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Multi-Agent Optimization and Learning: Resilient and Adaptive Solutions

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Abstract of the course

Recent technological advances have spawned a number of applications – ranging from decentralized learning to smart grids and IoT – in which the control of multi-agent decision-making systems is of central importance. In this context, many engineering problems can be cast as optimization and learning problems over networks of cooperating agents. The course will provide a thorough introduction to the solution methods that have been developed to tackle these challenging scenarios, as well as an overview of current trends and advanced topics. During the first part of the course, specific emphasis will be given to the challenging set-up of networks with asynchronous operations and faulty communications, leveraging both gradient- and non-expansive operator-based approaches. The second part will then discuss the application of these methods to learning in decentralized scenarios, and their translation to online problems, which are characterized by time-varying objectives and constraints.

Outline:

1. Introduction and motivating examples (smart grids, decentralized learning, sensor networks)
2. Consensus and distributed optimization
    - The consensus algorithm: standard, accelerated, push-sum/ratio, …
    - Consensus-based distributed optimization: gradient tracking and Newton
3. Non-expansive operators and distributed optimization
    - Non-expansive operators for optimization: background, operator-based algorithms (proximal gradient, ADMM, primal-dual, …)
    - Application to asynchronous and lossy networks: a stochastic operators approach
4. Advanced topics
    - Federated learning: background, links to distributed optimization, current trends
    - Online distributed optimization (prediction-correction, control-theoretical approaches)
    - Current trends: data-driven optimization, privacy, human-in-the-loop