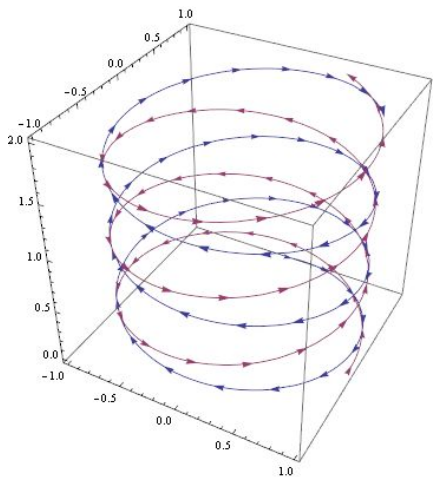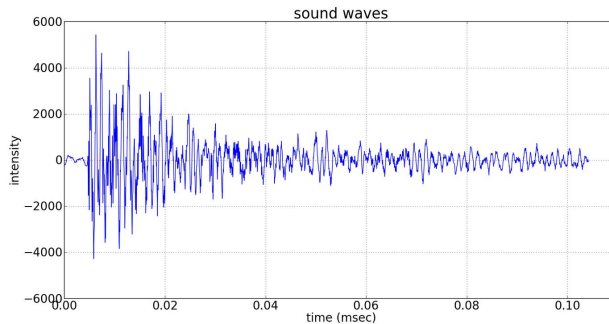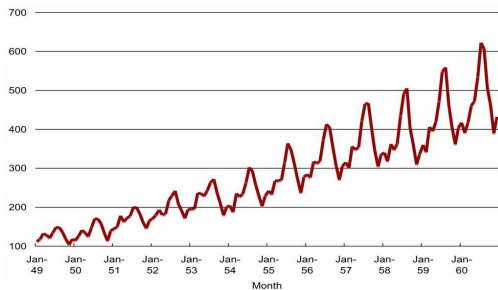# Time Series Analysis

Dušan Fedorčák
11/2019
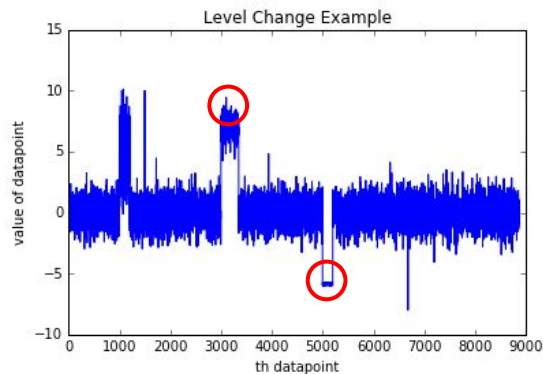
Machine Learning College

Time series – example data

Time series – example tasks
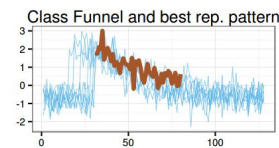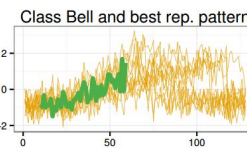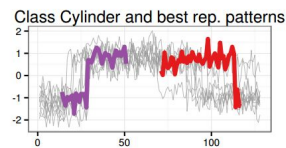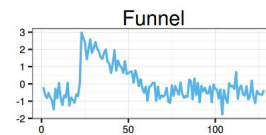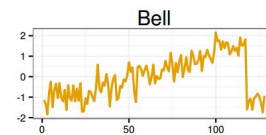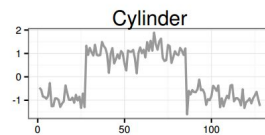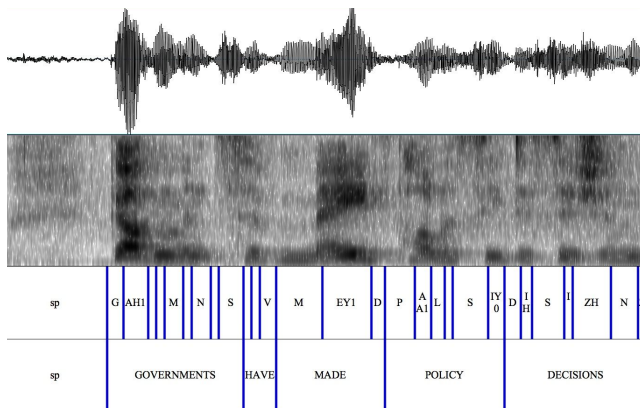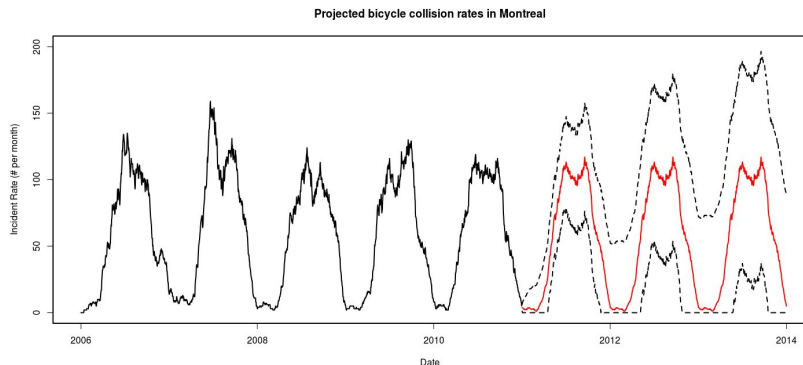
Time Series – classical analysis

- Decomposition
  - Inflation, trend, seasonality, differencing
- ARIMA models
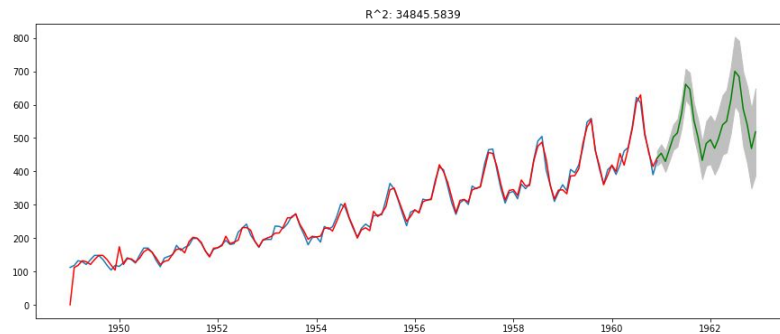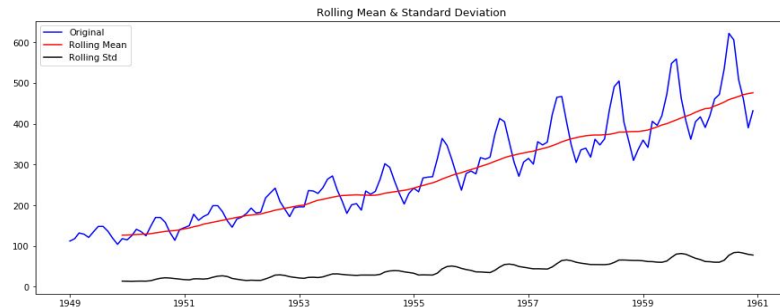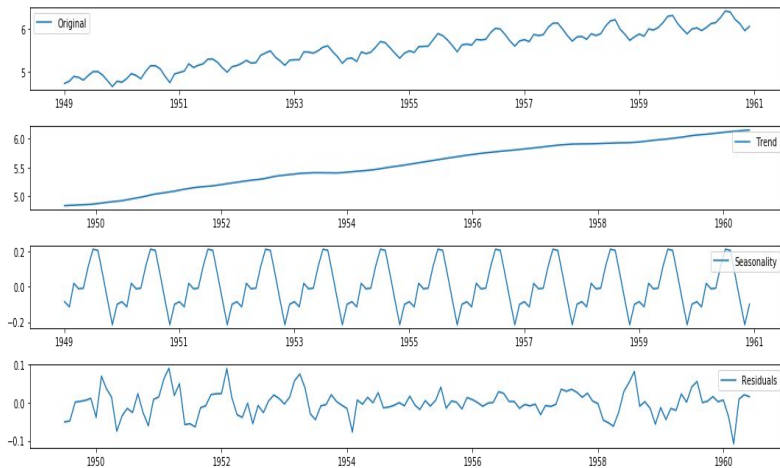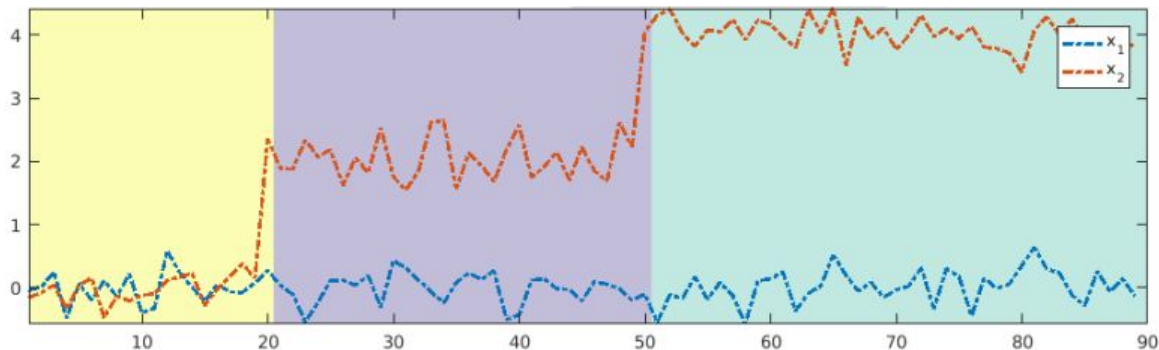 - http://people.duke.edu/~rnau/411home.htm

