

Time Series Analysis

08/2018



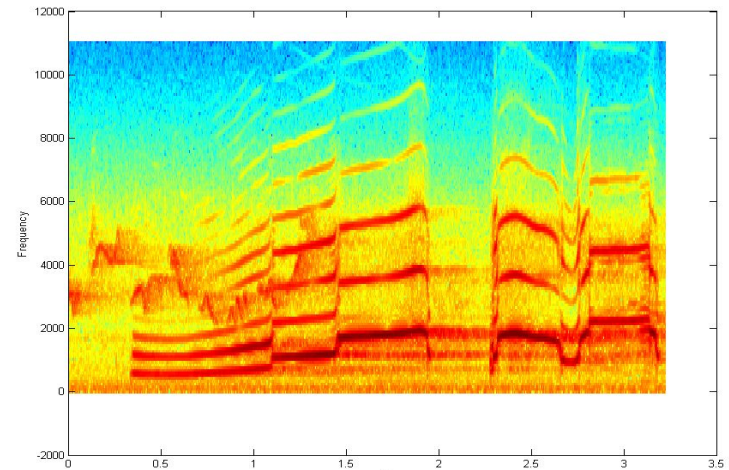
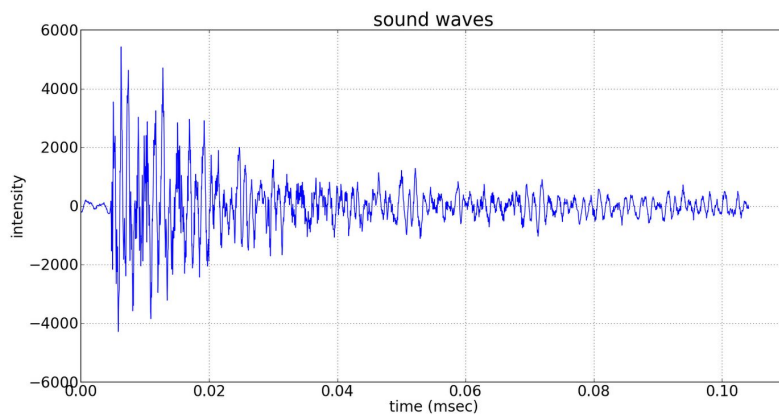
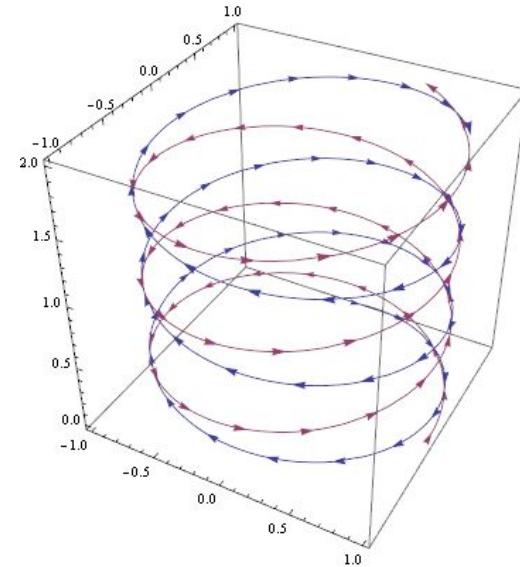
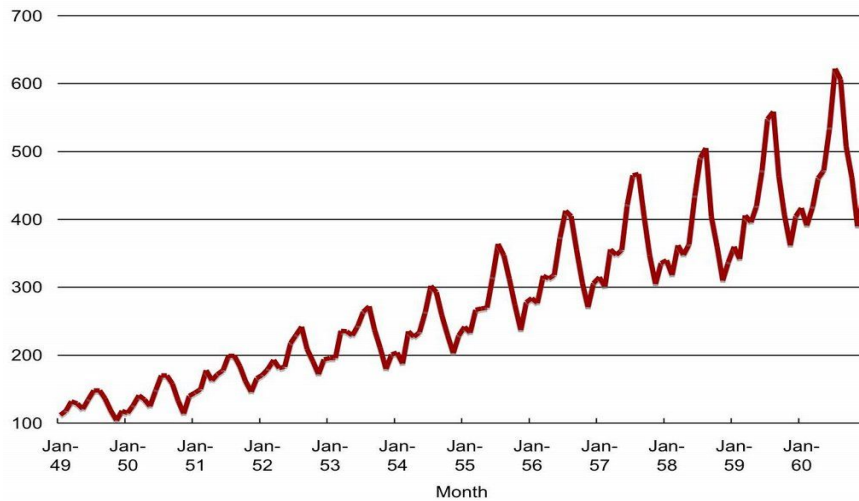
About me

- 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 real-time 3D visualizations
- 5 years in applied ML and artificial intelligence
 - Lead researcher in GoodAI - general artificial intelligence
 - CTO in NeuronSoudware - sound processing with ML
 - Lead ML in CEAI - natural language processing

