VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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THE SENSITIVITY ANALYSIS OF THE QUANTITATIVE MULTIPLE ATTRIBUTE DECISION MAKING METHODS

SUMMARY OF DOCTORAL DISSERTATION

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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

Rūta SIMANAVIČIENĖ

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Introduction

Topicality of the problem

Our life is greatly influenced by the decisions we make. The same can be said about the structure of the society whom we all constitute because it depends on the decisions made previously. Some decisions are easy to make because the problem considered is solved based on one or two criteria. However, some problems are analysed taking into account a number of evaluation criteria that may be conflicting or expressed in different units of measurement. To analyse such decisions multiple attribute decision-making methods are used.

In the present work, a set of multiple attribute decision-making methods are analysed where the values and significances of attributes are quantitative expressions. Decision making in engineering, industry, economics, environment protection, power generation, medicine and other areas is often associated with uncertainty caused by various factors, both objective and subjective.

The solution of engineering problems is based on quantitative measurement. Multiple attribute decision making methods based on quantitative measurements are used for developing deterministic models, which do not take into account possible random quality of the values and significances of the efficiency attributes depending on sometimes irrational behavior of a person. Then, the questions arise: is the results obtained by using these methods reliable and are the considered methods sensitive to variation of the initial data? The analysis of literature shows that the methods of evaluating multiple attribute-based decisions taking into account the significance values of particular criteria may be found. However, the methods of analysing sensitivity of MADM methods based on all attributes values and significances cannot be found. Therefore, sensitivity analysis of quantitative multiple attribute methods, used for effective decision making and the analysis of the reliability of decisions made by using these methods, are the significant research problems.

In the dissertation, the sensitivity analysis of quantitative multiple attribute decision- making methods with respect to the initial data is performed, and a model for evaluating decision reliability is offered.

Research object

The research object is the sensitivity of the quantitative multiple attribute decision-making methods to the initial data biases.

Aim and tasks of the work

The work is aimed at extending the possibilities of multiple attribute decision- making methods by developing the techniques that allow to evaluate the stochastic nature of these methods.

To achieve the stated task, the following problems should be solved:

1. To perform the analysis of quantitative multiple attribute decision-making methods and to determine the main problems associated with their sensitivity.
2. To consider the available methods of sensitivity analysis and possibilities of using statistical modeling and data analysis in sensitivity analysis of multiple attribute decision- making methods.
3. To perform the analysis of quantitative multiple attribute decision-making methods, based on the attribute values and significances and to offer the techniques for evaluating their sensitivity and reliability of decisions made by using these methods.
4. To analyse sensitivity of a set of multiple attribute decision- making methods at each step and to suggest an algorithm for improving this set of methods so that decision errors could be determined with their help.
5. To check the validity and practicability of the suggested methods by developing a prototype software package for their realization and to make experimental calculations based on the use of one of the considered methods.

Methodology of research

Statistical modeling and data analysis are used for determining sensitivity of the considered methods and reliability of the solution obtained by using them. To realize the methods suggested in the dissertation, the methods of experimental analysis are used.

Scientific novelty

The following scientifically new results were obtained in the work on the dissertation topic:

1. The method TOPSIS is more sensitive than the methods SAW and COPRAS in respect to both the attributes values and significances.
2. Multiple attribute decision- making methods are three times more sensitive to data distribution based on uniform distribution than on normal distribution law when the attribute values are the same.
3. The method of sensitivity analysis of multiple attribute decision-making methods based on the Monte Carlo approach is offered.

4. A method for evaluating the solution obtained by using multiple attribute decision-making methods, based on the model of evaluating the solution errors with respect to the attributes values and significances, as well as the assumptions of a particular method, is suggested.
5. Based on the developed methods, the prototypes were created and the experiments were performed and described. These experiments confirmed the validity of the suggested methods.

Practical value

The research results show that the methods suggested in the dissertation for evaluating the sensitivity of quantitative measurement- based multiple attribute decision- making methods and the reliability of the solution obtained by using these approaches may be applied to the design of decision support systems, the evaluation of multiple attribute decisions made with their help and sensitivity of multiple attribute decision- making methods.

Defended propositions

1. A new method of sensitivity analysis is developed, which may be used for determining sensitivity of multiple attribute decision- making methods based on quantitative measurements.
2. A new method for evaluating decision reliability is developed which may be used for evaluating the reliability of decisions made with the help of multiple attribute decision – making methods, based on quantitative measurements.

