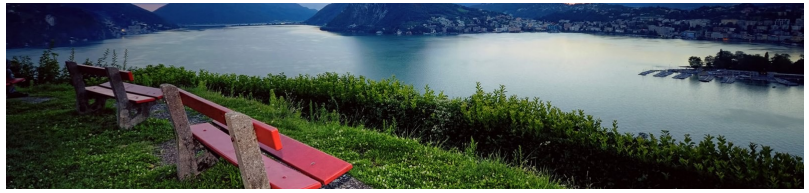
FAU/USI Double-Degree Kick-off Meeting

Felix Schmutter (FAU) Olaf Schenk (USI)



FRIEDRICH-ALEXANDER
UNIVERSITÄT
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Agenda

- Welcome (F. Schmutterer, O. Schenk)
- Introduction Blitz (T. Holt)
- FAU CE (M. Zikeli)
- USI MCS (E.Wit)
- FAU/USI Core Course, Efficient Computational Algorithms, I. Horenko
- Q&A

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG
TECHNISCHE FAKULTÄT

Computational Engineering
Rechnergestütztes Ingenieurswesen @ FAU

Welcome Event, Friday 24th September, Lugano

Florian Frank, Florian Klöppner, Johannes Lebender,
Michael Zikeli, Felix Schmutterer

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG
TECHNISCHE FAKULTÄT

1743 founded by Margrave Friedrich of Bayreuth

Knowledge in motion is our motto.
Innovation, diversity and passion our key values.

Today, we are one of the largest research universities in europe and a pioneer of innovative research, committed to unite research and teaching.

FAU Erlangen-Nürnberg

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
TECHNISCHE FAKULTÄT

5
faculties

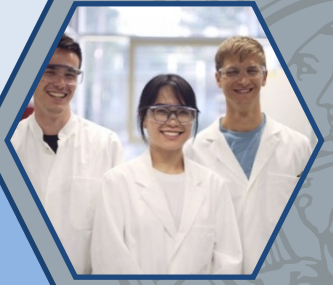
600
professors

39,000
students

260 degree programmes

85 Bachelor's
94 Master's
programmes

3,000
academic staff members



FRIEDRICH-ALEXANDER
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TECHNISCHE FAKULTÄT

M.Sc. Computational Engineering (interdisciplinary)

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TECHNISCHE FAKULTÄT

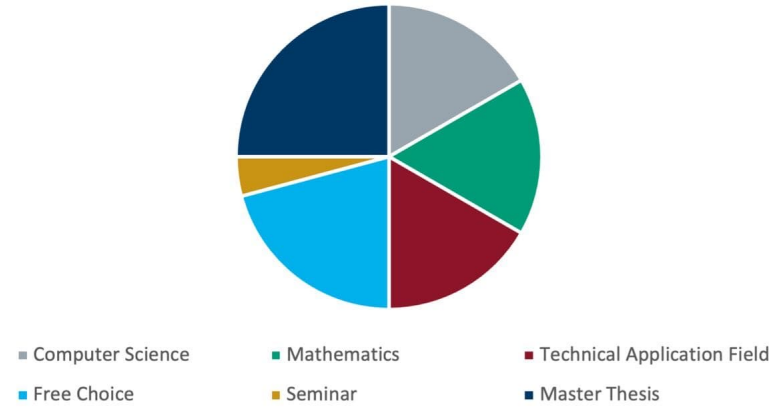
Computational Engineering

Bridging the gap between the disciplines

- Complex technical developments are based on mathematical principles.
- Efficient hard- und software are the key to empower engineering in order to develop products, compare technical solutions and to predict changes and results.

Computational Engineering combines computer science, mathematics and engineering as complimentary fields in one unique programme.

M.Sc. Computational Engineering Distribution



Technical Applications (TAFs)

The techical fields of applications are …

- Computational Optics
- Information Technology
- Mechatronics
- Thermo and Fluid Dynamics
- Solid Mechanics and Dynamics
- Computational Material Science
- Medical Engineering

Bavarian Graduate School of Computational Engineering (i.e. Elite Master)

FAU and TUM programme to achieve an additional Honours Certificate

Language

The courses are offered in English. Students with German language skills can choose from a larger variety of lectures.