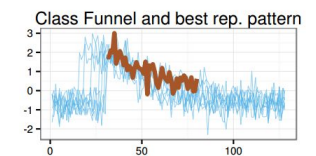
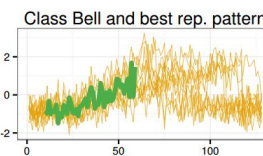
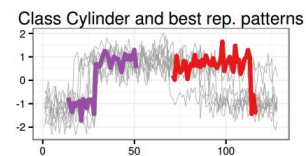
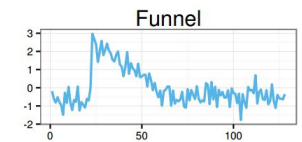
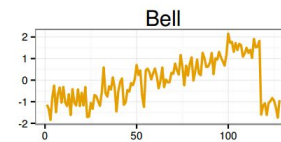
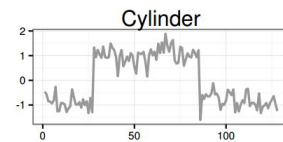
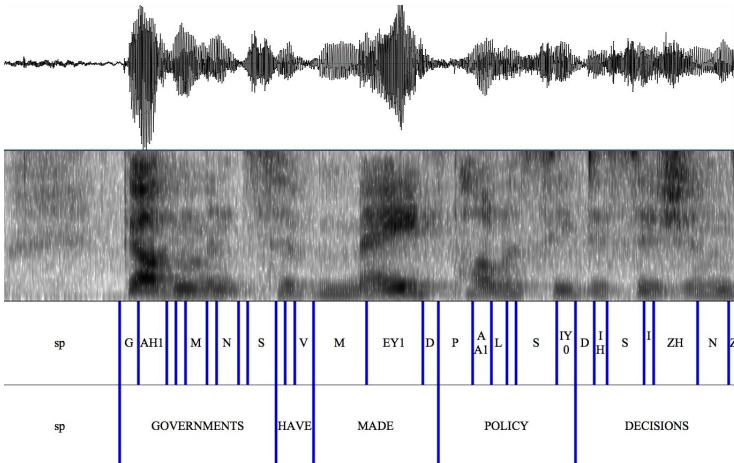
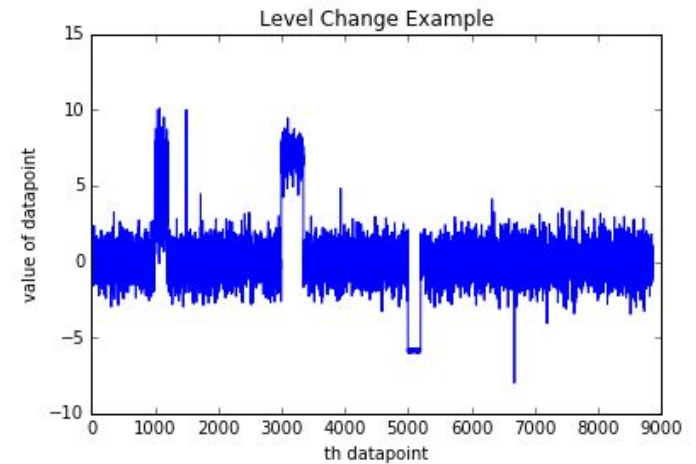
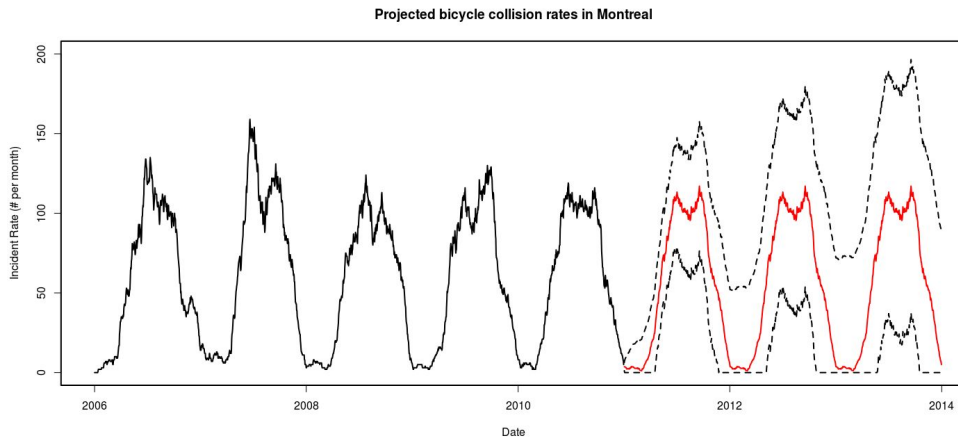
Outline

