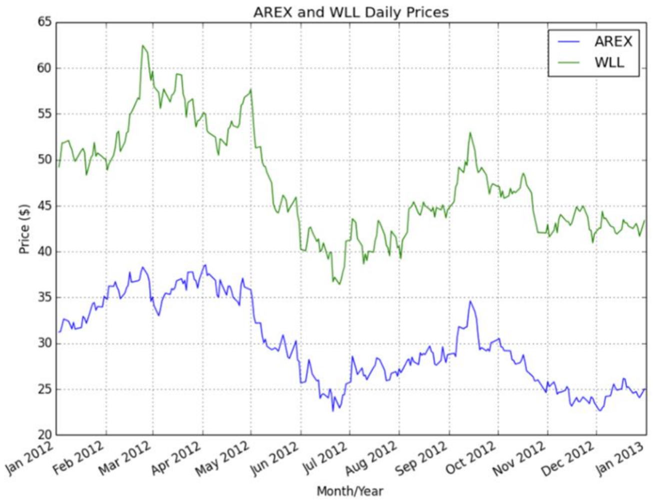
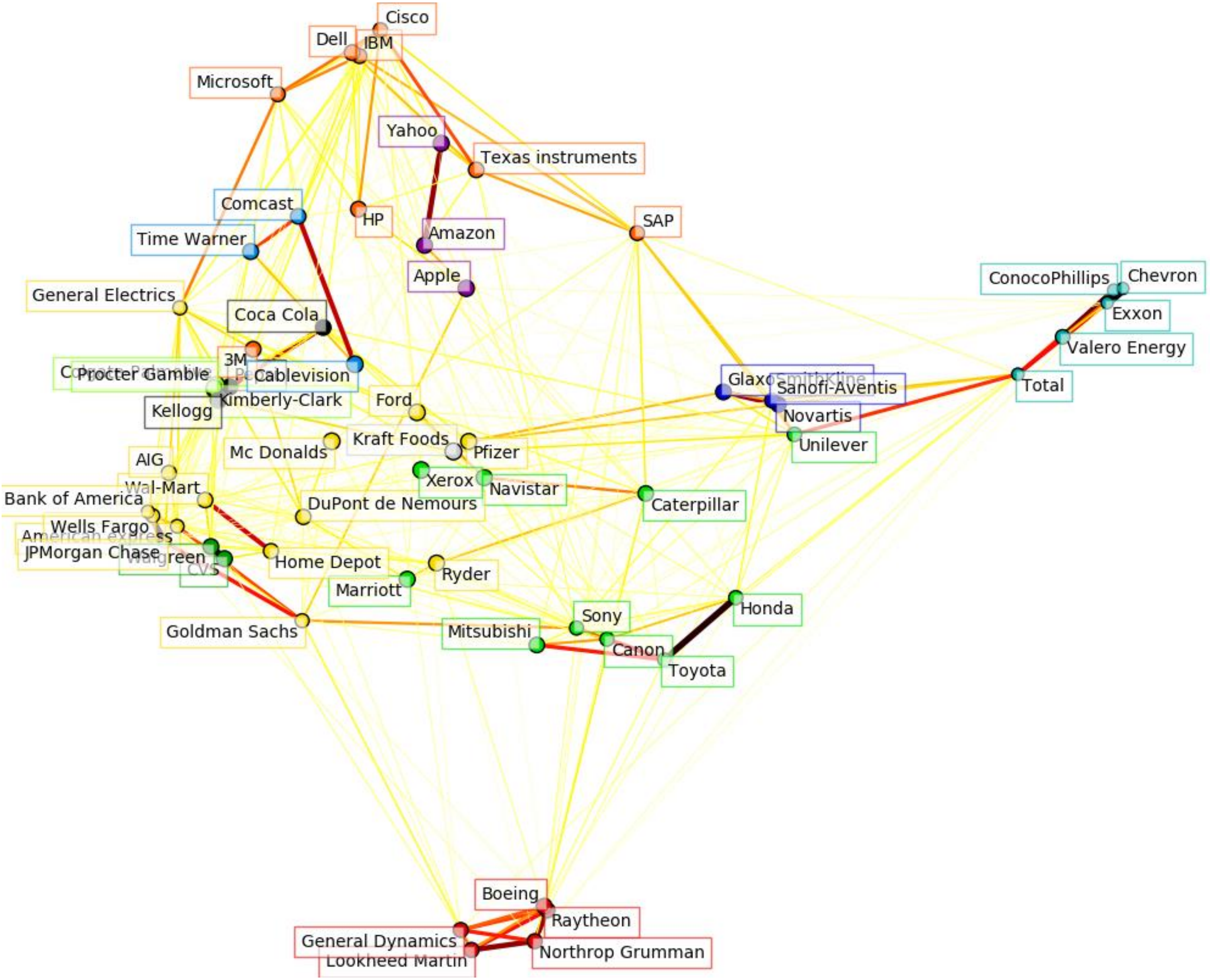
机器学习与量化交易实战

