Development of Project Management Models for Information Systems to Improve Website SEO Metrics

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Abstract

The study conducts a comprehensive investigation of project management methods for developing an application aimed at analyzing and improving website SEO metrics. The research covers both the theoretical justification for the need of such application and its practical implementation and performance evaluation. A conceptual management model has been built to structure the processes of planning, development, and deployment of the application, taking into account market needs, key functional capabilities, and modern technologies. In addition, a mathematical model has been proposed that formalizes the management of resources, risks, and time, enabling the assessment of project efficiency and the ability to forecast results. The application of these models enhances project adaptability to changes in search engine algorithms and market conditions. Results demonstrate that integrating the latest technologies and management methods is a crucial step in the effective development of applications designed to improve SEO.

Keywords

Project management, information system, application, SEO, website, conceptual model, mathematical model, risk.

1. Introduction

The modern Internet business landscape has become increasingly competitive, and maintaining a successful online presence has become critical for many companies. Search Engine Optimization (SEO) has emerged as a key tool for driving traffic and engaging target audiences. As the number of websites continues to grow, the importance of effective project management methods for developing applications designed to analyze and improve SEO performance also increases.

Research in this field includes studying the market needs and the requirements of website owners for SEO analysis and optimization tools, analyzing the key functionalities necessary for effectively improving SEO metrics, exploring available technologies and platforms for application development, conducting tests to ensure the efficiency and optimization of the application, as well as developing marketing strategies for promoting the application among the target audience and effectively launching it in the market. All these activities help developers and marketers better understand

market needs and requirements, as well as create applications that can assist website owners in improving their SEO strategies and increasing their competitiveness in the online environment. Given the constant changes in search engine algorithms and advancements in technologies, such research remains crucial for the ongoing improvement and adaptation of SEO strategies and tools.

Moreover, there is a growing awareness of the importance of not only increasing website traffic but also converting that traffic into customers. Therefore, research in the field of developing applications for analyzing and enhancing SEO metrics has become essential for achieving these goals.

The application of advanced artificial intelligence and machine learning technologies is also a crucial aspect in the development of such applications. These technologies offer accurate data analysis, predict changes in search engine algorithms, and even automate SEO optimization processes.

Finally, with the increase in mobility and widespread use of mobile devices to access the Internet, the development of mobile applications for the analysis and improvement of SEO metrics has become an additional advantage for web owners who want to optimize their sites for mobile devices and enhance their rankings in the search results displayed on such devices.

2. Research the factors that determine the importance of analyzing and improving SEO metrics for website

Analyzing and improving SEO (Search Engine Optimization) for websites is important for several reasons:

- Optimizing a website helps it rise in search results, which increases its visibility to potential users.
- High positions in search engines lead to a higher volume of organic traffic, which means an increase in visitors and potential customers.
- Many aspects of SEO optimization, such as page load speed, mobile compatibility, content quality, and navigation, also improve the user experience.
- Search engine optimization often results in better conversions because users brought in through organic traffic are more likely to convert into customers.
- A high position in search results allows you to stand out among competitors and attract more attention from users.
- SEO is an important component of the marketing strategy, as it allows you to attract the attention of the target audience without spending a lot of money on advertising.
- SEO optimization is an ongoing process that allows you to adapt a website to changes in search engine algorithms and user requirements.

SEO is not limited to just a set of approaches and methods; it is a complete strategy to increase visibility on the Internet and conversions and attract a larger target audience [1].

Organic traffic is one of the key indicators of SEO success, as it reflects the number of users who find a site through search engines without additional advertising campaigns. A high level of organic traffic indicates that the site is responding to user requests and has a high ranking for keywords.

The correct optimization of content, technical aspects of the site, and the development of quality backlinks are all essential components of a successful SEO strategy that helps to achieve desired results in Internet marketing.