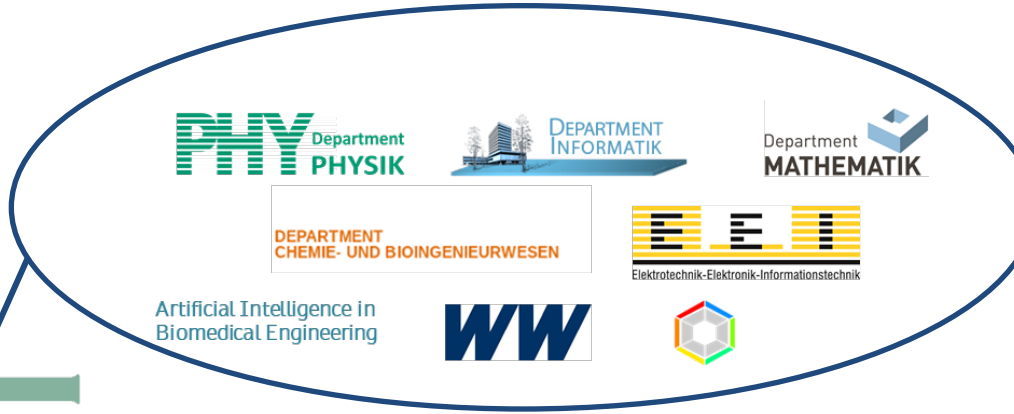
Module title	SWS (semester hours)				Total ECTS credits	Distribution of workload per semester in ECTS credits				Type and scope of the examination/ course achievement
	L	T	E	C		1st	2nd	3rd	4th	
Mathematics										
Funktionalanalysis für Ingenieure	2	2			5	5				EA (WE60) + CA (TA)
Optimierung für Ingenieure	3	2			7.5		7.5			EA (WE60) + CA (TA)
Compulsory elective modules mathematics: Modules from the module catalogue pursuant to Section 40a (4) (min. 7.5 ECTS) [1)]	6	3			≥7.5					EA/CA: MHB
Computer science										
Compulsory elective modules computer science: Modules from the module catalogue pursuant to Section 40a (3) (min. 20 ECTS) [1)]	12	8	4		≥20					EA/CA: MHB
Technical application fields (TAF)										
Compulsory elective modules technical application field: Modules from the module catalogue for the chosen TAF pursuant to Section 40a (5) (min. 20 ECTS) [1)]	12	8	4		≥20					EA/CA: MHB
Seminar				2	5					Section 50 (3)
Master's thesis					30				30	EA: written thesis (90%) and presentation with discussion (approx. 30+15 min, 10%)
Total SWS (semester hours)	35	23	8	2						
Total ECTS credits					120	30	30	30	30	

Hands on HPC experience at our RRZE Clusters

- CE Students get hands-on experience on our clusters “Meggy” and “Emmy”.
- RRZE is one of the biggest data centres in Europe.
- Additional Courses and opportunities to expand your knowledge and skills.

Unique opportunities

- Wide variety of departments involved in CE's different technical application fields.
- Major International Players in Industry nearby.
- Huge selection of student groups.



Student Association (FSI CE)

- Gather old lecture and exam materials to help our (new) students
- Organize Events to bring students together (e.g. Beer Pong Tournament)
- Open for questions
- Networking between faculty staff and students

Thanks for your Attention!
Any questions?