The scope of the scientific work

The scientific work consists of the general characteristic of the dissertation, four chapters, conclusions, the list of literature (114 items), the list of publications and the addenda. The total scope of the dissertation – 122 pages, 34 pictures, 33 tables and 3 addenda.

1. The analytical study of the multiple atribute decision-making methods

The application of multiple-atribute decision- making methods, based on quantitative measurements, carried out in deterministic calculations, does not consider the possible performance indicator values and the significance of chance, which are caused by irrational reasons. Decision-makers without regard to possible inaccuracies in the initial data, make decisions using already existing deterministic mathematical models, which apply strictly mathematically based methods. The human irrational decision-making tasks, quantitative criteria values are determined with some errors. If the original data is not accurate – the result is doubtful.

In the case of decision-making is concerned, not one, but several individuals may be in disagreement about determining the initial data. The question then arises: Does in such a situation the result of using a quantitative multiple criteria decision making methods are sensitive to input data?

A number of scientific works exist describing the multiple attribute decision-making techniques and sensitivity analysis of the obtained solutions of the individual indicators in respect of the significance of values, but there is no method for multiple attribute decision-making methods of sensitivity analysis.

Some works discuss using an alternative rationality multiple attribute decision-making methods of the complexes, but these works do not address data uncertainty problems, neither the sensitivity of the results or reliability of the resulting solution.

Medical decision-making methods prefer methods having a greater sensitivity to input data. Examined economic, engineering, social decision-making prefers methods more stable and less susceptible to errors.

There are works dealing with the reliability of the decision, but the decisions are based on the probability of occurrence of an event. Multiple attribute decision-making methods are deterministic. Evaluation methods for reliability solutions, with deterministic decision-making methods, evaluation methods have not been found in the literature.

A literature review has shown that there isno single method for multiple attribute decision-making techniques and sensitivity analysis to assess the reliability of the multiple attribute solution. Thus, the thesis is to propose techniques and algorithms, the sensitivity of such methods and multi-decision reliability with regard to the initial deflection of the data and the methods used assumptions that assessment.

This work focuses on the popular multiple attribute quantitative measurement-based decision-making methods: TOPSIS – (*Technique for Order Preference by similarity to Ideal Solution*) proximity ideal point method, SAW – (*Simple Additive Weighting*) simple additive weighting method and COPRAS – (*Complex Proportional Assessment*), an integrated approach of proportionality. During the question of methods of sensitivity analysis of input data, the hypothesis of the method sensitivity and reliability of decisions is formulated that may be true for all multiple attribute decision-making methods based on quantitative measurements and class methods.

2. The methods for sensitivity and statistical analysis

As seen in literature, there is no method for multiple attribute decision-making methods of sensitivity analysis, the values of attribute and targets in respect of materiality, to perform. Analysis has not found methods to obtain the perspective of deterministic calculations multiple attribute decision reliability. Thus, this work proposes methods for multiple attribute decision-making methods to determine the sensitivity and resolution obtained using these methods for reliability estimation.

Multiple attribute decision-making methods, which are dealt with in this work, are based on quantitative measurements, and thus a method of sensitivity analysis, reliability analysis or decision, has to work with samples. Thus, multiple attribute decision-making methods and solutions obtained by this method of analysis use these statistical methods:

1) Non-parametric assumptions about the distribution control;
2) The hypothesis of a two-sample averages of equality;
3) The average confidence intervals;
4) The rules of stochasic dominance.

Because of the initial data there can be errors, which may change the result of a decision, so there is a need to model more similar situations in the light of possible input data errors. The Monte Carlo method is a convenient simulation and analysis tool.

There are situations where the application of multiple atribute decision-making methods for the two alternative claims to be the first priorities in line position. To determine which alternative to the dominant, it is proposed to apply stochastic dominance rules. The attributes by which alternatives can be compared with those rules, it is proposed to take an alternative vector of values of rationality.

3. The proposed method for the sensitivity and reliability assessment

The third chapter details the methods performed TOPSIS, SAW COPRAS and sensitivity analysis. The sensitivity analysis methods for evaluating the sensitivity of the methods and reliability of the decisions are proposed. The proposed sensitivity analysis methods for the sensitivity and resolution methods for validating the significance of values in respect of the attributes and attributes of measurement uncertainty associated with possible errors of the experts.

