Stochastic optimization algorithms (FFR105, FIM711) LP I (first quarter), 2018

Basic information

Lecturer and examiner:
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Literature:
Wahde, M. *Biologically Inspired Optimization Methods: An Introduction,* WIT Press, 2008

Note! The course book is sold by Chalmers bookstore (Cremona). It is also possible to buy the book online (it is available at Amazon and many other bookstores).

Aim:
The aim of the course is for the students to attain an understanding of new methods in computer science inspired by natural processes such as evolution and cooperative behavior (for example, swarming), and also to be able to apply such methods. The methods studied in the course are relevant both in technical applications, for example in the optimization and design of autonomous systems, and for understanding biological systems, for example through simulation of evolutionary processes.

Learning outcomes *(after completion of the course the student should be able to...)*

- Implement and use several different classical optimization methods, e.g. gradient descent and penalty methods.
- Describe and explain the basic properties of biological evolution, with emphasis on the parts that are relevant for evolutionary algorithms.
- Describe and explain fundamental properties of cooperative behavior (e.g. swarming).
- Define and implement (using Matlab) different versions of evolutionary algorithms, particle swarm optimization, and ant colony optimization, and apply the algorithms in the solution of optimization problems.
- Compare different types of biologically inspired computation methods and identify suitable algorithms for a variety of applications.

Preliminary program:

Note: Page numbers refer to the course book, see *Literature* above.

Date	Time	Room	Contents
20180904	10.00-11.45	HB2	Course introduction and motivation, (pp. 1-8), Classical optimization methods (introduction, pp. 8-12)
20180905	08.00-09.45	HB4	Classical optimization methods (i), (pp. 12-21, Appendix B.1, pp. 173-174)
20180907	10.00-11.45	HB2	Classical optimization methods (ii), pp. 21-34, **Handout of programming problem**
20180911	10.00-11.45	FB	Evolutionary algorithms: background and introduction, (pp. 35-45, 82-83). **Handout of home problem 1**
20180911	18.00-21.00	MT9, 11-13	Introduction to Matlab programming for stochastic optimization algorithms
20180912	08.00-09.45	HB4	Evolutionary algorithms: components of EAs, (pp. 46-59)
20180914	10.00-11.45	KE	Evolutionary algorithms: properties, (pp. 59-71), Appendix B.2, pp. 174-183, **Handin of programming problem**
20180918	10.00-11.45	FB	Classical optimization methods and evolutionary algorithms (review, problem solving, Q&A, etc.)
20180919	08.00-09.45	HB4	Linear genetic programming and interactive evolutionary computation, (pp. 72-81)
20180921	10.00-11.45	FB	Neural networks (Appendix A, pp. 151-172), data analysis (Appendix C, pp. 193-204)
20180925	10.00-11.45	HB1	Evolutionary algorithms: Applications I (various papers etc.), **Handin of home problem 1**
20180926	08.00-09.45	-	**No lecture**
20180928	10.00-11.45	FB	Evolutionary algorithms, Applications II (various papers etc.), **Handout of home problem 2**
20181002	10.00-11.45	FB	Ant colony optimization: background and introduction, (pp. 99-106)
20181003	08.00-09.45	HB4	Ant colony optimization: AS vs. MMAS, applications, properties of ACO, (pp. 107-116), Appendix B.3, (pp. 183-187)
20181005	10.00-11.45	FB	Particle swarm optimization: Background and introduction, (pp. 117-124)
20181009	10.00-11.45	FB	Particle swarm optimization: Properties of PSO, applications, (pp. 124-138)
20181010	08.00-09.45	HB4	Problem-solving class (various problems), review
20181012	10.00-11.45	-	**No lecture**
20181016	10.00-11.45	FB	Performance comparison (EAs, ACO, PSO), (pp. 139-149)
20181017	08.00-09.45	HB4	Applications of biologically inspired optimization algorithms in autonomous robots, vehicles, and software agents. **Handin of home problem 2**
20181019	10.00-11.45	FB	Course summary
20181023	10.00-11.45	My office	Consultation (exam preparation)
20181024	08.00-09.45	-	**No lecture**

Examination:

The examination will consist of two sets of home problems, one separate (small) programming problem (to learn the coding standard) and an exam at the end of the course. The programming language used (for the home problems) will be Matlab (no exceptions allowed).

