# Gentle Introduction to Machine Learning with scikit-learn

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January 19th, 2012

# Outline

1. Introduction
2. Machine Learning Basics
3. Scikit-Learn
4. Conclusion

# What is the point of this talk?

- Get you playing around with Machine Learning techniques
- Get you excited about scikit-learn

## Caveats

- This talk won't change your life
- I won't focus too much on techiques
- This talk is low on math
- This talk won't make you an expert in scikit-learn

# What is Machine Learning?

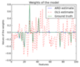
Machine Learning is the art of creating a compact explanation of the world using a large amount of data from the world

# Definitons

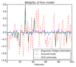
- Model the collection of parameters you are trying to fit
- Data what you are using to fit the model
- Target the value you are trying to predict with your model
- Features attributes of your data that will be used in prediction
- Methods algorithms that will use your data to fit a model

Note: Many methods are made to fit particular models

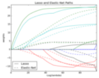
# Which method should I use?



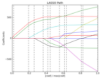
Automatic Relevance Determination Regression (ARD)



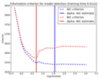
Bayesian Ridge Regression



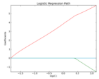
Lasso and Elastic Net



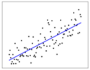
Lasso path using LARS



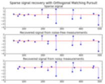
Lasso model selection: Cross-Validation / AIC / BIC



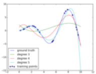
Path with L1- Logistic Regression



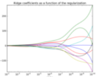
Ordinary Least Squares



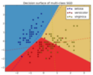
Orthogonal Matching Pursuit



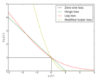
Polynomial interpolation



Plot Ridge coefficients as a function of the regularization



Plot multi-class SGD on the iris dataset



SGD: Convex Loss Functions

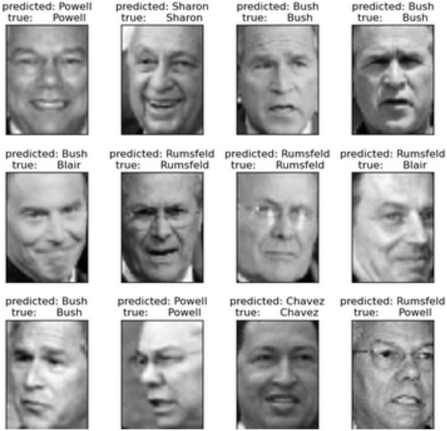
# Which method should I use?

- Standard Answer: Not really that important
- Cynical Answer: Whichever one performs the best
- Less Cynical Answer: The model that makes the most reasonable assumptions about your problem domain

