Learning Deep Learning with PyTorch

(3) Knowing PyTorch

Qiyang Hu
IDRE

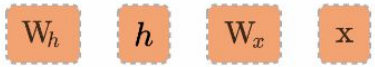
What is PYTORCH

- An open-source Python-based deep learning framework
  - Replacement for Numpy with supporting GPUs
  - A full set of deep learning libraries
- History
  - Lua-based Torch (2002 - 2011)
  - PyTorch 0.1 (2016): THNN
  - PyTorch 1.0 (2018): merging Caffe2
  - PyTorch 1.4 (Jan 15, 2020)
- About Fast.ai
  - Sitting on top of PyTorch
  - Fast.ai for PyTorch is not what Keras is for TF
  - Still unclear for the usage popularity

Why PYTORCH

- Simplicity & Flexibility from “Py”
  - Feels like Numpy
  - GPU acceleration
- Immediate execution mode
  - Defined by run
  - Tape-based autograd
  - Awesome debugging
- Hybrid front-end
  - JIT and TorchScript
  - Seamlessly switch between
    - Modes
    - Distributed training
    - Mobile deployment

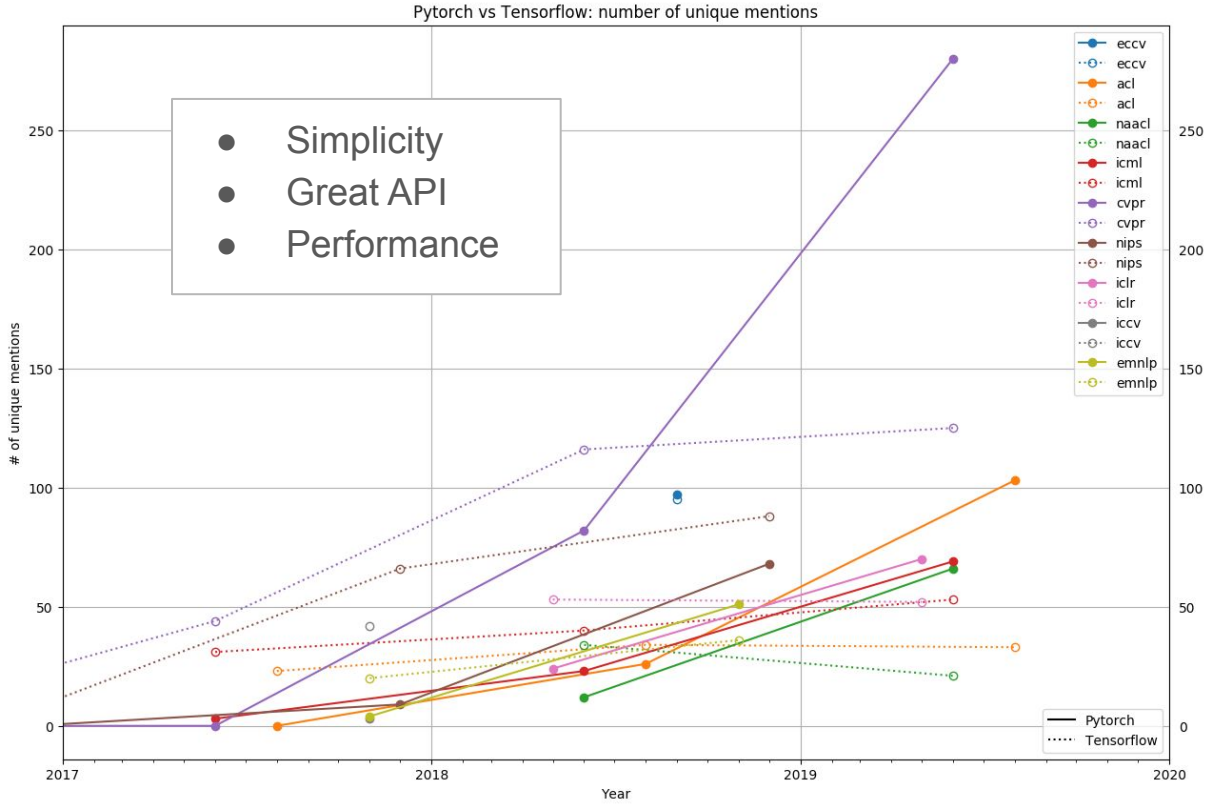
A graph is created on the fly




```
from torch.autograd import Variable

x = Variable(torch.randn(1, 10))
prev_h = Variable(torch.randn(1, 20))
W_h = Variable(torch.randn(20, 20))
W_x = Variable(torch.randn(20, 10))
```

