Pontificia Universidad Católica de Chile
Facultad de Ingeniería
Departamento de Ingeniería Eléctrica

Advanced Optimization for Electric Power Systems

ESTRUCTURA Y CONTENIDO DE PROGRAMA DE CURSO DE NIVEL POSTGRADO

CURSO	:	Advanced Optimization for Electric Power Systems
TRADUCCIÓN	:	Optimización Avanzada para Sistemas Eléctricos de Potencia
SIGLA	:	IEE3463
CRÉDITOS	:	10 UC / 10 SCT
MÓDULOS	:	2 MÓDULOS DE CÁTEDRA
REQUISITOS	:	ICS1113 (Optimización)
RESTRICCIONES	:	Ninguna
CONECTOR	:	Ninguno
CARÁCTER	:	Mínimo
TIPO	:	Cátedra
CALIFICACIÓN	:	Estándar
PROFESOR	:	Álvaro Lorca
DISCIPLINA	:	Ingeniería
PALABRAS CLAVE	:	Energía; Optimización; Sistemas de Potencia

I. DESCRIPCIÓN DEL CURSO

This course presents several optimization methods relevant for the analysis of electric power systems. The contents consist of various fundamental theoretical and algorithmic optimization concepts, including elements from convex optimization, mixed-integer optimization, decomposition methods, and optimization under uncertainty, and their applications to several problems that arise from the process of planning and operating power systems.

II. OBJETIVOS DE APRENDIZAJE

Objetivo general: Understand advanced optimization methods and their application to the management of electric power systems.

Objetivos específicos:

- Understand fundamental concepts from convex optimization, mixed-integer optimization, decomposition methods, and optimization under uncertainty, and their importance for electric power systems.
- Analyze and evaluate the use of different advanced optimization formulations relevant for different power system applications, including problems such as economic dispatch, alternating current optimal power flow, unit commitment, long-term expansion planning, and state estimation.

- Apply optimization methods and software to different problems associated to the process of planning and operating power systems.

III. CONTENIDOS

1. Introduction
   1.1. Challenges in the management of electric power systems
   1.2. Operating power systems
   1.3. Planning power systems
   1.4. The impact of new technologies

2. Fundamentals of convex optimization
   2.1. Mathematical background
   2.2. Convex optimization problems
   2.3. Lagrangian duality
   2.4. Karush-Kuhn-Tucker conditions
   2.5. Solution algorithms
   2.6. Power system applications
      2.6.1. Elements from power system modeling and analysis
      2.6.2. Formulation of the optimal power flow problem
      2.6.3. Optimization-based power flow analysis
      2.6.4. Convex relaxations of the optimal power flow problem

3. Fundamentals of mixed-integer linear optimization
   3.1. Basic concepts in mixed-integer linear optimization
      3.1.1. Branch-and-bound algorithms
      3.1.2. Cutting plane algorithms
   3.2. Power system applications
      3.2.1. Elements from power system modeling and analysis
      3.2.2. Unit commitment
      3.2.3. Generation and transmission expansion planning
      3.2.4. The PMU placement problem
      3.2.5. The transmission switching problem

4. Decomposition methods for large-scale problems
   4.1. Problem structures that fit decomposition methods
   4.2. Dantzig-Wolfe decomposition
   4.3. Benders decomposition
   4.4. Lagrangian relaxation
   4.5. Augmented lagrangian methods
   4.6. Other decomposition methods
   4.7. Power system applications

5. Optimization under uncertainty
   5.1. Motivation
   5.2. Review on probability and stochastic processes

5.3. Stochastic programming with recourse
5.4. Nested Benders decomposition for multi-stage stochastic programming
5.5. Stochastic dual dynamic programming
5.6. Progressive hedging
5.7. Robust optimization
   5.7.1. Robust optimization without recourse
   5.7.2. Adaptive robust optimization
   5.7.3. Two-stage robust unit commitment
   5.7.4. Robust unit commitment with linear decision rules
   5.7.5. Dynamic uncertainty sets
   5.7.6. Robust optimal power flow
   5.7.7. Robust expansion planning
5.8. Research challenges

IV. METODOLOGÍA PARA EL APRENDIZAJE

La metodología de aprendizaje se basa en:

- Clases expositivas.
- Lectura y discusión de textos.
- Talleres de implementación computacional.

V. EVALUACIÓN DE APRENDIZAJES

La evaluación de aprendizajes consiste de:

- Interrogaciones : 20%
- Tareas teóricas y de implementación computacional : 20%
- Presentación de un artículo científico : 10%
- Informes de avance proyecto de investigación : 30%
- Presentación final proyecto de investigación : 20%

VI. BIBLIOGRAFÍA

Bibliografía Mínima:

- Boyd, S. and Vandenberghe, L., Convex optimization, Cambridge University Press, 2004.
- Conejo, A. J., Castillo, E., Minguez, R. and Garcia-Bertrand, R., Decomposition Techniques in Mathematical Programming: Engineering and Science Applications, Springer, 2006.
- Morales, J. M., Conejo, A. J., Madsen, H., Pinson, P., Zugno, M., Integrating Renewables in Electricity Markets: Operational Problems, Springer, 2014.

Bibliografía Complementaria

- Gabriel, S. A., Conejo, A. J., Fuller, D. J., Hobbs, B. F. and Ruiz, C., Complementarity Models in Energy Markets, Springer, 2012.
- Luenberger, D., Optimization by Vector Space Methods, Wiley, 1997.
- Momoh, J. A., Electric Power System Applications of Optimization, Second Edition, CRC Press, 2008.

- Nocedal, J.,Wright, S., Numerical Optimization, Springer Series in Operations Research and Financial Engineering, 2006.
- Shapiro, Alexander, Darinka Dentcheva, and Andrzej Ruszczyński. Lectures on stochastic programming: modeling and theory. Society for Industrial and Applied Mathematics, 2009.
- Wolsey, Laurence A. Integer programming. Wiley, 1998.
- Wood, A. J., Wollenberg, B. F. and Sheblé, G. B., Power Generation, Operation and Control, Third Edition, New Jersey: John Wiley & Sons, 2013.

La bibliografía incluye además diversos artículos de revistas científicas líderes en sistemas eléctricos de potencia y optimización.