第三课

Outline

- 数据的获得与存储
- 时间序列分析实战





- 从下周开始，每次课前半小时为上次作业点评并给出解决方案的程序

数据的获取

- http://tushare.org/index.html

- **Yahoo Finance** - http://finance.yahoo.com
- **Google Finance** - https://www.google.com/finance
- **QuantQuote** - https://www.quantquote.com (S&P500 EOD data only)
- **EODData** - http://eoddata.com (requires registration)

存储方式

- csv
- NoSQL
- SQL
- 。。。

数据格式

- 交易所信息
- 数据来源
- Ticker/symbol
- 价格
- 企业行为（stock splits/dividend adjustments）
- 国家假日

容易出错的地方

- 企业行为
- “spikes”：用spike filter
- 缺失数据

搭建你自己的MySQL

- 安装

```
sudo apt-get install mysql-server
```

```
mysql -u root -p
```

```
mysql> CREATE DATABASE securities_master;
mysql> USE securities_master;
```

```
mysql> CREATE USER 'sec_user'@'localhost' IDENTIFIED BY 'password';
mysql> GRANT ALL PRIVILEGES ON securities_master.* TO 'sec_user'@'localhost';
mysql> FLUSH PRIVILEGES;
```

设计股票EOD数据的表

- Exchange
- DataVendor
- Symbol
- DailyPrice

```
CREATE TABLE ‘exchange‘ (
  ‘id‘ int NOT NULL AUTO_INCREMENT,
  ‘abbrev‘ varchar(32) NOT NULL,
  ‘name‘ varchar(255) NOT NULL,
  ‘city‘ varchar(255) NULL,
  ‘country‘ varchar(255) NULL,
  ‘currency‘ varchar(64) NULL,
  ‘timezone_offset‘ time NULL,
  ‘created_date‘ datetime NOT NULL,
  ‘last_updated_date‘ datetime NOT NULL,
  PRIMARY KEY (‘id‘)
) ENGINE=InnoDB AUTO_INCREMENT=1 DEFAULT CHARSET=utf8;
```

```
CREATE TABLE ‘data_vendor‘ (
  ‘id‘ int NOT NULL AUTO_INCREMENT,
  ‘name‘ varchar(64) NOT NULL,
  ‘website_url‘ varchar(255) NULL,
  ‘support_email‘ varchar(255) NULL,
  ‘created_date‘ datetime NOT NULL,
  ‘last_updated_date‘ datetime NOT NULL,
  PRIMARY KEY (‘id‘)
) ENGINE=InnoDB AUTO_INCREMENT=1 DEFAULT CHARSET=utf8;
```

```
CREATE TABLE ‘symbol‘ (
  ‘id‘ int NOT NULL AUTO_INCREMENT,
  ‘exchange_id‘ int NULL,
  ‘ticker‘ varchar(32) NOT NULL,
  ‘instrument‘ varchar(64) NOT NULL,
  ‘name‘ varchar(255) NULL,
  ‘sector‘ varchar(255) NULL,
  ‘currency‘ varchar(32) NULL,
  ‘created_date‘ datetime NOT NULL,
  ‘last_updated_date‘ datetime NOT NULL,
  PRIMARY KEY (‘id‘),
  KEY ‘index_exchange_id‘ (‘exchange_id‘)
) ENGINE=InnoDB AUTO_INCREMENT=1 DEFAULT CHARSET=utf8;
```

```
CREATE TABLE ‘daily_price‘ (
  ‘id‘ int NOT NULL AUTO_INCREMENT,
  ‘data_vendor_id‘ int NOT NULL,
  ‘symbol_id‘ int NOT NULL,
  ‘price_date‘ datetime NOT NULL,
  ‘created_date‘ datetime NOT NULL,
  ‘last_updated_date‘ datetime NOT NULL,
  ‘open_price‘ decimal(19,4) NULL,
  ‘high_price‘ decimal(19,4) NULL,
  ‘low_price‘ decimal(19,4) NULL,
  ‘close_price‘ decimal(19,4) NULL,
  ‘adj_close_price‘ decimal(19,4) NULL,
  ‘volume‘ bigint NULL,
  PRIMARY KEY (‘id‘),
  KEY ‘index_data_vendor_id‘ (‘data_vendor_id‘),
  KEY ‘index_symbol_id‘ (‘symbol_id‘)
) ENGINE=InnoDB AUTO_INCREMENT=1 DEFAULT CHARSET=utf8;
```

python同数据库连接

```
sudo apt-get install libmysqlclient-dev
pip install mysqlclient
```