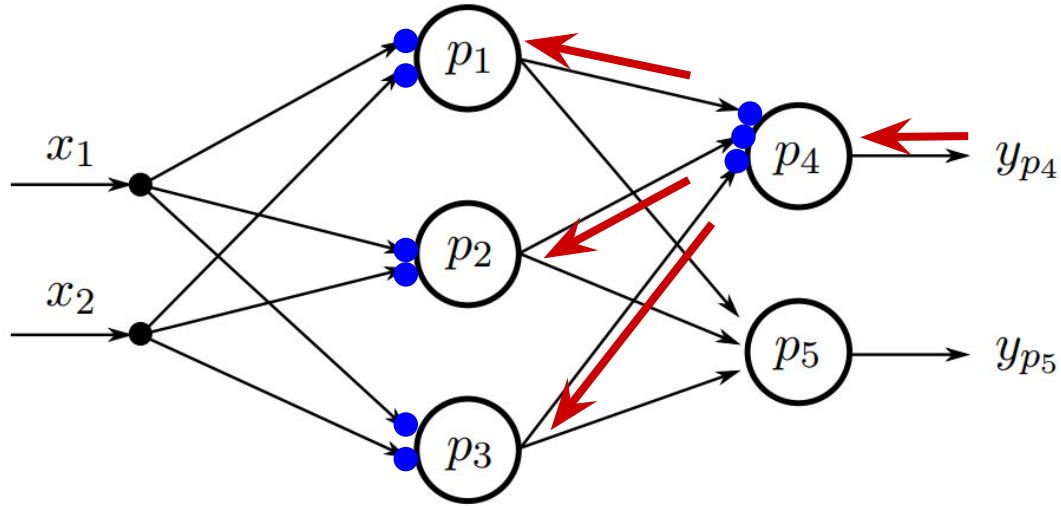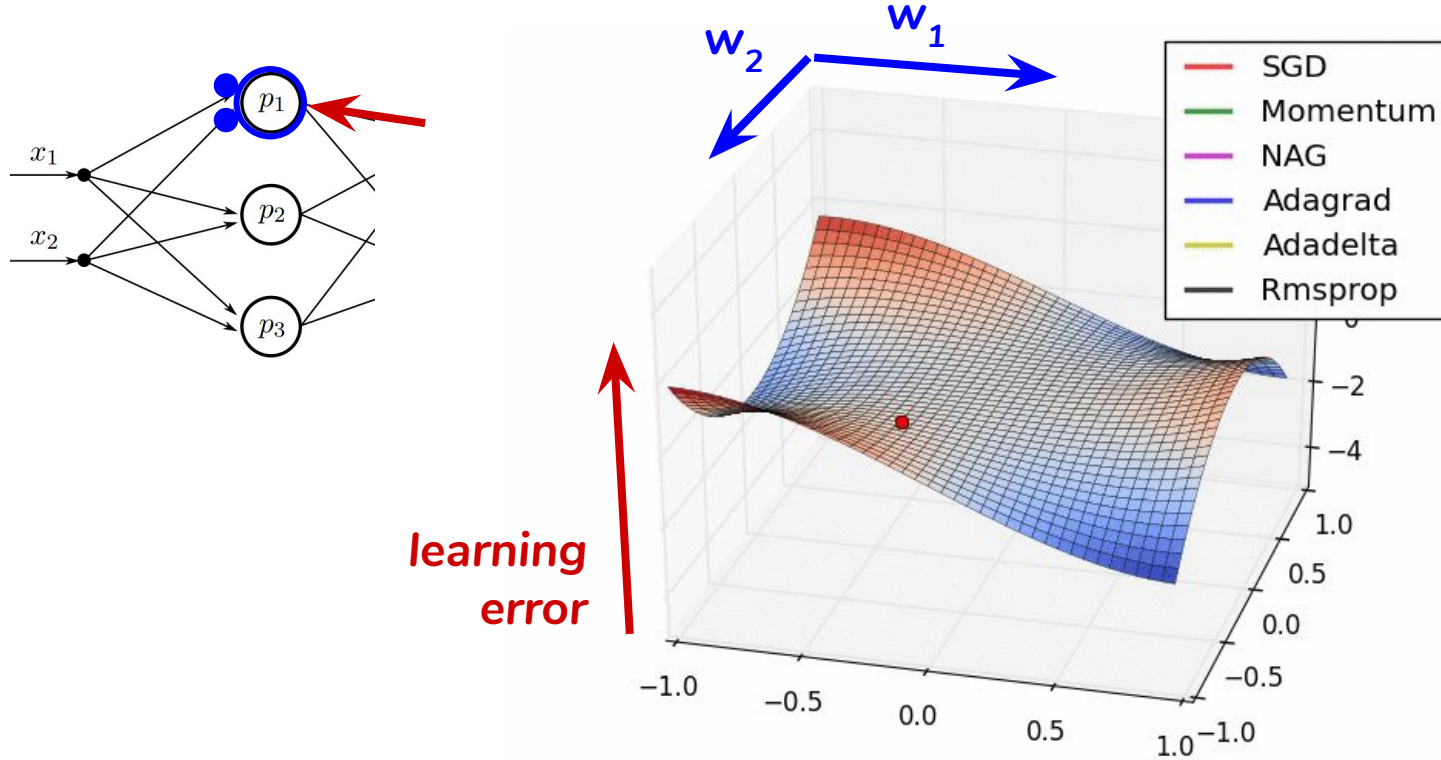# Hidden Markov Model
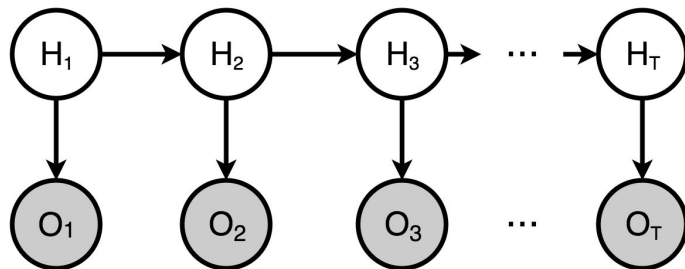
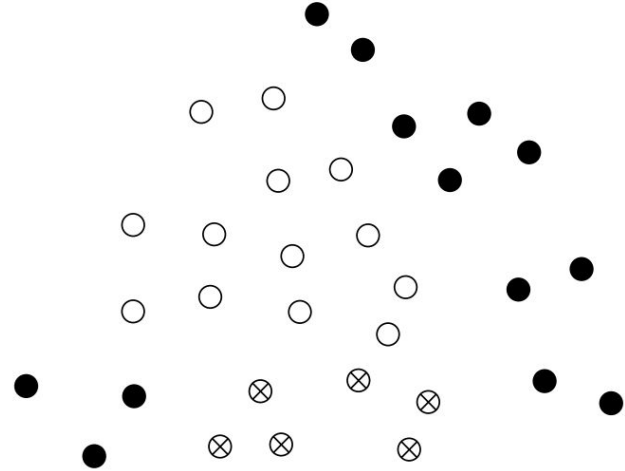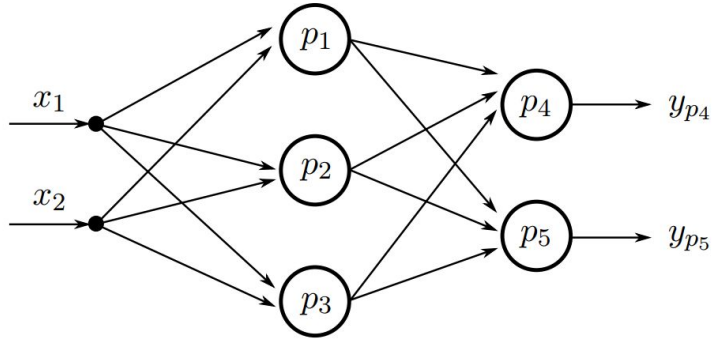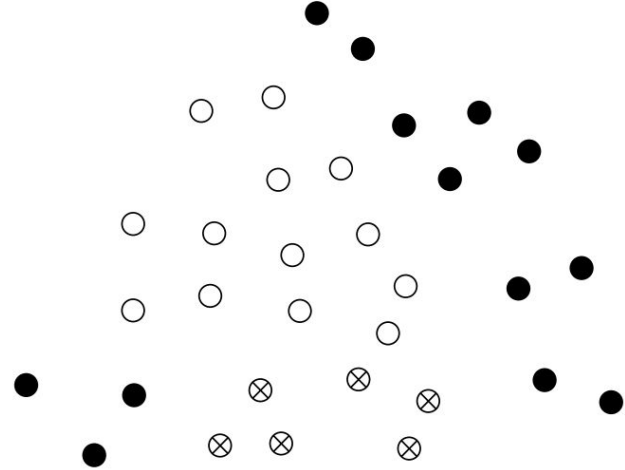# Neural networks
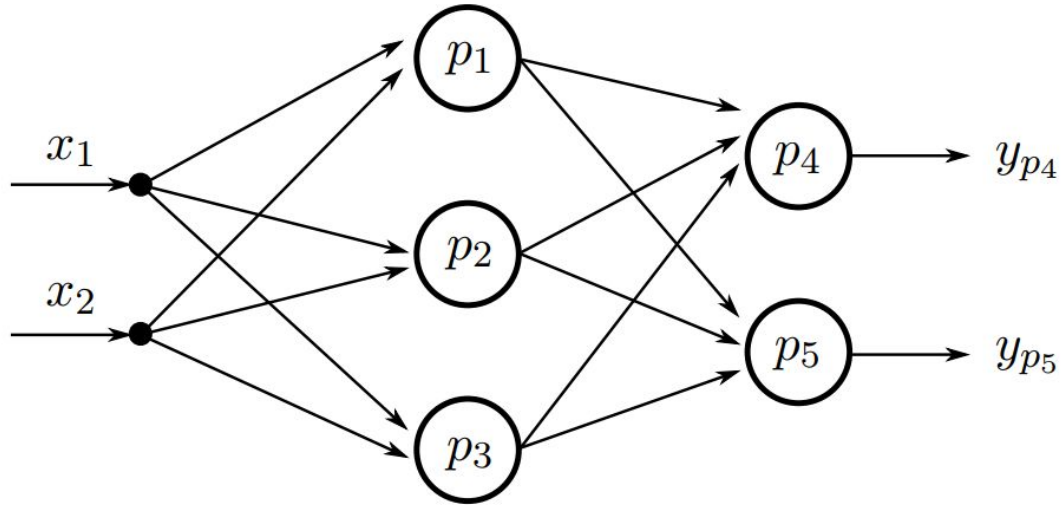
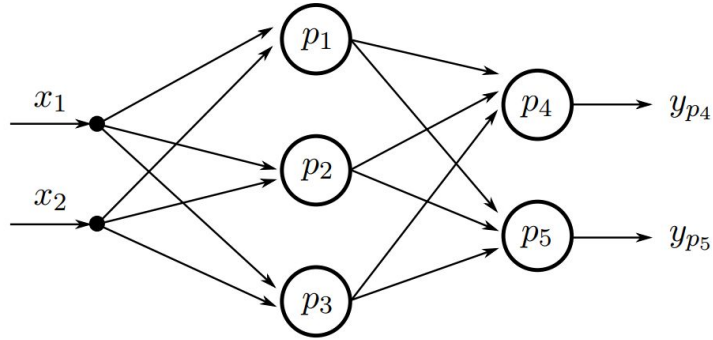# Neural networks - Backpropagation

Neural networks - Backpropagation

Neural networks - Input space separation

Neural networks - Input space separation

$$y = s(\Sigma\, w_i\, x_i - \theta) = s(w_1\, x_1 + w_2\, x_2 - \theta)$$

Neural networks - Input space separation
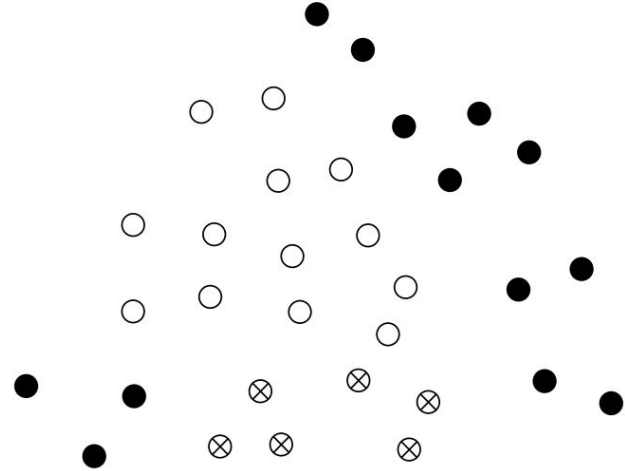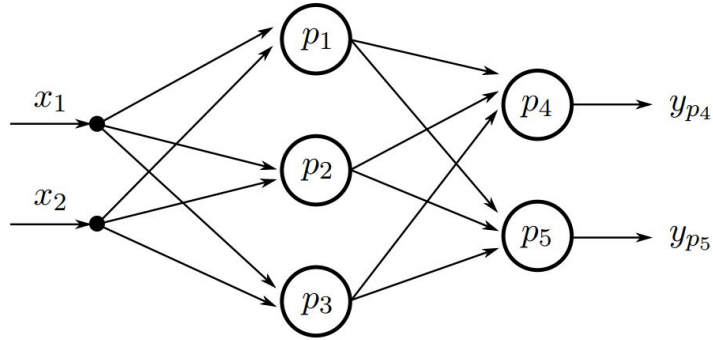
$$ax + by + c = 0$$

$$y = s(\Sigma\, w_i\, x_i - \theta) = s(w_1\, x_1 + w_2\, x_2 - \theta)$$

Neural networks - Input space separation

$(a,b) = (w_1, w_2)$

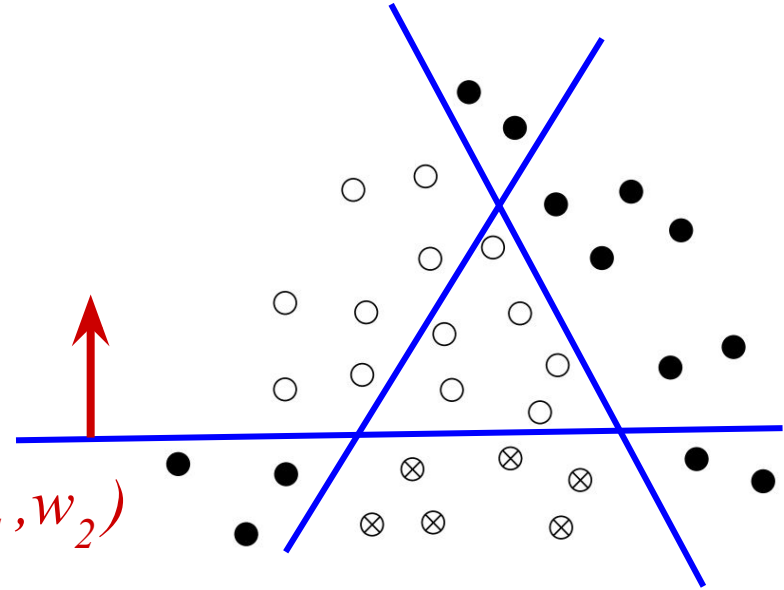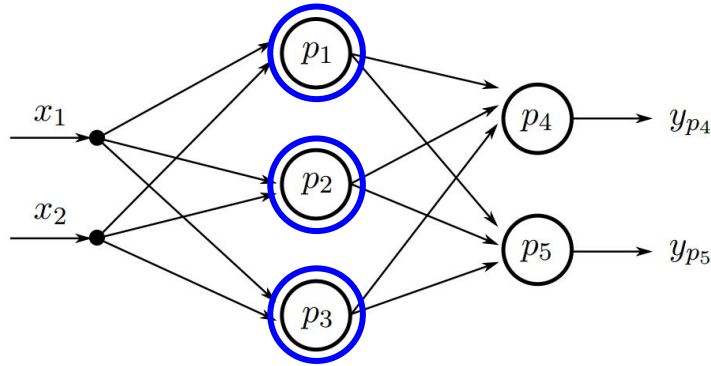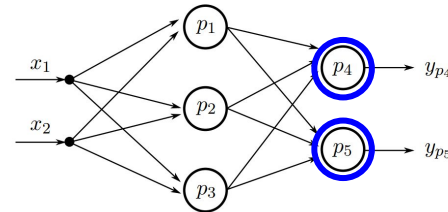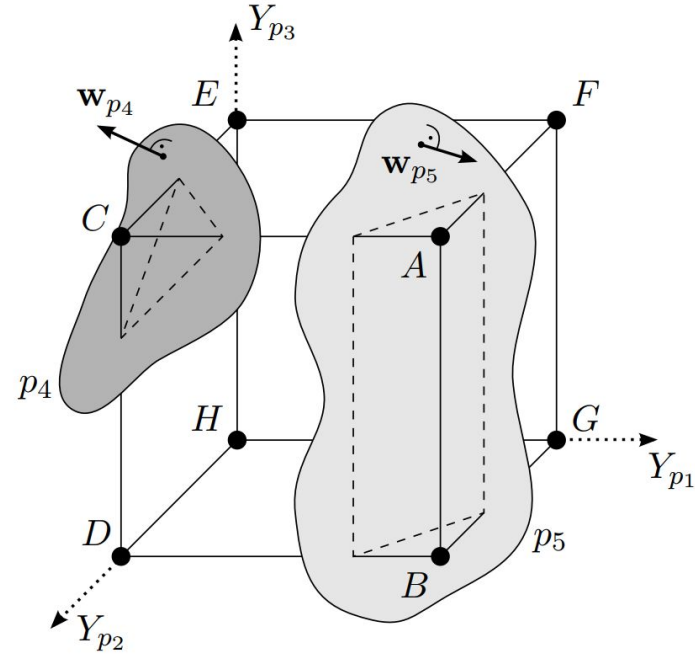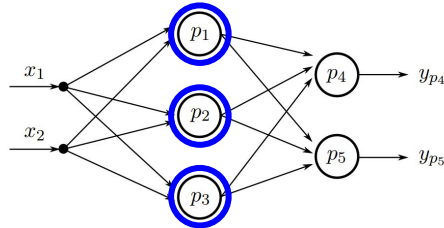$ax \ + \ by \ + \ c = 0$

