ДОДАТОК А

Опубліковані результати

Міністерство освіти і науки України
Харківський національний університет радіоелектроніки
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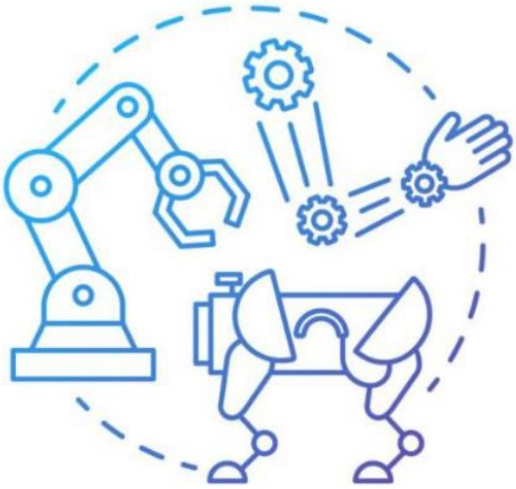
(КІТАР)



МАТЕРІАЛИ

ІІ Всеукраїнської конференції
«Комп'ютерно-інтегрованих технологій, автоматизації та робототехніки»
(Computer-integrated technologies, automation and robotics)
CITAR`25
16-17 травня 2025

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Харків 2025

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Комп'ютерно-інтегрованих технологій, автоматизації та робототехніки 2025: матеріали II-ої Всеукраїнської конференції, Харків, 16-17 травня 2025.: тези доповідей / [редкол. І.Ш. Невлюдов (відповідальний редактор)].-Харків: [електронний друк], 2025. – 132 с.

У збірник включені тези доповідей, які присвячені сучасним автоматизованим технологіям Industry 4.0 та їх впровадження; інформаційні управляючі системи технологічного призначення; математичні методи в системах автоматизації; розробка та програмування в робототехніці; штучний інтелект та машинне навчання в автоматизації; інтеграція технологій у виробництві та промисловості; сенсорні технології та взаємодія людини з роботами в Industry 5.0; ефективність використання роботизованих систем у виробництві; етика та правові аспекти в робототехніці; Інтернет речей та Інтегровані системи в комп'ютерно-інтегрованих технологіях, автоматизації та робототехніки; технологічні виклики та інновації у світі робототехніки.

Редакційна колегія: І.Ш. Невлюдов, В.В. Євсєєв.

Computer-integrated technologies, automation and robotics 2025: Proceedings of II st All-Ukrainian Conference, Kharkiv, May 16-17, 2025: Thesises of Reports / [Ed. I.Sh. Nevlyudov (chief editor).] .- Kharkiv .: [electronic version], 2025. - 132 p.

The collection includes abstracts devoted to modern automated technologies of Industry 4.0 and their implementation; information control systems for technological purposes; mathematical methods in automation systems; development and programming in robotics; artificial intelligence and machine learning in automation; integration of technologies in production and industry; sensor technologies and human interaction with robots in Industry 5.0; efficiency of using robotic systems in production; ethics and legal aspects in robotics; Internet of Things.

Editorial board: Igor.Sh. Nevludov, Vladyslav.V. Yevsieiev

OVERVIEW OF ALGORITHMIC APPROACHES TO FORECASTING IN CRM SYSTEMS

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Annotation: The paper considers mathematical methods that are used in algorithmic approaches to forecasting in CRM systems. Their effectiveness in personalizing marketing strategies, reducing the risks of customer churn and optimizing sales is described. Their advantages, disadvantages and areas of application in CRM systems are determined. The possibilities of using these algorithms to increase the efficiency of interaction with customers and automate business processes in companies are investigated.

Key words: CRM systems, forecasting, mathematical methods, clustering, decision trees.

ОГЛЯД АЛГОРИТМІЧНИХ ПІДХОДІВ ДО ПРОГНОЗУВАННЯ В CRM-СИСТЕМАХ

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Анотація: У роботі розглянуто математичні методи, які застосовуються в алгоритмічних підходах до прогнозування в CRM-системах. Описано їхню ефективність у персоналізації маркетингових стратегій, зниженні ризиків відтоку клієнтів та оптимізації продажів. Визначено їхні переваги, недоліки та сфери застосування в CRM-системах. Досліджено можливості використання цих алгоритмів для підвищення ефективності взаємодії з клієнтами та автоматизації бізнес-процесів у компаніях.