DDP FAQ

https://www.ce.studium.fau.eu/

studienberatung-ce@fau.de

fsi-ce@fau.de

Join our DDP WhatsApp Group

USI MCS (E.Wit)

Università
della
Svizzera
italiana

Master of Science

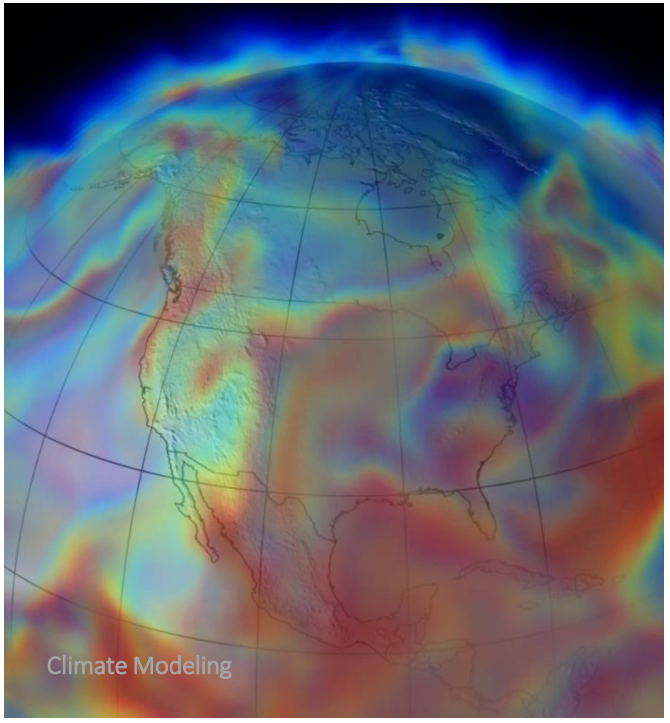
Double Master

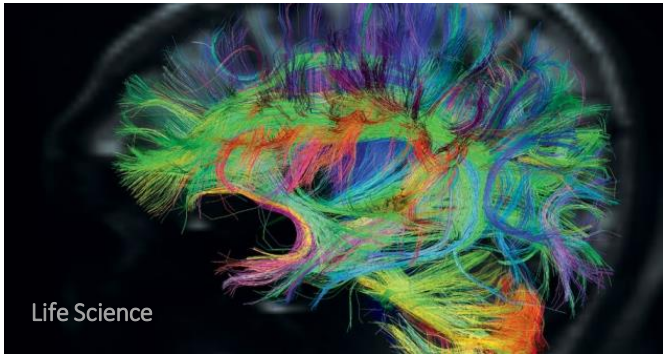
Computational Engineering (FAU) & Computational Science (USI)

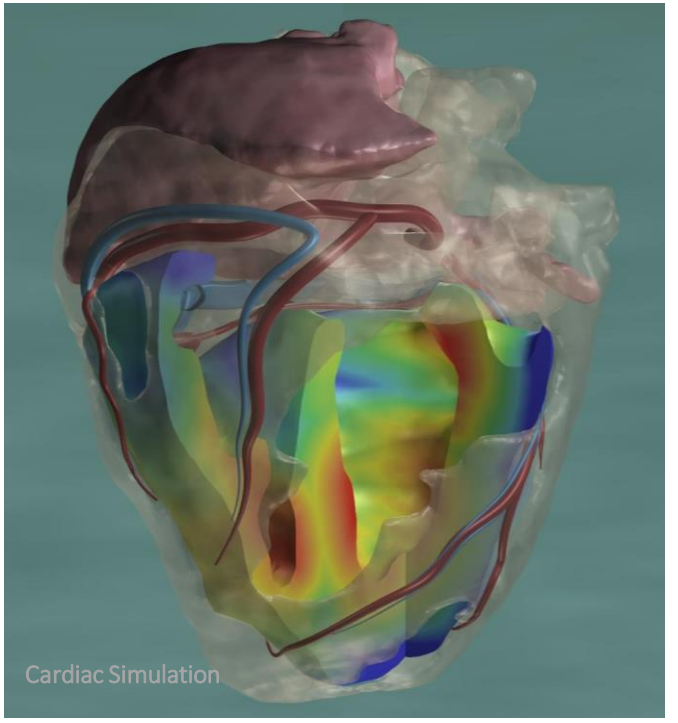
26 Ma

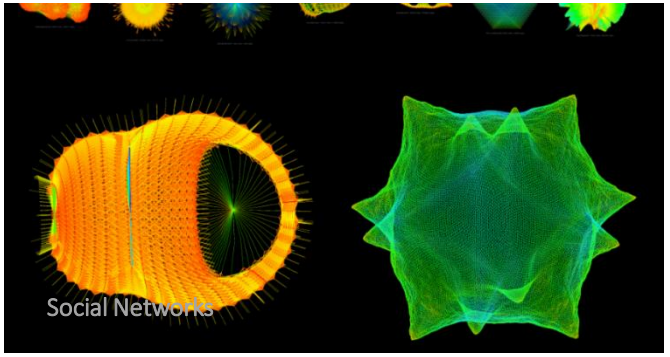
FAU

USI









Objectives & content:

