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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

DEVELOPMENT OF METHODS AND ALGORITHMS TO INCREASE THE EFFICIENCY OF ADVERTISING AND MARKETING ACTIVITIES IN THE INTERNET ENVIRONMENT

Specialty: 1203.01- Computer sciences

Field of science: Technical sciences

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GENERAL CHARACTERISTICS OF THE WORK

Relevance and level of development of the theme. With the development of Information and Communication Technologies (ICT) and the emergence of new virtual projects, the number of Internet users continues to grow every year. The fact that the Internet is open to everyone has made it a means of social communication for billions of users. Many companies actively use the Internet to promote themselves, attract more customers and enter the international market.

According to the Law of the Republic of Azerbaijan "On Amendments to the Law[1] of the Republic of Azerbaijan "On Advertising"" (07.12.2016), aimed at improving the welfare of citizens, developing the market economy, expanding small and medium business, "advertising is information published to attract the attention of the advertising consumer to the advertising object in any form using various means and methods, creating and maintaining his interest, promoting the product on the market and stimulating its sales".

The introduction of modern advertising and marketing technologies on the Internet has boosted the rapid development of the economy. Internet advertising is a way of attracting consumers in various ways, providing generalised information about various types of services in order to arouse their interest in the offered product and enthusiasm for e-commerce.

Today, financial transactions and commerce around the world are conducted over the Internet. Banks, insurance companies, government agencies and commercial organisations conduct financial transactions over the Internet. Internet advertising on popular websites is the most effective way to attract potential customers. For this reason, the study of digital advertising and marketing activities, the proposal of new

[1] Law of the Republic of Azerbaijan on Advertising, – Baku: –15 May 2015, No. 1281-IVQ // URL: https://e-qanun.az/framework/30348

approaches, conceptual views, the development of methods and algorithms to improve their effectiveness are of great importance.

Advertising information can be placed on the Internet using multimedia resources. This information is intended to provide goods and services to the customer by a company or intermediary in the global network. Advertising is a means of communication between the producer and the consumer, but it also represents the producer, promotes the product and informs the consumer. For example, ordering various goods over the Internet, making purchases using online payments, etc. are becoming part of people's everyday lives. The increase in the number of sites on the Internet and the habituation of users of social networks to making purchases in a virtual environment determine the need to increase the effectiveness of advertising and marketing activities.

As the Internet's capabilities surpass those of radio, television and traditional media, advertising campaigns are increasingly turning to the Internet. The capabilities of the Internet create the conditions for increasing the effectiveness of advertising and marketing, independent decision-making using project programmes and intelligent systems. The development of the information society has had a positive impact on digital advertising and marketing and has led to the placement of various advertisements on websites. For this reason, the Internet has brought to the fore such issues as the correct organisation of advertising, taking into account the interests of customers, ensuring the uniqueness and quality design of advertisements.

Artificial intelligence is the best tool for effective advertising and marketing, increasing the awareness of the advertised product in society and, ultimately, increasing sales. The growth of company revenues, the satisfaction of citizens and, ultimately, the development of the country's economy depend primarily on advertising and marketing that use the opportunities of the Fourth Industrial Revolution.

Taking into account the above, the thesis is devoted to the development of methods and algorithms for increasing the

effectiveness of advertising technologies in the Internet environment and achieving consumer satisfaction.

Subject and object of the study. The subject of the study is the organisation of advertising and marketing activities in the Internet space, and the subject of the study is the development of methods and algorithms for increasing the effectiveness of advertising and marketing activities in the Internet environment.

Aims and objectives of the study. The purpose of the dissertation is to develop methods and algorithms for increasing the effectiveness of advertising and marketing activities in the Internet environment and achieving consumer satisfaction.

In order to achieve the goal set in the dissertation, the following questions were considered:

–Development of a conceptual model based on CRM (Customer Relationship Management) for organising online advertising and marketing;

–Development of an algorithm for evaluating websites based on customer reviews to effectively solve advertising and marketing problems in the Internet environment;

–Development of a method for reducing the number of indicators to improve the effectiveness of advertising and marketing on the Internet;

–Development of a model for dynamically changing the effectiveness of an advertising campaign on the Internet;

–Development of a method for a recommendation system to predict customer interests in an e-commerce environment.

Research Methods. Methods of statistical analysis, machine learning, artificial intelligence, multi-criteria decision making and SEO (Search Engine Optimisation) were used to solve the tasks set in the thesis.

The main provisions presented for defence:

- Conceptual model based on CRM for organising online advertising and marketing;

- Algorithm for evaluating websites based on customer reviews for effective solution of advertising and marketing tasks in the online environment;

- Method for reducing the number of indicators for increasing the effectiveness of advertising and marketing on the Internet;

- Model for dynamically changing the effectiveness of an online advertising campaign;

- Method of a recommender system for predicting customer interests in an e-commerce environment.

Scientific novelty of the research. The following new results were obtained in the thesis:

- A conceptual model based on CRM for organising online advertising and marketing was developed;

- An algorithm for evaluating a website using the WMA (Weighted Moving Average) method based on customer reviews was developed to effectively address advertising and marketing issues in the online environment;

- A method for reducing the number of indicators based on the Euclidean distance method and the K-Nearest method was developed to improve the effectiveness of advertising and marketing on the Internet;

- A model for dynamically changing the effectiveness of an online advertising campaign has been developed;

- A hybrid method based on the Pearson correlation coefficient and the cosine measure of proximity has been developed for a recommender system that can predict customer interests in an e-commerce environment.

Theoretical importance of the study. The study contributes to the development of the theoretical foundations of Internet marketing, allows a deeper understanding of the processes of consumer interaction with Internet advertising and the mechanisms of consumer behaviour formation in the digital environment. The study is important for the development of new models for predicting the effectiveness of advertising campaigns and for a more accurate assessment of the results of marketing activities. The study focuses on

personalised advertising, targeting based on artificial intelligence and much more. This may lead to the emergence of new concepts and approaches in the field of internet marketing.

