Advanced Machine Learning 2014
(Introduction to Torch)

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November 25, 2014
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- **Torch**: I will give a short (hopefully concise) introduction to torch

- Assignment:
  - We will give out the second assignment training a MLP / ConvNet to recognize digits using torch + testing on a secret test-set ;)
  - Part 1: Reproduce results (maybe even state of the art) from previous work
  - Part 2: Train the best network you can design for MNIST and report classification error
  - Part 3: Give us up to 3 models that we can call using lua → we will test this on our secret test-data

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  - As before I have borrowed slides/examples from the torch developers who do a much better job than me at explaining their work
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  - not (yet) so great for large scale neural networks
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▶ **Theano (python)** a python language extension that allows you to define/evaluate mathematical expressions by compiling them to CPU / GPU code
  → re-creates most functionality of numpy (and plays well with it together)
  → compiles to quite fast code!
  → computes gradients automatically!
  → has an amazing neural network toolbox built on top (pylearn2)
  → can be hard to understand/extend/debug for beginners (you define a graph of functions rather than writing code directly)
Popular (Deep) Machine Learning Frameworks

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  - a fast and readable implementation of ConvNets in c++
  - extremely fast and well written c++ code
  - pre-trained models for ImageNet etc.
  - less good for rapid prototyping
  - restricted to (convolutional) neural networks

- **Torch (lua)**
  - a Matlab-like Environment for (deep and not so deep) Machine Learning
  - comes with an extremely versatile tensor (matrix) implementation
  - is very fast and easily packageable (thanks to lua)
  - computes gradients (semi)-automatically
  - provides high-level language for rapid-prototyping (easily understandable)
  - provides multiple tensor backends for even faster GPU/CPU computation
  - requires you to learn lua
  - (arguably) has less pre-trained state of the art models
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Torch: Getting Started

Your quick start into torch land:

▶ Torch’s main site and resources: www.torch.ch
  On Github: https://github.com/torch

▶ Torch cheat sheet
  https://github.com/torch/torch7/wiki/Cheatsheet

▶ Tutorials for Torch: http://torch.madbits.com
  On Github: https://github.com/clementfarabet/torch-tutorials

▶ Lua: http://www.lua.org

▶ LuaJIT: http://luajit.org/luajit.html

▶ Extensions by research teams of Google, facebook and wrappers to libraries by nvidia (see end of presentation)
Why does torch use lua with C++ backends?

- Just programming C can be very tiresome for research code
  → proper scripting language (LuaJIT)
- However C speed (and beyond) needed for large scale applications
  → compiled and optimized backend (C,C++,CUDA,OpenMP)
Torch: Why Lua

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Why not python?

→ Luajit provides

- Fastest scripting language, with a transparent JIT compiler
- Simple, readable (like Python)
- The cleanest interface to C (although now there is julia)
- Embeddable into any environment (iPhone apps, Video games, web backends ...)
Lua: a very short introduction

- A longer version (15 minutes) http://tylerneylon.com/a/learn-lua/
- The real deal: http://luatut.com/, http://www.lua.org/docs.html
- Good cheat sheets: http://thomaslauer.com/download/luarefv51.pdf

Let us look at code!
Torch: another very short introduction

- **Torch7** extends lua with one more object: the **Tensor**
- It is similar to matlab arrays or numpy arrays

Let us look at more code!
**Torch** ecosystem

- **Torch7** also provides a large set of packages
  - based on Matlab’s common routines (zeros, ones, eye, ...)
  - Linear algebra routines
  - Convolutions, Fourier transform, etc.
Torch: ecosystem

Package Manager

→ more packages are available via Lua’s package manager: luarocks

► check out what’s available here: http://github.com/torch/rocks
Torch: Neural Networks

The **nn** package

- When training neural nets, linear regression, convolutional networks; basically any machine learning model, we’re interested in gradients, and loss functions
- The nn package provides a large set of transfer functions, which all come with three methods:
  - `upgradeOutput()` – compute the output given the input
  - `upgradeGradInput()` – compute the derivative of the loss wrt input
  - `accGradParameters()` – compute the derivative of the loss wrt weights
- The nn package provides a set of common loss functions, which all come with two methods:
  - `upgradeOutput()` – compute the output given the input
  - `upgradeGradInput()` – compute the derivative of the loss wrt input
- You don’t have to compute your gradients yourself anymore! :)
- There exist *optimized* backends for almost all modules in **nn**
Let’s look at how to solve your exercise from Phase 1
Arbitrary models can be constructed using LEGO-like containers:

- `nn.Sequential()` – sequential modules
- `nn.ParallelTable()` – parallel modules
- `nn.ConcatTable()` – shared modules
- `nn.SplitTable()` – (N)dim Tensor, table of (N-1)dim Tensors
- `nn.JoinTable()` – table of (N-1)dim Tensors, (N)dim Tensor
Torch7 Resources Summary:

→ Torch7:
  http://www.torch.ch/ https://github.com/torch

→ Basic Demos: a bunch of demos/tutorials to get started
  https://github.com/clementfarabet/torch7-demos

→ Deep-Learning Tutorials: supervised and unsupervised learning
  http://code.madbits.com

→ luarocks: Lua’s package manager, to get new packages:
  luarocks search –all # list all packages
  luarocks install optim # install optim package

→ Torch Group: get help!
  https://groups.google.com/forum/?fromgroups#!forum/torch7

▶ For benchmarks comparing caffe/theano/torch/cuda-convet
  https://github.com/soumith/convnet-benchmarks

→ Useful packages from facebook:
  https://github.com/facebook/fblualib
  python bindings, serialization, better repl