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DETERMINING OPTIMAL NEURAL NETWORK PARAMETERS FOR PREDICTING THE SUCCESS OF IT PROJECTS

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The growing importance of IT projects in the modern economy necessitates the application of advanced analytical tools for assessing their potential success. This study is devoted to determining the optimal parameters of neural network models for predicting the success of IT projects. The main objective is to improve the quality, reliability, and stability of classification results through the justified selection of neural network architecture and its hyperparameters.

The research is based on a dataset of Ukrainian IT projects, which ensures the relative stability of the economic environment and minimizes the impact of structural shifts. A set of key factors influencing project success was identified, including financial indicators, user activity metrics, and digital presence characteristics. The success of a project is represented as a binary variable, allowing the problem to be formalized as a binary classification task.

Multilayer perceptron models were used as the primary modeling tool, while radial basis function networks were also tested but demonstrated insufficient performance. A series of computational experiments was conducted to determine the optimal number of neurons in the hidden layer. The results indicate that although models with fewer neurons provide higher average accuracy, models with a larger number of neurons ensure greater stability. Considering both accuracy and variability measures, the optimal configuration was identified as a neural network with 12 hidden neurons.

Furthermore, the study investigates the potential of ensemble approaches, which combine several neural network models with different configurations. The findings confirm that ensemble structures improve both predictive accuracy and robustness of classification results.

The obtained results contribute to the development of methodological approaches for optimizing neural network parameters in IT project success prediction and can be applied in decision-making processes by investors, venture funds, and project managers.

Keywords: IT project, startup, digital economy, project management, optimization, modeling, neural network, performance indicators.

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STATEMENT OF THE PROBLEM IN GENERAL TERMS AND ITS CONNECTION WITH IMPORTANT SCIENTIFIC OR PRACTICAL TASKS

One of the key factors in improving the management efficiency of modern IT projects is the ability to reliably predict their success at early stages of the life cycle. Conditions of high uncertainty, the dynamism of the technological environment, and the significant variability of influencing factors necessitate the application of intelligent data analysis methods, particularly neural networks, which are capable of modeling complex nonlinear dependencies between project characteristics and their final outcome.

The use of neural network models in IT project success prediction tasks allows for increased accuracy of investment and management decisions; however, the effectiveness of such models significantly depends on the choice of their architectural and training parameters. These parameters include the number of hidden layers, the number of neurons in each layer, activation functions, learning rate, optimizer type, and other hyperparameters that determine the model's generalization ability and resistance to overfitting.

In practice, the selection of optimal neural network parameters is often performed empirically or based on partial heuristic approaches, which do not guarantee achieving maximum predictive accuracy and may lead to inefficient use of computational resources. This necessitates the development of a systematic approach to determining the optimal configuration of a neural network model oriented toward the specifics of IT project success evaluation tasks.

Thus, the current scientific problem is the absence of a unified and well-founded approach to determining optimal neural network parameters for IT project success prediction tasks that would ensure high modeling accuracy, result stability, and practical applicability in investment analysis and IT initiative management processes.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Contemporary research in the field of predicting the success of IT and startup projects demonstrates a significant increase in the use of machine learning and neural network methods for investment attractiveness assessment tasks. Since 2020, the primary focus of researchers has been on improving model accuracy through feature optimization, the use of ensemble methods, and deep neural networks.

A number of studies emphasize that classical machine learning algorithms, such as logistic regression, support vector machines, and decision trees, remain foundational approaches for binary classification tasks of startups; however, they are inferior in accuracy to ensemble models, particularly Random Forest and Gradient Boosting. These methods demonstrate better generalization ability due to their capacity to account for complex nonlinear dependencies between project characteristics and their outcomes [1].

A separate research direction in 2020–2024 is related to the application of neural network approaches and machine learning methods for predicting startup success. It has been established that models are capable of effectively accounting for multidimensional nonlinear dependencies between financial, behavioral, and media characteristics of companies; however, their quality significantly depends on architecture and hyperparameter tuning [2]. This is why the issue of neural network structure optimization is critically important for ensuring stable results.