Practical importance of the study. The methods and algorithms proposed in the dissertation will allow companies to use their advertising budgets more effectively and achieve their marketing goals. Advertising based on personal data and customer reviews allows to offer more relevant products and services to customers and to increase their loyalty. Methods and algorithms developed to improve the effectiveness of advertising and marketing activities in the Internet environment play an important role in marketing decisions.Testing of the work and implementation of the results.

The main results of the thesis were presented at the following national and international conferences:

III Международная научно-практическая конференция (2011, Новосибирск); "Riyaziyyatın tətbiqi məsələləri və yeni informasiya texnologiyaları" adlı II Respublika elmi konfransı (2012, Sumqayıt, Azərbaycan); International Conference on European Science and Technology (2013, Germany); Elektron dövlət quruculuğu problemləri I Respublika elmi–praktiki konfrans (2014, Bakı, Azərbaycan); 2nd International Conference on Emerging Trends in Scientific Research 2014, Malaziya); İnformasiya və Kommunikasiya Texnologiyalarının müasir vəziyyəti və inkişafı perspektivləri, AzTU, Beynəlxalq elmi-texniki konfrans, (2014, Bakı, Azərbaycan); Beynəlxalq Telekommunikasiya İttifaqının 150 illiyinə həsr olunmuş İnformasiya təhlükəsizliyinin multidissiplinar problemləri üzrə II respublika elmi–praktiki konfrans (2015, Bakı, Azərbaycan); Big data: imkanları, multidissiplinar problemləri və perspektivləri I respublika elmi – praktiki konfransı (2012, Bakı, Azərbaycan); "Riyaziyyatın tətbiqi məsələləri və yeni informasiya texnologiyaları" adlı III Respublika elmi konfransı (2016, Sumqayıt, Azərbaycan); Proqram mühəndisliyinin aktual elmi–praktiki problemləri (2017, Bakı, Azərbaycan); İnformasiya təhlükəsizliyinin aktual multidissiplinar elmi–praktiki problemləri IV respublika konfrans (2018, Bakı, Azərbaycan); "İnformasiya təhlükəsizliyinin aktual

multidissiplinar elmi–praktiki problemləri" adlı V respublika konfrans (2019, Bakı, Azərbaycan); Cybersecurity for Critical Infrastructure Protection via Reflection of Industrial Control Systems Science for Peace and Security Series (2022, NATO, Amsterdam).

Published scientific works: 25 scientific works have been published on the topic of the dissertation, including 12 articles [1-12], 13 conference proceedings [13-25]. 1 article is included in the international database WoS (Scopus), 1 articles and 1 conference material are included in the database РИНЦ.

Name of the organisation where the thesis was completed: Completed at the Institute of Information Technologies of the Ministry of Science and Education of the Republic of Azerbaijan.

Structure and scope of the work:

The dissertation consists of an introduction, 4 chapters, the main results of the work, a list of 157 sources, appendices. The total volume of the thesis is 165 pages, of which the main part is 165 pages (178709 characters), including 8 tables and 14 figures. There are 420 characters on the title page, 1110 characters on the table of contents, 15045 characters on the introduction, 68561 characters on the first chapter, 41199 characters on the second chapter, 51629 characters on the third chapter, Chapter four - 11049 and 1352 characters on the conclusion.

CONTENTS OF THE WORK

The introduction justifies the relevance of the dissertation, defines the purpose of the study and identifies the issues to be addressed. The scientific novelty and practical significance of the results obtained are demonstrated.

The first chapter is devoted to "Analysis of the current state of scientific and practical problems of advertising and marketing technologies in the Internet environment". This chapter examines the history of advertising and marketing, the period of its development, the influence of the Internet on advertising and marketing, its new stage and the areas of application of modern technologies. The experience of the USA, Russia, Japan and China is also mentioned, as well as the results of research on Internet advertising in Azerbaijan. The stages of development of advertising and marketing on the Internet are studied, classified and problems in this area are identified [1, 25]. An analysis of Internet advertising technologies is carried out, and scientific and theoretical problems of the role of digital marketing in business development are studied [2, 3, 5]**.**

The second chapter is devoted to "Development of an algorithm for increasing the efficiency of advertising and marketing activities based on customer feedback in the Internet environment". This chapter analyses the issues of organising Internet advertising based on the CRM (Customer Relationship Management) system and develops a conceptual model for organising digital advertising (Figure 1) [18]. The second part of the second chapter presents an algorithm for evaluating websites based on customer feedback to effectively solve advertising and marketing problems in the Internet environment [9, 14]. In the theory of digital marketing, there are four main concepts of the company's market orientation.[2] These include the concepts of production, product, sales and marketing. CRM is a specialised

[2] Barry, C. In Search of Search Engine Marketing Strategy Amongst SME's in Ireland / C.Barry, D.Charleton // Communications in Computer and Information Science, –2009, 48, –pp.113–124

system designed to automate business processes, procedures and operations**.**

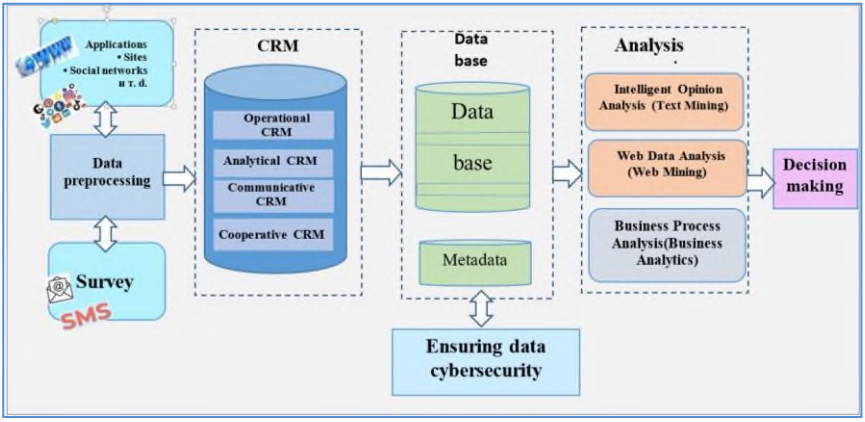

Figure 1. Conceptual model of advertising and marketing activities based on a CRM system

The working principle of the conceptual model consists of the following stages:

1. User data is collected and structured through various websites and social networks;
2. Data is cleaned, aggregated and pre-processed;
3. A database (data warehouse) is organised;
4. The analytical system is integrated with CRM technologies;
5. Intelligent analysis and evaluation is performed using web mining, text analysis, business process analysis and big data technologies;
6. Ensuring data cybersecurity is one of the key stages of advertising and marketing activities. The main problems are competition, theft of personal data, information attacks (DoS attacks, etc.).
7. The result is transferred to the output and used for its intended purpose based on the decision made.

