MASTER'S DEGREE PROGRAMME IN BIOINFORMATICS

Department of Computer Science
Department of Mathematics and Statistics
Exactum (Kumpula Campus)
PO Box 68
FI-00014 University of Helsinki
Phone 1911 (switchboard), direct dialling 191 + extension number

Web pages: www.cs.helsinki.fi/mbi

Professor in charge: Juho Rousu
Coordinator: Esa Pitkänen

Bioinformatics as a discipline

Bioinformatics is a new field of science that seeks answers to the questions of life, raised by biology and medicine, with computational means. It is possible to study the infective potential of a virus by modelling its three-dimensional surface structure. Furthermore, the function of genes can be uncovered by a computational study of DNA sequences. The utilization of renewable resources for, e.g. biofuel production can be improved by metabolic modelling. Finally, machine learning can be used to seek cellular mechanisms of cancer from gene expression and metabolomics data.

The analysis of measurement data is of vital importance in the modern research in biology and medicine. Understanding such data requires both robust statistical modelling and methods which are computationally feasible.

In general terms, bioinformatics is computer-aided collecting, processing and analysing of biological and medical information. Mathematics, statistics and computer science methods provide the foundation of bioinformatics, but it is necessary to have a thorough understanding of both the application area and methods. Thus, a bioinformatician often acts as an important mediator between the methodological and biological sciences.

The University of Helsinki (HY) and Helsinki University of Technology (TKK) offer excellent opportunities for bioinformatics studies. Research in bioinformatics at those institutions is of the highest quality in Europe. The universities have extensive contacts to universities and research institutes abroad. This guarantees a wide-range of options for student exchange and post-graduate studies.

Employment of bioinformaticians

Universities and other research institutes employ bioinformaticians in various research positions. Biotechnology companies have also been employing bioinformaticians as specialists in growing numbers. Biological and medical research groups require bioinformaticians for data analysis tasks and development of biodatabases. Furthermore, bioinformatics research groups need more theoretically oriented bioinformaticians for development of new statistical and computational bioinformatics methods. The current state of employment is very good: it has been estimated that the need for bioinformaticians will greatly exceed the number of bioinformaticians currently employed.

Organization

The Master's Degree Programme in Bioinformatics (MBI) is organized jointly by the University of Helsinki and Helsinki University of Technology. At the University of Helsinki, member faculties are the Faculties of Science, Biosciences, Medicine, and Forestry and Agriculture. At Helsinki University of Technology, the Programme is organized by the Faculty of Information and Natural Sciences.

The teaching is given by people working on the cutting edge of bioinformatics research. For instance, people from three research units chosen to be Centres of Excellence by the Academy of Finland have a central role in the development and implementation of the programme.

Degrees

The basic degree offered by the MBI programme is Master of Science (in HY: MSc, filosofian maisteri; in TKK: MSc (Tech), diplomi-insinööri), with bioinformatics as the major subject. The scope of the degree is 120 credits, and requires a suitable Bachelor's level degree as a prerequisite.

The MSc degree consists of a minimum of 70 credits of advanced studies in bioinformatics and a minimum of 40 credits of minor subject studies, including biology, computer science and mathematics. Both the MSc degree and the MSc (Tech) degree have been designed to be as similar as possible. The biological minor subject courses are offered by the Faculties of Biosciences, Medicine as well as Forestry and Agriculture at the University of Helsinki.

The intended time to complete the degree is two years. The detailed structure of the MSc degree is described in the section on degree requirements.

Obtaining the right to study

The right to study is obtained via successful application. The calls for application for the academic year 2009–10 will be published in autumn 2008. Selection protocols, criteria and the schedule will be published on the web pages of the Master's Degree Programme in Bioinformatics (www.cs.helsinki.fi/mbi). Students who are admitted may be required to complete a maximum of 60 ECTS credits of studies that supplement their prior education. These supplementary studies are not included in the minimum scope (120 ECTS credits) of the Master's degree.

