COURSE DESCRIPTION CARD - SYLLABUS

Course name
Algorithmic decision theory

Course

Field of study
Computing

Year/Semester
1/2

Area of study (specialization)
Artificial Intelligence

Profile of study
general academic

Level of study
Second-cycle studies

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
15

Other (e.g. online)

Tutorials

Projects/seminars

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
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Responsible for the course/lecturer:

Prerequisites

SStudents taking this course should have basic knowledge of discrete mathematics, linear algebra, combinatorial optimization, operational research, and decision support. They should solve basic linear programming problems, collect information from the indicated sources, and program in at least one language. They should also understand the need for widening their competencies within the scope of modeling real-world decision problems and using IT tools for their solving. When it comes to social competencies, they should represent honesty, reliability, persistence, curiosity, creativeness, personal culture, and respect for others.

Course objective

A general aim of the course is getting known by the students the theoretical and practical aspects of widely understood algorithmic decision theory, in particular:

1. Acquisition of advanced skills concerning game theory, i.e., analysis and identifying optimal action, e.g., in strategic, extensive, or congestions games.

2. Getting to know how to use data envelopment analysis to analyze the efficiency of decision-making units.

3. Learning the elementary multiple objective optimization methods based on linear programming and evolutionary algorithms and applying them in the context of real-world optimization problems.

4. Understanding the preference learning algorithms and their use for learning from extensive collections of examples decisions.

Course-related learning outcomes

Knowledge

has advanced and in-depth knowledge of decision support systems, theoretical foundations of their construction and methods, tools and programming environments used to implement them [K2st_W1]

has advanced detailed knowledge regarding selected IT issues concerning methods of algorithmic decision theory and their applications [K2st_W3]

has knowledge about development trends and the most important cutting edge achievements at the crossroads of computer science and economy [K2st_W4]

knows advanced methods, algorithms, techniques and tools used to solve complex engineering tasks and conduct research in algorithmic decision theory [K2st_W6]

Skills

can - when formulating and solving engineering tasks - integrate knowledge from different areas of computer science (e.g., operational research, decision support, game theory, machine learning) and economy and apply a systemic approach, also taking into account non-technical aspects [K2st_U5]

is able to assess the suitability and the possibility of using new achievements (methods and tools of decision analysis) and new IT products in solving decision-making problems [K2st_U6]

is able - using among others conceptually new decision analysis and support methods - to solve complex IT tasks, including atypical tasks concerning decision problems and tasks containing a research component [K2st_U10]

can communicate both in Polish and English using different techniques in a professional environment and in other environments, playing the role of a decision analyst, also using IT tools [K2st_U12]

Social competences

understands that in the field of IT the knowledge and skills quickly become obsolete and that to solve real-world decision problems, one needs to develop novel decision analysis suitably addressing the challenges of our times [K2st_K1]

understands the importance of using the latest knowledge in algorithmic decision theory in solving research and practical problems [K2st_K2]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) based on the answers to questions concerning the material covered by the lectures;

b) based on the regular assessment of the current status of the realization of projects and exercises.

Summative assessment:

a) lectures: verification of the assumed learning outcomes is conducted by:

- evaluation of knowledge and skills through an assessment test composed of problems with various characteristics, including test questions, blank spaces to be filled, simple computational and algorithmic tasks, and problem tasks of an increased complexity; the assessment test is passed if students obtain at least 50% of points;

- a discussion of the assessment test results;

b) laboratory classes: verification of the assumed learning outcomes is conducted by:

- constant assessment of knowledge and skills related to the solutions of exercises, programming assignments, and case studies;

- evaluating reports prepared by the students in part during the classes and in part as their homework; this evaluation also refers to the ability to work in a team.

Collection of bonus points for extra activities such as:

- discussing additional aspects of the problem;

- efficiency of using acquired knowledge for solving the assigned tasks;

- ability of teamwork when solving some detailed tasks during the classes;

- developing software used during laboratory classes.

Programme content

The lectures discuss the following topics on game theory, data envelopment analysis, multiple objective optimization, and preference learning:

• Strategic games: the employment of game theory in different application fields, stability and efficiency, solutions concepts, Pareto optimality, pure and mixed Nash equilibria, iterative elimination of strictly dominated strategies, correlated equilibrium;

• Congestion games: examples and definitions; potential games as a tool for analyzing congestion games, the existence of equilibria, better response dynamics, price of anarchy;

• Extensive games: representation in the form of a tree with complete information, strategies distributed over time, identifying the best strategy while accounting for the order of actions, sub-perfect game equilibria, ultimatum and centipede games;

• Basics of iterative, coalitional, and Bayesian games;

• Data envelopment analysis: analysis of efficiency of decision-making units, real-world examples of efficiency analysis, input- and output-oriented CCR and BCC models, super-efficiency, cross-efficiency, weight constraints, robustness analysis, the Monte Carlo simulations;

• Multiple objective optimization methods: example real-world optimization problems, classical methods based on a weighted sum, epsilon constraint methods, and achievement scalarizing function; evolutionary algorithms based on fronts (NSGA-II iandSPEA2), indicators (SMS EMOA), and decomposition (MOEA/D).

• Preference learning: example applications of preference learning, efficiency and quality measures, basic preference learning algorithms.

The particular topics discussed during the lectures are illustrated during the laboratory classes. Moreover, the students are expected to solve real-world case studies by using the presented methods in practice.

Teaching methods

1. Lectures: multi-media presentation enriches with illustrative examples; demonstration of selected IT systems based on the algorithmic decision methods.

2. Laboratory classes: task solving, practical and programming assignments, conduction of experiments, discussion, teamwork, case studies, demonstration of selected decision support systems, generation of real decision problems, and their solution with methods available in the laboratory, multi-media presentation.

Bibliography

Basic

. P. Straffin, Teoria gier. Wydawnictwo Naukowe Scholar, Warszawa, 2001.

2. J. Branke, K. Deb, K. Miettinen, R. Słowiński, Multiobjective Optimization: Interactive and Evolutionary Approaches. Springer, Berlin, 2008.

3. W.W. Cooper, L.M. Seiford, M. Lawrence, K. Tone, Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software, Springer, US, 2007.

4. J. Fürnkranz, E. Hüllermeier, Preference Learning. Springer, Berlin, 2010.

Additional

1. M.J. Osborne, An Introduction to Game Theory. Oxford University Press, 2004.

2. A. Charnes, W.W. Cooper, A.Y. Lewin, L.M. Seiford, Data Envelopment Analysis: Theory, Methodology, and Applications, Springer, Netherlands, 1994.

3. M. Kadziński, A. Labijak, M. Napieraj, Integrated framework for robustness analysis using ratio-based efficiency model with application to evaluation of Polish airports, Omega 67, 1-18, 2017.

4. M. Tomczyk, M. Kadziński, Decomposition-based interactive evolutionary algorithm for multiple objective optimization, IEEE Transactions on Evolutionary Computation, 24(2), 320-334, 2020.

5. J. Liu, M. Kadziński, X. Liao, X. Mao, Data-driven preference learning methods for value-driven multiple criteria sorting with interacting criteria, INFORMS Journal on Computing, 2020.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,0
Classes requiring direct contact with the teacher	30	1,5
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	45	1,5

[1] delete or add other activities as appropriate