Double Degree Program

«System Analysis and Decision-making»

The lecture № 1

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Topics of lectures

1. Classification of decision-making problems and methods for their solution. Effective and poorly effective solutions. Methods of decision-making (MDM) in conditions of determination .
2. MDM in conditions of indeterminate form and risk. Multistage methods of decision-making. The Bellman's method.
3. Methods of analysis of expert information. Assessments of the consistency of expert assessments.
4. Classification of the main types of indeterminate form. Fuzzy statements, fuzzy sets, fuzzy and linguistic variables. Fuzzy numbers. The principle of generalization when working with fuzzy numbers. Representation of fuzzy numbers in α-levels. LR-representation of fuzzy numbers.
5. The method of constructing the fuzzy set membership function. Fuzzy situational advisory system. Principle of operation of the state assessment unit. The principle of the decision-making unit. The operating principle of the control output unit.
6. Neural decision-making systems. Perceptron of Rosenblatt. Perceptron learning algorithm, geometric interpretation of the algorithm.
7. The method of analyzing hierarchies. The choice of options for decision-making in the presence of many complex structured criteria. The Saati procedure. Method of transitive scales.

Self-instructional topics

1. Fundamentals of system analysis.

The main stages of development of system analysis. Problems of system analysis. Classification of systems. Principles of system analysis.

Classification of types of modeling systems. Principles and approaches to the construction of mathematical models of systems. Stages of building models of systems.

Homeostatic principles of organization of systems. Synergetic foundations of the theory of systems. Organizational and orderly system. Interaction of systems with the environment. Mutual interaction of systems. The potential of the system.

Procedures for system analysis.

Fundamentals of evaluation of complex systems. Main types of measurement scales. Processing of characteristics measured in different scales. Quality and efficiency of systems.

Induction. Types of induction. Basic procedure of system analysis.

Literature on the course

Main literature:

1 Chernorutsky IG Methods of decision making: Proc. manual for universities. St. Petersburg: BHV-Petersburg, 2005. 408 p.

2 Spintsnadel V.N. Fundamentals of system analysis. SPb .: Izd. house "Business Press", 2000.

3 Denisov A.A. Modern problems of system analysis: Information bases: Textbook. St. Petersburg: Publishing house SPbSTU, 2005. 295 p.

4 O'Connor, McDermott I. The art of system thinking: the necessary knowledge of systems and creative approach to problem solving. Moscow: Alpina Business Books, 2006 256 p.

5 System approach in modern science (to the 100th anniversary of Ludwig von Bertalanffy). Moscow: Progress-Traditsiya, 2004. 560 p.

Literature on the course

Additional literature

1. Larichev OI Theory and methods of decision-making. M .: Logos, 2006.
2. Larichev OI Verbal analysis of solutions. M.: Science, 2006. 181p.
3. Wesserman F. Neurocomputer technology: theory and practice. M ,: 2002.
4. Komartsova LG, Maksimov AV Neurocomputers. Moscow: MSTU, 2004.
5. Greshilov A.A. Mathematical methods of decision making. M .: MSTU Bauman, 2006.
6. Gladkov LA, Kureichik VV, Kureichik V.V. Genetic algorithms. M .: Fizmatlit, 2006.
7. Kureichik V.M. Genetic algorithms and their application. Taganrog: ed. TRTU, 2002.Paul Goodwin and George Wright, Decision Analysis for Management Judgment, 3rd edition. Chichester: Wiley, 2004
8. Tomasz D. Gwiazda, Genetic Algorithms Reference Vol.1 Crossover for single- objective numerical optimization problems, Tomasz Gwiazda, Lomianki, 2006
9. ZHANG. J, Chung. H and Lo. W. L, "Clustering-Based Adaptive Crossover and Mutation Probabilities for Genetic Algorithms", IEEE Transactions on Evolutionary Computation vol.11, no.3, pp. 326-335, 2007.
10. Kevin Swingler "Applying Neural Networks. A practical Guide', Morgan Kaufman Publishers Inc., San Francisco, 2001.

Internet resources:

1.www.coursera.org (*Machine Learning, Prof. Andrew Ng, Stanford University, Learning how to Learn, Dr. Terrence Sejnowski, Dr. Barbara Oakley, UCSanDiego*)

2. http://www.intuit.ru/
3. http://freevideolectures.eom/#
4. http://exponenta.ru/

The term *"system analysis"* will be understood as a set of methods based on the use of computer technology and focused on the study of complex systems - technical, economic, environmental, software, etc.

