Data processing for IoT

Sandor Markon
Kobe Institute of Computing

ICTP Workshop on Open Source Solutions for the Internet of Things, Jun 25-29, 2017

Brief self-introduction

- Born in Budapest, got Dipl. Ing. degree in Electrical Engineering
- 6 years in electromagnetic field analysis for a Hungarian manufacturer, incl. 2 years in Japan
- 29 years in computer applications for a Japanese manufacturer, PhD from Kyoto University
- 12 years teaching at Kobe Institute of Computing
- Besides: 2.5 companies, visiting researcher at hospital...

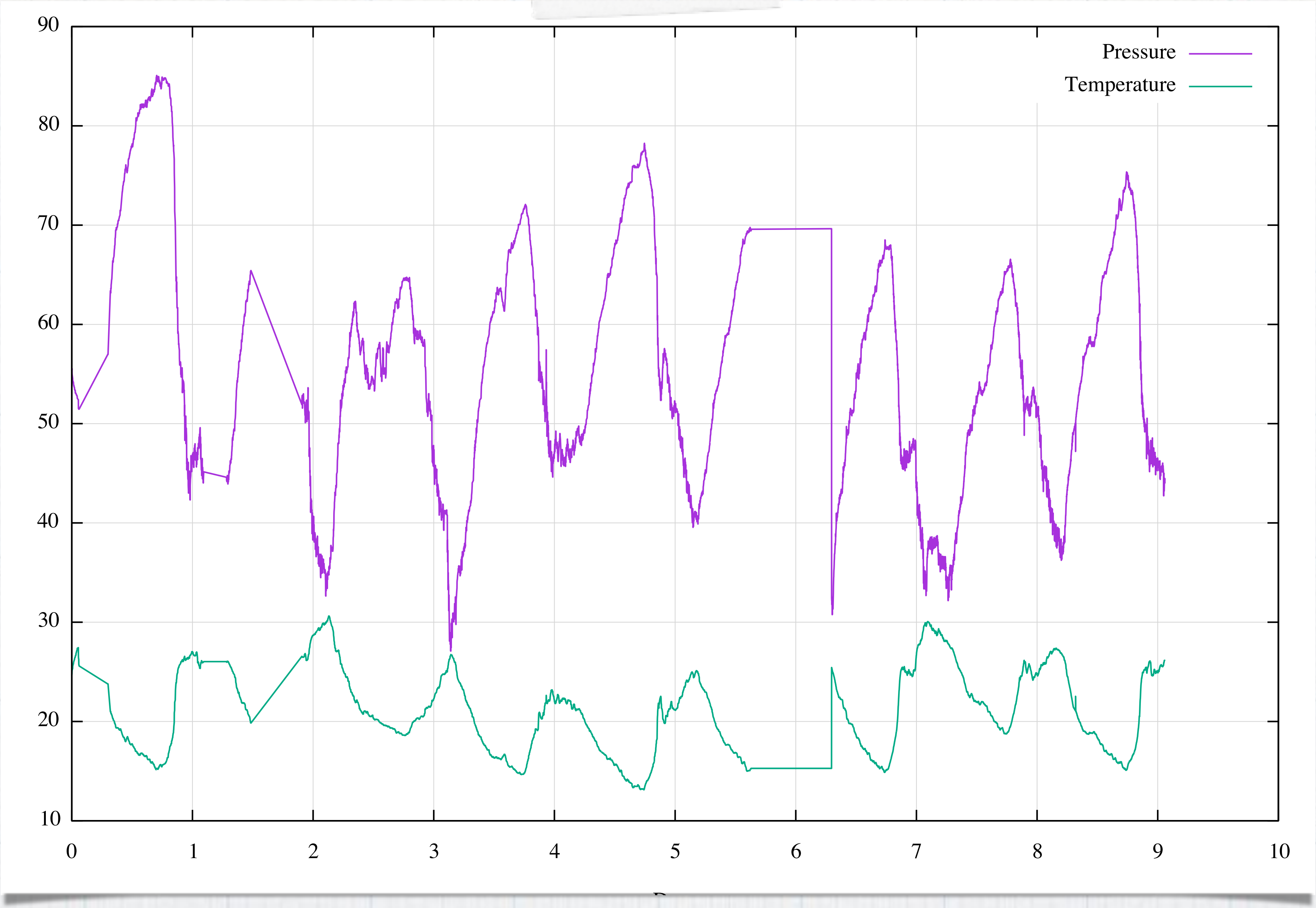
What to do with your data in the cloud?

- Data:
  capture - send - collect - now what???

- Convert "data" into "information"

- Convert "information" into "knowledge"

- Convert "knowledge" into "action"



Temporal data

Time series: evidence of some process going on

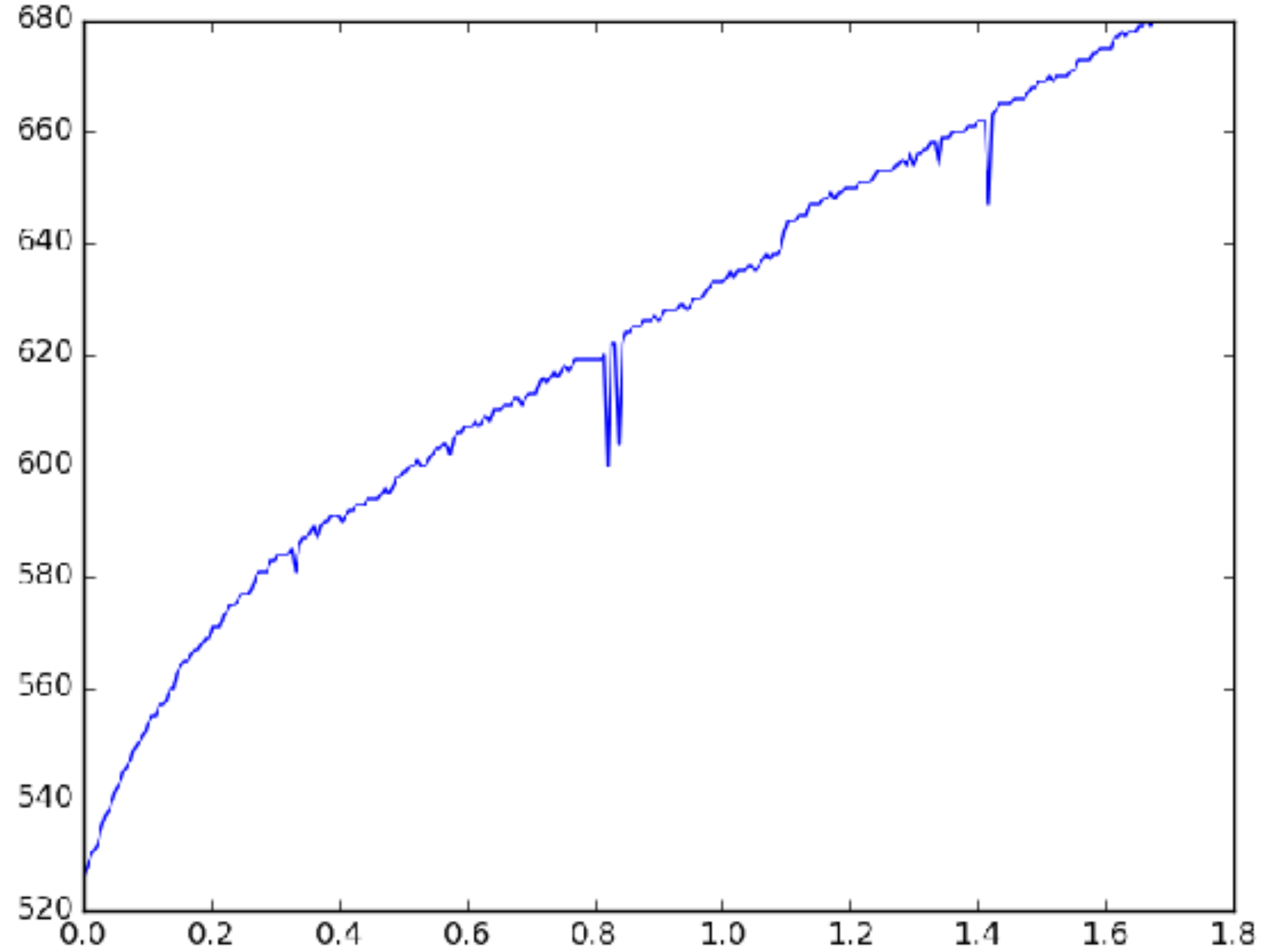
Usual task: prediction

What to do with time series?