- 课件
- Insert_symbols.py

List of S&P 500 companies

From Wikipedia, the free encyclopedia

The **S&P 500** stock market index, maintained by S&P Dow Jones Indices, comprises **505** common stocks issued by **500** mid an
75 percent of the American equity market by capitalization. The index is weighted by free-float market capitalization, so more va
and the constituent weights are updated and checked on regularly using rules published by S&P Dow Jones Indices. Although tl
two share classes of stock from 5 of its component companies.[1][2] The index constituents listed below were current as of July 1:

Contents [hide]

S&P 500 Component Stocks [edit]

Ticker symbol	Security	SEC filings	GICS Sector	GICS Sub Indust
MMM	3M Company	reports	Industrials	Industrial Conglomerates
ABT	Abbott Laboratories	reports	Health Care	Health Care Equipment & S
ABBV	AbbVie	reports	Health Care	Pharmaceuticals
ACN	Accenture plc	reports	Information Technology	IT Consulting & Other Servi
ATVI	Activision Blizzard	reports	Information Technology	Home Entertainment Softwa
AYI	Acuity Brands Inc	reports	Industrials	Electrical Components & Ec
ADBE	Adobe Systems Inc	reports	Information Technology	Application Software
AAP	Advance Auto Parts	reports	Consumer Discretionary	Automotive Retail
AES	AES Corp	reports	Utilities	Independent Power Produc Traders

```python
def obtain_parse_wiki_snp500():
    """
    Download and parse the Wikipedia list of S&P500
    constituents using requests and BeautifulSoup.
    Returns a list of tuples for to add to MySQL.
    """
    # Stores the current time, for the created_at record
    now = datetime.datetime.utcnow()
    # Use requests and BeautifulSoup to download the
    # list of S&P500 companies and obtain the symbol table
    response = requests.get(
        "http://en.wikipedia.org/wiki/List_of_S%26P_500_companies"
    )
    soup = bs4.BeautifulSoup(response.text)
    # This selects the first table, using CSS Selector syntax
    # and then ignores the header row ([1:])
    symbolslist = soup.select('table')[0].select('tr')[1:]
    # Obtain the symbol information for each
    # row in the S&P500 constituent table
    symbols = []
    for i, symbol in enumerate(symbolslist):
        tds = symbol.select('td')
        symbols.append(
            (
                tds[0].select('a')[0].text,  # Ticker
                'stock',
                tds[1].select('a')[0].text,  # Name
                tds[3].text,  # Sector
                'USD', now, now
            )
        )
    return symbols
```

- 课件
- Insert_symbols.py

```python
def insert_snp500_symbols(symbols):
    """
    Insert the S&P500 symbols into the MySQL database.
    """
    # Connect to the MySQL instance
    db_host = 'localhost'
    db_user = 'sec_user'
    db_pass = 'password'
    db_name = 'securities_master'
    con = mdb.connect(
        host=db_host, user=db_user, passwd=db_pass, db=db_name
    )

    # Create the insert strings
    column_str = """ticker, instrument, name, sector,
                 currency, created_date, last_updated_date
                 """
    insert_str = ("%s, " * 7)[:-2]
    final_str = "INSERT INTO symbol (%s) VALUES (%s)" % \
        (column_str, insert_str)

    # Using the MySQL connection, carry out
    # an INSERT INTO for every symbol
    with con:
        cur = con.cursor()
        cur.executemany(final_str, symbols)
```

- 课件
- Price_retrivel.py

```python
def get_daily_historic_data_yahoo(
        ticker, start_date=(2000,1,1),
        end_date=datetime.date.today().timetuple()[0:3]
    ):
    """
    Obtains data from Yahoo Finance returns and a list of tuples.

    ticker: Yahoo Finance ticker symbol, e.g. "GOOG" for Google, Inc.
    start_date: Start date in (YYYY, M, D) format
    end_date: End date in (YYYY, M, D) format
    """
    # Construct the Yahoo URL with the correct integer query parameters
    # for start and end dates. Note that some parameters are zero-based!
    ticker_tup = (
        ticker, start_date[1]-1, start_date[2],
        start_date[0], end_date[1]-1, end_date[2],
        end_date[0]
    )
    yahoo_url = "http://ichart.finance.yahoo.com/table.csv"
    yahoo_url += "?s=%s&a=%s&b=%s&c=%s&d=%s&e=%s&f=%s"
    yahoo_url = yahoo_url % ticker_tup

    # Try connecting to Yahoo Finance and obtaining the data
    # On failure, print an error message.
    try:
        yf_data = requests.get(yahoo_url).text.split("\n")[1:-1]
        prices = []
        for y in yf_data:
            p = y.strip().split(',')
            prices.append(
                (datetime.datetime.strptime(p[0], '%Y-%m-%d'),
                p[1], p[2], p[3], p[4], p[5], p[6])
            )
    except Exception as e:
        print("Could not download Yahoo data: %s" % e)
    return prices
```