Contemporary studies also actively investigate hybrid approaches that combine structured data (financial indicators, investment rounds) with unstructured data (description texts, social networks). Such fused models demonstrate improved prediction accuracy due to the expansion of the model's information base and the reduction of significant factor loss [3].

Particular attention is paid to the problem of limited sample sizes and instability of model training in startup prediction tasks. Recent studies show that with small or biased samples, classical neural network approaches may demonstrate unstable results, while modern methods, including few-shot learning approaches, allow for partial compensation of data deficiency [4].

An important direction in contemporary literature is also the use of ensemble structures of neural networks, which allow combining the advantages of different models and reducing the variance of results. It has been empirically proven that ensembling several neural network models increases the stability and accuracy of classification in tasks of predicting the financial success of startups [5].

Thus, the analysis of contemporary publications indicates that the most promising research directions are the optimization of neural network hyperparameters, the use of ensemble structures, the integration of heterogeneous data sources, and increasing model robustness to changes in data distribution (concept drift). It is precisely these approaches that form the modern scientific foundation for IT project success prediction tasks.

UNRESOLVED PARTS OF THE GENERAL PROBLEM TO WHICH THE ARTICLE IS DEVOTED

Despite significant advances in the application of machine learning and neural network models for predicting the success of IT projects and startups, a number of important theoretical and practical issues remain insufficiently resolved. These limitations primarily concern the selection of optimal neural network architectures, the stability of model performance, and the reproducibility of results under different data conditions.

One of the key unresolved problems is the absence of a unified and theoretically grounded approach to selecting optimal hyperparameters of neural networks for classification tasks in the context of IT project success prediction. In most existing studies, the configuration of multilayer perceptrons and related models is performed empirically or through heuristic search strategies, which do not guarantee global optimality and may lead to unstable performance across different datasets.

Another important issue is the sensitivity of neural network models to the structure and distribution of input data. In particular, changes in temporal coverage, feature distribution, and class imbalance significantly affect the stability of trained models. This phenomenon, often referred to as concept drift, is insufficiently addressed in existing approaches, especially in applied studies focused on startup ecosystems where external economic and technological conditions change rapidly.

Furthermore, there is still no generally accepted methodology for balancing two conflicting objectives in neural network design: predictive accuracy and model stability. Empirical evidence shows that architectures with higher complexity may achieve better performance on training data but demonstrate overfitting on test data, while simpler models may be more stable but less accurate. The lack of formalized criteria for selecting an optimal trade-off remains an open research problem.

Additionally, although ensemble approaches have been proposed as a means to improve classification performance, there is no systematic framework for selecting heterogeneous neural network configurations for inclusion in an ensemble. In particular, the problem of combining models with different numbers of hidden neurons, different convergence properties, and different variance characteristics has not been sufficiently studied in the context of IT project success prediction.

Finally, existing studies often lack a comprehensive methodology for interpreting model performance variability. While average accuracy is commonly reported, less attention is given to dispersion measures such as variance and coefficient of variation, which are crucial for assessing the robustness of predictive models in real-world decision-making scenarios.

Thus, the unresolved aspects of the general problem include the need for: formal optimization of neural network hyperparameters, increased robustness under distributional shifts, balanced trade-off between accuracy and stability, and systematic design of ensemble neural architectures for IT project success prediction. These issues define the research gap addressed in this article.

FORMULATION OF ARTICLE OBJECTIVES

The objective of the study is to develop and substantiate an approach to determining optimal neural network parameters for the task of predicting IT project success, which ensures improved classification accuracy and stability of the obtained modeling results.

PRESENTATION OF THE MAIN RESEARCH MATERIAL

Data on IT startups operating in Ukraine during the 2017–2021 period were used as statistical material. This choice was driven by the need to ensure relative homogeneity of the economic and investment environment in which IT startups operated. The specified period is characterized by the stability of the main venture financing mechanisms and the absence of critical external shocks of global scale that could significantly distort the patterns of startup ecosystem development.