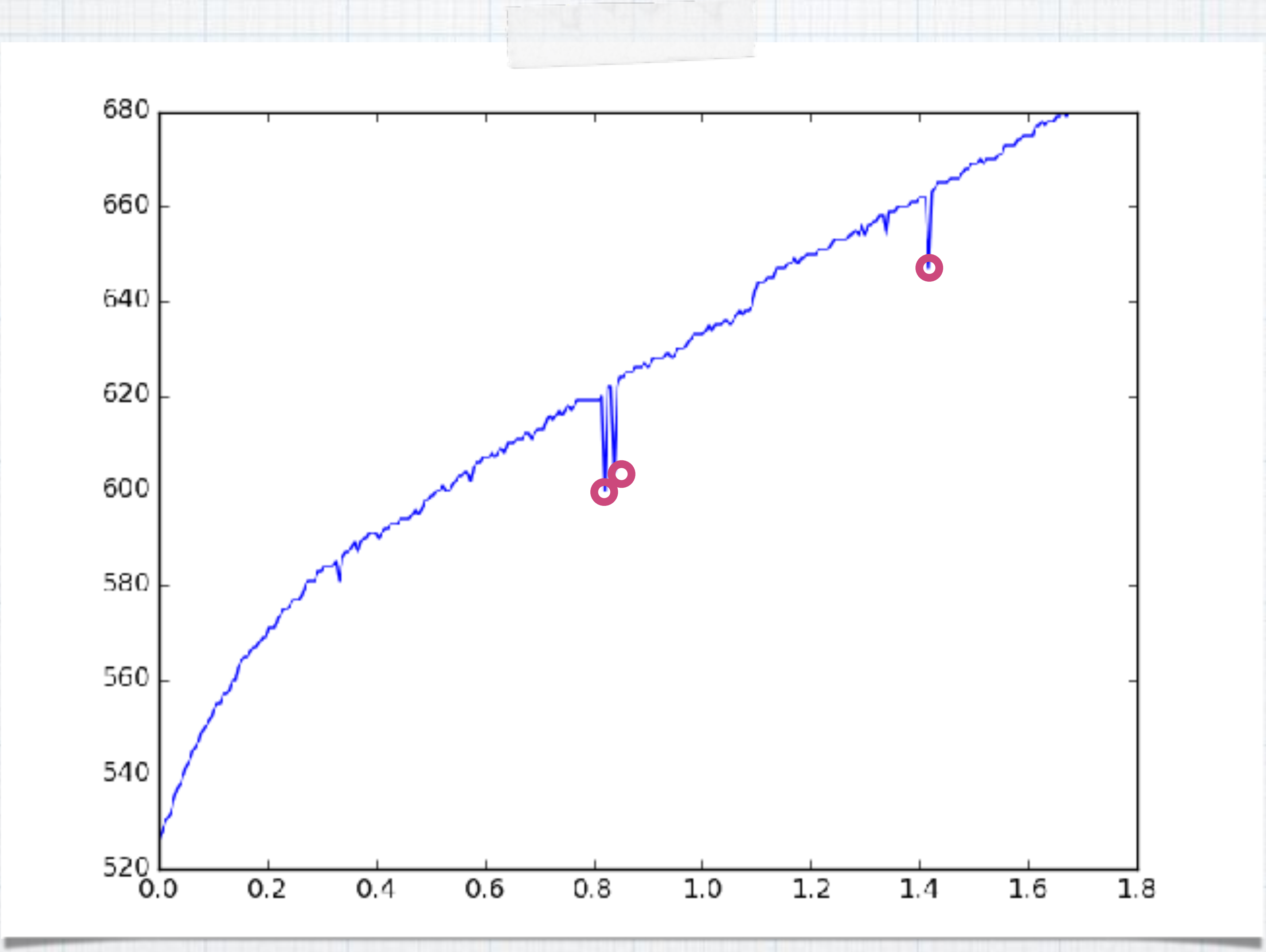
- Clean up the dirty data:
  noise
  outliers
  missing data

- Visualize it

- Predict the future



Data with outliers

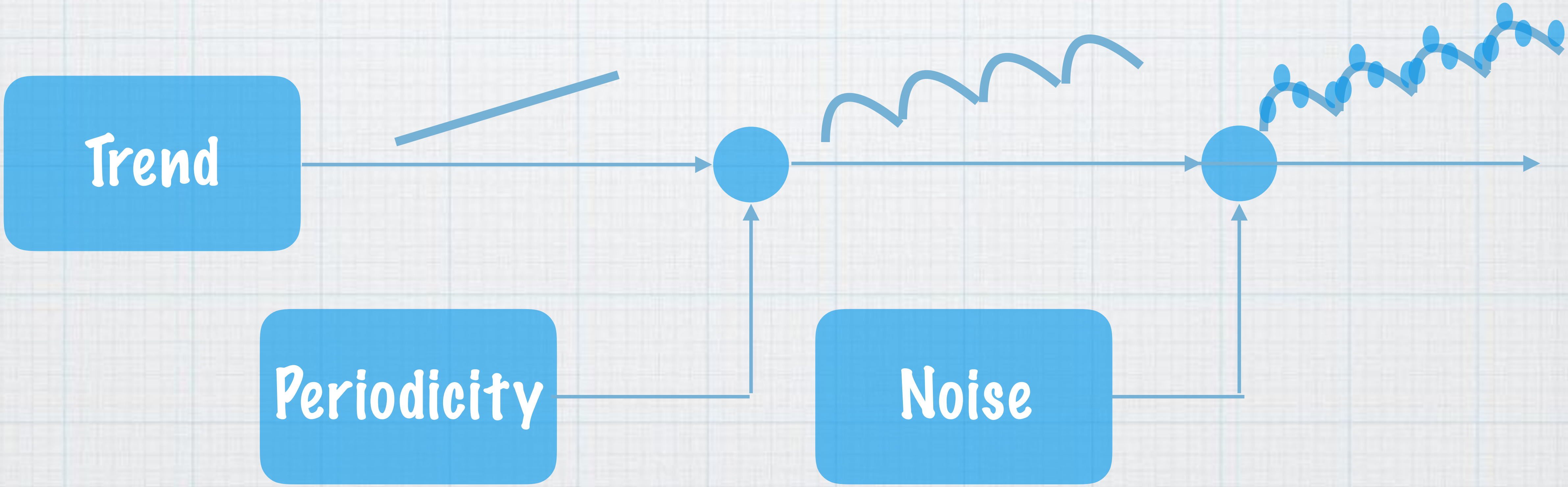


Data with outliers

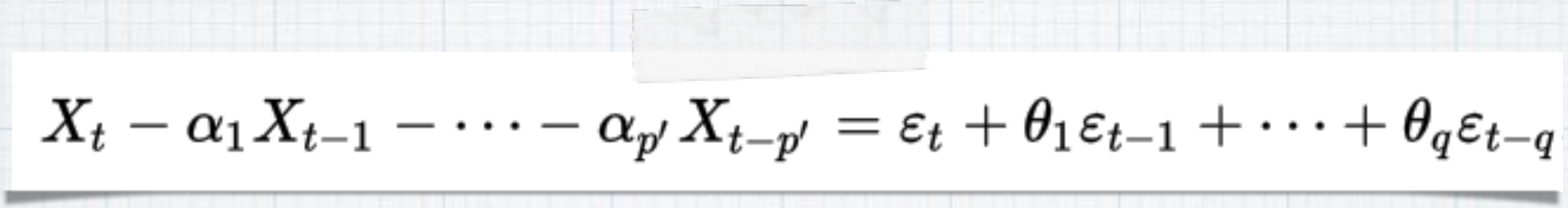
The spikes are not real data

Why can we predict?