Learn essential skills and theory

- **Data science** (e.g. machine learning, statistics)
- **Numerical algorithms** (e.g. optimization, differential equations…)
- **High-performance computing** (e.g. computational algorithms)

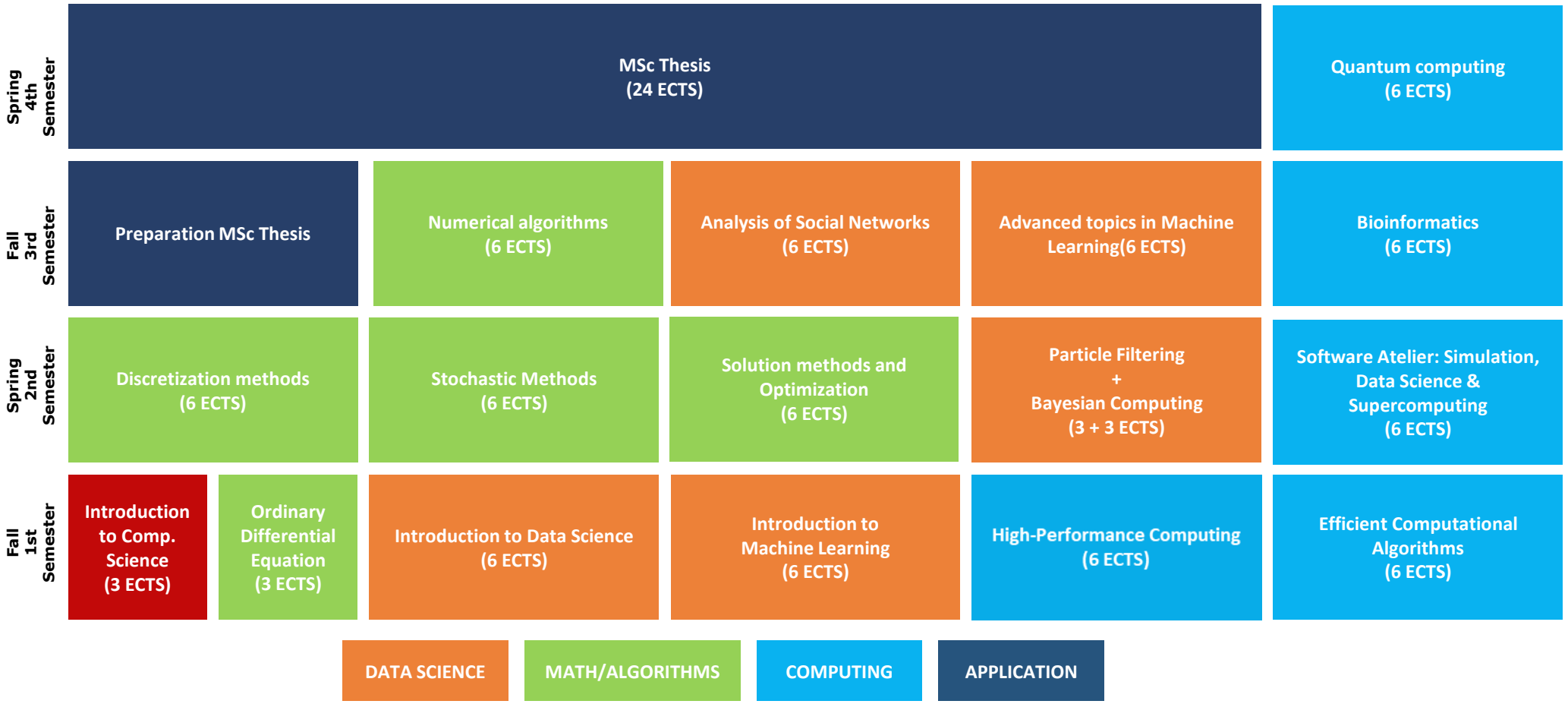
Focus on important computational engineering applications

