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Correction coefficients of neural network algorithms for assessing the development of residential neighborhoods

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Abstract. The paper presents the correction coefficients of neural network algorithms for assessing the development of residential neighborhoods: the corresponding model of correction coefficients is shown, its features are discussed, the relevance and prospects for the use of correction coefficients in the planning of new neighborhoods are substantiated.

1 Introduction

The development of the modern urban planning industry is a complex systemic task in which various aspects of creating a comfortable urban environment are interconnected. The issues of organizing convenient and practical places for social, medical, cultural and sports purposes, as well as the development of recreational, park and pedestrian zones, infrastructure of road networks, bike paths and other facilities play an important role in shaping the attractiveness of new areas. The size, location and quality of the service available to the population, as well as transport connectivity with the rest of the city and nearby settlements also significantly affect these areas. In addition, the uniqueness of the applied technologies, engineering solutions, layout and design in the design and construction is of significant importance [1-4].

However, when implementing ambitious and advanced projects, it is necessary to take into account their economic feasibility and efficiency. The development of new construction technologies opens up new opportunities for engineers, designers and designers in technical terms, but the cost of projects and their payback period often remain outside the framework of new technologies and are limited by external factors [5-7].

Today, the most promising projects for urban development are projects that determine the appearance of entire neighborhoods [8-10]. This includes the construction of residential areas with full social infrastructure in new territories. When developing such projects, well-known approaches of system analysis can be used, such as the morphological approach, which describes all the elements of the system and their interrelationships. Although the size of the morphological description of the system depends on the number of objects, since the number of relationships between them increases in proportion to the square of the number of objects, for the scale of microdistricts, the morphological description is acceptable [13-15]. [11]

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To calculate the economic efficiency of the construction project of individual facilities and the microdistrict as a whole, it is required to use only a small part of the data contained in the project documentation. When considering this information as input parameters of the microdistrict model, it is possible to optimize its development in order to achieve maximum economic efficiency both in the construction process and in the subsequent use of housing.

It should also be noted that construction and investment projects go through certain stages of development [16-18], including project preparation (ideas, concepts), design (sketch, design, working documentation), preparation of the object (planning, general preparation, local preparation), construction (preparatory period of construction and installation works, the main period of construction-installation works), completion of the project (commissioning of the facility), operation (initial period of operation, main period of operation, pre-liquidation period), and liquidation (preparation, demolition, reclamation). Therefore, for correct calculations of economic efficiency, the microdistrict model must take into account the features of its life cycle, including parameters that depend on the project stage and the duration of the stage. The initial results of the calculations will also be related to the stages, but the performance indicators will cover the project as a whole throughout all its stages from the idea and concept to demolition and reclamation or a certain number of life cycle stages.

To describe evolving systems within the framework of the theory of system analysis [11], it is proposed to use a genetic-prognostic approach that expands the morphological description of system objects and their interrelations by including temporary states [12].

When building a model to assess the effectiveness of a neighborhood, practical problems arise related to the limited formalization of a number of parameters, such as the attractiveness of the neighborhood for potential residents. To solve this problem, it is proposed to use fuzzy logic, which provides the possibility of creating appropriate fuzzy models. The advantages of fuzzy logic [19] are a convenient description of the problem conditions in natural language and the possibility of approximation of mathematical systems using fuzzy logic, which is confirmed by the fuzzy approximation theorem [20]. The disadvantages of fuzzy approaches are associated with a certain degree of freedom (subjectivity of the expert) in the formation of fuzzy rules and membership functions of input and output parameters of models. However, these disadvantages can be eliminated with the help of adaptive algorithms, the parameters of which are adjusted during application [19]. Traditionally, algorithms based on fuzzy logic are called neural networks. They serve as the basis for the development of intelligent systems, also known as artificial intelligence systems [21-23].

The purpose of this work is to determine the correction coefficients of neural network algorithms for assessing the development of residential neighborhoods. The technology will optimize economic efficiency by changing the parameters of design, construction and operation, taking into account the features of the life cycle of construction and investment projects.

2 The proposed model of correction coefficients

Determining the effectiveness of the development of the territory at an early stage is a critical step that affects the economic efficiency of this development.