- 课件
- Price_retrivel.py

```python
def insert_daily_data_into_db(
        data_vendor_id, symbol_id, daily_data
    ):
    """
    Takes a list of tuples of daily data and adds it to the
    MySQL database. Appends the vendor ID and symbol ID to the data.

    daily_data: List of tuples of the OHLC data (with
    adj_close and volume)
    """
    # Create the time now
    now = datetime.datetime.utcnow()

    # Amend the data to include the vendor ID and symbol ID
    daily_data = [
        (data_vendor_id, symbol_id, d[0], now, now,
        d[1], d[2], d[3], d[4], d[5], d[6])
        for d in daily_data
    ]

    # Create the insert strings
    column_str = """data_vendor_id, symbol_id, price_date, created_date,
                 last_updated_date, open_price, high_price, low_price,
                 close_price, volume, adj_close_price"""
    insert_str = ("%s, " * 11)[:-2]
    final_str = "INSERT INTO daily_price (%s) VALUES (%s)" % \
        (column_str, insert_str)

    # Using the MySQL connection, carry out an INSERT INTO for every symbol
    with con:
        cur = con.cursor()
        cur.executemany(final_str, daily_data)
```

- 课件
- Retrieving_Data.py

price_date	adj_close_price
2015-06-09	526.69
2015-06-10	536.69
2015-06-11	534.61
2015-06-12	532.33
2015-06-15	527.20

```python
from __future__ import print_function

import pandas as pd
import MySQLdb as mdb


if __name__ == "__main__":
    # Connect to the MySQL instance
    db_host = 'localhost'
    db_user = 'sec_user'
    db_pass = 'password'
    db_name = 'securities_master'
    con = mdb.connect(db_host, db_user, db_pass, db_name)

    # Select all of the historic Google adjusted close data
    sql = """SELECT dp.price_date, dp.adj_close_price
             FROM symbol AS sym
             INNER JOIN daily_price AS dp
             ON dp.symbol_id = sym.id
             WHERE sym.ticker = 'GOOG'
             ORDER BY dp.price_date ASC;"""

    # Create a pandas dataframe from the SQL query
    goog = pd.read_sql_query(sql, con=con, index_col='price_date')

    # Output the dataframe tail
    print(goog.tail())
```

More on Yahoo finance

```
from __future__ import print_function

import datetime
import pandas.io.data as web

if __name__ == "__main__":
    spy = web.DataReader(
        "SPY", "yahoo",
        datetime.datetime(2007,1,1),
        datetime.datetime(2015,6,15)
    )
    print(spy.tail())
```

```
                  Open        High         Low       Close     Volume  \
Date
2015-06-09  208.449997  209.100006  207.690002  208.449997   98148200
2015-06-10  209.369995  211.410004  209.300003  210.960007  129936200
2015-06-11  211.479996  212.089996  211.199997  211.649994   72672100
2015-06-12  210.639999  211.479996  209.679993  209.929993  127811900
2015-06-15  208.639999  209.449997  207.789993  209.100006  121425800

             Adj Close
Date
2015-06-09  208.449997
2015-06-10  210.960007
2015-06-11  211.649994
2015-06-12  209.929993
2015-06-15  209.100006
```

Quandl

- Quandl_data.py

```
def download_contract_from_quandl(contract, dl_dir):
    """
    Download an individual futures contract from Quandl and then
    store it to disk in the 'dl_dir' directory. An auth_token is
    required, which is obtained from the Quandl upon sign-up.
    """
    # Construct the API call from the contract and auth_token
    api_call = "http://www.quandl.com/api/v1/datasets/"
    api_call += "OFDP/FUTURE_%s.csv" % contract
    # If you wish to add an auth token for more downloads, simply
    # comment the following line and replace MY_AUTH_TOKEN with
    # your auth token in the line below
    params = "?sort_order=asc"
    #params = "?auth_token=MY_AUTH_TOKEN&sort_order=asc"
    full_url = "%s%s" % (api_call, params)

    # Download the data from Quandl
    data = requests.get(full_url).text

    # Store the data to disk
    fc = open('%s/%s.csv' % (dl_dir, contract), 'w')
    fc.write(data)
    fc.close()
```


```python
if __name__ == "__main__":
    symbol = 'ES'

    # Make sure you've created this
    # relative directory beforehand
    dl_dir = 'quandl/futures/ES'

    # Create the start and end years
    start_year = 2010
    end_year = 2014

    # Download the contracts into the directory
    download_historical_contracts(
        symbol, dl_dir, start_year, end_year
    )

    # Open up a single contract via read_csv
    # and plot the settle price
    es = pd.io.parsers.read_csv(
        "%s/ESH2010.csv" % dl_dir, index_col="Date"
    )
    es["Settle"].plot()
    plt.show()
```