Structure

2-year Double M.Sc. Programme

- Before start
  - Enroll for **Computation Engineering** MSc at FAU
  - Apply for **Computational Science** MSc double degree. at USI
- Year 1
  - Attend 1st + 2nd semester at FAU (*home* institution)
  - Attend special online course at USI (Efficient Computational Algorithms)
- Year 2
  - Attend 3rd semester at USI in Lugano (*host* institution)
  - Complete 4th semester at FAU (or even in Lugano!).
- After graduation: obtain 2 MSc degrees:
  - “Computational engineering” (FAU)
  - “Computational Science” (USI)

Structure and organization (an example)



Where is Lugano?

Our new East Campus hosts the

Master in Computational Science

in **Lugano** (5-10 minutes walk from the lake)

Registration at USI

- Copy of online **confirmation** message signed and stamped by coordinator of exchange studies of your faculty;
- A photocopy of the relevant pages of your **passport** or ID;
- Copy of most recent **transcript** of records;
- Copy of **Language Certificate** and signature from your home university that guarantees that you are sufficiently competent in the English language (a B2 is compulsory but C1 is strongly recommended);
- A photocopy of the **European Health Insurance card** (if available);

Deadlines:

- Autumn/Spring semester:
    - The official approval from FAU to relint@usi.ch by May 1st / October 15th.
    - The online registration must be completed by May 15th / November 1st .

Health Insurance

The International Relations Service (relint@usi.ch) will assist exchange students with the procedures upon arrival.

- Every person residing in Switzerland is required to have a **health and accident insurance** within three months from their first entry in Switzerland.
- Students may be exempted from buying health insurance in Switzerland:

  - Coming from EU/EFTA countries with a European Health Insurance Card;
  - With private insurance in EU/EFTA countries who can prove that it complies with Swiss standards, i.e., that it is **unlimited**.
  - With private insurance in Non-EU/EFTA countries who can prove that it complies with Swiss standards, i.e., that it is **unlimited**.

For more information: www.desk.usi.ch/en/health-insurance-students

VISA requirements

International Relations Service (relint@usi.ch) will assist exchange students with procedure before beginning of semester:

- **EU/EFTA students** do not need a visa to enter Switzerland.
- **Non-EU/EFTA students** bound by a visa requirement must request a student visa to Swiss Embassy or Consulate in their home country before entering Switzerland.
  - Some Non-EU/EFTA countries are visa-exempt, check VISA requirements: www.sem.admin.ch/sem/en/home/publiservice/weisungen-kreisschreiben/visa/liste1_staatsangehoerigkeit/leg_visum.html
  - All the necessary forms are available at the Swiss Embassies and Consulates.

Residence permit

Foreign students must apply for a residence permit “L” for educational purposes:

- Application must be submitted within 14 days **after** arrival in Switzerland.
- After submitting the application, the candidate is free to live in Switzerland while awaiting the immigration authority decision.
- Please be aware that the Permit of stay usually arrives only after 2-3 months.
- Permit allows students to **work** a maximum of 15 hours per week.

www4.ti.ch/di/home-sp/servizi-online/permessi-per-stranieri/ dimora-temporanea-l

Housing

USIHome

USI manages a student house (**USIHome**) but *cannot guarantee* accommodation to all exchange students.

Advice

The housing service provides free one-to-one advice:

- www.usi.ch/en/housing

Exchange students seeking accommodation can contact:

- alloggi@usi.ch

Facebook

To help students seeking for an accommodation, USI has a Facebook page:

- www.facebook.com/usialloggi

Welcome meeting

In 2nd week of September USI will offer an orientation weekend:

- An event to meet your new fellow students,
- receive first-hand information about USI facilities and practicalities,
- discover the region and
- get ready to start your academic adventure.