An important prerequisite for selecting this particular interval is the desire to minimize the impact of structural shifts in the behavior of investors and technology companies, which are particularly pronounced during post-crisis and wartime periods. In particular, the period after 2021 is characterized by significant instability caused by global and regional factors, which may lead to the emergence of the concept drift effect and, accordingly, complicate the interpretation of modeling results.

Furthermore, the 2017–2021 interval provides a sufficient volume of observations for forming a representative sample that includes both successful and unsuccessful IT projects, and allows for correct class balancing during the construction of neural network models. This, in turn, increases the statistical reliability of the obtained results and ensures the stability of the model training process.

Thus, the selection of the 2017–2021 period is justified from the perspective of ensuring structural data homogeneity, sufficient feature variability, and correctness of comparative analysis of neural network models in the task of predicting IT startup success.

The sample encompasses a set of quantitative and qualitative project characteristics that potentially influence their success and investment attractiveness. Specifically, the feature system includes: the location of the headquarters, time to first financing, growth of activity on proprietary media channels according to the Alexa platform, the number of website visitors over the past 12 months, the volume of the first investment round, the presence of positive reviews on the Facebook and Twitter social networks, as well as the total number of investment rounds.

The target variable of the task is defined as binary and characterizes the success of an IT project: a value of 1 corresponds to cases of attracting financing, while 0 indicates its absence. Thus, the prediction task is formalized as a binary classification problem. Two types of neural network architectures were employed in the study: the multilayer perceptron and the radial basis function neural network.

The multilayer perceptron is one of the most widely used artificial neural network models. In this architecture, the neurons of the input layer serve the function of presenting the values of explanatory variables. Each neuron of the input layer is connected to all neurons of the first hidden layer. Subsequently, each successive hidden layer is fully connected to the previous one, and the output layer has connections with all neurons of the last hidden layer.

Due to the ability to vary the number of layers and the number of neurons in each of them, such a network is capable of approximating functions of virtually any complexity. Fig. 1 presents a schematic representation of the multilayer perceptron.

The following notation is introduced: x_i – value of the *i*-th input indicator, $w_{ij}^{[k]}$ – value of the weight coefficient connecting the *i*-th neuron of the (k –1)-th layer (or the *i*-th input variable) with the *j*-th neuron of the *k*-th layer, k – layer number, $b_j^{[k]}$ – bias parameter of the summator of the *j*-th neuron of the *k*-th layer, $u_j^{[k]}$ – summator calculation of the *j*-th neuron of the *k*-th layer (weighted sum of input signals), $\psi_j^{[k]}$ – activation function of the *j*-th neuron of the *k*-th layer, y_l – value of the *l*-th output indicator, $l = \overline{1, m_K}$.

The summator calculation for each neuron is performed using the formula:

$$u_j^{[k]} = b_j^{[k]} + \sum_{i=1}^{m} w_{ij}^{[k]} x_i, \quad j = \overline{1, m_k}, \quad k = \overline{1, K},$$

where m_k – number of neurons in the *k*-th layer, K – number of layers in the perceptron.