As you can see in Figure 1, the conceptual model is built around CRM.

- Operational CRM is used to automate and manage data to support virtually every aspect of the customer interaction strategy.
- Analytical CRM is a subsystem of CRM in which a company collects interaction data to improve customer satisfaction and retention. Analytical CRM includes loss analysis, cost calculation, etc.
- Communicative CRM, in contrast to analytical CRM, is the management of all communication channels between the customer and the company.
- Corporate CRM simplifies communication and task management and ensures that the process is carried out on a compatible platform.

In the second part of the second chapter, an algorithm for evaluating websites based on customer feedback was developed to effectively solve online advertising and marketing problems.

In online commerce, websites need to ensure that the most relevant search queries used by potential customers to find the products or services on offer[3] are selected.

In order to quickly obtain the desired product, the user must have basic information about the site he is visiting. The value that customers place on websites can be described as a price vector. Let's say that CPV (Customer Price Vector) is the cost of each request to a promotional site:

$$CPV = (p_1, p_2, .., p_n) \quad (1)$$

where are the components of the price vector obtained from different sources. From the prices given by m different customers, a matrix of customer prices is formed, i.e. CPM (Customer Price Matrix) - a matrix for customer relationship management:

[3] Soloshenko, M. Methodology for assessing the economic value of an Internet site as a means of communication // Marketing and marketing research in Russia – 2000. No. 6. – p. 57–59.

$$CPM = \begin{pmatrix} p_{11}, p_{12}, \ldots, p_{1n} \\ \ldots \\ p_{m1}, p_{m2}, \ldots, p_{mn} \end{pmatrix} \quad (2)$$

In this matrix, each row corresponds to a customer and the number of rows corresponds to the number of customers visiting the site for different purposes. The number of columns corresponds to the number of price sources for customers.

In order to evaluate websites, it is necessary to give customers the opportunity to leave comments on the site and to encourage them to do so.

Comments posted by customers on the site, messages sent by SMS or text replies to enquiries are small in volume. The volume of traffic on the site per unit of time is calculated as follows

$$V = \sum_{i=1}^{M} f_m \cdot \upsilon_m \quad (3)$$

Where, f_m –m–is the estimated frequency of access of the m-th client, v_m – i is the average volume of traffic generated with each access to the site of the i-th client.

The price obtained as a result of the calculation cannot be obtained separately from the frequency of requests of each client and user. This price can be formed on the basis of the frequency of requests of active users, collectively, periodically and simultaneously for all clients.

Each time a client visits the site, the frequency of this client's visits must be calculated. The frequency of use is calculated as follows

$$\Delta t_m = T_m - T_{m-1}$$

where, T_m is the time of the last current access, T_{m-1} is the access time before the last one. Thus, the calculated frequency of filing an application for the m-th time of filing an application for the j-th client is determined as follows:

$$f_{mj} = \frac{1}{\Delta t_{mj}} \quad (4)$$

If the evaluation is based on customer requests to the site, the last current price cannot be accepted as the final price. Dynamic changes in the frequency of use should be taken into account. This method of solving the valuation excludes the occurrence of random values. To solve the problem, we use autoregressive methods and, in special cases, variables (floating), we use the application of various options for the average price: $m \in [1, M]$

When this condition is met, the frequencies of use f_m, which will form the price for the consumer, can be determined by the exponential law:

$$f_m^j = \alpha f_{m,j} + (1-\alpha) f_{m,(j-1)} \cdots$$

Here, $0 < \alpha < 1$ by assigning different values of α in the range α, we can find the $f_m = f_m^j$ that gives the smallest mean square difference. Let's assume that eventually the client access frequencies (f_m) for an arbitrary state $m \in [1, M]$ were somehow found. Since these values are positive, then, by performing simple transformations on them, we can form client values that fall in the range $[-10,+10]$ from the reference frequencies:

$$m\_q_m = \frac{f_m}{\max\{f_m\}} 20 - 10 \qquad (5)$$

The customer value found by formula (4) is one of $P_{m,n}$. Summarizing the above, we can write the total value given by customers to websites.

If we assume the weight vectors of customers and sources as follows:

$$W = (\omega_1, \omega_2, \ldots, \omega_N)$$

$$F = (\varphi_1, \varphi_2, \ldots, \varphi_M)$$

The price of the web page will be (siteprice-SP):

$$SP = \sum_{j=1}^{M} \omega_j \sum_{i=1}^{N} \varphi_i p_{ij} \qquad (6)$$

ω_j – weight of customers who rated the page, φ_i – shows the weight of the various sources listed above. $P_{i,j}$ The values are obtained using formula (5) and normalized to the range of $[-10,+10]$. The proposed algorithms and methods can be successfully used by websites engaged in digital advertising and wishing to evaluate customer activity. Assessing customer attitudes towards websites can play a positive role in improving business efficiency, leading to increased customer and consumer satisfaction.

The third chapter is dedicated to "Developing methods and algorithms for intelligent analysis to improve the efficiency of advertising and marketing activities in the Internet environment". This chapter analyses and defines key performance indicators (KPIs) for assessing the effectiveness of Internet advertising [7, 12]. The first section of the third chapter develops a methodology for reducing the number of indicators (summarising indicators) to improve the efficiency of advertising and marketing on the Internet. The analysis is carried out in the following stages:Evaluation of the effectiveness of online advertising activities;

– Reduce the number of performance indicators;
– Determine the proximity of performance indicators.

