Module 35

Tensorflow/Pytorch Tutorials

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Week

8

Introduction to TF/Torch

After this module, you should independently be able to:

1. **get an intuition of the differences between the two libraries.**
2. **transition between programming, math and theory, specifically, the different optimizations and gradients.**
3. **load and augment data.**
4. **independently use any of the libraries to implement neural models of choice.**
5. **be able to effectively debug and read through documentation.**
6. **get some sense of residual nets are implemented on a basic level.**

Prerequisite knowledge:

1. EE16A
2. CS61A/B or equivalent programming experience
3. Module 21 - Backpropagation
4. Module 23 - Hyperparameter Tuning
5. Module 34 - CNNs
6. Module 35 - Transfer Learning
7. EE16B *(Concurrently)*

History of ML Libraries

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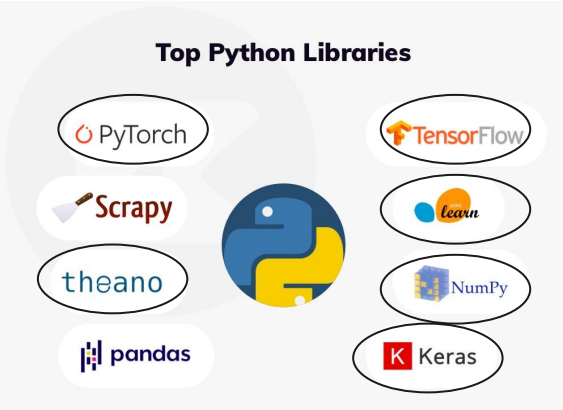


- **1991:** Python invented
- **1995:** Numeric, predecessor NumPy, launched
- **2000s:** SciPy
- **2006:** NumPy
- **2007:** Theano, Scikit-Learn
- **2010:** Deep Learning skyrocketing due to cheap and many GPUs
- **2015:** Keras, TensorFlow
- **2016:** PyTorch

Objective: Faster, more-intuitive to create scientific computing tool through smart data structures and architecture

Current Deep Learning Frameworks

Current Deep Learning Frameworks

Library/ Framework		theano		
Developer/Year	Google Brain (2015)	University of Montreal (2007)	Facebook AI (2016)	Francois Chollet (2015)
High/Low Level	High/Low	Low	Low	High (Based on TF)
Strength	Large-Scale Employment	Fast, Prototyping	Dynamic	High Level

Tensorflow

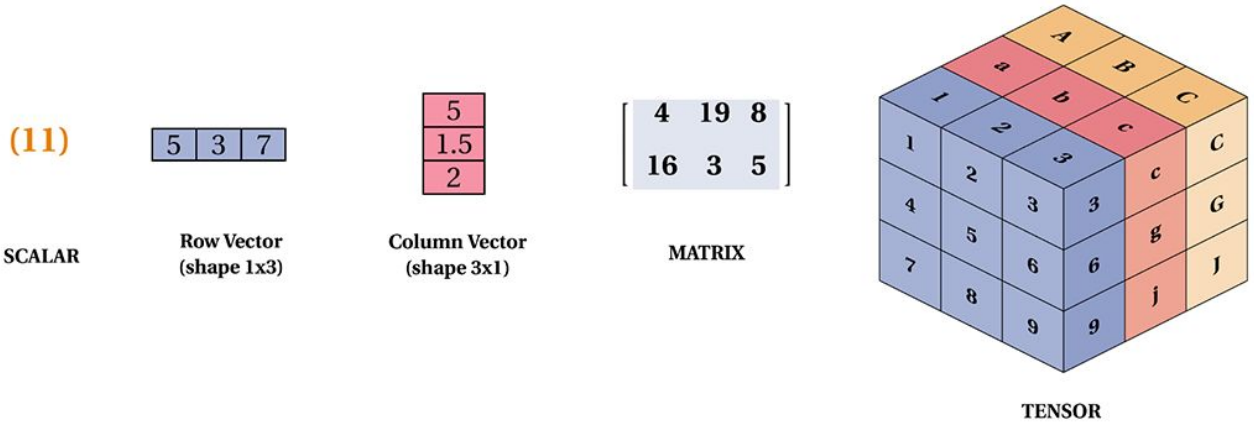
What is and Why Tensorflow?