Introductory programming problem: Even though many students are probably used to programming in Matlab (and other programming languages), some students are not. In order to make sure that all students reach an acceptable level of programming knowledge, you will have to begin by solving a (simple) programming problem, *making sure to follow the coding standard*. This problem will be handed out on 20180907, and it should be handed in on (or before) 20180914. In order to get a passing grade for this assignment (which is *required*), you should make sure that your program (i) solves the problem, and (ii) follows the coding standard.

Home problems:
The problem sheets will be handed out on 20180911 (set 1) and 20180928 (set 2), and should be handed in no later than 20180925 (set 1) and 20181017 (set 2). Maximum total score: 25p. Each set will contain both mandatory problems (that must be solved satisfactorily in order to pass the course) and voluntary problems (that are necessary to solve for students aspiring to receive a high grade; see the next page below).

Penalties for delays: Students should hand in the home problems on time. The hand-in time is defined as the time when the last e-mail (for the *entire* home problem set in question) is *received*. Thus, students should submit each home problem set as one e-mail attachment (.zip or .rar), before the deadline. The penalties for delays are as follows: < 6 hours: 0p, 6 hours - 24 hours: 1p, 24 hours - 48 hours: 2p, >48 hours: 3p. These penalties are non-negotiable.

Strict final deadline: In addition to the penalties for delays, please note that the very latest time to hand in *both* home problem sets is 20181030, 23.59.59. In case the problems (= a serious solution attempt for each problem set) have not been handed in by then, *you will need to redo the home problems next year*. **Please note:** No hand-ins (except corrected solutions, of course) will be accepted after 20181030.

Corrected solutions (where applicable, i.e. in cases where you have been required to submit a revised solution) should preferably be handed in during the course or immediately afterwards. Such solutions can, however, be handed in at any time after the course, but they will then be corrected *only in connection with the re-exams.* Corrected solutions submitted in November or December will thus be corrected and graded in connection with the re-exam period in January 2019.

Exam:
Date: 20181031, 14.00-18.00. Maximum total score: 25p.

For the exam, students are allowed to bring (i) a calculator, provided that it cannot store any text (Chalmers has a list of three simple standard calculators - those *are* allowed to use during the exam), (ii) mathematical tables (such as Beta, Standard Math etc.) as long as no text has been added, (iii) writing material (but not a red pen (red is reserved for correction) or scrap papers. Papers will be provided during the exam). No other equipment is allowed. Thus, students may ***not*** bring any papers from the course (or blank papers) to the exam: It is ***not*** allowed to bring the course book, any lectures notes, any printouts of papers provided during the course, any old exams etc. etc. No forms of electronic equipment (except calculators as described above) are allowed.

Grade requirements:
The minimum requirements for a passing grade (grade 3) are (i) to obtain at least 10 p *on the exam* and (ii) to generate and submit satisfactory solutions to the mandatory home problems. The additional requirements for the various grades are as follows: (the numbers refer to the sum of the exam result and the home problems, maximum 50p in total)

Chalmers:
5 Total score in [42,50]
4 Total score in [33,41.5]
3 Total score up to 32.5 (i.e. just the minimum requirements; see above)

GU:
VG: Total score in [39,50]
G: Total score up to 38.5 (i.e. just the minimum requirements; see above)

ECTS:
ECTS grades are offered to Erasmus Mundus students, using the same ranges as for Chalmers grades (i.e. A=5, B=4 etc.)

Changes made since last year: The changes relative to the previous year are rather minor. The home problems have been updated (modified), and some of the slides have also been updated. For example, additional examples (from the literature) are given in some of the lectures on stochastic optimization algorithms.