Assessing the effectiveness of advertising campaigns:

The effectiveness of advertising campaigns is measured by the amount of revenue they generate [24].

The number of performance indicators in advertising and marketing analysis is quite large, which complicates the analysis and increases the load on the algorithm. To simplify the task, it is important to reduce the number of indicators and choose the optimal solution.

Algorithm 1: It is necessary to align the number of values obtained for each indicator. To do this, assume that the number of elements of the CU_i indicator is N_i and that these indicators are collected at intervals of Δ_{it} during the following period:

$$T_i = (N_i - 1)\Delta_{it} \quad (7)$$

Let us denote the maximum value of the collection periods of the indicators involved in the analysis by *T*, and the maximum value of their number by *N*:

$$T = \max_i \{T_i\} \text{ and } N = \max_i \{N_i\}$$

The collected indicators can be written as indicators C_i, the number of which is equal to *N*. The interval between index elements written in this way is $h = \frac{T}{N-1}$.

$$C_i[m] = \begin{cases} CU_i[1]; & m = 1; \\ CU_I[j] + \frac{CU_i[j+1] - CU_I[j]}{h \cdot m - j \cdot \Delta_{it}} \cdot \Delta_{it}; & 1 < m < N; \end{cases} \quad (8)$$

where $C_i[m]$ is the number of collected performance indicators, $j - hm \in [j\Delta_{it}; (j+1)\Delta_{it}]$ is determined by the condition.

As a result, the number of indicators is *N*, and the elements are distributed uniformly over time *T*. It should be noted that the number and duration of indicators can be reduced using formulas (7) and (8). $T < \min\{T_i\}$ and $N < \min\{N_i\}$ Under certain conditions, the number of indicator elements and the distribution period will decrease.

Algorithm 2: To calculate the values of the indicators in the interval $[-1;1]$, the absolute maximum value of the values of the elements involved in the analysis is found, and each of the $C_i[m]$ values is divided by this maximum value:

$$C_{\max} = \max_{i=1} \{U^i C_i\} \quad (9)$$

$$C_i[m] = \frac{C_i[m]}{C_{\max}} \quad (10)$$

The number of elements of the performance indicators involved in the analysis is aligned, and their values are calculated in $[-1;1]$ intervals. We define the elements of the feature vector to determine

the proximity distances between the performance indicators. Calculate the average price:

$$V_i[1] = \bar{C}_i = \frac{\sum_{n-1}^{N} C_i[m]}{N} \quad (11)$$

Calculating the root mean square difference:

$$V_i[2] = \sigma = \sqrt{\frac{\sum_{m-1}^{N} (C_i[m] - \bar{C}_1)^2}{N}} \quad (12)$$

If *C(i)*s are the values of the spectral separation components:

$$S = \sum_{i=1}^{N} C(i) \quad (13)$$

The number of spectral separation components can be quite large. Such a vector can be created for each performance indicator. The Euclidean distance between two vectors can be taken as a measure of the closeness between two corresponding performance indicators. Let us denote the Euclidean distance between two performance indicators *i* and *j* by d_{ij} :

$$d_{ij} = \sqrt{\frac{\sum_{k=1}^{N} (V_i[k] - V_j[k])^2}{N}} \quad (14)$$

d_{ij} – one of the two performance indicators that gives the lowest value may be excluded from the analysis process for a certain period of time.

In the second part of the third chapter, a model of dynamic change in the effectiveness of an Internet advertising campaign is developed. In order to assess the effectiveness of advertising activities and analyse the dynamics of change in the parameters characterising it, it is necessary, first of all, to achieve accuracy and consistency in the calculation of the parameters [4, 21].

Construction of a matrix of parameter values characterising the effectiveness of advertising activities:

Let us assume that N indicators are involved in the analysis of dynamic changes in Internet advertising and marketing data. For each

of these indicators, values have been obtained or calculated with a time interval between them. Thus, we obtain M values of each selected parameter in the time interval [0,T], with a certain $T = M\Delta h$. Since the number of selected parameters is *N*, these values for each $n \in [1, N]$ take the vector P_n .

$$P_n = P_{n1}, P_{n2}, ..., P_{nM} \tag{15}$$

Where, $P_{nm}, n \in [1, N], m \in [1, M]$ is the m-th value of the n-th parameter. The values of the selected parameters together give the following matrix of parameters:

$$P = \begin{pmatrix} P_{11} & \dots & P_{1M} \\ \vdots & \ddots & \vdots \\ P_{n1} & \dots & P_{nM} \end{pmatrix} \tag{16}$$

Suppose that for any $n \in [1, N]$ the values of the parameter P_n were obtained at time intervals different from the time interval Δh. If these different time intervals do not differ too much from the common time interval, the vector of corresponding values can be interpolated into a vector with the interval between values Δh. The vector of parameter values at time intervals different from Δh will have the form:

$$P^f_n = (P^f_{n1}, P^f_{n2}, ..., P^f_{nM}) \tag{17}$$

Let us denote the time interval between the *i*-th and *i+1*-th values of this vector as Δh^f_m :

$$J \cdot \Delta h \in \left[\sum_{m=1}^{M-1} \Delta h^f_m , \sum_{m=1}^{M} \Delta h^f_m \right] \tag{18}$$

For any *J* satisfying the condition, we can write ($m = 1$):

$$P_{n1} = P^f_{n1} , \ \forall m \in [2, J] \tag{19}$$

If there is such *k*: $m\Delta h = \sum_{i=1}^{k} \Delta h^f_i$, onda $P_{nm} = P^f_{nk}$ otherwise, if

$$m\Delta h \in \left[\sum_{i=1}^{k-1} \Delta h^f_i , \sum_{i=1}^{k} \Delta h^f_i \right] \tag{20}$$

$$P_{nm} = \frac{n(k-1)[m \cdot \Delta h - \sum_{i-1}^{k} \Delta h_i^f] + p_{nk}^f [\sum_{i=1}^{k} \Delta h_i^f - m\Delta h]}{\Delta h_k^f} \quad (21)$$