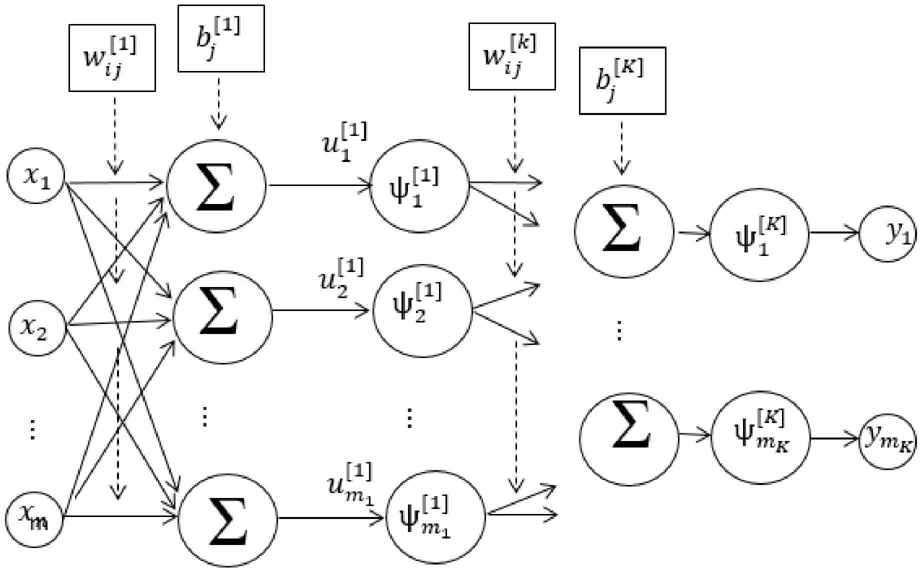

Fig. 1. Schematic representation of the multilayer perceptron

Source: developed by the authors

The high effectiveness of the multilayer perceptron in solving classification tasks is determined by its ability to reproduce more complex response surfaces compared to linear models. As the complexity of such a surface shape increases, the accuracy of object classification improves.

Despite the fact that signal aggregation in neurons (summator) is linear with respect to input variables, the subsequent application of a nonlinear activation function (in particular, sigmoidal) transforms this signal. As a result, nonlinear response surfaces with characteristic "sigmoidal" transitions are formed.

Another type of neural architecture used in the study is the radial basis function neural network. Its functioning is based on a distinct approach to output signal formation. This approach reproduces the behavior of a certain class of biological neurons characterized by signal propagation only within a limited spatial region.

Networks constructed on the basis of artificial neurons with pronounced local properties serve as an alternative to multilayer perceptrons and are known as radial basis function neural networks. In such models, neuron activation functions have a radial dependence relative to a given center and assume nonzero values only in the vicinity of this center.

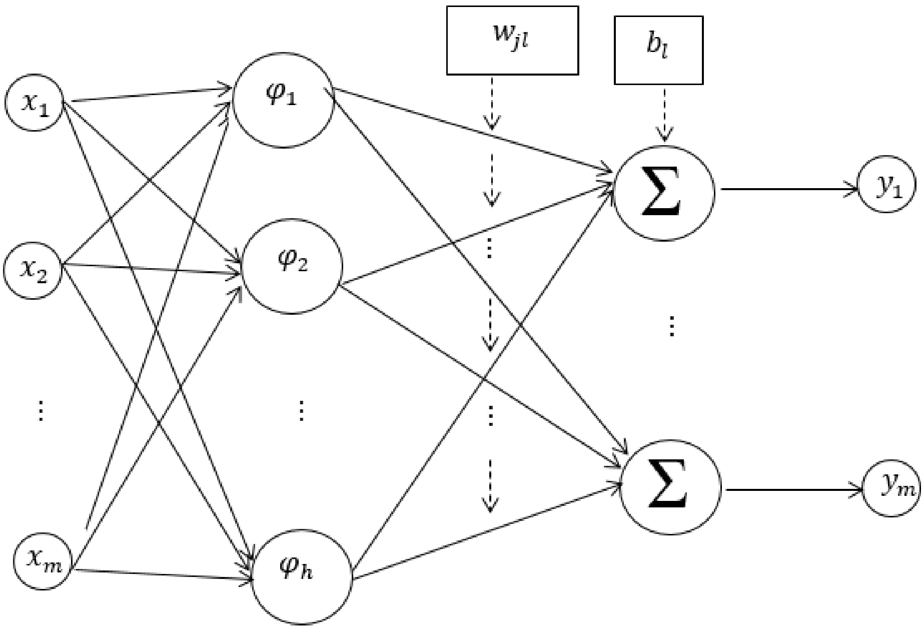

Fig. 2. Schematic representation of the radial basis function network structure
Source: developed by the authors

