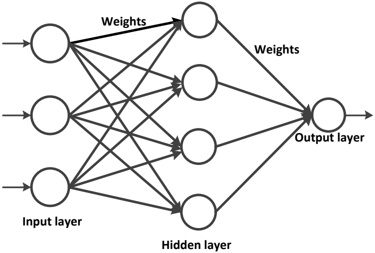
Exercise Session: Machine Learning in Power Systems

SMART DISTRIBUTION SYSTEMS

March 28, 2017

Aritificial Neural Networks

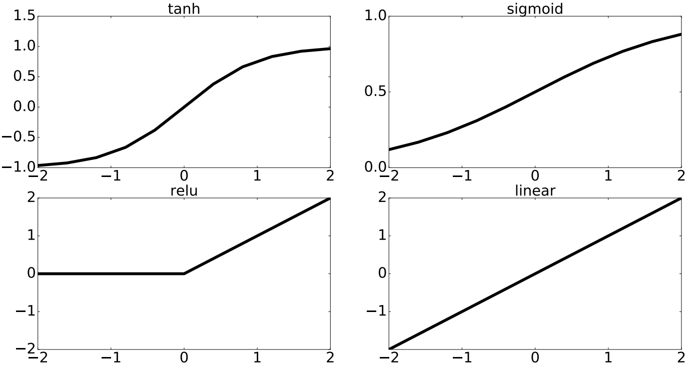
- Computing systems capable of **massive data processing** & **knowledge representation**
- Organized in layers → neurons, inputs,outputs & activation function
- Number of neurons in output layer = number of outputs
- Used in optimization, control and **forecasting**



Structure of a NN

Artificial Neural Networks

Activation Functions



Examples of activation functions

Set-up Machine Learning Environment

- Download & install Anaconda
  - Install python
  - Create a **virtual environment**
- Install deep learning libraries → tensorflow or **theano** & **keras**

Linux terminal in a nutshell

changing the current directory (folder)

cd path_to_directory

Replace path_to_directory with the folder of your choice. Some notes:

- seperate folders with a forward slash /
- you can press TAB to autocomplete the folder name
- enter the command ls to see what is in your current directory

You can refer to a path in two ways

1. Absolute: you start from the root folder and you enter the full path.
   - e.g.: cd `/users/electa/ruelensf/test2`
     This will open the Downloads folder in your current folder
2. Relative: you specify the path relative to the current folder
   - e.g.: cd `Downloads`
     This will open the Downloads folder in your current folder

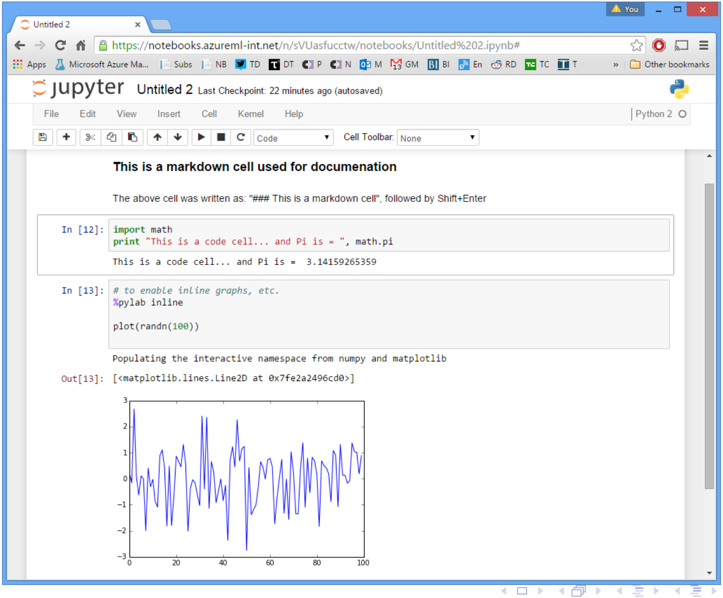
Set-up Machine Learning Environment

Linux Instructions

- open terminal & enter:
- git clone https://github.com/frederikruelens/Machine-Learning-in-Power-Systems
- cd Machine-Learning-in-Power-Systems
- source /users/electa/ruelensf/test2/bin/activate
- jupyter notebook

Note:
You can paste in the terminal with the combination CTRL+SHIFT+V

Jupyter notebook



This is a markdown cell used for documenation

The above cell was written as: "### This is a markdown cell", followed by Shift+Enter

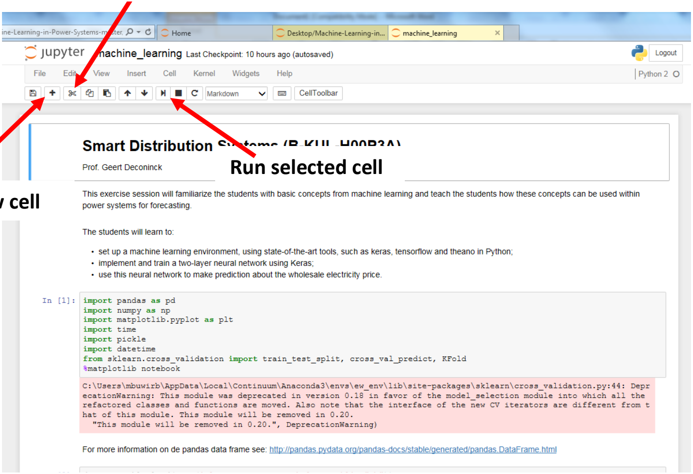
```
In [12]: import math
         print "This is a code cell... and Pi is = ", math.pi

         This is a code cell... and Pi is =  3.14159265359
```

```
In [13]: # to enable inline graphs, etc.
         %pylab inline

         plot(randn(100))

         Populating the interactive namespace from numpy and matplotlib

Out[13]: [<matplotlib.lines.Line2D at 0x7fe2a2496cd0>]
```