Sensitivity analysis based on statistical modeling method Monte Carlo, which help generate attributes of pair-wise comparison matrix, carried out by using an rationality of the alternative evaluation of the method and results of statistical analysis. Statistical characteristics, providing the sensitivity and resolution of the reliability of numerical expressions, are based on dispersion estimates.

The coefficient of variation attributes the percentage of alternative rationality average other alternatives to the rationality of the following values:

1) Calculated by the following numerical characteristics: mean, standard deviation, median, first and third quartiles, coefficient of variation (*cvp*), the difference of quartiles (*IQR*), which is less sensitive to the outliers.
2) The coefficient of variation attributes the percentage of alternative rationality average deviated other alternatives to the rationality of the following values

$$cvp_i = \frac{s_i}{\bar{x}_i} \cdot 100\%, \quad \left(i = \overline{1, m}\right) \tag{3.1}$$

where $s_i, \left(i = \overline{1, m}\right)$ – *i-th* alternative to the standard deviation of the values of rationality. When the coefficient of variation is greater; the calculation method used is more sensitive to changes in input data.

3) Determine what the best law of distribution of the results taken. Determines the selected distribution sufficiently well represented by the sample in question, calculating in Anderson-Darling criterion.
4) The results of statistical analysis of the findings depicted graphically used a "box-Whisher" and "ScaterPlot" types of charts.
5) Reliability assessment of the decision. If an alternative rationality values A_i *and* A_l distributed according to the normal law, the averages are calculated confidence intervals. If the confidence intervals are intersecting:

$$PI(A_i) \cap PI(A_{i+1}) \neq \varnothing . \tag{3.2}$$

6) Alternatives to the averages of the confidence intervals Connections event, check the hypothesis of two independent samples of average equity, the standard deviation is unknown (Cekanavicius 2004). If the zero hypotheses are accepted, then the difference between the average values of an alternative rationality is statistically insignificant. Otherwise, an alternative rationalization of average values considered statistically significantly different. Such decision is reliable.

7) Decision of the reliability analysis of a case, the availability of alternative values of rationality, the alternatives given rank values. Determine the most common rank value of each alternative and calculate the ranking values of repetition rate:

$$p(A_i) = \frac{n(l)}{K} \cdot 100\% \qquad (3.3)$$

where *p(Ai)* – assigned to an alternative known as *Ai*-level estimate of the reliability of *K* – the number of iterations *n(l)* – the most frequent grade alternative values of the frequency *l*.

4. The proposed method for evaluating the biases of the methods and decisions

To evaluate the biases of a decision made with the help of multiple attribute decision making methods, when the biases of the initial data are given. The decision bias depending on the biases of the attribute values Δ_{ij}, $\left(i=\overline{1,m}\right)$, $\left(j=\overline{1,n}\right)$ is denoted by $\Delta_*^A(M)$; the decision bias depending on the attribute significance biases Δ_j^q, $\left(j=\overline{1,n}\right)$ is denoted by $\Delta_*^B(M)$; the joint bias of decision, depending on the biases of the attribute values and the attribute significance biases is denoted by $\Delta^*(M)$.

The total optimality bias $\Delta^*(M)$ of the alternative, which obtained the highest rank (one), is calculated for the variances of the results obtained by the applied method *M,* where $M \in \{TOPSIS, SAW, COPRAS\}$.

The application of the method of evaluating $\Delta^*(M)$ involves three stages: stage I – the calculation of the variances of the results obtained by the applied method M $S_A^2(M)$, depending on the biases of the attribute values Δ_{ij}, $\left(i=\overline{1,m}\right)$, $\left(j=\overline{1,n}\right)$; stage II – the calculation of the variances of the results obtained by the applied method M $S_B^2(M)$, depending on the attribute significance biases Δ_j^q, $\left(j=\overline{1,n}\right)$; stage III – the calculation of the joint decision bias $\Delta^*(M)$ is based on the variances of the results $S_A^2(M)$, $S_B^2(M)$.
The actions of the stages I-II are performed by using the algorithm (Fig. 1).

