Advanced Time Series

Lecture 2:
Forecasting - I

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HW 1 review

A **lot** of confusion and trivial mistakes.

- `sum` instead of `mean` in P2 and P4
- trying to open local files
- series, tuples, whatever instead of tensors in P4
- missing imports, undefined variables, `Test` instead of `TEST`

HW 1 review

Solution:

- **new deadline** on midnight Tue/Wed
- only if you submitted the first time
- only simple fixes, no rewrites
- If you have already got 5, 6 or 7 - just let it go

HW 1 review

Solution:

- we'll take a couple of days to figure out how to manage the class
- slides and notebooks are universally available
- Slack and HW validation - only in full mode

Today

Time series forecasting:

- **high-level** discussion
- **classical model** and its limitations
- naive **LSTM encoder-decoder** model and next steps

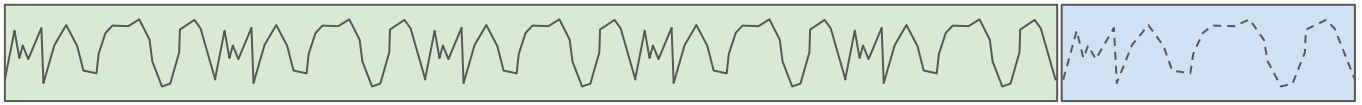
TS forecasting problem

Forecasting:

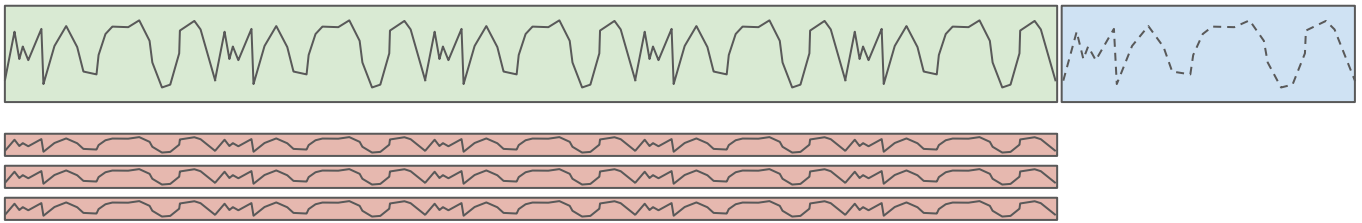
- estimate the **target time series in the future** using past data (endogenous)
- sometimes, you may know **something else besides target** (exogenous)
- depends strongly on **time scales** of relevant processes

TS forecasting setup

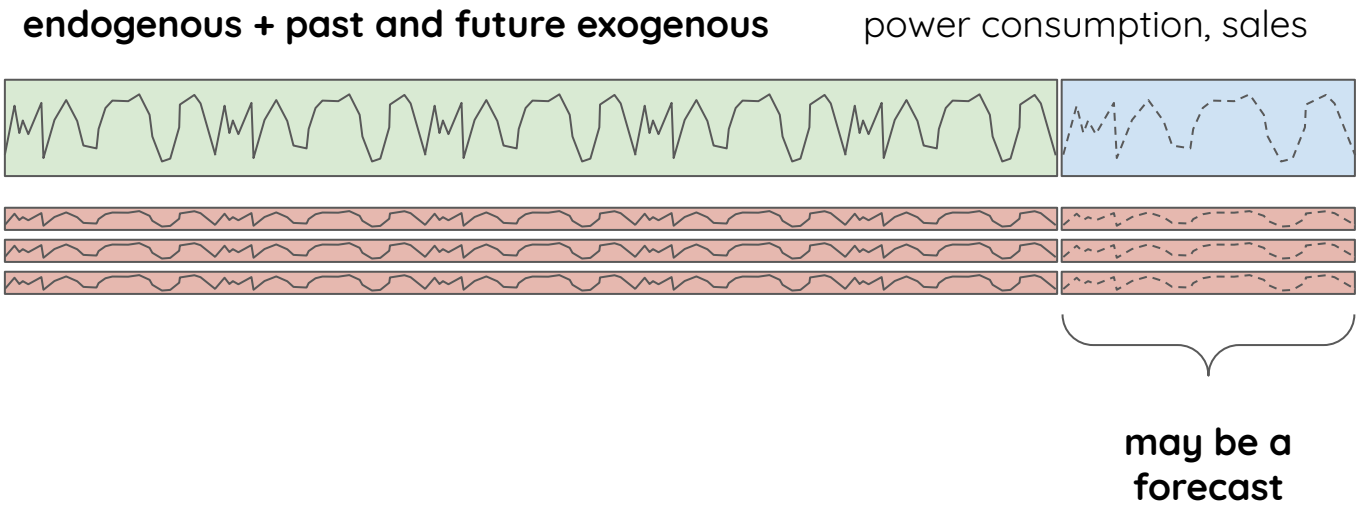
endogenous only weather time series, power consumption, sales



