Time Series Analysis

02/2017

Machine
Learning
College

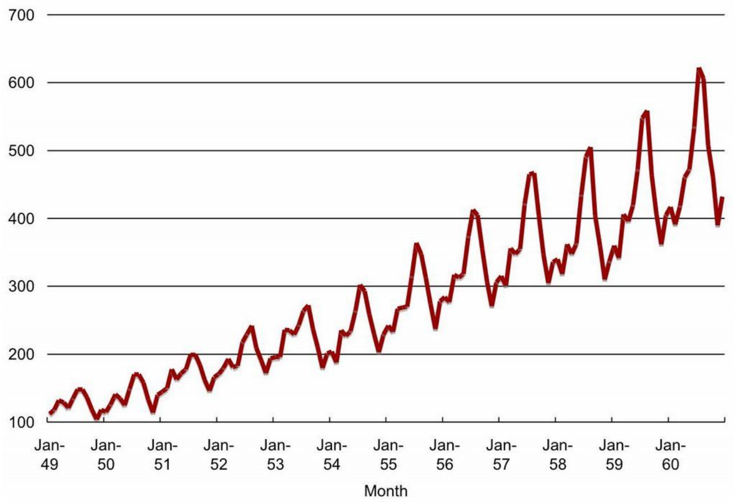
About me

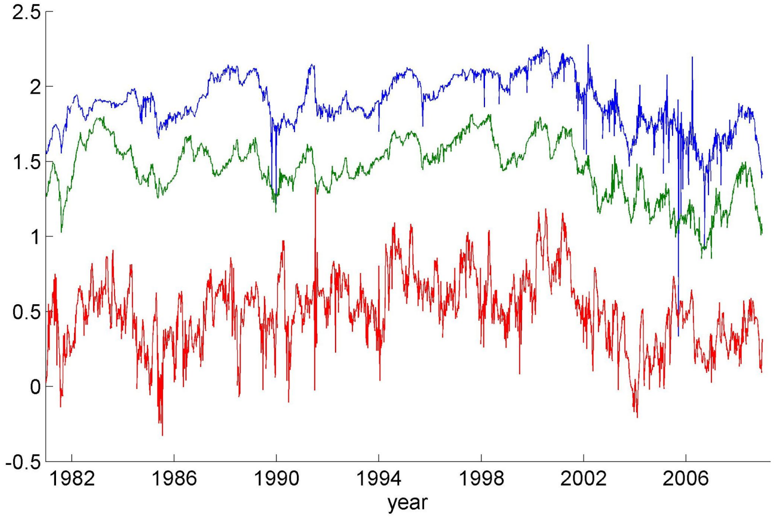
- Ph.D. In computer science at VŠB-TU Ostrava
  - Neural networks & unsupervised self-organization
- Experienced in simulations
  - flood prediction system for MSK
  - traffic monitoring & prediction systems
- Experienced in computer graphics & scientific visualization
  - GIS related realtime 3D visualizations
- 5 years in applied ML and artificial intelligence
  - Lead researcher in GoodAI - general artifical intelligence
  - CTO in NeuronSoudware - sound processing with ML
  - Lead ML in CEAI - natural language processing

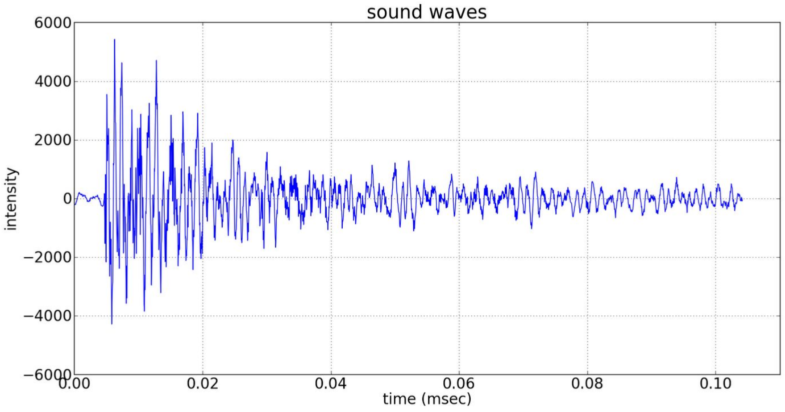
Outline

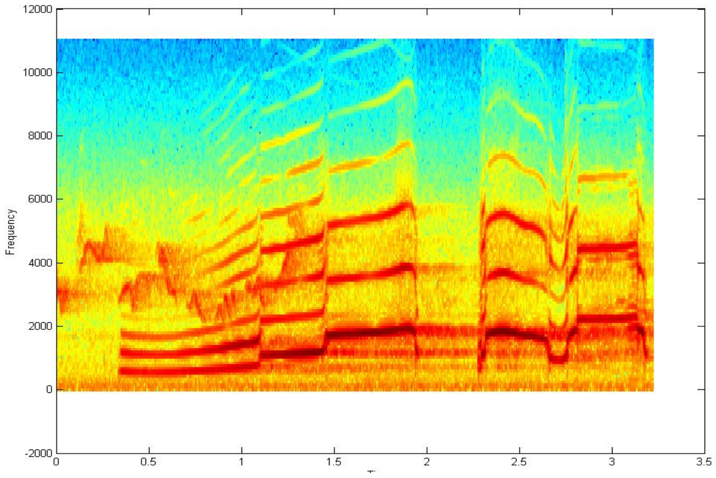
- Time series intro
  - Examples, tasks
- Classical analysis
  - Stationarity, decomposition, ARIMA
- Stochastic model example
  - Hidden Markov Model
- Neural networks
  - Feed-forward networks & backpropagation
  - Recurrent networks, unfolding, BPTT, LSTMs
- Task-related data preparation
  - Normalization, supervised or unsupervised task
- Practical Examples
  - Recurrent networks test
  - Simulated rainfall-runoff model prediction
  - Trampoline jump classifier
  - Weather forecast