- Data is generated by some process
- Usual assumption: deterministic + noise



ARIMA model

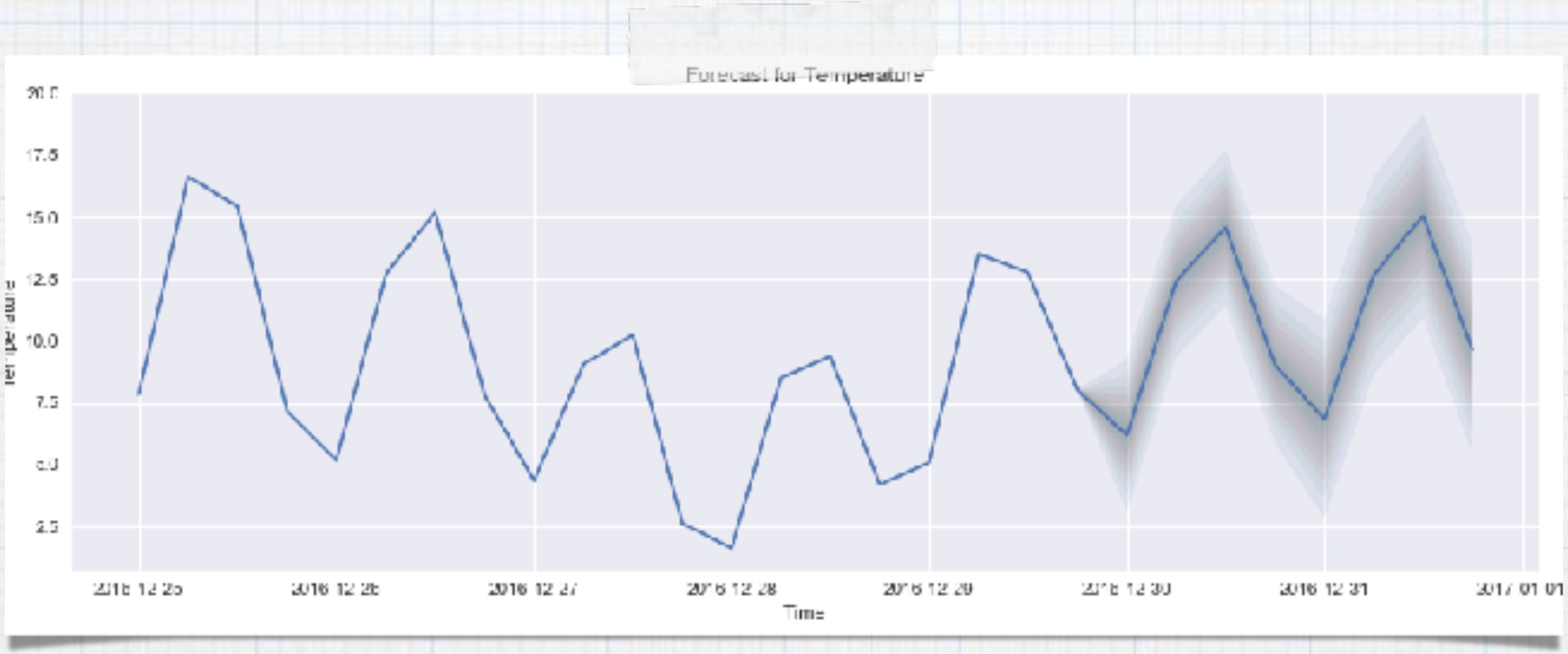


$$X_t - \alpha_1 X_{t-1} - \cdots - \alpha_{p'} X_{t-p'} = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}$$

- The measurement at time `t` depends on previous instances `t-1,t-2,…,t-p`
- It also depends on the “noise” at `t` and at `t-1,t-2,…,t-q`

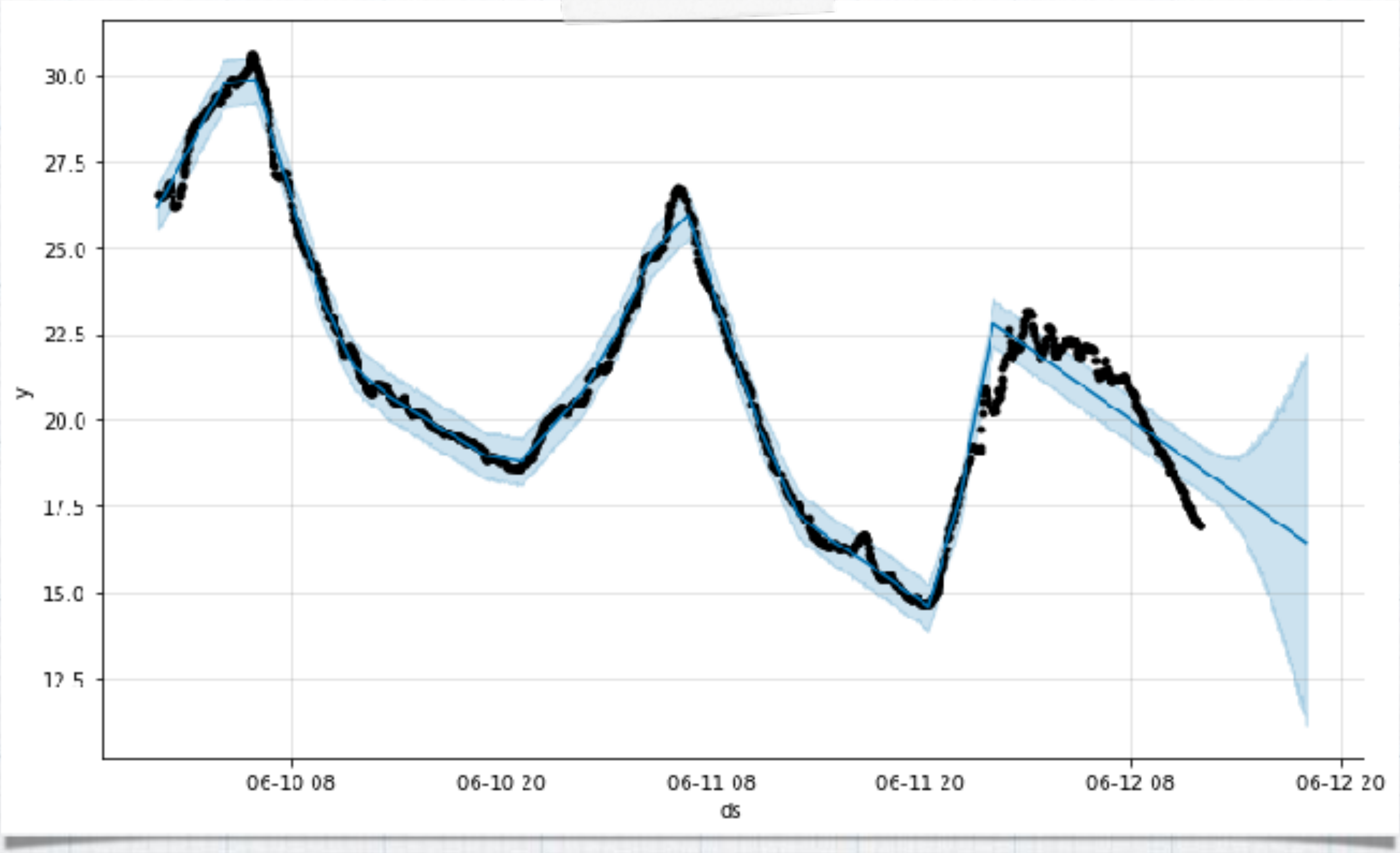
Time series in Python

- Numerics: numpy, scipy
- Plotting: matplotlib
- Time series: pandas
  http://pandas-docs.github.io/pandas-docs-travis/
- Prediction (statistical): pyflux
  http://www.pyflux.com
- Prediction (AI): FB Prophet
  https://arnesund.com/2017/02/26/using-facebook-prophet-forecasting-library-to-predict-the-weather/



ARIMA prediction

We get confidence intervals too...