Notation in Fig. 2: x_i – value of the i-th input indicator, $i = \overline{1,m}$, φ_j – radial basis function, $j = \overline{1,h}$, h – number of hidden layer neurons, w_{jl} – value of the weight coefficient connecting the j-th neuron of the radial basis function layer and the l-th neuron of the output layer, b_l – parameter bias of the summator of the l-th neuron of the output layer, y_l – l-th output indicator, $l = \overline{1, m_F}$. The network output calculation is performed using the formula:

$$y_l = b_l + \sum_{j=1}^{h} w_{jl}\,\varphi_j, \quad l = \overline{1, m_F}.$$

The characteristics of such a network are determined by radial basis functions, which serve as key elements of hidden layer neurons:

$$\varphi_j = \Phi(\|x - c_j\|, \sigma_j).$$

The radial basis function is a multidimensional dependency whose value is determined by the distance $\|x - c_j\|$ between the input vector x and the center c_j, as well as the parameter σ_j, which is typically interpreted as the radius of influence. The most common variant is Gaussian functions, which reach their maximum at the center and gradually decrease with increasing distance from it.

Similar to how a response surface is formed in a multilayer perceptron, a radial basis function network approximates dependencies using a system of hyperspheres in the feature space.

Compared to the multilayer perceptron, radial basis function networks have a number of advantages. In particular, they do not require selecting the number of hidden layers, as they use only one such layer, and the output signal is formed as a linear combination of hidden neuron activations. This ensures relatively fast model training. At the same time, to reproduce complex functional dependencies, such networks typically require a larger number of neurons compared to the perceptron. Therefore, the choice of neural network type for classification tasks should be made based on experimental verification taking into account the available data.

Experimental studies showed that the quality of neural network training largely depends on the class balance in the sample. Since the initial data were characterized by a significant predominance of successful projects, a training sample balancing technique through artificial equalization was applied. As a result, a training sample containing 376 objects of each class was formed, as well as a test sample that included 95 objects for each class.

One of the key problems of neural network modeling is the need to select a significant number of hyperparameters that directly affect prediction quality. For the multilayer perceptron, such parameters include the number of hidden layers, the number of neurons in each layer, activation functions, and training process parameters. Within this study, an approach to determining optimal parameters is proposed, based on a series of experimental calculations with gradual variation of the studied hyperparameter values and recording of model quality indicators. The obtained results form an empirical relationship between the parameter value and model effectiveness, which allows assessing the robustness and stability of prediction.

Calculations were performed using the Statistica software package. Initial experiments showed that radial basis function neural networks demonstrated unstable results on the task data: classification accuracy on the training sample ranged from 33–77%, while on the test sample it was 35–60%. In contrast, the multilayer perceptron demonstrated significantly higher modeling quality: accuracy on the training sample was 90–100%, and on the test sample 68–99%.

The obtained results indicate the advisability of using the multilayer perceptron as the base architecture for further research and determination of optimal parameters of the neural network model for predicting IT project success.

It has been experimentally established that for the available dataset, the use of the multilayer perceptron as the base neural network architecture is appropriate. The selection of this model type is determined by its ability to effectively model complex nonlinear dependencies between IT project characteristics and their success.

A key stage in configuring the neural network model is determining the optimal number of neurons in the hidden layer, as this parameter significantly affects the model's generalization ability and prediction quality. Considering the stochastic nature of neural network weight initialization, training results may vary with each model run, which necessitates multiple experimental testing of different configurations.

In connection with this, series of computational experiments with varying numbers of neurons in the hidden layer were conducted. The Statistica software package was used for implementing the experiments, which provides the capability of automated launching of multiple models within a single session (up to 20 configurations simultaneously) with subsequent selection of the best results according to the chosen classification quality criteria.

Based on the results of the conducted experiments, it has been established that for the available dataset, perceptrons with the number of neurons in the hidden layer ranging from 4 to 13 are optimal. In this interval, the highest stability of modeling results and the optimal ratio between classification accuracy and the model's generalization ability are observed.

The decrease in modeling quality when increasing the number of neurons beyond 13 is explained by the overfitting effect. In this case, the model acquires excessive parametric complexity, which allows it not only to reproduce general patterns in the data but also to adapt to random noise components of the training sample. As a consequence, a decrease in the generalization ability of the neural network occurs, which manifests itself in deteriorating classification quality on test data while maintaining high performance on the training sample. Additionally, increasing the number of parameters with a limited data volume increases the variance of model estimates and makes the training process less stable.