Ключові слова: CRM-системи, прогнозування, математичні методи, кластеризація, дерева рішень.

RELEVANCE OF THE WORK. In today's business environment, process automation is becoming a key factor in increasing the efficiency of companies. CRM systems (Customer Relationship Management) occupy an important place among customer relationship management tools, allowing businesses to analyze large amounts of data, predict customer behavior, and optimize sales and marketing processes. One of the most significant areas of CRM development is the use of mathematical methods to predict future trends, which helps companies make informed decisions.

Forecasting in CRM systems is based on algorithmic approaches that allow you to identify possible customer behavior scenarios, predict sales, analyze the risks of customer churn, and find optimal interaction strategies. For this purpose, various mathematical models are used, including regression analysis, clustering methods, and decision trees. Each of these approaches has its own characteristics and scope, depending on the tasks to be solved.

Process automation greatly simplifies the use of mathematical models, accelerating data analysis and increasing the accuracy of forecasts [1-6].

The use of information systems also plays a key role in the implementation of mathematical models, providing rapid data analysis, improved forecast accuracy, and more efficient decision-making [7-11].

In order to understand which method is used for which purposes, it is necessary to clearly understand how they work.

MATERIALS AND RESEARCH RESULTS. First, let's look at regression analysis. This is a statistical method used to identify relationships between variables and predict future values based on available data. In CRM systems, this approach helps to analyze customer behavior, assess the likelihood of making a purchase or customer churn. This method also helps to identify key factors that affect the success of customer interaction.

The method works by building a mathematical model that reflects the relationship between independent variables, such as advertising spend, number of customer interactions, age of the customer, and a dependent variable, such as purchase probability or expected customer revenue. The most common and simplest option is linear regression, which looks for a direct relationship between factors.

Regression analysis can be used in CRM systems to predict customer churn. By analyzing historical data, such as purchase frequency, average check amount, and level of interaction with marketing campaigns, the model can identify customers who are at high risk of abandoning the company's services. This allows you to apply personalized retention strategies in advance, such as offering discounts or bonuses.

The main advantages of this method are its clarity, which makes it easy to understand the influence of each factor, and its efficiency when dealing with linear dependencies. At the same time, regression analysis has its limitations: it does not work well in the case of complex nonlinear relationships, is sensitive to the presence of irrelevant variables, and can produce inaccurate results if the input data contains a significant level of error. Nevertheless, regression analysis remains one of the most popular mathematical forecasting methods. It is widely used in CRM systems to optimize business processes and increase the efficiency of customer interaction.

Next, let's look at the clustering method. This is a machine learning method used to automatically group objects in a data set based on their similarity. In CRM systems, this approach allows you to segment your customer base by identifying groups of customers with similar behaviors, preferences, or characteristics. This helps companies to apply personalized marketing strategies, optimize customer interactions, and improve sales performance.

The clustering method works by analyzing a large amount of data and grouping similar objects (clusters). The k-means clustering algorithm is one of the most popular due to its simplicity and speed. Its essence lies in the fact that you first set the number of groups (k) into which you want to divide the data. Then the algorithm randomly selects k points that become the centers of these groups. Next, each customer or other object is assigned to the group whose center is closest to it according to certain characteristics, such as the frequency of purchases or the average amount of spending. After that, the centers of the groups are updated. Their new average value is calculated, and the process is repeated until the distribution becomes stable. As a result, customers with similar behavioral characteristics end up in the same group, which helps companies better customize their advertising strategies.

For example, in a CRM system, clustering can be used to segment customers based on their purchasing activity. By dividing into groups of regular customers, new customers, customers with a high average check, and passive users, the company can develop targeted marketing strategies for each of these groups separately. Regular customers can be offered loyalty programs, and passive customers can be offered personalized discounts to encourage them to make repeat purchases.

The main advantages of clustering are the ability to automatically detect patterns in large data sets, flexibility in applying to different tasks, and increased efficiency of marketing strategies.

The disadvantages of this method are that it can be sensitive to the choice of the number of clusters, and it requires preliminary data normalization for correct operation. Nevertheless, clustering remains one of the most powerful tools in CRM systems, allowing businesses to better understand their customers and improve the quality of service.

Also, one of the most popular forecasting methods is decision trees. Decision trees are an algorithmic method used for classification and forecasting based on the gradual separation of data according to certain conditions. In CRM systems, this approach helps to make automated decisions about customer interaction, analyze the likelihood of customer churn, predict user behavior, and personalize marketing strategies.