Jupyter notebook

Important commands

Delete selected cell


ine-Learning-in-Power-Systems-master
Home
Desktop/Machine-Learning-in...
machine_learning
jupyter
machine_learning Last Checkpoint: 10 hours ago (autosaved)
Logout
File
Edit
View
Insert
Cell
Kernel
Widgets
Help
Python 2
Markdown
CellToolbar

Run selected cell

Create new cell

Smart Distribution Systems (B-KUL-H00P3A)

Prof. Geert Deconinck

This exercise session will familiarize the students with basic concepts from machine learning and teach the students how these concepts can be used within power systems for forecasting.

The students will learn to:

- set up a machine learning environment, using state-of-the-art tools, such as keras, tensorflow and theano in Python;
- implement and train a two-layer neural network using Keras;
- use this neural network to make prediction about the wholesale electricity price.

In [1]:

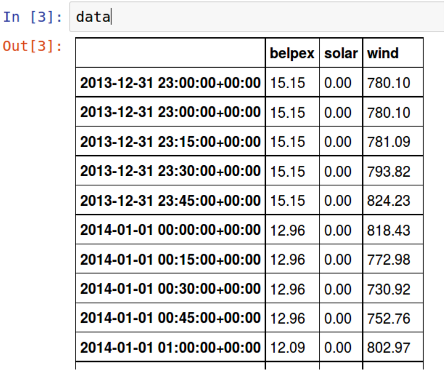
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import time
import pickle
import datetime
from sklearn.cross_validation import train_test_split, cross_val_predict, KFold
%matplotlib notebook
```

```
C:\Users\mbuwirb\AppData\Local\Continuum\Anaconda3\envs\ew_env\lib\site-packages\sklearn\cross_validation.py:44: Depr
ecationWarning: This module was deprecated in version 0.18 in favor of the model_selection module into which all the
refactored classes and functions are moved. Also note that the interface of the new CV iterators are different from t
hat of this module. This module will be removed in 0.20.
  "This module will be removed in 0.20.", DeprecationWarning)
```

For more information on de pandas data frame see: http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.html

Data set (Pandas format)

- Belgian electricity price in [MWh] (source www.belpex.be)
- Aggregated solar production in [MW] (source www.elia.be)
- Aggregated wind production in [MW] (source www.elia.be)



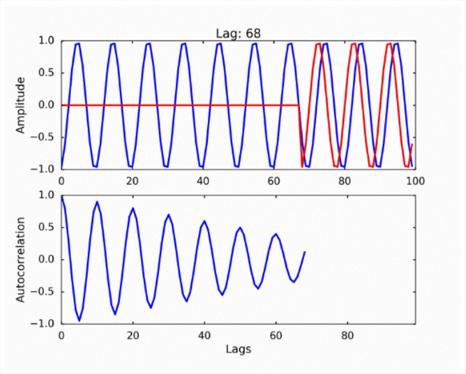
```
In [3]: data
Out[3]:
```

	belpex	solar	wind
2013-12-31 23:00:00+00:00	15.15	0.00	780.10
2013-12-31 23:00:00+00:00	15.15	0.00	780.10
2013-12-31 23:15:00+00:00	15.15	0.00	781.09
2013-12-31 23:30:00+00:00	15.15	0.00	793.82
2013-12-31 23:45:00+00:00	15.15	0.00	824.23
2014-01-01 00:00:00+00:00	12.96	0.00	818.43
2014-01-01 00:15:00+00:00	12.96	0.00	772.98
2014-01-01 00:30:00+00:00	12.96	0.00	730.92
2014-01-01 00:45:00+00:00	12.96	0.00	752.76
2014-01-01 01:00:00+00:00	12.09	0.00	802.97

Data visualization using pandas

Data set (Autocorrelation)

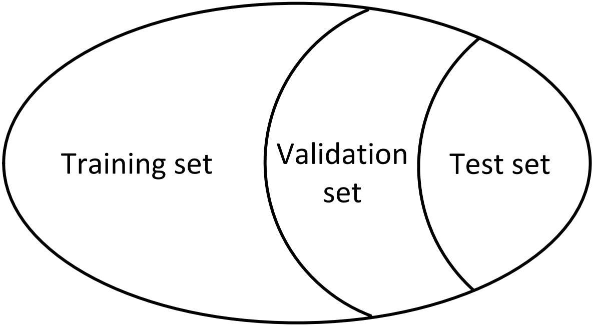
- Similarity between a **signal** and a **delayed copy** of itself
- Dependence of a data point with a previous or future data point



Autocorrelation of a sine wave

Data set (Data splitting)

- **Training set:** for **training/learning** network parameters
- **Validation set:** **tuning** network parameters → number of hidden layers/neurons
- **Test set:** evaluate network **performance**



Lab session tasks

Summary

- 1. Visualization
- 2. Remove outliers
- 3. Data Grouping
- 4. Auto-correlation
- 5. Linear regression
- 6. Naive implementation
- 7. **Assignment**

Lab session tasks

- Visualize & clean given data → remove outliers
- Auto-correlation of data
- Use linear regression for electricity price prediction

Assignment

1. Create train & test data sets
   - Training set: data 2014
   - Test set: data 2015
2. Modify a predefined NN to obtain better price prediction
   - Changing number of hidden layers
   - Trying different activation functions