Time series - examples

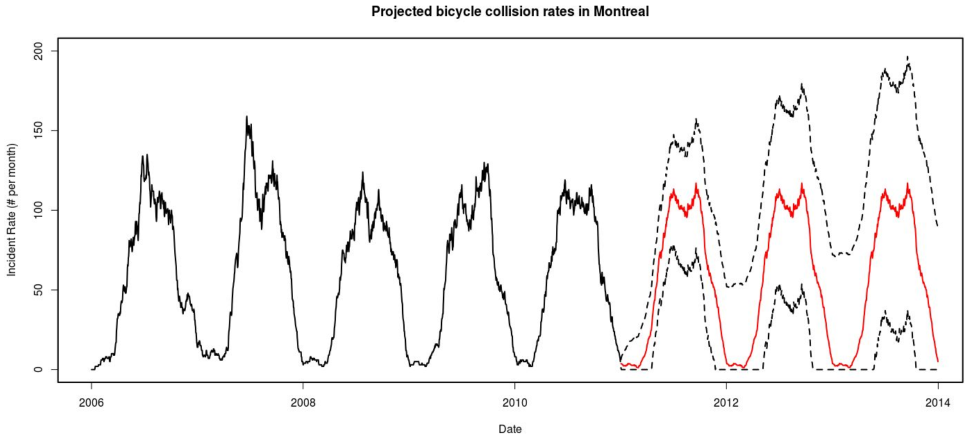


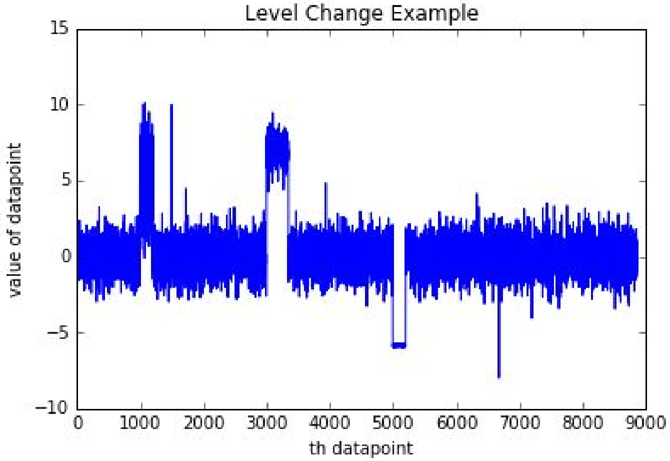


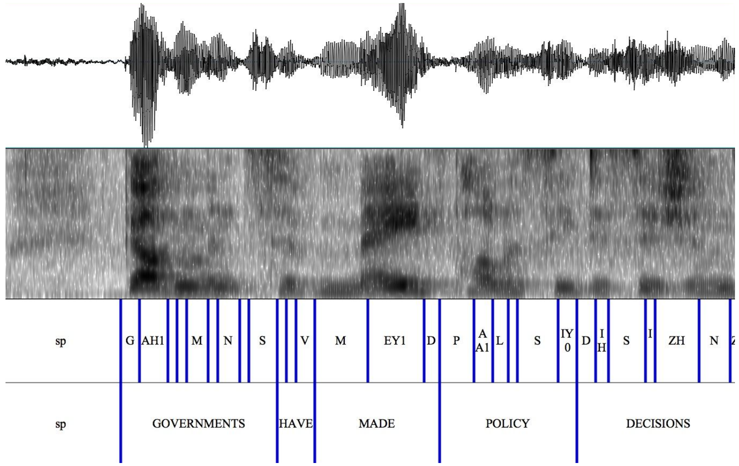


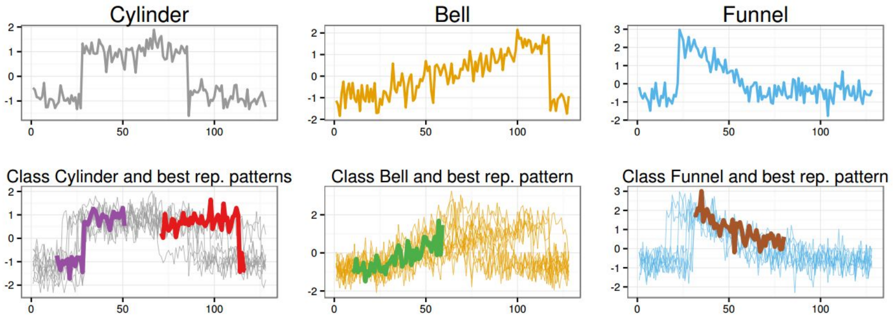


Time series - tasks

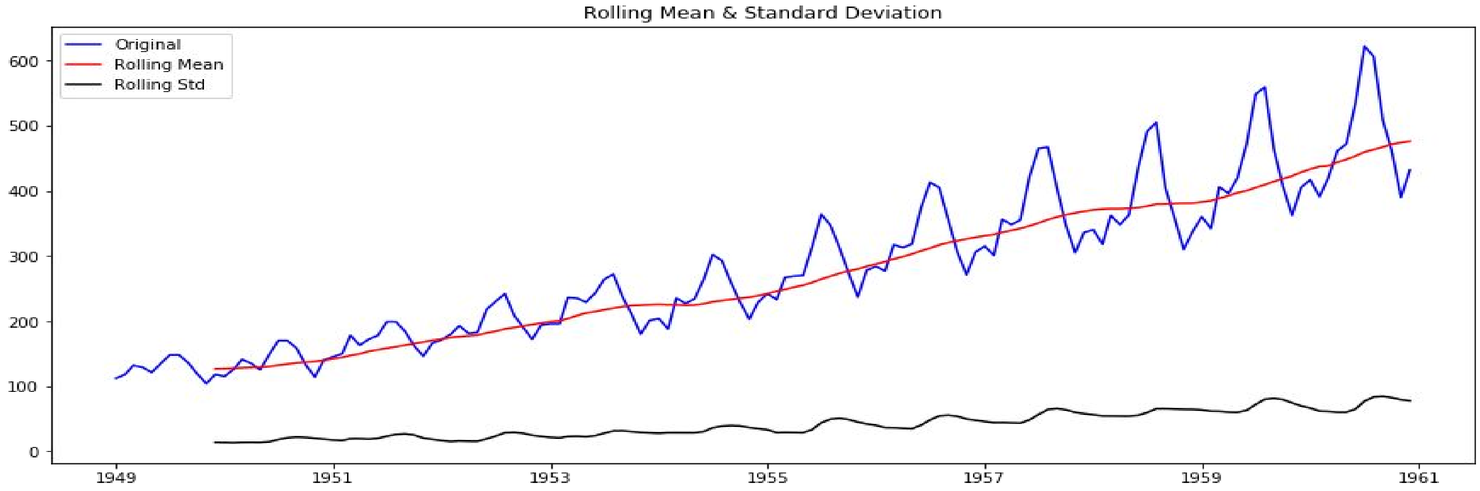


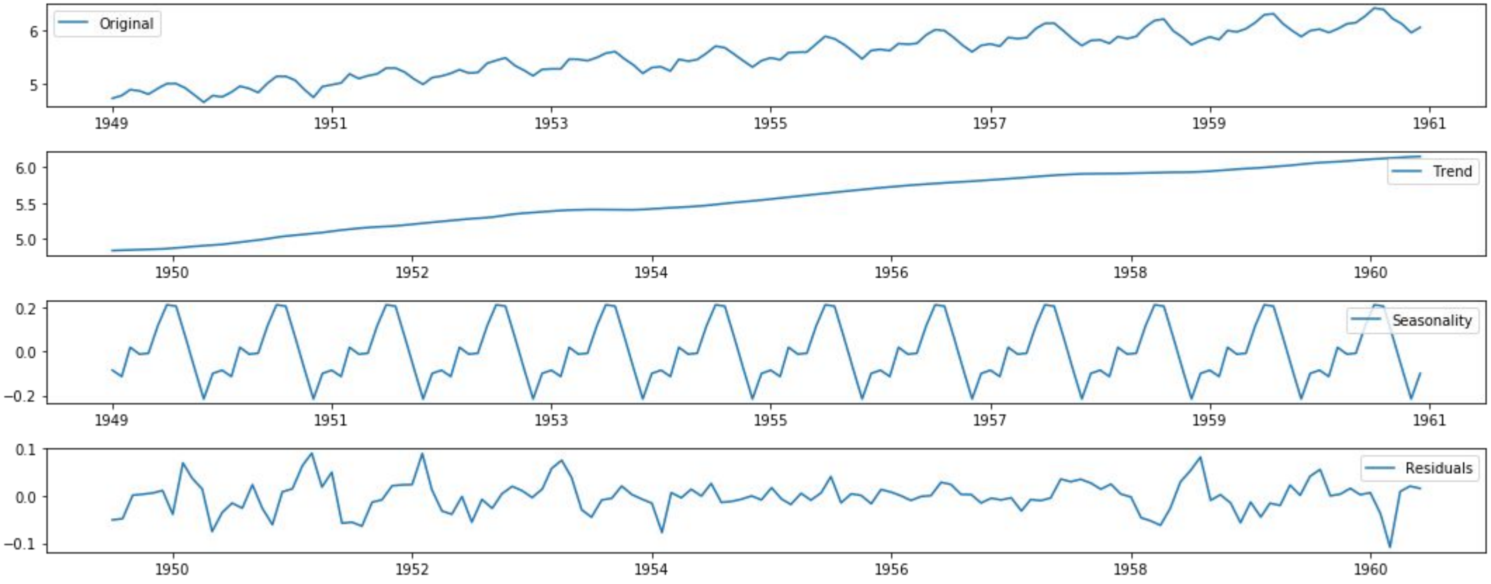