The method works on the principle of building a hierarchical structure consisting of nodes and branches. Each node represents a certain parameter, such as the frequency of purchases, average check, or level of interaction, and the branches represent possible variants of the node's values. The algorithm gradually divides the data into subgroups, creating a logical chain of conditions leading to the final decision.

For example, in CRM systems, decision trees can be used to analyze customer churn. The model can identify key factors that influence the likelihood of losing a customer, such as a decrease in the frequency of purchases or a negative experience with support. If a customer falls into a high-risk group, the system can automatically offer him or her a special discount or a personalized offer to retain him or her.

The main advantages of decision trees are their clarity, visualization of decision-making logic, and ability to work with heterogeneous data. They do not require complex data preparation and can be effectively used in business intelligence. However, the method also has its drawbacks: it can create overly complex trees, which leads to model overtraining, and is also sensitive to changes in the source data. Nevertheless, decision trees are widely used in CRM systems to automate decision-making processes and improve the effectiveness of business strategy.

We should also mention the random forest method. This method is based on the concept of decision trees, but eliminates their disadvantages by combining many trees. In this approach, a large number of decision trees are created, each of which is trained on a random sample of data and uses only a portion of the available features. When predicting, for example, future sales, each tree produces a different result. The final decision is formed by averaging.

Another of the most common methods is Bayesian methods. These are approaches to probabilistic data analysis that allow updating probability estimates based on new data. In CRM systems, these methods are used to predict customer behavior, assess the risk of customer churn, personalize marketing campaigns, and automate decision-making.

Let's look at how Bayesian methods work. First, there is an initial assumption about the probability of an event, but over time, as new information becomes available, this probability is updated, allowing for more accurate forecasts. In other words, the method gradually refines the estimate based on new data. For example, if a customer used to actively respond to email newsletters and now starts ignoring them, the probability of losing them as a regular customer increases.

A practical example of the use of Bayesian methods in CRM systems is determining the probability of a customer's response to an advertising campaign. If historical data shows that a certain segment of customers responds more often to discounts on weekends, then when a new promotion is introduced, the system can predict the likelihood of success and optimize the time of its launch. These methods can also be used in chatbots to assess the most likely customer requests and provide appropriate responses.

The main advantages of Bayesian methods are the ability to work efficiently with small data sets, adaptation of forecasts in real time, and the ability to take into account additional information. At the same time, the disadvantages are high sensitivity to the quality of the initial data and significant computational costs when working with large amounts of information. Nevertheless, Bayesian methods remain a powerful tool for CRM systems, allowing to increase forecasting accuracy and improve customer interaction.

CONCLUSIONS. To summarize, forecasting in CRM systems, based on mathematical methods such as regression analysis, clustering, decision trees, random forests, and Bayesian approaches, provides companies with powerful tools for making informed decisions. These methods help personalize marketing strategies, minimize the risk of customer churn, and optimize sales processes. Thanks to the use of these methods in CRM systems, companies significantly increase the automation of business processes and the efficiency of customer relationship management. Such systems allow not only to analyze large amounts of data but also to predict future trends.

This approach is revolutionary because it allows businesses not only to react to changes but also to anticipate them, which gives them a competitive advantage. Deep analytics and algorithmic forecasting contribute to a more accurate understanding of customer needs, reduce advertising costs, and increase customer loyalty. In today's digital transformation environment, such CRM systems are becoming not just a useful, but an indispensable tool for sustainable business development.

Further research in the field of algorithmic approaches to forecasting in CRM systems will allow developing more accurate models for predicting customer behavior, improving existing methods, and creating new integrated solutions. A particularly promising area is the combination of several methods into hybrid models, which can compensate for the shortcomings of individual approaches.

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ДОДАТОК Б

Демонстраційний матеріал

№ документа	Позначення	Найменування	Додаткові відомості
		Текстові документи	
1	ГЮИК. 143500.025 ПЗ	Пояснювальна записка	А4, 110 с.
		Додаткові матеріали	
2		Опубліковані результати	А4, 8 с.
3			
4		Демонстраційний матеріал	А4, 15 с.

					ГЮИК. 143500.025 ВД			
Змін.	Арк.	Номер докум.	Підпис	Дата				
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Перевір.		Сотник С.В.				Н	1	1
						Кафедра КІТАР ХНУРЕ		
Н.контр.		Стародубцев М.Г.						
Затв.		Невлюдов І.Ш.						