PyTorch is increasing dominance in research



Source

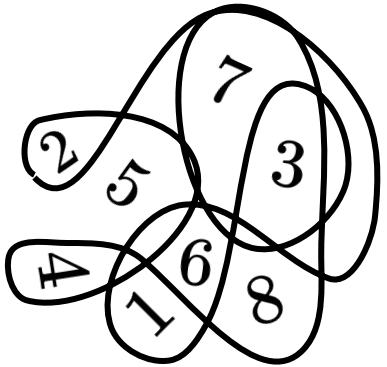
Tensors as building blocks

$$1$$

$$\begin{bmatrix} 2 \\ 5 \\ 4 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 1 & 3 \\ 5 & 7 & 9 \\ 4 & 8 & 6 \end{bmatrix}$$

$$\begin{bmatrix} \begin{bmatrix} 4 & 6 & 9 \\ 1 & 2 & 5 \\ 8 & 7 & 3 \end{bmatrix} \end{bmatrix}$$



Scalar	Vector	Matrix	Tensor	Tensor
0-D	*1*-D	*2*-D	*3*-D	*n*-D
$X = 1$	$X[1] = 5$	$X[2, 1] = 8$	$X[0, 1, 2] = 5$	$X[2, 3, \ldots, 1] = 6$
				N indices

“Py” and “Non-Py” in PyTorch

- Tensors and Numpy arrays
  - Easy conversion
  - Zero copy: share their underlying memory locations (if on CPU)
  - Unboxed contiguous memory blocks containing unboxed C numeric types
    - Not python objects as in lists or tuples of numbers
    - Views by tensor metadata, e.g. sizes, strides, offsets
- PyTorch = Python + C/C++ + CUDA
  - Python extension objects in C/C++
  - Code base components:
    - The core Torch libraries: TH, THC, THNN, THCUNN
    - Vendor libraries: CuDNN, NCCL
    - Python Extension libraries
    - Additional third-party libraries: NumPy, MKL, LAPACK, DLPack

Colab Hands-on

bit.ly/LDL_01

Automatic differentiation

- Autograd package
  - Track all operations of tensors
  - Compute derivatives analytically via back-prop
  - Natively loaded in torch module
  - Can be used in other scientific domains
- Simple usage
  - Set tensor's .requires_grad as TRUE
  - Call .backward()
    - Gradient accumulated into .grad attribute
    - Tensor's creation function recorded in .grad_fn attribute
- Stop a tensor from tracking history
  - .detach()
  - Wrap the code block in with torch.no_grad()

Neural Networks in PyTorch

- torch.nn package
  - Contains all building blocks for NN architectures
  - All blocks subclassed from nn.Module (e.g. nn.Linear)
- Define a network
  - For simple networks:
    - concatenate modules through the nn.Sequential container
  - For complex networks:
    - Subclassing nn.Module
- nn.Module package expects first index as first batch size of samples
  - Need to reshape the input by .unsqueeze()
- Loss functions in torch.nn:
  - L1Loss, MSELoss, CrossEntropyLoss, MarginRankingLoss, ...

Optimizers in PyTorch

- torch.optim package
  - Provides various optimization algorithms
  - Need to move model to GPU before constructing optimizers
  - Must zero the gradient explicitly:
    - optimizer.zero_grad()
  - Take an optimization step:
    - optimizer.step() in GD method
    - optimizer.step(closure) in CG or LBFGS method
  - Optional: adjust the learning rate based on the number of epochs.
    - optimizer.lr_scheduler

Don’t forget to

- Sign in your info to the class
  - To get the email notifications

- Contact me for questions or discussions
  - huqy@idre.ucla.edu
  - Office: Math Sci #3330
  - Phone: 310-825-2011