

Software Packages for Deep Learning

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Outline

Introduction

Python

Torch

Caffe

TensorFlow

MxNET

Comparison

Machine Learning



- ML gives computers the ability to learn without being explicitly programmed [Samuel 1959]
- ML explores the study and construction of algorithms that can learn from and make predictions on data
- Data mining, computational statistics, optimization, ...
- Fourth paradigm, big data, deep learning, artificial intelligence

General Tasks of ML

- **Classification:** Inputs are divided into two or more classes, and the learner must produce a model that assigns unseen inputs to one or more (multi-label classification) of these classes
- **Clustering:** Inputs are divided into groups. Unlike in classification, the groups are not known beforehand, making this typically an unsupervised task
- **Regression:** Similar to classification, but the outputs are continuous rather than discrete
- **Other tasks:** density estimation, dimensionality reduction, ...

Packages for General Machine Learning

What is the purpose?

- Solving problems from practical applications (user interface)
- Developing algorithms and optimizing implementation (development)
- Theoretical analysis for machine learning

What do we want for a ML package?

- Easy for new tasks and new network structures (less steep learning curve)
- Easy for debugging (with good support and large community)
- Performance and scalability



Deep Learning



Comparison

Table: Framework Comparison: Basic information

Viewpoint	Torch	Caffe	TensorFlow	MXNet
Started	2002	2013	2015	2015
Main Developers	Facebook, Twitter, Google, ...	BVLC (Berkeley)	Google	DMLC
License	BSD	BSD	Apache	Apache
Core Languages	C/Lua	C++	C++ Python	C++ Python
Supported Interface	Lua	C++/Python Matlab	C++/Python R/Java/Go	C++/Python R/Julia/Scala

Comparison



Table: Framework Comparision: Performance

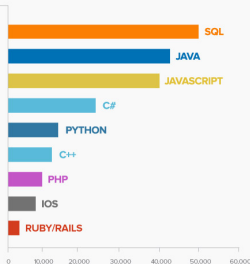
Viewpoint	Torch	Caffe	TensorFlow	MXNet
Pretrained Models	Yes	Yes	No	Yes
Low-level Operators	Good	Good	Fairly good	Very few
High-level Support	Good	Good	Good	Good
Speed One-GPU	Great	Great	Not so good	Excellent
Memory Management	Great	Great	Not so good	Excellent
Parallel Support	Multi-GPU	Multi-GPU	Multi-GPU	Distributed

Python: A general-purpose programming language

- Created by Guido van Rossum in 1989 and first released in 1991
- Named after “the Monty Python” (British comedy group)
- An interpreted language—simple, clear, and readable
- Python has many excellent packages for machine learning
- The language of choice in introductory programming courses

Languages ranked by number of programming jobs

Data from
Indeed.com
2016



Feb 2017	Change	Programming language	Share	Trends
1		Java	22.6 %	-1.3 %
2		Python	14.7 %	+2.8 %
3		PHP	9.4 %	-1.2 %
4		C#	8.3 %	-0.3 %
5	↑↑	Javascript	7.7 %	+0.4 %
6		C	7.0 %	-0.2 %
7	↓↓	C++	6.9 %	-0.6 %
8		Objective-C	4.2 %	-0.6 %
9	↑	R	3.4 %	+0.4 %
10	↓	Swift	2.9 %	+0.1 %

Python for Scientific Computing

Why Python for scientific computing?

- Strong introspection¹ capabilities (???What does even mean???)
- Full modularity, supporting hierarchical packages
- Exception-based error handling
- Dynamic data types and automatic memory management

Why consider such a slow language for simulation?

- Good for proof-of-concept
- Implementation time versus execution time
- Code readability and maintenance — short code, fewer bugs
- Well-written Python code is “fast enough” for most computational tasks
- Time critical parts executed through compiled language or **available packages**

Built-in Data Structures

- Numeric types—int, float, complex, ex: `a=1`, `b=1.0`, `c=1L`, `d=0xf`, `e=010`, `f=1+2j`
- Sequence types—list, tuple, str, dict, ex: `g=[3.14, True, 'Yes', [1], (1L,)] + [False] + [None]*3`, `h=(3.14, True, 'Yes', [1], ())`, `i='Hello' + "," + "'world!'"`, `j={1: 'int', 'pi': 3.14}`

Control Flow

- If-then-else

```
1      a = 1
2      if a > 0:
3          print "a is positive"
4      elif a=0:
5          print "a is zero"
6      else:
7          print "a is negative"
```

- For loop

```
1      for i in range(10):
2          print i
```

- While loop

```
1      sum = 0, i = 0
2      while i < 10:
3          sum += i
4          i += 1
```

Functions and Modules

- Defining functions

```
1      def square(x):  
2          return x*x
```

- Using modules

There are 3 different ways to use modules. Examples are below.

1. `import math`
This will only introduce the name `math` into the name space in which the `import` command was issued. The names within the `math` module will not appear in the enclosing namespace: they must be accessed through the name `math`. For example: `math.sin(3.14)`.
2. `from math import *`
This does not introduce the name `math` into the current namespace. It does however introduce all public names of the `math` module into the current namespace, directly using: `sin(3.14)`
3. `from math import sin`
This will only import the `sin` function from `math` module and introduce the name `sin` into the current namespace, but it will not introduce the name `math` into the current namespace, directly using: `sin(3.14)`

Programming interface



Example 1



Programming interface



Example 1

Computational graph



Programming interface



Visualization



Example 1: SoftMax

```
1 import tensorflow as tf
2
3 X = tf.placeholder(tf.float32, [None, 28, 28, 1])
4 W = tf.Variable(tf.zeros([784, 10]))
5 b = tf.Variable(tf.zeros([10]))
6 init = tf.initialize_all_variables()
7
8 # model
9 Y= tf.nn.softmax(tf.matmul(tf.reshape(X,[-1, 784]), W) + b)
10
11 # placeholder for correct answers
12 Y_ = tf.placeholder(tf.float32, [None, 10])
13
14 # loss function
15 cross_entropy = -tf.reduce_sum(Y_ * tf.log(Y))
16
17 # % of correct answers found in batch
18 is_correct = tf.equal(tf.argmax(Y,1), tf.argmax(Y_,1))
19 accuracy = tf.reduce_mean(tf.cast(is_correct,tf.float32))
```

Example 1:SoftMax

```
1 optimizer = tf.train.GradientDescentOptimizer(0.003)
2 train_step = optimizer.minimize(cross_entropy)
3
4 sess = tf.Session()
5 sess.run(init)
6
7 for i in range(10000):
8     # load batch of images and correct answers
9     batch_X, batch_Y = mnist.train.next_batch(100)
10    train_data={X: batch_X, Y_: batch_Y}
11
12    # train
13    sess.run(train_step , feed_dict=train_data)
14
15    # success ? add code to print it
16    a,c = sess.run([ accuracy , cross_entropy ], feed=train_data)
17
18    # success on test data ?
19    test_data={X:mnist.test.images , Y_:mnist.test.labels}
20    a,c = sess.run([ accuracy , cross_entropy ], feed=test_data)
```

Programming interface



Example 1



Numerical tests



Thank You!