Deep Learning library open-sourced by Google

- Deep Learning -- neural networks!
- Distributed Computing & Scalability
- GPU/TPU Support & Pipelining
- Flexibility

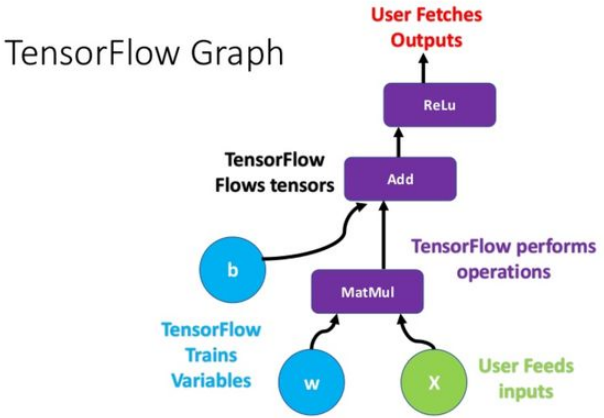
Tensors

N-dimensional array of data

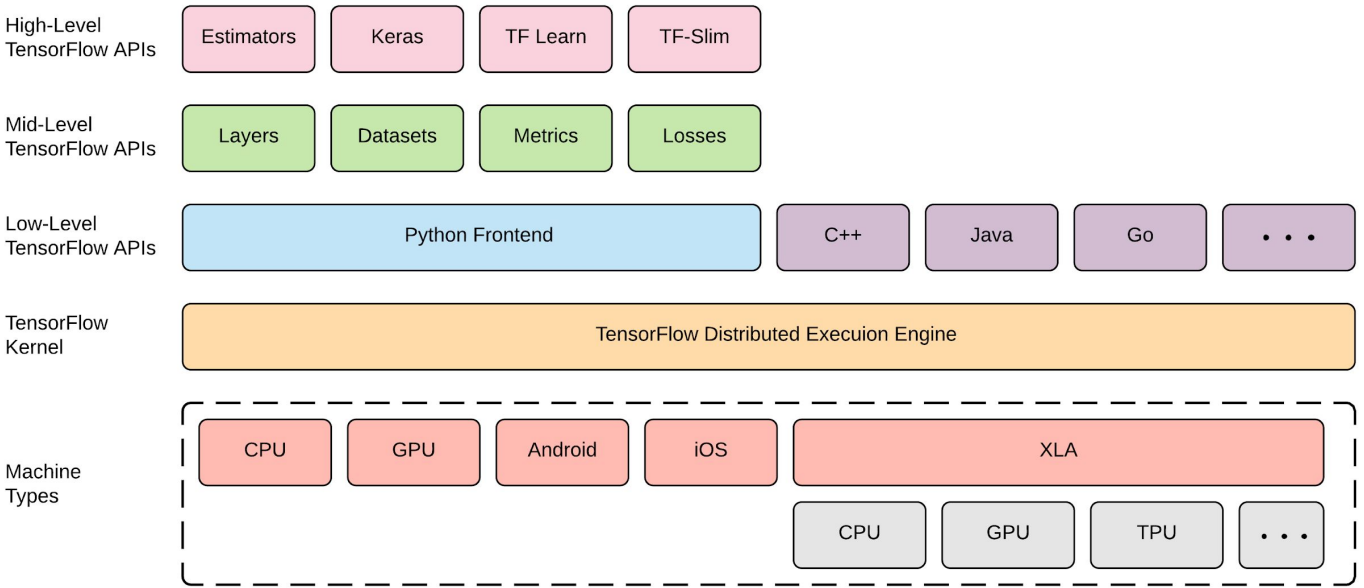


Graphs

Represent computations as dependencies between various operations



Abstraction Layers



Work on
Assignment 1A

Work on
Assignment 2A

Pytorch

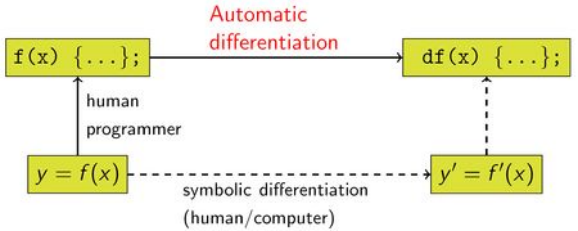
PyTorch

- PyTorch is **open-source machine learning framework**
- Created by Facebook AI in **2016**
- More dynamic and pythonian
- Data parallelism
- Easier navigation
- Majority of researchers, **Tesla's autopilot** and **UBER pyro**

PyTorch Tensors, Dimensionality and NumPy

- PyTorch is extremely similar to **NumPy**
- Tensors, unlike in TF, are used in a similar fashion as NumPy's Arrays
  - Arithmetics are the same
  - Mutations are the same
- Slightly different syntax

Autograd



- PyTorch tensors allow for the fast computation of **derivatives** through **autograd,** automatic differentiation framework
- Automatic Differentiation vs Symbolic Differentation
- To use **autograd,** initialize tensor with `requires_grad=True` and take gradient with `.backward()` and `tensor.grad`
- Detach using `tensor.detach()