The result of these studies, generally, is the choice of a certain *alternative*: the treatment choice plan, the development of the company, the design parameters, the project management strategy, etc.

System analysis is a discipline dealing with problems of decision making in conditions when the choice of an alternative requires analysis of complex information characterizing the real situation.

The main goal of this course of lectures is to develop the skills of using decision support systems (DSS) among students.

Areas of application of the theory of DSS

- the choice of personnel in the firm (for example, when hiring);
- problems of optimal choice of parameters (numerical characteristics) of any system (or organization) - projected or actually existing;
- choice of the optimum nomenclature of the goods in trade and other organizations;
- tasks of implementing optimal strategies for replacing equipment;
- tasks of the rational organization of software development for computer systems;
- problems solved in real estate firms that provide services to the population in the real estate market (for example, the selection of apartments);
- formation of optimal strategies for behavior in the securities market;
- the tasks of making decisions in the financial market under conditions of risk and uncertainty;
- the tasks of maximizing revenues in the conditions of auction bidding, and so on.

Having good software and hardware is only a necessary, but **not sufficient**, condition for effectively solving practical problems.

Obligatory is the high professional training of the person making the decision (PMD): the head of the firm, the system analyst or the department of system analysis.

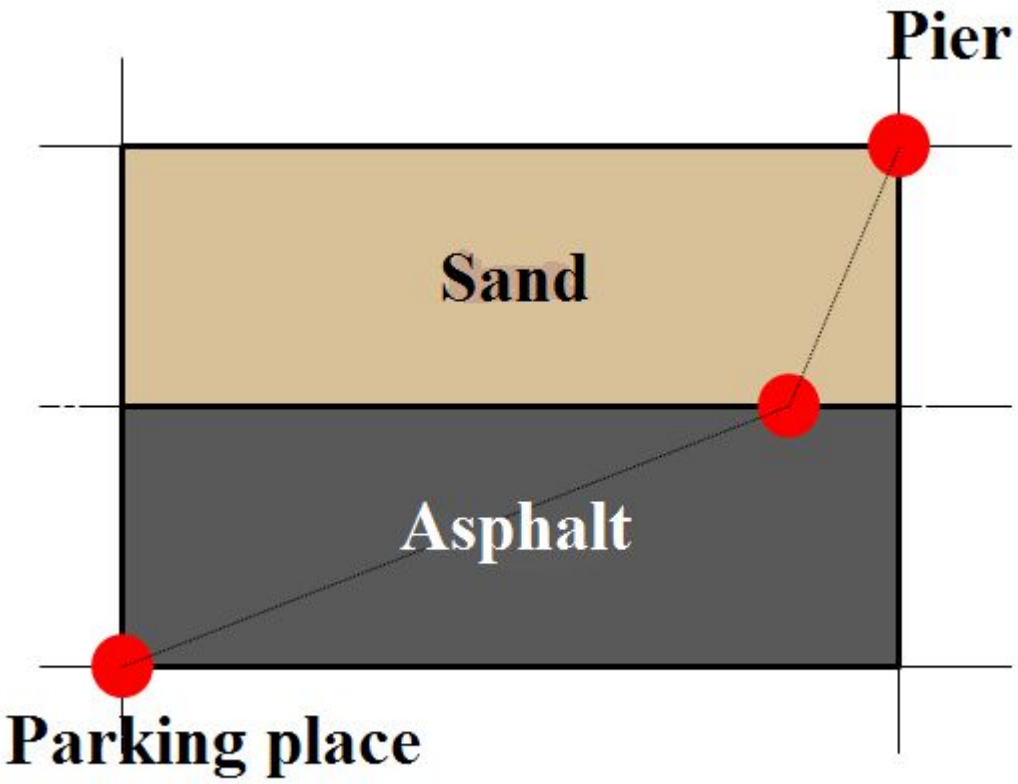
It is important to apply the decision-making methods in practice **correctly.**

The decision-making task is the task of choosing the best mode of action from a certain set of admissible variants.

