МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ

ЗАТВЕРДЖЕНО
на засіданні кафедри
інформаційних систем.
Протокол № 1 від 22.08.2023 р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи

_____ Каріна НЕМАШКАЛО

СИСТЕМИ ПІДТРИМКИ ПРИЙНЯТТЯ РІШЕНЬ

робоча програма навчальної дисципліни (РПНД)

Галузь знань	**12 "Інформаційні технології"**
Спеціальність	**121 "Інженерія програмного забезпечення"**
Освітній рівень	**перший (бакалаврський)**
Освітня програма	**Інженерія програмного забезпечення**

Статус дисципліни	**вибіркова**
Мова викладання, навчання та оцінювання	**англійська**

Розробник(и):
д.пед.н, к.техн.н,
професор підписано КЕП Олександр КОЛГАТІН

Завідувач кафедри
інформаційних
систем _____ Дмитро БОНДАРЕНКО

Гарант програми _____ Олег ФРОЛОВ

Харків
2024

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

APPROVED
at the meeting
of the Information Systems Department
Protocol № 1 від 22.08.2023 р.

AGREED
Vice-rector for educational and methodical work

_____ Karina NEMASHKALO

DECISION SUPPORT SYSTEMS

Programme of the course (course description)

Field of knowledge	**12 "Information Technologies"**
Specialty	**121 "Software Engineering"**
Educational level	**first (bachelor)**
Educational programme	**Software Engineering**
Course status	**selective**
Language	**English**

Developers:
Doctor in Pedagogics, Professor — digital signature — Oleksandr KOLGATIN

Head of Information Systems Department _____ Dmytro BONDARENKO

Head of the study program _____ Oleg FROLOV

Kharkiv
2024

INTRODUCTION

Decision support systems are a modern direction of application of computer science achievements in information management systems. This field is developing rapidly due to the growth of computer power and the improvement of optimization and modeling methods, in particular the development of the theory and practice of neural networks.

A feature of this course is a systematic overview of different approaches to modeling the decision-making process, from traditional ones based on deterministic models to the latest approaches to modeling non-linear non-stationary stochastic systems. The course has a practical orientation, specific approaches and proposed tasks are considered, according to the considered areas of modeling the decision-making process.

The purpose of the course is the formation of higher education students' outlook on the issues of information management of complex processes and the acquisition of skills in the practical application of optimization methods and decision-making in various systems.

The objectives of the course are:

- familiarization of students of higher education with the concept of a decision support system, algorithms and technologies used in such systems;
- familiarization with modern achievements in solving practically significant optimization problems;
- familiarization with modern achievements regarding the application of forecasting (regression) in solving practically significant problems;
- familiarization with modern achievements regarding the application of regression in solving practically significant problems;
- mastering technologies that implement elements of artificial intelligence in relation to decision-making tasks. The object of the course is the software development process.

The subject of the course is technologies and methods of building algorithms for optimization, regression analysis, classification analysis, data systematization using elements of artificial intelligence.

The object of the course is the process of creating software for decision support systems.

The learning outcomes and competencies formed by the course are defined in table 1.

Table 1

Learning outcomes and competencies formed by the course

Learning outcomes	Competencies
LO05	GC01, GC02, SC01, SC02
LO13	GC01, GC02, SC02

LO15	GC02, SC10, SC13
LO18	GC02, SC07, SC13
LO19	GC02

LO05. Know and apply relevant mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modeling for software development.

LO13. Know and apply methods of developing algorithms, designing software and data and knowledge structures.

LO15. Motivated to choose programming languages and development technologies to solve the tasks of creating and maintaining software.

LO18. Know and be able to apply information technologies for data processing, storage and transmission.

LO19. Know and be able to apply software verification and validation methods.

GC01. Ability to think abstractly, analyze and synthesize.

GC02. Ability to apply knowledge in practical situations.

SC02. Ability to participate in the design of software, including modelling (formal description) of its structure, behavior and processes of operation.

SC10. The ability to accumulate, process and systematize professional knowledge about creating and maintaining software and recognizing the importance of lifelong learning.