Neural network algorithms are increasingly being used to assess the effectiveness of the development of territories. The adjustment of the neural network model is carried out using binary coefficients. This approach is an important tool for debugging the algorithm and its adaptation to specific territories and regulatory policy in construction.

Taking into account the features of specific objects that affect regular construction costs can be performed using corrective binary coefficients that are selected in the process of training a neural network on real objects. Regular costs play a special role at the stage of operation of microdistricts, especially because of the duration of this stage.

In addition to costs, the construction and operation of a residential area should bring profit to investors, buyers of residential and commercial premises (when selling or renting), tenants of commercial premises and the state (through taxes and deductions). Profit estimation, similar to expenses, can be performed using appropriate weighting and binary coefficients that are associated with the types and categories of neighborhood objects and their areas. The initial calculation coefficients can be obtained from the state systems of monitoring and statistical accounting of economic and economic activity. The remaining features of the functioning of objects, depending on their type or additional parameters, should be taken into account later with the help of correction coefficients adjusted on real examples specific to the region under consideration.

When calculating the correction coefficients in the model, attention should be paid to the attractiveness of the neighborhood, which in the first approximation depends on the number of objects of various types and their relative location. Taking into account the opinion of residents about attractiveness is carried out on the basis of their conclusions formulated using fuzzy logic (for example, "the more, the better", "the closer, the better", "the closer, the better, but not closer than a quarter", etc.).

Thus, depending on the location of the residential building and other objects of the microdistrict, paired relationships arise, formalized by the function xij between i and j objects, reflecting the degree of compliance of the current configuration of the microdistrict with the ideal expectations of residents. The value of the xij function changes from 0 – complete non–compliance with expectations, to 1 - full compliance.

One of the most desirable options is the proximity of the park to a residential building. The idea expressed linguistically as "the closer the park is to the house, the better" is of great importance for assessing the attractiveness of the neighborhood. To formalize this idea, a function m(r) is introduced, where the argument is the distance r between a house with coordinates (x0, y0) and a park with coordinates (x1, y1). By varying the position of the park relative to the house, you can significantly increase the attractiveness of the neighborhood.

However, it is important to take into account that the location of the park relative to the houses is only one of the factors influencing the overall assessment of the attractiveness of the neighborhood. Other factors, such as the availability of schools, shops, sports facilities and transport infrastructure, also play an important role in determining the attractiveness of the neighborhood for potential residents.

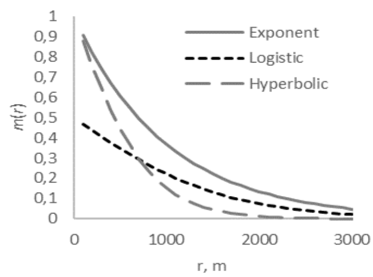
When developing a model for assessing the effectiveness of the development of the territory, it is necessary to take into account all these factors and the interrelationships between them. This will create a more accurate and complete model that can predict the impact of various factors on the attractiveness of the neighborhood.

The use of neural network algorithms in such a model can significantly improve its accuracy and reliability. Neural network algorithms are trained based on real data about neighborhoods, taking into account various parameters and factors, including the distance from houses to parks. This allows you to create a model that can take into account the complex relationships between various aspects of development and predict their impact on the attractiveness of the neighborhood.

Thus, the construction of a model for assessing the effectiveness of territory development based on neural network algorithms and taking into account many factors, including the distance to parks, is an important step in creating attractive and sustainable neighborhoods.

The explicit form of the function x(r) is largely arbitrary [19] and can be represented by various analytical expressions (see Table 1).

Table 1. Possible variants of the explicit expression of the characteristic function x(r), where r_0 are the parameters of the model.

Function name	**Explicit form of the function**	**Graphical display of the function**
Exponential with saturation (Exponent)	$x(r) = \exp(-r / r_0)$	
Logistic	$x(r) = \exp(-r / r_0) / [1 + \exp(-r / r_0)]$	
Hyperbolic tangent (Hyperbolic)	$x(r) = -2\exp(-r / r_0)] / [\exp(r / r_0) + \exp(-r / r_0)]$	

There are various objects in the microdistrict, each of which can perform certain functions. For example, the proximity of a park to a residential building may have a greater impact on attractiveness than proximity to a school. To obtain a general characteristic of the attractiveness of each residential object, taking into account all paired mij functions between this object and the others, you can enter an integral mij attractiveness function for each object in the neighborhood.