Organic traffic, or traffic from search engines, is a significant source of income for many websites because of its high conversion potential. The total number of users and the number of new visitors are key indicators for evaluating the performance of a website [2].

Keywords also play an important role in SEO. The position of the site for a specific key query in the search results is determined by the rank, and the higher this ranking is, the more traffic you can

get from search engines. Tools like SemRush, Ahrefs, Serpstat, and others help measure keyword positions and perform competitor analysis to improve SEO.

The important stage of the SEO strategy to ensure the success of the site in rendering is support and constant analysis of positions.

Website visibility is a critical metric for promoting a business online. The more the site appears in search results, the more opportunities to attract potential customers. Improving the visibility of the site is done through various SEO techniques, such as accurate selection of keywords, creation of unique and useful content, backlinking, and optimization of titles, meta tags, and others [3].

Services such as Google Search Console, Neilpatel, Ahrefs, and others provide the ability to measure site visibility. They allow for the analysis of not only the overall visibility of the site but also visibility by individual keywords, regions, devices, and other parameters. This helps to understand how effectively the site is displayed in search results and allows you to take appropriate measures to improve SEO and increase visibility [4].

Backlinks are one of the important ranking factors in the search engine, as they indicate the authority and popularity of the site. Search engines, such as Google, Bing, and others, take into account not only the number of backlinks (backlinks) but also their quality, amount of traffic, etc. Link quality depends on the authority and relevance of the source linking to you. Links from authoritative and topically relevant sites have a greater impact on ranking than from less authoritative or off-topic resources.

Services like Google Search Console, Ahrefs, and others provide tools to measure the quality and quantity of backlinks to a site. They allow you to analyze not only the number of links but also their donor domains (i.e., source), DR, types, anchor text, popular queries, and other characteristics. This helps you get a complete view of your backlink profile and take appropriate actions to improve your SEO and search engine rankings [5].

In general, a combination of backlink quality analysis and conversions will allow you to get a complete view of SEO performance and help improve your site to achieve better results [6].

SEO is an integral part of a successful online business and requires constant improvement and analysis. Key SEO metrics include aspects such as keyword ranking, site traffic, conversion rates, page load speed, content quality, mobile optimization, and more. It is important to regularly monitor these indicators, analyze their changes, and take measures to improve results, which will ensure the stable growth of online businesses and maintain a competitive advantage.

3. Analysis of recent research and publication

First of all, we analyze studies that consider the issues and features of SEO. In the study [7], it is noted that an important aspect of web optimization is SEO, which not only enhances the visibility of a website in search engines but also improves user experience. The proper application of SEO strategies positively affects page loading speed, navigation convenience, and content relevance. This, in turn, can lead to an increased duration of user engagement on the site, thereby enhancing the likelihood of converting them into customers. In the work [8], the author discussed the processes for optimizing a website's link structure based on SEO algorithms.

The authors of the study [9] assert that the White Hat SEO method is a search optimization approach that complies with search engine guidelines and aims to enhance website traffic. Utilizing this strategy involves optimizing keywords, page structure, content, and backlinks, which ensures better visibility in search engine results pages (SERP). The primary goal is to achieve high rankings in search engines, as approximately 95% of users rely on them for browsing the internet. In the document [10], a model for SEO positioning is described, employing natural language processing (NLP) and deep learning to improve companies' marketing strategies. The proposed methodology allows for the automatic generation of relevant content based on user search query data. The study also examines tools such as sitemaps and Google Cloud for implementing this model across various organizations, with the aim of attracting new customers.

Technical aspects of SEO are also important, including crawling, indexing, page load time, and site structure. The author of the work [11] pays particular attention to HTML tags, verifying the compliance of URLs with the requirements of search engines such as Google, Baidu, etc. They also explore optimizing page loading speed and implementing canonical tags to enhance site structure. Equally important is the analysis of tools and mechanisms for managing IT projects, including those related to SEO. It is noted that the quality of a website's interface largely depends on the effectiveness of project management, including the timeliness and accuracy of metric processing. The article also discusses the use of the BPMS methodology to improve interface quality and its positive impact on economic and social indicators.