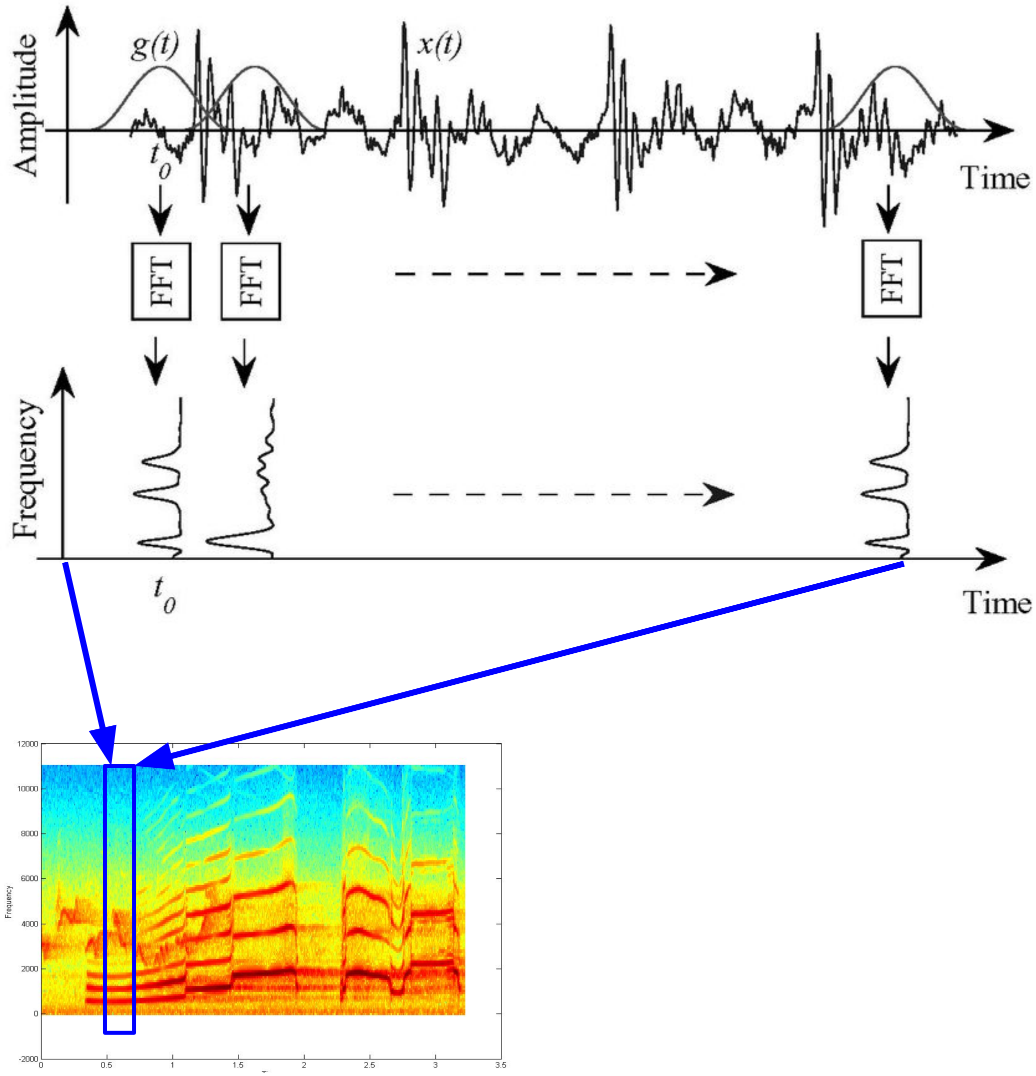


Time series - decomposition

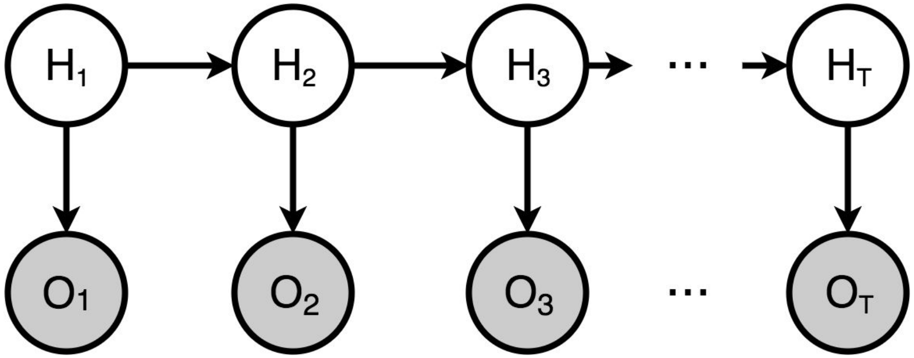


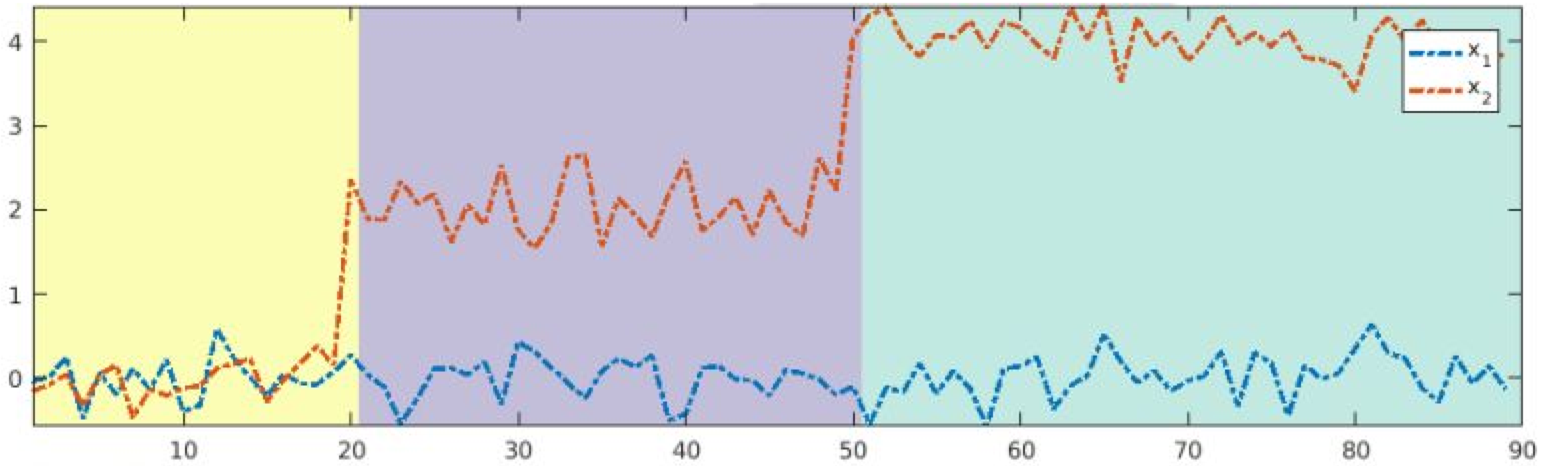


Time series - Short-time Fourier Transform

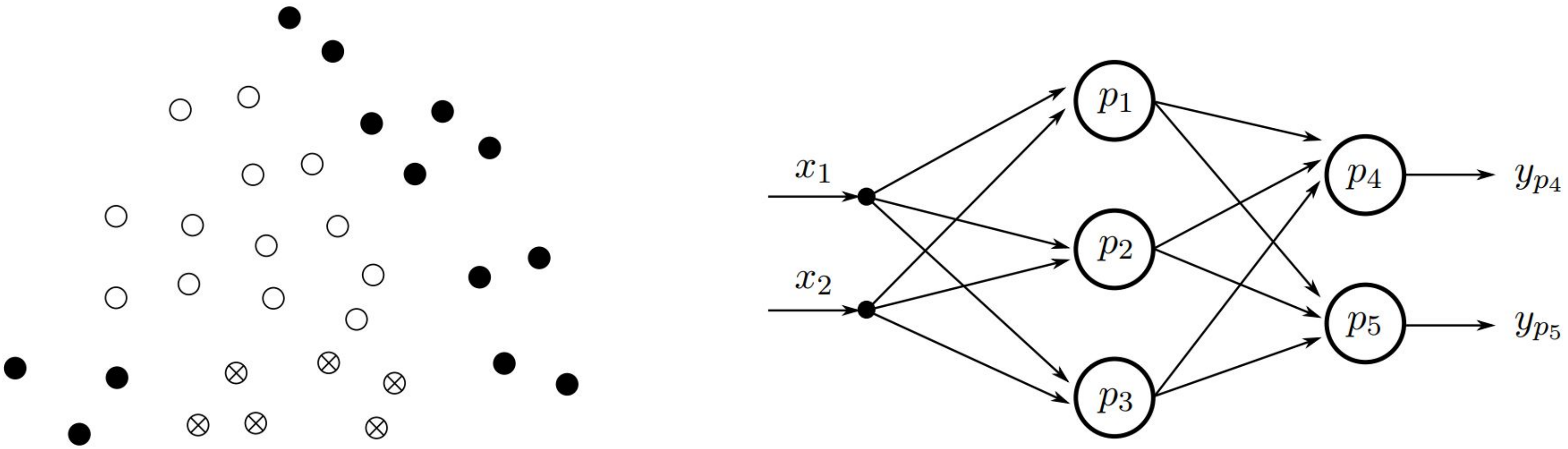


Hidden Markov Model





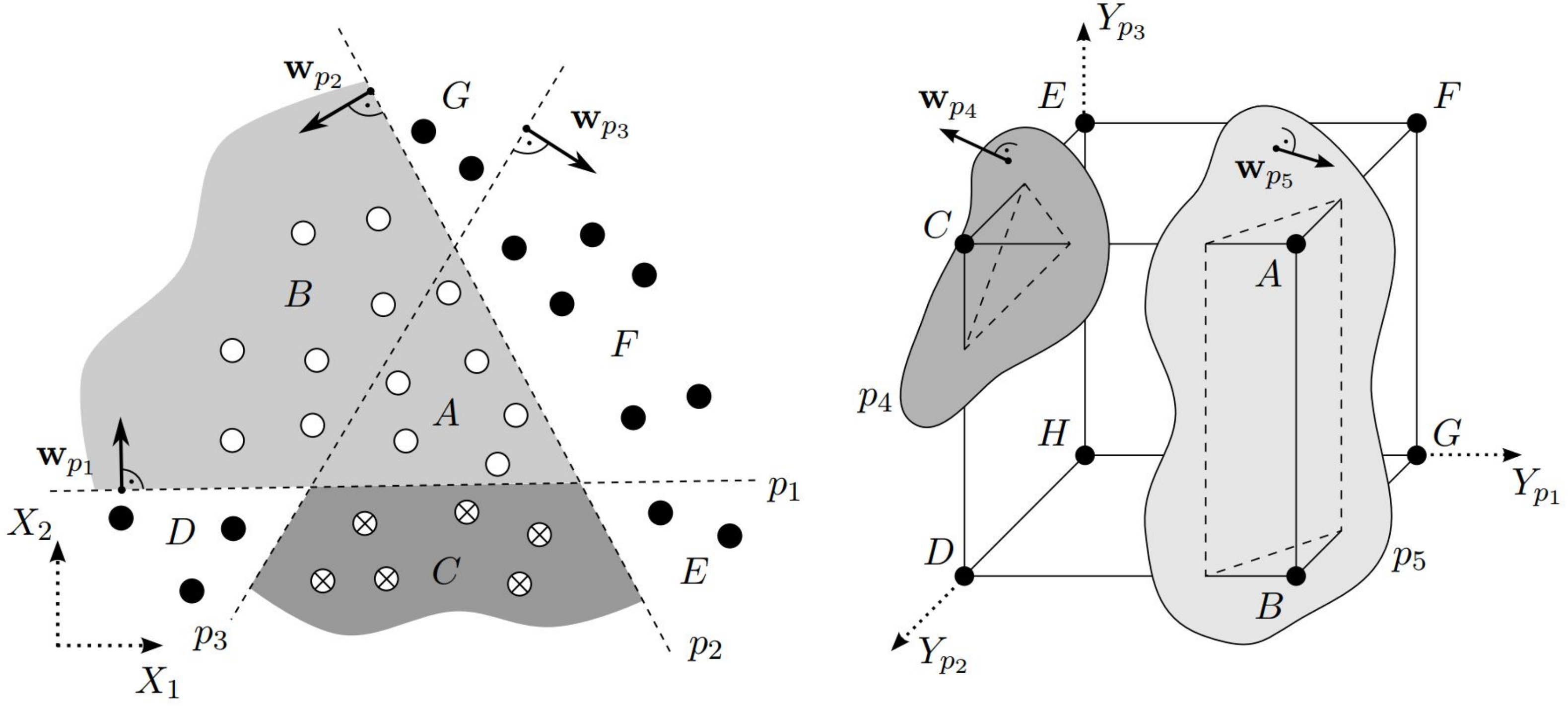