$y = s(\Sigma \, w_i \, x_i - \theta) = s(w_1 x_1 + w_2 x_2 - \theta)$
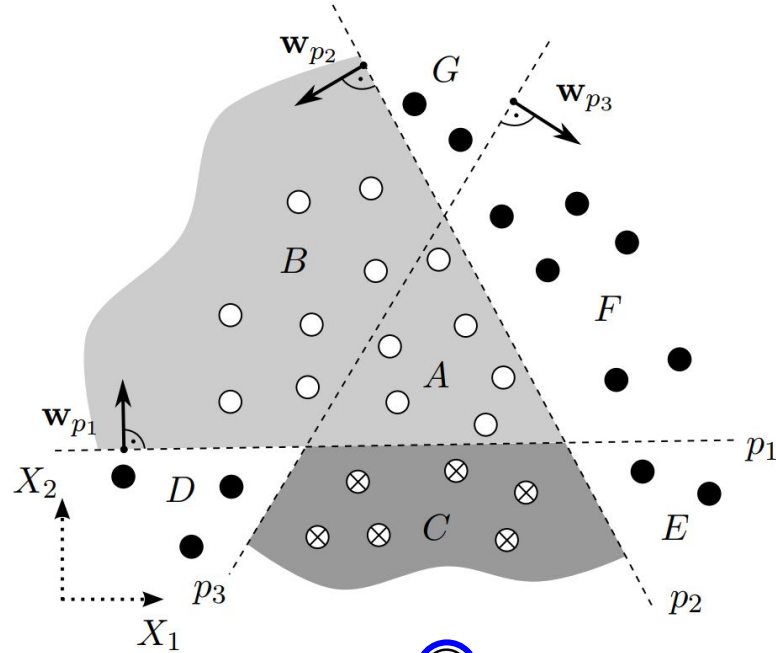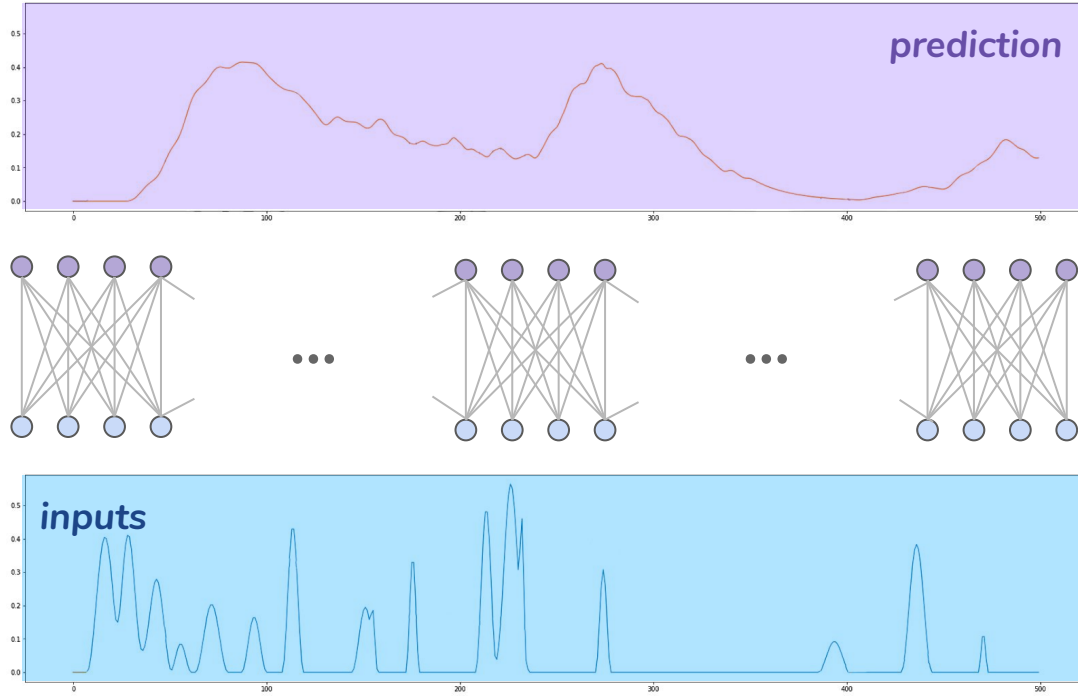
Neural networks - input space separation

Time Series with Neural Networks
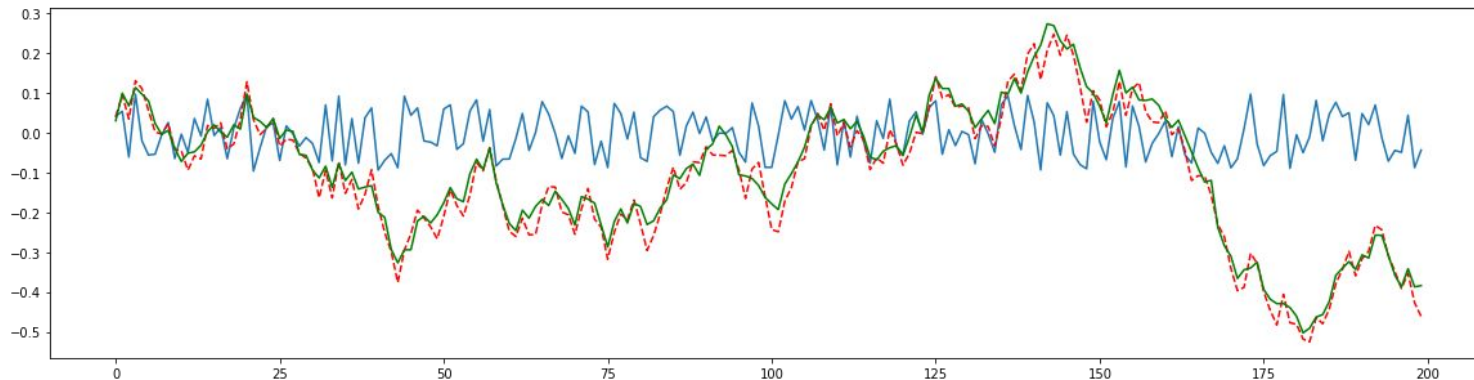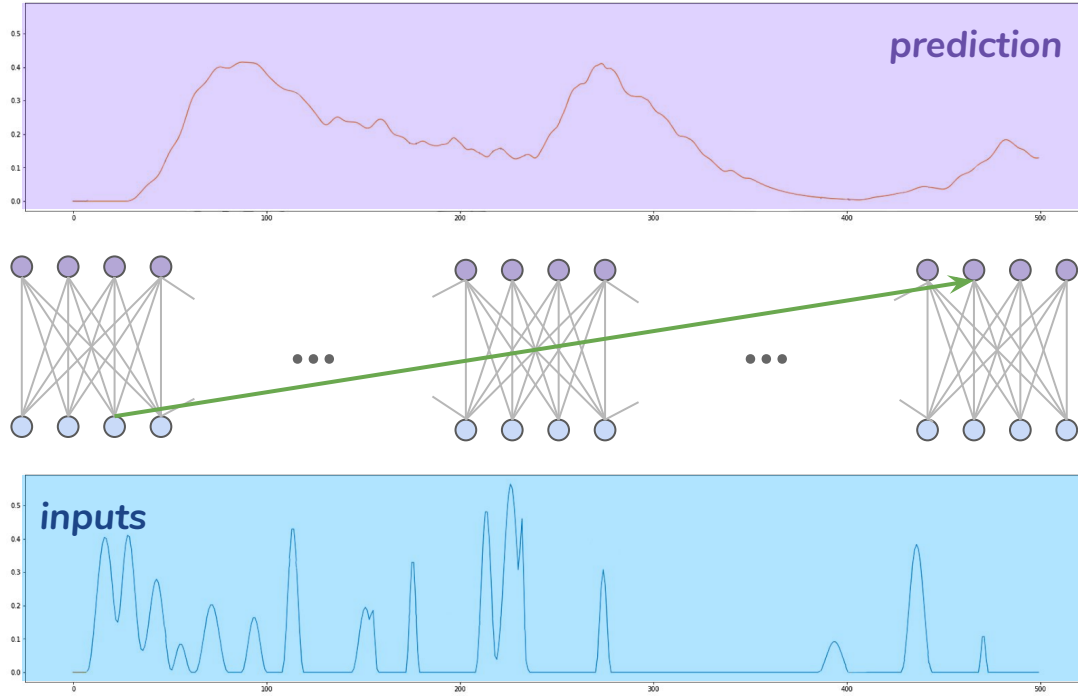

- Simple regression example (random input ⇒ cumulative sum)
- Neural Networks
    - How to **create the model**?
    - How to **generate training data**?
    - How to **express time domain**?
    - How to **train the network**?
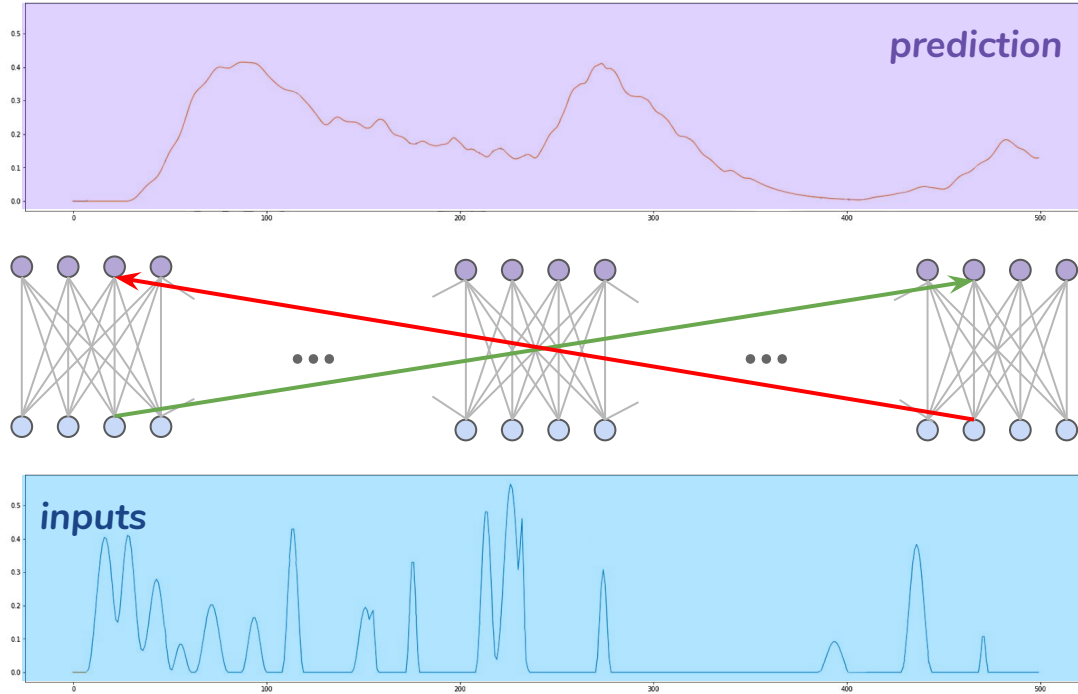
How neural network fits?

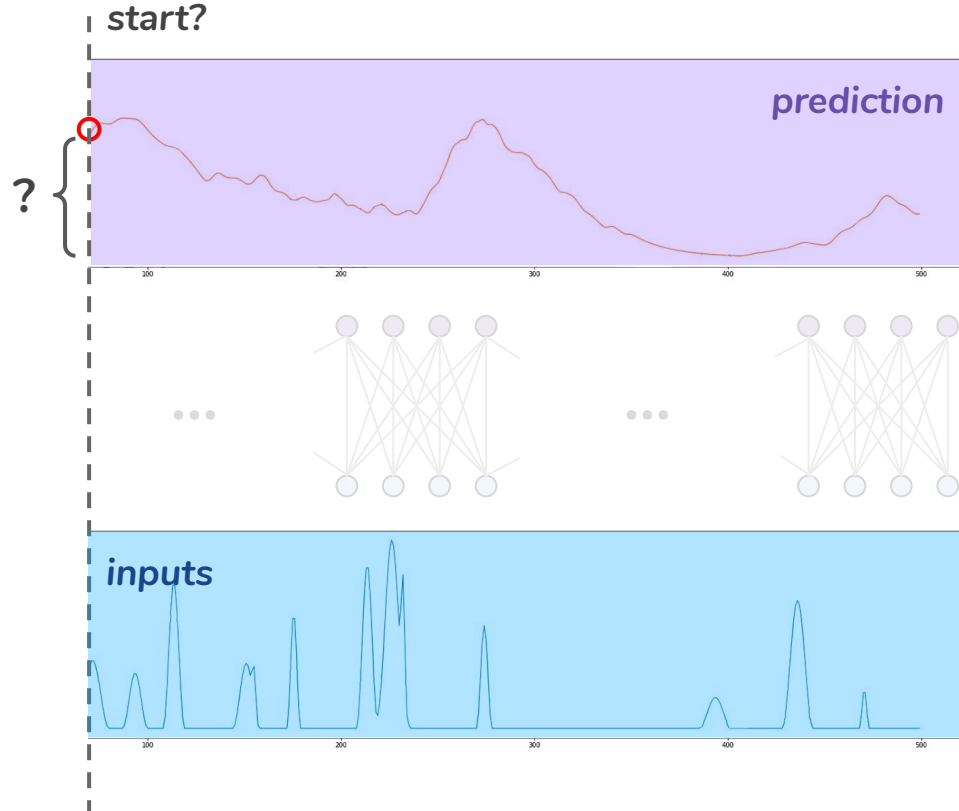# How neural network fits?

