

ML Week

Time Series

Jeff Abrahamson

23–24 novembre 2016

Introduction to time series

This is hard, but it depends on your goals. And on context.

Introduction to time series

Definition (discrete time series):

$$\{\mathbf{s}_t \mid t \in \mathbb{R}^+ \wedge \mathbf{s} \in \mathbb{R}\}$$

(though \mathbf{s} in any vector space is fine)

Introduction to time series

Examples domains:

- Weather
- Economics
- Industry (e.g., factories)
- Medicine
- Web
- Biological processes

Introduction to time series

Why?

- Predict
- Control
- Understand
- Describe

Introduction to time series

Some strategies:

- Clustering
- Hidden Markov Models (HMM)
- Recurrent neural networks (RNN)
- Autoregressive integrated moving average

Introduction to time series

One model:

$$s_t = g(t) + \phi_t$$

where

$g(t)$ is deterministic: signal (or trend)

ϕ_t is stochastic noise

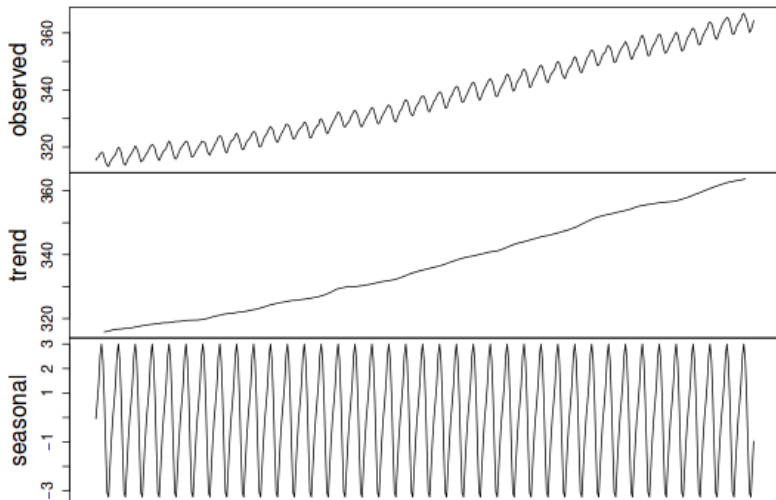
Introduction to time series

Variation types:

- Trend (g)
- Seasonal effect (g)
- Irregular fluctuation (residuals: ϕ)

Introduction to time series

Decomposition of additive time series



Introduction to time series

Some easy things to try

- Introduce features to break out seasonality
- Introduce lags as features
- Some domain-specific transformation

HMM

“simplest dynamic Bayesian network”

Markov Chains

A **Discrete time Markov chain (DTMC)** is a random process that undergoes state transitions.

Markov Chains

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nn} \end{bmatrix} \begin{bmatrix} v_1^{(i)} \\ v_2^{(i)} \\ \vdots \\ v_n^{(i)} \end{bmatrix} = \begin{bmatrix} v_1^{(i+1)} \\ v_2^{(i+1)} \\ \vdots \\ v_n^{(i+1)} \end{bmatrix}$$

$$Xv_j = v_{j+1}$$

Markov Chains

Examples:

- Random walks
- Weather (first approximation in many places)
- Thermodynamics
- Queuing theory (so also telecommunications)
- Spam

Markov Chains

Properties:

- Stochastic process
- Memoryless (“Markov property”)

HMM's

- State is not visible
- Output of state is visible

Examples: noisy sensor, medical diagnosis

HMM's

What we have:

- State space $S = \{s_1, \dots, s_n\}$
- Observation space $O = \{o_1, \dots, o_k\}$
- Transition matrix A of size $n \times n$
- Emission matrix B of size $n \times k$
- Initial state probabilities $\pi = \{\pi_1, \dots, \pi_n\}$
- A sequence of observations $X = \{x_1, \dots, x_T\}$

Here

- $y_t = i \iff$ observation at time t is o_i
- $\Pr(x_1 = s_i) = \pi_i$

We want the sequence of states $X = \{x_1, \dots, x_T\}$.

HMM's

Some pointers to learn more about HMM:

- Forward-Backward Algorithm
- Viterbi Decoding
- Baum-Welch Algorithm

Questions?

ml-week.com/1