- 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

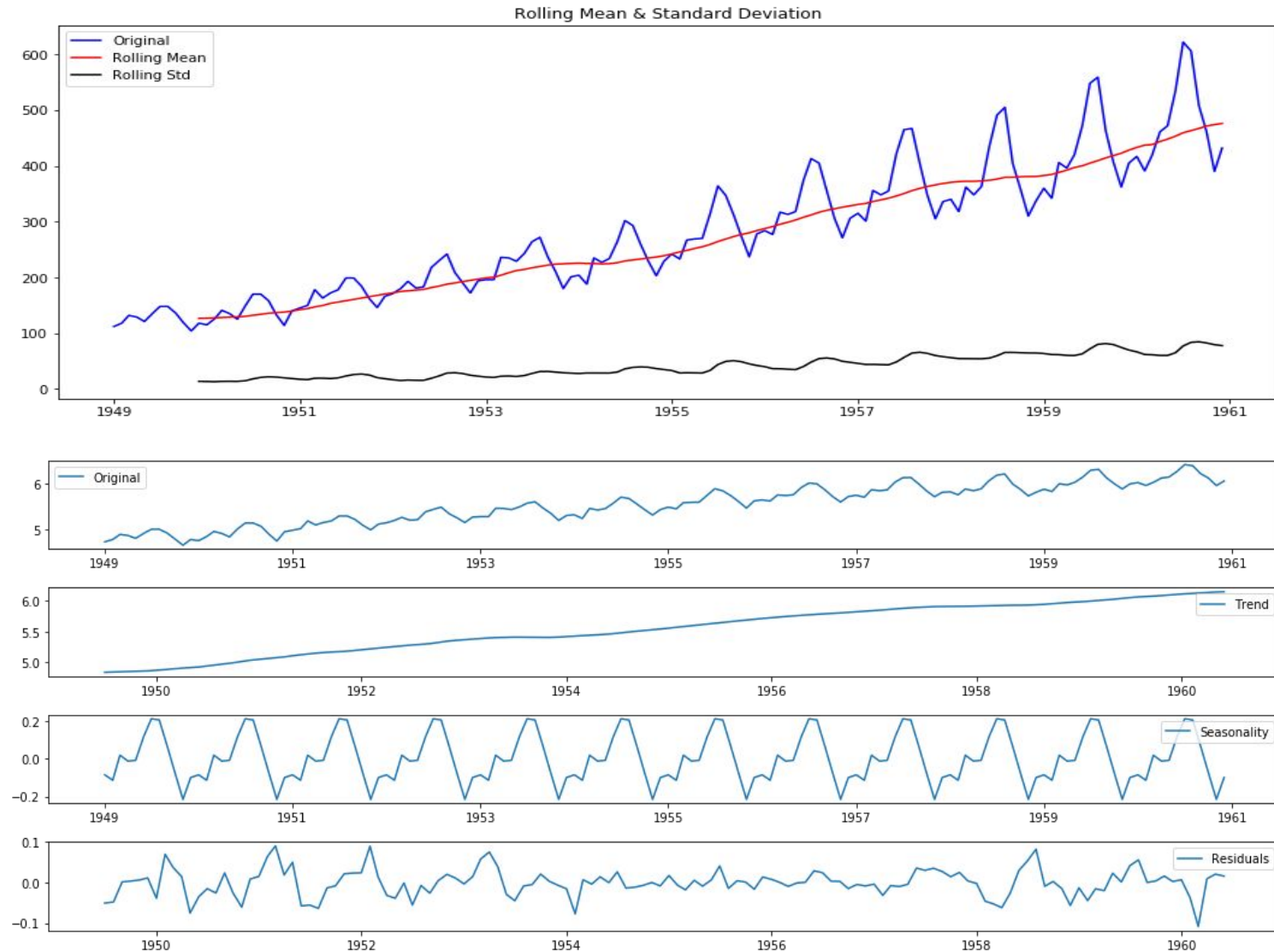
Time series - examples



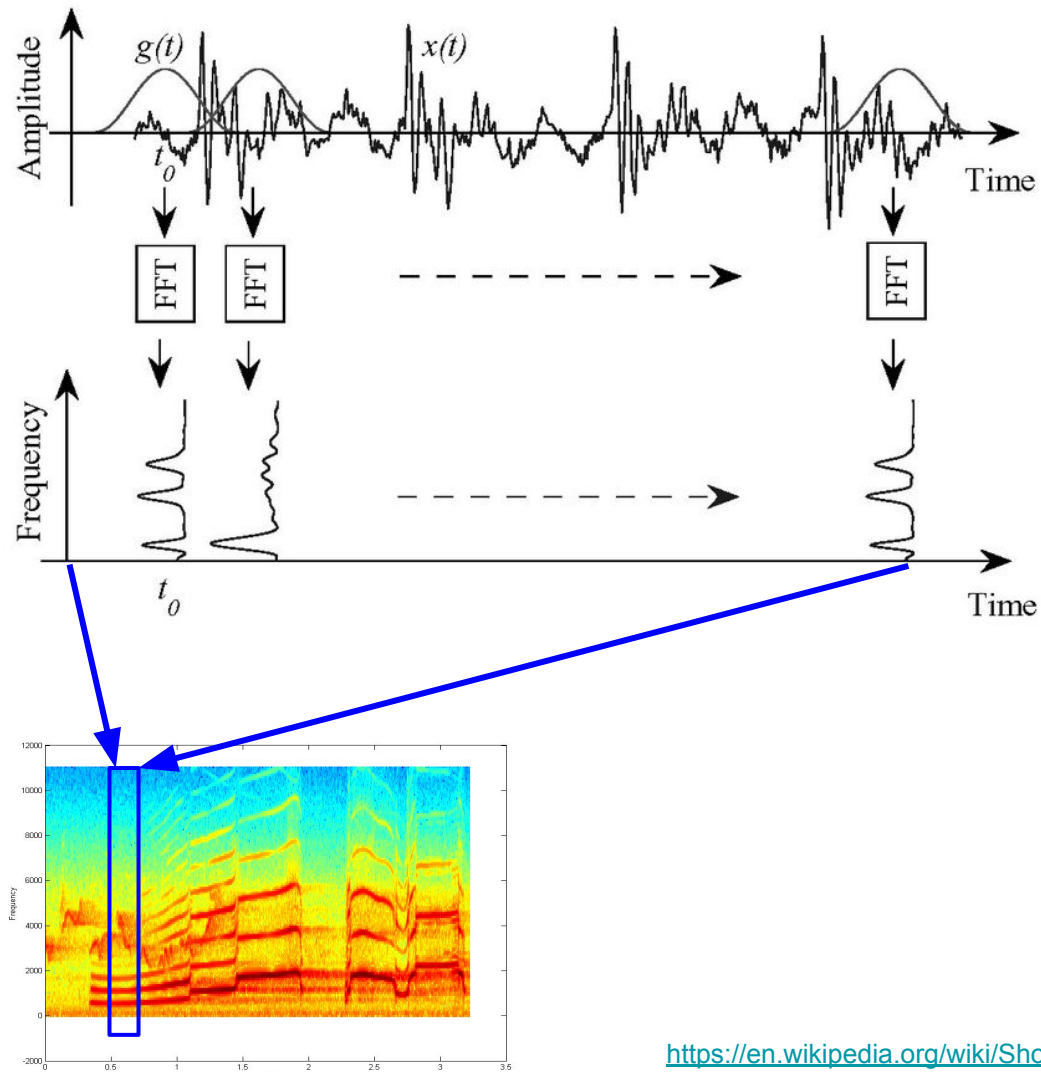
Time series - tasks



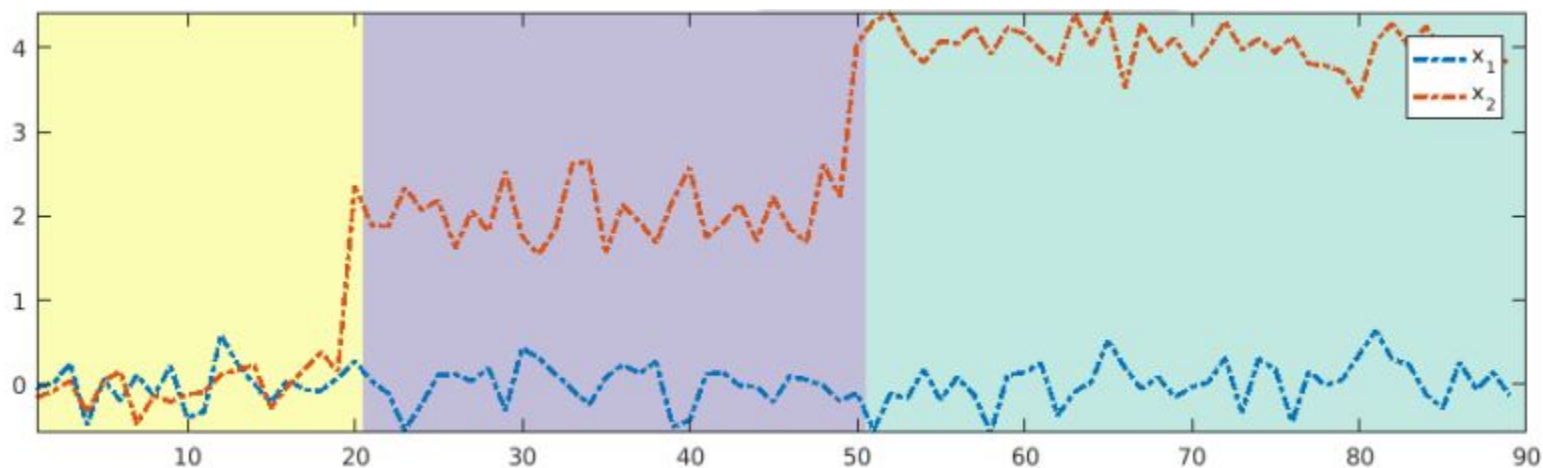
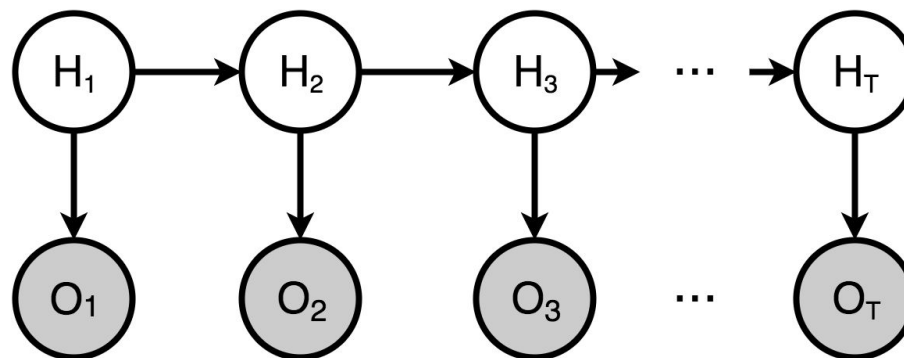
Time series - decomposition