After performing the interpolation operation on each parameter vector, an equal number of elements can be taken from each vector, starting from the last element, to write the parameter matrix. This number is defined as the minimum number of elements in the vectors remaining after interpolation. The matrix (16) is obtained by taking M values from each of the N parameters. To check the correlation between the vectors making up the matrix, the cross-correlation coefficients are calculated. For this purpose, the average value of each element of the vector is calculated as follows:

$$\mu_n = \frac{1}{M} \sum_{k=1}^{M} P_{nk}, \quad n \in [1, N], \quad (22)$$

the root mean square difference of each element of the vector will be equal to:

$$\sigma_n = \sqrt{\frac{1}{M} \sum_{k=1}^{M} [P_{nk} - \mu_n]^2}, \; n \in [1, N] \quad (23)$$

The correlation coefficient between two vectors *i* and *j* will be:

$$\sigma_{ij} = \frac{1}{M} \sum_{k=1}^{M} (P_{ik} - \mu_i)(P_{jk} - \mu_j), \; i, \; j \in [1, N] \quad (24)$$

$\rho_{ij} = \sigma_{ij} / (\sigma_i \sigma_j)$ is calculated as. The obtained correlation coefficients, in turn, form a matrix of correlation coefficients. Let us assume that K parameters are selected:

$$P = \begin{pmatrix} P_{11} & \dots & P_{1M} \\ \vdots & \ddots & \vdots \\ P_{K1} & \dots & P_{KM} \end{pmatrix} \quad (25)$$

The importance and weight of each selected parameter can be assigned to analyze the dynamic changes of online advertising marketing data. This $\sum_{j=1}^{k} \omega_j = 1$ who meets the condition $w = (w_1, w_2, ..., w_k)$ can be written as a vector. If we multiply the

weight vector by the matrix (25), we can obtain the values of the integral parameter:

$$(w_1, w_2, ..., w_K)\begin{pmatrix} P_{11} & ... & P_{1M} \\ .... & ... & P... \\ P_{K1} & ... & P_{KM} \end{pmatrix} = (I_1, I_2, ..., I_M) \quad (26)$$

$$I_m = \sum_{\iota=1}^{k} w_\iota P_{\iota m} \quad (27)$$

By adding the resulting integral parameter to the matrix (25), we obtain a more complete matrix of indicator parameters. To build the model, we assume that the monitoring of the change in the values of the selected parameters starts at time T, and the Internet advertising campaign starts at time T1. We can assume that the campaign has ended, the parameter values have reached the values before the campaign, and the whole monitoring period has ended. With the help of practical experiments, we can imagine the change in the values of the parameter P(t) over time during the monitoring period of successful Internet advertising campaigns, as shown in Figure 2.

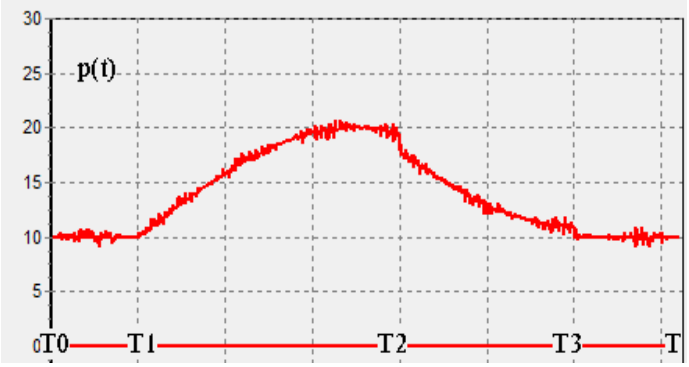

Figure 2. Graph of the dependence of the values of the parameters of the effectiveness of a successful advertising campaign on time during the monitoring period

To perform the necessary operations on the obtained analytical function, it is necessary to apply the method corresponding to each time interval.

Step 1: In fragment $[T_0,T_1]$, $P_1(t)=C,$, where C can be taken as a constant number equal to the mean value P in fragment $[T_0,T_1]$.

Step 2: The function can be defined as $P_2(t)=a_2t^2+b_2t+c_2$ on the subinterval $(T_1,T_2]$. The coefficients of the square trinomial are defined as follows: We write the values included in the half-interval $(T_1,T_2]$ as a separate sequence $P_{21},P_{22},...,P_{2R}$. Here the first index indicates that the values belong to the second half-interval. The value of R is found as the largest R satisfying the condition $T_1+R\le T_2$.

The coefficients of the square trinomial must be found in such a way that the mean square difference between the function values obtained by assigning the argument the values $t_r=T_0+r,r\in[1,R]$ and the values of the sequence is the smallest. If we write the mean square difference as $E=\frac{1}{R}\sum_{r=1}^{R}(P(t_r)-P_{2r})^2$ and take into account the above, we will see that the mean square difference depends on the coefficients of the square trinomial.

Step 3: For the half-interval (T1,T3] the function $P_3(t)=a_3t^2+b_3t+c_3$ can be created in a similar way. Thus, the change in the values of the selected parameter over time during the monitoring period can be determined as follows:

$$P(t)=\begin{cases}P_1(t)=c,t\in(T_0,T_1]\\ P_3(t)=a_3t^2+b_3t+c_3,t\in(T_2,T_3]\\ P_3^2(t)=a_3^2t^2+b_3^2t+c_3^2\ t\in(T_2,T_3]\end{cases}$$

The resulting function is a model of dynamic change in the performance indicators of an Internet advertising campaign. The average value of this function at any time interval can be set as follows.

$$P=\frac{1}{T_m-T_n}\int_{T_n}^{T_m}P(t)dt \qquad (28)$$

The following coefficient is calculated as a measure of the dynamic change from the time T_1, when the online advertising campaign began, to any $t \in (T_1, T_2]$ current points in time:

$$\gamma_t = \frac{\int_{T_1}^{t} P(t)dt}{t - T_1} : \frac{\int_{T_0}^{T_1} P(t)dt}{T_1 - T_0} \tag{29}$$

The growth of the above coefficient over time is an indicator of the success of an online advertising campaign. However, a decrease in the value of the coefficient γ_t already indicates a decrease in the effectiveness of the advertising campaign.