Game theory provides valuable insights for understanding interaction strategies in project management, particularly for improving communication. The research emphasizes the importance of this theory for team leaders in SEO projects, helping to optimize stakeholder analysis and enhance management practices [12].

The study [13] analyzes the selection of project management methodologies, specifically comparing the Agile methodology with the traditional Waterfall approach. The authors examine Scrum as the most popular Agile approach, detailing its key elements and ceremonies. They also reveal the interconnection between Agile and DevOps and DevSecOps practices, which are often seen as a natural extension of Agile projects.

In the work [14], the importance of implementing best practices in IT project management is emphasized to achieve efficiency and successful project execution. It highlights the significance of continuous learning, which helps teams adapt to new technologies and improve processes. By adopting a dynamic approach to planning, resource management, and risk management, organizations can enhance project performance and reduce the likelihood of failure.

In the scientific work of the author collective [15], the impact of artificial intelligence (AI) on strategic project management (SPM) is explored, highlighting its role in enhancing efficiency and adaptability. Key aspects influenced by AI are discussed, including data-driven decision-making, task automation, and resource optimization. Special attention is given to risk management and improved communication through NLP technologies. Adaptive planning and continuous project monitoring using AI enable managers to respond quickly to changes. The ethical aspects of using AI are also important, ensuring the responsible integration of technologies into the project management process.

The study [16] examines which project management methodology is most suitable for AI transformations, focusing on aligning projects with business objectives. Standardizing processes and methodologies helps ensure the successful execution of such projects. It also evaluates how common methodologies support rapid changes, particularly in conditions brought about by Covid-19.

In turn, the authors of work [17] note that innovative projects are developed in environments characterized by high uncertainty and complexity, necessitating adaptations by management to ensure success. Artificial intelligence (AI) technologies are employed to enhance productivity in such settings, particularly in managing risks, costs, and timelines. The research analyzes the impact of AI in these areas, highlighting its active use in industries such as construction and software development.

4. The purpose of the study

The purpose of this research is to develop and justify conceptual and mathematical models for project management in the creation of applications designed to analyze and enhance the SEO performance of websites. The study covers an overview of existing project management methodologies and the implementation of innovative models that allow optimization of development and increase the effectiveness of the application of SEO strategies, which will ultimately contribute to the improvement of the positions of websites in search engines.

Among the main research tasks, it is worth highlighting two, namely:

1. To develop a conceptual project management model that describes the key stages and strategies for developing applications for analyzing and improving the SEO performance of websites, taking into account the characteristics of project teams, time constraints, and budgets;

2. To construct a mathematical project management model for the development of applications for SEO optimization, which formalizes the processes of planning, assessment of resources, and effectiveness of actions, taking into account risk factors and probabilities of achieving the desired outcomes.

5. Development of a conceptual model of the information system for analysis and improvement of SEO website metrics

5.1. Definition of the preliminary configuration of the information system

The preliminary configuration of the system in the context of software development is a crucial step in defining the technical and software requirements necessary for the successful implementation of a project. In the case of developing an application for analyzing and improving the SEO performance of websites, a number of key components must be considered to ensure the effectiveness of the application and its alignment with user needs and market requirements.

Technological Stack. The selection of the technological stack should be based on an analysis of the most modern technologies that are optimally suited for processing and analyzing large volumes of data, which is critical for SEO analysis. Programming languages such as Python or JavaScript, which support a wide range of libraries for data processing and web scraping, are recommended. Databases like PostgreSQL or MongoDB can be used for efficient data storage and retrieval.

System Architecture. To ensure scalability and high availability, the system should be designed using a microservices architecture, which allows independent scaling of components. This approach also facilitates integration with external APIs to collect data on websites' SEO metrics.