Recommended contents of a Bachelor's Degree

It is recommended that a student considering applying to the MBI programme has a strong background in computer science, mathematics and statistics: ideally one of these subjects is the major subject in the Bachelor's degree and at least one of the two others is a minor subject in the Bachelor's degree. A minor in a biological subject is also useful. Taking one of the modules

Basic studies in Genetics (Perinnöllisyystieteen perusopinnot), 25 cr
Basic studies in Genetic Bioinformatics (Geneettisen bioinformatiikan perusteet), 25 cr,

offered by the Faculty of Biosciences is recommended for prospective MBI applicants at the University of Helsinki. Note that the contents of the two modules overlap.

It is possible to apply to the MBI programme with a major in a biological or medical subject. However, a significant amount of minor subject studies in methodological sciences (computer science, mathematics or statistics) are required. The module

Minor Subject Studies in Computer Science, Mathematics and Statistics (Menetelmätieteiden sivuainekokonaisuus), 60 cr,

offered by the Faculty of Science is a recommended minimum for a prospective MBI applicant at the University of Helsinki.

It is recommended that an applicant to the Programme would have studied some of the following subjects: algorithms, biomathematics, computational modelling, databases, discrete mathematics, linear algebra, probability calculus and statistics. In particular, for the students of University of Helsinki, the following courses of the University of Helsinki are recommended.

Department of Mathematics and Statistics:
Differential equations I (Differentiaaliyhtälöt I)
Introduction to probability (Johdatus todennäköisyyslaskentaan)
Introduction to statistical inference (Johdatus tilastolliseen päättelyyn)
Linear algebra and matrices I+II (Lineaarialgebra ja matriisilaskenta I+II)
Single variable calculus (Analyysin peruskurssi)

Department of Computer Science:
Computational Data Analysis I+II (Laskennallinen data-analyysi I+II)
Data Structures (Tietorakenteet)
Design of Algorithms (Algoritmien suunnittelu)
Introduction to Databases (Tietokantojen perusteet)
Introduction to Programming (Ohjelmoinnin perusteet)
Models of Computation (Laskennan mallit)
Programming in Java (Java-ohjelmointi)

Student counselling and the personal study plan

Students are required to make a personal study plan (FM-HOPS) as part of their MSc degree, which is approved by the special tutor of the programme and the supervising professor. The personal study plan is to be approved by the end of the first period of the first year of study in the Programme. The study plan will be updated when needed as the studies progress.

In particular, it is important that the minor subject studies are planned to complement the previous studies in the Bachelor's degree, so that the methodological studies and biological studies form a meaningful whole.

Counselling for students are given by the following people:

University Lecturer Esa Pitkänen, special tutor of the programme, computer science (HY)
Professor Elja Arjas, mathematics and statistics (HY)
University Lecturer Päivi Onkamo, minor subject studies in biology (HY)
University Lecturer Outi Monni, minor subject studies in medicine (HY)
Lecturing Researcher Jarkko Salojärvi (TKK)

More information can be found on the web pages on student counselling:
http://www.cs.helsinki.fi/mbi/counselling/

Degree requirements

Students who have obtained the right to study in the Master's Degree Programme in Bioinformatics in Autumn 2008 will follow these requirements. The old requirements for the bioinformatics

subprogramme within the computer science degree programme are available in old study guides. Requirements for TKK can be found in the study programme of TKK.

MASTER OF SCIENCE DEGREE (120 CREDITS)

1. Major subject studies (minimum of 70 credits)

584329   ADVANCED STUDIES IN BIOINFORMATICS (70 CREDITS)
582606   Introduction to bioinformatics, 4 cr
582604   Practical course in biodatabases, 4 cr

Optional advanced courses in bioinformatics (other than seminars), minimum of 16 cr

Seminars, 6 cr

50151 or 57631 Master's thesis, 40 cr, containing
993734 Academic Writing for Students in English-Medium Master's Degree Programmes 1, 2 cr
993735 Academic Writing for Students in English-Medium Master's Degree Programmes 2, 2 cr
58307312 Master's thesis seminar, 3 cr
50041 Maturity test