Thus, exceeding the optimal level of model complexity leads to a disruption of the bias–variance trade-off, which is one of the key reasons for the deterioration of the neural network's predictive quality.

The results of the conducted experiments are summarized in Table 1.

Table 1

Perceptron classification results on test data depending on the number of hidden layer neurons

	Number of hidden layer neurons									
	4	5	6	7	8	9	10	11	12	13
Model performance on test data	96	98	97	95	92	90	95	94	96	93
	94	97	95	98	88	92	96	91	95	94
	95	96	96	97	90	89	94	92	97	92
	93	95	94	96	87	91	95	90	96	91
Mean value	94,50	96,50	95,50	96,50	89,25	90,50	95,00	91,75	96,00	92,50
Standard deviation	1,291	1,291	1,291	1,291	2,217	1,291	0,816	1,708	0,816	1,291
Coefficient of variation	0,014	0,013	0,014	0,013	0,025	0,014	0,009	0,019	0,009	0,014

Source: calculated by the authors

Based on the experimental results presented in Table 1, it was established that changing the number of neurons in the hidden layer affects both the level of classification accuracy and the stability of the obtained results.

Specifically, the highest mean accuracy values are observed for models with 5, 7, and 12 neurons, where the average performance level exceeds 96%. This indicates a high ability of the corresponding configurations to identify patterns in the input data and form correct classification decisions.

At the same time, the analysis of variability indicators allows for deeper conclusions regarding model reliability. The lowest values of standard deviation and coefficient of variation were recorded for models with 10 and 12 neurons (CV ≈ 0.009), indicating high result stability and low sensitivity to stochastic training factors. In contrast, models with 8 and 9 neurons demonstrate significantly lower mean accuracy levels (below 91%) and increased result variability. This may be related to insufficient or, conversely, inefficient model complexity for the given sample, leading to a loss of generalization ability.

Thus, the obtained results confirm the existence of a trade-off between accuracy and stability of neural network models. Although certain configurations (e.g., 7 neurons) demonstrate somewhat higher mean accuracy values, it is the models with 10 and 12 neurons that provide the most balanced combination of high classification quality and result stability.

Considering this, for practical use in IT project success prediction tasks, it is advisable to select the neural network configuration with 12 neurons in the hidden layer as optimal. This model ensures a sufficiently high level of accuracy with a minimal level of variation, which is critically important under conditions of uncertainty and data limitations.

The scientific literature [7] notes that one of the effective ways to improve the quality of classification models based on neural networks is the application of ensemble structures. The essence of this approach lies in selecting several models with the best performance indicators and subsequently aggregating their predictions using an appropriate generalization rule, which allows reducing the variance of results and improving model robustness.

Within the conducted study, it was established that different neural network configurations demonstrate unequal effectiveness in terms of absolute and relative classification quality indicators. At the same time, the best results by individual criteria are achieved by different models, indicating the absence of a clearly dominant configuration.

In view of this, a promising direction for improving the quality of IT project success prediction is the use of a neural network ensemble. It is advisable to include models with different numbers of neurons in the hidden layer in such an ensemble, specifically 5, 7, and 12 neurons. This is justified by the fact that the model with 5 neurons demonstrates better results in terms of absolute indicators in individual experiments, while the model with 7 neurons provides the highest mean performance values, and the model with 12 neurons is characterized by greater stability and better variation indicators.

Thus, combining the aforementioned models within an ensemble structure allows uniting their strengths and compensating for the individual shortcomings of each separate neural network, which potentially ensures improved overall IT project classification quality.

At the same time, it should be noted that such an approach can be extended to other parameters of neural network models, including activation functions, training parameters, and architectural characteristics, which allows forming more flexible and adaptive ensemble prediction systems.

CONCLUSIONS FROM THIS RESEARCH AND FURTHER PROSPECTS IN THIS DIRECTION

The conducted study confirms that the application of neural network models is an effective tool for predicting the success of IT projects and can serve as a reliable analytical basis for substantiating managerial decision-making. The obtained results demonstrate that the quality of classification depends not only on the selected model type but also significantly on the appropriate choice of its hyperparameters. In particular, it has been established that increasing the number of neurons enhances the model's flexibility but may lead to overfitting, whereas the optimal configuration—identified as a multilayer perceptron with 12 neurons in the hidden layer—ensures a balanced trade-off between predictive accuracy and model stability.

