Sequential decision making under uncertainty
KTH/EES, FEL5443

The course aims at introducing a set of selected fundamental sequential decision problems under uncertainty and at providing tools towards exact or approximate solutions. The course is primarily devoted to stochastic models and more precisely to Markov Decision Processes, but also presents some recent advances in optimal decision making in adversarial scenarios and games. Numerous examples of applications are provided.

After completing this course, you will be able to rigorously formulate and classify sequential decision problems, to estimate their tractability, and to propose and efficiently implement methods towards their solutions.

Keywords. Dynamic programming, Markov Decision Process, Multi-armed bandit, Kalman filter, Online optimization.

Credits: 7.5 p
Two home exams and a project.
Teacher: Alexandre Proutiere (alepro@kth.se)

Schedule.

Introduction. Overview and examples of sequential decision problems.

<u>PART I - Stochastic models</u>
1. Review of probabilistic tools. Markov chains, Martingales, basic inequalities.
2. Discrete time Markov Decision Processes (MDPs).
    2a. Finite time-horizon. Principle of optimality, backward induction.
    2b. Infinite time-horizon. Principle of optimality, value / policy iteration, modified policy iteration, linear programming.
3. Solving MDPs - part 1. Exact solutions based on structural properties of the MDP.
4. Solving MDPs - part 2. Some approximation methods.
5. Extensions. Constrained MDPs, Partially Observable MDPs, Decentralized MDPs.
6. Limit theorems. Going from MDPs to deterministic continuous-time control.
7. Optimal stopping time problems.
8. Kalman filter.
9. Prediction with expert advice and Multi-Armed Bandit (MAB) problems.

<u>PART II - Adversarial models and Games</u>.
1. Prediction with expert advice and MAB problems in adversarial scenarios.
2. Sequential decision making in games. Internal regret, Correlated equilibria, Convergence to and selection of Nash Equilibria.
3. Recent advances in online optimization.