The integral attractiveness function xij is the result of fuzzy inference from the general set of mij functions, taking into account the corresponding significance coefficients for each mij function. These coefficients reflect the importance of individual functions in assessing attractiveness. For some models, negative significance coefficients can be applied, which take into account factors that reduce the attractiveness of the neighborhood.

Using the integral attractiveness function mij allows you to take into account many interrelated functions and factors when assessing the attractiveness of a neighborhood. This makes it possible to get a more objective and comprehensive assessment of each object in the context of the entire neighborhood.

To achieve the accuracy and reliability of the neighborhood attractiveness assessment model, it is necessary to correctly select the significance coefficients for each mij function. This may require data analysis, research, and expert opinion to determine the relative importance of each factor and its impact on the attractiveness of the neighborhood.

In general, the use of the integral attractiveness function mij, which takes into account all paired mij functions and the corresponding significance coefficients, allows for a more complete and objective assessment of the attractiveness of each residential object in the neighborhood, taking into account both positive and negative factors affecting this assessment.

There are several methods of fuzzy inference, such as Mamdani, Tsukamoto, Sugeno, Larsen and others algorithms [19]. When choosing a specific algorithm for fuzzy inference, as well as when determining characteristic functions, there is some flexibility, which, however, has a limited impact on the results of calculations of the proposed model.

Choosing a fuzzy inference algorithm is an important step in building a model for assessing the attractiveness of a neighborhood. Each of these algorithms has its own characteristics and is used in different situations. For example, the Mamdani algorithm is widely used to model linguistic variables and inference rules. The Tsukamoto algorithm is well suited for solving problems with fuzzy input data and consistent application of rules. The Sugeno algorithm offers a more precise mathematical formulation of the output based on a linear combination of rules. The Larsen algorithm is used to model the relationship between input and output variables.

Despite the variety of algorithms, the choice of a specific fuzzy inference method does not significantly affect the results of the model. This is because the basic principles of fuzzy logic, such as fuzzy sets, inference rules, and aggregation, are applied in all of these algorithms. Thus, even when using different algorithms, similar results can be obtained if the characteristic functions and rules are set correctly.

It is important to note that the choice of fuzzy inference algorithm and the definition of characteristic functions require expert knowledge and experience. It is necessary to take into account the specifics of a specific task and the available information about the neighborhood. It may also be necessary to conduct experiments and analyze the results to choose the most appropriate approach. All these steps will help to create a reliable and accurate model for assessing the attractiveness of a neighborhood.

The developed correction coefficients for neural network algorithms used to assess the development of the territory are an effective solution that can be easily implemented within the framework of such algorithms. This opens up opportunities for creating an intelligent system capable of evaluating the effectiveness of a neighborhood project and optimizing its development already at the early stages of design. In addition, such a system can be integrated with existing information models of buildings and neighborhoods in general.

The use of correction coefficients in neural network algorithms provides significant advantages in assessing the effectiveness of the development of the territory. They allow you to take into account the features of specific objects that affect costs and profits, as well as take into account factors that affect the attractiveness of the neighborhood.

The creation of an intelligent system for evaluating the effectiveness of a neighborhood project at the early stages of design is an important step to ensure the sustainable and successful development of the territory. This system can take into account various aspects, such as economic efficiency, attractiveness for residents, potential profit for investors and the state, as well as compliance with building regulations and policies.

The integration of the evaluation system with information models of buildings and microdistricts allows us to take into account various aspects and relationships between objects. This provides a more accurate and comprehensive assessment that can be used to make informed decisions on the planning and development of the neighborhood.

Thus, the use of correction coefficients in neural network algorithms is a promising and innovative approach to assessing the effectiveness of the development of the territory. This makes it possible to create an intelligent system that can take into account many factors and ensure optimal use of resources at the early stages of neighborhood design.

3 Demonstration of the correction factor model

To assess attractiveness, the formula $x(r) = \exp(- r / r0)$ is used, where r0 is a parameter of the model and is equal to 1500 meters. This formula represents the relationship between the distance r and the attractiveness of the object. The closer the object is to the point under study, the higher its attractiveness, expressed as a numerical coefficient m.