AI prediction

Generalized model beyond periodicity and trend
(but not very good in this case...)

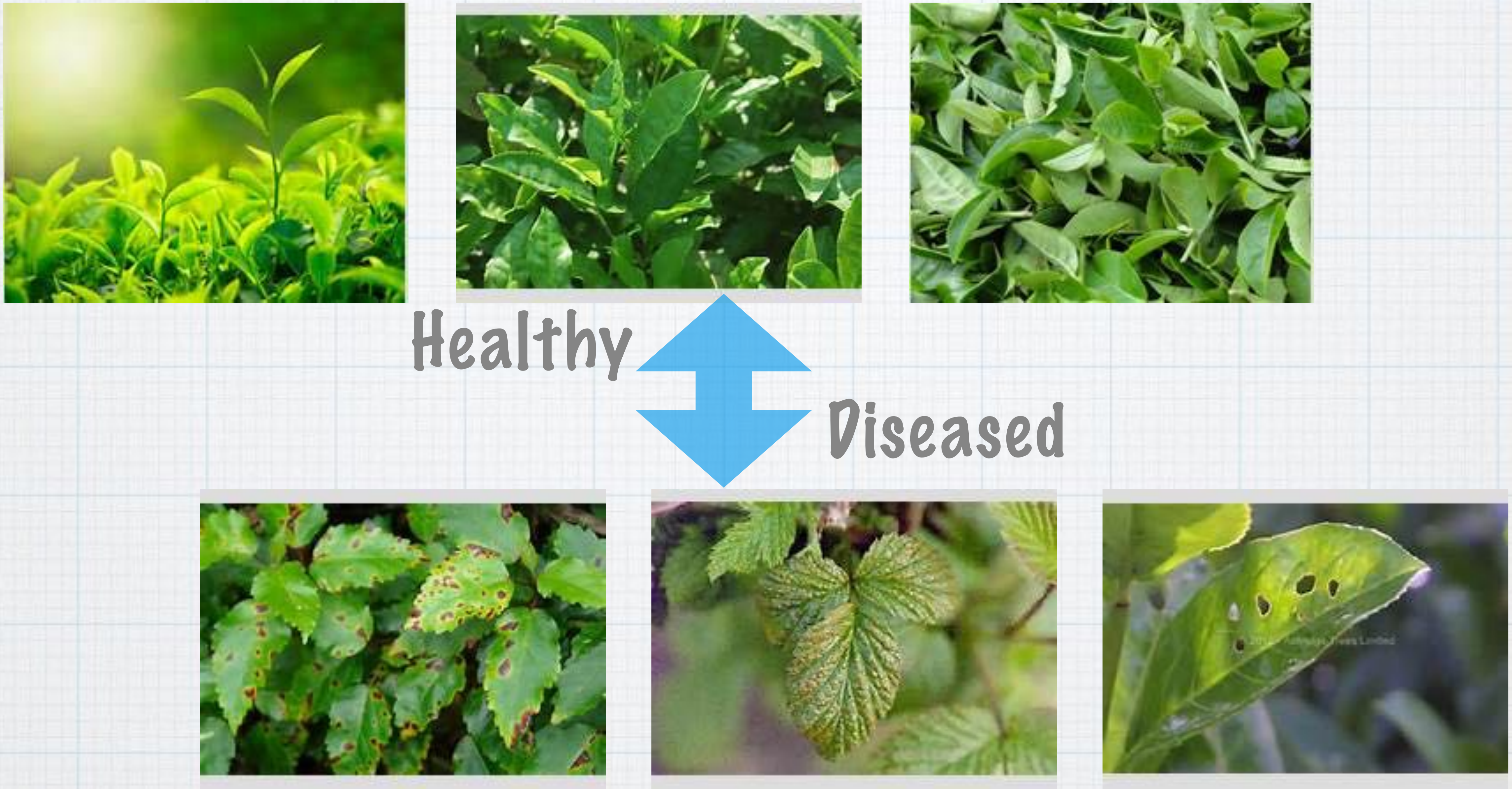


Image data

Photos, videos: evidence of some status

Usual task: classification

Images + Python + AI

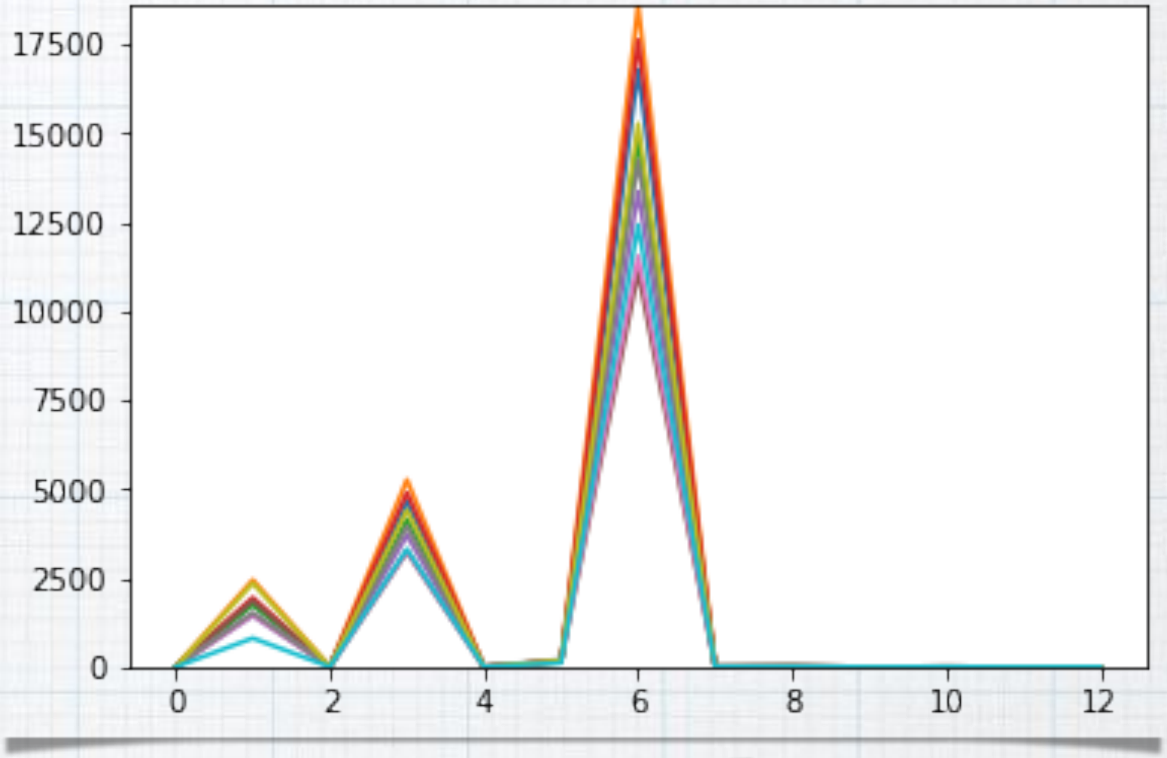
- Basics: OpenCV
- Image features: Mahotas
- Classification: milk

(or scikit-learn: http://scikit-learn.org/stable/)