Optimizers

- **Optimizers,** a smart optimization to do **backprop** for you!
- **`torch.optim`**
- Workflow:
  - Initialize **optimizer** with **coefficients, learning rate, momentum factor**
    - **Momentum factor:** degree of using previous gradients for directionality
  - Define **loss function (also called criterion)**
  - Run model on **input**
  - Calculate **loss**
  - Call `.backward()` on **loss**

Neural Networks

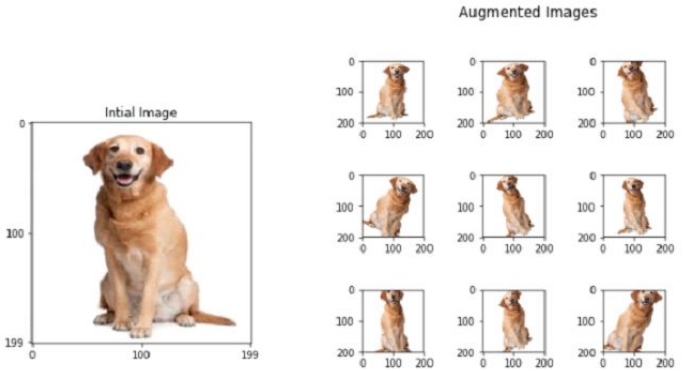
- Neural Networks and (generally DAGs) encapsulated in **classes** in PyTorch
- **Library:** `torch.nn`
- These classes need to contain the following structure:
  - **Initializer:** inherit from super class
  - **Forward(input):** calculations when neural network is called on input
  - **num_flat_features() [OPTIONAL]:** sometimes you need to flatten something and it is nice to have.

Data Utilities

- Datasets are also custom classes
- These classes need to contain the following structure:
  - **Initializer(data, labels, transforms):** need to create class variables storing data and labels or alternatively file paths
  - **__get__(idx):** Return one sample located at x
  - **len:** the length of your dataset
- Training can happen through using a one-liner **data loading**

Work on
Assignment 1B

Data Augmentation



- How do we prevent **overfitting** and **increase our dataset?**
  - Data Augmentation
  - i.e. from one picture we can create 10 pictures for training
- **Transforms** in your **dataset** class allow you to do that.
  - Pre-defined functions: https://pytorch.org/docs/stable/torchvision/transforms.html
- **Disclaimer:** If you crop or translate, make sure that the region of interest is still in the picture.

CUDA

- Parallel Computing Platform to allow GPUs for general processing
- To use GPUs, we need to send to **DEVICE** first
  - Model
  - Data/Labels
- Define a **device**
- Sending data through
  - `tensor.to(device)`
- If you want to extract the values, you simply append `.data`

ResNet

- We will not go too much in-depth about the mechanics behind Residual Nets, but you are encouraged to use this in your assignments.
- State-of-the-art
- Deep Learning Networks became deeper and deeper (yet also shrunk in filter sizes)
- Researchers found out that the residual block in a CNN is useful
- Not entirely sure (still being researched)
- **Different flavors:** ResNet 18, 34, 50, …., 1202

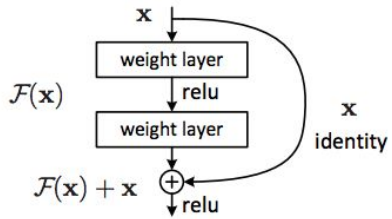


Figure 2. Residual learning: a building block.

Work on
Assignment 2B

Project Overview

Capstone Project: MURA

- **Goal:**
  - Create a classifier given **bone x-rays** to classify whether a x-ray is **normal** or **abnormal**
- Pick either PyTorch or TensorFlow to create a classifier from start to end.
- Create a model and optimize through hyper-parameter tuning.
- Include a small write-up about the medical implications of **machine learning** in **medicine**

Work on
Project

Ethics

Ethics: Machine Bias

- **Take the moral machine test**
- **How biased are you?**
- **Observe:**
  - Bias is culturally dependent
  - Bias embedded in technical systems have far more reach than one person has ⇒ *Machine Bias*
- Case:
  - African Americans are more likely to be classified as criminal
  - Women are more likely to be advertised traditionally feminine jobs.

Ethics

Capstone Project

- **BONUS POINTS**
  - **Implement one or more of the following components to make your project more 'ethical':**
    - Meta analysis
      - See whether you see any patterns amongst misclassified x-rays.
      - Check whether there are any signs of overfitting.
    - Transparency
      - Visualize the learned filters. Do they make sense?
    - Create other metrics to capture the performance of your model
      - Think about ROCAUC/PRC

Take the
Quiz

End of Module 35 - Introduction to TF/Torch

Since you have completed the module successfully, you can:

1. get an intuition of the differences between the two libraries.
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3. load and augment data.
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