Detailed programme and registration procedure will be communicated by mid-August at the website: https://www.usi.ch/en/welcome2020.

Learn Italian!

- USI is only University of Italian language and culture in the Swiss Academia and since 2006 it is particularly committed in the organization of Italian language courses.
- Each year about 600 USI students enroll in the Italian language courses.

- International Exchange students are entitled to receive ECTS points after having passed the final test and attended at least the 75% of the course. 2 ECTS points are assigned for the Intensive courses and 1 ECTS point for the semestral courses. The evaluation is expressed by a binary system (Pass or Fail).
- For more information about the schedule and content of the courses offered, as well as application, please refer to the following link: http://www.italiancourse.usi.ch/.
- Registration begins in May (for Autumn semesters) and late November (for Spring semesters).
- A **guided city tour, a guided visit of a museum and Italian film viewing** are part of the course.

- Official Italian Language proficiency PLIDA:

  Università della Svizzera italiana also offers an official Italian language proficiency test twice a year in cooperation with the Società Dante Alighieri in Italy. For more information: www.desk.usi.ch/en/convenzioni-certificati-di-lingua.

Transcript

At the end of the exchange term, the student will receive an **official transcript**:

- certificate will show **title of course**, **ECTS** and **grade** obtained.
- All examinations are graded on a scale of 1 (min) to 10 (max), including half points.
- 6 is the passing grade.
- Examination results are released approximately 6 weeks after the end of the exams.
- An official transcript will be sent **by email** to
  - the student's personal address and
  - home university's exchange office.

Master in Computational Science

The Master of Science degree in Computational Science (MCS) at the Università della Svizzera italiana (USI) offers students the opportunity to acquire an in-depth understanding and set of skills in computational science, numerical simulation, applied mathematics, statistics, and data science. It provides an innovative combination of methodological and applied competencies in both computational and data science, which endow students with the knowledge and skills that are needed to operate at the forefront of science and industry.

Computational Science is not to be confused with Computer Science, which deals with the science and engineering of computers. Computational Science represents a broader approach to interdisciplinary problems and projects, using computer simulations in model based approaches that represent the interaction between theory and experiment.

Awarded degree

After the successful completion of the programme, students will be awarded a Master of Science in Computational Science.

Apply Now

Are you interested?

Master in Computational Science
Overview
Double degree

Structure and contents
Career Prospects
Admission
Application Procedure
Fees and grants
Practical information
Open days and study advisory
Contact us
FAQ

Optional joint Double Degree with

LUT University

FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

Ask us anything!

- About organizational issues: International Student Service relint@usi.ch
- About the Computational Science Master:
  - Ernst Wit wite@usi.ch or
  - Olaf Schenk olaf.schenk@usi.ch

FAU/USI Core Course, Efficient Computational **Algorithms, I. Horenko**

Master Course **"Efficient Computational Algorithms"**

Illia Horenko

Edoardo Vecchi

What is an efficent computational algorithm?

It is an algortithm that allows a **non-obvious** but simultaneosly **qualitative** and **scalable** solution for a **relevant** computational problem

Usually, it involves one or several quite **non-obvious 'tricks'**

course page on iCorsi: https://www.icorsi.ch/course/view.php?id=12648

Master Course **"Efficient Computational Algorithms"**

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Example: **"Fast Fourier Transformation"** as an engine of the digital revolution

- What is the computational problem?

  - Transforming **analog** signal (with very many **N** values) to **digital** (with very few values), by representing it as an **optimal** linear combination of sine/cosine functions
  - One can show mathematically that this is equivalent to multiplying the **NxN**-matrix with an **Nx1**-vector

↓

cost scales as **$O(N^2)$:** for **$N=10^3$** it takes **10^{-4} sec** → for **$N=10^8$** (as in CT imaging) already **11 days (!)**

- What is the **trick** when applying FFT?