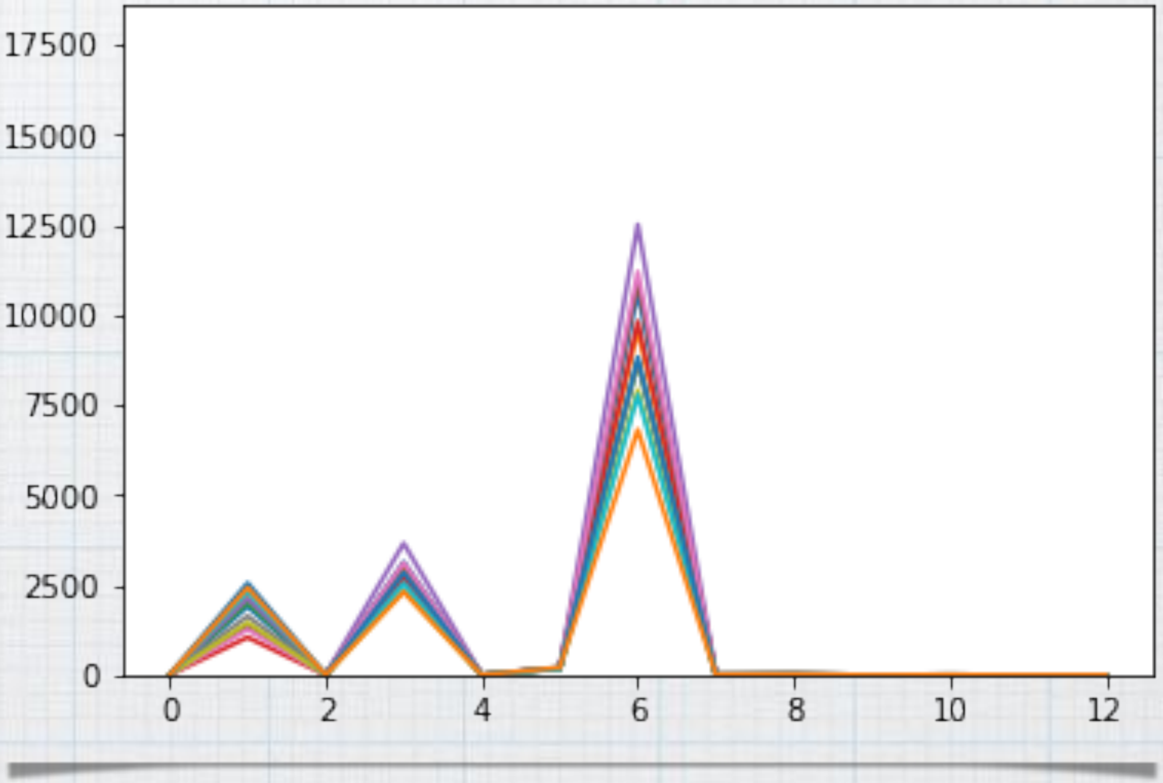
Simple AI for images

- Generate numerical feature vectors
- Select part of the images as a training set:
  N_p positive samples
  N_n negative samples
- Train a classifier with the training set
- Test it with the rest of the data

