CS 591/491 - Numerical Optimization

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Wednesdays 9:30-12:00, E&SCP Room 110

Overview: Computational science, engineering and applied mathematics face a growing need to develop algorithms, methods, and simulation codes that solve difficult and large scale problems. Solutions are desired that can provide designs, controls, and inversion results for the best choice of input parameters. Numerical optimization algorithms can provide computer scientist, engineers and mathematicians an avenue to the most desirable solution, automate the execution, and achieve efficient convergence rates. This class will provide the theoretical and practical foundation for numerical optimization. A variety of dynamical systems will be used as application examples and provide the basis for projects. Our primary programming environment will be Matlab.

Course Topics:

1. Introduction - general concepts, simple examples, global vs local, gradient vs non-gradient, black box vs intrusive methods.
2. Unconstrained optimization - overview of algorithms, optimality conditions, solution techniques.
3. Globalization - line search methods, trust region methods.
4. Conjugate Gradient - linear, nonlinear, basic properties.
5. Newton Methods - Hessian calculation, line search, trust region, convergence issues, quasi-newton, BFGS, SR1, Broyden, limited memory BFGS, Gauss Newton Methods, nonlinear issues.
6. Constrained Optimization - optimality conditions, nonlinear cases.
7. Quadratic Programming - range and null space methods, active set methods for inequalities, penalty methods, sequential quadratic programming.
8. Advanced topics - implementation, parallelization, interfaces, applications.

Projects, Assignments, Format: Homeworks will consist of simple algorithm implementation in Matlab and solving specific problems. Longer term projects may be assigned instead of midterm and final exams.

Prerequisites: Calculus, basic linear algebra and numerical methods, and some programming skills.

Grading, and Texts: The recommended text is Numerical Optimization (Second Edition) by J. Nocedal and S.Wright.