

CIVIL-606

## Inference for large-scale time series with application to sensor fusion

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Cursus	Sem.	Type
Civil & Environmental Engineering		Opt.

Language of teaching	English
Credits	2
Session	
Exam	Oral presentation
Workload	60h
<b>Hours</b>	<b>30</b>
Lecture	12
Exercises	8
Practical work	10
<b>Number of positions</b>	

### Frequency

Every 3 years

### Remark

Next time: Spring 2025, block course

### Summary

Large-scale time series analysis is performed by a new statistical tool that is superior to other estimators of complex state-space models. The identified stochastic dependences can be used for sensor fusion by Bayesian (e.g. Kalman) filtering or for studying changes in natural/biological phenomena.

### Content

Linear dynamic systems

- state-space notation and propagation of errors
- modeling of sensor errors and state vector augmentation
- the need for stochastic model identification and parameter estimation in Bayesian filtering

Time series fundamentals

- measuring dependence, examples
- stationarity and fundamental representation
- ARMA models

Properties of estimators

- extremum estimators
- Maximum Likelihood
- Generalized Method of Moments
- consistency and asymptotic normality

Allan Variance

- Allan Variance definition, properties and estimation
- Allan Variance-based estimation of stochastic parameters

Generalized Method of Wavelet Moments (GMWM)

- wavelet variance
- GMWM estimator and its properties
- model selection

**GMWM Extensions**

- covariate-dependent models and examples
- multivariate-based modeling

**GMWM usage**

- 'R' and its GMWM package with documentation
- on-line computational platform
- examples

**Keywords**

Statistics, modeling, estimation, sensor-fusion, time-series, Bayesian/Kalman filtering, state-space models

**Learning Prerequisites****Required courses**

Linear algebra, basic signal processing, basic statistics, basic programming

**Learning Outcomes**

By the end of the course, the student must be able to:

- Calculate Allan/Wavelet variances from time time-series data
- Identify structure of latent stochastic processes within a time series
- Estimate model parameters together with its confidence intervals
- Apply estimated models in state-space estimation

**Expected student activities**

The lectures alternates with labs during 2 week block. Students then work on a 32h project (distributed data or -after an agreement - their own data). The evaluation is based on written project report that is presented first orally before its due date - 1.5 month after block end.

**Resources****Bibliography**

Applied Time Series Analysis with R: <https://smac-group.github.io/ts/>

An Introduction to Statistical Programming Methods with R: <https://smac-group.github.io/ds/>

Moodle: (TBD)

**Notes/Handbook**

Freely accessible website with "tutorial / exercises" and slides.

<https://gmwm.netlify.com>

**Websites**

- <https://gmwm.netlify.com>

**Moodle Link**

- <https://go.epfl.ch/CIVIL-606>