Neural networks



(a) Input set

(b) Example network

NN - Classification example



(a) Input space of first layer

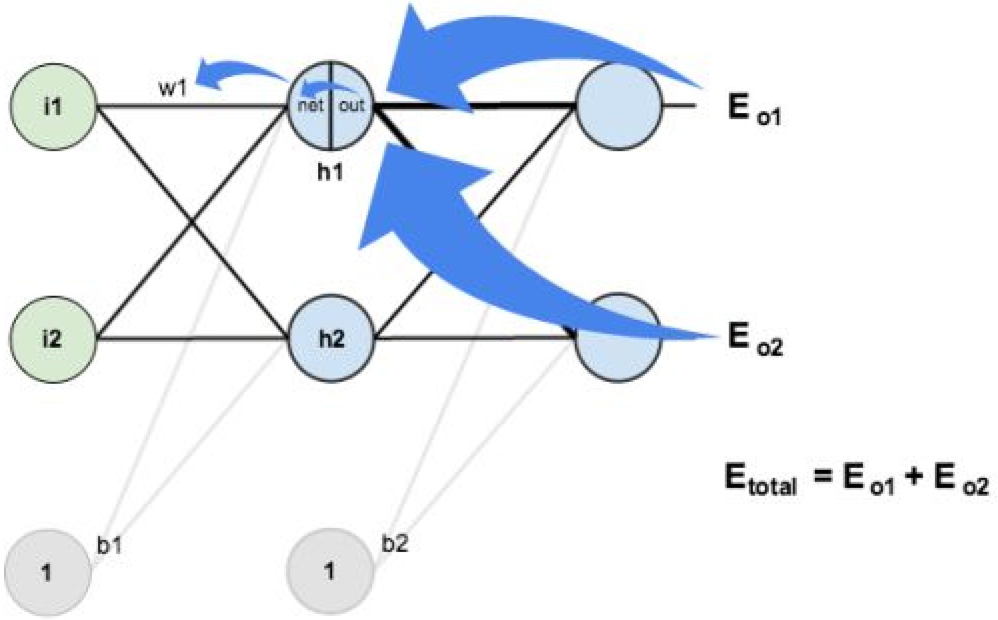
(b) Input space of second layer

NN - Backpropagation

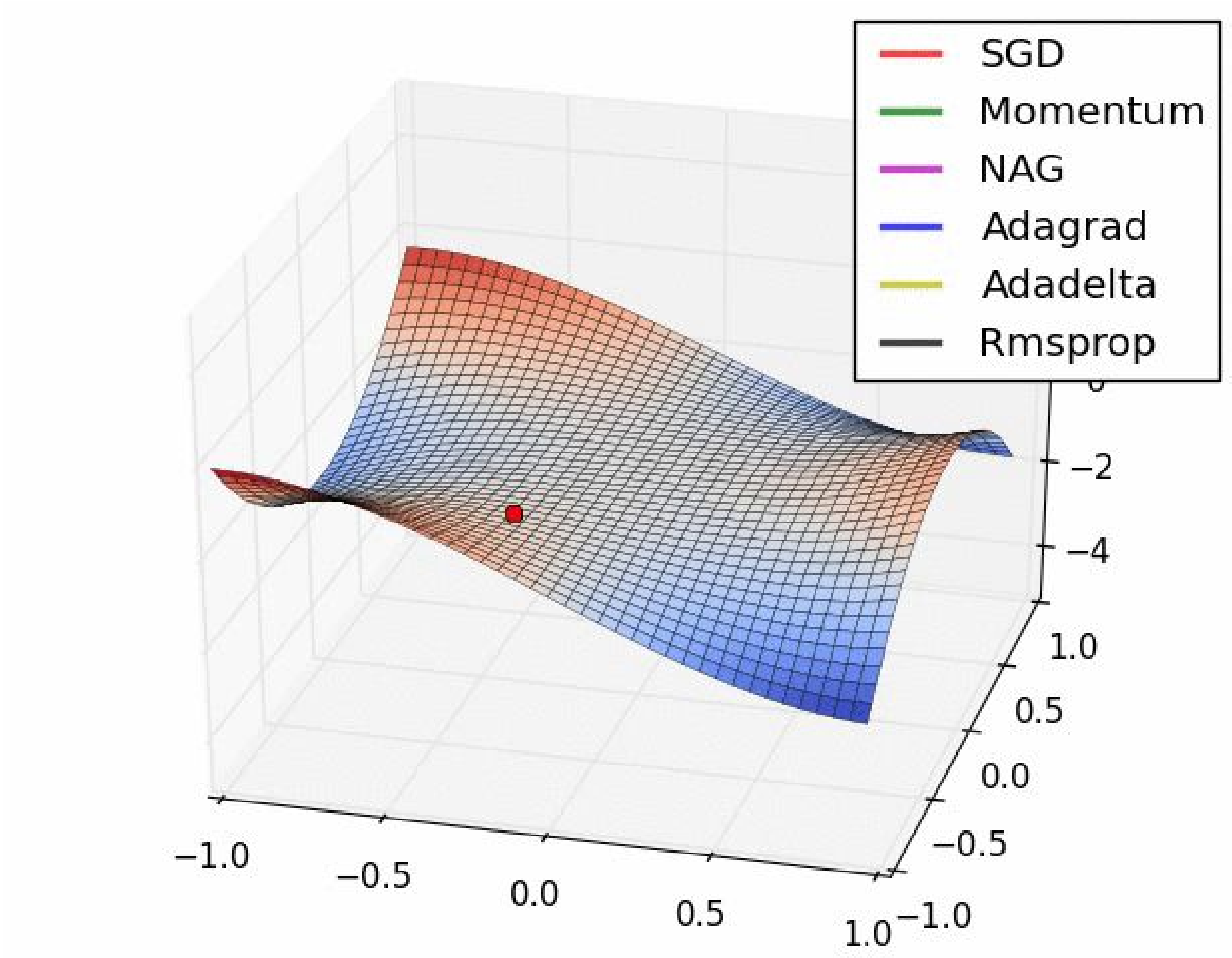
$$\frac{\partial E_{total}}{\partial w_1} = \frac{\partial