An important outcome of the study is the justification of the need to consider not only average performance indicators but also measures of variability when evaluating model effectiveness. This approach makes it possible to select models that provide more stable and reliable predictions, which is particularly important in IT project management, where decisions are often made under conditions of uncertainty and risk.

The results obtained can be applied in practice to support decision-making at various stages of IT project management, including project selection, investment assessment, and risk evaluation. The use of neural network models enables a more objective assessment of project potential, reduces the influence of subjective factors, and enhances the efficiency of resource allocation.

Furthermore, the study demonstrates the potential of ensemble approaches, which make it possible to combine the advantages of several models with different configurations. The use of such approaches contributes to improving both the accuracy and robustness of classification results, thereby strengthening the analytical support for managerial decisions.

Further research in this area should be focused on the development of systematic methods for neural network hyperparameter optimization, including automated search procedures and adaptive algorithms. Another promising direction is the integration of additional data sources, such as textual information and user behavior indicators, which can increase the informational value of predictive models. Moreover, particular attention should be given to studying model performance under changing data distributions and to developing approaches that ensure robustness to concept drift.

In conclusion, the proposed approach contributes to the development of data-driven decision support systems in IT project management and provides a foundation for improving the effectiveness, transparency, and adaptability of managerial decision-making in the digital economy.

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ОПТИМІЗАЦІЯ ПАРАМЕТРІВ НЕЙРОМЕРЕЖЕВИХ МОДЕЛЕЙ У ЗАДАЧАХ ПРОГНОЗУВАННЯ УСПІШНОСТІ ІТ-ПРОЄКТІВ

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Зростаюча роль ІТ-проєктів у сучасній економіці зумовлює необхідність застосування сучасних аналітичних інструментів для оцінювання їх потенційної успішності. Дане дослідження присвячене визначенню оптимальних параметрів нейромережевих моделей для прогнозування успішності ІТ-проєктів. Основною метою є підвищення якості, надійності та стабільності результатів класифікації шляхом обґрунтованого вибору архітектури нейронної мережі та її гіперпараметрів.

Дослідження базується на вибірці українських ІТ-проєктів, що забезпечує відносну стабільність економічного середовища та мінімізує вплив структурних зрушень. Було визначено сукупність ключових факторів, що впливають на успішність проєктів, зокрема фінансові показники, характеристики користувацької активності та параметри цифрової присутності. Успішність проєкту представлено у вигляді бінарної змінної, що дозволяє формалізувати задачу як задачу бінарної класифікації.

Основним інструментом моделювання обрано багатошаровий персептрон, тоді як радіально-базисні нейронні мережі також були протестовані, але продемонстрували недостатню ефективність для наявних даних. Проведено серію обчислювальних експериментів для визначення оптимальної кількості нейронів у прихованому шарі. Отримані результати показали, що, хоча моделі з меншою кількістю нейронів забезпечують вищу середню точність, моделі з більшою кількістю нейронів характеризуються вищою стабільністю. З урахуванням як показників точності, так і варіативності результатів, оптимальною визначено конфігурацію нейромережі з 12 нейронами у прихованому шарі.

Крім того, у дослідженні розглянуто можливості застосування ансамблевих підходів, які передбачають поєднання кількох нейромережевих моделей із різними конфігураціями. Отримані результати підтверджують, що ансамблеві структури дозволяють підвищити як точність, так і стійкість результатів класифікації.

Отримані результати сприяють розвитку методичних підходів до оптимізації параметрів нейронних мереж у задачах прогнозування успішності ІТ-проєктів і можуть бути використані у процесах прийняття рішень інвесторами, венчурними фондами та менеджерами проєктів.

Ключові слова: ІТ-проєкт, стартап, цифрова економіка, управління проєктами, оптимізація, моделювання, нейромережа, показники ефективності.