Python ML Tools

Motivation

- Python is a great language, but slow compared to Java, C, and many others
- Python packages are available to represent and operate on matrices
- We'll briefly review numpy and scipy
- You need some familiarity to be able to create or access datasets for training, evaluation and results

What is Numpy?

- NumPy supports features needed for ML
  Typed multi-dimentional arrays (matrices)
  - Fast numerical computations (matrix math)
  - High-level math functions
- Python does numerical computations slowly
- 1000 x 1000 matrix multiply
  - Python triple loop takes > 10 min.
  - Numpy takes ~0.03 seconds

NumPy Arrays Can Represent …

Structured lists of numbers

- **Vectors**
- **Matrices**
- Images
- Tensors
- Convolutional Neural Networks

$$\begin{bmatrix} p_x \\ p_y \\ p_z \end{bmatrix}$$

$$\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix}$$

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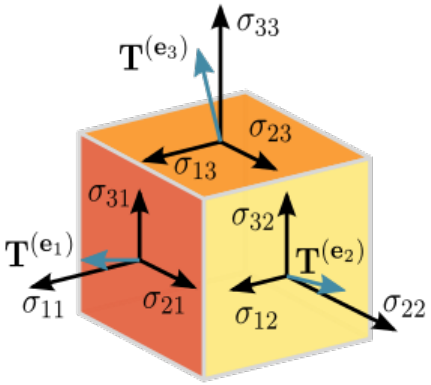

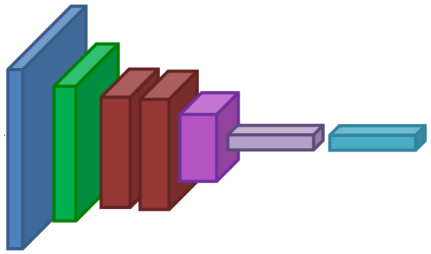

NumPy Arrays, Basic Properties

```
import numpy as np
a = np.array([[1,2,3],[4,5,6]],dtype=np.float32)
print a.ndim, a.shape, a.dtype
```

1. Arrays can have any number of dimensions, including zero (a scalar).
2. Arrays are typed: np.uint8, np.int64, np.float32, np.float64
3. Arrays are dense. Each element of the array exists and has the same type.

NumPy Array Indexing, Slicing

```
x[0,0]      # top-left element
x[0,-1]     # first row, last column
x[0,:]      # first row (many entries)
x[:,0]      # first column (many entries)
```

Notes:

- Zero-indexing
- Multi-dimensional indices are comma-separated (i.e., a tuple)

ScyPy

- SciPy builds on the NumPy array object
- Adds additional mathematical functions and sparse arrays
- **Sparse array** is one where most elements = 0
- An efficient representation only explicitly encode the non-zero values
- Access to a missing element returns 0

SciPy Sparse Array Use Case (1)

- NumPy and SciPy arrays are numeric
- We can represent a document's content by an vector of features
- Each feature is a possible word
- A feature's value is:
  - TF: number of times it occurs in the document;
  - TF-IDF: … normalized by how common the word is
  - And maybe normalized by document length

SciPy Sparse Array Use Case (2)

- We may be interested only in the 50,000 most frequent words found in a large document collection and ignore others
- We assign each English word a number
- The sentence “the dog chased the cat”
  - Would be a numPy vector of length 50,000
  - Or a sciPy sparse vector of length 4
- A 800 words news article may only have 100 unique words; The Hobbit has about 8,000