The coefficients of variation, expressed as a percentage, given as the bias of efficiency values of the alternatives $\Delta_*^A(M)$ and $\Delta_*^B(M)$. These calculations are performed by using the algorithm (Fig. 1).

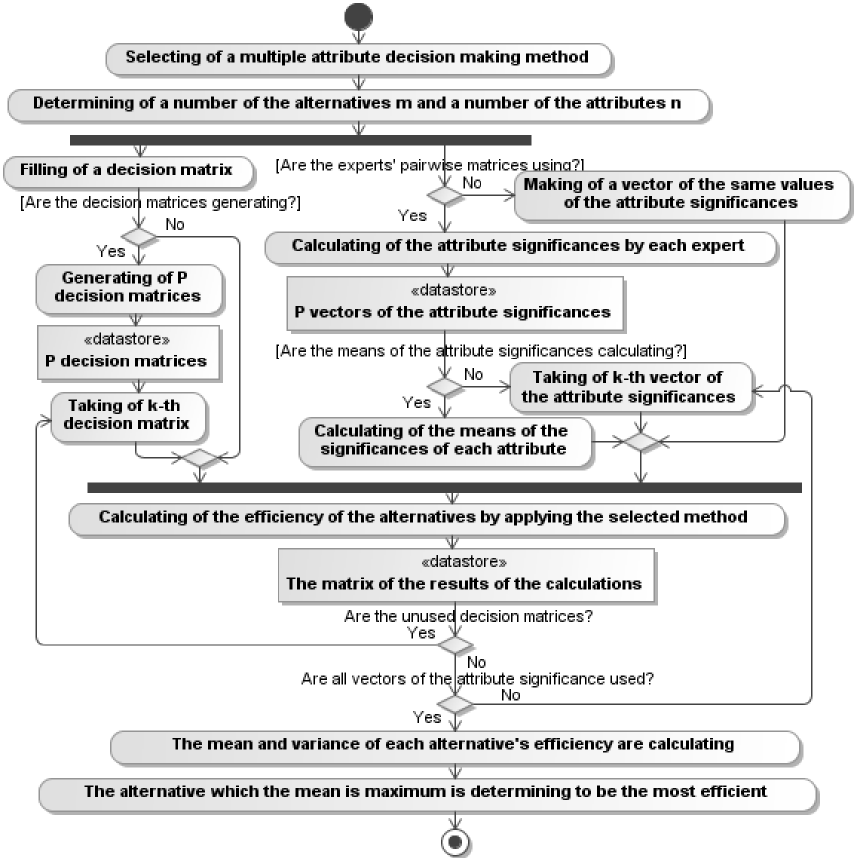

Fig. 1. The algorithm of the calculation of the decision biases depending on the initial data

The actions of the stage III

In the light of the property of variance: if two variable X and Y are independent, the variance of their sum is given by $D(X+Y)=DX+DY$, then the standard deviation of variable $(X+Y)$ is given by $S=\sqrt{D(X+Y)}$.

The coefficient variation (cv) is defined as the ratio of the standard deviation to the mean is given by:

$$cv=\frac{S}{\bar{x}} \tag{4.1}$$

The coefficients of variation, expressed as a percentage, given as the bias of efficiency values of the most efficient alternative

$$cv_*(M)=\frac{\sqrt{S_{*A}^2(M)+S_{*B}^2(M)}}{\bar{x}_*} \tag{4.2}$$

where $\bar{x}$ – is the mean of the efficiency estimates of the most efficient alternative given by stage I and stage II.

The bias of the method *M*, is denoted by Δ^M. The calculation of this bias consists of the three stages:

1) Using the decision matrixes $X_{[m\times n]}^k, \left(k=\overline{1,P}\right)$ and taking the vectors of the attributes' significances $q_k^*=\left(q_{1k}^*, q_{2k}^*, \ldots, q_{nk}^*\right), \left(k=\overline{1,P}\right)$, the efficiency of the alternatives is calculated by applying each methods *M*, $M\in\{TOPSIS, SAW, COPRAS\}$. $P\times P$ variants of efficiency estimates of the alternatives are obtained $G^t(M)=\left(g_{1M}^t, g_{2M}^t, \ldots, g_{mM}^t\right), \left(t=\overline{1,P\times P}\right)$, by each method *M*, using the algorithm (Fig. 1).
2) Using data $G^t(M), \left(t=\overline{1,P\times P}\right)$, the mean efficiency values of each alternative $\overline{G}(M)=\left(\bar{g}_{1M}, \bar{g}_{2M}, \ldots, \bar{g}_{mM}\right)$ are calculated and the matrix $\mathbf{R}=\{r_{ij}\}, \left(i=\overline{1,m},\ j=\overline{1,Mt}\right)$ is composed, where m – is number of alternative, *Mt* – is number of methods, $\{r_{ij}\}$ – is the mean values of *i-th* alternative by applying *j-th* method.
3) The elements of matrix ***R*** are normalized using formula:

$$\widetilde{r}_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}. \qquad (4.3)$$