In the third section of the third chapter, an algorithm for a recommendation system for predicting customer interests in an e-commerce environment is developed [15, 22].

The system compares the entered word or phrase with the keywords in its library and database and selects the closest base word. As a result, a recommendation can be made by searching for the word found. For this purpose, proximity measures between two words, two sets or two vectors can be used. The chosen measure of proximity between two vectors must fulfil the following properties:

$d(x, y) \geq 0$ the property of not being negative;

Equation $d(x, y) = 0$ is true only if the vectors x and y are equal. The distance of a vector from itself is zero;

$d(x, y) = d(x, y)$ property of symmetry;

$d(x, y) = d(x, z) + d(y, z)$ property of a triangle.

In simple cases, the Jaccard closeness measure can be used. The Jaccard closeness of two words A and B is calculated:

$$sim(A, B) = \frac{n(A \cap B)}{n(A) + n(B) - n(A \cap B)} = \frac{n(A \cap B)}{n(A \cup B)} \tag{30}$$

If we calculate the measure of difference, we get:

$$dif(A, B) = 1 - \frac{n(A \cap B)}{n(A) + n(B) - n(A \cap B)} = \frac{n(A \cup B) - n(A \cap B)}{n(A \cup B)} \tag{31}$$

It follows that $0 \leq sim(A, B) \leq 1$ in special cases there will be:

$$sim(A,B)=\begin{cases}1, A=B\\ 0, A\cap B=\varnothing\end{cases}$$

Instead of two words, we can also talk about the proximity of two sentences or two texts. Our goal is to generate possible numerical values from the text values that the user provides about the object.

Therefore, these texts can be stored in memory and processed using various algorithms. Thus, the value assigned to the object by the user can be formed using the following algorithms:

Step 1: The text is split into text blocks and written to the Txt array, the size of the array is determined and written to the integer parameter T_c.

Step 2: Each element in the alphabet array is compared to the words in the Txt array and assigned a Jaccard proximity measure using the formula. To do this, the size of the array is first set to zero:

$\forall j\in[1,N_i], T(j)=0\ \forall j\in[1,N_I]$

$$T(j)=\max\left\{sim(L_j,Txt_1), sim(L_j,Txt_2),..., sim(L_j,Txt_T)_c\right\} \quad (32)$$

The final price will be:

$$m_q=\max\left\{T(j), j\in[1,N_i]\right\}$$

This parameter is a numeric expression of the value assigned to objects by the customer or the user in text form: $m_q=\in[0,1]$.

This price range can be scaled to any other range. If we want to scale the value to the range $[-\alpha,\alpha]$, we can write, $m_q=2am_q-a=a(2m_q-1)$.

Once this value has been calculated, it can be added to the time series (31) using formula (32) according to the date the texts were written.

It is known that recommender systems form the current price taking into account the previous prices of the buyer for the object, and this current price is included in the array of user prices.

If the name of the analysed object appears more often than others in different media, this frequency can indicate the importance of the object for users. However, sometimes the frequency of one of the two

objects can be much higher than the frequency of the other. In this case, the reduction of the difference between them can be significant:

$$w_{t,d} = \begin{cases} 0 \\ 1+\lg tf_{t,d} \end{cases}, \quad tf_{t,d} > 0, \tag{33}$$

We can form a matrix of prices that buyers assign to objects (items, goods, services, etc.):

$$R = (r_{i,a})_{i=1,a=1}^{MN} \tag{34}$$

where, r_i, is the price set by the *i*-th buyer for the object "*a*". In this matrix, the number of users is *M*, and the number of objects is *N*. Each row shows the ratings given by a user to different objects, and each column shows the ratings given by different users to the same object. In this matrix, each column and each row is a vector. Here we can calculate the similarity measure of two vectors using different methods.

Basically, we will use the Pearson correlation coefficient and the cosine similarity measure. Therefore, we will give these dimensions using the elements of the matrix *R*. The similarity measure between two users is the Pearson correlation coefficient between the two row vectors:

$$sim(i, j) = \frac{\Sigma_{p \in P}(r_{i,p} - r_{i,a})(r_{j,p} - r_{j,a})}{\sqrt{\Sigma_{p \in P}(r_{i,p} - r_{i,a})^2}\sqrt{\Sigma_{p \in j}(r_{j,p} - r_{j,a})^2}} \tag{35}$$

where *i, j* denote users; *p* denotes a set of goods or services, $r_{i,p}$ indicates the price specified by the *i*-th user for an object, good or service *p*; $r_{i,a}$ shows the average price specified by the *i-th* user for objects, goods or services $P \in P$. If there are *Np* objects in the set *P*, then:

$$r_{i,a} = \frac{\Sigma_{p \in P} r_{a,p}}{N_p}$$

$r_{i,a}$ – indicates the price indicated by the *j*-th user for the object, product or service p;

$r_{j,a}$ – indicates the average price indicated by the *j*-th user for objects, products or services:

$$r_{j,a} = \frac{\Sigma_{p \in P} r_{a,p}}{N_p}$$

The closeness of ratings given to two objects by different users can be expressed as the cosine measure of closeness between two column vectors:

$$\omega_{a,b} = \frac{\Sigma_i r_{i,a} r_{i,b}}{\sqrt{\Sigma_i} r_{i,a}^2 \sqrt{\Sigma_i} r_{i,b}^2} \quad (36)$$