How neural network fits?
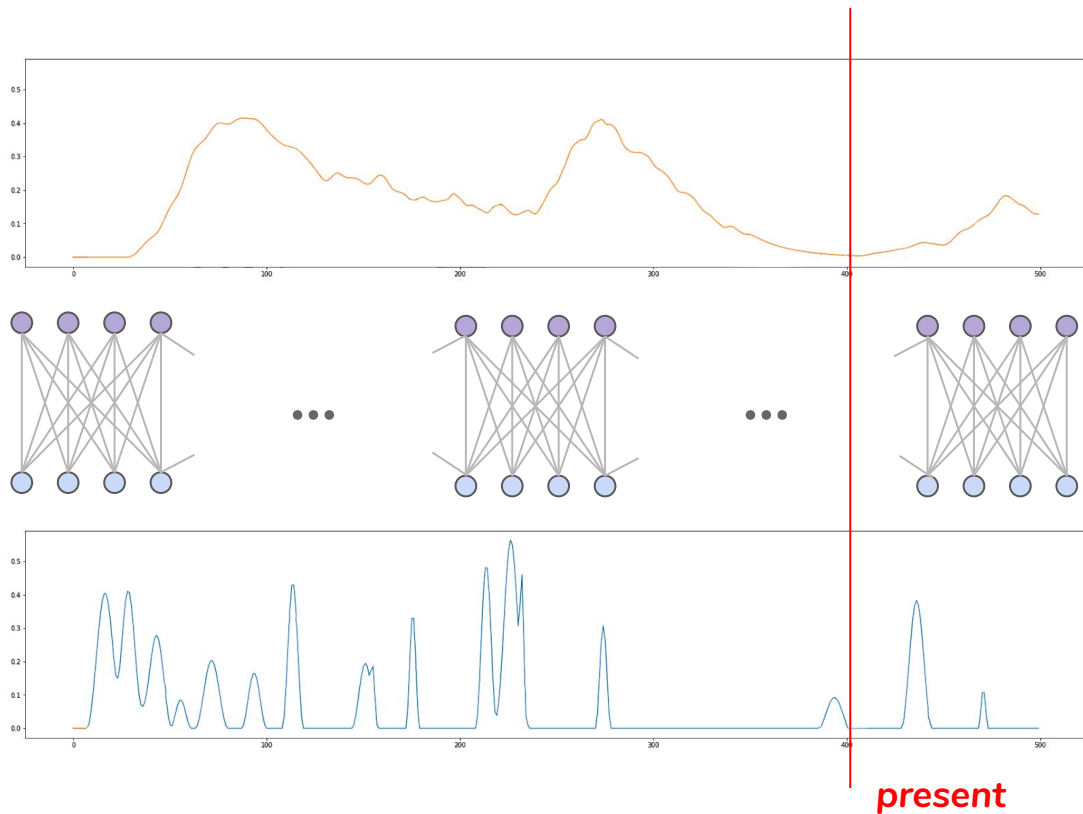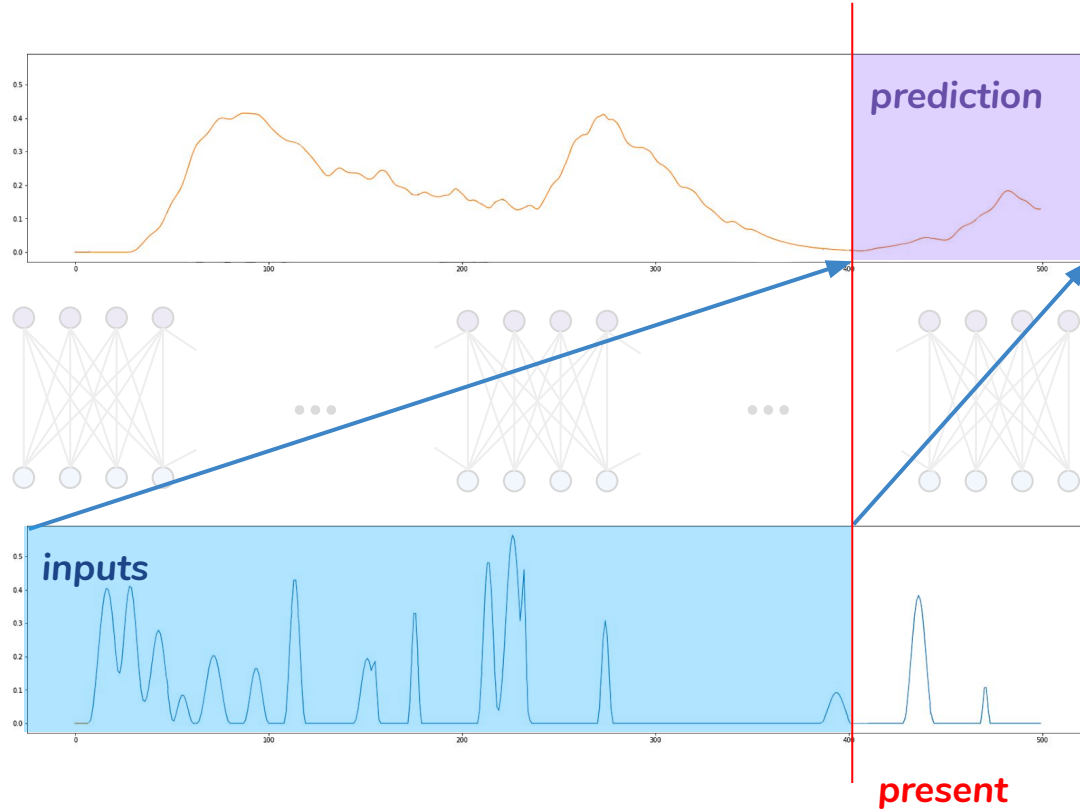

prediction

inputs

predicting
from future ?

How neural network fits?

start?

prediction

?

inputs

How neural network fits?

present

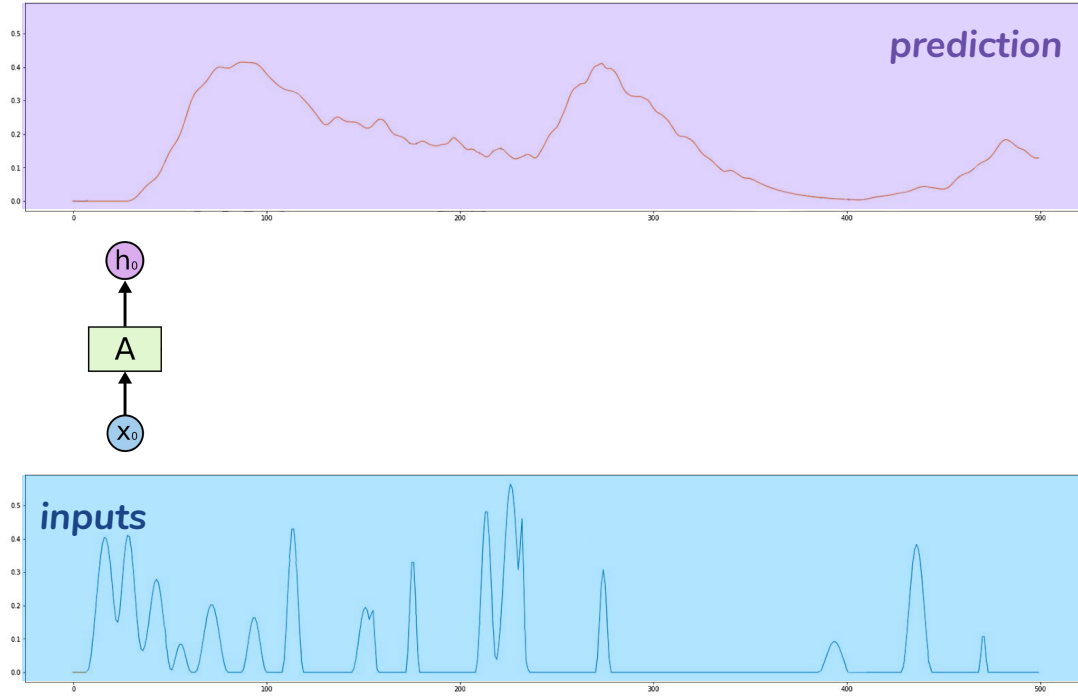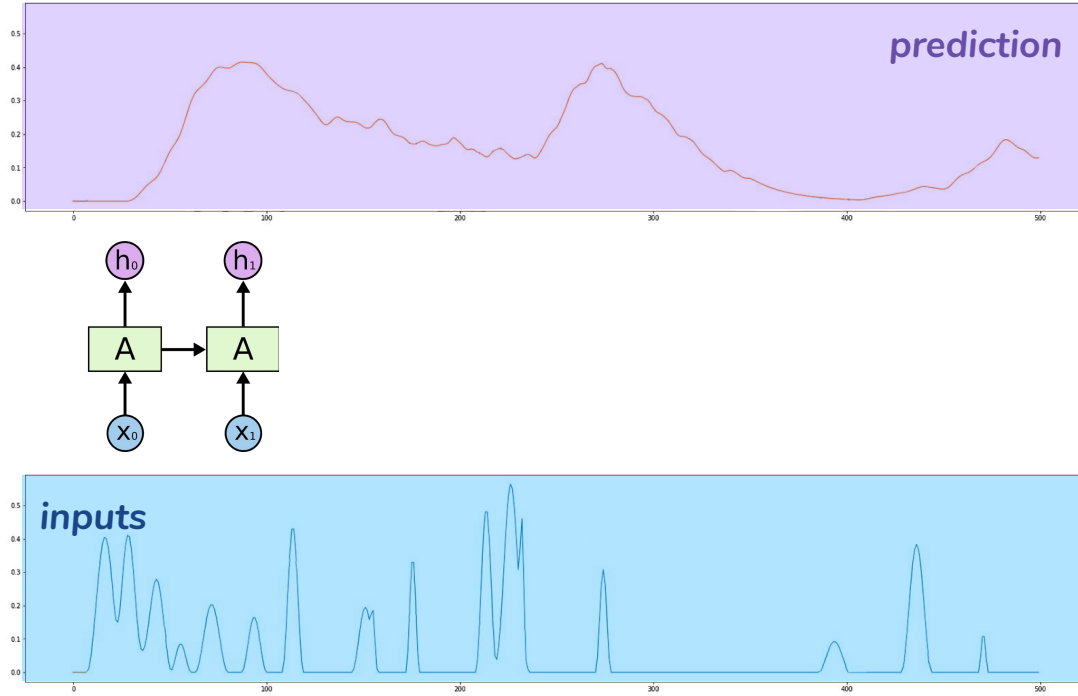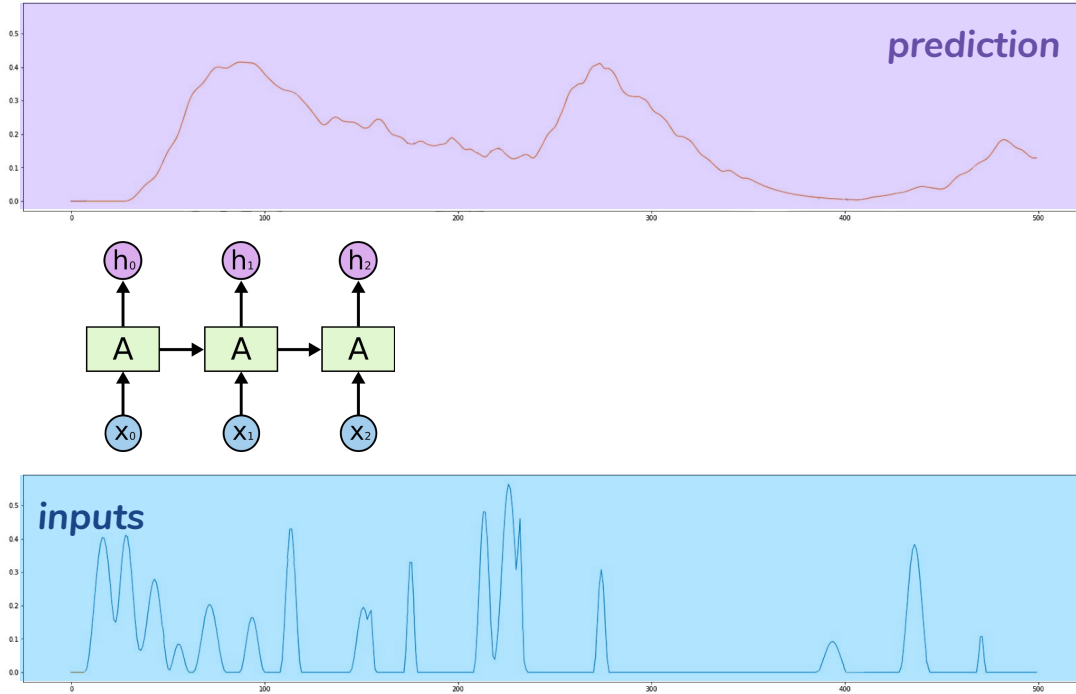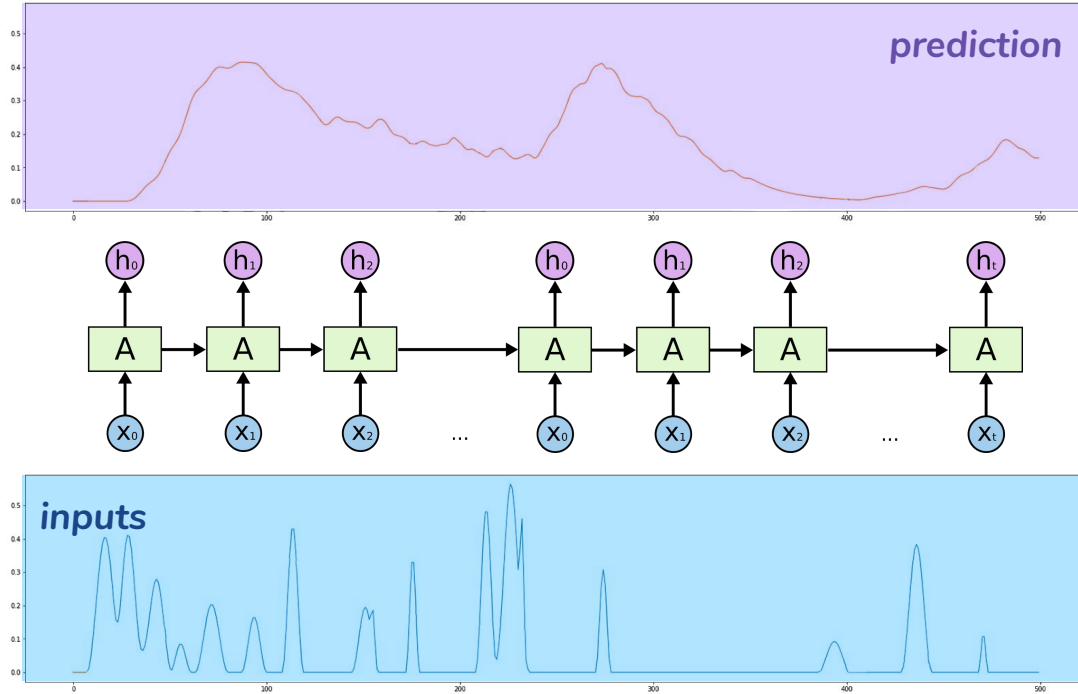# How neural network fits?

