Computing Across the Disciplines (CAD); a new Center/Department at the University of Oslo

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A proposal to the board of the Mat-Nat Fakultetet of the University of Oslo; Establish a center by fall 2018 and as a new department by fall 2020

Why should we focus on Computational Science and Data Science?

- By 2020, it is expected that one of every two jobs in the STEM fields will be in computing (Association for Computing Machinery, 2013)
- Computation is an essential and cross-cutting element of all STEM disciplines
- Computational science has developed into a discipline of its own right
- Computations and the understanding of large data sets will play an even larger role in basically all disciplines of STEM fields, Medicine, the Social Sciences, the Humanities and education
- Students at both undergraduate and graduate level are unprepared to use computational modeling, data science, and high performance computing – skills valued by a very broad range of employers.
- The 3rd Industrial Revolution will alter significantly the demands on the workforce. To adapt a highly-qualified

Goals

- Position UiO as a leader in computational science by recruiting faculty whose expertise pertains to large-scale computing and mathematical foundations of data science - both generalists (algorithm/tool developers) and specialists (focused on specific disciplines).
- Develop a comprehensive set of courses and degree programs at both undergraduate and graduate levels that will give students across the university exposure to practical computational methods, understanding how to analyse data and more generally to the idea of computers as problem-solving tools.
- Develop an all university PhD program in Computational Science and Data Science
- Develop an all university Master of Science Program in Computational Science and Data Science
- Develop courses and course modules in Computational Science and Data Science for the private and the public sectors
- Develop a PhD program in Computational Science and Data Science tailored to the needs of the private and the public

Strengths, Possibilities and Synergies

- ▶ Several Centers of excellence in research where Computational Science plays a major role
- ▶ Newly established center of excellence in education research
- ▶ Newly established Master of Science programs in Computational Science and Data Science
- ▶ Several excellent groups in STEM fiels who do Computational Science
- ▶ Computational topics are included in all undergraduate STEM programs, possibility to develop a bachelor program in Computational Science
- ▶ Several educational prizes and awards related to computational science
- ▶ With a center and later a department we have the possibility to really position UiO as the leading Norwegian and perhaps European institution within Computational Science and Data Science
- ▶ Lead in the development of computations in Life Science
- ▶ Strong links with SIMULA research lab

Enhance Computational Science and Data Science across the disciplines

Data driven discovery and data driven modeling play already a central role in research. The global objective here is to strengthen and coordinate such activities by bringing together scientists and students across the disciplines. UiO has already strong computational research and education activities within Mathematics and the Natural Sciences. The aim here is to extend this to include

- ▶ Computational Science and data science in Mathematics and all of the physical sciences
- ▶ Computational biology and life science (includes medicine)
- ▶ Computational economics and data science and computing in the social science
- ▶ Data science and computing in the Humanities

The new department will host and coordinate research and educational programs in Computational Science and Data Science. In particular research and education that involve data analysis and machine Learning will play a central role here. Similarly, this new department will be responsible for developments in quantum

The Center/Department

- Administratively located under the Mat-Nat college
- Composed of 25-30 full time equivalent positions, including some current UiO faculty and when it becomes a department a larger number of new hires.
- Most of these faculty will have joint appointments with other units and/or departments at the University of Oslo and SIMULA research laboratory. As an example, one can have a 70% appointment in Mathematics and 30% at the new department.
- Faculty will focus on computational science, data science and large-scale and high-performance computation
- Faculty will be incentivized to engage in cross disciplinary and cross-department/college research collaborations
- Nurturing environment to attract these faculty and pursue large and interdisciplinary grants
- Close ties to SIMULA research laboratory and the HPC center at USIT

Benefits

- Recruitment of new faculty who are incentivized to collaborate across the university both in terms of research and education.
- Opportunities for existing UiO faculty to expand their computation-related capabilities, and to train students to use computational techniques.
- Broad and deep educational opportunities for both undergraduate and graduate students across the university.