## But yes its not the important question

Good Features are more important than Good Methods

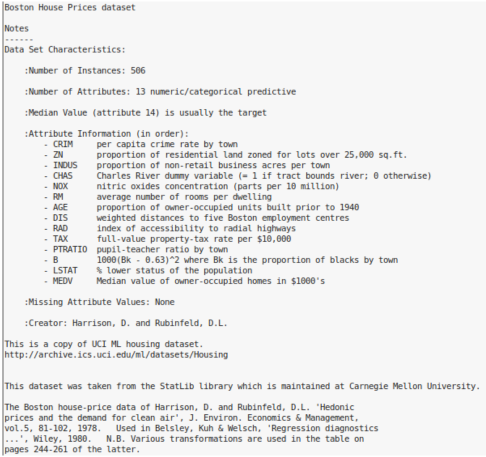
# Good Features is what counts



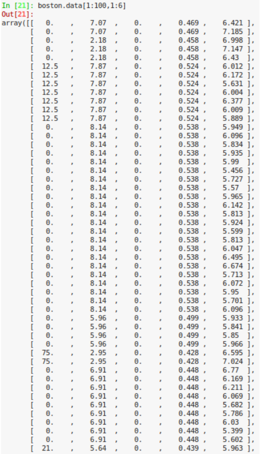
# Simple Example Model

OK I don't want to cheat you

# Meet the Boston Housing Dataset

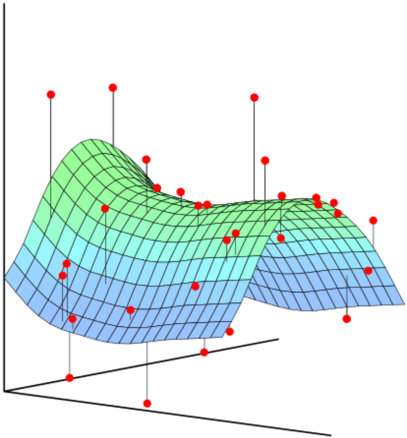


```
Boston House Prices dataset

Notes
------
Data Set Characteristics:

    :Number of Instances: 506

    :Number of Attributes: 13 numeric/categorical predictive

    :Median Value (attribute 14) is usually the target

    :Attribute Information (in order):
        - CRIM     per capita crime rate by town
        - ZN       proportion of residential land zoned for lots over 25,000 sq.ft.
        - INDUS    proportion of non-retail business acres per town
        - CHAS     Charles River dummy variable (= 1 if tract bounds river; 0 otherwise)
        - NOX      nitric oxides concentration (parts per 10 million)
        - RM       average number of rooms per dwelling
        - AGE      proportion of owner-occupied units built prior to 1940
        - DIS      weighted distances to five Boston employment centres
        - RAD      index of accessibility to radial highways
        - TAX      full-value property-tax rate per $10,000
        - PTRATIO  pupil-teacher ratio by town
        - B        1000(Bk - 0.63)^2 where Bk is the proportion of blacks by town
        - LSTAT    % lower status of the population
        - MEDV     Median value of owner-occupied homes in $1000's

    :Missing Attribute Values: None

    :Creator: Harrison, D. and Rubinfeld, D.L.

This is a copy of UCI ML housing dataset.
http://archive.ics.uci.edu/ml/datasets/Housing


This dataset was taken from the StatLib library which is maintained at Carnegie Mellon University.

The Boston house-price data of Harrison, D. and Rubinfeld, D.L. 'Hedonic
prices and the demand for clean air', J. Environ. Economics & Management,
vol.5, 81-102, 1978.   Used in Belsley, Kuh & Welsch, 'Regression diagnostics
...', Wiley, 1980.   N.B. Various transformations are used in the table on
pages 244-261 of the latter.
```



```
In [21]: boston.data[1:100,1:6]
Out[21]:
array([[   0.   ,    7.07 ,    0.   ,    0.469 ,    6.421 ],
       [   0.   ,    7.07 ,    0.   ,    0.469 ,    7.185 ],
       [   0.   ,    2.18 ,    0.   ,    0.458 ,    6.998 ],
       [   0.   ,    2.18 ,    0.   ,    0.458 ,    7.147 ],
       [   0.   ,    2.18 ,    0.   ,    0.458 ,    6.43  ],
       [  12.5  ,    7.87 ,    0.   ,    0.524 ,    6.012 ],
       [  12.5  ,    7.87 ,    0.   ,    0.524 ,    6.172 ],
       [  12.5  ,    7.87 ,    0.   ,    0.524 ,    5.631 ],
       [  12.5  ,    7.87 ,    0.   ,    0.524 ,    6.004 ],
       [  12.5  ,    7.87 ,    0.   ,    0.524 ,    6.377 ],
       [  12.5  ,    7.87 ,    0.   ,    0.524 ,    6.009 ],
       [  12.5  ,    7.87 ,    0.   ,    0.524 ,    5.889 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.949 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    6.096 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.834 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.935 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.99  ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.456 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.727 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.57  ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.965 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    6.142 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.813 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.924 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.599 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.813 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    6.047 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    6.495 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    6.674 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.713 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    6.072 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.95  ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    5.701 ],
       [   0.   ,    8.14 ,    0.   ,    0.538 ,    6.096 ],
       [   0.   ,    5.96 ,    0.   ,    0.499 ,    5.933 ],
       [   0.   ,    5.96 ,    0.   ,    0.499 ,    5.841 ],
       [   0.   ,    5.96 ,    0.   ,    0.499 ,    5.85  ],
       [   0.   ,    5.96 ,    0.   ,    0.499 ,    5.966 ],
       [  75.   ,    2.95 ,    0.   ,    0.428 ,    6.595 ],
       [  75.   ,    2.95 ,    0.   ,    0.428 ,    7.024 ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    6.77  ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    6.169 ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    6.211 ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    6.069 ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    5.682 ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    5.786 ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    6.03  ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    5.399 ],
       [   0.   ,    6.91 ,    0.   ,    0.448 ,    5.602 ],
       [  21.   ,    5.64 ,    0.   ,    0.439 ,    5.963 ],
```

# This data plotted might resemble this



# We assume these numbers can be linearly combined to predict housing price

$$y(\mathbf{x}, \mathbf{w}) = w_0 + w_1 x_1 + \ldots + w_D x_D$$

# Now this is how its done

```
from sklearn.linear_model import RidgeRegression
from sklearn import datasets

boston = datasets.load_boston()
X = boston.data
y = boston.target

clf = RidgeRegression()
clf.fit(X, y)
clf.predict(X)
```