For the recommender system to work successfully, it is necessary to reduce the size of the matrix (34). To do this, we can select the rows from the matrix corresponding to specific users and the columns corresponding to objects. Thus, if we know that the *i*-th user is interested in some *c*-th object, we can recommend the user objects at the intersection of columns close to the *i*-th object with the rows corresponding to users close to the *i*-th user, and provide him with information about the selected products. As mentioned above, we take the measure of closeness between rows as the Pearson measure of closeness, and the measure of closeness between columns as the cosine measure of closeness. The system of inequalities of the solution of the recommender system:

$$\begin{cases} sim(i,j) = \dfrac{\Sigma_{p \in P}(r_{i,p} - r_{i,a})(r_{j,p} - r_{j,a})}{\Sigma \sqrt{\Sigma_{p \in P}(r_{i,p} - r_{i,a})^2} * \sqrt{\Sigma_{p \in j}(r_{j,p} - r_{j,a})^2}} \le \Delta sp \\ \omega_{a,b} = \dfrac{i \;\; i,a \;\; i,b}{\sqrt{\Sigma_i} r_{i,a}^2 \sqrt{\Sigma_i} r_{i,b}^2} \le \Delta\omega \end{cases} \quad (37)$$

$j \in [1, M]sp$, $b \in [1, N]$

This system of inequalities can be called the system of inequalities-decisions of the recommender system. *sp* is the similarity threshold. For very small values of this parameter, there may be an *i*-th row that satisfies the condition. If the similarity threshold exceeds $sim(i, j)$ –, then users *i* and *j* are sufficiently similar. $\Delta\omega$ – a parameter that determines the width of the selected columns.

The goal is to evaluate how accurately the recommender system predicts user preferences using the precision, recall and F1 score metrics. The average value of each metric is calculated for all users. The resulting result provides a qualitative assessment of the recommendations for the system as a whole. The *MAP* metric is used to evaluate the recommender system. *MAP* (mean accuracy) is a metric that evaluates the accuracy of recommendations based on the order in which they are presented. It is particularly useful for ranking questions where the order of recommendations is important. *MAP* takes into account the consistency of the recommendations. The higher a product is in the list, the more it will influence the final *MAP* score.

$$MAP = \frac{\sum_{i=1}^{n} (AP_{user\_i})}{N_{user}} \tag{38}$$

AP_{user_i} – the average value of the accuracy metric for the *i*-th user. Nuser – number of users (clients). Each user has a purchase history or product rating.

$$AP_{user} = \frac{\sum_{i=1}^{n} \Pr ecision_{at\_k} \times rel_i}{total_{rel}} \tag{39}$$

$\Pr ecision_{at\_k}$ – accuracy of the *k*-th position in the ranked list; rel_i – indicator of relevance (1 if the product is relevant, 0 otherwise); $total_{rel}$ – the total amount of relevant goods intended for the user. Figure 3 shows how relevant the list of recommended products is.

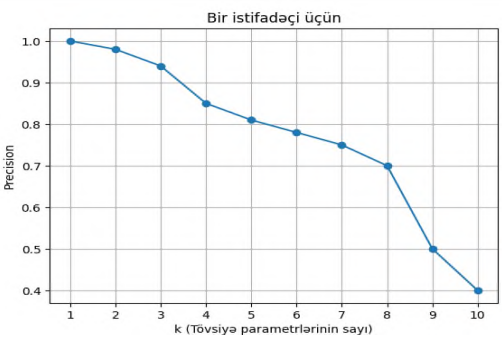

Figure 3. Indicators of the MAP metric for the client in the recommendation system

The results of the evaluation of the effectiveness of the recommendation system are presented in *table 1*.

Table 1.

Recommender System Evaluation

Metrics	**Prices**	**Note**
Precision	0,85	85% of the recommended products fit the user.
Recall	0,92	The system found 92% of all relevant products.
F1-size	0,88	The score obtained on the basis of accuracy and completeness indicators.
MAP	0,95	Average accuracy of recommendations in various situations in the list of users.

The experiment used Python with scikit-learn libraries. The following list was used in the calculations:

- List of relevant products for each user;
- List of recommended products for each user.

Depending on the area, recommendation systems with different focus and nature can be created, based on practice. In user profiles, different aspects of each object can be found and evaluated differently. A set of given prices can be created by selecting, for each object, the prices given by the user for different objects in different sources.

The fourth chapter is dedicated to "Experimental verification of the proposed methods and algorithms". The results obtained in the previous chapter were also processed in the Delphi and C# programs [6]. In the first part of the fourth chapter, the software for the web page rating algorithm based on customer reviews was developed and tested. First of all, it is necessary to create an algorithm - an alphabet - for forming a price from the information that the customer enters on the website in the form of a numerical price. For example, the relational alphabet can be created from words such as "excellent", "good", "useful", "sufficient" with a weight vector (p_1, p_2, ..., p_n) for a positive relationship and from words such as "very bad", "bad", "useless", "harmful" with an internal weight vector (m_1, m_2 .., m_n) for a negative relationship. The result of the algorithm in the weight vector can be written in the range [-10, +10]:

P = (10, 8, 6, 4, 2, –2, –4, –6, –8, –10) The estimate can be written as *N_l*-dimensional vectors, *L* and *P*, of string, prepositional and real types, respectively (table 2).

Table 2.
Correspondence table between vectors L and P.

P	10	8	6	4	2	-2	-4	-6	-8	-10
L	excellent	good	useful	sufficient	quite	harmful	badly	futile	bad	very bad

The size of this array is determined during the filling process. For example, it can be shown that in the case _l=10, L = (“excellent”, “good”, “useful”, “sufficient”, “quite”, “harmful”, “badly”, “futile”, “bad”, “very bad”) can be created as. Thus, the original value in text form can be formed using three blocks of the algorithm:

Step 1: Divide the text into text blocks and write it to the Txt array, determine the size of the array and write it to the numeric parameter T_c.

To solve this problem, it is necessary to determine the array of text separators (Natural Separaters N_s) and the number of its elements (N_s_c). The array N_s can be formed as follows:

N_s=(‘ ‘, ‘,’, ‘!’, ’?’, ‘.’, ...,10, 13). Here, the codes 10 and 13 are used to go from line to line and return to the beginning of the line.