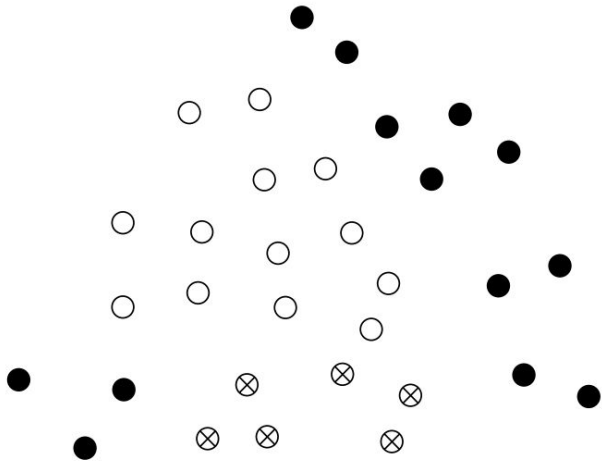
Time series - Short-time Fourier Transform



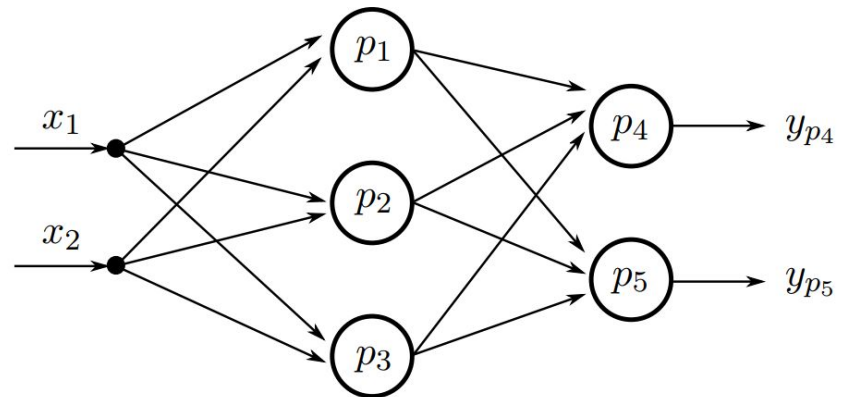
Hidden Markov Model



Neural networks

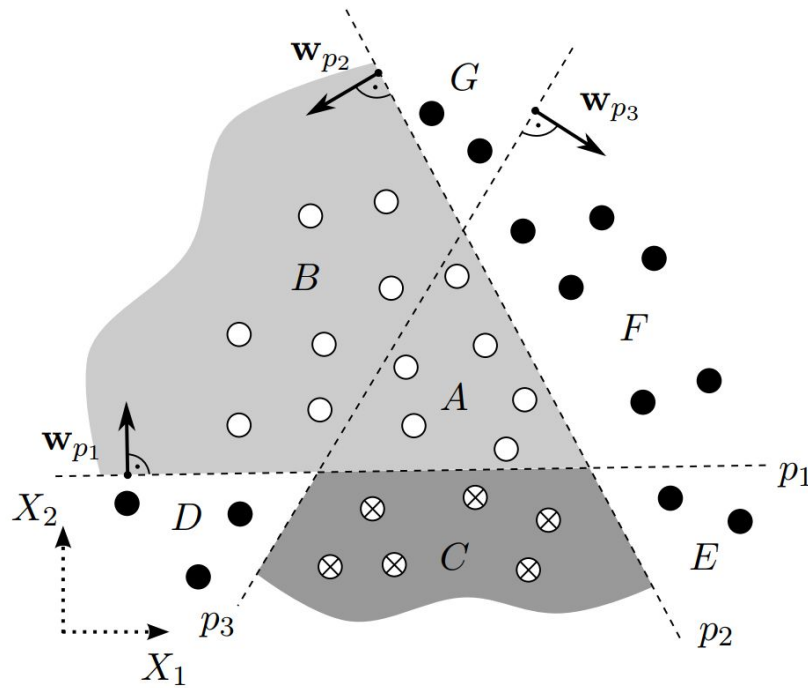


(a) Input set

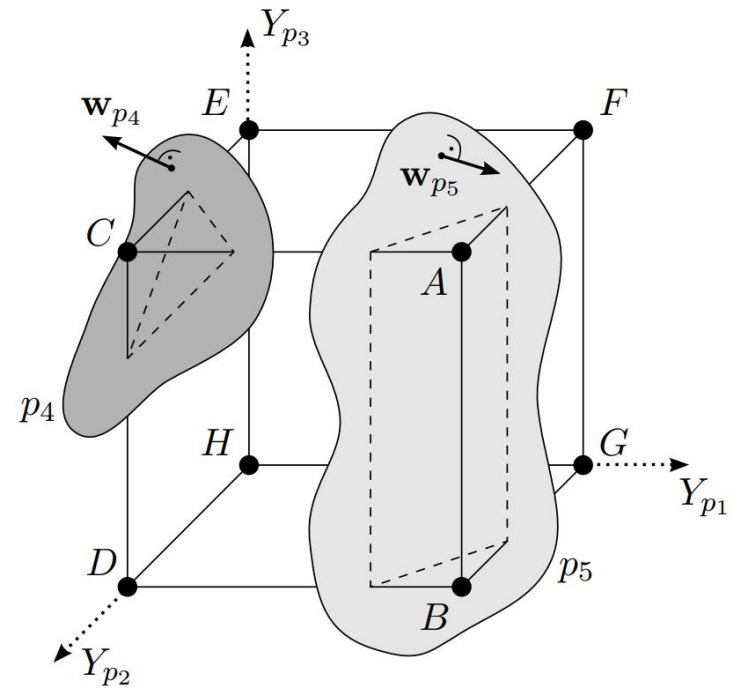


(b) Example network

NN - Classification example



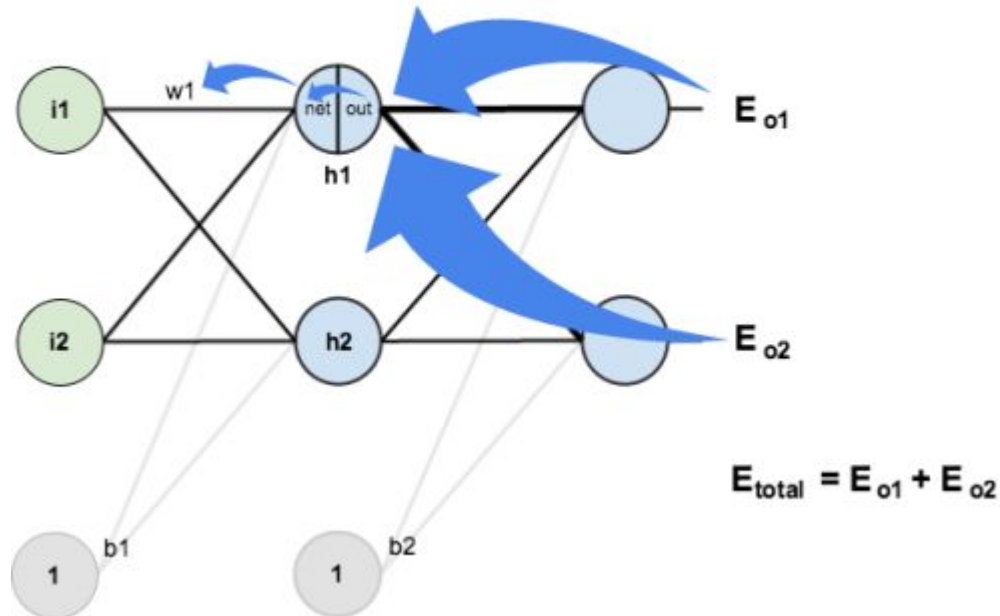
(a) Input space of first layer



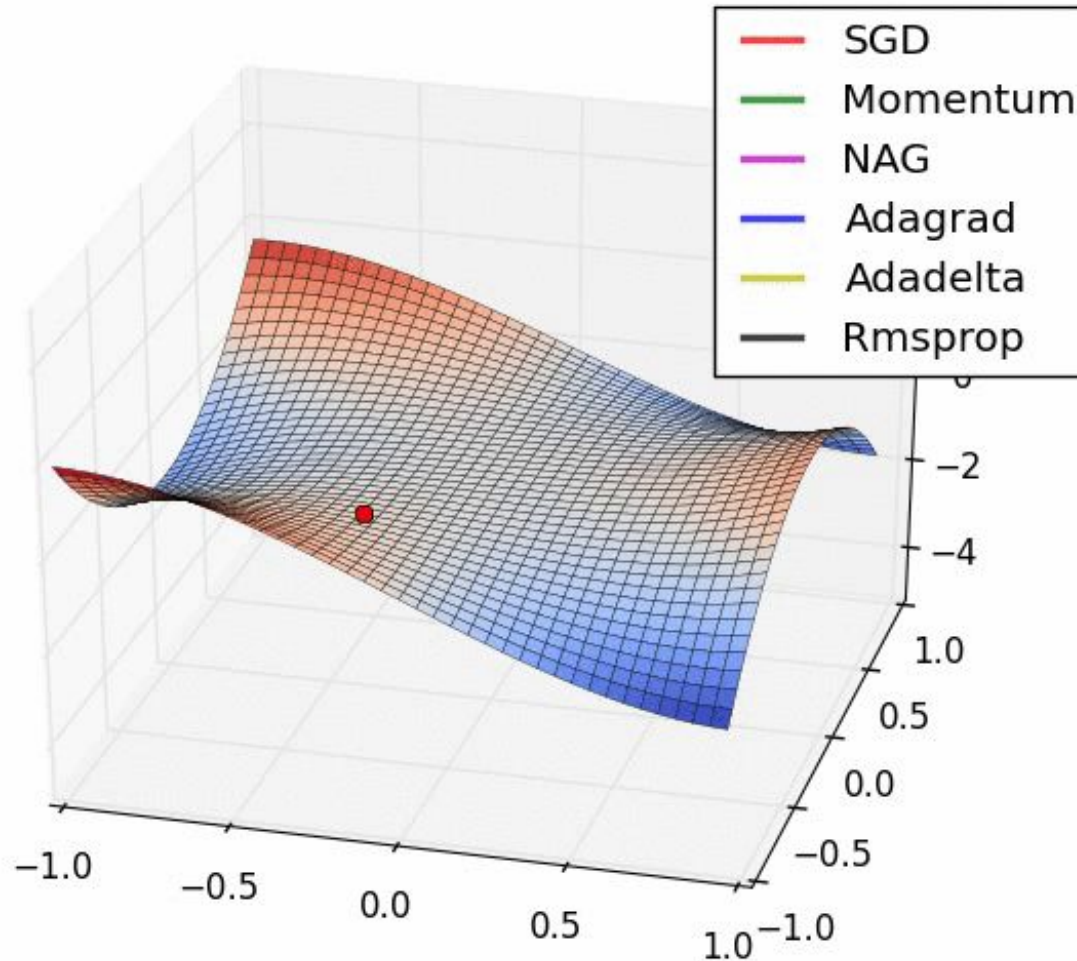