Recurrent Neural Networks
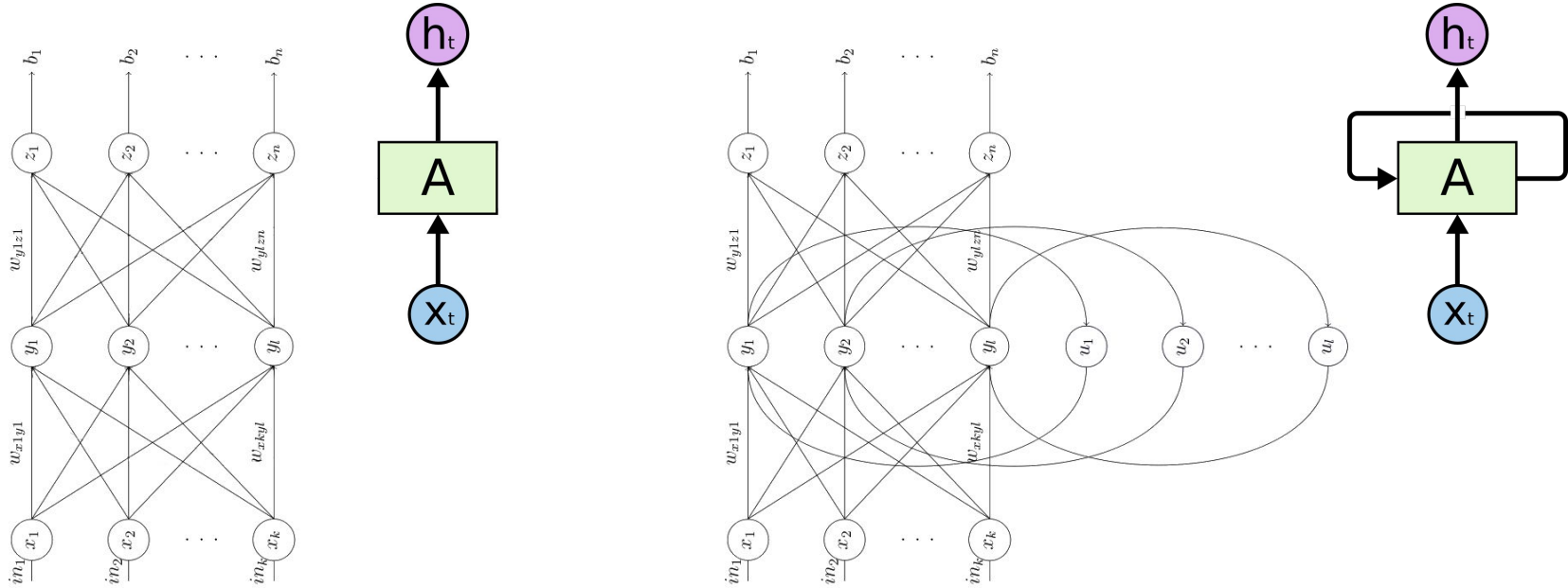
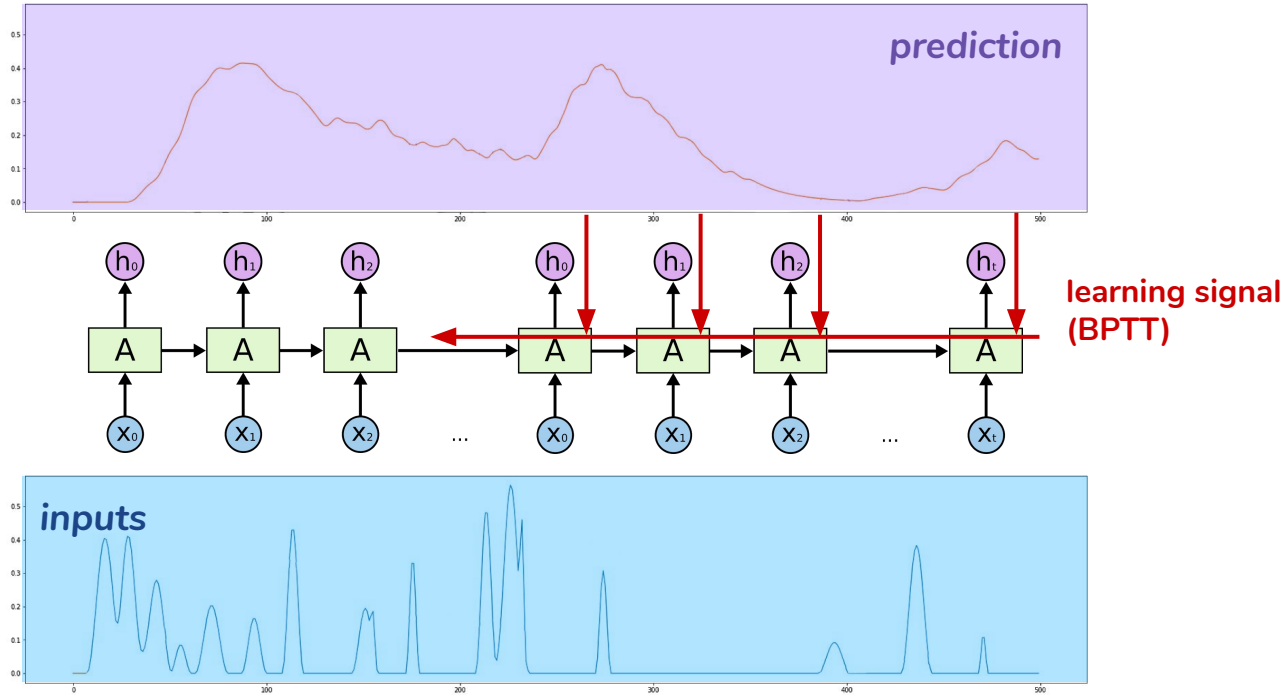# RNN for time series prediction

RNN for time series prediction

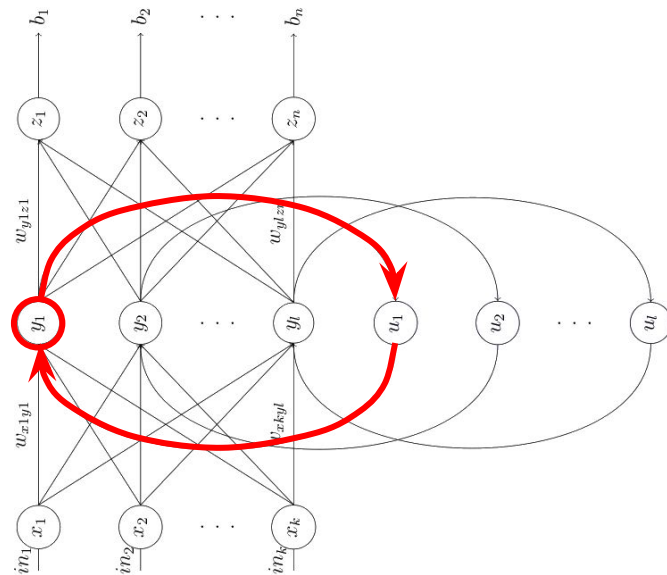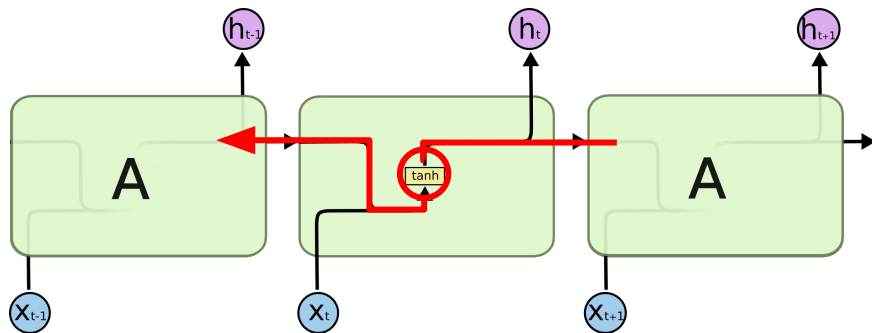# RNN for time series prediction

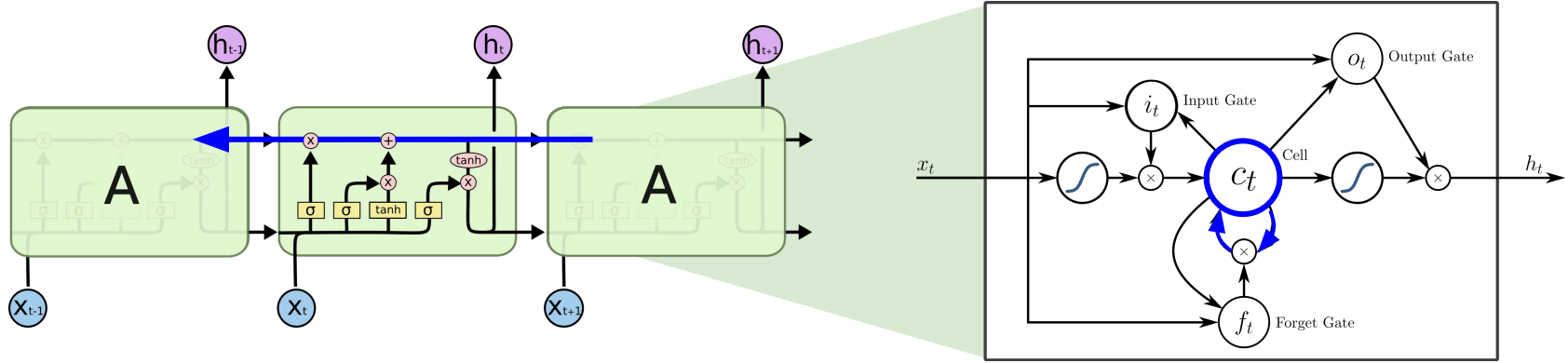# RNN for time series prediction
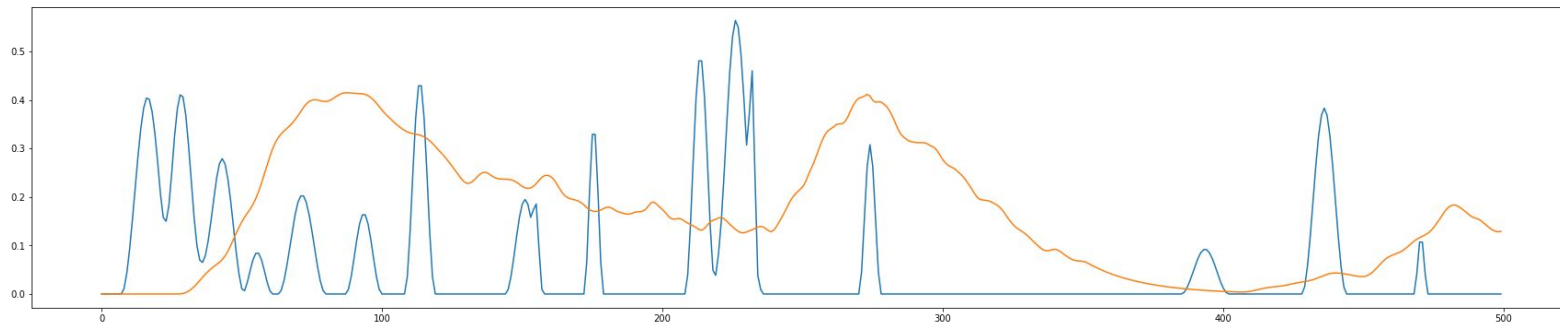
RNN for time series prediction

RNN – Vanishing gradients

Long short-term memory – LSTM

Rainfall-runoff example

- Long delay between **rainfall** on input and **runoff** on output
- Highly **nonlinear dependency** between input and output
- Neural networks
  - embedded nonlinearity
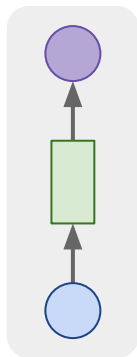 - can handle a lot of inputs

Trampoline jumping example

- Data preparation
  - Dataset normalization
  - Sequence padding
- Binary classification task
  - Target values & dimensions
  - Loss functions
- Training & evaluation
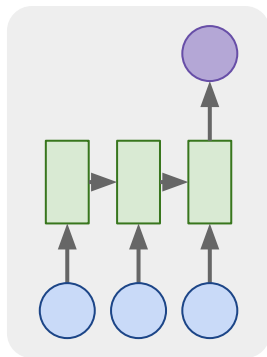 - Inference visualization
  - Evaluation metrics
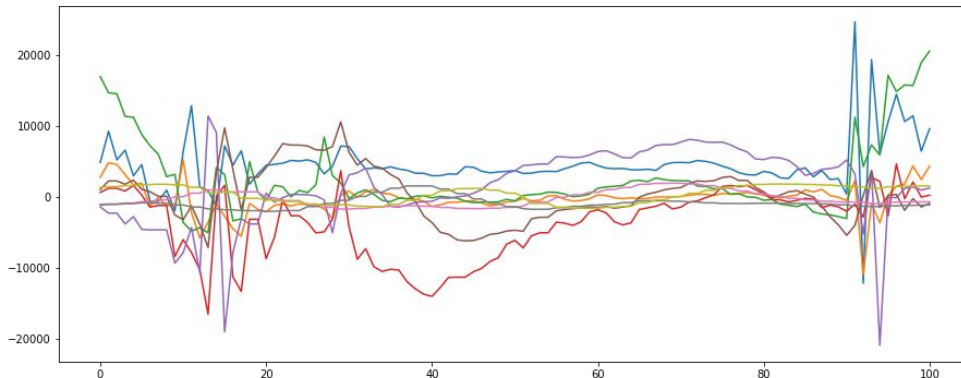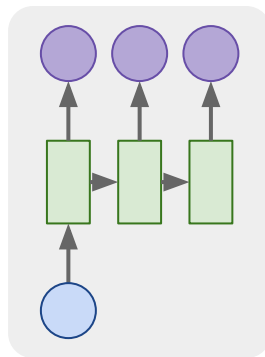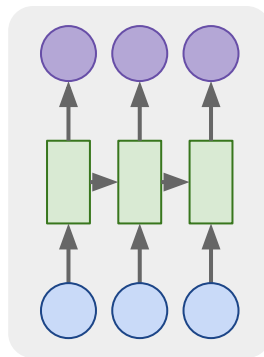
RNN and sequence data
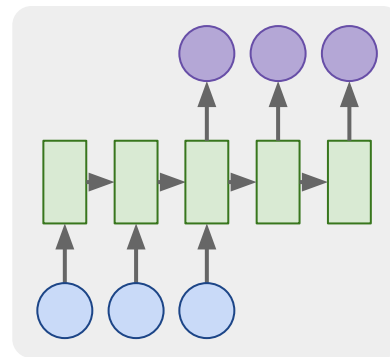
one-one many-one one-many many-many many-many