# What just happened?

# Why Scikit-Learn?

- Weka is terrible

# No really it is very bad

- Documentation is scattered
- Interfaces are terrible
- Code has well-known bugs
- Software is not actively maintained
- It's Java code of the worst kind

# Why Scikit-Learn?

- Weka is terrible
- Most libraries are just research code

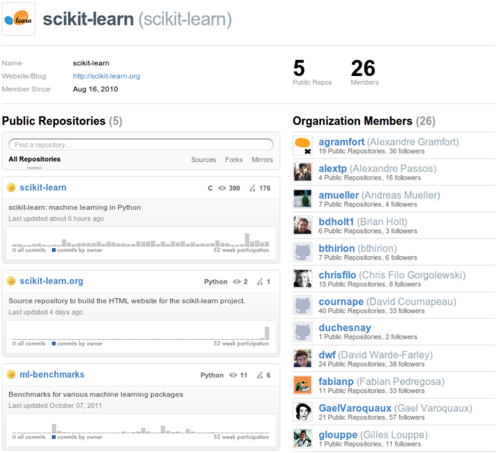
# If you've been there you know

- Documentation is non-existent (libsvm)
- Interfaces are idiosyncratic
- Software is unmaintained (libsvm, pybrain)
- Software is for educational purposes (nltk)

# Why Scikit-Learn?

- Made on top of cython and scipy
- Fantastic community

# Full of practitioners and researchers



## scikit-learn (scikit-learn)

Name scikit-learn
Website/Blog http://scikit-learn.org
Member Since Aug 16, 2010

5 Public Repos
26 Members

### Public Repositories (5)

**scikit-learn** C 390 176

scikit-learn: machine learning in Python
Last updated about 6 hours ago

**scikit-learn.org** Python 2 1

Source repository to build the HTML website for the scikit-learn project.
Last updated 4 days ago

**ml-benchmarks** Python 11 6

Benchmarks for various machine learning packages
Last updated October 07, 2011

### Organization Members (26)

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**fabianp** (Fabian Pedregosa)
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**GaelVaroquaux** (Gael Varoquaux)
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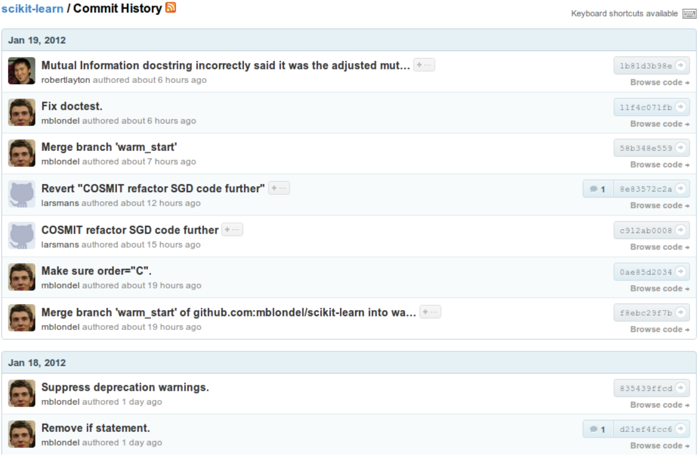
**glouppe** (Gilles Louppe)
1 Public Repositories, 11 followers

# Very Active



scikit-learn / Commit History

Keyboard shortcuts available

**Jan 19, 2012**

**Mutual Information docstring incorrectly said it was the adjusted mut...**
robertlayton authored about 6 hours ago
1b81d3b98e — Browse code

**Fix doctest.**
mblondel authored about 6 hours ago
11f4c071fb — Browse code

**Merge branch 'warm_start'**
mblondel authored about 7 hours ago
58b348e559 — Browse code

**Revert "COSMIT refactor SGD code further"**
larsmans authored about 12 hours ago
1 — 8e83572c2a — Browse code

**COSMIT refactor SGD code further**
larsmans authored about 15 hours ago
c912ab0008 — Browse code

**Make sure order="C".**
mblondel authored about 19 hours ago
0ae85d2034 — Browse code

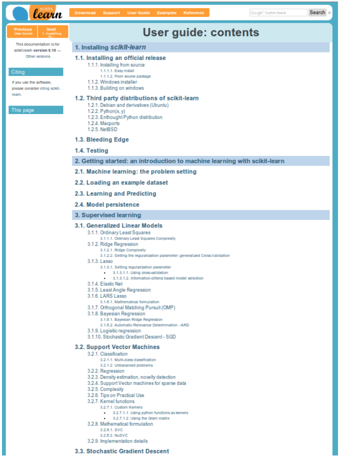
**Merge branch 'warm_start' of github.com:mblondel/scikit-learn into wa...**
mblondel authored about 19 hours ago
f8ebc29f7b — Browse code

**Jan 18, 2012**

**Suppress deprecation warnings.**
mblondel authored 1 day ago
835439ffcd — Browse code

**Remove if statement.**
mblondel authored 1 day ago
1 — d21ef4fcc6 — Browse code

# Very pythonic



This documentation is for scikit-learn **version 0.10** — Other versions

If you use the software, please consider citing scikit-learn.