(b) Input space of second layer

NN - Backpropagation

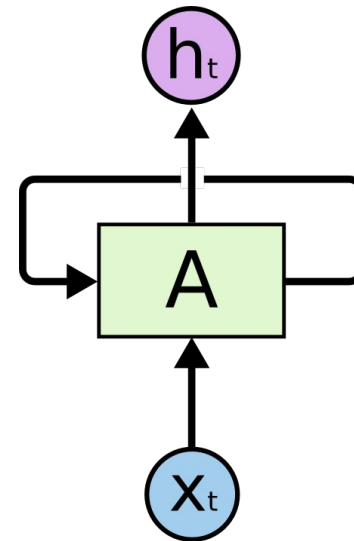
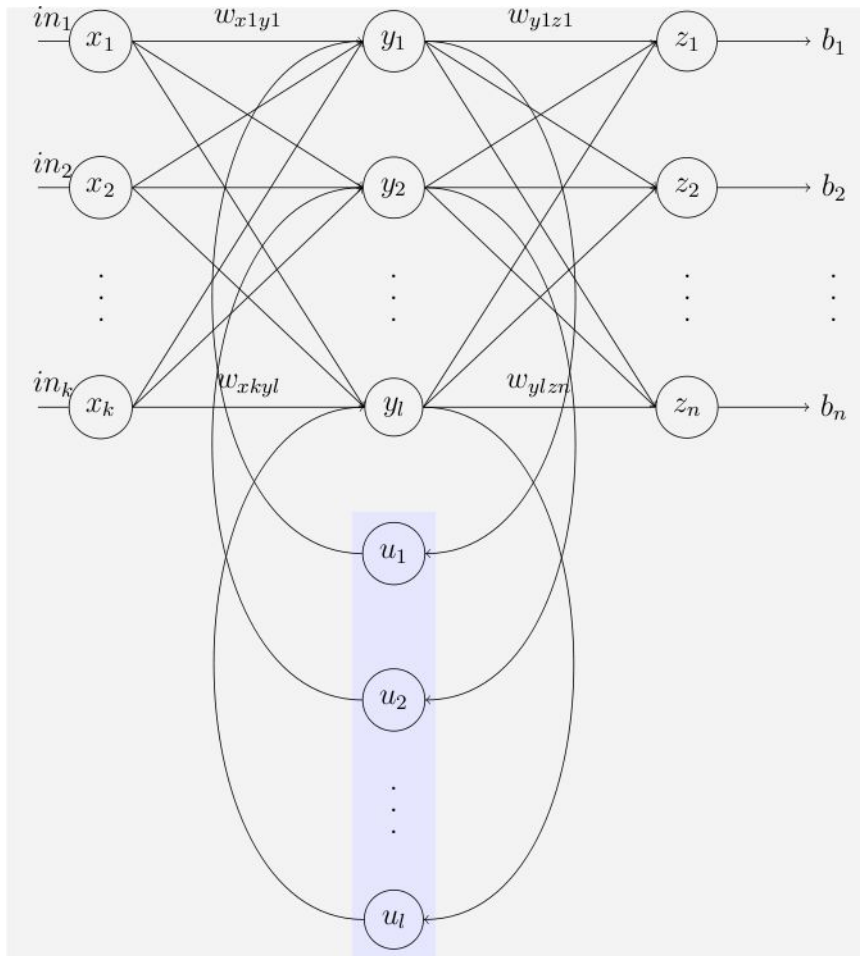
$$\frac{\partial E_{total}}{\partial w_1} = \frac{\partial E_{total}}{\partial out_{h1}} * \frac{\partial out_{h1}}{\partial net_{h1}} * \frac{\partial net_{h1}}{\partial w_1}$$
$$\downarrow$$
$$\frac{\partial E_{total}}{\partial out_{h1}} = \frac{\partial E_{o1}}{\partial out_{h1}} + \frac{\partial E_{o2}}{\partial out_{h1}}$$