sequence classification

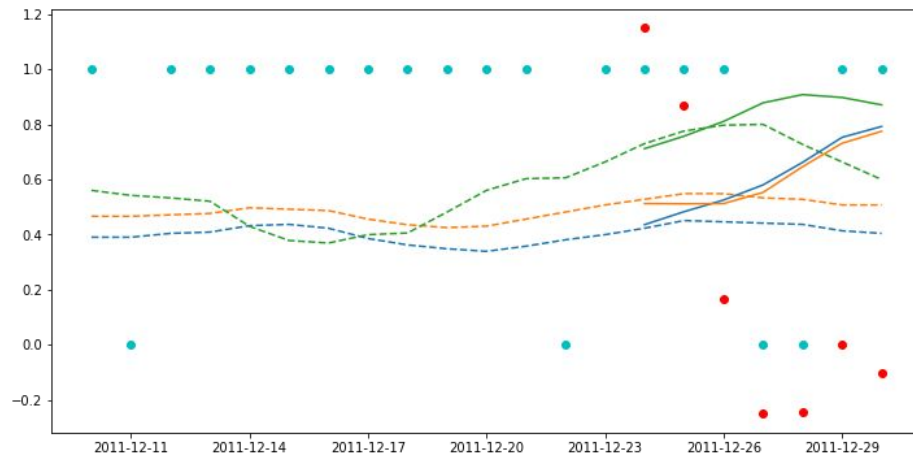image captioning
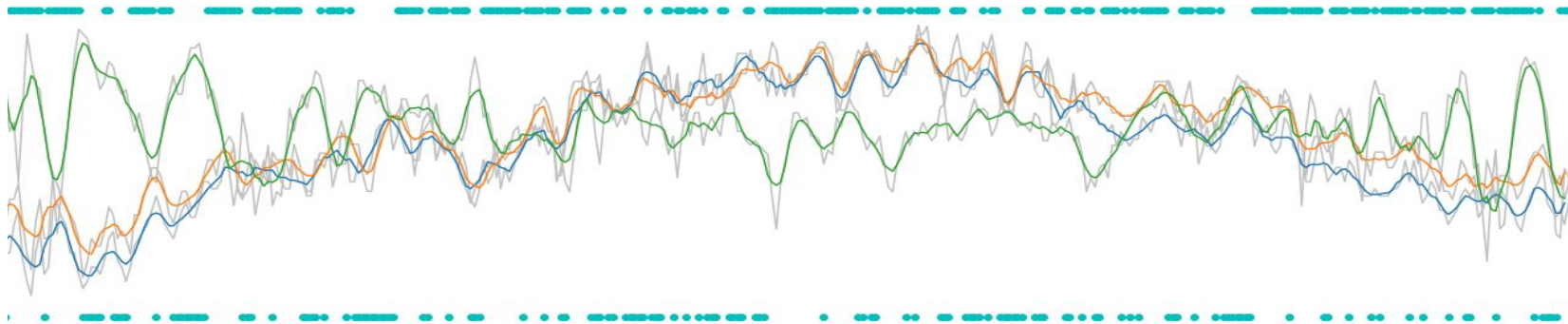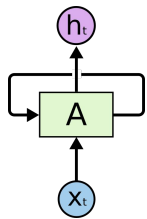
time series prediction

machine translation

Machine
Learning
College

Weather forecast example

- Data preparation
  - Features selection & smoothing
  - Training set generation
- Multivariate regression task
  - Categorical vs. continuous variables
  - Multiple loss functions
- Model variants
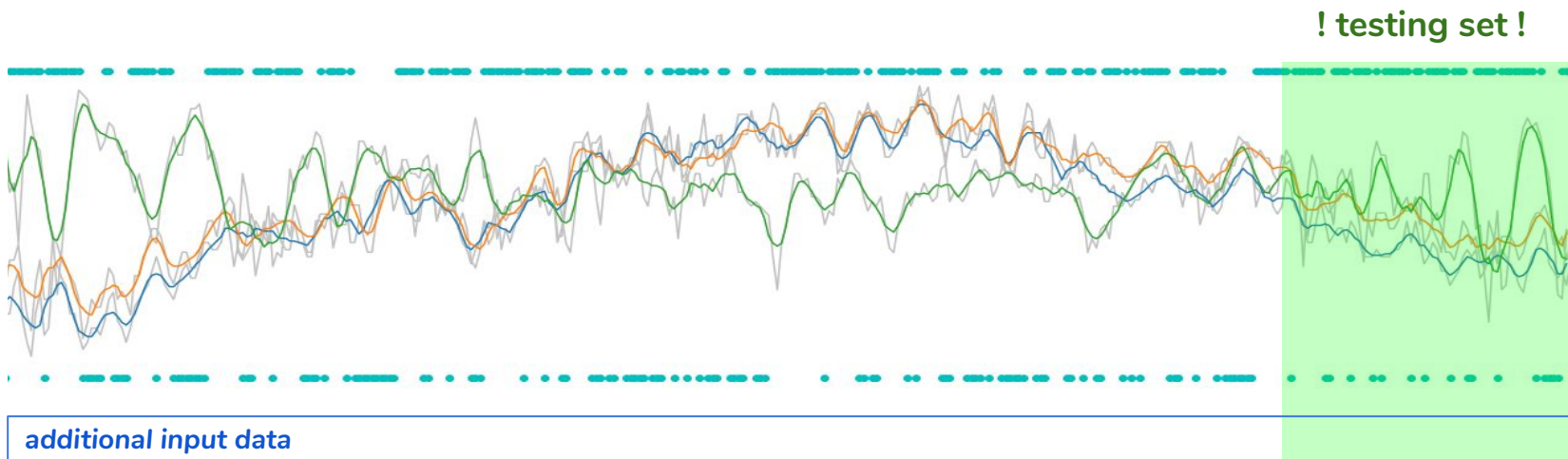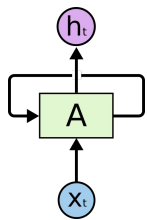 - "many-to-one" vs. "many-to-many"
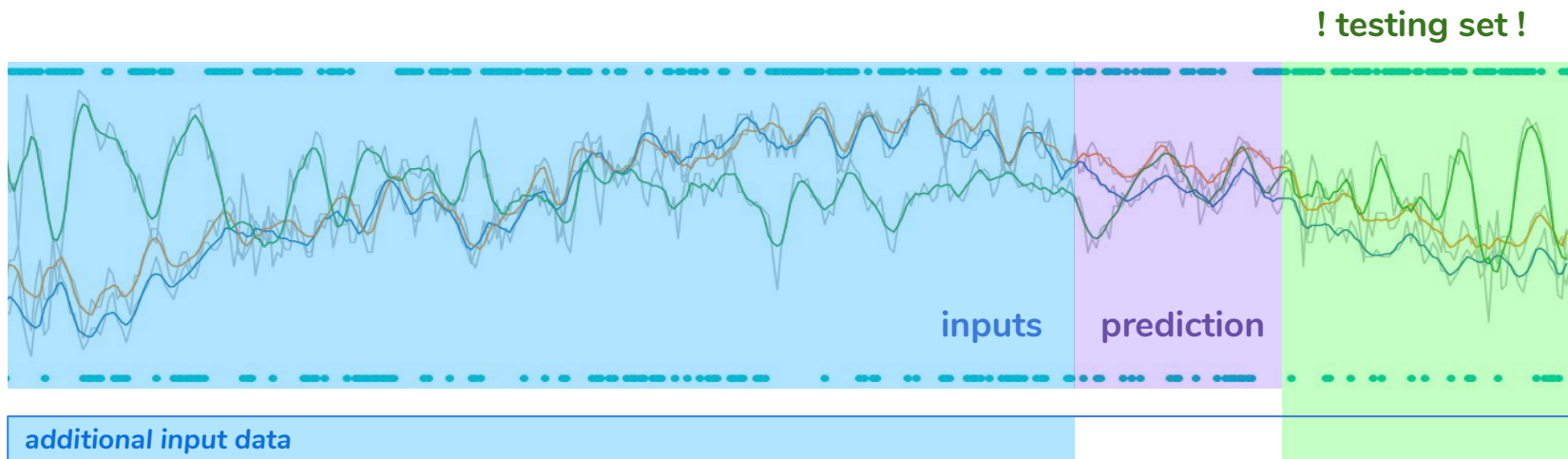 - Off-sample forecasting

Training set construction

additional input data

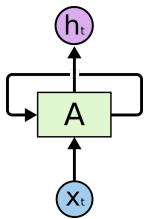# Training set construction

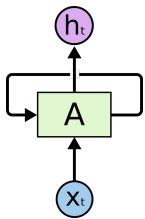! testing set !

additional input data

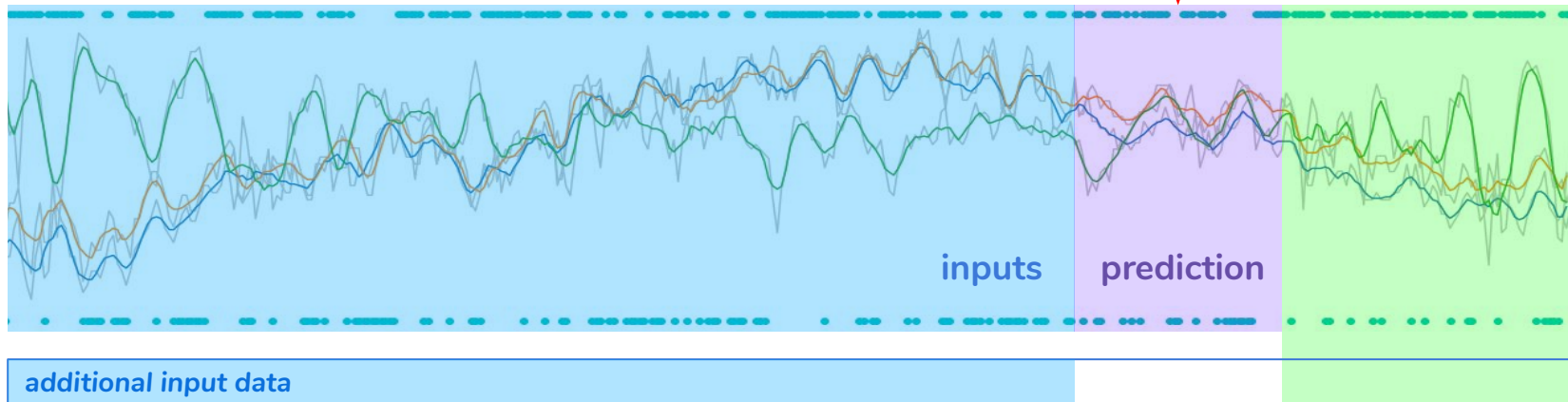# Training set construction

Training set construction

Training set construction

! testing set !

additional input data
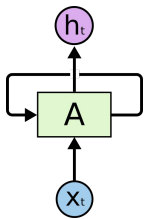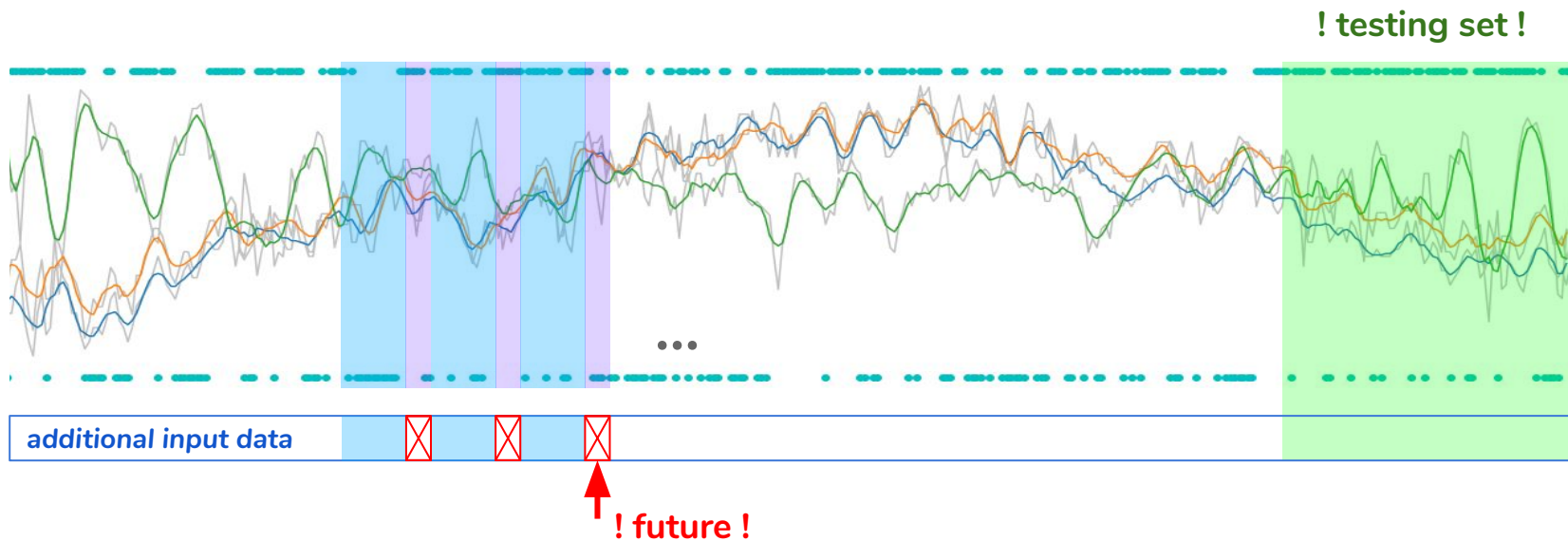
Training set construction

! testing set !