2. Minor subject studies (minimum of 40 credits)

584330   MINOR SUBJECT STUDIES IN BIOINFORMATICS (40 CREDITS)
A minimum of 40 credits of the following subjects, in accordance with an approved personal study plan (FM-HOPS)

– Computer science
– Mathematics and statistics
– Biology, medicine or other suitable subject

3. Other studies (minimum of 2 credits)

Personal study plan (FM-HOPS), 1 cr
Advanced internship or vocational orientation studies, 1–3 cr
Optional courses

An additional requirement is that Bachelor's and Master's degree together must contain
Studies in biology, medicine or other suitable subjects, minimum of 25 credits
Studies in mathematics, statistics and computer science, minimum of 60 credits

General study instructions

Bioinformatics studies consist both of lectures and practical work. Major subject studies involve mostly lecture courses, where a lecture course may include practical project work. In minor subject courses in biology, practical work may include either computer classes, laboratory work (wetlab), or both.

Lecture courses

A lecture course typically contains lectures and exercises. As a general rule of thumb, a student should spend double the amount of time used for lectures and exercises for each course. For instance, if the course has four hours of lectures and two hours of exercises per week, the student should study a minimum of 12 hours per week in his or her own time. In addition, attention should

be paid to fulfilling the prerequisites before attending the course. Passing a lecture course usually requires completion of a sufficient number of exercises, and passing the course exam. An alternative way to pass a course is by a separate exam.

Laboratory courses ("wetlab")

Sufficient skills for further biological laboratory work will be provided during the courses Biology for methodological scientists and Measurement techniques for bioinformatics. The student is required to take these courses if he or she has not taken equivalent courses earlier.

Seminars

At least two seminars (6 credits) have to be included in the Master's degree. A seminar usually consists of student presentations and discussion. Seminars usually meet once a week for two periods (a whole semester). Each student is required to give at least one presentation on the topic of the seminar and actively participate in discussions. Passing a seminar involves writing a seminar paper. Grading is based on the oral presentation, participation in discussions and the written paper. Students are required to be present during at least 3/4 of the weekly meetings.

Registration for the courses and examinations

Students register for courses and separate examinations offered by the University of Helsinki according to the registration practices in the department organizing the course. At the Department of Computer Science, the web address of the registration system is http://ilmo.cs.helsinki.fi, and at the Department of Mathematics and Statistics, the address is http://ilmo.cs.helsinki.fi/matematiikka. Students register for courses and separate examinations offered by Helsinki University of Technology with the following registration system: https://webtopi.tkk.fi.

Teaching times

Teaching is given in four periods that are slightly different between HY and TKK.

University of Helsinki

Academic year 2008–2009
I 1 September – 19 October 2008
Period break 20–26 October 2008
II 27 October – 14 December 2008
III 12 January – 1 March 2009
Period break 2–8 March 2009
IV 9 March – 17 May 2009

Academic year 2009-2010
I 7 September – 25 October 2009
Period break 26 October – 1 November 2009
II 2 November – 20 December 2009
III 18 January – 7 March 2010
Period break 8–14 March 2010
IV 15 Match – 23 May 2010

IV periods include an intensive phase of two weeks in the end of periods.

Helsinki University of Technology

Academic year 2008–2009

I 8 September – 24 October 2008
Period break 25 October – 2 November 2008
II 3 November – 12 December2008
III 19 January – 6 March 2009
Period break 7–15 March 2009
IV 16 March - 5 May 2009

Teaching periods at TKK in the academic year 2009–2010 will be announced at the MBI web pages in Spring 2009.

Each period consists of six weeks of teaching, followed by an exam week. No teaching will be given during the period breaks 22–28 October and 3–9 March.

Advanced internship

The degree includes an obligatory advanced internship phase. The internship position is intended to be either in a research group or in a company working in a related field. The aim of the internship is to familiarise the student with real-world bioinformatics and with people working with it. The internship position is agreed on with the student counsellor as a part of the study plan. The Master's degree programme may financially support the internship phase. Some available positions for the internship will be announced on the MBI web page: http://www.cs.helsinki.fi/mbi/internship.