endogenous + past exogenous manufacturing



TS forecasting setup



TS forecasting: past and future

- future values may depend on past information
- they can depend on the future information as well
- you cannot forecast if you do not have information
- **no free lunch**

TS forecasting: past and future

Power consumption **tomorrow** depends on:

- consumption **today, yesterday**, etc.
- weather **tomorrow**,
- traffic **tomorrow**

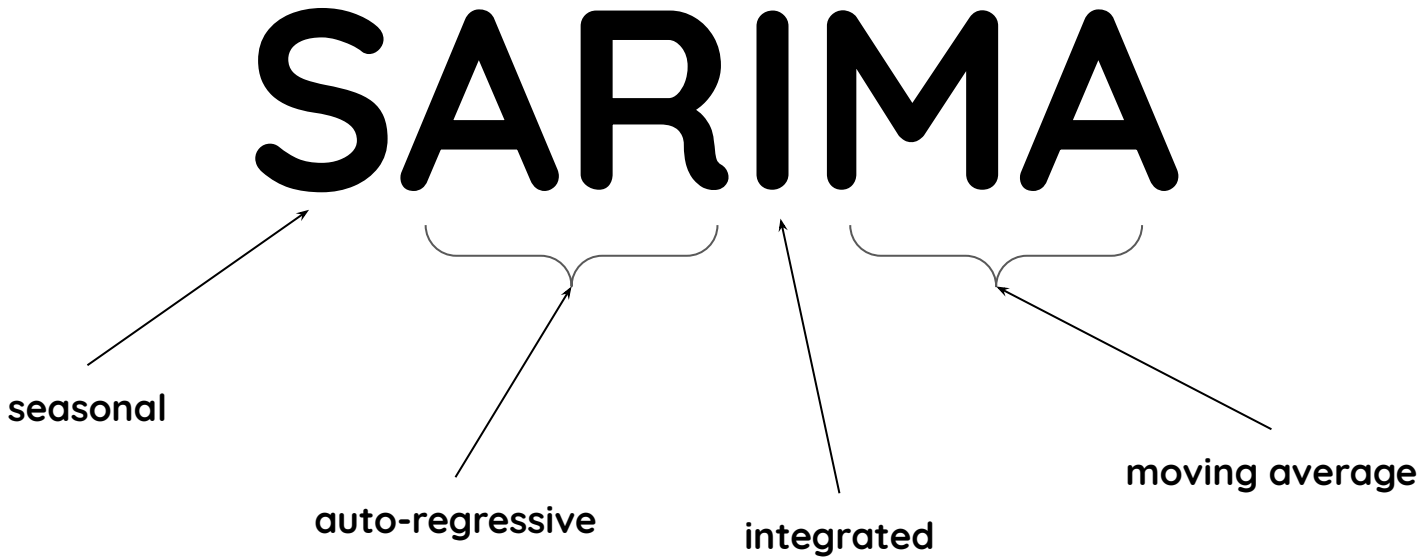
Classical TS forecasting

Power consumption

Power consumption data in US grid:

- multiple years
- hourly
- generally clean
- seasonality patterns on multiple scales

