Introduction

We discuss here the evolution of the Master Track. It's important to ensure that the program is meeting the needs of students and providing them with the skills and knowledge necessary for success in their chosen careers.

the main purpose of the CSMI Master's program is to provide students with advanced skills in both mathematics and computer science, with a focus on modeling, simulation, optimization, signal and image processing, data mining, and high-performance computing. The program aims to equip students with the theoretical and practical knowledge necessary to tackle complex problems in the socio-economic world, and to prepare them for careers in research and development departments of companies, service companies, specialized consulting firms, or engineering positions in universities and public or private research organizations.

In real life work, the skills developed in the CSMI program are highly valued by employers in a wide range of fields. For example:

- Modeling, simulation, and optimization skills are highly relevant in industries such as finance, energy, transportation, and healthcare, where companies must optimize complex systems to improve efficiency and reduce costs.
- Signal and image processing skills are valuable in fields such as telecommunications, defense, and medical imaging, where companies must analyze and interpret large volumes of data.
- Data mining skills are highly sought after in industries such as marketing, e-commerce, and finance, where companies must analyze large datasets to identify trends and patterns.
- High-performance computing skills are valuable in many scientific and engineering fields, where companies must simulate complex systems or process large amounts of data in a timely manner.

Overall, the CSMI Master's program is designed to prepare students for highly rewarding careers in a wide range of fields, where they can apply their skills to tackle complex real-world problems and make a positive impact on society.

EISEM report

The EISEM report, which was commissioned by the governement the Agency for mathematics in interaction with entreprises and mathematical societies, in 2015 and updated in 2022, to evaluate the socio-economic impact of mathematics in France. The report highlighted the crucial role that mathematics plays in driving innovation and competitiveness in a wide range of industries, and identified key technologies that are central to the needs of the socio-economic world.

The CSMI Master's program at the University of Strasbourg is specifically designed to address these needs, by providing students with advanced skills in the key technologies identified by the EISEM report. For example, the program includes courses in modeling, simulation, optimization, signal and image processing, data mining, and high-performance computing, which are all key areas highlighted in the EISEM report.

By equipping students with these advanced skills, the CSMI program aims to prepare them for

careers in research and development departments of companies, service companies, specialized consulting firms, or engineering positions in universities and public or private research organizations. These are all areas where mathematics plays a crucial role in driving innovation and competitiveness, and where the skills developed in the CSMI program can make a significant contribution.

The november 2022 version is available here.

Evolution

There are several reasons why updating the Master track CSMI could be beneficial. Here are a few potential reasons:

Keeping up with changing industry demands

The world of mathematics and computer science is constantly evolving, and so are the needs of employers. By updating the Master track CSMI, you can ensure that your graduates have the skills and knowledge that are most in demand in the current job market.

Attracting more students

Students are often drawn to Master's programs that offer cutting-edge courses and relevant, practical training. By updating the CSMI program with new courses on high-performance computing, machine learning, and data assimilation, you may be able to attract more students who are interested in these fields.

Strengthening industry partnerships

By incorporating projects with companies and internships throughout the program, as well as courses that are directly relevant to industry needs, you can build stronger partnerships with companies and potentially create more job opportunities for your graduates.

Enhancing the reputation of the program

By offering a program that is up-to-date and relevant, you can enhance the reputation of the CSMI program and increase its visibility both nationally and internationally. This can help attract the best students and faculty to the program, and create more opportunities for collaboration and funding.

- Updating the course offerings to reflect new developments in mathematics and computer science
- Introducing new courses or modifying existing courses to better meet the needs of students
- Increasing the number of courses taught in English to better prepare students for international settings
- Providing more opportunities for practical experience, such as internships or industry partnerships
- Incorporating more interdisciplinary coursework to help students understand the connections between mathematics and computer science and other fields

Here's a proposed modification to the semester courses of CSMI:

- First Semester (30 ECTS)
  - Algorithms - 3 ECTS
  - Database - 3 ECTS
  - Functional Analysis - 3 ECTS
  - C++ - 3 ECTS
  - Parallel Computing - 3 ECTS
  - Scientific Computing 1 - 3 ECTS
  - Graph 1 - 3 ECTS
  - Random Models - 3 ECTS
  - High-Performance Computing 1 (Multigrid, Domain Decomposition) - 3 ECTS
  - Scientific Computing 2 - 3 ECTS
- Second Semester (30 ECTS)
  - Signal Processing 1 - 3 ECTS
  - Project - 3 ECTS
  - Numerical Methods PDE - 3 ECTS
  - Optimization - 3 ECTS
  - Operating System - 3 ECTS
  - Data Processing and Mining - 3 ECTS
  - High-Performance Computing 2 (MPI, OpenMP, CUDA) - 3 ECTS
  - Machine Learning 1 (Scientific Machine Learning) - 3 ECTS
  - Internship or Thesis - 3 ECTS
- Third Semester (30 ECTS)
  - Signal Processing 2 - 3 ECTS
  - Optimal Control - 6 ECTS
  - 3 - 3 ECTS
  - Numerical Methods for PDE - 3 ECTS
  - Compilation - 3 ECTS
  - Project - 3 ECTS
  - Networks - 3 ECTS
  - Uncertainties - 3 ECTS
  - High-Performance Computing 3 (Optimization, Code Optimization) - 3 ECTS
  - Machine Learning 2 (Generative Adversarial Networks) - 3 ECTS
- Fourth Semester (30 ECTS)
  - Internship - 30 ECTS

In this modification, we added three courses on high-performance computing, which covers various topics such as multigrid, domain decomposition, MPI, OpenMP, CUDA, and optimization of codes for high-performance computing architectures. We also added two courses on machine learning, one on scientific machine learning and the other on generative adversarial networks. Finally, we included a course on data assimilation and digital twins in the third semester.