negatives

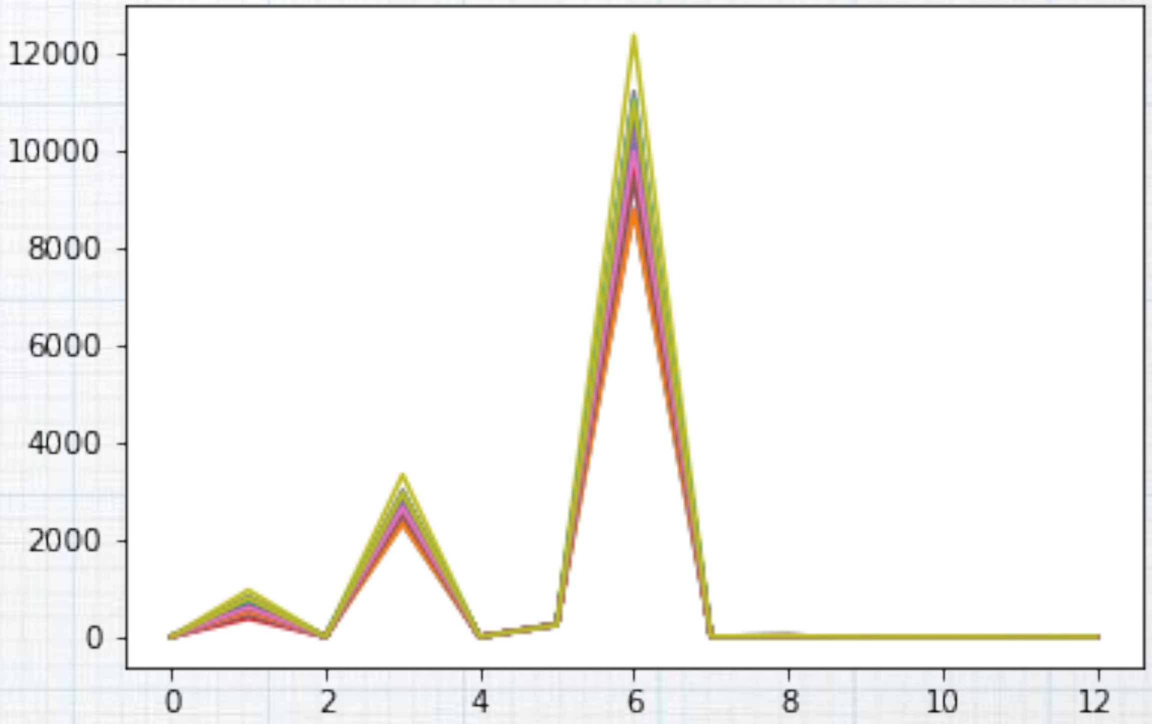


Features

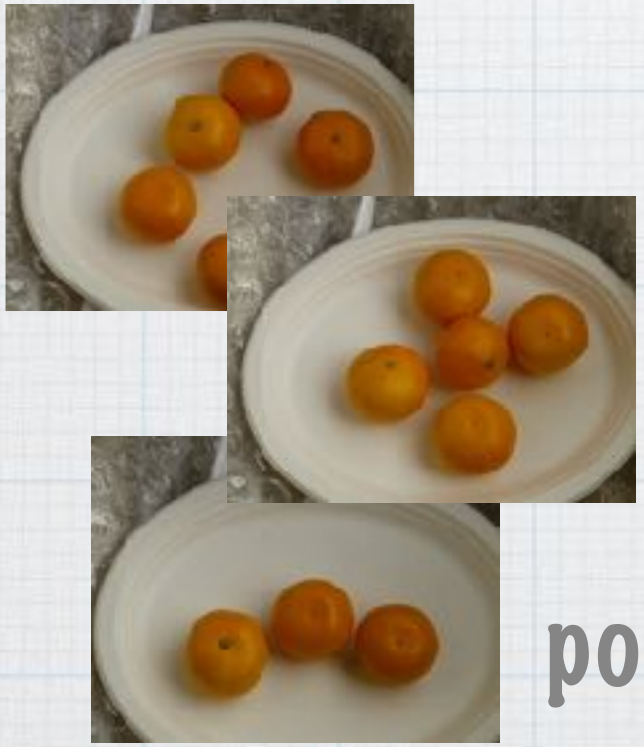


positives

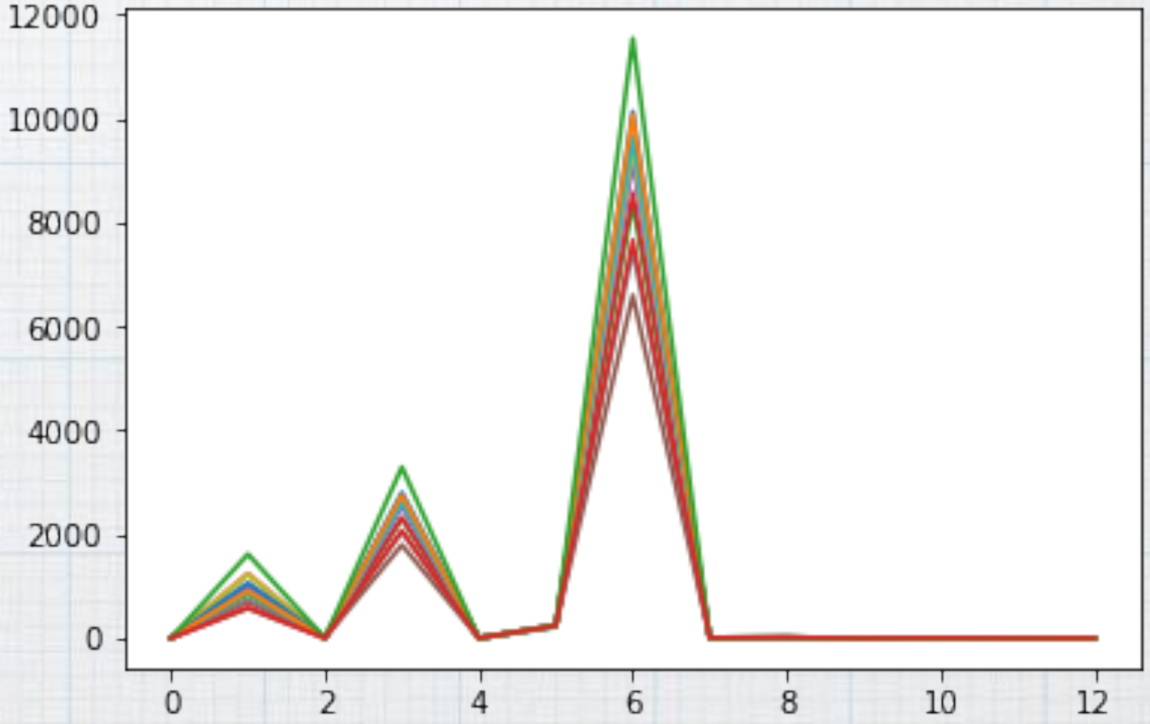
negatives



Features

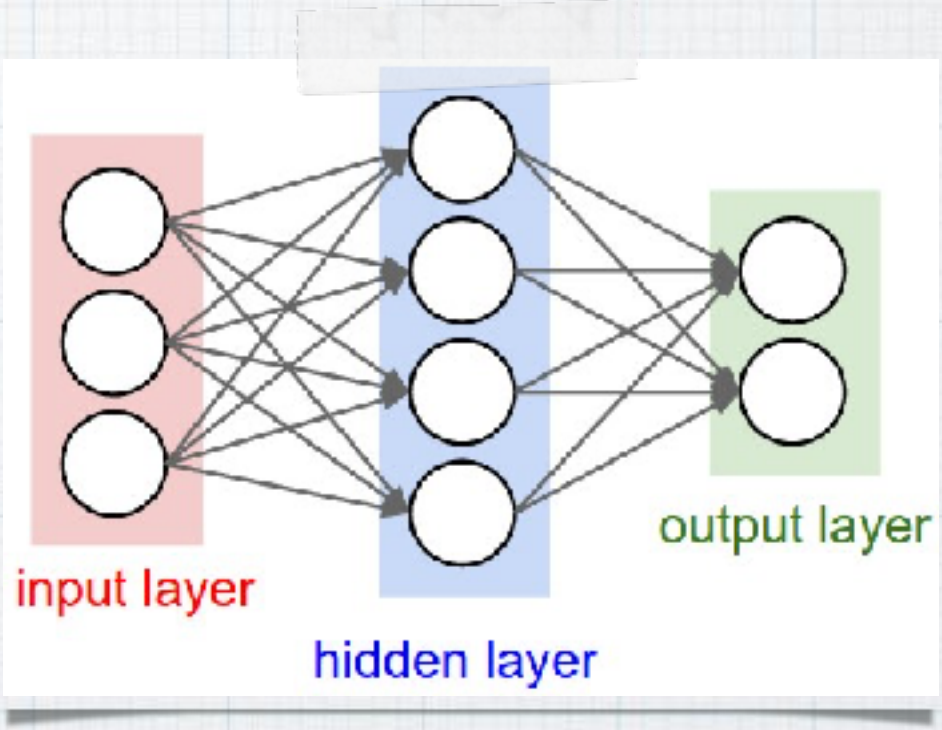


positives



Neural network

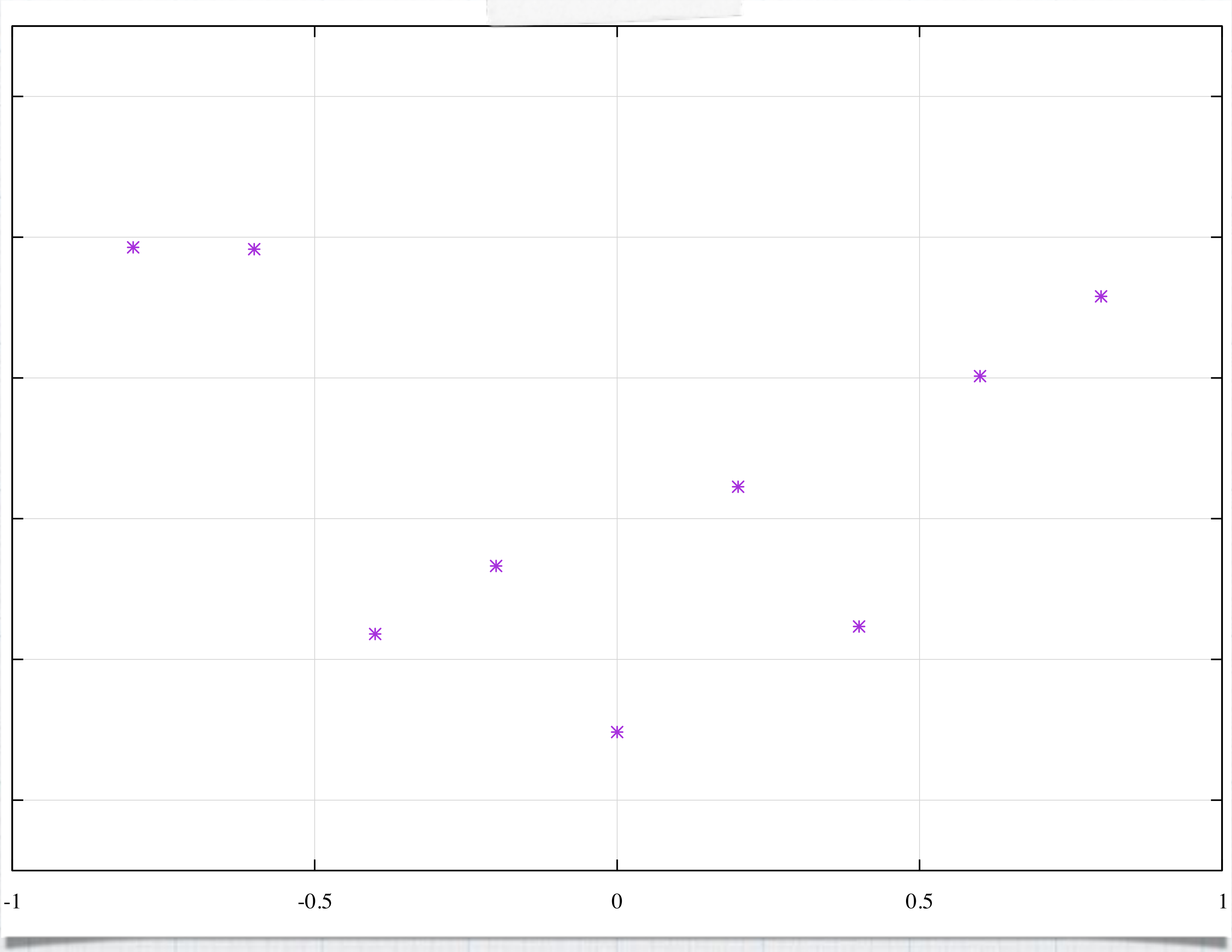
- Feed features to input layer
- Calculate hidden and output layer activations through connection weights
- Compare output with known correct output
- Adjust weights until output becomes correct for all input samples