Grading

All courses are graded either on the six-step scale 0–5 or the two-step scale fail/pass. The lowest passing grade is 1/5, for which the student usually needs to get half the maximum points. To get the highest grade 5/5, the student usually needs at least 5/6 of the maximum points.

Teaching language

The teaching language in the Programme is primarily English. Exceptions are noted in the Teaching programme.

Master's thesis

The Master's thesis is the final thesis done independently by the student for the MSc degree. The extent of the thesis is 40 credits (HY) or 30 credits (TKK). In the Master's Degree Programme in Bioinformatics, the Master's thesis is written during the second year of studies.

The topic of the thesis is agreed upon with a professor of the Programme. Usually the topic is related to research problems of a bioinformatics research group. Ideally, the work involves members from both methodological and application fields. The following list provides the names and some research interests of professors working with methodological bioinformatics. The list serves as a starting point for finding a suitable topic for the Master's thesis.

Biological data fusion: Samuel Kaski, Hannu Toivonen
Biological data mining: Heikki Mannila, Hannu Toivonen
Functional genomics: Liisa Holm, Samuel Kaski, Juho Rousu
Gene expression data analysis: Elja Arjas, Samuel Kaski
Genetic mapping: Elja Arjas, Heikki Mannila, Hannu Toivonen, Esko Ukkonen
Sequence analysis: Heikki Mannila, Esko Ukkonen
Metabolic networks: Juho Rousu, Esko Ukkonen
Structured population dynamics, evolution and natural selection, ecological modelling: Mats Gyllenberg

A more complete list is provided on the web pages of the Programme.

The work is divided into three phases. The first phase involves writing a one-page subject proposal where the research question is formulated. During the second phase, a research plan is written. The research plan should already contain most of the literature references of the final thesis. Both the proposal and the research plan must be approved by the instructor of the thesis. Finally, the thesis is written.

While working on the Master's thesis, the student is expected to participate in the Master's thesis seminar on a regular basis and give two presentations, one on the research plan and the other on the (nearly) completed thesis in the seminar.

Additionally, the student must take a course in Scientific writing in English before completing the Master's thesis in accordance with the personal study plan. Suitable courses for fulfilling this requirement are given in the Teaching programme under section Language courses.

Maturity test

The maturity test required for the Master's degree is taken as a separate exam when the Master's thesis has been submitted for evaluation. A new test is required even if the student has given the test at the Bachelor level. If a Finnish student has previously taken the Bachelor level maturity test in his or her mother tongue, the student may take the Master's level maturity test either in English or in mother tongue. Otherwise, the Finnish student is required to take maturity test in mother tongue. Non-Finnish students take the maturity test in English.

Note that at Helsinki University of Technology, the maturity test is required only if the student has not already taken one at the Bachelor level.

Registration of completed modules

To register the study module Advanced Studies in Bioinformatics, the student should hand in a copy of the transcript of records maintained by the university and an application form with the list of courses that the student wants to include in the module. The application form and contact information of persons who approve the application are available from the Programme webpage.

Bioinformatics as a minor subject

The recommended way to study bioinformatics as a minor subject is to take the Basic module in genetic bioinformatics (25 cr) offered by the Faculty of Bioscience. For details, see the study guide of the Faculty of Biosciences, or contact either Professor Liisa Holm or University Lecturer Päivi Onkamo.

Computer access

The Department of Computer Science and the Department Mathematics and Statistics provide classrooms with computers that may be used in studies. To access the computers, you need a personal user account. Please see the Study guide sections for Computer Science and Mathematics and Statistics for details.

Post-graduate studies

Post-graduate studies aiming for a Doctor of Philosophy or Licenciate of Philosophy degree are typically pursued in conjunction with research groups working in the field of Bioinformatics.
A list of such groups can be found on the web pages of the Master's programme.

