network-architectures-156e5bad51ba
- http://cs231n.stanford.edu/slides/2017/cs231n_2017_lecture9.pdf
- Training advanced: https://github.com/pytorch/examples/tree/master/imagenet

Assignment

- **none**

Week 8: Final projects proposals

Oct 11 ONE DAY ONLY!

- Present your class final project ideas and group (part I) - we will ask some of you at random about your project and discuss project tips and guidelines

Assignment

- **Homework-06** (link): Train classifier of AlexNet
- **Final project proposal**: let's say your team is made of person A (or A and B). A creates a `project` folder in their repository with a `README.pdf` inside. The format is as following:

  # Title
  Blah, blah, blah.
  ## Team members
  NameA , NameB
  ## Goals
  Blah, blah, blah.
  ## Challenges
  Blah, blah, blah.
  ## Restrictions *--optional--*
  I want to eat ice-cream if I pass.

  Due October 11th

- **Practical 3.4** - https://youtu.be/ejr6eaJKtcs

Week 9: Recurrent neural networks (RNN) and Applications / RNN applications

Oct 16-18

- **Practical 4.0** - https://youtu.be/bUIAsEw7_9U
- **Practical 4.1** - https://youtu.be/WwsIsYQX77s
- **Practical 4.2** - https://youtu.be/FL_VTcp9jvw
- **Practical 4.3 -** https://youtu.be/lRN0wayLTeo
- Simple explanation of LSTM / GRU / RNN modules: http://colah.github.io/posts/2015-08-Understanding-LSTMs/
- LSTM original paper: link
- NOTE: you do NOT need to learn Torch7 nngraph. It is not used in PyTorch
- http://karpathy.github.io/2015/05/21/rnn-effectiveness/
- Easy PyTorch tutorial: http://pytorch.org/tutorials/intermediate/char_rnn_classification_tutorial.html
- http://www.wildml.com/2015/10/recurrent-neural-networks-tutorial-part-3-backpropagation-through-time-and-vanishing-gradients/
- Advanced: http://people.idsia.ch/~rupesh/rnnsymposium2016/program.html
- Advanced material: NEW USES OF RNN: Chris post: http://distill.pub/2016/augmented-rnns/

Assignment

- **none**

Week 10: Unsupervised Learning

Oct 23-25

- Lecture video 10.1
- Readings: https://medium.com/intuitionmachine/navigating-the-unsupervised-learning-landscape-951bd5842df9 and all referenced papers
- Read and learn new network topologies, predictive networks: https://medium.com/towards-data-science/a-new-kind-of-deep-neural-networks-749bcde19108 and: https://engineering.purdue.edu/elab/CortexNet/
- GAN:https://medium.com/ai-society/gans-from-scratch-1-a-deep-introduction-with-code-in-pytorch-and-tensorflow-cb03cdcdba0f and https://pytorch.org/tutorials/beginner/dcgan_faces_tutorial.html and https://github.com/eriklindernoren/PyTorch-GAN
- Advanced: http://cs231n.stanford.edu/slides/2017/cs231n_2017_lecture13.pdf
- Advanced: transparent latent space GAN: https://github.com/SummitKwan/transparent_latent_gan

Week 11: Hardware for Deep Learning

Oct 30 - Nov 1

- Low-precision: https://petewarden.com/2015/05/23/why-are-eight-bits-enough-for-deep-neural-networks/, various recent research papers
- How convolutions are computed in CPU and GPUs - BLAS: https://petewarden.com/2015/04/20/why-gemm-is-at-the-heart-of-deep-learning/
- Read paper: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6910056
- RNN: https://arxiv.org/pdf/1511.05552.pdf