Semester	Course Title	ECTS	Course Content
1	Mathematics Foundations for CSMI	12	Linear algebra, calculus, probability, statistics, algorithms, functional analysis, graph theory
1	High-Performance Computing 1	6	Multigrid, domain decomposition, iterative solvers, parallel algorithms
1	Signal Processing 1	6	Time and frequency analysis, filtering, sampling, modulation
1	Data Processing and Mining	6	Data cleaning, pre-processing, feature selection, clustering, classification
2	Numerical Methods for PDE	6	Finite difference, finite element, spectral methods
2	Optimization	6	Linear and nonlinear programming, convex optimization, duality
2	Machine Learning	6	Supervised and unsupervised learning, deep learning, generative models
2	Operating Systems and Compilation	6	Memory management, process synchronization, optimization, code generation
3	High-Performance Computing 2	6	Performance modeling, profiling, optimization, GPU computing,

Semester	Course Title	ECTS	Course Content
3	Data Assimilation and Digital Twins	6	Kalman filtering, ensemble methods, model reduction, digital twin technology
3	Scientific Machine Learning	6	Physics-informed learning, uncertainty quantification, model discovery
3	Project	3	Group project on real-world industrial problems
4	Internship	30	Applied research internship in a company or research laboratory

Appendix A: Master CSMI: Description and Main Components

Description

The CSMI Master's program is at the heart of the digital revolution, focusing on models, data, and algorithms. It aims to train students to be key players in the digital revolution, equipping them with cross-disciplinary skills in mathematics and computer science and a strong grasp of various application domains such as health, environment, economy, and micro-technology.

The program is designed to prepare students for the rapid technological changes and challenges in the digital world by providing them with the knowledge and skills needed in the areas of image processing, modeling, simulation, optimization, and high performance computing.

Main Components

Data and Machine Learning

This component covers the fundamentals of data analysis and machine learning. Students will learn about statistical methods, data analysis techniques, and machine learning algorithms. They will gain the ability to analyze and interpret complex datasets, and develop algorithms to learn from and make predictions or decisions based on data.

Modeling Simulation Optimisation

Modeling, Simulation, and Optimisation (MSO) is considered the third pillar of scientific progress and innovation, alongside experimentation and theory. In this component, students will learn about mathematical modeling, simulation techniques, and optimization methods. They will gain the ability to develop precise methods for MSO, which is increasingly important in the context of the growing importance of high-performance computing and Big Data technologies.

High Performance Computing

High Performance Computing (HPC) involves the use of supercomputers and parallel processing techniques for solving complex computational problems. In this component, students will learn about the architecture of high-performance computers, parallel programming techniques, and the design and optimization of high-performance algorithms.

Signal and Image Processing

Signal and image processing involves the analysis, interpretation, and manipulation of signals and images. In this component, students will learn about various methods and techniques for signal and image processing, including filtering, pattern recognition, and image enhancement. They will gain the ability to develop algorithms for processing and analyzing signals and images.

Course Summary and List

First Semester Courses

Course	ECTS	CM	CI	TD	TP	TE
Algorithmique 3	6 ECTS	-	56 h	-	-	-
Calcul scientifique 2	3 ECTS	-	28 h	-	-	-
Informatique graphique	3 ECTS	-	28 h	-	-	-
Graphe 1	3 ECTS	-	28 h	-	-	-
Optimisation	3 ECTS	-	28 h	-	-	-
Langue S1	3 ECTS	-	-	16 h	-	60 h

Second Semester Courses

Course	ECTS	CM	CI	TD	TP	TE
Traitement du signal 1	3 ECTS	-	28 h	-	-	-
Calcul scientifique 2	3 ECTS	-	28 h	-	-	-
Informatique graphique	3 ECTS	-	28 h	-	-	-
Graphe 1	3 ECTS	-	28 h	-	-	-
Optimisation	3 ECTS	-	28 h	-	-	-
Langue S2	3 ECTS	-	-	16 h	-	60 h

Third Semester Courses

Course	ECTS	CM	CI	TD	TP	TE
Traitement du signal 2	3 ECTS	-	28 h	-	-	-
Contrôle optimal	6 ECTS	-	56 h	-	-	-
Calcul scientifique 3	3 ECTS	-	28 h	-	-	-
Méthodes numérique pour les EDP	3 ECTS	-	28 h	-	-	-
Compilation	3 ECTS	-	28 h	-	-	-
Projet	3 ECTS	-	28 h	-	-	-
Réseaux	3 ECTS	-	28 h	-	-	-
Incertitudes	3 ECTS	-	28 h	-	-	-
Graphe 2	3 ECTS	-	-	-	-	-

Fourth Semester Courses

Course	ECTS	CM	CI	TD	TP	TE
Mémoire	27 ECTS	-	-	-	-	-
Langue S4	3 ECTS	-	-	16 h	-	60 h