Introduction to Mathematical Optimization

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**Background**
- PhD Aeronautics & Astronautics, 2011, Stanford University (PhD Minor in CME)
- Principal Member of Technical Staff, Sandia National Laboratories, 2014–2019
- Distinguished Member of Technical Staff, Sandia National Laboratories, 2019–2019
- Research Scientist, Facebook Research, 2019–

**Research interests:** machine learning, computational physics, high-performance computing, model reduction, uncertainty quantification, numerical optimization, Krylov-subspace methods, time-parallel methods
Pre-course feedback

I will not assume you have any previous knowledge
Yet, we will cover some advanced topics and tools for the 5-7 people
Pre-course feedback

Provided Jupyter notebooks that can be run without experience with Python
Those with Python experience can quickly figure out how to use optimization tools
Pre-course feedback

Rate your experience level with CVXPY

61 responses

- No previous knowledge is needed
- CVXPY has a shallow learning curve: designed to allow you to "express your problem in a natural way"
Pre-course feedback

We will briefly cover optimization aspects of machine learning
  ▶ stochastic gradient descent
  ▶ neural networks
  ▶ distributed optimization
Lots of interest in machine learning, Python, general knowledge
Course materials

Add the shared folder to your account:

▶ Go to drive.google.com and log in with your Google account
▶ Go to https://tinyurl.com/yye7vlfx to access the shared Google Drive folder
▶ Click on “Introduction to Mathematical Optimization 2019” > “Add to My Drive”.

Try the notebooks:

▶ In Google Drive, go to “Introduction to Mathematical Optimization 2019” > “Notebooks”
▶ Double click any notebook; click “Open with Google Colaboratory” at the top
▶ You now have three options:
  1. Look at the notebook and its output: Simply scroll around.
  2. Interact with the notebook: Click on “Open in playground” at the top left to modify the notebook and interact with it. Because this remains part of the original folder, you cannot make permanent changes to the notebook.
  3. Make a copy of the notebook: Click on “Copy to Drive” at the top, which will create a copy in “My Drive” > “Colab Notebooks”. This is your own separate copy, and you can make permanent changes to the notebook.
Outline

Session 1: 9:00am–10:30am
- Introduction to optimization (2_introduction.pdf)
- Unconstrained optimization (3_unconstrained.pdf)

Session 2: 10:45am–12:00pm
- Optimization in Python (4_optimization-in-python.pdf)
- Constrained optimization (5_constrained.pdf)

Session 3: 2:00pm–3:15pm
- Optimization for machine learning (6_optimization-for-ml.pdf)

Session 4: 3:30pm–4:45pm
- Convex optimization (7_convexity.pdf)
- Convex-optimization examples (8_modeling.pdf)
References

- These slides
  - A lot of content
  - Very verbose to make self-contained
  - Excellent lectures by S. Boyd online
  - Class notes and lectures for EE364a, EE364b online
  - CVX101 MOOC
  - Advanced recent review article
Hub at Stanford: Critical inter-disciplinary field using advanced mathematics and computing to address complex problems
55+ affiliated faculty across Stanford

School of Education

School of Medicine

School of Business

Humanities & Sciences

School of Earth Sciences

Stanford Linear Accelerator
150+ MS and PhD students

- Degre-granting graduate program
- Over 60 courses offered annually
ICME Industry Affiliate Partnership Program

- Concierge-style recruiting of ICME students
- Invitations to quarterly events (roundtables, symposia, seminars)
- Professional development in data science & machine learning
- Faculty liaison
- State-of-the-art facilities
- Discounts at the summer workshops
- Email Karen Matthys (kmatthys@stanford.edu) if interested in participating
- https://icme.stanford.edu/partnership-programs