COURSE DESCRIPTION CARD - SYLLABUS

Course name
Intelligent Decision Support Systems

Course

Field of study
Computing

Year/Semester
1/1

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	Laboratory classes	Other (e.g. online)
30	30	
Tutorials	Projects/seminars	

Number of credit points

5

Lecturers

Responsible for the course/lecturer:
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Prerequisites

Students 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

1. Providing basic knowledge on intelligent decision support systems, their theoretical foundations and

computer implementations, with an emphasis on constructive learning of preferences as an approach characteristic for artificial intelligence.

2. Acquiring knowledge about selected methods and tools of the widely understood decision theory using elements of computer science, mathematics, artificial intelligence, management and cognitive sciences.

3. Developing the skills of an analyst of the decision-making process consisting in the ability to select the most appropriate method of intelligent decision support for a given decision problem, depending on the type of available data, the form of expected results and the type of the assumed preference model.

4. Acquiring skills in using software implementing selected intelligent decision support methods.

5. Developing the skills of mathematical modeling of the decision-making process in deterministic conditions, as well as under risk and uncertainty, including: definition of a set of decision variants (actions), construction of a coherent family of criteria (dimensions) for their assessment, aggregation of criteria and constructive learning of preferences in an interactive way.

6. Learning some exemplary practical applications of intelligent decision support methods, as well as methods and tools of widely understood decision theory.

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

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

9. 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.

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

11. Building students' teamwork skills.

Course-related learning outcomes

Knowledge

1. Has advanced and in-depth knowledge of widely understood information systems, theoretical foundations of their construction, and methods, tools and programming environments used to implement them [K2st_W1]

2. Has knowledge about development trends and the most important cutting edge achievements in computer science and other selected and related scientific disciplines [K2st_W4]

3. Has advanced and detailed knowledge of the processes occurring in the life cycle of hardware or software information systems [K2st_W5]

4. Knows advanced methods, techniques and tools used to solve complex engineering tasks and conduct research in a selected area of computer science [K2st_W6]

5. Has detailed knowledge of selected areas of mathematics, artificial intelligence, management and cognitive sciences, in relation with intelligent decision support and widely understood decision theory [-]

6. Knows examples of practical applications of intelligent decision support methods [-]

Skills

1. Is able to obtain information from literature, databases and other sources (both in Polish and English), integrate them, interpret and critically evaluate them, draw conclusions and formulate and fully justify opinions [K2st_U1]

2. Can use analytical, simulation and experimental methods to formulate and solve engineering problems and simple research problems [K2st_U4]

3. When formulating and solving engineering tasks, is able to integrate knowledge from different areas of computer science (and if necessary also knowledge from other scientific disciplines) and apply a systemic approach, also taking into account non-technical aspects [K2st_U5]

4. Is able to assess the suitability and the possibility of using new achievements (methods and tools) and new IT products [K2st_U6]

5. Is able to use conceptually new methods to solve complex IT tasks, including atypical tasks and tasks containing a research component [K2st_U10]

6. Can determine the directions of further learning and implement the process of self-education, including other people [K2st_U16]

7. Is able to formulate decision problems, model the preferences of participants of the decision-making process, and design methods of multi-criteria decision analysis under deterministic conditions and under risk and uncertainty [-]

Social competences

1. Understands that in the field of IT the knowledge and skills quickly become obsolete [K2st_K1]

2. Understands the importance of using the latest knowledge in the field of computer science in solving research and practical problems [K2st_K2]

3. Understands the importance of popularization activities concerning the latest achievements in the field of computer science [K2st_K3]

4. Is able to interact and work in a group, assuming various roles in it: analyst, decision maker or designer of an intelligent decision support system [-]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Forming assessment:

a) in terms of lectures:

- on the basis of answers to questions about the material presented during the lectures.

b) in terms of laboratories/exercises:

- on the basis of an assessment of the progress in the implementation of assigned tasks.