4) A normalized matrix is denoted by $\widetilde{R} = \{\widetilde{r}_{ij}\}, \left(i = \overline{1,m},\ j = \overline{1,Mt}\right)$. The mean values $\overline{\widetilde{r}}_j, \left(j = \overline{1,Mt}\right)$ of the rows' elements of the matrix $\widetilde{R} = \{\widetilde{r}_{ij}\}, \left(i = \overline{1,m},\ j = \overline{1,Mt}\right)$ are determined to be the real values of alternatives efficiency.
5) The biases of the methods for each alternative are calculated by the formula:

$$\Delta_i^j = \left|\overline{\widetilde{r}}_j - \widetilde{r}_{ij}\right|, \left(i = \overline{1,m},\ j = \overline{1,Mt}\right). \qquad (4.4)$$

The authors for paper are offered to calculate the biases of the methods by the formula:

$$\overline{\Delta}^j = \frac{1}{m}\sum_{i=1}^{m}\Delta_i^j, \left(j = \overline{1,Mt}\right). \qquad (4.5)$$

A multiple attribute decision making problem is composed to present the proposed method. A multiple attribute decision making problem, aimed at determining the best of three alternatives, evaluated based on four attributes, is stated. The values of the attributes are given in Table 1.

Table 1. Decision matrix

	X1	***X2***	***X3***	***X4***
A1	50	0,214	571	193
A2	78	0,213	665	299
A3	50	0,222	690	191
Max/min	Max	Min	Min	Min

A group of 13 experts, who helped to determine the attribute significance values, is formed. Based on the assumption that the biases of the attribute values are equal to 5% and following the normal distribution, 13 decision matrixes were generated. According to the methods TOPSIS, SAW and COPRAS, the best alternative was *A1*. The real efficiency value of alternative *A1* is 0.455. Using the proposed method for the calculation of the decision biases, the values of the biases are given (Table 2).

Table 2. The biases of decisions

	TOPSIS-A1	SAW-A1	COPRAS-A1
$\Delta_*^A(M)$	0,123	0,026	0,017
$\Delta_*^B(M)$	0,034	0,002	0,002
$\Delta^*(M)$ *(%)*	10,2%	2,5%	1,8%
Δ^M	0,077	0,039	0,038

According to the method TOPSIS, the total efficiency bias of this alternative reaches 10,2%, while that obtained by using the method SAW is 2,5%, the method COPRAS – 1,8%. Based on the obtained decision biases, it is concluded that the decision yielded by COPRAS has the smallest bias and is more reliable (efficient) than the decision obtained by the method TOPSIS or the method SAW.

General conclusions

After developing the modification of sustainable multiple attribute methods' complex and after performing a computer experiment based on this model and after verification the following scientific and practical conclusions have been formulated:

1. Both indicators of value and significance of the set of human characteristics and human behavior may be irrational caused by subjective reasons. Thus, when such data influence deterministic calculations, the decision result may raise doubts.
2. A review of methods of sensitivity analysis has shown that there are sensitivity analysis techniques for mathematical models of the sensitivity of the parameters in respect to multiple attribute decisions and sensitivity to the rate in respect to which is the most sensitive solution. For assessing the reliability of the multiple attribute decision, we can rely on the results of averages, confidence intervals and hypothesis of equality of averages, the statistical findings.
3. Sensitivity analysis techniques based on the Monte Carlo method enable multiple attribute decision-making methods for sensitivity

analysis of the significance of attribute and values of attribute. Multiple attribute decision-making methods are more sensitive for the distribution of values of the attribute under the law of uniform than the normal distribution, the significance of the attributes being the same.

