DOI: 10.32347/2412-9933.2023.55.104-108
UDC 004.8

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"SOFT" CALCULATION METHODS IN THE EVALUATION OBJECTS OF COMPLEX SYSTEMS

Abstract. *Today, humanity in its activities quite often interacts with complex systems of economic, transport, construction and many other industries. The complexity of these systems will be manifested in a large number of connections between elements that are connected not only to each other, but also to other subsystems. Each of these industries consists of already well-studied and analyzed systems, such as employee payroll. But, in addition, they also include systems based on a qualitative component that do not yet have a developed mathematical description. Such systems include the influence of the internal climate that unites the members of the organization's team on labor productivity. Scientists have proposed many different approaches to solving this problem based on the use of statistical, differential methods. Even machine learning, which is quite popular today, is also used in these tasks. But the vast majority of them have a complex structure, which is manifested in the use of the apparatus of higher mathematics. Because of this understanding of the model itself, its application recedes into the background. Accordingly, the first place is the requirement to know and navigate in a complex mathematical description. Because of this, only a narrow circle of specialists is able to use models built using this technology. The authors of this article propose their approach, which is based on the method of artificial intelligence. We are talking about "soft" methods consisting of such components as neural networks, genetic algorithms and fuzzy sets. It was on the latter that the authors focused most of their attention for evaluating the objects of complex systems. Of course, one method is not enough for the developed model to adequately represent the operation of the system under study. And thus, to ensure the possibility of its dynamic description, genetic algorithm methods were also used. Of course, these methods also have a mathematical description. But, in contrast to strict mathematical methods, in these two approaches of artificial intelligence, the visual component is quite well represented. This allows you to almost immediately answer the question of how this or that value was obtained during the operation of the model, with the option of not using formulas for this. As a result of the work carried out, a structural fuzzy model was created, which was expanded by the methods of crossing over and selection.*

Keywords: objects of complex systems; "soft" calculations; influencing factors; comfort; fuzzy sets

Introduction

In this article, it is proposed to consider and investigate the objects of a complex system using the example of a model for evaluating the factors influencing the choice of an apartment based on the comfort level. Moreover, it is apartment buildings that are taken into consideration. As a result of the work of this model, ranks should be placed for each considered apartment. Since the factors have vague, blurred, qualitative, and accordingly not quantitative indicators, fuzzy sets are used for their processing. Let's consider the studied area in more detail. The following factors are proposed for analysis:

- the dimensions of the apartment, which is understood as the existing area (respectively, if it is provided in the technical passport) of the balcony or, in the absence of such, the loggia;
- the spaciousness of the apartment, which means the isolation of all available rooms, the entrance to which should be through separate doors, and the spaciousness of the kitchen, which should be convenient not only for cooking, but also for its consumption at a separate table by the whole family;
- apartment planning, which includes the influence of existing values of solar insolation, air humidity and average temperature;
- the location of the apartment, which means the number of the floor where the apartment is located and its relation to the total number of floors of the building, excluding the elevator, as well as the view from all windows of the apartment under consideration.

For the convenience of working with the considered factors and their components, it is suggested to present them in the form of Table 1.

*Table 1 – **Factors and their indicators of influence on the comfort of the apartment***

Name of the factor	Indicator
dimensionality	balcony
	loggia
infinitude	room
	kitchen
planning	insolation
	humidity
	temperature
location	floor
	kind

Accordingly, each of the indicated indicators of influence factors has units of measurement presented in Table 2.

*Table 2 – **Units of measurement of indicators of influence factors***

Indicator	Units of measurement
balcony	dimensionality
loggia	
room	isolation
kitchen	infinitude
insolation	comfort
humidity	
temperature	
floor	convenience
kind	pleasure

The purpose of the article

The purpose of writing the article is to present the structural diagram of the model that manages the objects of complex systems on the example of assessing the factors affecting the comfort of an apartment in an apartment building. This model will be implemented using artificial intelligence methods representing "soft" computing.