E_{total}}{\partial out_{h1}} * \frac{\partial out_{h1}}{\partial net_{h1}} * \frac{\partial net_{h1}}{\partial w_1}$$

$$\downarrow$$

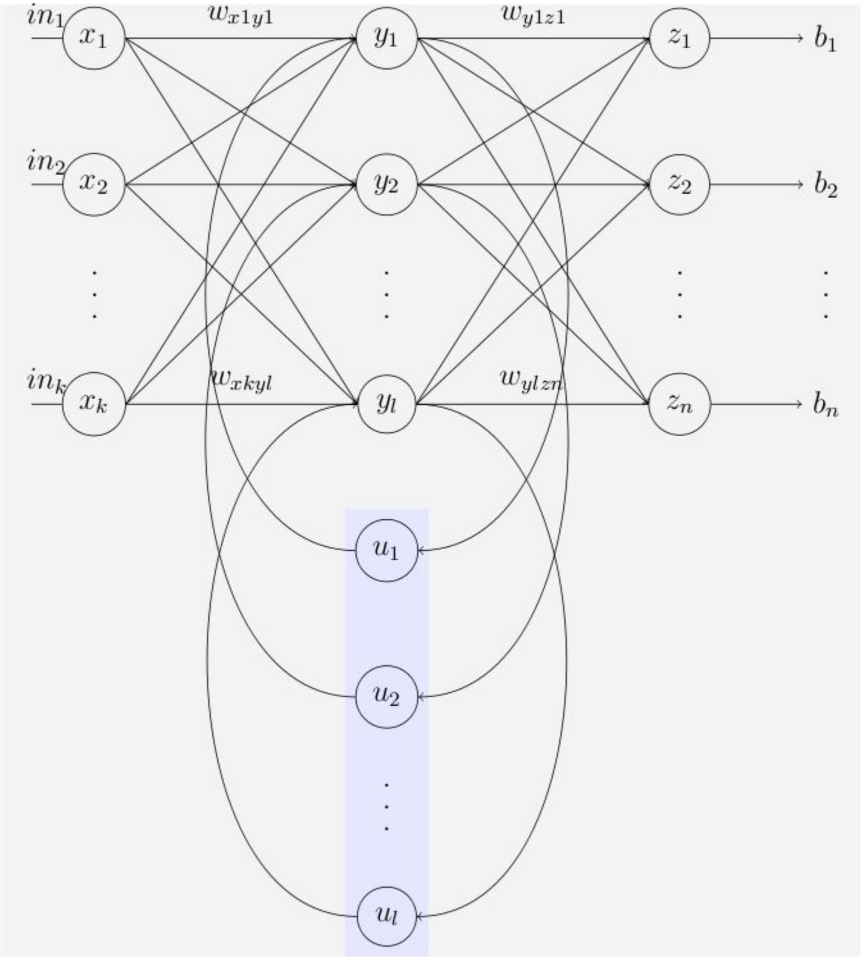
$$\frac{\partial E_{total}}{\partial out_{h1}} = \frac{\partial E_{o1}}{\partial out_{h1}} + \frac{\partial E_{o2}}{\partial out_{h1}}$$