作业1

利用http://tushare.org/index.html 中介绍的api，爬取http://tushare.org/trading.html 页面中的所有交易数据存入本地数据库（或csv文件夹）。

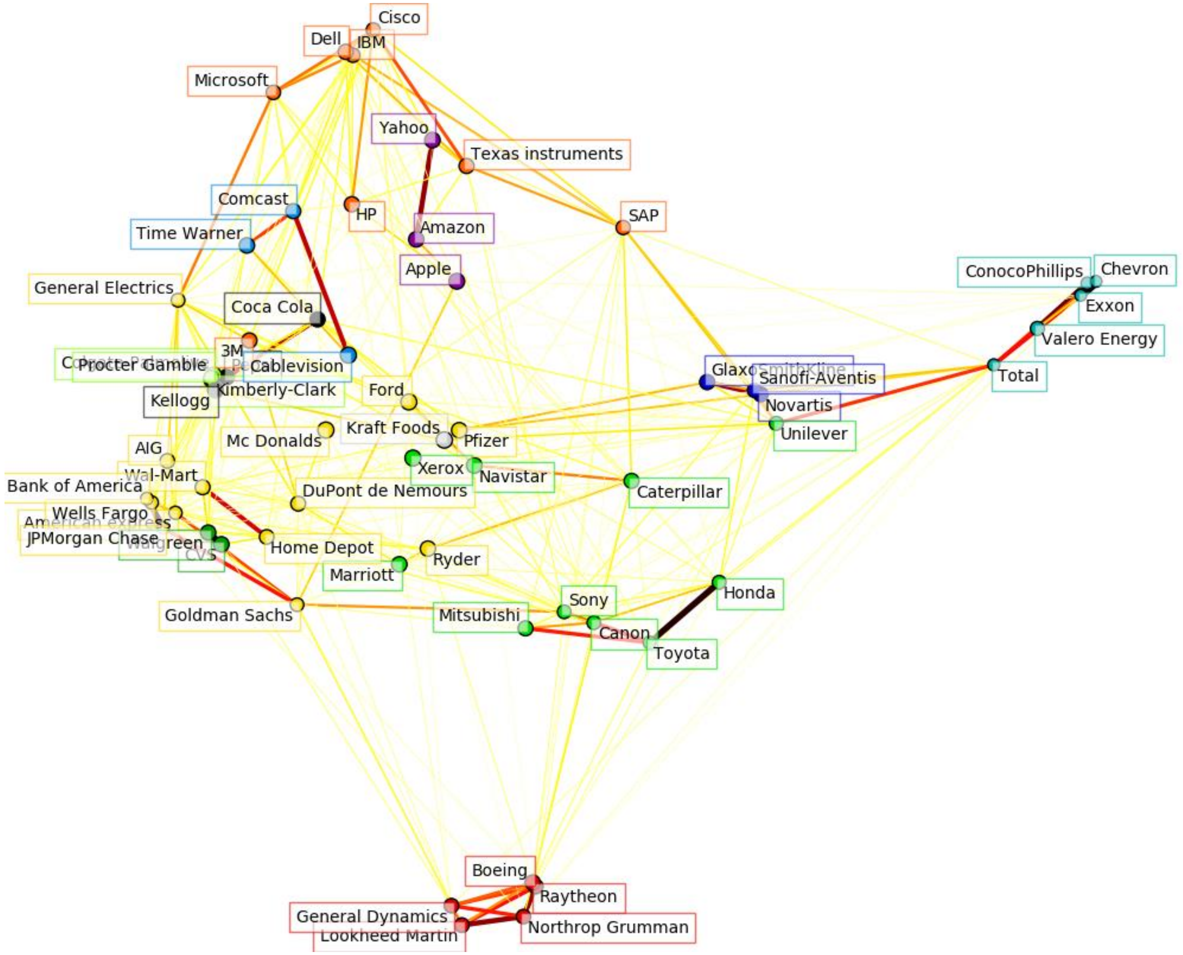
hint: 参考 http://tushare.org/storing.html

Due date：Next Week

Bottom Line：会使用api

作业2

对沪深三百股票进行聚类
并画出右图所示的二维嵌入



Hint：

http://scikit-learn.org/stable/auto_examples/applications/plot_stock_market.html#stock-market

时间序列分析

- Mean Reversion and Ornstein-Uhlenbeck process

$$dx_t = \theta(\mu - x_t)dt + \sigma dW_t$$

ADF Test

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \epsilon_t$$

- Calculate the *test statistic*, DF_τ, which is used in the decision to reject the null hypothesis
- Use the *distribution* of the test statistic (calculated by Dickey and Fuller), along with the critical values, in order to decide whether to reject the null hypothesis