4. The bias ofmultiple attribute decision-making method TOPSIS is twice higher than the biases for methods SAW and COPRAS. SAW and COPRAS biases are the same.
5. The software package based on the proposed method allows the prototype to perform the calculation using the set of decision matrices at the same time, which is convenient for performing the sensitivity, reliability and decision analysis.

List of Published Works on the Topic of the Dissertation
In the reviewed scientific periodical publications

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KIEKYBINIŲ DAUGIATIKSLIŲ SPRENDIMO PRIĖMIMO METODŲ JAUTRUMO ANALIZĖ

Mokslo problemos aktualumas

Kiekvieno iš mūsų gyvenimas priklauso nuo priimtų sprendimų, taip kaip ir visos socialinės erdvės, kurios dalimi esame, struktūra priklauso nuo anksčiau priimtų sprendimų. Vienus sprendimus priimti paprasta, nes nagrinėjama problema sprendžiama atsižvelgiant į vieną ar du rodiklius. Tačiau yra problemų, kurios nagrinėjamos daugelio rodiklių atžvilgiu, kai vertinimo kriterijai prieštarauja vieni kitiems, kai vertinimo rodikliai matuojami skirtingais matavimo vienetais. Tokių sprendimų analizei taikomi daugiatiksliai sprendimo priėmimo metodai. Šiame darbe analizuojama daugiatikslių sprendimo priėmimo (*Multiple attribute decision making – MADM*) metodų klasė, kurioje rodiklių reikšmės ir reikšmingumai yra kiekybiniai įverčiai.

Sprendimų priėmimas inžinerijoje, pramonėje, ekonomikoje, aplinkos apsaugoje, energetikoje, medicinoje ir kitose srityse yra dažnai susijęs su neapibrėžtimi, sąlygojama įvairių priežasčių, tiek objektyvių, tiek subjektyvių. Inžinerinių problemų sprendimas remiasi kiekybiniais matavimais. Daugiatiksliai, kiekybiniais matavimais pagrįsti sprendimo priėmimo metodai taikomi determinuotiems modeliams, kuriuose nevertinamas galimas efektyvumo rodiklių reikšmių ir reikšmingumų atsitiktinumas, sąlygojamas asmens neracionalumo priežasčių. Tuomet kyla klausimai: ar gautas rezultatas, taikant šiuos metodus yra patikimas, ar šie metodai jautrūs pradinių duomenų pokyčiams? Nagrinėtoje literatūroje yra metodų vertinančių daugiatikslių sprendimų jautrumą atskirų rodiklių reikšmingumo reikšmių atžvilgiu. Tačiau neteko rasti jautrumo analizės metodų, kurie vertintų MADM metodų jautrumą atžvilgiu visų nagrinėjamų rodiklių reikšmių, atžvilgiu visų rodiklių reikšmingumų. Todėl kiekybinių daugiatikslių sprendimo priėmimo metodų, naudojamų racionalių sprendimų prėmimui, jautrumo analizė ir sprendimų gautų taikant šiuos metodus patikimumo analizė, yra aktualūs mokslo uždaviniai.

Disertacijoje numatoma atlikti kiekybinių daugiatikslių sprendimų priėmimo metodų jautrumo analizę atžvilgiu pradinių duomenų, bei pasiūlyti metodą skirtą daugiatikslio sprendimo, gauto taikant šiuos metodus, patikimumo vertinimui.

Tyrimų objektas

Disertacijoje tiriamas daugiatikslių, kiekybiniais matavimais pagrįstų sprendimo priėmimo metodų jautrumas ir sprendimų, gautų taikant šiuos metodus, patikimumas.

Darbo tikslas

Šio darbo pagrindinis tikslas – praplėsti daugiatikslių sprendimo priėmimo metodų galimybes, sukuriant metodus, leidžiančius įvertinti daugiatikslių sprendimo priėmimo metodų stochastiką.

