# SIE 649 TOPICS OF OPTIMIZATION: Optimal Learning

Fall 2017

**Class meeting times & location:**

TR 5:00-6:15pm, SIE 301

**Instructor**:

Prof. Matthias Poloczek

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Office hours: Tuesdays and Thursdays after class, and by appointment

**Course Description:**

We consider optimization problems whose objective function is unknown and hence has to be learned. Such information collection problems are pervasive in science and industry, e.g., when designing prototypes of vehicles, tuning hyper-parameters of machine learning algorithms, setting prices to maximize the revenue, developing pharmaceutical drugs etc.

We address the problem of collecting information efficiently while making sequential decisions. We introduce a general framework in which to understand and formulate information collection problems, and provide a survey of problems, methods, and theoretical results within optimal learning.

**Recommended texts:**

- W.B. Powell and I.O. Ryzhov, *Optimal Learning*, ISBN-13: 978-0470596692
- C.E. Rasmussen and C. K. I. Williams, *Gaussian Processes for Machine Learning*, ISBN-13: 978-0262182539, available at http://www.gaussianprocess.org/gpml/chapters/RW.pdf
- C.M. Bishop, *Pattern Recognition and Machine Learning*, ISBN-13: 978-0387310732
- Further references will be provided in class

**Prerequisites:**

I will assume solid knowledge of probability, linear algebra, and multivariable calculus. You should be comfortable with random variables, conditional probability and expectation, common probability

distributions and their properties (e.g., binomial, geometric, exponential, Poisson, Gaussian).
You should also be comfortable coding small programs for homeworks, and will be expected to complete a larger program for the project. While Python is recommended, the choice of the programming language is yours. The instructor cannot provide individual assistance ("debugging"). We will have an online forum to facilitate solving coding issues collaboratively.
Please e-mail the instructor if you are concerned about having appropriate prerequisites.
Students from electrical, systems and industrial engineering, applied math, and computer science are welcome.

**Computer Support:**
PC with internet access.

**Assignments**:
10% homework, 5% readings, 20% exam, 40% project, 10% presentation, 10% peer reviews, 5% participation.

Project: There will be a project in the second half of the semester that allows you to apply lessons learned in a research project of your choosing. The project involves

- *Formulating an original research proposal* based on the content of the course,
- *Solving* it, where "solving" could mean computing the optimal solution, evaluating different algorithms experimentally, or proving structural results,
- Writing a *project report*, and giving a *presentation* of your work.

You are encouraged to pursue a research topic that you find interesting, e.g., related to your thesis research or private interests. Please feel free to consult with me about the proposal early.
For the project report, I suggest an interactive document (e.g., Jupyter, Matlab, Mathematica) which states the problem and results, and has interactive demonstrations of your work. (A static document is also accepted without penalty.)

Readings: From time to time, I will point you to reading materials that may provide the foundation for topics presented in class or a deeper treatment, for which you are required to write a concise summary (at most one page). Note that you will receive full credit for an assignment if the summary is submitted on time (subject to a grace period of 24 hours) and demonstrates a reasonable effort to understand the material.

Peer reviews: You will be asked to review up to three project reports according to criteria specified in class. These reviews will be "single blind", i.e. reviewers will know the identity of the author, whereas the reviewers' identities are only known to the instructor.

Presentation: Each students will present one selected scientific work in class. The instructor will provide a list of suitable topics and manuscripts that for example apply techniques discussed in the course to problems in engineering, health care, transportation, machine learning etc. In addition, you may propose a work, e.g., related to your research project. In this case, please reach out to the instructor early.

Homeworks: Homeworks are due on the specified date and time (with a grace period of 24 hours).

Exam: There will be an oral or a written exam. The type of the exam will be announced in the first lecture based on the enrollment. Written exams are closed book and closed notes and have a duration of 90 minutes. The duration of oral exams is about 30 minutes. More details will be provided in the first lecture.

Participation: Participations points are given for active participation in class and for assisting other students in the online forum (but not for raising questions). Naturally active participation in class is not applicable for remote students.

**Grading:**

A: 90 - 100%, B: 80 - 89%, C: 70 - 79%, D: 60 - 69%, E: 0 - 59%

**Preparation, Disputes, and Late Submission:**

You may discuss the homework, readings and project with other current students of the class, but showing each other written solutions is not acceptable. Each student must write their submissions independently and individually. (Sharing write-ups, or submitting copies will be considered a violation of the code of academic integrity, and appropriate actions will be taken.)

If there is a dispute about grading, you may turn in the entire assignment for a re-grade within a week of the work being returned, with a short explanation of the error. All of the work, not just the disputed question, will be regraded.

Submissions are due at the designated date, subject to the applicable grace period stated above. Later submissions will not be graded, unless there is a convincing, properly documented reason why you were unable to finish the submission throughout the given time period.

**Attendance Policy:**

Students are expected to attend class. If you miss class you are responsible for obtaining the class notes, assignments, and announcements. Phone usage is not allowed during the class; please put your phone into "quiet", or "vibrate" mode prior to start of the class.

**Accommodation for Students with Special Needs:**

Students with disabilities or special needs for accommodations (including in class meetings and exams) are required to contact both the instructor and the S.A.L.T. Center (www.salt.arizona.edu) or the Disability Resource Center (http://drc.arizona.edu) as early as possible in the semester. They are also required to submit appropriate documentations to the instructor before accommodations could be offered.

**Statement of Inclusion:**

Inclusive Excellence is a fundamental part of the University of Arizona's strategic plan and culture. As part of this initiative, the institution embraces and practices diversity and inclusiveness. These values are expected, respected and welcomed in this course.

**Name and Pronoun Usage Statement:**

This course supports elective gender pronoun use and self identification; rosters indicating such choices will be updated throughout the semester, upon student request. As the course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect.

**Academic honesty:**

All students are expected to commit themselves to be honest in all academic work and understand that failure to comply with this commitment will result in disciplinary action. This is a reminder to uphold your obligation as a UA student and to be honest in all work submitted and exams taken in this course and all others.

**This syllabus is tentative and the instructor reserves the right to make modifications if appropriate.**

MP 08/21/2017