Main part

To display the input parameters of the model, let's present the factors and their indicators from Table 1 according to the following notations, indicated respectively in brackets:

- dimensions (a1)
- ✓ balcony (a11)
- ✓ loggia (a12)
- spaciousness (a2)
- ✓ room (a21)
- – the first (a211)
- – friend (a212)
- – the third (a213)
- ✓ kitchen (a22)
- planning (a3)
- ✓ insolation (a31)
- ✓ humidity (a32)
- ✓ temperature (a33)
- location (a4)
- ✓ floor (a41)
- ✓ type (a42)

As can be seen from the presented list, only those apartments with a number of rooms from one to three will be considered. That is, studio apartments and apartments with more than three rooms according to the technical passport will not be considered. This is done for the convenience of calculations.

Parameters a11 and a12 are considered only one at a time or are omitted altogether, since the apartment can have either a loggia or a balcony. Apartments without balconies and loggias can also be evaluated.

It can be represented schematically with the help of fig. 1.

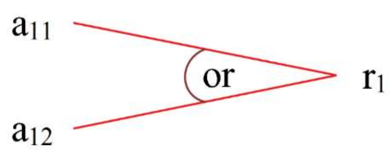

Figure 1 – Schematic representation of the calculation of parameters a11 and a12

r1 in fig. 1 is the result of a vague estimation of parameters a11 or a12. It can have intermediate values from 0 to 1 or exactly 0 in the absence of both a balcony and a loggia.

Parameters from a211 to a42 will be evaluated together according to the influence factor, as for example in fig. 2.

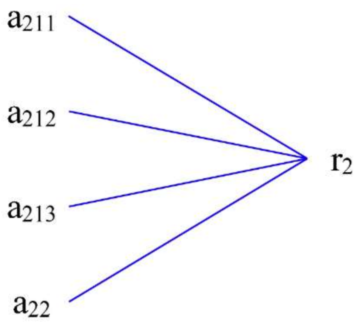

Figure 2 – Schematic presentation of the calculation of parameters a211 - a22

r2 in fig. 2 will contain the result of not only one parameter a211 or a22, but all four. Therefore, there is no OR designation in this figure.

Each parameter will be evaluated using a fuzzy set consisting of three terms of the membership functions, which will have a triangular shape.

Accordingly, table 3 presents terms for each unit of measurement according to table 2.

*Table 3 – **Terms of measurement units of indicators of influence factors***

Units of measurement	The name of the term	The value of U
dimensionality	insignificant	[0…100]
	average	
	high	
isolation	inconvenient	
	average	
	good	
infinitude	insignificant	
	average	
	high	
comfort	bad	
	average	
	wonderful	
convenience	unlucky	
	average	
	nice	
pleasure	inconvenient	
	average	
	good	

Table 3 presents the column responsible for the value of U, which contains the value of the universal set, the elements of which will measure the units of the indicator at the stage of fuzzification.

By the way, the fuzzification stage will be carried out in two stages. At the first step, the parameters for each indicator will be estimated: r1...r4. After that, the obtained four defuzzification values will be phased again (stage 2) in order to obtain the defuzzification value r5. This process is schematically presented in fig. 3.