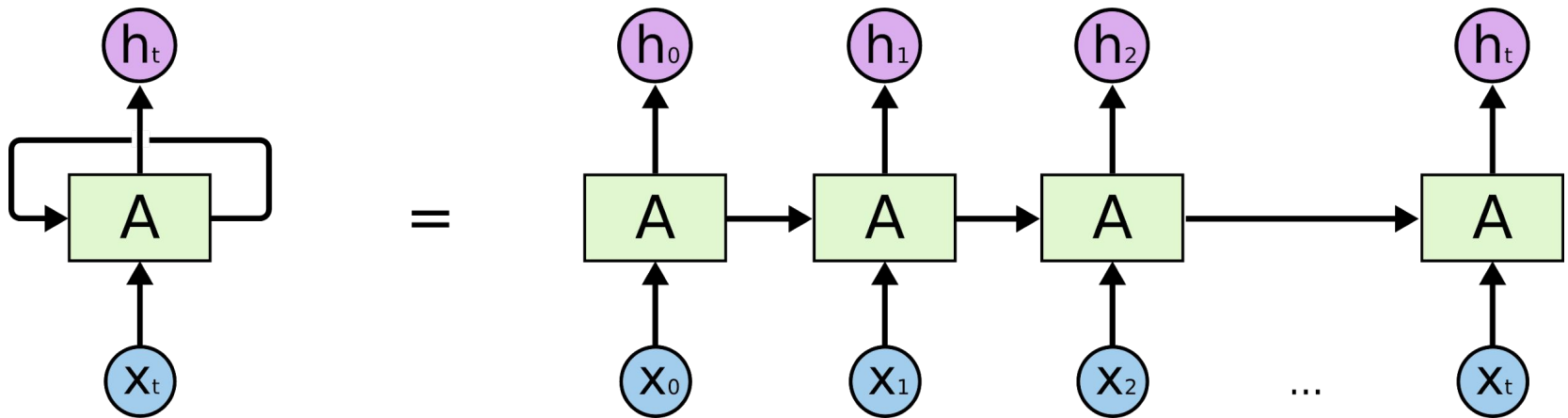
NN - Backpropagation



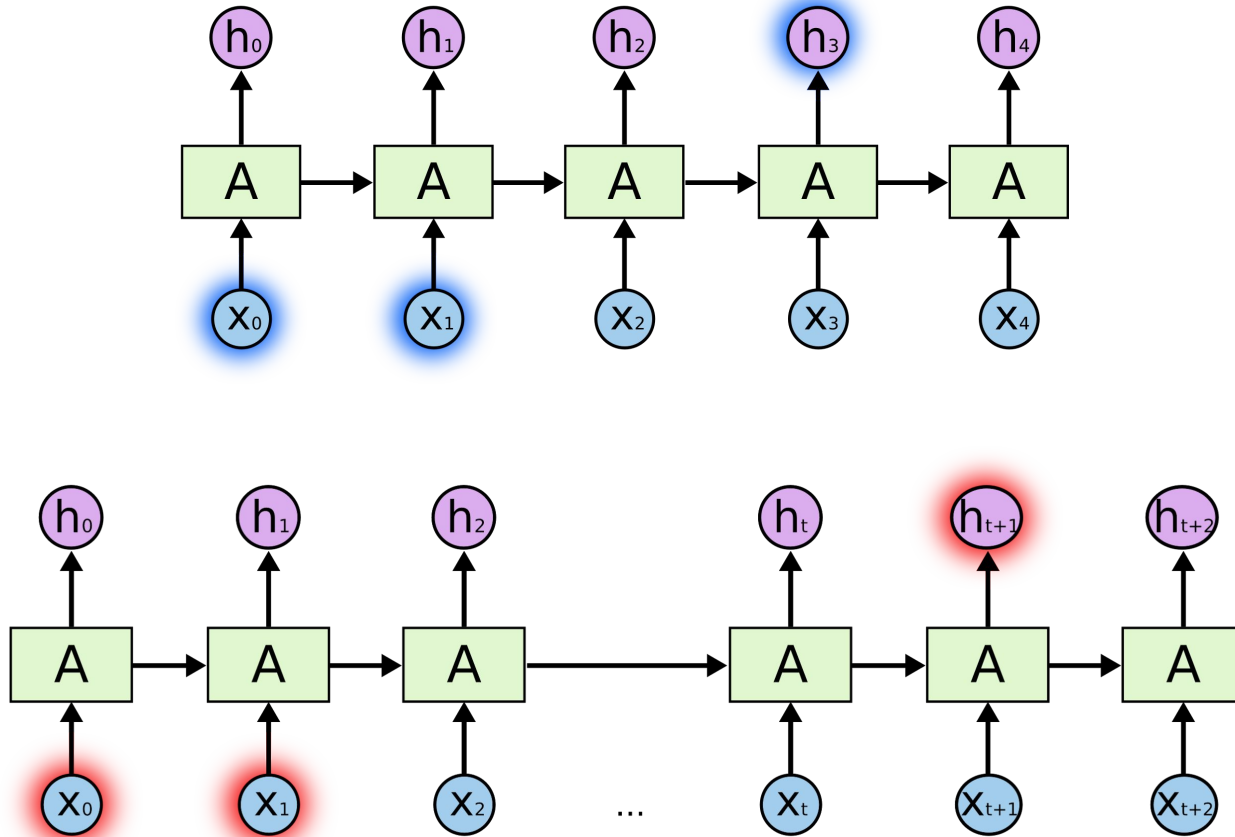
Recurrent NN



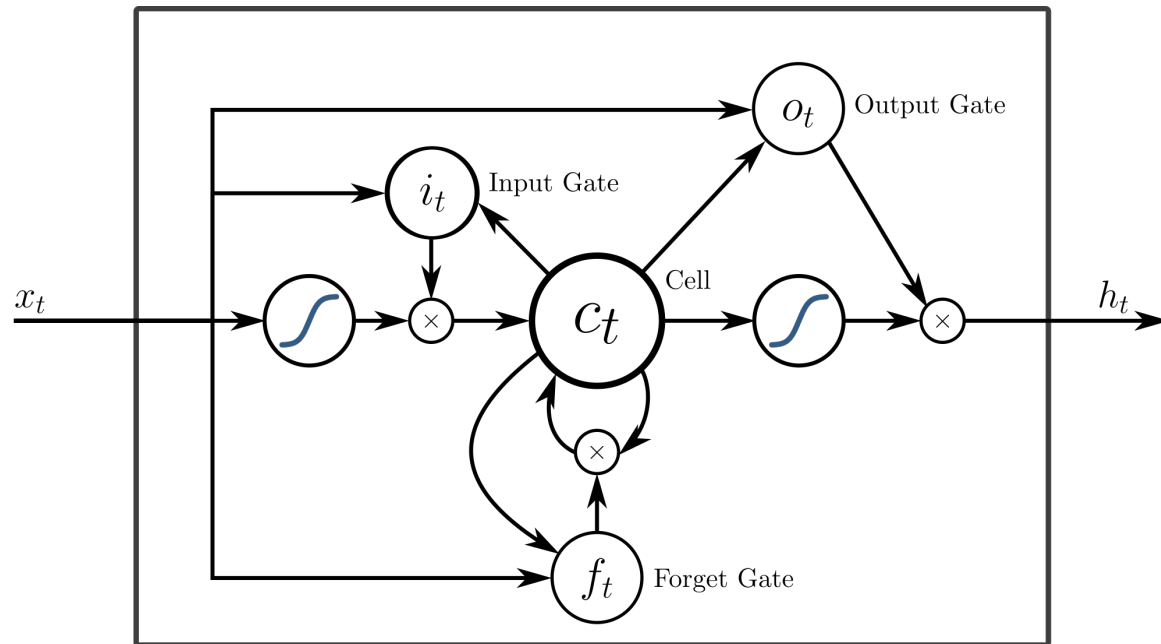
Recurrent NN - unfolded



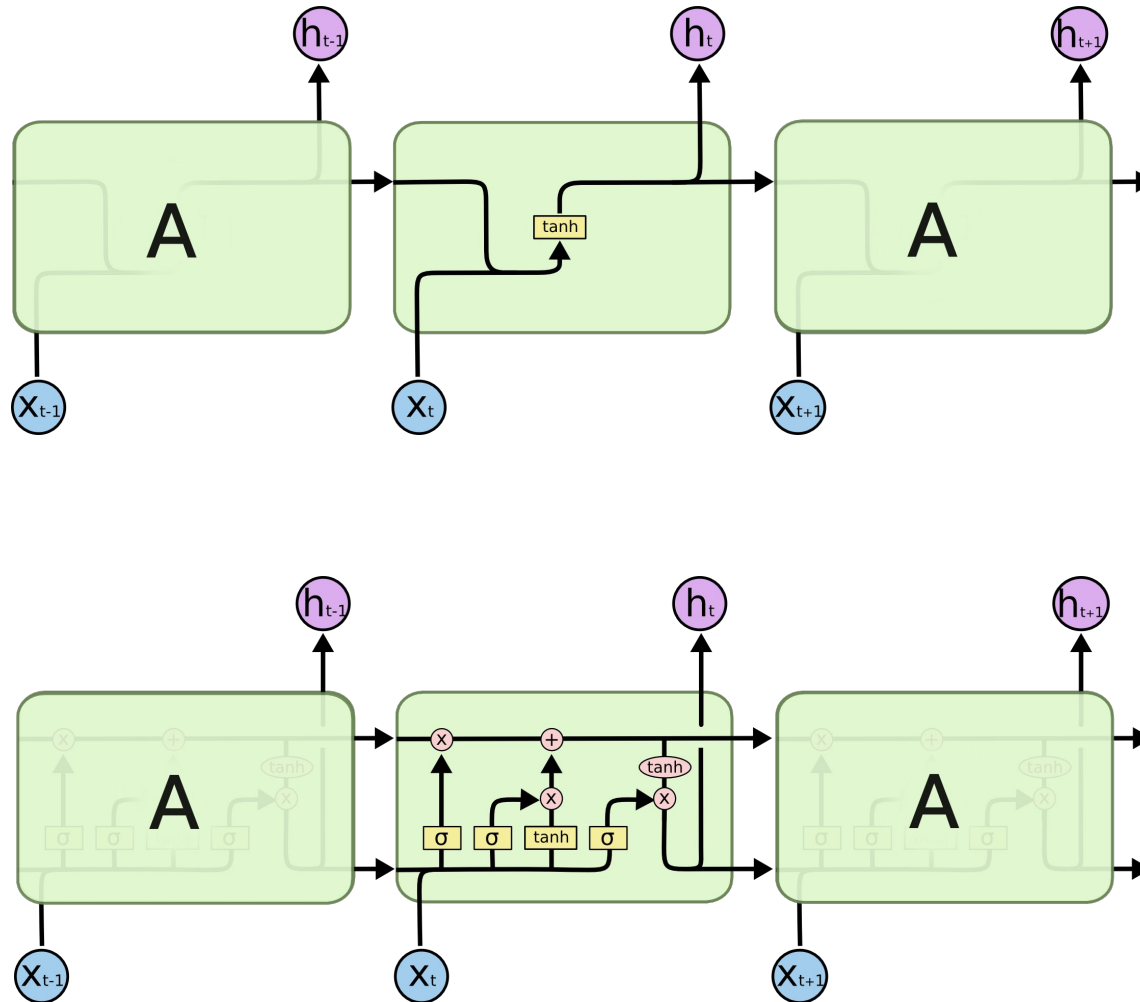