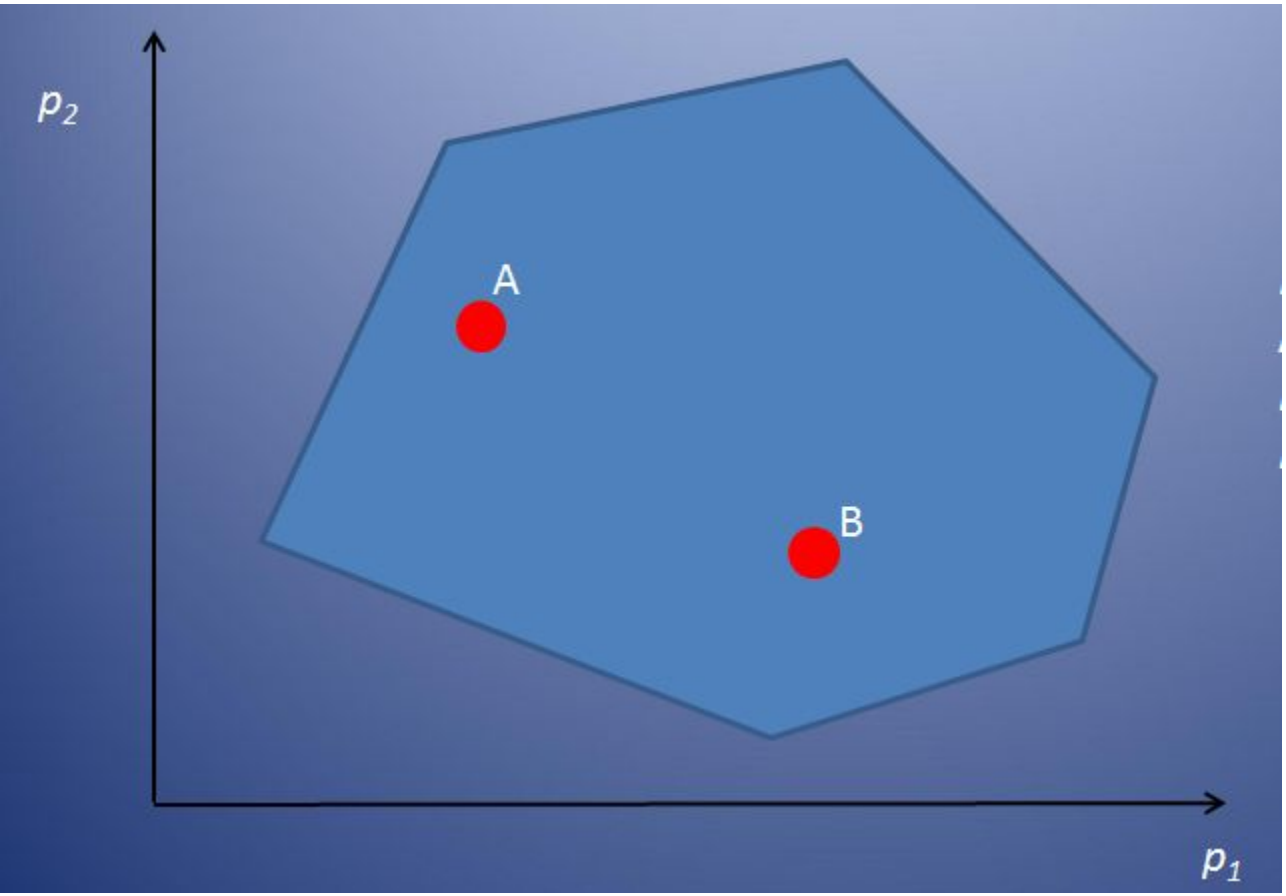
A set of variants X (finite or infinite) is given. The choice of any of the options leads to some outcome, where Y is the set of possible outcomes. It is required to choose such an option in order to obtain the most favorable outcome in a certain sense.

Many variants of X are a *set of alternatives.*

Example 1 . Selecting a route
The task of making a decision in conditions of determination



Example 2 Optimization by two criteria
The task of making a decision in conditions of determination



It is necessary to maximize / minimize both parameters (p1 and p2)

The main goal is not to find the optimal solution, but to define the concept of an optimal solution

Example 3 . The task of making a decision of in conditions of indeterminate (indeterminate of the environment)

Alternative	**State of the environment**	
	The controller will come	The controller will not come
Buy a ticket	50 rubles	50 rubles
Not buy a ticket	1000 rubles	0 rubles

Example 4 Prisoner's Dilemma

The wording: arrested two suspects in committing a serious crime. There is no complete proof of their guilt, and the outcome of the trial is entirely dependent on the behavior strategy of the suspects. Each of them has two alternatives - to confess to committing a crime or not.