Integration with External Services. The important aspect is the integration with various external services, such as Google Analytics, SEMrush, or Moz, to get necessary analytics about SEO metrics and website traffic. This includes the development of secure and reliable authentication and authorization mechanisms.

Security Requirements. Since the system will handle sensitive information, it is important to implement strict security measures, including data encryption at rest and in transit and regular security audits to identify and address potential vulnerabilities.

Usability and User Interface. The final aspect of the preliminary configuration is the development of an intuitive and visually appealing user interface that simplifies interaction with the system and enhances overall user productivity. Utilizing frameworks such as React or Angular can significantly improve the quality and responsiveness of the system.

5.2. Development of the Conceptual Model

Development of a conceptual model of an information system is the process of creating an abstract description of the structure and relationships of the system, which allows you to understand its essence and basic principles of operation. This model can define the concept, constituent elements, relationships, and properties of the system.

The conceptual level of building the architecture of the information system (IS) is an important stage at which the conceptual model (CM) or model of the subject area of this information system is developed. In this model, the objects and relationships between them that characterize the subject area are defined.

The main purpose of the conceptual model is to represent domain objects, to display their relationships and properties, as well as the main processes that must be implemented to achieve the project's goals. This makes it possible to create a general idea of the subject area, which is the basis of the development of the information system.

1. Definition of system objects.

Key objects of the information system are the following:

- websites (objects for which SEO indicators will be analyzed);
- SEO parameters (various characteristics of websites that directly affect their search engine optimization);
- analytical tools (tools for collecting and analyzing data on SEO indicators);
- users (system administrators, SEO experts, and end users of the information system).

2. Interactions between objects.

Key interactions include:

- data collection (automation of the process of collecting data on SEO indicators from various websites);
- data processing (using algorithms to analyze collected data and generate reports);
- presentation of results (development of the user interface for convenient presentation of the results of the analysis of SEO indicators).

3. Description of processes.

The main processes of the system include:

- analysis of user needs (determination of user requirements for the functionality of the information system);
- development of system modules (design and coding of modules for data collection, processing and display);
- testing and setting (conducting tests to check the functionality, security, and efficiency of the system);
- implementation of the system (deployment of the system in a real environment and training of users).

4. Data model.

A data model should cover:

- database scheme (data structuring for efficient storage and access);
- means of ensuring integrity (mechanisms to ensure accuracy and reliability of data);
- data protection methods (application of modern encryption and authorization methods to protect information).

We can create a model that demonstrates the real impact of the internal and external environment on the project based on the input data and interaction process between nodes (see Figure 1).

According to such indicators, it is possible to track the input data, in our case, «connecting the SEO analytics service» which is transferred to the project's information system, performing data processing processes from the database on the server. Thus, the raw data is issued in the form of «received analytics of the site to the client».

The development of the conceptual model of the information system is not only an important but also a critically necessary stage, which lays the foundation for the further development of the project. This allows you to understand the structure and relationships of all system components, including both internal and external elements. For example, connecting an SEO analytics service can create new opportunities for collecting and processing data related to user behavior on the site. By tracking this data, the team can not only gather analytics for the client but also discover patterns that maximize user engagement and optimize content. This information can become key for making decisions that determine the project's development strategy.

In addition, it is important to consider the influence of the external environment, which includes competition, user behavior, and feedback from the product support team. For example, changes in competitor behavior may require an immediate response from your team, which may include adjusting your marketing strategy or improving your product. Interaction with stakeholders can also influence the final product. Involving them in the development process can provide a better