  - making problem seemingly more complex: transform 1D to 2D problem → cost from **$O(N^2)$** to **O(NlogN)**

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for **$N=10^3$** it takes **10^{-5} sec** → for **$N=10^8$** (as in CT imaging) **11.5 seconds**

- Why is it **relevant**?

  - image compression: FFT is the main core component behind MP3, JPEG, MP4
  - image denoising: FFT is the main core component of CT, NMR, fMRI, ... in medicine
  - molecular simulations: FFT is crucial for solving PDEs in chemistry and physics

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Swiss Chemist R.R.Ernst (1933-2021), Nobel Price for FFT in NMR in 1992

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Master Course **"Efficient Computational Algorithms"**: 15 topics

Algorithms and References

Here below you can find the algorithms with the relevant material. In case an [Overview] paper is provided, please consider also the references provided inside. You are free and encouraged to search or ask the instructors for additional references.

(1) Metropolis algorithm for Monte Carlo

- [Overview] The Metropolis Algorithm

(2) Simplex Method for Linear Programming

- [Overview] The (Dantzig) Simplex Method for Linear Programming

(3) Krylov Subspace Iteration Methods

- [Overview] Krylov Subspace Iteration

(4) The Decompositional Approach to Matrix Computations

- [Overview] The Decompositional Approach to Matrix Computation

(5) QR Algorithm for Computing Eigenvalues

- [Overview] The QR Algorithm

(6) Quicksort Algorithm for Sorting

- [Overview] A Perspective on Quicksort

(7) Fast Fourier Transform

- [Overview] The FFT: An Algorithm the Whole Family Can Use

(8) Integer Relation Detection

- [Overview] Integer Relation Detection

(9) Fast Multipole Methods

- [Overview] The Fast Multipole Algorithm

(10) Gradient Descent and Stochastic Gradient Descent

- An Overview of Gradient Descent Optimisation Algorithms
- Learning Long-Term Dependencies with Gradient Descent is Difficult
- Stochastic Gradient Descent Tricks
- Parallelised Stochastic Gradient Descent
- Large-Scale Machine Learning with Stochastic Gradient Descent

(11) Viterbi Algorithm for Signal Detection

- The Viterbi Algorithm
- Implementing the Viterbi Algorithm
- A Viterbi Algorithm with Soft-Decision Outputs and its Applications

(12) ML Dimension Reduction Algorithms based on Matrix Factorization

- Probabilistic Latent Semantic Analysis

(13) Scalable Quadratic Programming Algorithms for Portfolio Optimization in Finance

- Quadratic Programming for Large-Scale Portfolio Optimization

(14) Scalable Probabilistic Approximation Algorithms in ML

- Low-Cost Scalable Discretization, Prediction, and Feature Selection for Complex Systems
- On a Scalable Entropic Breaching of the Overfitting Barrier for Small Data Problems in Machine Learning

(15) Regularised Scalable Probabilistic Approximation Algorithm for Image Denoising

- Quality-Preserving Low-Cost Probabilistic 3D Denoising with Applications to Computed Tomography

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Quality-Preserving Low-Cost Probabilistic 3D Denoising with Applications to Computed Tomography

Course Organisation

An introductory meeting will take place on MS Teams on **Monday, September 27, at 10.30am**, during which we will present the relevant material for the 15 algorithms object of this seminar. You can group up with other students (max 3 people) to work on the final project. The students will have time till **Monday, October 18, at 11.59pm** to list three potential topics (in order of preference) and to submit them to the instructors by email. The assignment of the topics for the final project will be performed on a first come, first served basis. Mondays and Thursdays will be dedicated to Q&A slots with the instructors: please contact us in advance by email in case you want to schedule a meeting, either alone or with your group.

A Viterbi Algorithm with Soft-Decision Outputs and its Applications

[Overview] The QR Algorithm

(12) ML Dimension Reduction Algorithms based on Matrix Factorization

Probabilistic Latent Semantic Analysis

(6) Quicksort Algorithm for Sorting

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On a Scalable Entropic Breaching of the Overfitting Barrier for Small Data Problems in Machine Learning

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Q&A

We wish you all a good and successful start for your academic year 2021 / 2022 at FAU and USI