Recurrent NN - time dependencies



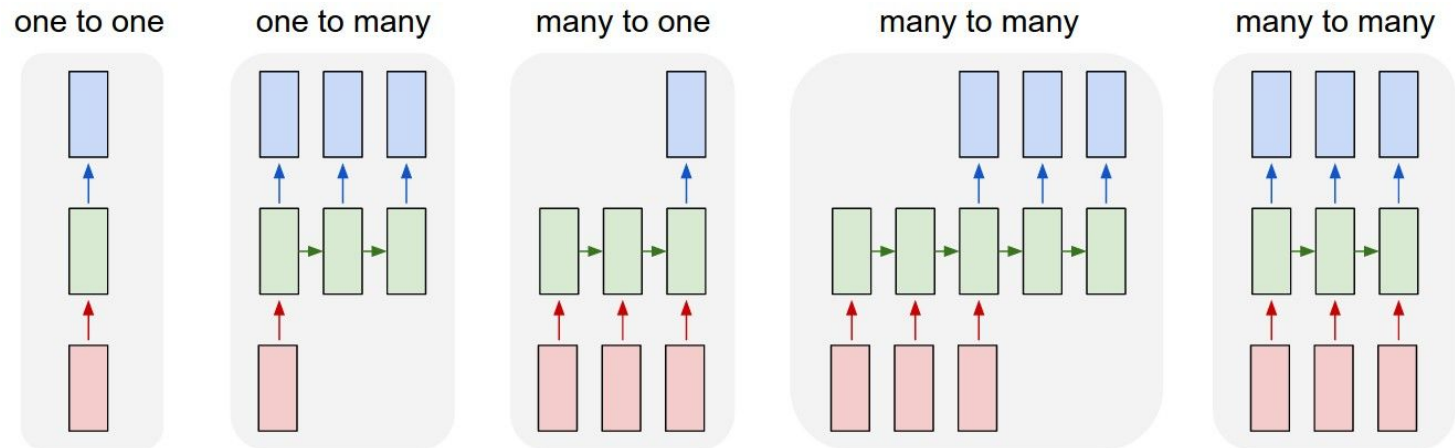
LSTM network



LSTM network vs. simple RNN

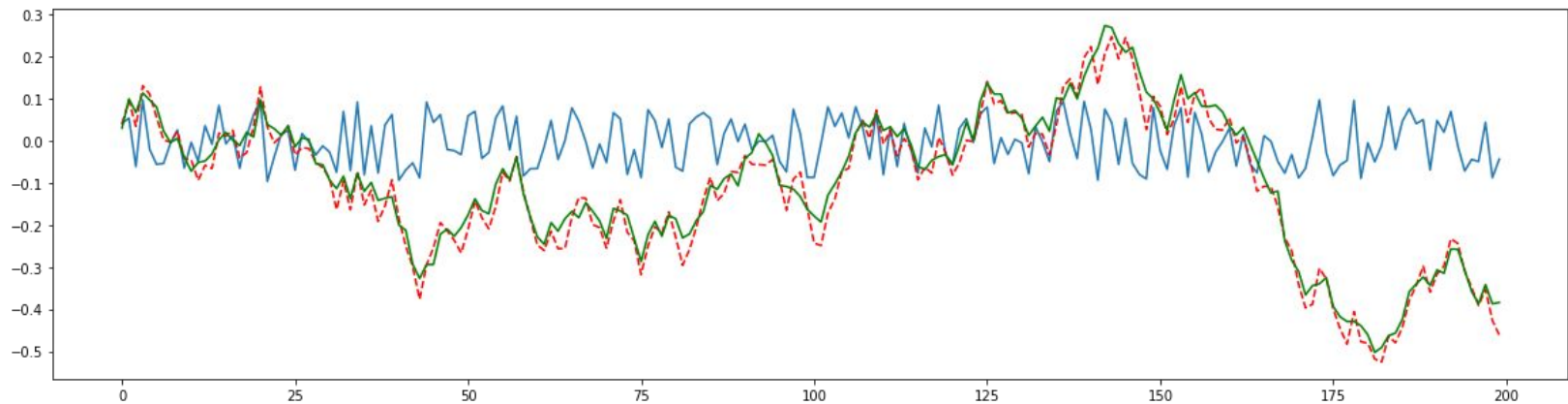


RNNs & sequences



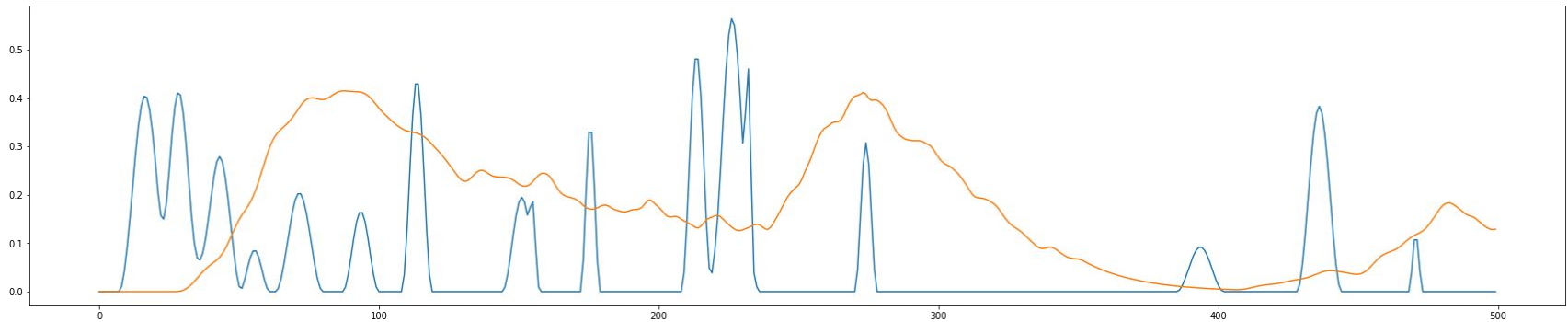