The attractiveness of an object according to this model has a direct impact on the cost of its implementation. The increase in value is $(1 + x)$ times, where m is the attractiveness coefficient calculated by the formula m(r).

This evaluation model allows you to take into account the importance of the distance between objects and determine their relative attractiveness. The closer an object is to the point under study, the more it will be perceived as attractive, which affects its cost of implementation.

In addition to taking into account the distance, this model can be supplemented by other factors, such as the availability of additional facilities, infrastructure, natural resources, etc.

This will allow you to get a more comprehensive assessment of the attractiveness of the object and more accurately determine its cost of implementation.

As a result, using the formula x(r) = exp(– r / r0) and the coefficient (1 + x) to assess the attractiveness of objects allows us to take into account the importance of their location and form a more accurate estimate of the cost of their implementation. It can be a useful tool in planning and decision-making in various fields, such as urban planning, real estate, territorial development, etc.

As a result of the analysis carried out in Table 2, a clear relationship was found between the increase in the efficiency of a conditional microdistrict and the relative location of its objects. This table allows you to evaluate these indicators both in the form of integral values and in the context of the stages of the construction and investment project.

In this demonstration of the model, the neural network algorithm was not trained. However, in practice, the training of such an algorithm is performed using standard methods, including back propagation algorithms. These methods allow the algorithm to adjust its weight coefficients based on training data, which contributes to improving the accuracy and efficiency of the algorithm.

The training of a neural network algorithm includes the submission of training examples, error calculation and subsequent correction of weight coefficients in order to minimize the error. Back propagation algorithms are widely used in the field of machine learning and artificial neural networks to effectively train models and achieve optimal results.

The result of the calculation is the value of the difference between income and expenses, given for the different location of a social object relative to a residential building. The calculation results are presented in Table 2.

Table 2. Results of calculation of the demo model, million rubles.

Coordinates of object No. 1	Construction and investment stage (number/name)							Total
	1	2	3	4	5	6	7	
	Preparation of an invest. project	Designing	Approvals and access to the site	Construction	Initial operation	Exploitation	Liquidation	
(600; 600)	-24	-38	-43	62	538	19	-58	**455**
(300; 500)	-24	-38	-43	75	556	19	-58	**486**
(200; 200)	-24	-38	-43	109	606	21	-58	**573**

Thus, the inclusion of the neural network algorithm training stage allows you to create a more accurate and adapted model that takes into account the specific features and requirements of the neighborhood project. This ensures more reliable and realistic results, which in turn contributes to informed decision-making in the construction and investment process.

4 Conclusions

In conclusion, the analysis and study of the correction coefficients of neural network algorithms for assessing the development of residential neighborhoods led to the following conclusions:

1. Neural network algorithms are an effective tool for assessing the attractiveness and effectiveness of neighborhood projects. Their use makes it possible to take into account many factors interacting between various objects of the microdistrict and provide an objective assessment.

2. The introduction of correction coefficients allows us to take into account the influence of various factors on the attractiveness of the neighborhood. These coefficients can be determined based on statistical data, expert assessments or simulation results.

3. The formulation of an integral attractiveness function based on all paired functions between the objects of a microdistrict allows us to obtain a general characteristic of attractiveness for each residential object. This allows you to make informed decisions in the process of designing and optimizing the development of the neighborhood.

4. Training neural network algorithms is an important step to achieve more accurate and adapted models. Back propagation algorithms are widely used to adjust weight coefficients and minimize errors. This helps to increase the efficiency and reliability of estimates, as well as ensures integration with existing information models of buildings and the neighborhood as a whole.

5. Evaluation of the attractiveness of a neighborhood can be carried out using various fuzzy inference algorithms, such as Mamdani, Tsukamoto, Sugeno, Larsen, etc. The choice of a specific algorithm depends on the requirements and objectives of the study, as well as the available data.

In general, the use of correction coefficients of neural network algorithms to assess the development of residential neighborhoods is a promising area of research. This makes it possible to create intelligent systems capable of providing more accurate and objective assessments of the attractiveness of neighborhoods at the early stages of design. Such assessments can be useful for developers, investors and urban planners when making decisions to optimize development and create comfortable living conditions for residents of the neighborhood.

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