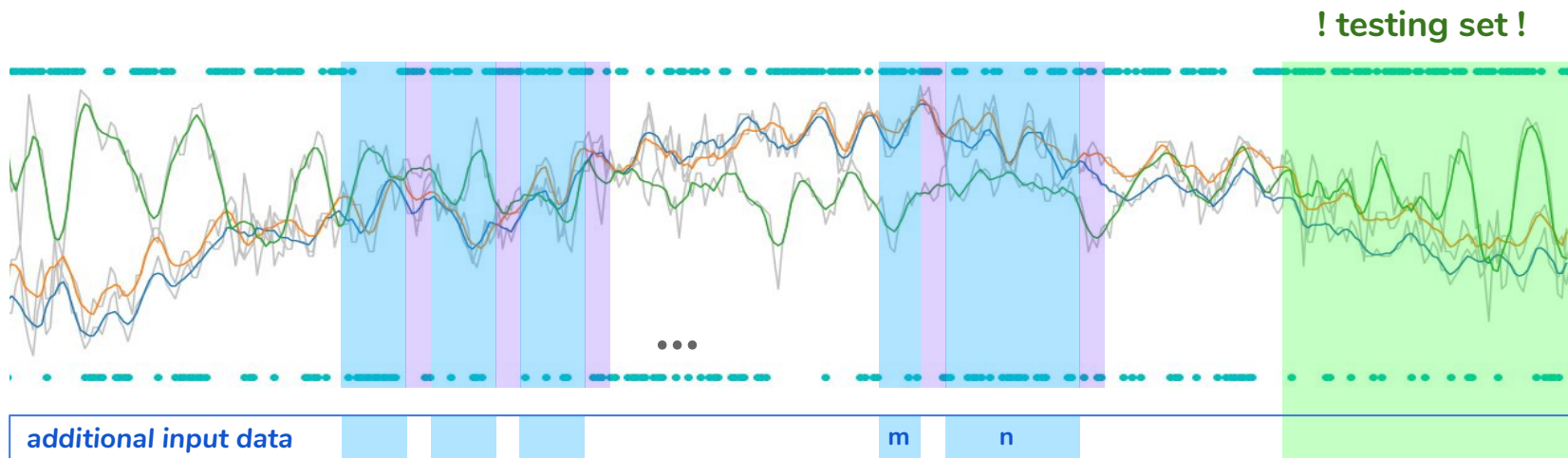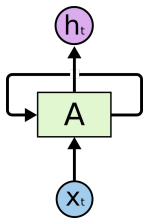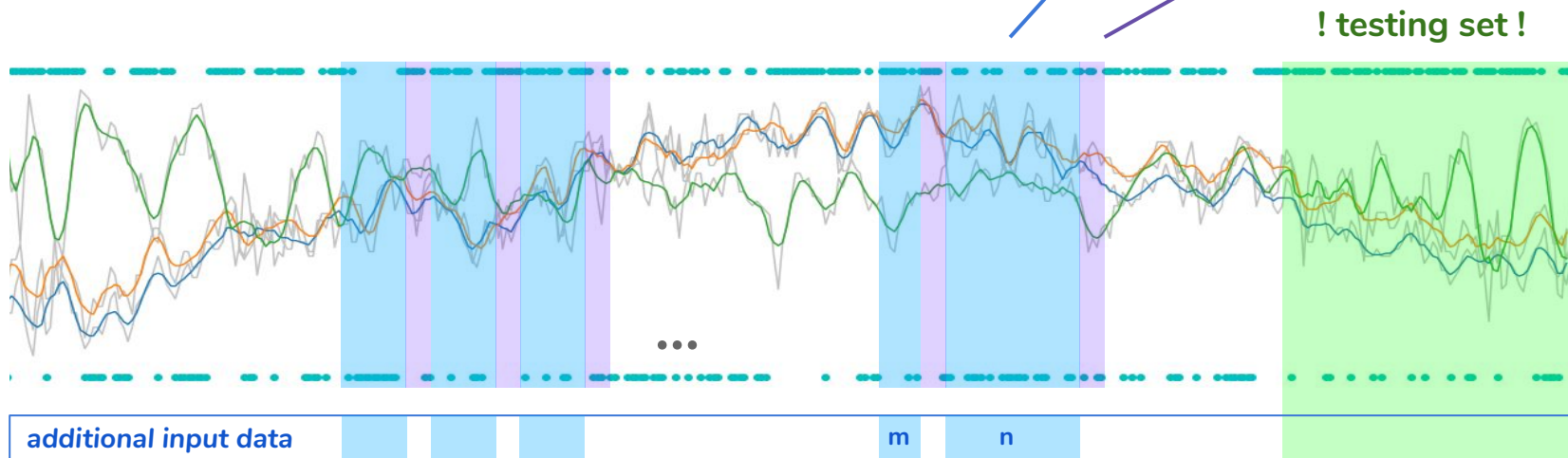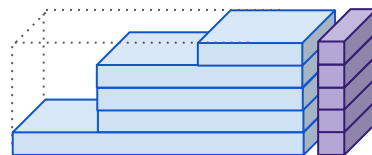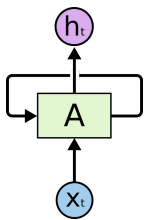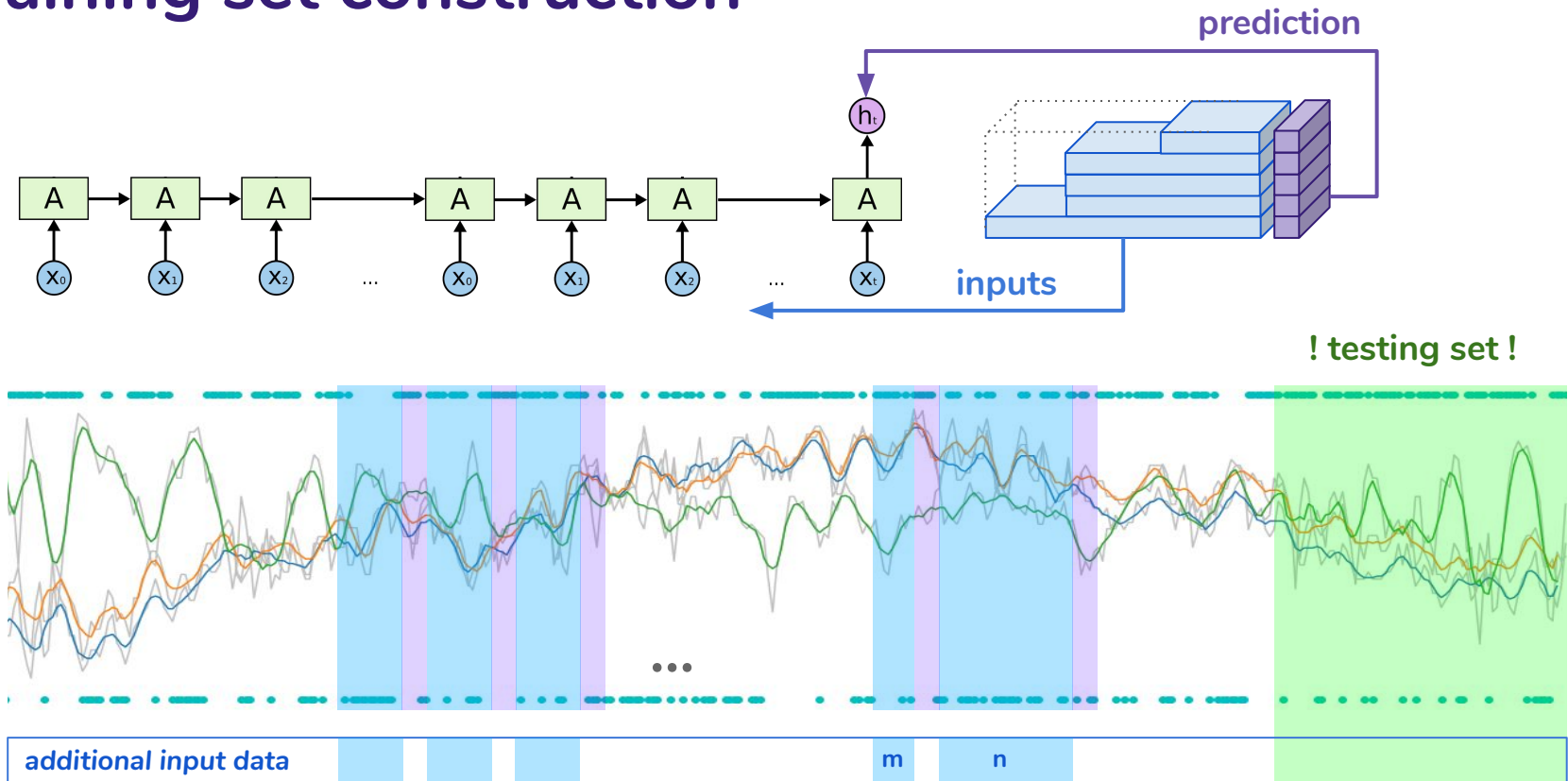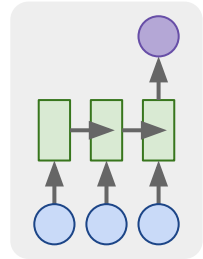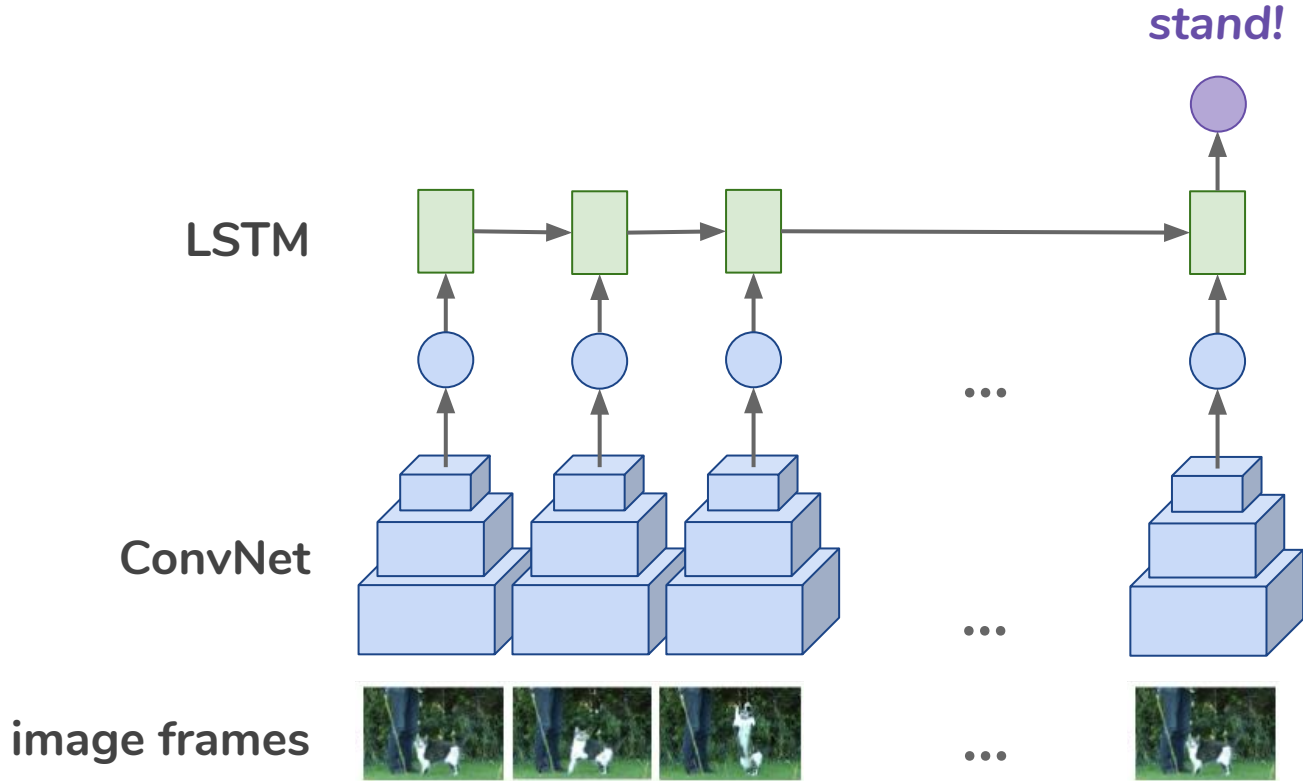additional input data

! future !

Training set construction

! testing set !