Darbo uždaviniai

Siekiant realizuoti suformuluotą tikslą, reikia išspręsti šiuos uždavinius:

1. Atlikti kiekybinių daugiatikslių sprendimo priėmimo metodų analizę ir nustatyti kokios pagrindinės problemos susijusios su šių metodų jautrumu.
2. Išnagrinėti esamus jautrumo analizės metodus ir statistinių modeliavimo ir duomenų analizės metodų panaudojimo galimybes daugiatikslių sprendimo priėmimo metodų jautrumo analizei.
3. Atlikti daugiatikslių, kiekybiniais matavimais pagrįstų sprendimo priėmimo metodų jautrumo analizę: rodiklių reikšmių, rodiklių reikšmingumų atžvilgiu ir pasiūlyti metodus daugiatikslių sprendimo priėmimo metodų jautrumui ir sprendimo gauto taikant šios metodus patikimumui vertinti.
4. Išanalizuoti selektonovacijos metodų komplekso jautrumą, kiekviename šio komplekso žingsnyje ir pasiūlyti algoritmą leidžiantį patobulinti šį metodų kompleksą, taip, kad būtų galima įvertinti sprendimo paklaidą.
5. Patikrinti pasiūlytų metodų įgyvendinamumo galimybes ir naudą – sukuriant programinio paketo prototipą, kuriame jie būtų realizuoti ir jį naudojant atlikti eksperimentinius skaičiavimus.

Tyrimų metodika

Metodų jautrumas ir gautų sprendimų patikimumas analizuojamas pasitelkiant statistinio modeliavimo ir duomenų analizės metodus. Darbe pasiūlytų metodų praktinei realizacijai naudojami eksperimentinės analizės metodai.

Mokslinis naujumas

Rengiant disertaciją buvo gauti šie informatikos inžinerijos mokslui nauji rezultatai:

1. Nustatyta, kad artumo idealiajam taškui metodas yra jautresnis tiek rodiklių reikšmėms, tiek rodiklių reikšmingumams lyginant su SAW ir COPRAS metodais.
2. Nustatyta, kad daugiatiksliai metodai žymiai jautresni pradinių duomenų pasiskirstymui pagal tolygųjį dėsnį nei pagal normalųjį, kai

rodiklių reikšmingumai vienodo dydžio. Kai rodiklių reikšmingumai skirtingi, metodai jautresni rodiklių reikšmių pasiskirstymui pagal normalųjį dėsnį nei pagal tolygųjį.

3. Pasiūlytas daugiatikslių sprendimo priėmimo metodų jautrumo analizės ir sprendimo patikimumo vertinimo metodas, sukurtas Monte Karlo metodo pagrindu.
4. Pasiūlytas daugiatikslio sprendimo, gauto taikant daugiatikslius sprendimo priėmimo metodus, paklaidų skaičiavimo metodas.
5. Siūlomų metodų pagrindu buvo sukurti prototipai, atlikti ir aprašyti eksperimentai. Eksperimentai patvirtino pasiūlytų metodų naudą.

Praktinė vertė

Tyrimo rezultatai parodė, kad disertacijoje pasiūlyti daugiatikslių, kiekybiniais matavimais pagrįstų sprendimo priėmimo metodų jautrumo analizės ir gautų sprendimų patikimumo vertinimo metodai gali būti naudojami projektuojant sprendimo paramos sistemas, vertinant daugiatikslių sprendimų patikimumą bei daugiatikslių sprendimo priėmimo metodų jautrumą.

Ginamieji teiginiai

1. Sukurtas naujas jautrumo analizės metodas padeda parinkti daugiatikslį sprendimo priėmimo metodą atsižvelgiant į jo jautrumą ir įvertinti sprendimo, gauto taikant daugiatikslį sprendimo priėmimo metodą, patikimumą.
2. Sukurtas naujas sprendimo paklaidos vertinimo metodas padeda įvertinti sprendimą, gautą taikant daugiatikslius, kiekybiniais matavimais pagrįstus sprendimo priėmimo metodus, ir paklaidą.

Darbo apimtis

Darbą sudaro įvadas, 4 skyriai, išvados, literatūros sąrašas, publikacijų sąrašas ir priedai. Darbo apimtis yra 121 puslapiai, neskaitant priedų, tekste panaudotos 83 numeruotos formulės, 34 paveikslai ir 30 lentelių. Rašant disertaciją buvo panaudota 111 literatūros šaltinių.

Pirmajame disertacijos skyriuje analizuojami kiekybiniai daugiatiksliai sprendimo priėmimo metodai ir nustatomos pagrindinės problemos, susijusios su šių metodų jautrumu ir sprendimų, gautų taikant šiuos metodus, patikimumu. Skyriaus pabaigoje detalizuojami mokslinio darbo uždaviniai.