Classification

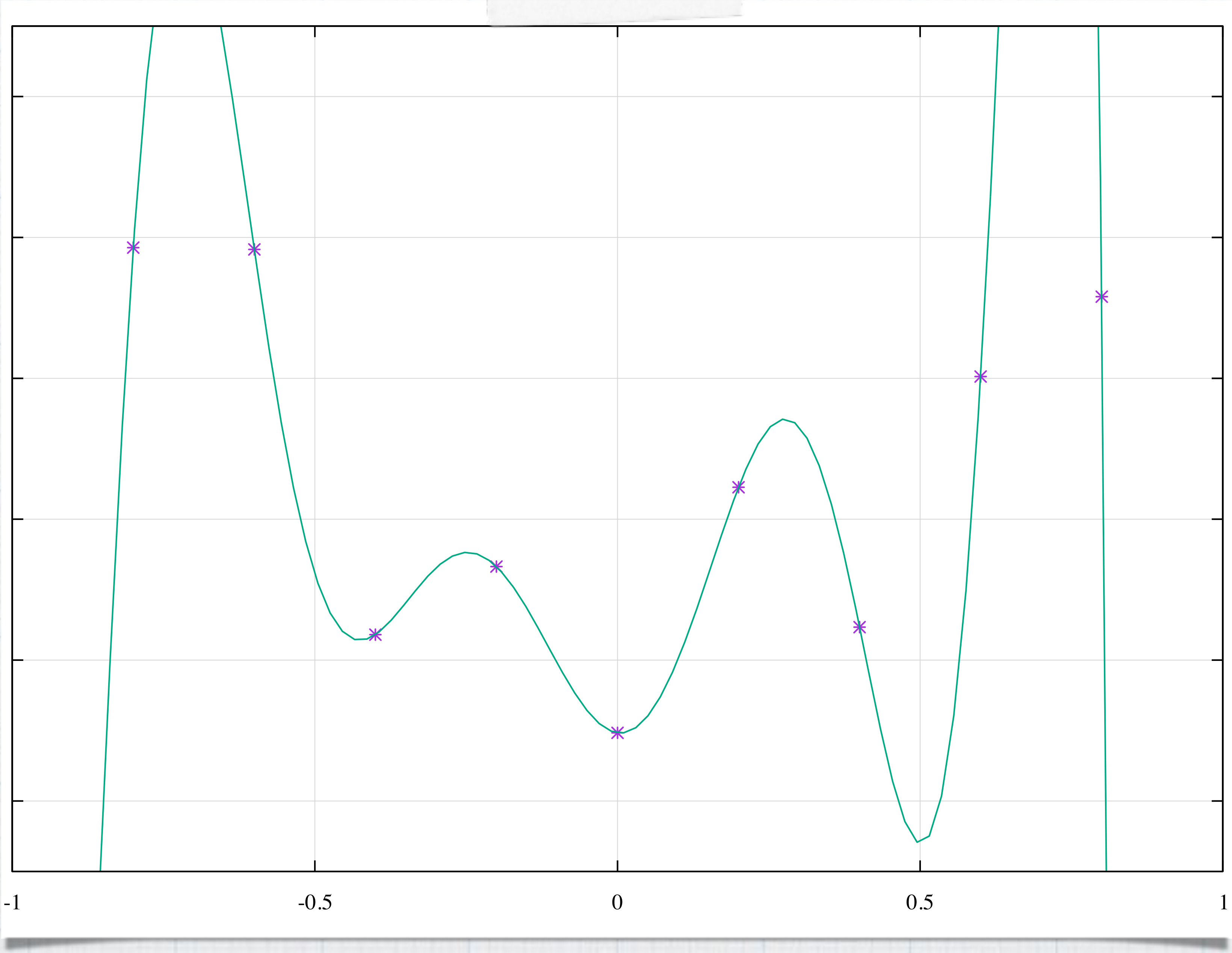
- After training, the neural network classifies correctly the training samples
- Hopefully it will also correctly classify unknown data
- Some common problems (and many others...):
  - overfitting (can classify only the training set)
  - poor flexibility (too simple for the task)
- Illustration: with curve fitting

