Module Description

From Fourier to Wavelets

General Information

Number of ECTS Credits

3

Abbreviation

FTP_Fourier

Version

19.02.2015

Responsible of module

Franz Müller

Language

	Lausanne	Bern	Zürich
Instruction	☐ E x F	☐ D ☐ E ☐ F	x D x E
Documentation	☐ E x F	☐ D ☐ E ☐ F	x D x E
Examination	☐ E x F	☐ D ☐ E ☐ F	x D x E

Module category

☒ Fundamental theoretical principles

☐ Technical/scientific specialization module

☐ Context module

Lessons

☒ 2 lecture periods and 1 tutorial period per week

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 quite a number of important applications.

In ordert to get to the applications quickly after two weeks theory there will be a first example in the third week.

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,
  (speech recognition, electrocardiogram, jpeg, jpeg2000, …)

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.

Prerequisites, previous knowledge, entrance competencies

- 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

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)

Participation in exercises relating to applications (second part)

Written module examination

Duration of exam :	120 minutes
Permissible aids:	Open book (any written or printed material), Pocket calculator, no other electronic devices