Antrajame disertacijos skyriuje nagrinėjami esami jautrumo analizės metodai. Analizuojami statistinių modeliavimo ir duomenų analizės metodų taikymo galimybės daugiatikslių sprendimo priėmimo metodų jautrumui analizuoti.

Trečiajame disertacijos skyriuje atliekama daugiatikslių, kiekybiniais matavimais pagrįstų sprendimo priėmimo metodų jautrumo analizė: rodiklių reikšmių ir rodiklių reikšmingumų atžvilgiu. Taikant antrame skyriuje išanalizuotus metodus pasiūlyti metodai daugiatikslių sprendimo priėmimo metodų jautrumui rodiklių reikšmingumams ir rodiklių reikšmėms analizuoti ir sprendimo patikimumui vertinti.

Ketvirtajame disertacijos skyriuje pasiūlytas metodas sprendimo, gauto taikant daugiatikslius sprendimo priėmimo metodus, paklaidoms skaičiuoti. Aprašyti eksperimentiniai skaičiavimai, pasitelkiant siūlomą metodą.

Bendrosios išvados

1. Atlikus daugiakriterinių sprendimo priėmimo metodų analizę, nustatyta, jog šie metodai yra jautrūs rodiklių reikšmėms ir rodiklių reikšmingumams. Tiek rodiklių reikšmės, tiek rodiklių reikšmingumai nustatomi žmogaus, o žmogaus elgesys gali būti neracionalus, sąlygojamas subjektyvių priežasčių. Tad su tokiais duomenimis atliekant deterministinius skaičiavimus, sprendimo rezultato patikimumas kelti abejonių.
2. Jautrumo analizės metodai yra taikomi siekiant nustatyti matematinių modelių jautrumą parametrams ir daugiatikslių sprendimų jautrumą. Tiriant pastarąjį ieškoma rodiklio, kuriam sprendimas yra jautriausias. Nagrinėtų jautrumo analizės metodų pagrindas – statistinis modeliavimas ir statistinė analizė, todėl kiekybinių daugiatikslių sprendimo priėmimo metodų tyrimui tikslinga taikyti statistinius metodus.
3. Atlikus daugiatikslių sprendimo priėmimo metodų jautrumo analizę rodiklių reikšmių atžvilgiu nustatyta:
   - 3.1. Kai rodikliai vienodai reikšmingi, daugiatiksliai metodai jautresni rodiklių reikšmių pasiskirstymui pagal tolygųjį dėsnį nei pagal normalųjį. Kai rodikliai ne vienodai reikšmingi, metodai jautresni reikšmių pasiskirstymui pagal normalųjį dėsnį.
   - 3.2. Daugiatikslio sprendimo rezultatai reikšmių nuokrypių atžvilgiu pasiskirstę pagal normalųjį dėsnį, todėl vertinant daugiatikslio sprendimo patikimumą, galima remtis rezultatų vidurkių pasikliautinųjų intervalų ir hipotezių apie vidurkių lygybę statistinėmis išvadomis.
   - 3.3. Daugiatikslio sprendimo rezultatams rodiklių reikšmingumų, kurie priklauso nuo ekspertų nuomonės, atžvilgiu negalima apibrėžti konkretaus pasiskirstymo dėsnio.

4. Monte Karlo metodo pagrindu sukurti jautrumo analizės metodai leidžia atlikti daugiatikslių sprendimo priėmimo metodų jautrumo analizę rodiklių reikšmingumų ir rodiklių reikšmių atžvilgiu, bei įvertinti nagrinėjamo sprendimo patikimumą. Stochastinio dominavimo taisyklės gali būti taikomos alternatyvų dominavimo nustatymui, kai kiekybiniai daugiatiksliai sprendimo priėmimo metodai pateikia nevienodą alternatyvų rangavimą.
5. Taikant pasiūlytą paklaidų skaičiavimo metodą, buvo įvertinta, jog metodas TOPSIS alternatyvų racionalumo rezultatams suteikia dvigubai didesnę paklaidą nei metodai SAW ir COPRAS. Metodų SAW ir COPRAS paklaidos yra vienodo dydžio.

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THE SENSITIVITY ANALYSIS OF THE QUANTITATIVE MULTIPLE ATTRIBUTE DECISION MAKING METHODS

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