		Suspect 1	
		H	C
Suspect 2	H	(1,1)	(10,0)
	C	(0,10)	(7,7)

Indeterminate of the type of "active partner".

The effectiveness of the solution in such a task essentially depends on the strategy of the second person's behavior, as well as on the awareness of both subjects about the intentions of the other party.

Example 5. Pairwise comparisons

PMD can only specify a set of all pairs of outcomes for which the first outcome in a pair is preferable to the second one. In this case, there are no numerical estimates of outcomes in principle.

Example: a young specialist chooses a place for his future work:

x1 - assistant in an international corporation with a salary of 500 y. e.

x2 - engineer in one of the leading Russian companies 800 y. e.

x3 - chief engineer in a little-known provincial firm with a salary of 1000 y. e.

The system of preferences is given by the set of pairs: (x1, x2), (x2, x3), (x3, x1). Consequently, there is not the most preferred alternative here.

What principles should be used to make decisions in such situations?

Example 6. Hardly formalizable problems

It is difficult to formalize the tasks of the PR, which do not have an adequate traditional mathematical description, for example, the problems of medical diagnostics, in which, according to the known initial information (results of analyzes, external manifestations of the disease), it is required to decide on the type of disease.

Special software packages are used for the solution - expert systems.

The most important role in such decision-making systems becomes the problem of constructing an initial knowledge base for a specific subject area and procedures of logical inference (rules) that allow making reasonable conclusions from initial facts or statements.

Rules of the type are used: "IF (condition), TO (action)“

- IF x defended all laboratory works and scored more than 85 points for a semester, then x can claim "excellent" by the semester results.
- This format of recording knowledge is characteristic for the most important class of expert systems - product expert systems.

Example 7. Group selection of solutions

The main task is to indicate the "fair" principles of accounting for individual elections, leading to a reasonable public (or group) decision.

Examples:

- meeting of the medical consultation
- budget planning (state, organization, family)
- selection of a new tomograph in the clinic

It is logical to use the obvious rule of the majority, but there are difficulties associated with the natural principles of harmonization, such as the majority rule or the average score.

