Computational Science: Imaging and Biomedical Computing

Department of Informatics, University of Oslo

Planned start: Fall 2018

Why Imaging and Biomedical Computing

Advanced image analysis and computational tools are increasingly important across many areas of modern society. Over the last few decades these tools have revolutionized advanced healthcare, have been extremely important in large industries such as the petroleum sector, and form key parts of emerging technologies such as autonomus vehicles. All these results are rooted in fundamental knowledge of computer science and computational mathematics.

A Master's degree in Imaging and Biomedical Computing will give you a solid background to contribute to this development, by providing a deep insight into the technology that underlies modern modern imaging and simulation tools. The graduated candidates will have a solid foundation in mathematics and computing, which is applicable across many branches of science and engineering.

The direction will have two separate but tightly connected branches. One is primarily focused on image analysis, image classification and signal processing, using a range of computational and mathematical tools (fill in more...)

The other branch of the study direction is focused on computational modeling of physical processes, with particular focus on biomedical applications. Computational models are increasingly important in medical research, and are also making their way into clinical use. Advanced mathematics and computational tools are used to build computer simulations of organs and organ systems, which describe the physiology and function of the body in health and disease, and may be used for diagnosis and as virtual test beds for optimizing treatment. Although the main focus of this branch is on biomedical applications, the underlying tools of numerical analysis and computational mathematics are generally applicable, and the candidates are well prepared for tasks in many areas of science and engineering.

Structure and courses

The table here is an example of a suggested path for a Master of Science project, with course work the first year and thesis work the last year.

	10 ECTS	10 ECTS	10 ECTS
4th semester	Master thesis	Master Thesis	Master Thesis
3rd semester	Master thesis	Master Thesis	Master courses
2nd semester	Master thesis	Master courses	Master courses
1st semester	Master courses	Master courses	Master courses

This program is very flexible in its structure and students may opt for starting with their thesis work from the first semester and scatter the respective course load across all four semesters. Depending on interests and specializations, there are many courses on computational science which can make up the required curriculum of course work. Furthermore, courses may be broken up in smaller modules, avoiding thereby the limitation of 10 ECTS per course only. Some of these courses are listed below.

Courses. Depending on specialization, the following courses that can be included as part of the compulsory 60 ECTS needed for a Master of Science degree are described here.

Graduate Certificates. The program plans to offer graduate certificates in

- Three of the courses with label CS-MATH gives a certificate in Computational Mathematics
- Three of the courses with label CS-PHYS gives a certificate in Computational Physics, Astrophysics, Chemistry, Materials Science and Geoscience
- Three of the courses with label CS-BIO gives a certificate in Computational life science.
- Three of the courses with label CS-INF gives a certificate in High-performance computing.

Dual Degrees. The program plans to offer dual degrees (more text to come)

Description of learning outcomes

The study direction Imaging and biomedical computing has two main branches. One is focused on image analysis and one is focused on computational modeling of biomedical phenomena. Both branches give a solid foundation of computational mathematics and computer science, but with slightly different flavours. In addition to the general learning outcomes for the Computational Science program, the following outcomes apply to the Imaging and biomedical computing direction.

- **Knowledge**: A candidate from this program
  - has deep knowledge of the scientific foundation of image analysis or biomedical computing, meaning that the candidate

1. has the ability to understand advanced mathematical models of

biomedical phenomena

1. has fundamental understanding of numerical methods and tools for

solving computational problems in biomedicine

1. has a thorough understanding of the particular challenges that

arise in biomedical computing problems

- **Skills**: A candidate from this program

  - has a deep understanding of how computing is applied for imaging and

  biomedical problems, entailing several or all of the topics listed below

  1. can implement image analysis tools or solvers for partial differential equations using different tools and programming languages
  2. is able to analyse the efficiency of the developed computational methods and analysis tools
  3. can use imaging tools and measurements for parameter estimation and valdidation of computational models

- **General competence**: A candidate from this program

  - is able to develop professional competence through the thesis work, entailing:
    1. can work effciently in highly interdisciplinary teams
    2. can collaborate across scientific boundaries, and communicate

  efficiently with experts from other fields

Admission criteria: Imaging and Biomedical Computing

The program has a minimum course requirement of 120 ECTS (European Credit Transfer System) at the undergraduate level (bachelor degree or equivalent) in Astrophysics, bioscience, chemistry, computer science and informatics, geoscience, mathematics, materials science, mechanics and physics.

1. Of these 120 ECTS, 80 ECTS have to be within Informatics/Mathematics/Statistics (courses labeled as INF/IN, INF-MAT, MAT-INF, MAT and STK) where of 50 ECTS have to include basic mathematics and programming courses, equivalent to the University of Oslo mathematics courses MAT1100, MAT1110, MAT1120 and the corresponding computing and programming courses INF1000/INF1110 and INF1010/IN2900.

2. A total of at least 40 ECTC out of the 120 ECTC have to be advanced undergraduate courses at the 2000 and 3000 level.

3. An average mark C (European grading scale) is required for the above-specified 80 ECTS in Informatics/Mathematics/Statistics.

Study abroad and international collaborators

Students at the University of Oslo may choose to take parts of their degrees at a university abroad. The University of Oslo has exchange agreements with other universities in different parts of the world. The MN Faculty has additional exchange agreements with many universities abroad.

Students in this program have a number of interesting international exchange possibilities. The involved researchers have extensive collaborations with: University of California San Diego through the Suurph program

Career prospects

Candidates with solid understanding of complex systems in natural science are in short supply in society in general, and in particular in the biomedical field. Career opportunities include hospitals, become increasingly technologically advanced, and employ a large number of physicists, mathematicians, and computer scientists, as well as businesses in the growing biomedical industry. Candidates from the Imaging and Biomedical Computing direction will be attractive members in research and development teams, as well as for advanced analysis in clinical settings.

Many of the challenges seen in medical imaging or biomedical computing are shared with other branches of science and engineering. The strong and generic background in computational modeling and analysis makes the candidates attractive across many traditional and emerging industries in Norway and abroad.