Fall 2014

Computer Aided Water Management and Control - Colorado State University

John Labadie
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COURSE SYLLABUS
CIVE 645: Computer Aided Water Management and Control

Credits: 3

Term(s) to be offered: Fall Semester

Prerequisites: ENGR 510 or CIVE 546, or equivalent, or consent of the instructor

Catalog Description: Real-time management and control of water resources systems; application of computer control concepts to improve system performance.

Instructor: John W. Labadie
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Office Hrs: MWF 9 - 11 (or by appointment)

Class Time/ Place: M: 11-11:50 [11-12:50 on lab days]; T and Th: 10-10:50
C205 Engineering

Textbook: Free on-line book: *Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications*, by D. P. Loucks and E. van Beek, UNESCO and Delft Hydraulics, The Netherlands, 2005.

Software: All students (on-campus and distance) will be provided access to CSUDP and MODSIM software, as well as other software as appropriate.

Course Objectives: Present modern computer-aided tools of systems analysis to planning, design, and operation of water resource systems. Topics covered include: optimal operation of multipurpose reservoir systems; optimal flood control system operations; coordinated unit commitment in hydropower systems; optimal multicrop allocation of seasonal and intraseasonal irrigation water; risk-based design of stochastic reservoir operating policies; economic evaluation of integrated design of water storage and conveyance systems; optimal conjunctive use of surface water and groundwater; optimal reservoir operations for water quality management; and optimal investment timing and selection of water resource projects. Several case studies are presented for river basins in the U.S., Dominican Republic, Brazil, Sri Lanka, India, Egypt, and Korea. Systems analysis tools studied include dynamic programming, stochastic optimization, network flow optimization, genetic algorithms, neural networks, agent-based reinforcement learning methods, multiobjective optimization, and fuzzy optimization.

Methods of Evaluation: The course grade will be based on the following distribution:

Homework/Lab Exercises	30%
Midterm Exam	30%
Final Class Project or Final Exam (to be determined)	40%

Course Schedule

CIVE 645 – Computer-Aided Water Management and Control

Fall 2014

Week	Date	Lecture	Reading
1	**Aug 25**	Application of optimization methods in water resource systems analysis: State-of-the-art	Ch. 1 [L-vB]
	Aug 26	Decision support systems in water resources	
	Aug 28	Implicit vs. explicit stochastic optimization of water resource systems	Ch. 2 [L-vB]
2	**Sep 2**	Combining simulation and optimization: Case Study: Nizao River Basin	Ch. 3 [L-vB]
	Sep 4	Introduction to dynamic programming; feedback vs. open loop policies; noninverted vs. inverted	Ch. 4 [L-vB]
3	**Sep 8**	Forward DP; determining useful closed-loop policies; optimal solutions through any system state	
	Sep 9	Reaching DP; optimal traceback solutions; max-min solutions; General format for DP problems	
	Sep 11	General format for DP problems; resource allocation problems	
4	**Sep 15**	Computer Lab: Introduction to generalized dynamic programming software CSUDP; Application of CSUDP to simple reservoir operation problem	Ch. 11 [L-vB]
	Sep 16	Application of CSUDP to simple reservoir operation problem (cont.)	
	Sep 18	Continuous dynamic programming; example problem of canal conveyance design	
5	**Sep 22**	Computer Lab: CSUDP setup for optimal operation of Valdesia Reservoir	
	Sep 23	Optimal multicrop allocation of seasonal and intraseasonal irrigation water; spatial and temporal decomposition	
	Sep 25	Optimal multicrop allocation (cont.)	
6	**Sep 29**	Computer Lab: Application of CSUDP to multicrop allocation problem	
	Sep 30	Multidimensional dynamic programming methods; Incremental DP (IDP)	
	Oct 2	Dynamic programming successive approximations method (DPSA); comparison of methods	
7	**Oct 6**	Computer Lab: Application to Mahaweli Project, Sri Lanka	
	Oct 7	Dynamic programming: with inclusion of flow routing for optimal flood control; Routing coefficient method	
	Oct 9	Dynamic programming for optimal flood control (cont.)	
8	**Oct 13**	Case Study: Integrated flood control operations, Han River Basin, South Korea	
	Oct 14	Network flow modeling approach to river basin management	
	Oct 16	Introduction to MODSIM River Basin Management Decision Support System	
9	**Oct 20**	**Midterm Examination (tentative date)**	
	Oct 21	Numerical Illustration of network flow modeling approach in MODSIM	

	Oct 23	Advanced features of MODSIM	
10	**Oct 27**	Computer Lab: Application of MODSIM to the Poudre River Basin	
	Oct 28	Application of MODSIM to conjunctive use of surface and groundwater	Ch. 12 [L-vB]
	Oct 30	Application of MODSIM (cont.)	
11	**Nov 3**	Case Study: Application of MODSIM/GeoMODSIM to the Lower Arkansas River Basin	
	Nov 4	Introduction to stochastic dynamic programming; Example application of stochastic DP to reservoir operations	
	Nov 6	Stochastic DP for reservoir operations (cont.); inclusion of conditional risk in optimal feedback decision rules	
12	**Nov 10**	Case Study: Evaluation of optimal stochastic operational policies for the High Aswan Dam, Egypt	Ch. 7 [L-vB]
	Nov 11	Certainty equivalence and the LDQ problem for stochastic optimization of multireservoir systems	Ch. 8 [L-vB]
	Nov 13	Comparison of feedback control policies between stochastic DP and the LDQ model	
13	**Nov 17**	Introduction to reinforcement learning (RL) for stochastic optimization of water resources systems	
	Nov 18	Case Study: Application of RL to the Geum River Basin, South Korea	
	Nov 20	Intelligent agent for optimal river-reservoir management	
	Nov 22 -30	**Thanksgiving Break**	
14	**Dec 1**	Introduction to Artificial Neural Networks;	Ch. 6 [L-vB]
	Dec 2	Case Study: Neural-optimal control for real-time regulation of Metro Seattle combined sewer system	Ch. 13 [L-vB]
	Dec 4	Case Study: Neural-optimal control (cont.)	
15	**Dec 8**	Introduction to Genetic Algorithms	Ch. 5 [L-vB]
	Dec 9	Case Study: Optimal control of stormwater discharges for ecosystem restoration (cont.)	Ch. 10 [L-vB]
	Dec 10	Case Study: Optimal control of stormwater discharges for ecosystem restoration (cont.)	
Finals Week		Student Project Presentations	