Training data



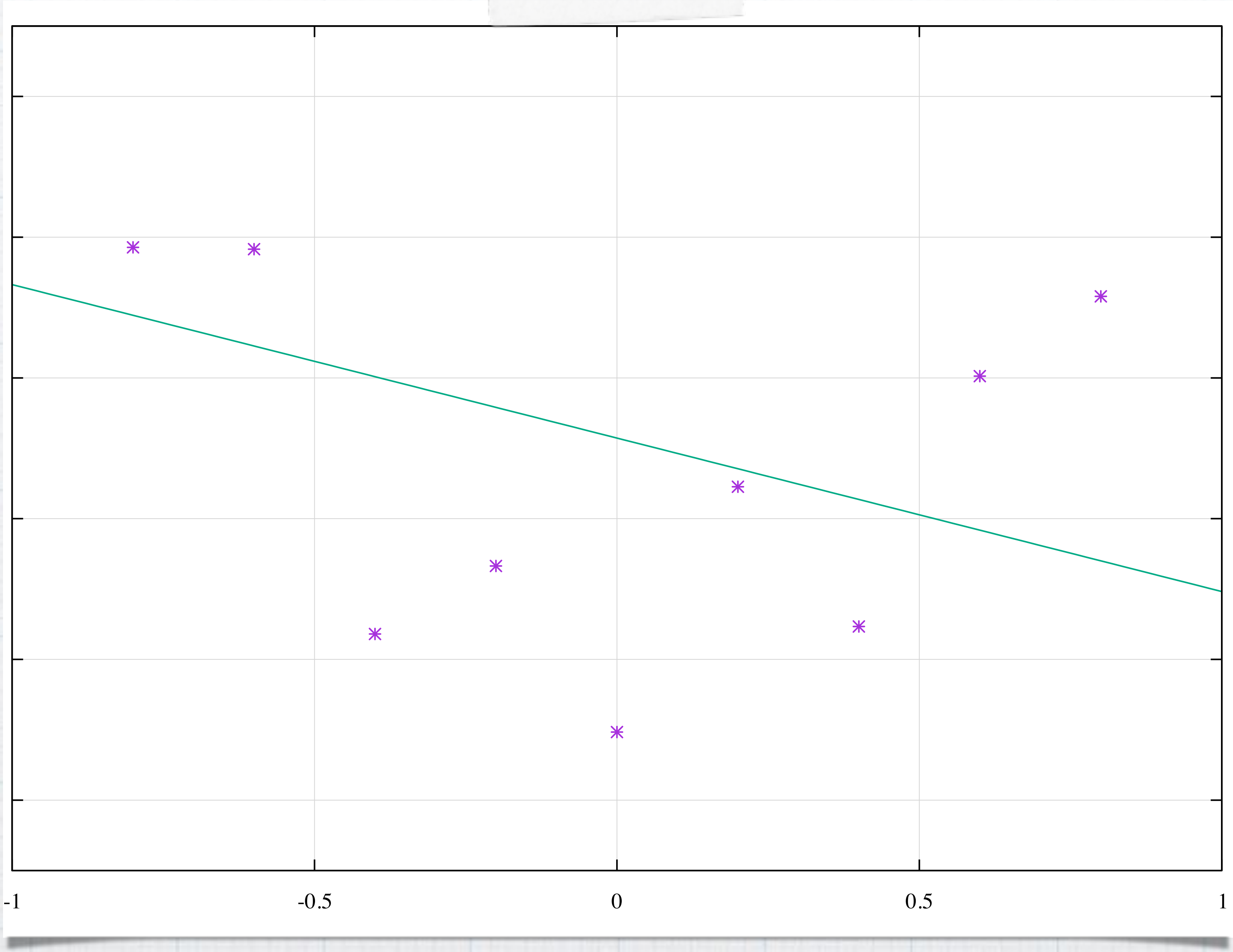
Find a good match for the points

Overfitting



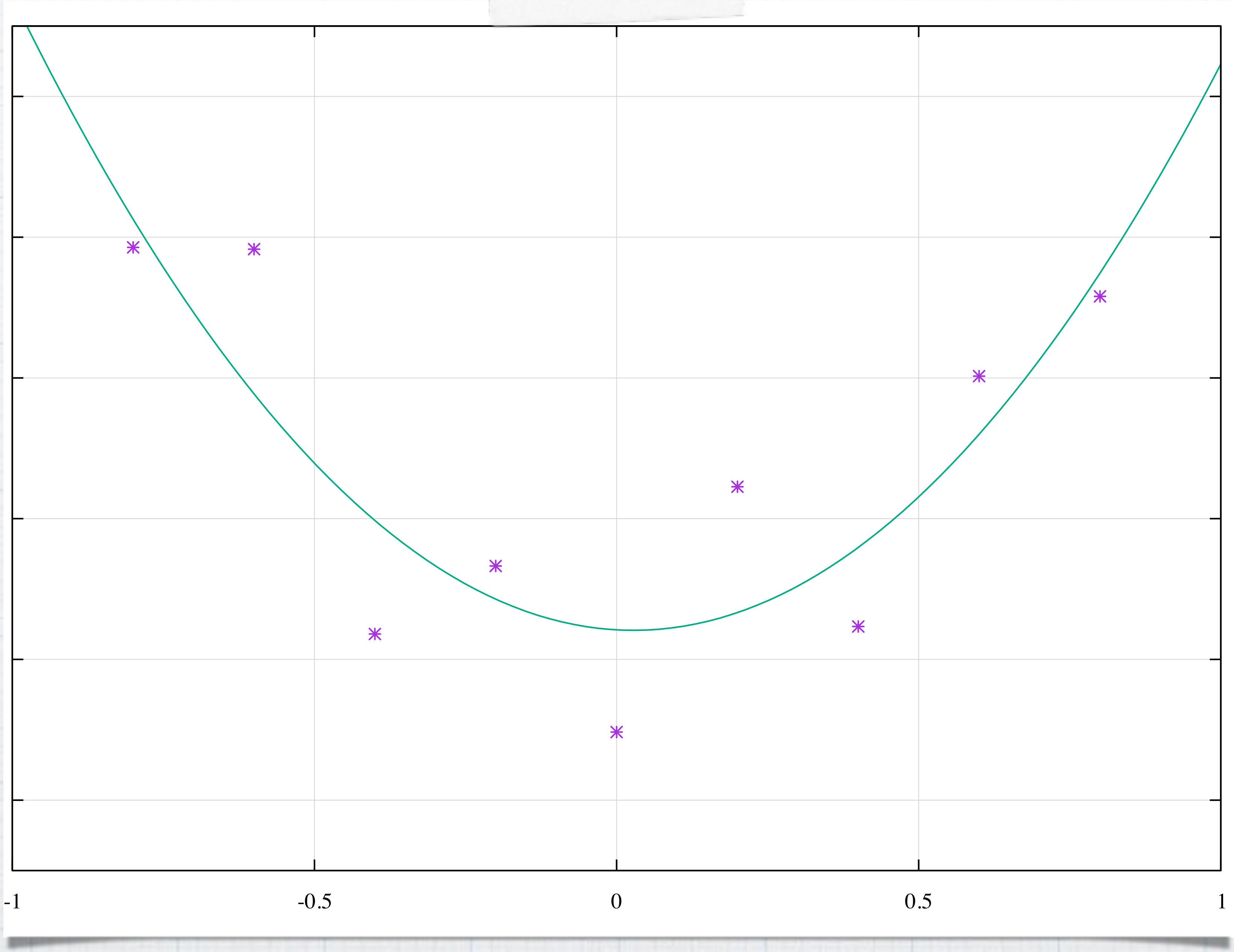
Too generic function: cannot find the hidden rule

Underpowered



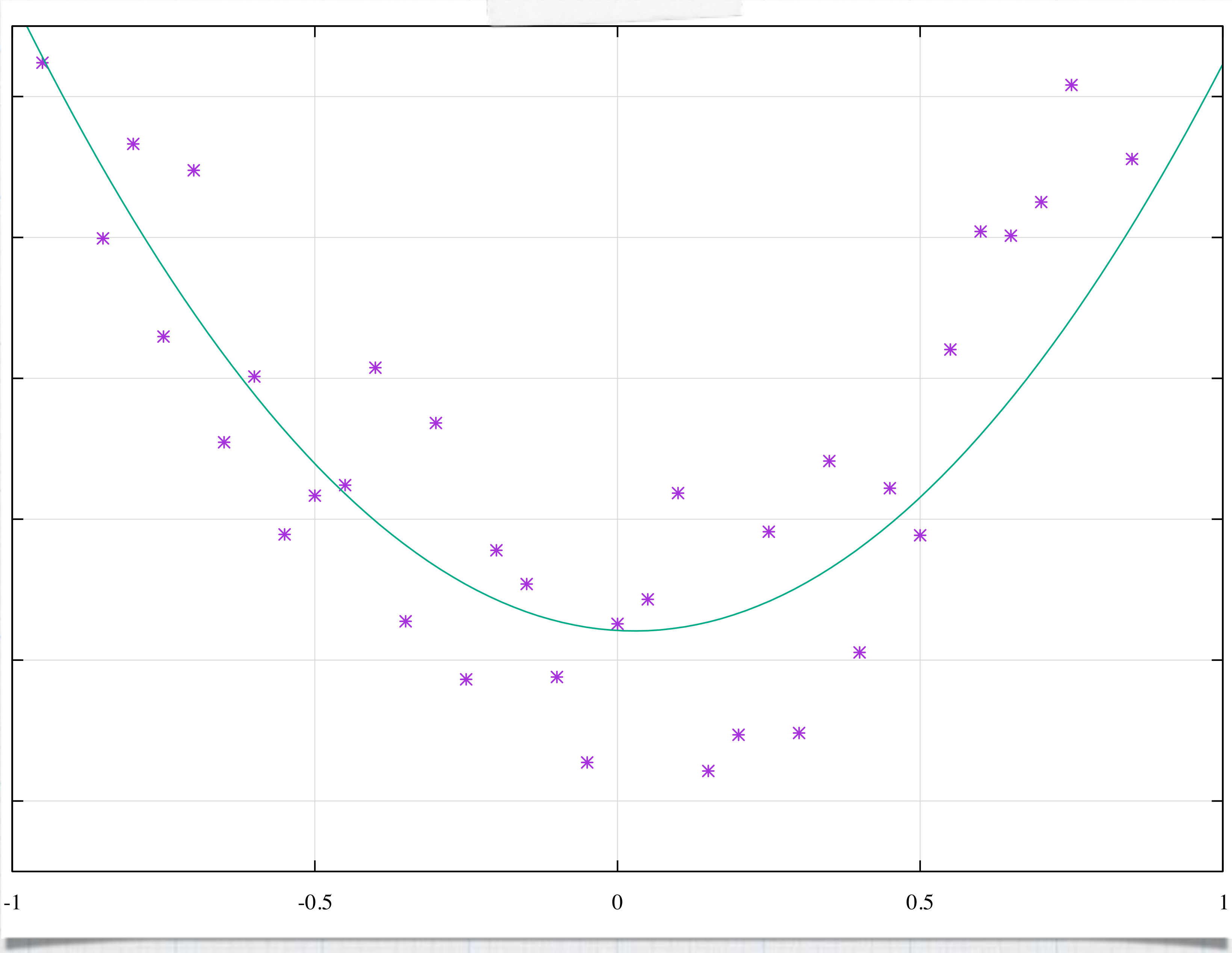
Too simple function: cannot follow the data

Best fit



2nd order polynomial matches the hidden rule

Best fit, new data



A good fit will match the new data too

Some hints for neural networks

- Prepare **LOTS** of data!
- Choose the right network topology (multi-layer, feed-forward; recurrent; etc.)
- Choose the right complexity
- Use regularization to fight over-fitting
- Try self-organizing feature processing