Simple RNN test

- 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



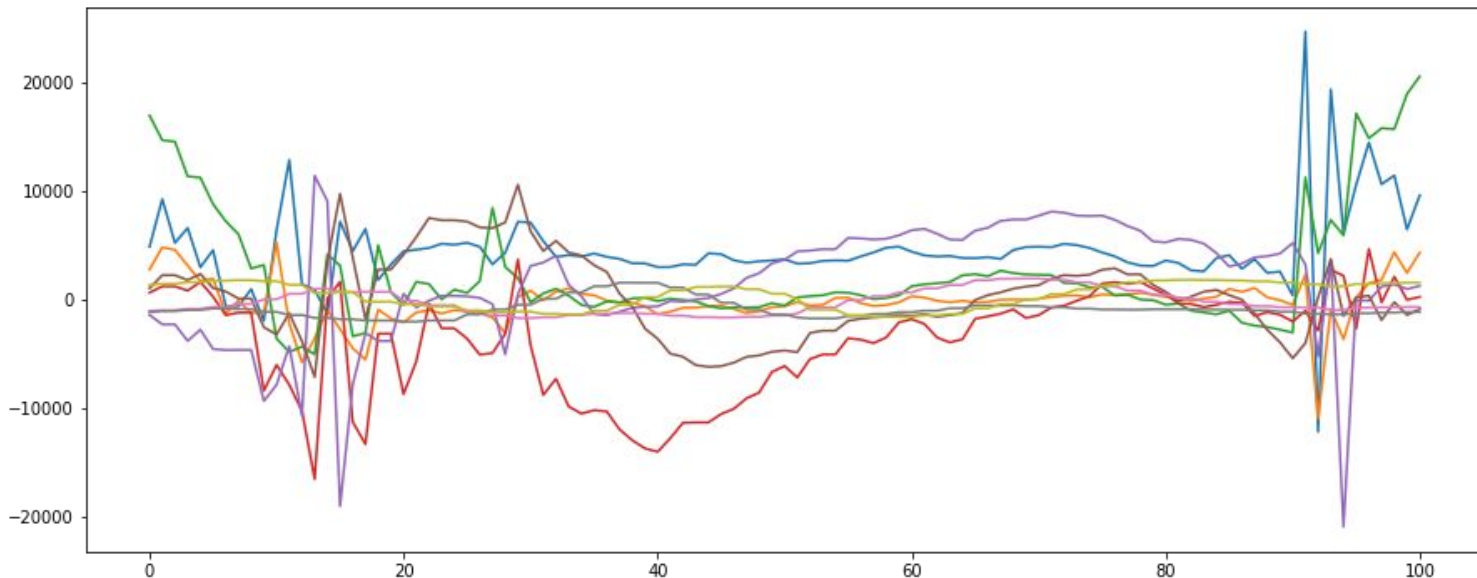
Rainfall-runoff example

- 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