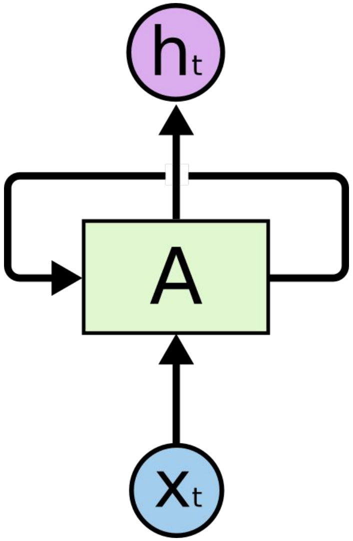


NN - Backpropagation

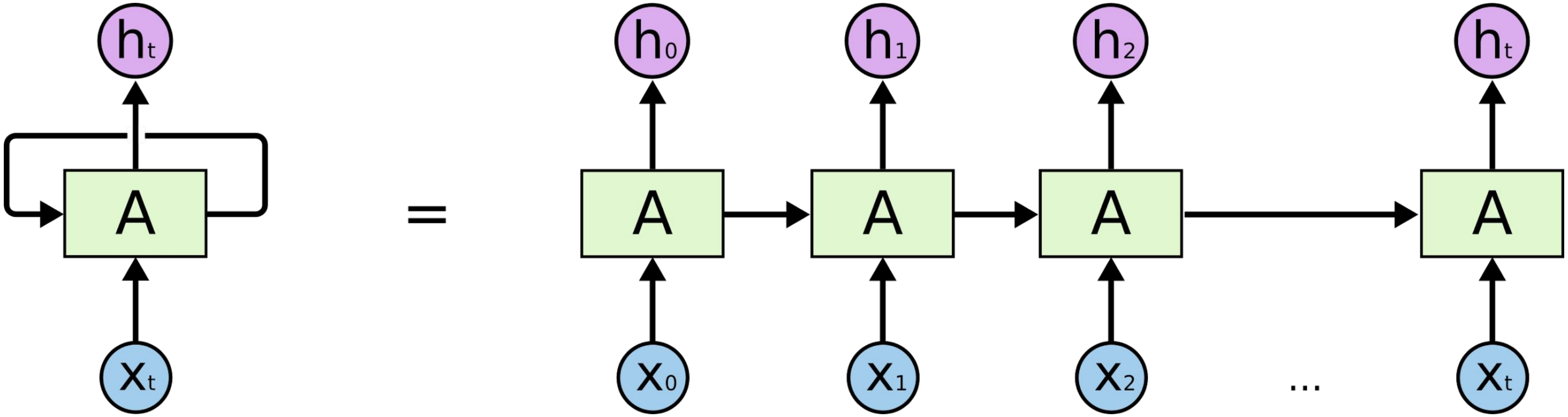


Recurrent NN



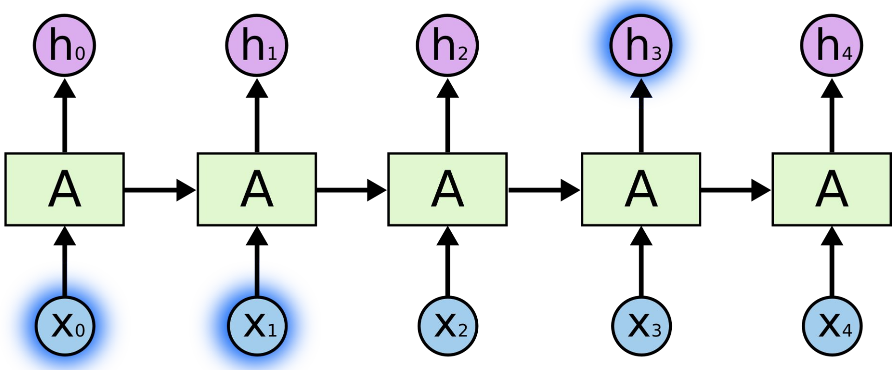


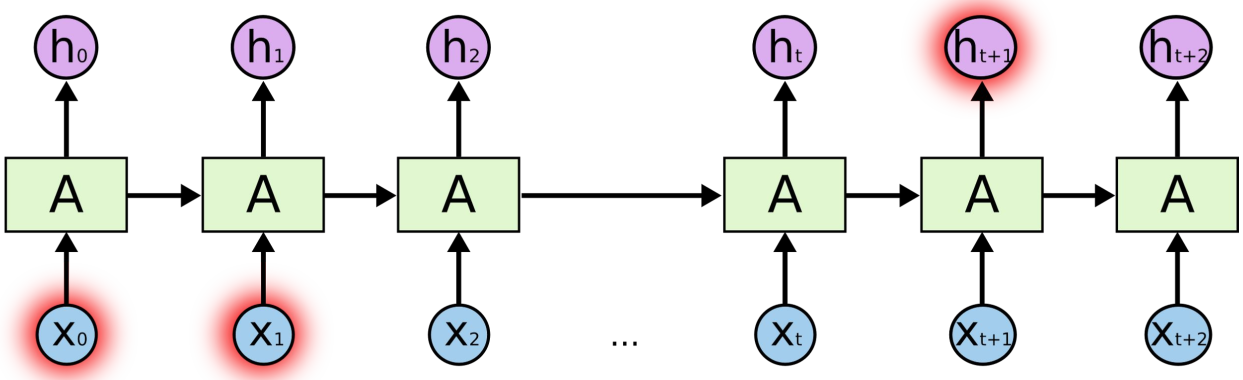
Recurrent NN - unfolded



*http://colah.github.io/posts/2015-08-Understanding-LSTMs/

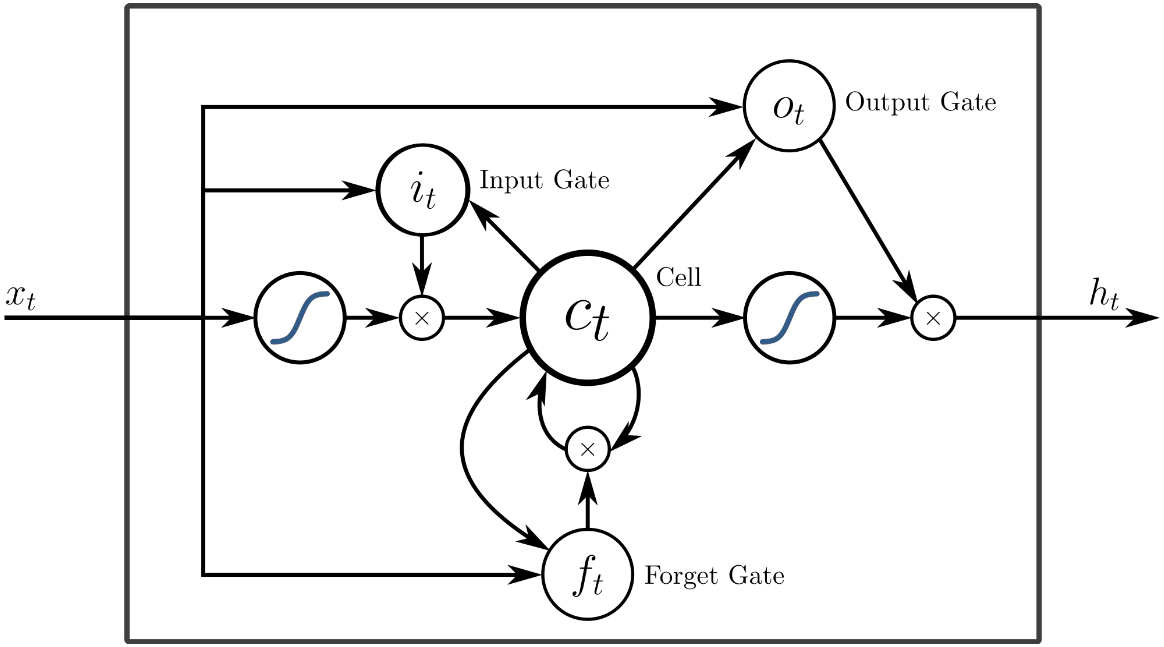
Recurrent NN - time dependencies



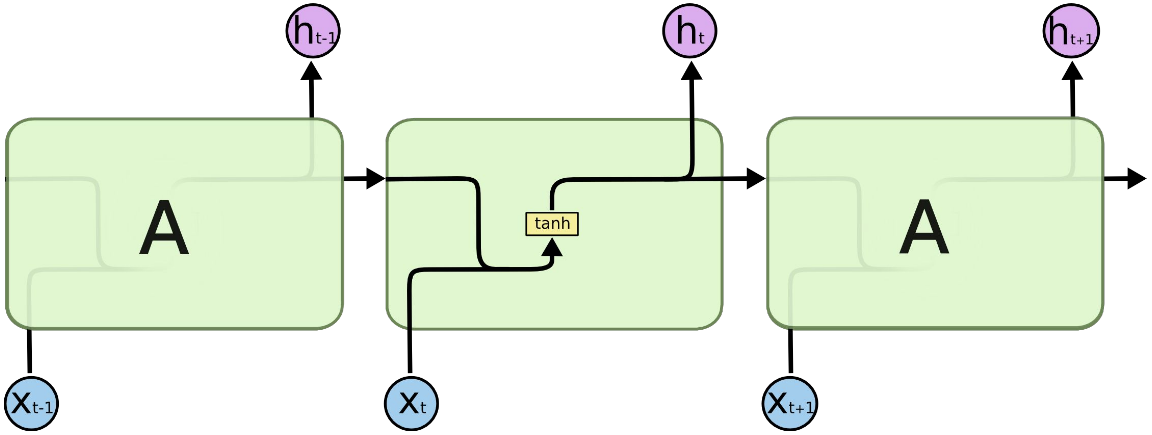


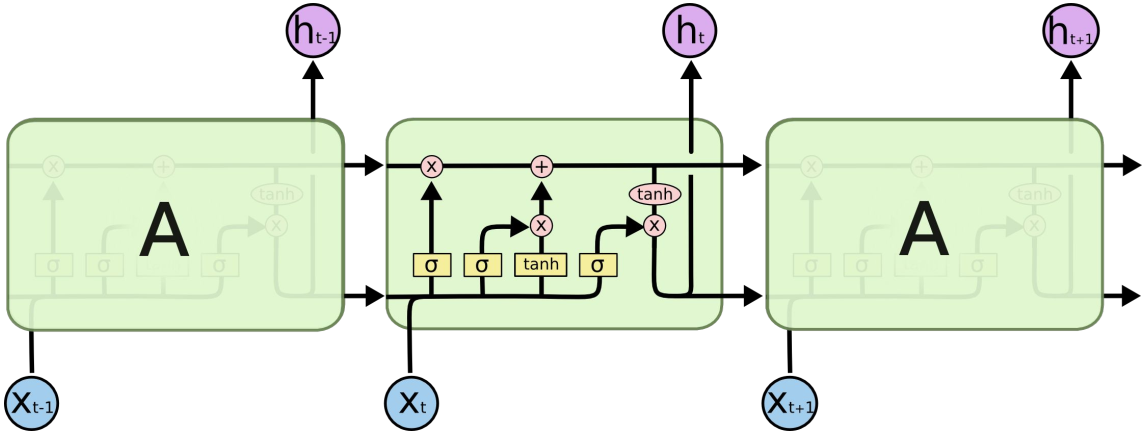
*http://colah.github.io/posts/2015-08-Understanding-LSTMs/

