Course title: *MA797 – Convex Optimization Methods in Data Science*

Instructor: Patrick L. Combettes, plc@math.ncsu.edu

Term: Fall 2019

Time: Tuesdays and Thursdays, from 10:15 to 11:30

Office hours: Tuesdays and Thursdays from 11:35 to 12:35, SAS 3276

Course objectives: This course is intended to provide an account of convex optimization methods and their applications in various areas of data science (signal and image processing, inverse problems, statistical data analysis, machine learning, classification, etc.). The basic theory will be provided and a strong emphasis will be placed on algorithm design and concrete applications.

Prerequisite: Calculus, basic linear algebra, and (preferable but not indispensable) elementary convex analysis

Content: Course overview and motivations • Iteration principles • Fixed point algorithms • Convex sets and convex cones • Best approximation paradigms • Projection methods in convex feasibility problems – applications to data fusion and image recovery • Convex functions • Conjugation of convex functions • Duality in convex optimization • Subdifferential calculus • Subgradient algorithms for convex feasibility and best approximation – applications in inverse problems • Proximity operators • Proximal calculus • Forward-backward splitting and variants (Dykstra-like methods, Chambolle-Pock algorithm, dual ascent method, etc.) • Douglas-Rachford splitting and variants (parallel proximal algorithm, alternating direction method of multipliers, composite primal-dual method, etc.) • The monotone+skew decomposition principle – primal-dual algorithms • Proximal modeling of statistical information • Proximal information extraction • Proximal sparsity enforcement • Proximal data classification • Proximal principal component analysis • Proximal image reconstruction • Proximal learning • Scalability: proximal methods in big data problems • Special topics

Grading: HW 20%, midterm 30%, final or project 40%.

Reference material (no purchase necessary):

- H. H. Bauschke and P. L. Combettes, *Convex Analysis and Monotone Operator Theory in Hilbert Spaces, 2nd ed.* Springer, New York, 2017.
- P. L. Combettes, The convex feasibility problem in image recovery, in: *Advances in Imaging and Electron Physics* (P. Hawkes, Ed.), vol. 95, pp. 155–270. Academic Press, New York, 1996.
- P. L. Combettes and J.-C. Pesquet, Proximal splitting methods in signal processing, in *Fixed-Point Algorithms for Inverse Problems in Science and Engineering,* (H. H. Bauschke et al., eds), pp. 185–212. Springer, New York, 2011.
- S. Sra, S. Nowozin, and S. J. Wright, *Optimization for Machine Learning*. MIT Press, Cambridge, MA, 2012.