Step 2: Determine the number of repetitions of alphabetic elements in the text (formation of the T array). At the beginning of the problem, the array of numbers is initialized to zero before the operation. That is, $\forall j \in [1, N_i], T(j) = 0$

For $\forall j \in [1, N\_l]$, it is checked whether the element L(j) is present in each of the $Txt(i)$ text elements for $i \in [1, T\_c]$. During inspection

If it is $L(j) \subset Txt(i)$, the corresponding element of the number array is incremented:

$$T(j) = T(j) + 1$$

Step 3: The formation of the customer's price (m_q) will be the sum of the prices obtained by multiplying each number collected in the array of numbers by the corresponding element of the vector P to calculate the parameter m_q:

$$\sum_{j=1}^{N\_l} T(j) \cdot P(j)$$

To normalize this value, the sum of the values collected in the numerical array must be divided by the sum of the numbers (repetitions) multiplied by $\sum_{j=1}^{N\_l} T(j)$. Thus, we obtain the following expression for the consumer price:

$$m\_q = \frac{\sum_{j=1}^{N\_l} T(j) \cdot P(j)}{\sum_{j=1}^{N\_l} T(j)} \qquad (40)$$

That is, each alphabetical element is multiplied by the number of times it occurs in the analyzed text and summed up. The resulting sum

is divided by the sum of repetitions. This parameter can take the following values:

$$m\_q \in [-10;+10]$$

P if the vector is defined as follows:

$$P = (10, 8, 6, 4, 2, -2, -4, -6, -8, -10)$$

figures obtained as a result of text analysis $T = (1,2,0,3,0,0,2,0,0,0)$ If this is the case, then we will get the price for the client based on formula (40):

$$m\_q = \frac{1 \cdot 10 + 2 \cdot 8 + 3 \cdot 4 + 2 \cdot (-4)}{1 + 2 + 3 + 2} = 3.75 \quad (41)$$

If the client who rated the site is in the *m*-th place in the list of clients, and the source being rated is in the *n*-th place, then the value in the *CPM* array will be as follows:

$$p_{m,n} = m\_q$$

The rating that customers give to a site is not based on the customers themselves, but indirectly on the calculation and assessment of the frequency of their visits to the site.

Figure 4 shows the relationship of 1000 customers and users based on their ratings on the site.

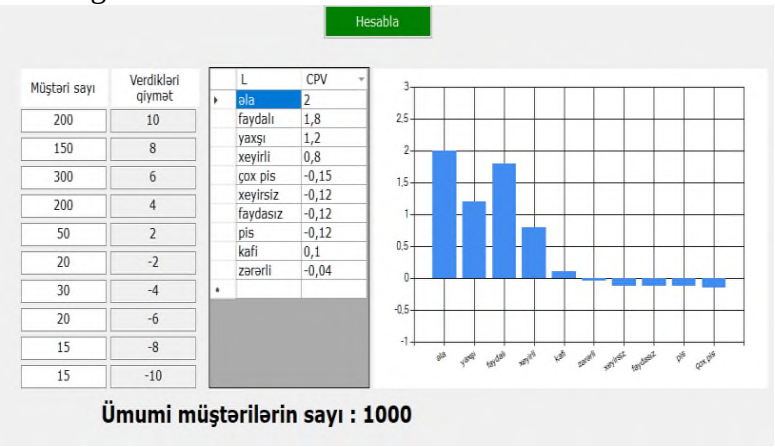

Figure 4. Results based on customer site ratings

In the second part of the fourth chapter, a software module was developed for the use of advertising and marketing performance indicators in the Internet environment.

To increase sales through advertising, it is recommended to use the complex performance indicators ROI, CPA, CVR:

$$ROI = (Investment\ Return - Advertising\ Costs) / Advertising\ Costs \times 100\%$$

$$CPA = Advertising\ Costs / Number\ of\ Users$$

$$CVR = Number\ of\ conversions / Number\ of\ users \times 100\%$$

Using ROI, CPA and CVR together allows us to get a full picture of the effectiveness of marketing campaigns and make informed decisions to improve results.

In general, the most important factor is the calculation of return on investment. When analysing advertising campaigns, a large number of performance indicators can complicate the analysis process. Therefore, using fewer performance indicators in the analysis can simplify the analysis process. To reduce the number of performance indicators, you can take one of the indicators that are close in meaning. A sequence of different values of indicators obtained over a period of time can be considered as a time series. From the indicators whose values are obtained, it is possible to create different time series and reduce the number of those that show statistical proximity between these series.

In the course of the research carried out for the dissertation, the questions posed were resolved and the following main scientific results were obtained.

CONCLUSION

In the process of developing the dissertation, the issues raised on the proposed topic were resolved and the following results were achieved:

1. A conceptual model based on CRM for organizing online advertising and marketing was developed [1, 2, 8, 9, 11, 18];
2. To effectively solve the problems of advertising and marketing in the Internet environment, an algorithm for evaluating a website using the WMA (weighted moving average) method based on customer reviews is proposed. The method allows optimizing advertising campaigns on websites and increasing the effectiveness of marketing activities [3, 5, 10, 14, 20];
3. To improve the effectiveness of advertising and marketing on the Internet, a method for reducing the number of indicators based on the Euclidean distance and the K-Nearest method has been developed. This method provides an optimal solution to the problem and more targeted advertising [7, 12, 16, 17, 24];
4. A model of dynamic change in the effectiveness of an online advertising campaign is proposed. The model can be important for the effective solution of forecasting problems in advertising activities and increasing profits [4, 6, 13,21];
5. A hybrid method based on the Pearson correlation coefficient and the cosine measure of proximity for a recommendation system for forecasting customer interests in an e-commerce environment is developed. The method allows creating a recommendation system that forecasts customer interests, increases their satisfaction and increases sales [15, 19, 22, 23, 25].

THE MAİN CONTENT OF THE DİSSERTATİON İS PUBLİSHED İN THE FOLLOWİNG SCİENTİFİC WORKS:

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