Module Description

From Fourier to Wavelets

General Information

Number of ECTS Credits

3

Module code

FTP_Fourier

Responsible of module

Franz Müller, ZHAW

Language

Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Berne	Lausanne			Lugano	Zurich		
Instruction	☐ E 100%	☐ E 100%		☐ F 100%	☐ E 100%	☑ E 100%		☐ D 100%
Documentation	☐ E 100%	☐ E 100%	☐ E %	☐ F %	☐ E 100%	☑ E 100%	☐ E %	☐ D %
Examination	☐ E 100%	☐ E 100%	☐ E 100%	☐ F 100%	☐ E 100%	☑ E 100%	☐ E 100%	☐ D 100%

Module category

☑ FTP Fundamental theoretical principles

☐ TSM Technical/scientific specialization module

☐ CM Context module

Lessons

2 lecture periods and 1 tutorial period per week

Entry-level competencies

Prerequisites, previous knowledge

- Basics of analysis:
  Integration methods (substitution, integration by parts), complex numbers, zeros of polynomials
- Basics of linear algebra:
  decomposition of a vector in a basis, scalar product, matrix calculus (addition, multiplication, inversion)
- Basics of Fourier series:
  real / complex Fourier series, calculation of their coefficients for basic examples

Brief course description of module objectives and content

Wavelet analysis offers an alternative to - and in many cases, such as signal and image processing, an improvement over - Fourier analysis. This is due to its adaptability to localised properties of data.
In this module, wavelet theory is developed in detail and its advantages over Fourier analysis are highlighted.

After the elaboration of wavelet theory, the second part of the course will focus on a number of important applications.

Aims, content, methods

Learning objectives and acquired competencies

- The students know the basics of Fourier and wavelet theory. They know the advantages of the latter.
- The students are able to apply this knowledge, i.e. to analyse, filter and reconstruct data in the framework of both theories.
- The students gain some familiarity with applicable software.
- The students are able to apply wavelet theory in practice, within the framework of selected applications. In particular they know the advantages of the most commonly used wavelet bases.

Contents of module with emphasis on teaching content

- **Fourier theory:**
  Real and complex Fourier series, Fourier transform (FT) and its inverse, properties and examples, further topics: discrete/fast FT, sampling, filtering, windowing, selected applications
- **Wavelet theory:** advantages of wavelets over Fourier,
  basic example: Haar, multiresolution analysis, filters from wavelets, basic filter relations, discrete/fast wavelet transform, tensor wavelets, further topics, software
- **Wavelets in general:** vanishing moments, regularity, compact support, …
  Specific examples: Daubechies, Coifman, …
- **Applications,** selected among: denoising, compression, object detection/recognition, …

Teaching and learning methods

The module has a theory and an applications part.
The two parts can be taught by different lecturers.

- **Theory part :** lecturing, guided exercises
- **Applications part :** In the second part selected applications are presented by the lecturer. The students then work on problems relating to these selected applications. During the exercise class, they get advice from the lecturer.

Literature

W. Bäni. *Wavelets: eine Einführung für Ingenieure*, second edition. Oldenbourg, 2005.
B. Burke. *Ondes et ondelettes*. Pour la science, 1996.
S. Mallat. *A wavelet tour of signal processing*, second edition. Academic Press, 1999.
Y. Meyer. *Ondelettes*. Hermann, 1989.
G. Strang and T. Nguyen. *Wavelets and filter banks*, revised edition. Wellesley-Cambridge Press, 1997.

Further references and much more: www.wavelet.org (site hosted by EPFL)

Assessment

Certification requirements for final examinations (conditions for attestation)

None.

Basic principle for exams:
All the standard final exams for modules are written exams.
The repetition exams can be either written or oral.

Standard final exam for a module and written repetition exam

Kind of Exam	written
Duration of exam	120 minutes
Permissible aids	☐ no aids
	☑ permissible aids:
	☑ Electronical aids: _pocket calculator_(no other)
	☐ Hardcopy form: _____
	☑ any written/printed material (open book)

Special case: Repetition exam as an oral exam

If an oral exam is set (only possible for ≤ 4 students), the following applies:

Kind of Exam	oral
Duration of exam	30 minutes
Permissible aids	no aids