**Syllabus for IE481: Special Topics in Industrial Engineering I**

**(Data-Driven Decision Making and Control)**

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| **Instructor** | |  |
|  | Jinkyoo Park  Office : E2-1, #4212  Email : [jinkyoo.park@kaist.ac.kr](mailto:jinkyoo.park@kaist.ac.kr)  Office hours: Tue/Th: 2:00-4:00 pm (other times are available by appointment by email) | |

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| **Time/Location** | |  |
|  | Time: Tue/Th from 10:30 – 11:45 pm  Location : (E2) Industrial Engineering & Management Bldg., Lecture room 1 (#1120) | |

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| **Course TA** | | |  | |
|  | | Lee, Senghoon (ianian0606@kaist.ac.kr) | | |
| **Prerequisites** | | | |  |
|  | * IE241 Engineering Statistics or similar courses * IE331 Operations Research I or similar courses | | | |

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| **Textbook** | |  |
|  | Richard S. Sutton and Andrew G. Barto, *Reinforcement Learning: An Introduction,* MIT Press, 1998  (available: http://webdocs.cs.ualberta.ca/~sutton/book/the-book.html) | |

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| **References (advanced)** | |  |
|  | * Andrew Gelman, *Bayesian Data Analysis, CRC Press* * Hastie, T., Tibshirani, R., Friedman, J. (2001). The Elements of Statistical Learning. New York: Springer * Mykel J. Kochenderfer, *Decision-making Under Uncertainty: Theory and Application*, MIT Press, 2015 | |

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| **Overview** | |  |
|  | With advancements in sensing technologies and Big data analytics, lots of attention is drawing to intelligent systems that can automate data analysis and decision making for improving the system performances. To realize the intelligent systems, it is imperative to develop an efficient algorithm that can derive the optimum decisions considering model uncertainty, state uncertainty and environment uncertainty.  This course provides an overview of various decision-making methodologies in both modeling and computational perspectives. The course mainly covers probabilistic (Bayesian) modeling approaches, which is advantageous in modeling uncertainties encountered in various decision- making problems and in combining the learning (exploration) and the optimization (exploitation) in a single framework.  Following an introduction to probabilistic models and decision theory, the course will mainly focus on data-driven dynamic decision making strategies. The course first discusses modeling technique of a dynamical system using data. The course then discusses how to derive the optimal decision making strategy (i.e., policy) utilizing the dynamic model trained from the data. Finally the course covers an alternative dynamic decision making strategy, model-free reinforcement learning. Value-based reinforcement learning, policy gradient, and actor-critic algorithm will be overviewed with practical examples. | |

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| **Objectives** | |  |
|  | Upon successful completion of the course, you are able to   * *understand* various mathematical models describing decision making problems. * *formulate* real-world decision making problems in a mathematical form. * *implement* key algorithms and approaches to solving various decision making problems. * *Interpret* the results of decision-making problems. | |
| **Topics (tentative)** | |  |
|  | 1. Bayesian Modeling and Inference (3 weeks)   * Probability distributions * Prior, Likelihood, and Posterior * Conjugate models * Hierarchical Modeling * Elements of Computational Bayesian Statistics * Bayesian Regression   2. Learning Dynamic Model from Data (3 weeks)   * Dynamic Bayesian Network * Hidden Markov Model * Linear Gaussian Model   3. Model-Based Reinforcement Learning (6 weeks)   * Markov Decision Process (MDP) and Dynamic Programming * Stochastic Control and Dynamic Programming * Model-Predictive Control   4. Model-Free Reinforcement Learning (6 weeks)   * Value Function Based Reinforcement Learning * Policy Gradient Reinforcement Learning * Actor-Critic Reinforcement Learning | |

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| **Sessions (tentative)** | |  |
|  | * Jupyter session * Linear Algebra review * Probability review * Statistics review * .....subject can be changed upon requests | |

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| **Evaluations (tentative)** | |  |
|  | * 5 sets of homework (25%) * Midterm exam (20%) * Final exam (30%) * Final project (20%) * Attendance and class participation(quiz) (5%) | |

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| **Projects** | |  |
|  | The objective of the project is to encourage students to define their own problems of interests and formulate them in a formal mathematical way. The topic should be related to the general theme of the course. As part of the project you should:   * *formulate* a target problem * *apply* a decision making methodology to solve the formulated problem * *present* the results to other people | |