ADF Test

```
(0.049177575166452235,
 0.9624149632563063,
 1,
 3771,
 {'1%': -3.4320852842548395,
  '10%': -2.5671781529820348,
  '5%': -2.8623067530084247},
 19576.116041473877)
```

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \epsilon_t$$

```
# Download the Amazon OHLCV data from 1/1/2000 to 1/1/2015
amzn = web.DataReader("AMZN", "yahoo", datetime(2000,1,1), datetime(2015,1,1))
# Output the results of the Augmented Dickey-Fuller test for Amazon
# with a lag order value of 1
ts.adfuller(amzn['Adj Close'], 1
```

Hurst Exponent

$$\langle | \log(t+\tau) - \log(t)|^2 \rangle \sim \tau^{2H}$$

- $H < 0.5$ - The time series is mean reverting
- $H = 0.5$ - The time series is a Geometric Brownian Motion
- $H > 0.5$ - The time series is trending

```python
def hurst(ts):
    """Returns the Hurst Exponent of the time series vector ts"""
    # Create the range of lag values
    lags = range(2, 100)

    # Calculate the array of the variances of the lagged differences
    tau = [sqrt(std(subtract(ts[lag:], ts[:-lag]))) for lag in lags]

    # Use a linear fit to estimate the Hurst Exponent
    poly = polyfit(log(lags), log(tau), 1)

    # Return the Hurst exponent from the polyfit output
    return poly[0]*2.0
```

```
# Create a Gometric Brownian Motion, Mean-Reverting and Trending Series
gbm = log(cumsum(randn(100000))+1000)
mr = log(randn(100000)+1000)
tr = log(cumsum(randn(100000)+1)+1000)

# Output the Hurst Exponent for each of the above series
# and the price of Amazon (the Adjusted Close price) for
# the ADF test given above in the article
print("Hurst(GBM):   %s" % hurst(gbm))
print("Hurst(MR):    %s" % hurst(mr))
print("Hurst(TR):    %s" % hurst(tr))
```

```
# Assuming you have run the above code to obtain 'amzn'!
print("Hurst(AMZN):  %s" % hurst(amzn['Adj Close']))
```

```
Hurst(GBM):   0.502051910931
Hurst(MR):    0.000166110248967
Hurst(TR):    0.957701001252
Hurst(AMZN):  0.454337476553
```

作业三

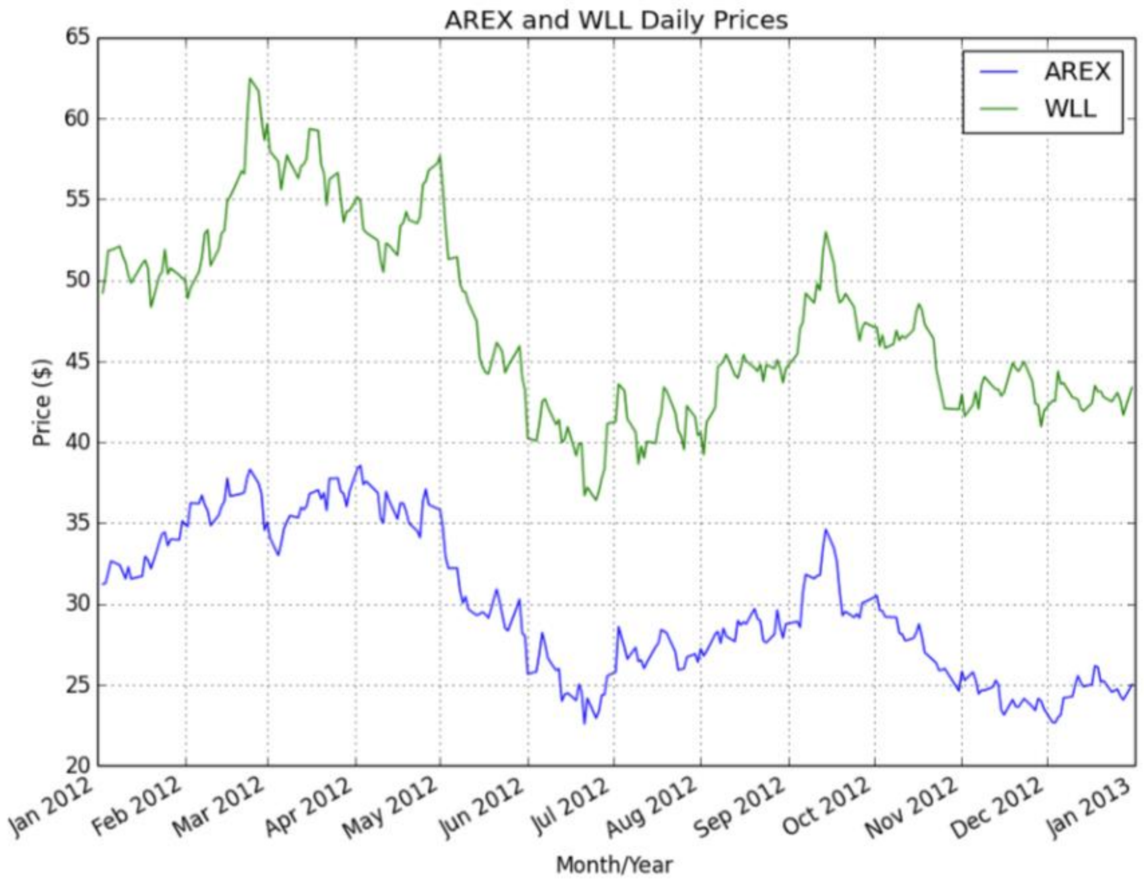
分别对沪深三百股票进行上述两者统计检测（2010-2015），并汇报出具备mean-reverting 的股票（如果存在的话）