Research opportunities

- ▶ Data driven discovery and data-driven modeling where machine learning plays a central role
- ▶ Research challenges that require computation-oriented multidisciplinary and interdisciplinary approaches.
- ▶ Research problems that require "bleeding edge" (e.g., multi-petaflop/petabyte) computational approaches to interpret experimental data and complex data.
- ▶ Computational and data science research and education scattered across many departments. New department can strengthen computational science.
- ▶ Develop research programs on Quantum Computing, the future of computing. The Wallenberg foundation in Sweden and Chalmers University of technology have funded a project on developing quantum computing technologies with SEK 1 billion. The aim is to position Sweden in a top global top position in quantum technology.
- ▶ Center-level funding opportunities (e.g., SFF, Marie Curie etc etc).

More research opportunities

- Simulations of complex quantum mechanical systems using novel algorithms, with applications spanning from quantumchromodynamics on the lattice and subatomic physics, via materials to the equation of state of stars.
- Exploring algorithms from quantum computing in order to solve complicated quantum mechanical problems
- Study complex materials or the DNA using large-scale molecular dynamics simulations
- Using machine learning to solve complicated problems, from neuroscience (our brain), physiology to complicated materials
- Using machine learning to develop new tools for learning
- Bioinformatics, Computational Biology and Life science
- Computational economy and computing in the Social Sciences
- Data-driven discovery and modeling in the Humanities

Possible steering committee (2018)

1. Institute for theoretical Astrophysics and Rosseland Center for Solar Physics: Mats Carlsson and Viggo Hansteen
2. Bioscience: Tom Andersen and Lex Nederbragt
3. Chemistry and Hylleraas Center for Quantum Molecular Sciences: Michele Cascella, Thomas Bondo Pedersen, Trygve Helgaker and Simen Kvaal
4. Geoscience: John Burkhart, Joe Lacasce and Thomas Vikhamar Schuler
5. IFI Bioinformatics: Torbjørn Rognes
6. IFI Imaging and Biomedical Computing (coupling to Simula): Andreas Austeng, Xing Cai, Joakim Sundnes and Simon Funke
7. Math and Mechanics: Karsten Trulsen and Kent-Andre Mardal, Andreas Carlsson
8. Math and Computational Finance, Statistics and Risk Analysis: Arne Bang Huseby and Geir Olve Storvik
9. Math and Cmputational Mathematics: Geir Dahl, Ragnar Winther, Knut Mørken, Martin Reimers, Michael Floater
10. Physics and Center of Computing in Science Education:

Timeline

1. Establish a center called **Center for Computing across Disciplines** by Fall 2018 and co-locate with the new Center for Computing in Science Education
2. Establish a department called **Department of Computational and Data Sciences** by Fall 2020
3. New Master of Science Program on Computational Science starts fall 2018
4. New Master of Science Program on Data Science starts fall 2018
5. Extend these Masters progrms to become cross-college programs
6. Establish a cross-college PhD program in Computational and Data Sciences, start fall 2020. This PhD program will be a collaboration between the Natural Sciences, Humanities, Social Sciences, Medicine and Education.
7. Develop an all university Master of Science Program in Computational Science and Data Science based on the present Computationa Science and Data Science programs by 2020
   7.1 Develop courses and course modules in Computational Science

Role and functioning of Department

For this part, see the long write-up with details and suggestions

Centers and Departments at other universities

In Norway it is only UiO which offers a Masters program on Computational Science and Data Science. All other universities have only Master programs on Computer Science. The University of Bergen has a Masters program on Applied Mathematics while UMB has only a Masters on Bioinformatics and Data analysis. These are limited and more focused programs. Nationally, UiO is the only university which offers broad programs in Computational Science and Data Science.

Norway	University	Comp Science and Data dept	Bachelor program	Ma
	UiO	No	No	
	NTNU	No	No	
	UiT	No	No	
	UiB	No	No	
	UMB	No	No	Yes (Bio

Out of 95 universities polled in the USA, there are less than 15 which have a department on Scientific Computing and more than 50 that have a center on Scientific Computing. Between 20 to 30 of these offer a bachelor, Master of Science or PhD program. On Data Science there are approximately 30 departments and 40 centers. Almost 50 of these universities offer a Masters degree in

Educational programs at other universities

The Society for Industrial and Applied Mathematics (SIAM) keeps track of graduate programs in computational Science. The list is most likely not complete.