additional input data   m   n

Training set construction

! testing set !
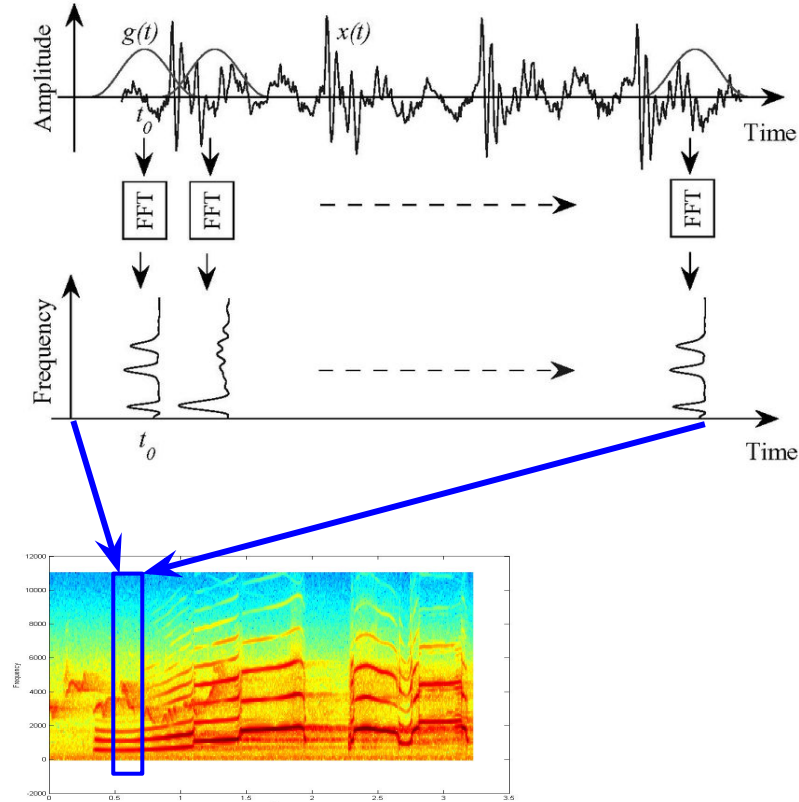
additional input data   m   n
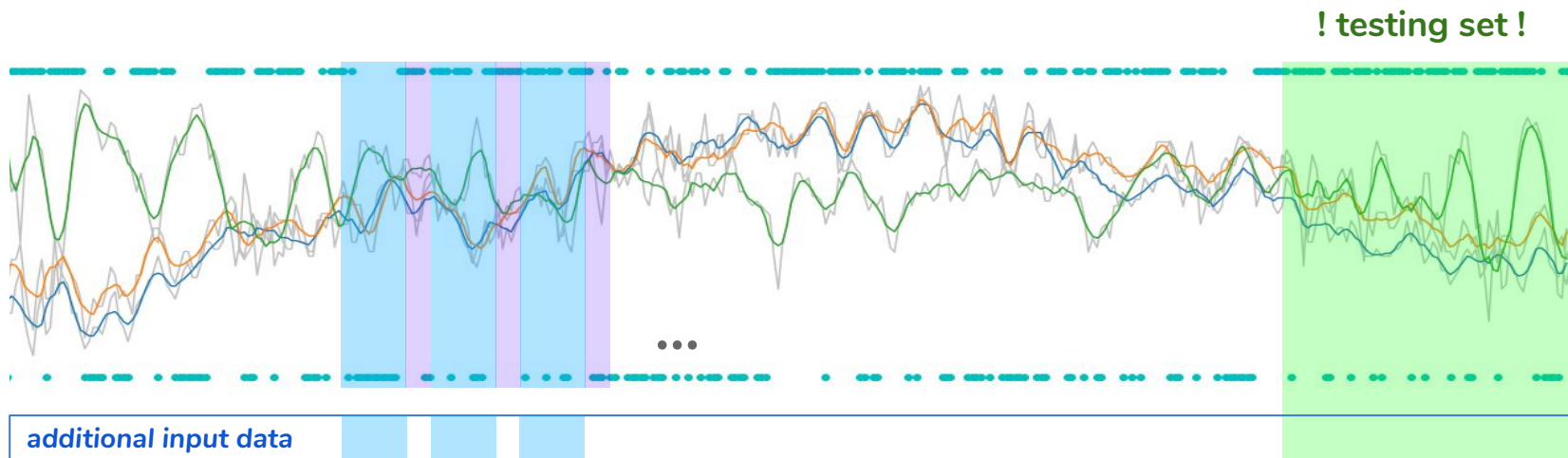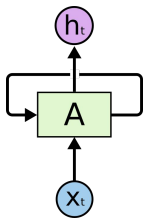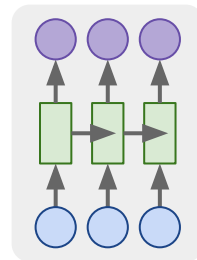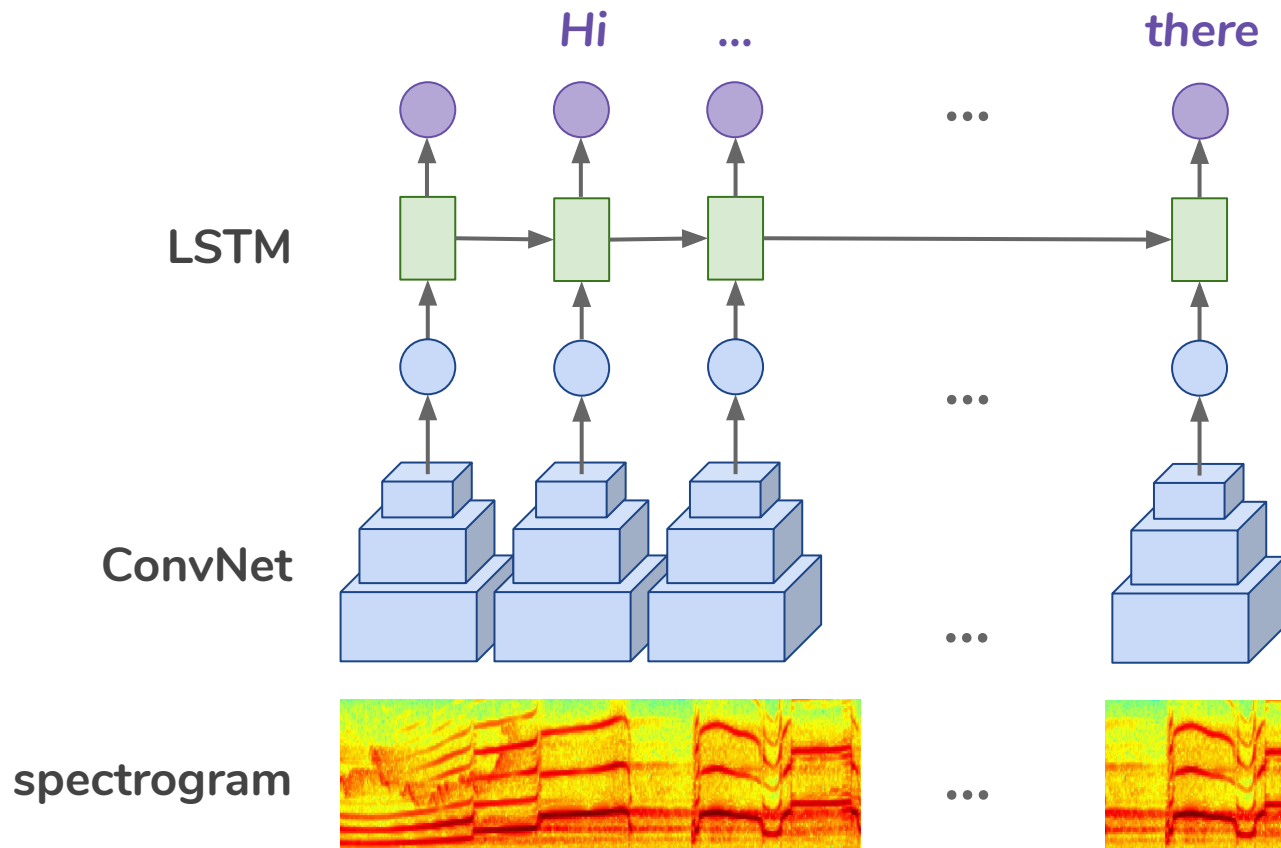
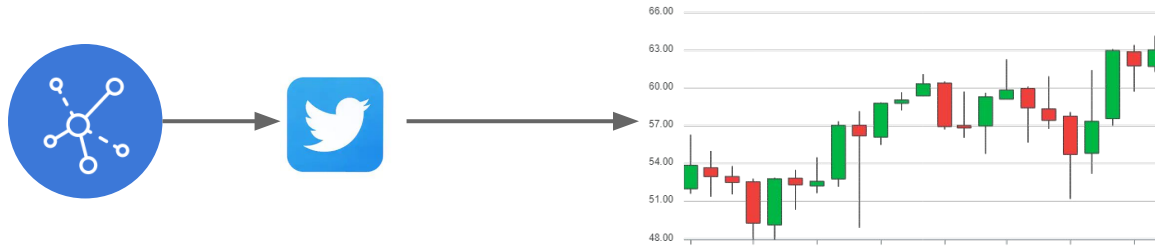# Training set construction

Video clip classification
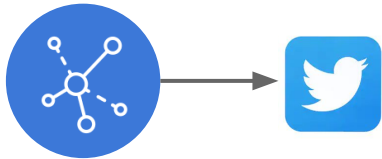
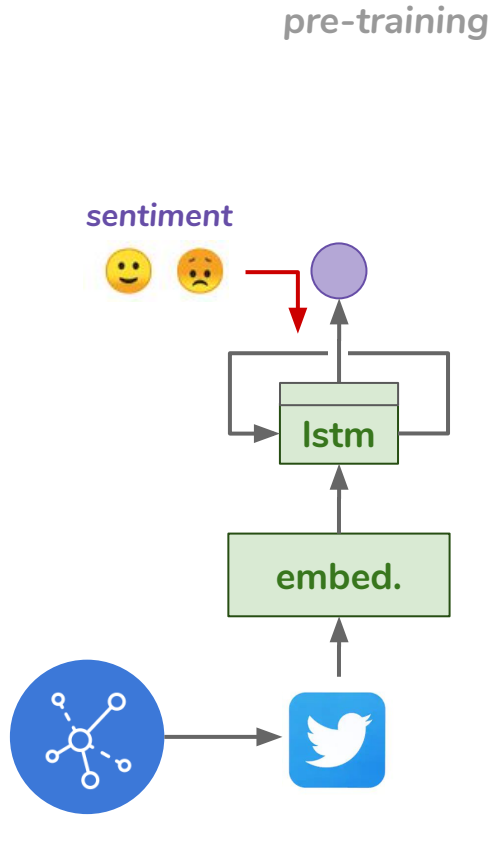# Short-time Fourier Transform

Speech recognition
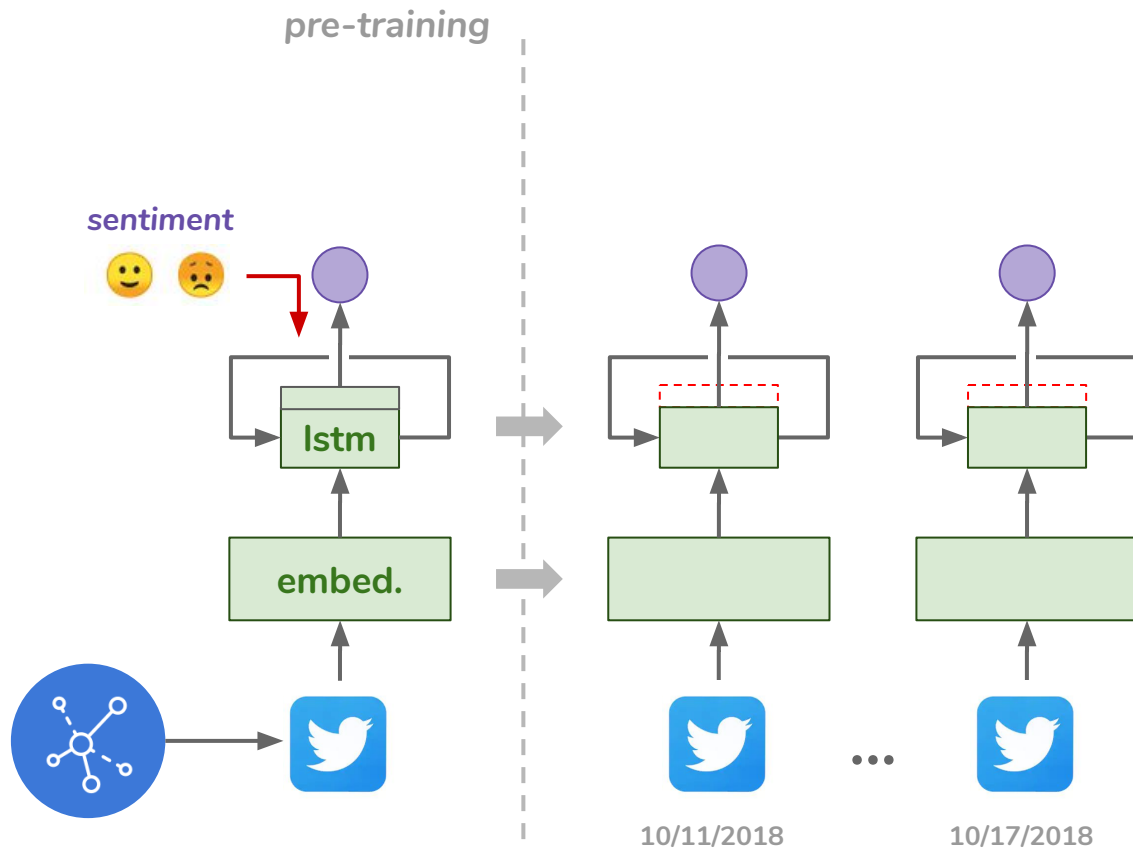
Time series prediction from textual data
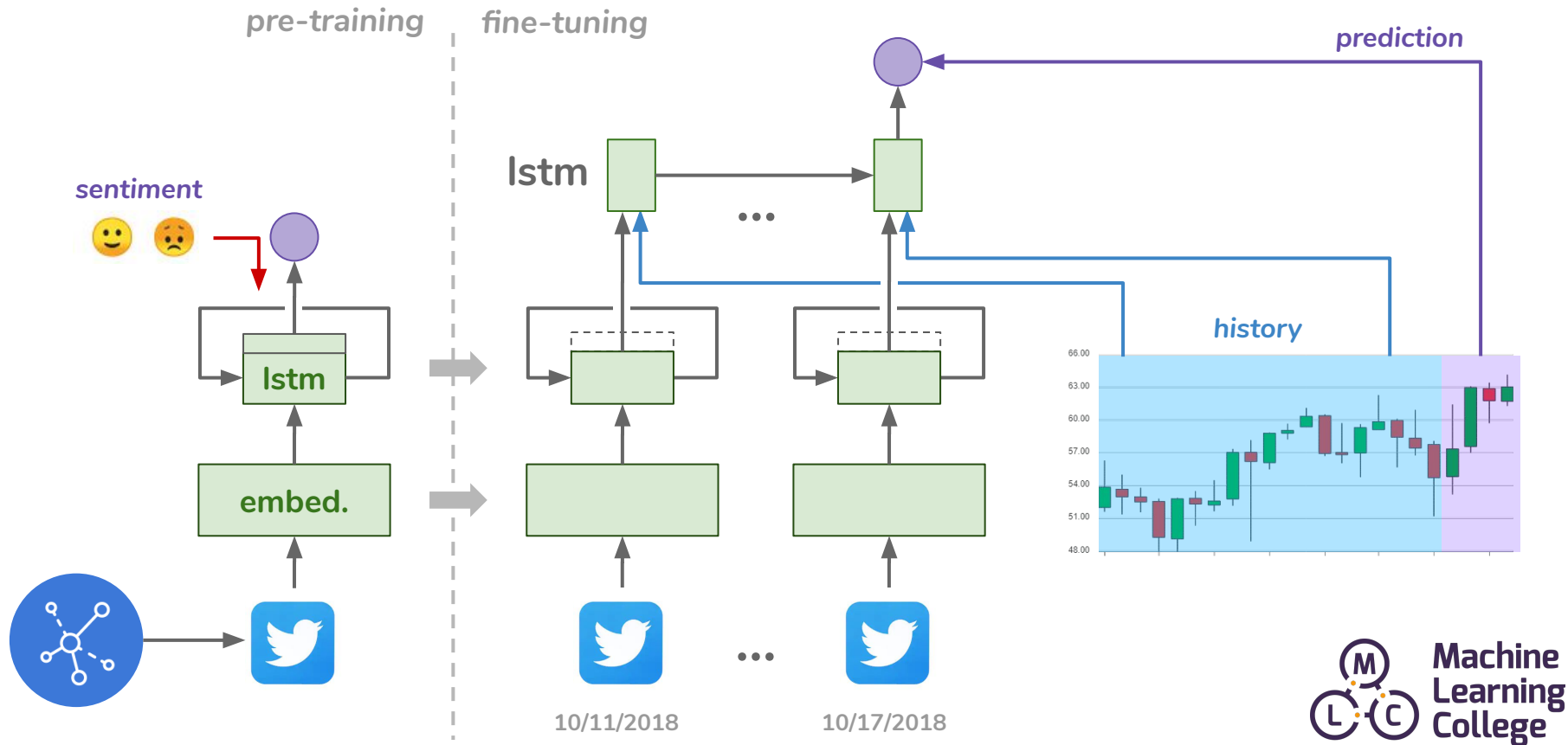
Time series prediction from textual data

Pre-training with additional data

Transfering model & exposing feature layer

Fine-tuning with time series target data

Fine-tuning with time series target data