SC13. The ability to reasonably choose and master software development and maintenance tools.

COURSE CONTENT

Content module 1: Decision support in deterministic systems

Topic 1. Fundamentals of control process and optimization

Conceptual apparatus in the field of control of complex systems. Concept of the system. Open and closed systems. System-forming connections. Feedback as the basis of control. The concept of control.

Decision-making as a component of control. The concept of a decision support system.

Decision making strategies: 1) optimization; 2) the first that is acceptable; 3) strategy of aspect exclusion; 4) incremental; 5) mixed scanning (viewing); 6) analytical and hierarchical approach.

The concept of optimization. Objective function. Optimization with constraints. Optimization without constraints.

Artificial intelligence in control systems. Features of building the human-machine interface of the future. Prospects for the development of artificial intelligence. A range of tasks to which artificial intelligence is involved.

Effectiveness of using artificial intelligence in control systems. Problems of information security in the conditions of artificial intelligence application.

Topic 2. Methods of optimization and decision-making based on a continuous deterministic objective function

Methods of multidimensional optimization. Basic concepts and definitions. The concept of convergence. The rate and order of convergence. Approaches to numerical analysis error estimation.

Optimization methods in problems with a linear objective function.

Descent methods. Coordinate descent methods. Gradient descent method. Newton's method. Heuristic optimization methods. The deformed polytope method (also Nelder–Mead method and its modifications, downhill simplex method, amoeba method, or polytope method).

Evolutionary algorithms in solving multidimensional optimization problem. The particle swarm method. Genetic algorithm of multidimensional optimization.

Numerical methods of predicting the deterministic systems parameters. Interpolation and extrapolation. Numerical methods of solving ordinary differential equations. Numerical methods of solving equations in partial derivatives.

Examples of management problems that can be solved based on the search for extrema of a continuous deterministic objective function.

Topic 3. Control in discrete systems. Knowledge base models

Deterministic classification systems as a component of the information control system. Methods of building a knowledge base. Facts as the basis of the knowledge base. Semantic network. Development of a knowledge base on frames (frames). Using chains of reasoning for deductive reasoning. Application of trees to organize data.

Topic 4. Methods of optimization and decision-making based on discrete models

The concept of inference based on deterministic discrete models. Intelligent turn-based games. Algorithm construction methods. Classification as establishing relationships between objects. Evaluation and comparison of solutions. Work of experts, consideration of expert evaluation. Statistical processing of expert evaluations.

Search and optimization algorithms on graphs. Graph exploration methods. Methods of exhaustive search and heuristic methods of optimization. Dijkstra's algorithm. Productions as a rules system for building chains of successive states of a discrete deterministic system.

Content module 2: Control in stochastic systems

Topic 5. Forecasting in uncertainty conditions

Sources of uncertainty. The synergistic approach as a methodology for the study of complex non-equilibrium systems. Formulation of the forecasting problem in

conditions of uncertainty. Models of a system, optimization criteria of model parameters. The method of least squares as an approach to determining model parameters. Linear and non-linear regression models. Neural network as a specific form of representation of functional dependencies. Activation functions. Determination of model parameters (machine learning) as an optimization problem solution. Error backpropagation algorithm. Advantages of hardware implementation of neural networks.

Software tools for modeling in conditions of uncertainty. Modeling neural networks in Python, using pycaret, numpy, pandas modules.

Topic 6: Methods of optimization and decision-making based on stochastic models

Examples of forecasting problems under conditions of uncertainty. Topologies of neural networks. Multilayer neural networks. Kohonen network. Backpropagation neural networks. Neural networks of Hopfield and Hamming. Networks with radial basis functions (RBF). Probability Neural Network (PNN). Generalized regression neural network (GRNN - Generalized Regression Neural Network). Linear neural networks.

Neural network modeling software. Modeling neural networks in Python, using pycaret, numpy, pandas modules. Neuro-fuzzy modeling in the MatLab environment.

Topic 7: Classification analysis under conditions of uncertainty

Classification analysis as a component of the control process.