从单一股票到投资组合

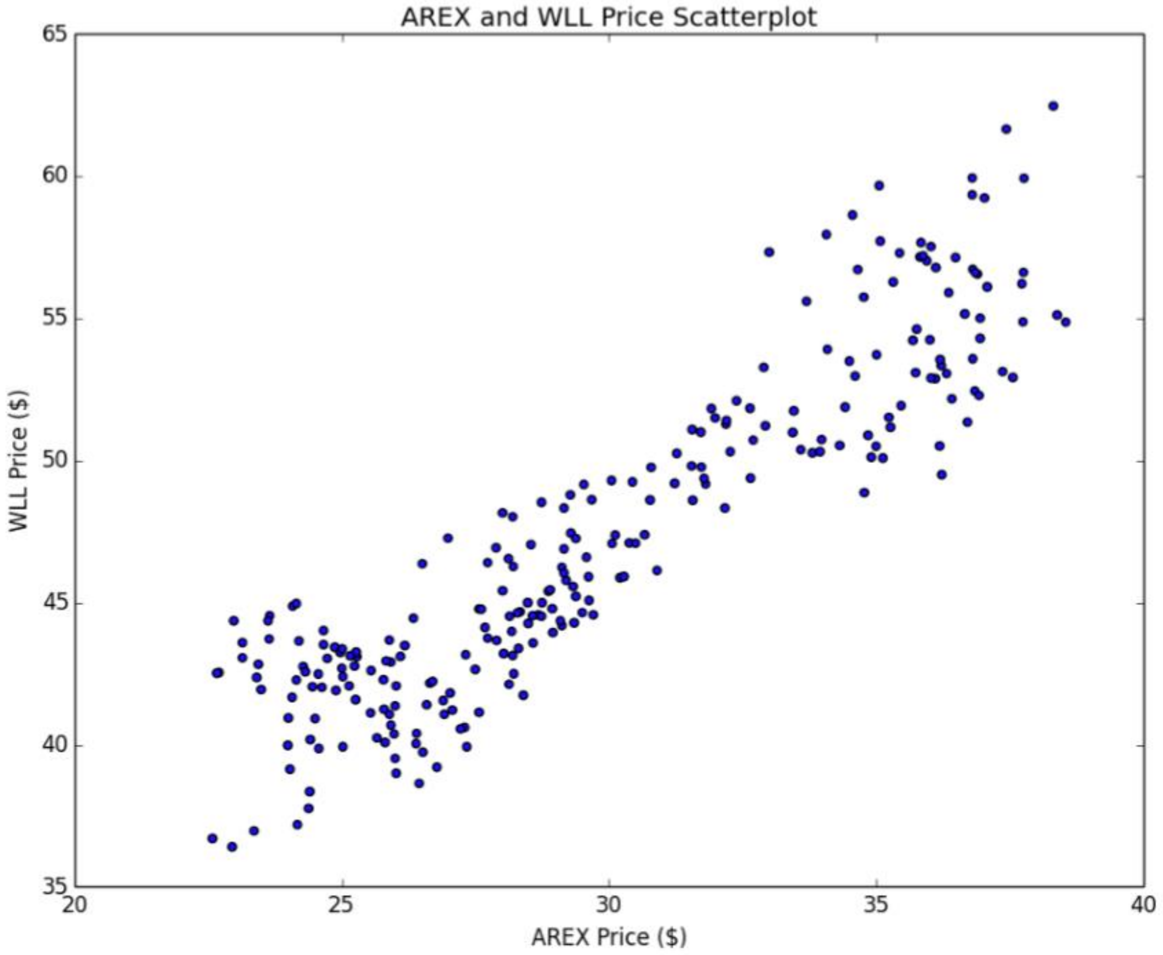
- Cointegrated Augmented Dickey-Fuller Test