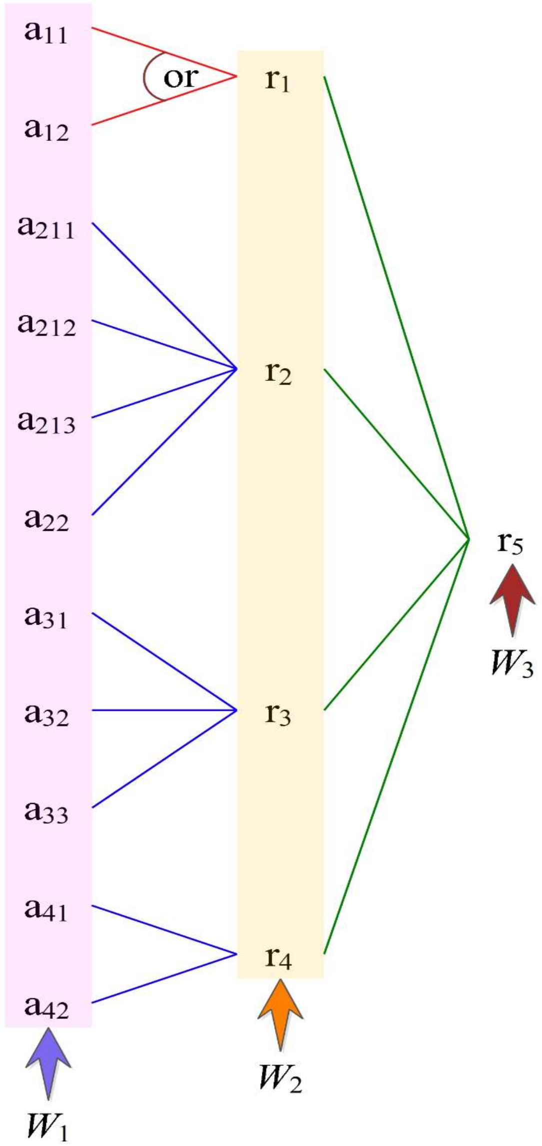

Figure 3 – The main stages of fuzzy logic inference in the model

Figure 3 shows the following designations:

- W1 is phase 1 phase;
- W2 is defuzzification (intermediate) and phase 2 fuzzification;
- W3 is the final defuzzification.

Accordingly, stage 2 phase phasing will be carried out according to the terms presented in Table 4.

*Table 4 – **Terms of units of measurement of phase 2 phase***

The value of defuzzification	The name of the term	The value of U
from 0 to 0.3	small	[0…100]
from 0.31 to 0.6	average	
from 0.61 to 1	high	

In order to provide a model of dynamism, as mentioned in the abstract, the value of U is planned to be influenced by selection and crossbreeding. The authors took this step in order to change the values of U and to check the adequacy of the model. It is schematically presented in fig. 4.

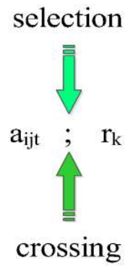

Figure 4 – Effect of genetic algorithm on U value

In fig. 4 a_{ijt} is the designation of units of measurement of indicators of influence factors, and r_k is the value of defuzzification before the second stage of fuzzification.

Thus, different values of r5 will be obtained, which explains the different views on the evaluation of the selected apartment by influencing factors. After conducting at least 10 such experiments, the average value taken will tell about the R rank of this apartment. The saved R data can be used to determine the comfort of a particular apartment.

We present the general structural diagram of the considered model in Fig. 5.

The created model uses genetic algorithm methods to replace the opinions of experts. Since fuzzy logical derivation requires the participation of an expert who determines his professional opinion when specifying data for stages of fuzzy sets. But this leads to significant costs. In order not to constantly involve experts in this subject area on the one hand and to provide the system with dynamic development.