LSTM network

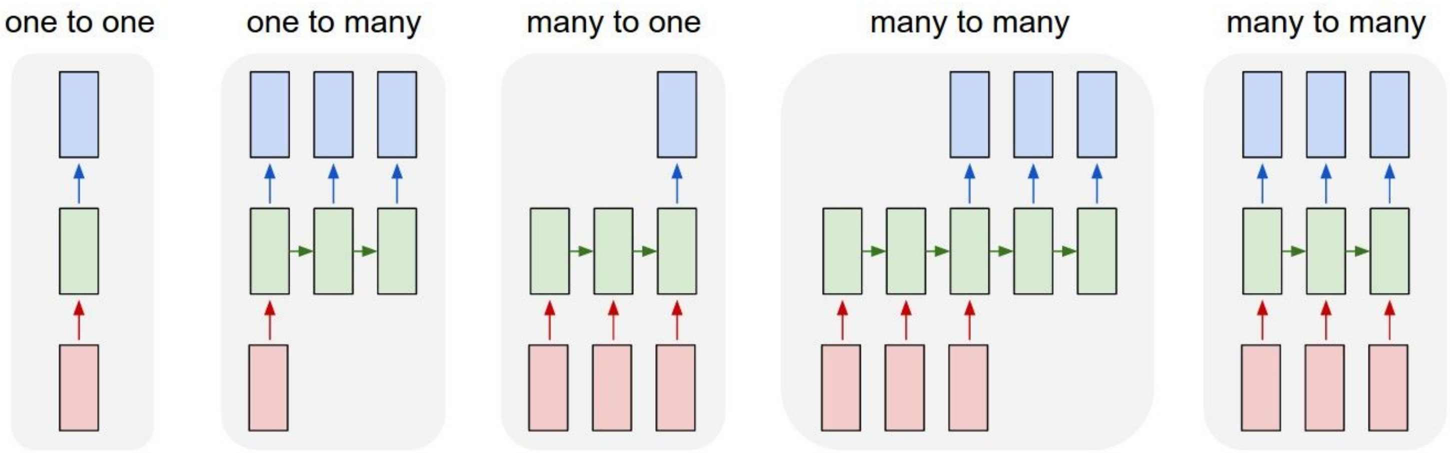


LSTM network vs. simple RNN



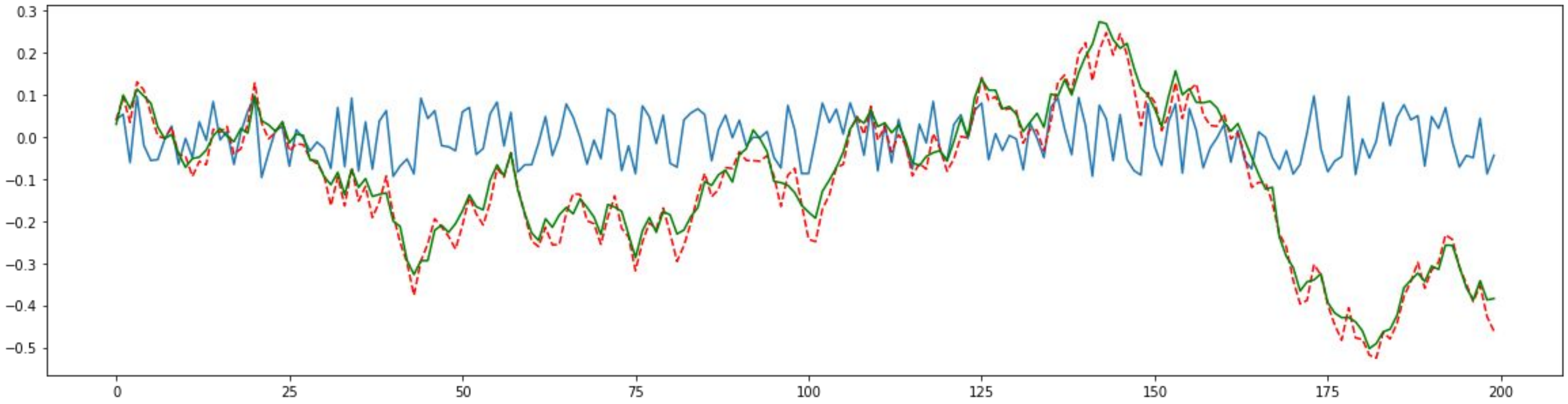


RNNs & sequences



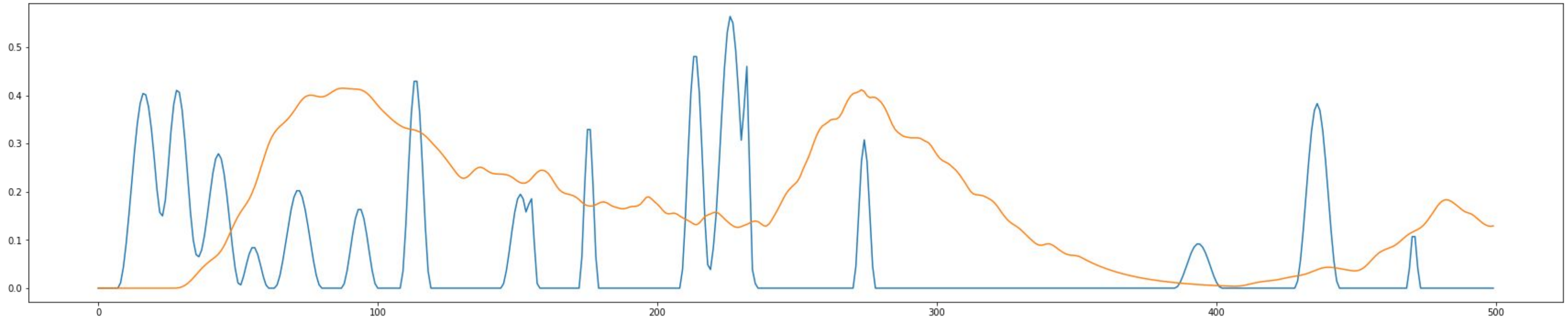
Simple RNN test

- Regression task
  - Simple cumulative sum function as input
- Data preparation
  - Generate samples, visualize
  - Construct training set
- Build model
  - NN with fixed window, Simple RNN, LSTM
- Test RNN on longer sequences
  - For windowed model
  - For LSTMs



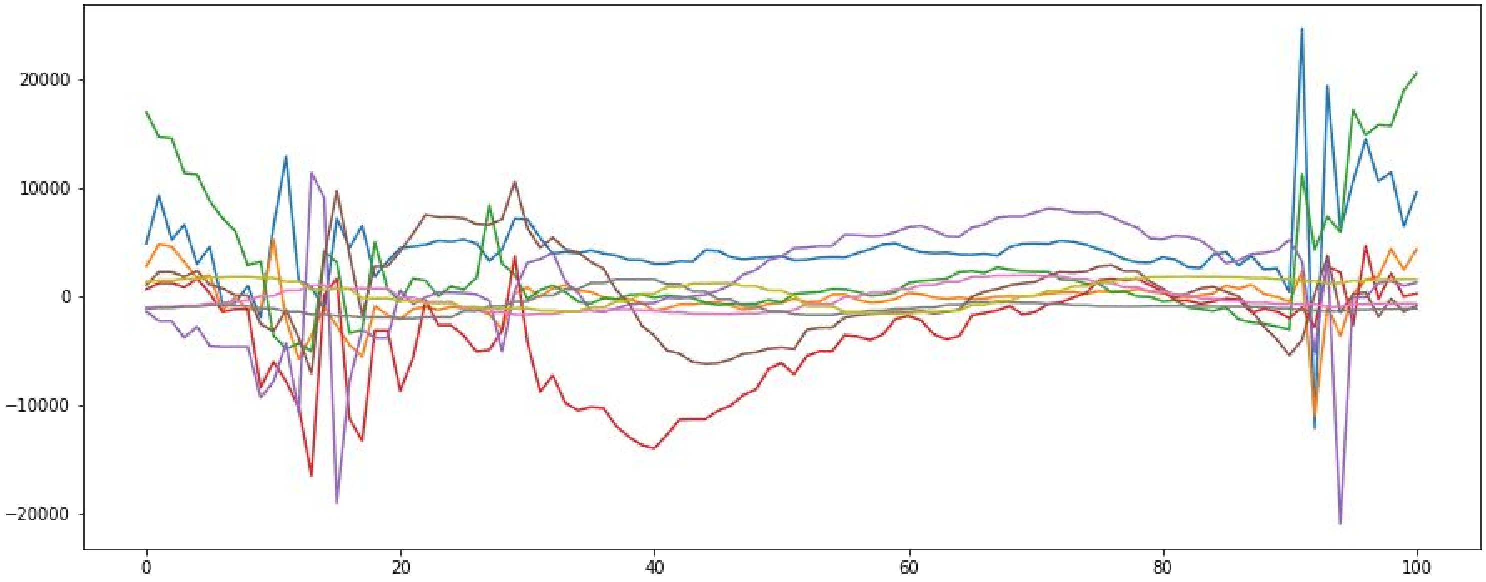
Rainfall-runoff example

- Regression task
- Data preparation
  - Generate samples visualize
  - Construct training set
- Build model
  - NN with fixed window, Simple RNN, LSTM
- Build predictor for continuous prediction
  - For windowed model
  - For LSTMs