SARIMA


SARIMA
seasonal
auto-regressive
integrated
moving average

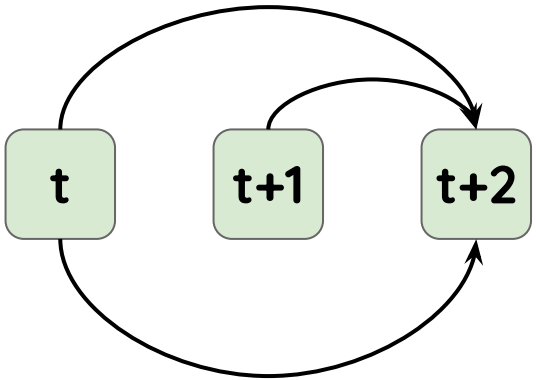
SARIMA: tools

`statstools`:

- a lot of time series functionality
- a lot of classical time series models
- convenient plotting

SARIMA: ACF & PACF

ACF: MA part



PACF: AR part

Classical models limitations

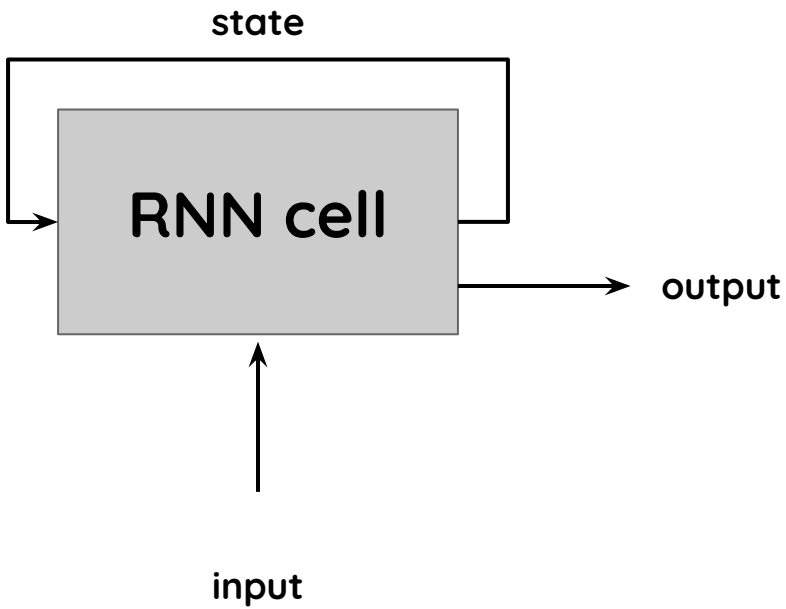
- linearity
- multiple seasonalities
- stationarity
- somewhat tricky
- **good baseline**

Data generation process

- all the underlying processes, which result in the observed data
- may be multilayered and non-linear
- not everything is known at inference time

Recurrent models

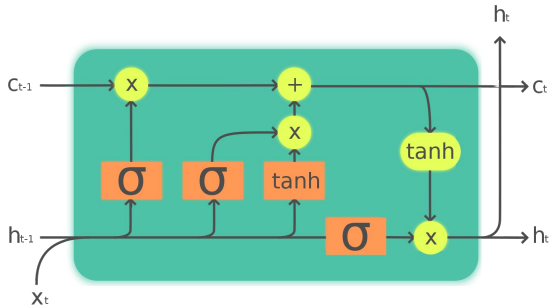
Recurrent neural network



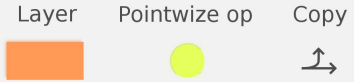
Recurrent neural network

- **sequential** data
- have their own problems
- can be combined with other blocks (CNN)

LSTM: idea



Legend:



$$
\begin{aligned}
f_t &= \sigma_g(W_f x_t + U_f h_{t-1} + b_f) \\
i_t &= \sigma_g(W_i x_t + U_i h_{t-1} + b_i) \\
o_t &= \sigma_g(W_o x_t + U_o h_{t-1} + b_o) \\
\tilde{c}_t &= \sigma_c(W_c x_t + U_c h_{t-1} + b_c) \\
c_t &= f_t \circ c_{t-1} + i_t \circ \tilde{c}_t \\
h_t &= o_t \circ \sigma_h(c_t)
\end{aligned}
$$

Assignment

- review a paper

questions?