## User guide: contents

**1. Installing *scikit-learn***

**1.1. Installing an official release**

- 1.1.1. Installing from source
  - 1.1.1.1. Easy install
  - 1.1.1.2. From source package
- 1.1.2. Windows installer
- 1.1.3. Building on windows

**1.2. Third party distributions of scikit-learn**

- 1.2.1. Debian and derivatives (Ubuntu)
- 1.2.2. Python(x, y)
- 1.2.3. Enthought Python distribution
- 1.2.4. Macports
- 1.2.5. NetBSD

**1.3. Bleeding Edge**

**1.4. Testing**

**2. Getting started: an introduction to machine learning with scikit-learn**

**2.1. Machine learning: the problem setting**

**2.2. Loading an example dataset**

**2.3. Learning and Predicting**

**2.4. Model persistence**

**3. Supervised learning**

**3.1. Generalized Linear Models**

- 3.1.1. Ordinary Least Squares
  - 3.1.1.1. Ordinary Least Squares Complexity
- 3.1.2. Ridge Regression
  - 3.1.2.1. Ridge Complexity
  - 3.1.2.2. Setting the regularization parameter: generalized Cross-Validation
- 3.1.3. Lasso
  - 3.1.3.1. Setting regularization parameter
    - 3.1.3.1.1. Using cross-validation
    - 3.1.3.1.2. Information-criteria based model selection
- 3.1.4. Elastic Net
- 3.1.5. Least Angle Regression
- 3.1.6. LARS Lasso
  - 3.1.6.1. Mathematical formulation
- 3.1.7. Orthogonal Matching Pursuit (OMP)
- 3.1.8. Bayesian Regression
  - 3.1.8.1. Bayesian Ridge Regression
  - 3.1.8.2. Automatic Relevance Determination - ARD
- 3.1.9. Logisitic regression
- 3.1.10. Stochastic Gradient Descent - SGD

**3.2. Support Vector Machines**

- 3.2.1. Classification
  - 3.2.1.1. Multi-class classification
  - 3.2.1.2. Unbalanced problems
- 3.2.2. Regression
- 3.2.3. Density estimation, novelty detection
- 3.2.4. Support Vector machines for sparse data
- 3.2.5. Complexity
- 3.2.6. Tips on Practical Use
- 3.2.7. Kernel functions
  - 3.2.7.1. Custom Kernels
    - 3.2.7.1.1. Using python functions as kernels
    - 3.2.7.1.2. Using the Gram matrix
- 3.2.8. Mathematical formulation
  - 3.2.8.1. SVC
  - 3.2.8.2. NuSVC
- 3.2.9. Implementation details

**3.3. Stochastic Gradient Descent**

# Getting it: You want the latest

```
pip install -U scikit-learn
```

# A more *realistic* example

*That's what she said*

# Loading the example

```
import numpy as np
y = np.concatenate((np.zeros(5796),np.ones(2091)))

DATADIR = "/home/zv/custom_builds/twss-classifier/data"
data = itertools.chain(file(DATADIR+"/fmylife-parsed.txt"),
                       file(DATADIR+"/texts-from-last-night-pa
                       file(DATADIR+"/twss-stories-parsed.txt'
```

# Feature Extraction

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer()
X = vectorizer.fit_transform(data)
```

# Learning

```
from sklearn.naive_bayes import MultinomialNB
clf = MultinomialNB(0.01)
clf.fit(X,y)
```

# Testing

```
text = "Something inappropiate"
if clf.predict_proba(vectorizer.transform(text)) > 0.995:
       print "TWSS"
```

# Why this matters?

Machine Learning in Python isn't a coincidence

# Why this matters?

Python has a robust data ecosystem

- numpy
- scipy
- cython
- pandas

# Why this matters?

- Python is what data scientists are using
- Python will become the center of the data science universe

# Conclusions

Scikit-Learn is awesome, pythonic and fast

# Conclusions

Now go make some cool!

# References

- http://www.scikit-learn.org
- https://github.com/scikit-learn/scikit-learn
- http://nltk.org
- http://wit.io/posts/ruby-is-beautiful-but-im-moving-to-python

Questions?