$$y(t) = \beta x(t) + \epsilon(t)$$

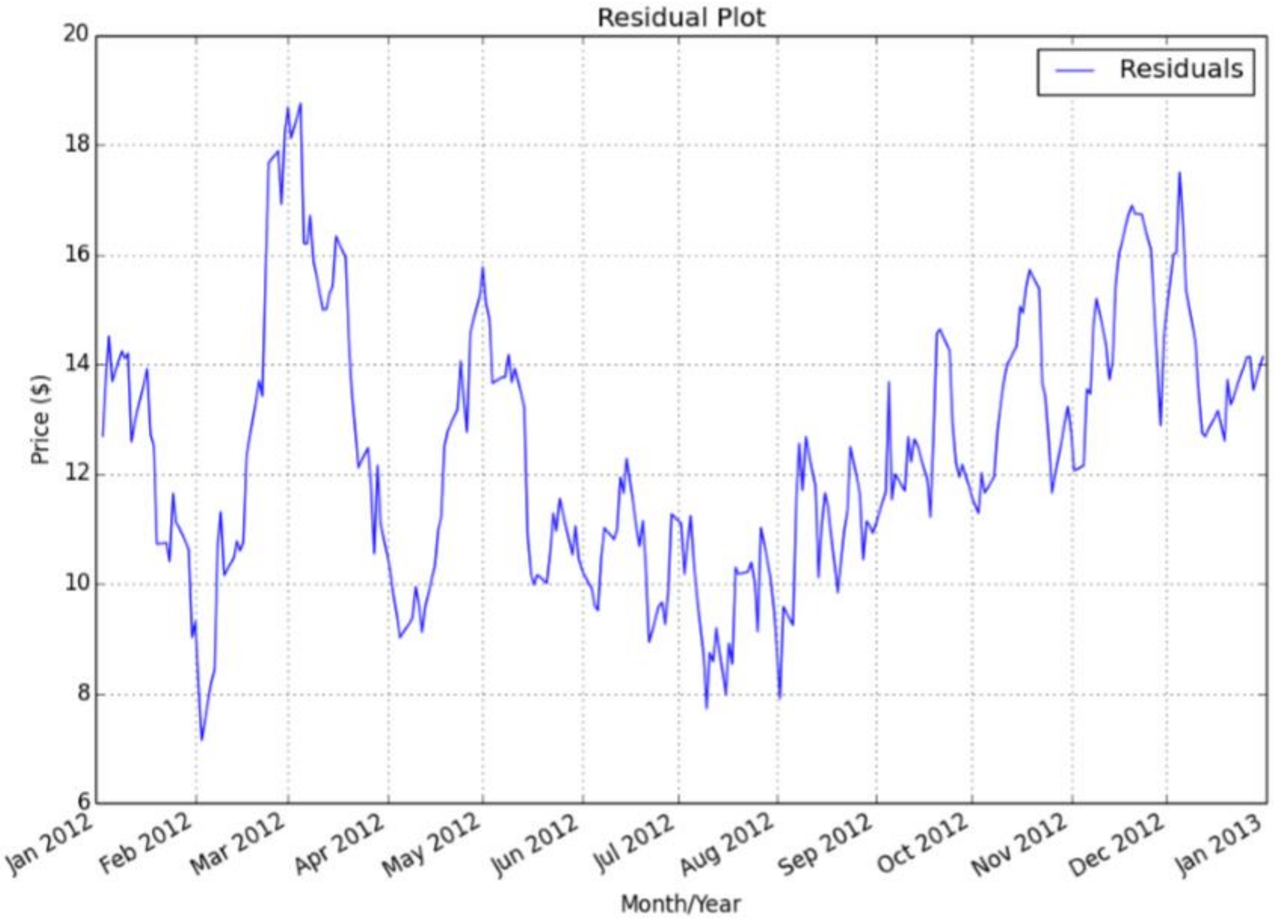
- 课件
- Cadf.py



AREX and WLL Daily Prices
AREX
WLL
Price ($)
Month/Year
65
60
55
50
45
40
35
30
25
20
Jan 2012
Feb 2012
Mar 2012
Apr 2012
May 2012
Jun 2012
Jul 2012
Aug 2012
Sep 2012
Oct 2012
Nov 2012
Dec 2012
Jan 2013


AREX and WLL Price Scatterplot
WLL Price ($)
AREX Price ($)
65
60
55
50
45
40
35
20
25
30
35
40

```
(-2.9607012342275936,
 0.038730981052330332,
 0,
 249,
 {'1%': -3.4568881317725864,
  '10%': -2.5729936189738876,
  '5%': -2.8732185133016057},
 601.9684925629599 1)
```



作业四

撰写脚本，提取沪深三百股票中具备上述协整关系的pairs