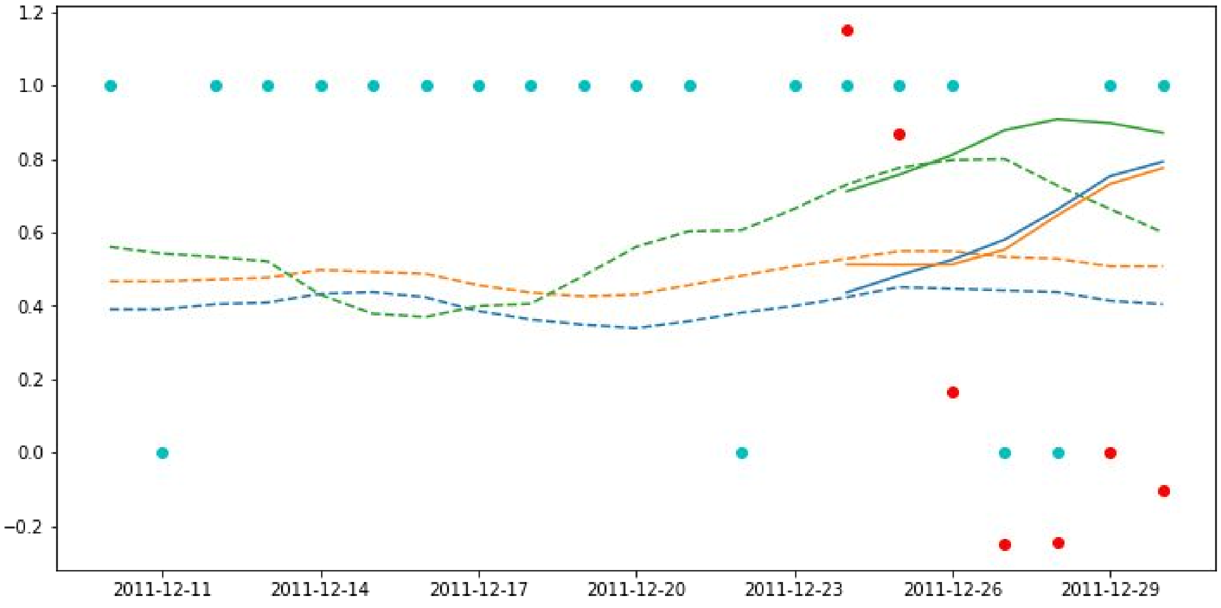
Trampoline example

- Binary classification task
- Data preparation
  - Load into numpy arrays, visualize, select inputs
  - Normalize, pad, construct training set
- Build model
  - NN with fixed window, LSTM
- Build predictor for continuous prediction
  - Test on truncated sequences



Weather forecast example

- Regression task
  - Explore feed forward model for inspiration
- Data preparation
  - Load into pandas dataset, visualize
- Build model
  - LSTM with fixed forecast window
  - Sequence-to-sequence LSTM (one step ahead forecast)
- Build predictor for continuous self-feed prediction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1.0
0.8
0.6
0.4
0.2
0.0
−0.2
2011-12-11
2011-12-14
2011-12-17
2011-12-20
2011-12-23
2011-12-26
2011-12-29