UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Decision Models

2627-1-FDS02Q002-FDS02Q00202

Aims

This module will emphasizes the relevance of data in decision making. The general aim is to develop skills in mathematical modeling, algorithms and computational methods to solve and analyze decision problems. The course will illustrates how to formulate real world problems using case studies and examples; how to use efficient algorithms – both old and new – for solving these models; and how to evaluate, draw useful conclusions and derive useful planning information from the output of these algorithms.

Specific aims of the course module are:

1. To give students the basic concepts of decision theory, modeling and solution methods of decision making problems with applications
2. Guide students in using different models and methods of operations research
3. Teach students different methods that are used for numerical decision making
4. Make students gain skills in finding optimal solutions to problems
5. Use programming languages as AMPL or Python

According tto the Dublin Descriptors:

1. **Knowledge and Understanding**
   By the end of the course, students will have acquired:
   A solid foundation in decision theory, mathematical modeling, and quantitative analysis of decision-making problems.
   An understanding of how real-world problems can be translated into formal mathematical models using operations research techniques.
   Knowledge of both classical and modern algorithms used to solve decision models efficiently.

2. **Applying Knowledge and Understanding**
   Students will be able to:
   Apply decision-making models to real-world case studies and formulate quantitative problem

representations.
Use appropriate algorithms to solve mathematical models related to decision processes.
Implement models and solution methods using programming languages such as AMPL or Python.
Extract meaningful planning and optimization insights from the algorithmic results.

3. **Making Judgements**
   Students will develop:
   Critical thinking skills for selecting appropriate models and methods based on the characteristics of a given decision problem.
   The ability to evaluate and interpret results, even in the presence of data uncertainty or incomplete information.
   A reflective attitude toward the practical implications and reliability of model outcomes in real decision contexts.

4. **Communication Skills**
   Students will be able to:
   Clearly and effectively communicate the logic behind the models and algorithms used, as well as the results obtained.
   Present and justify methodological choices and conclusions to peers, instructors, or decision-makers.

5. **Learning Skills**
   The course provides students with:
   The ability to independently deepen their knowledge in mathematical modeling and decision-making analysis.
   Practical tools to explore advanced methods and programming applications beyond the scope of the course.
   A foundation for integrating decision science skills with interdisciplinary knowledge in dynamic and complex scenarios.

Contents

1. Types of decisions
2. Types of decision models
3. Decision trees: Value of information and value of perfect information
4. Basic mathematical programming models: linear programming, linear integer programming, nonlinear programming
5. Network optimization models

Detailed program

1. Types of decisions:

- Structured and programmed decision
- Unstructured and non-programmed decision
- Descriptive, predictive and prescriptive analytics
- Decision making conditions: certainty, uncertainty

2. Types of decision models: Model-driven and Data-driven

3. Decision trees:

- Basic definitions and examples
- Value of information: value of sampled information and value of perfect information

4. Basic mathematical programming models:

- linear programming examples and their formulation
- solution of linear programming problems
- sensitivity analysis for linear programming problems
- integer linear programming examples and their formulation
- Branch and Bound method for integer linear programming problems
- nonlinear programming examples and their formulation
- optimality conditions, duality theory and algorithms for nonlinear programming problems
- applications of nonlinear duality theory to Support Vector Machines and epsilon-Support Vector regression

5. Network optimization models:

- transportation problems
- the shortest path problem
- the maximum flow problem

Prerequisites

Linear algebra: sum and product between matrices, determinant and trace of a matrix, eigenvalues and eigenvectors of a matrix, solving linear systems.

Teaching form

The course will be held in english.
The course is hands-on. In particular, we use different case studies to show how to formulate and solve different types of problems.
Case studies will be the starting point to illustrate how the decision problem can be formulated and solved.
Practical exercises using software AMPL.
Assignments will be given periodically to access the student critical thinking skills.
Teaching with lecture hours and practice activities:

- 28 hours of lectures conducted in face-to-face delivery mode;
- 18 hours of tutorials delivered in face-to-face interactive mode. These activities will be distributed dynamically so as to make their use by students as flexible as possible.

Assignments: Individual assignments will be released and reviewed by the tutor.
It is not planned to conduct in-progress tests during the course.

Textbook and teaching resource

Textbook:
Cliff Ragsdale, Spreadsheed modeling and decision analysis, any edition.

Instructors make available slides, in-class exercises data and models, additional reading papers.

Semester

II semester

Assessment method

Written Exam + Oral exam (optional)

- A written exam will consist of solving exercises and answering both closed and open questions about the topics presented during thee course to assess: Knowledge of Fundamental Concepts, Overall Understanding, Knowledge of specific models and methods.

- Finally, students can ask to take an oral exam (optional) to assess also the students' Argumentation ability.

The final grade for the “Machine Learning and Decision Models” course will be equal to the arithmetic mean (rounded up to the nearest integer) of the grades obtained in the “Machine Learning” and “Decision Models” modules.

Office hours

By appointment.

Sustainable Development Goals