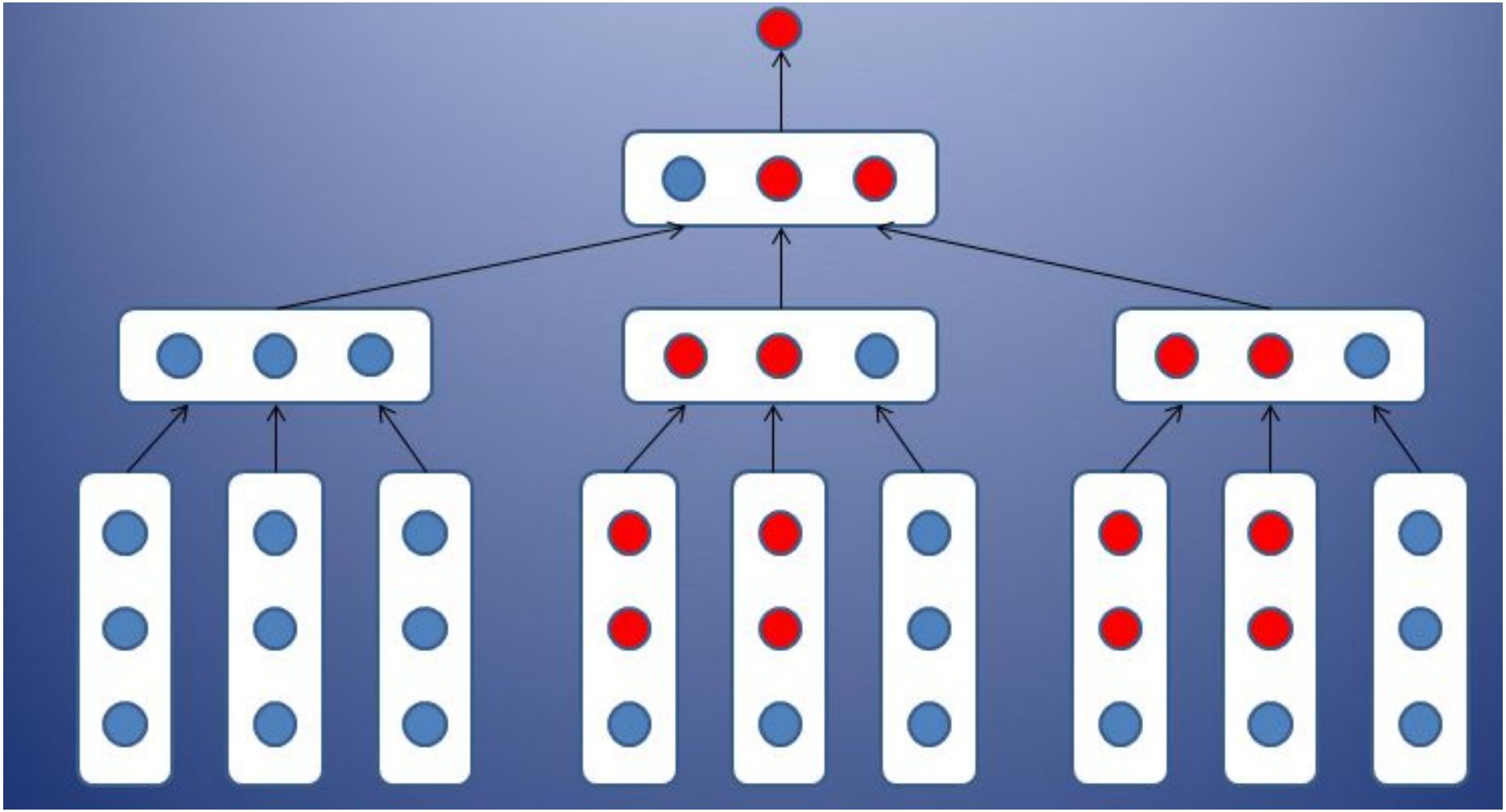
The Paradox of Voting

Adoption of the bill. Suppose that three groups with approximately the same number of votes discuss three options for some alternative a, b, c in order to approve one "best" option. Let the group preference systems have the following form, respectively:

- a>b>c, R1 = {(a, b), (b, c), (a, c)}.
- b > c > a, R_2= {(b, c), (c, a), (b, a)}.
- *c*>*a*> b, R_3= {(c,a), (a,b), (c, b)}.

- It was decided to act according to the rule of the simple majority. Then, as a result of voting, we get a> b, because the pair (a, b) is present in R1 and R3, and the pair (b, a) is only in R2. Similarly, we establish that b> c and c> a, that is, a> b> c> a.
- We get the "vicious circle" and the loss of the transitivity property in the group preference.

Elections of the president (the paradox of a multistage vote)

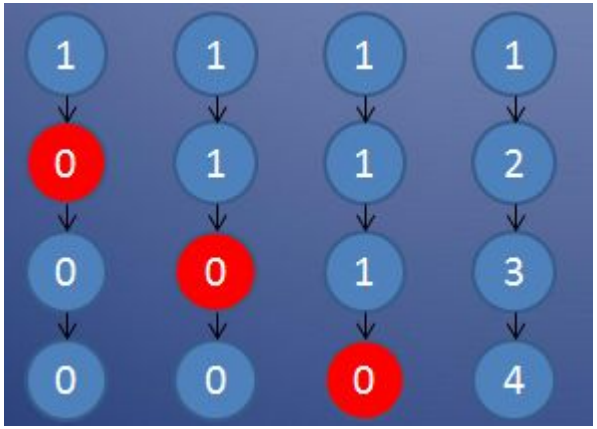


A minority (8) imposed an opinion on the majority (19)

Resource allocation task

Let some resource be distributed between n terms of some system. In this case, the state of the community (system) will be called the vector (*a1, a2, ... an*), where a_i is the volume of the resource owned by the *i-th* member of the community. The total amount of the resource is constant and is equal to: $a = \sum_{i=1}^{n} a_i$

The state *b* is not worse than the state a for the *i-th* subject, if $b_i >= a_i$. We will redistribute resources on the basis of a very strong majority: the new state will be no worse than the old one for all members of the community except, perhaps, one (total-majority rule).



Proportional distribution

Resource in one hand

The total-majority path can connect any two states of the system!

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Thank you!

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