Summary assessment:

a) in terms of lectures, verification of the expected learning outcomes is carried out 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;

- analysis and presentation of the exam results,

b) in terms of laboratories/exercises, verification of the expected learning outcomes is carried out 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.

The laboratory final assessment grade is awarded taking into account the total number of points according to the scale: at least 50% of points – grade 3.0; 60% - grade 3.5; 70% - grade 4.0; 80% - grade 4.5; 90% - grade 5.0.

Programme content

The program of lectures covers the following topics:

1. Intelligent Decision Support Systems (IDSS) - definitions. Decision problems: choice (optimization), classification (ordinal), ranking. The aspect of multidimensionality and methods of resolving conflicts between dimensions. Decision support process: elicitation of preferential information, building a preference model, developing recommendations. Application of the artificial intelligence paradigm to constructive preference learning.

2. Preference models for multidimensional decision problems: (i) utility function, (ii) relational system, (iii) set of decision rules.

3. IDSS based on a function preference model: robust ordinal regression methods, hierarchical problem analysis (AHP). Handling interactions - Choquet integral. Links with stochastic multiobjective acceptability analysis (SMAA).

4. IDSS based on a relational preference model: methods with the outranking relation (ELECTRE III/IV; PROMETHEE I, II), robust ordinal regression methods (ELECTRE^GKMS).

5. IDSS based on a rule-based preference model: methods using dominance-based rough set theory (DRSA) for multi-attribute ordinal classification and ranking.

6. IDSS supporting negotiations and group decisions.

7. 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;

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

9. 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;

10. 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;

11. 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).

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

Laboratory classes are organized in the form of fifteen 2-hour exercises, taking part in the laboratory. Individual issues discussed during the lecture are illustrated with tasks during laboratory classes. In addition, students analyze real-world decision problems (case studies), which allow the application of knowledge about the learned methods in practice.

Teaching methods

Lecture: multimedia presentation supplemented with illustrative examples. Demonstration of selected systems in the field of algorithmic decision theory.

Laboratory exercises: solving problems, practical and programming exercises, discussion, team work, case studies, demonstration of selected systems, modeling of real decision problems and solving them with methods available in the laboratory, multimedia show.

Bibliography

Basic

S.Greco, M.Ehrgott, J.R. Figueira (eds.), Multiple Criteria Decision Analysis: State of the Art Surveys, Springer, 2016; https://doi.org/10.1007/978-1-4939-3094-4

S.Corrente, S.Greco, M.Kadziński, R.Słowiński, Robust Ordinal Regression in Preference Learning and Ranking, Machine Learning, 93 (2013) 381-422; https://doi.org/10.1007/s10994-013-5365-4

R. Słowiński, Y. Yao (eds.), Rough Sets, Part C of the Handbook of Computational Intelligence, Springer, 2015, pp. 329-451; http://dx.doi.org/10.1007/978-3-662-43505-2

M. Cinelli, M. Kadziński, M. Gonzalez, R. Słowiński, How to Support the Application of Multiple Criteria Decision Analysis? Let Us Start with a Comprehensive Taxonomy, Omega, 96 (2020) 102261; https://doi.org/10.1016/j.omega.2020.102261

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

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

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.

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

Additional

S. Greco, M. Kadziński, V. Mousseau, R. Słowiński, ELECTRE^GKMS: Robust Ordinal Regression for Outranking Methods, European Journal of Operational Research, 214 (2011) 118-135; http://dx.doi.org/10.1016/j.ejor.2011.03.045

S. Greco, M. Kadziński, V. Mousseau, R. Słowiński, Robust Ordinal Regression for Multiple Criteria Group Decision: UTA^GMS-GROUP and UTADIS^GMS-GROUP; Decision Support Systems, 52 (2012), 549–561; https://doi.org/10.1016/j.dss.2011.10.005

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

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

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.

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

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, 2021.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,0
Classes requiring direct contact with the teacher	60	3,0
Student's own work (literature studies, preparation for laboratory classes, preparation for tests/exam, project preparation) [1]	65	2,0

[1] delete or add other activities as appropriate