Week 12: Reinforcement learning and applications

Nov 6-8

- Simple course with all components: https://simoninithomas.github.io/Deep_reinforcement_learning_Course/
- Basics and Q-learning: http://mnemstudio.org/path-finding-q-learning-tutorial.htm and http://outlace.com/Reinforcement-Learning-Part-3/
- Actor-critic A2C: https://hackernoon.com/intuitive-rl-intro-to-advantage-actor-critic-a2c-4ff545978752
- Q-learning or A2C? https://flyyufelix.github.io/2017/10/12/dqn-vs-pg.html this one has a good intuitive explanation of Q-learning and Policy Gradients, Acgtor-Critic, A2C!!! Please read this!
- Alpha Zero: https://medium.com/applied-data-science/alphago-zero-explained-in-one-diagram-365f5abf67e0 and https://web.stanford.edu/~surag/posts/alphazero.html
- Advanced: read paper http://www.nature.com/nature/journal/v518/n7540/full/nature14236.html
- Advanced: https://www.sanyamkapoor.com/machine-learning/policy-gradients-nutshell/ and https://lilianweng.github.io/lil-log/2018/02/19/a-long-peek-into-reinforcement-learning.html
- Issues in deep RL: https://www.alexirpan.com/2018/02/14/rl-hard.html

Week 13: Scene parsing, segmentation, localization, counting instances

Nov 13-15

- Summary material: https://medium.com/@culurciello/segmenting-localizing-and-counting-object-instances-in-an-image-878805fef7fc

- Read paper: https://arxiv.org/abs/1606.02147 and http://mi.eng.cam.ac.uk/projects/segnet/
- Advanced: https://instancetutorial.github.io/ and https://medium.com/@phelixlau/speed-accuracy-trade-offs-for-modern-convolutional-object-detectors-bbad4e4e0718
- Localization material: Overfeat, YOLO, SSD, RCNN, Faster RCNN

Week 14: Applications of Deep Learning

Nov 27 - 29

- **Students: suggest topics of interest**
- Discussion of class projects and ideas
- Topics: Face identification, similar images, memory systems, speech recognition, story summarization, etc.
- **Thu: Early final project presentation (contact us if you want to present early!)**

TOPICS:

- **Attention:** https://towardsdatascience.com/memory-attention-sequences-37456d271992
- **Capsules: https://arxiv.org/abs/1710.09829 and https://medium.com/mlreview/deep-neural-network-capsules-137be2877d44 and https://medium.com/@pechyonkin/understanding-hintons-capsule-networks-part-ii-how-capsules-work-153b6ade9f66 and Alf video: https://www.youtube.com/watch?v=EATWLTyLfmc&t=76s**
  Visual attention and captioning: https://blog.heuritech.com/2016/01/20/attention-mechanism/
- **multi-server deployments**
- **Continuous learning: https://medium.com/@culurciello/continual-learning-da7995c24bca and https://arxiv.org/abs/1806.08568**

Week 15: Final project reports and presentations

Dec 4-6

Students final project presentations (picked at random from all students participants): 5 Minutes per group + 2 for questions while switching presenter. Suggested slides: 5-10 max.
Format: Introduction, other work, our contribution, results, discussion
We will notify you of presenting groups 1-2h before each class.
Also submit a **group** project report in PDF as per Syllabus: 4 pages max, same **format as above**. Record a 5 minutes video of your presentation and post it on YouTube or similar (send us link!).

Final Project report and video due: Sunday Dec 9th before 11.59pm
Submission instructions: one email per project to instructor and TA, with:

- **Link to presentation video**
- **PDF of project report**
- **ZIP file of project code, no binaries or large files**

No more than 15 MB in total, please

Presentation schedule:

TUE Dec 4th:
1.

THU Dec 6th:
1.

Advanced topics:

Read these if you plan to advance in this field:

Language processing:
http://blog.aylien.com/a-review-of-the-recent-history-of-natural-language-processing/

Optimization / Learning to learn:
http://bair.berkeley.edu/blog/2017/09/12/learning-to-optimize-with-rl/

Attention is all you need:
Very important paper to replace RNN with attention modules and save computation:
https://github.com/jadore801120/attention-is-all-you-need-pytorch

Interesting topics:

http://www.wildml.com/2015/09/implementing-a-neural-network-from-scratch/

NLP:
https://jalammar.github.io/illustrated-word2vec/
https://github.com/sebastianruder/NLP-progress