Concept of classification analysis. Discriminant analysis. The essence and task of discriminant analysis. Conditions for discriminant analysis. Parametric methods of discriminant analysis. Fisher's linear discriminant analysis.

The concept of dimensionality reduction. Why is dimensionality reduction needed? Feature selection and feature extraction. Methods of dimensionality reduction.

Neural networks as a classification method. Modern practice of using neural networks for pattern recognition. Approaches to network architecture in image recognition tasks.

Topic 8: Cluster analysis

Clustering procedures. Hierarchical (connectivity-based) and non-hierarchical (Centroid-based, model-based, density-based, grid-based etc.) methods of cluster analysis. Agglomerative and divisive methods. Algorithms of agglomerative and divisive hierarchical clustering. Methods of grouping objects into clusters. Methods of nearest neighbor search (NNS). Ward's method. Lance-Williams formula.

Fuzzy clustering, in which a real value is determined for each object, indicating the degree of cluster membership. Membership function. Basic algorithm of fuzzy k-means (Fuzzy c-means). Other methods of fuzzy clustering: Gustafson-Kessel algorithm, fuzzy c-ellipsoid algorithm, Shell-clustering algorithm.

The list of laboratory studies in the course is given in table 2.

Table 2

The list of laboratory studies

Name of the topic and/or task	Content
Topic 1 Task 1	Work with the decision support system in user and expert modes
Topic 2 Task 2	Construction of a decision-making algorithm based on a continuous deterministic objective function
Topic 3 Task 3	Building a deterministic model of knowledge
Topic 4 Task 4	Implementation of a decision support system through the construction of chains of consecutive system states
Topic 5 Task 5	Implementation of forecasting using linear and non-linear regression models
Topic 6 Task 6	Neural network programming
Topic 7 Task 7	Solving the problem of classification analysis
Topic 8 Task 8	Solving the problem of cluster analysis

The list of self-studies in the course is given in table 3.

Table 3

List of self-studies

Name of the topic and/or task	Content
Topic 1-8	Studying lecture material. Learning new material: reading and noting literary sources of information; watching videos
Topic 1-8	Preparation for laboratory classes. Software development according to tasks
Topic 1-8	Training for the exam

The number of hours of lectures, laboratory studies and hours of self-study is given in the technological card of the course.

TEACHING METHODS

In the process of teaching the course, in order to acquire certain learning outcomes, to activate the educational process, it is envisaged to use such teaching methods as:

Verbal (lecture (Topic 1–8), problem lecture (Topic 1–8)).

Visual (demonstration (Topic 1, 2, 4, 5), illustration (Topic 1–8)).

Practical (laboratory work (Topic 1–8), presentation, speaking in front of the audience (Topic 1-8), business game (Topic 1, 4), interactive distance learning (Topic 1–8)).

FORMS AND METHODS OF ASSESSMENT

The University uses a 100-point cumulative system for assessing the learning outcomes of students.

Current control is carried out during lectures, laboratory classes and is aimed at checking the level of readiness of the student to perform a specific job and is evaluated by the amount of points scored: (for courses with a form of semester

control as an exam) maximum amount is 60 points; minimum amount required is 35 points.

The final control includes current control and an exam.

Semester control is carried out in the form of semester exam

The final grade in the course is determined as the amount of all points received during the current control and the exam grade.

During the teaching the course, the following control measures are used:

Current control: proving the laboratory work (48 points for semester); current assessment (12 points for semester).

Semester control: Exam (40).

More detailed information on the assessment system is provided in the technological card of the course.

Exam Card Example

Simon Kuznets Kharkiv National University of Economics
First (bachelor) educational level
Specialty «Software Engineering»
Educational program «Software Engineering».
Semester 1
Course «Decision Support Systems»

EXAM CARD № 1

Task 1 (diagnostic, 5 grade points).
Using chains of reasoning for deductive reasoning.
Task 2 (diagnostic, 5 grade points).
Forecast problem statement in uncertainty conditions.
Task 3 (heuristic, 30 grade points).
Develop a support system for car malfunction diagnostics.