The Graduate School in Computational Biology, Bioinformatics, and Biometry: ComBi

The Graduate School in Computational Biology, Bioinformatics, and Biometry (ComBi) is a post-graduate programme jointly offered by the Universities of Helsinki, Tampere and Turku as well as Helsinki University of Technology. The school was established at the beginning of 1998, and the Department of Computer Science at the University of Helsinki is the coordinating institution. The research goal of ComBi is to develop computational, mathematical, and statistical methods and models for natural sciences. The thesis projects are carried out in close cooperation with one or more research groups in the application fields (such as biochemistry, molecular biology, genetics and biotechnology, ecology, research into evolution and systematics, geography and economics). More information including activities, application deadlines, funding of studies, etc. may be acquired from the director of the graduate school, Academy Professor Heikki Mannila (HY), and from the general secretary Heikki Lokki (HY) as well as electronically on the web page http://www.cs.helsinki.fi/combi/ or by email to combi@cs.helsinki.fi.

ComBi is a partner programme in Bioinformatics Research and Education Workshop (BREW). BREW aims to introduce PhD students to the work modes of international conferences at an early stage in their PhD work, to bring together PhD students and experienced researchers in an atmosphere of cooperation and inspiration, to establish research contacts across Europe, to be utilized in the student's subsequent research and to contribute to the development of bioinformatics education and to the formation of the research community across Europe. More information on BREW is available on the ComBi web page.

Other related graduate schools

The following list includes graduate schools that offer postgraduate programmes in fields related to bioinformatics in the Helsinki region. Contact information for graduate schools can be found on the MBI web pages.

Biomaterial Graduate School
Clinical Drug Trials Graduate School
Finnish Graduate School in Plant Biology
Finnish Graduate School of Neuroscience
Functional Research in Medicine Graduate School
Graduate School in Computational Methods of Information Technology (ComMIT)
Graduate School in Pharmaceutical Research
Helsinki Biomedical Graduate School
Helsinki Graduate School in Biotechnology and Molecular Biology
Helsinki Graduate School in Computer Science and Engineering (HeCSE)
National Graduate School of Clinical Investigation
The Finnish Graduate School on Applied Bioscience: Bioengineering, Food & Nutrition Environment (ABS)
Viikki Graduate School in Biosciences

Course descriptions

Course descriptions can be found on the MBI web pages at http://www.cs.helsinki.fi/mbi/studies.html.

Teachers

Please contact teachers during their office hours. Contact information and office hours are available at http://www.cs.helsinki.fi/mbi/people.

Arjas, Elja, PhD, Professor, HY
Geritz, Stefan, PhD, University Lecturer, HY
Gyllenberg, Mats, D.Sc. (Tech.), Professor, HY
Hautaniemi, Sampsa, D.Sc. (Tech.), Adjunct Professor, HY and TKK
Holm, Liisa, PhD, Professor, HY
Hoyer, Patrik, D.Sc. (Tech.), HY
Hyvärinen, Aapo, PhD, Professor, HY
Kaski, Samuel, D.Sc. (Tech.), Professor, TKK
Kivioja, Teemu, PhD, HY
Mannila, Heikki, PhD, Academy Professor, HIIT and TKK
Mäkinen, Veli, PhD, Postdoctoral Fellow, HY
Monni, Outi, PhD, Adjunct Professor, HY
Niklander-Teeri, Viola, PhD, Adjunct Professor, HY
Onkamo, Päivi, PhD, Adjunct Professor, University Lecturer, HY
Pitkänen, Esa, MSc, University Lecturer, Coordinator, HY
Rousu, Juho, PhD, Adjunct Professor, Professor, HY
Salojärvi, Jarkko, MSc (Tech.), Lecturing Researcher, TKK
Toivonen, Hannu, PhD, Professor, HY
Ukkonen, Esko, PhD, Professor, Research Director of HIIT, HY
Valkonen, Jari, D.Sc. (Agr. & For.), Academy Professor, HY
Varvio, Sirkka-Liisa, PhD, Adjunct Professor, HY
Vigario, Ricardo, D.Sc. (Tech.), Adjunct Professor, TKK