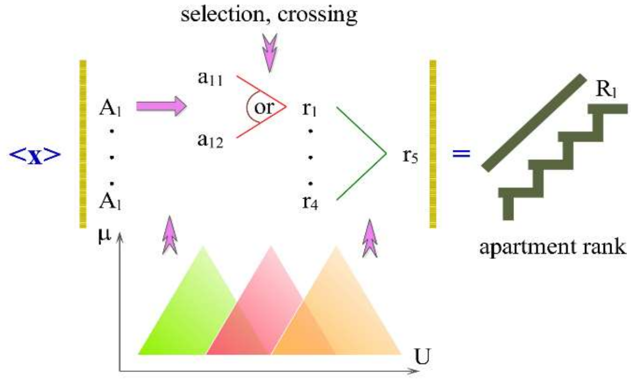

Figure 5 – General structural diagram of the model

Conclusion

In this article, the authors presented a structural diagram of the model for assessing influencing factors that determine the comfort level of an apartment in an apartment building. For its construction, approaches using artificial intelligence technologies were proposed: "soft" computing. Precise sets and genetic algorithm methods became the basis of the described model. In this way, conditions were created for conducting experiments in real life. In the following scientific studies, the authors plan to use this model in brokerage activity. The obtained data will be compared with the data existing in the field of buying and selling apartments. This will, firstly, provide an impetus for further optimization of this fuzzy, fuzzy, complex system, and secondly, help to improve the model proposed by the authors.

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The article has been sent to the editorial board 07.09.2023

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«М'ЯКІ» МЕТОДИ ОБЧИСЛЕННЯ В ОЦІНЦІ ОБ'ЄКТІВ СКЛАДНИХ СИСТЕМ

Анотація. *На сьогодні людство у своїй діяльності доволі часто взаємодіє зі складними системами економічної, транспортної, будівельної та багатьох інших галузей. Складність цих систем проявляться у великій кількості зв'язків між елементами, що поєднані не лише між собою, а й з іншими підсистемами. Кожна з таких галузей складається з уже добре вивчених і проаналізованих систем, як, наприклад, нарахування заробітної плати працівникам. Але, окрім того, до їх складу входять також системи, які спираються на якісну складову, що ще не мають розвиненого математичного опису. До таких систем належить вплив внутрішнього клімату, що поєднує членів колективу організації, на продуктивність праці. Науковцями запропоновано для вирішення цієї проблеми багато різних підходів, що ґрунтуються на використанні статистичних, диференційних методів. Навіть доволі популярне на сьогодні машинне навчання також використовується в таких задачах. Але переважна більшість з них має складну структуру, що проявляється у використанні апарату вищої математики. Через це розуміння самої моделі, її застосування відходить на другий план. Отже, насамперед постає вимога знати й орієнтуватися в складному математичному описі. Через це лише вузьке коло спеціалістів здатне застосовувати моделі, що побудовані з використанням такої технології. Автори статті пропонують свій підхід, в основі якого лежить метод штучного інтелекту. Йдеться про «м'які» методи, що складаються з таких складових, як нейронні мережі, генетичні алгоритми та нечіткі множини. Саме на останніх автори і зосередили найбільше свою увагу для оцінки об'єктів складних систем. Звичайно, одного методу замало, щоб розроблена модель змогла адекватно представити роботу системи, що досліджується. Отже, для забезпечення можливості її динамічного опису також були задіяні методи генетичного алгоритму. Звичайно, такі методи також мають математичний опис. Але, на відміну від строгих математичних методів, у цих двох підходах штучного інтелекту доволі добре представлена наочна складова. Це дає змогу майже відразу відповідати на питання, як було отримано те чи інше значення в процесі роботи моделі з можливістю не використовувати для цього формули. У результаті проведеної роботи створено структурну нечітку модель, що розширена методами кросинговеру та селекції.*

Ключові слова: об'єкти складних систем; «м'які» обчислення; фактори впливу; комфортність; нечіткі множини

Посилання на публікацію

APA Tsiutsiura, M., Yerukaiev, A., Kruk, P. & Lysytsin, O. (2023). "Soft" calculation methods in the evaluation objects of complex systems. *Management of Development of Complex Systems*, 55, 104–108, dx.doi.org\10.32347/2412-9933.2023.55.104-108.

ДСТУ Цюцюра М. І., Єрукаєв А. В., Крук П. О., Лисицін О. Б. "М'які" методи обчислення в оцінці об'єктів складних систем. *Управління розвитком складних систем.* Київ, 2023. № 55. С. 104 – 108, dx.doi.org\10.32347/2412-9933.2023.55.104-108.