Approved at the meeting of the Information System Department
Protocol № ____ of «___»_____20___.

Examinator Oleksandr KOLGATIN

Head of Information Systems Department Dmytro BONDARENKO

Assessment Criteria

Exam work is performed on computers. The examination card includes 3 tasks. Each task is graded separately and then the task grades are summarized. In total, the completed exam work is scored on a 40-point scale. The maximum number is 40 points; the minimum that is credited is 25 points. In this case, the student gets:

task 1 - 5 points;
task 2 - 5 points;
task 3 - 30 points.

The total score for the exam consists of the sum of points for all the tasks, which are rounded to the whole by the rules of mathematics.

Task 1 (diagnostic) is rated at 5 points as follows:

a student shows all obligatory facts according to given field of study with appropriate citing: + 3 points;

a student shows some examples of use the theoretical knowledge in practice according to the given field of study with appropriate citing: + 1 point;

a student explains the problems, their interconnection and future development in the given field of study: + 1 point.

Task 2 (diagnostic) is rated at 5 points as follows:

a student shows all obligatory facts according to given field of study with appropriate citing: + 3 points;

a student shows some examples of use the theoretical knowledge in practice according to the given field of study with appropriate citing: + 1 point;

a student explains the problems, their interconnection and future development in the given field of study: + 1 point.

Task 3 (heuristic) is rated at 30 points as follows:

correct choice of the correct solution of the task - 10 points;

the presence of a clear sequence of decision - 10 points;

obtaining and fixing the correct results - 10 points.

If the above parts of the task are completed in part, the maximum score is divided by 2. Also, 0.5 points are deducted for each group of homogeneous irrelevant errors (for example, incorrect formulation of concepts). 1.0 points are deducted for each group of homogeneous material errors (incorrect presentation of knowledge, lack of correct result, etc.). The overall results of the exam are not counted (0 points) when a fact of academic misconduct is detected.

RECOMMENDED LITERATURE

Main

1. Системи і методи підтримки прийняття рішень : підручник / П. І. Бідюк, О. Л. Тимощук, А. Є. Коваленко, Л. О. Коршевнюк. – К. : Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського», 2022. – 610 с. – Режим доступу : https://ela.kpi.ua/bitstream/123456789/48418/1/Systemy_i_metody_pidtrymky_pryiniattia_rishen.pdf

2. Рубан І. В. Особливості створення системи підтримки прийняття антикризових рішень в умовах невизначеності вхідної інформації при надзвичайних ситуаціях / І. В. Рубан, В. В. Тютюник, О. О. Тютюник // Сучасні інформаційні технології у сфері безпеки та оборони. – 2021. – №1(40). – С.75-84. – Режим доступу : http://repository.hneu.edu.ua/handle/123456789/25600.

3. Kolgatin O. Stochastic process computational modeling for learning research / O. Kolgatin, L. Kolgatina, N. Ponomareva // Educational Dimension. – 2022. – Jun. 2022. – P. 68-83. – DOI : https://doi.org/10.31812/educdim.4498. – Access mode : http://repository.hneu.edu.ua/handle/123456789/28513.

Additional

4. Методи оптимізації без використання похідних: практикум з дисципліни «Дослідження операцій»[Електронний ресурс]: навч. посіб. / Т. С. Ладогубець, О. Д. Фіногенов; КПІ ім. Ігоря Сікорського. – Київ: КПІ ім. Ігоря

Сікорського, 2020. – 45 с. – Режим доступу : https://ela.kpi.ua/bitstream/123456789/43382/1/MO_BVP_Praktykum.pdf.

5. Конспект лекцій з дисципліни «Інтелектуальні методи в управлінні» / Укладач – Дранишников Л.В. – Кам'янське : ДДТУ, 2020 – 188с. – Режим доступу : https://www.dstu.dp.ua/Portal/Data/3/19/3-19-kl19.pdf.

Information resources

6. Персональна навчальна система «Системи підтримки прийняття рішень». – Режим доступу : https://pns.hneu.edu.ua/course/view.php?id=10725.