understanding of market requirements and user needs, which, in turn, will increase the chances of a successful project completion.
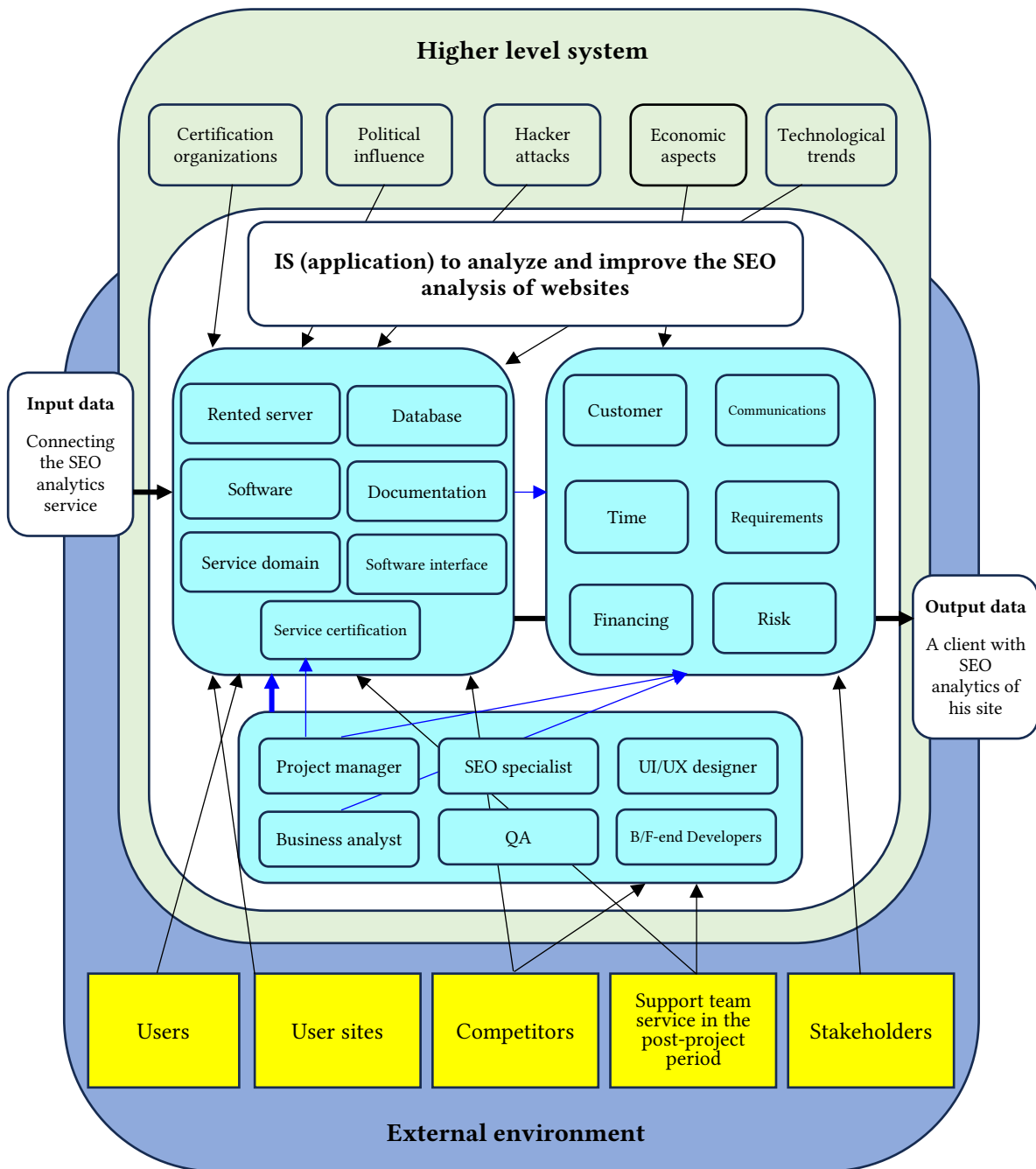

Figure 1: Conceptual model of an information system for analyzing and improving SEO indicators of sites

The development of a conceptual model also provides an opportunity to identify risks in the early stages of the project. Identifying potential problems that may arise due to changes in customer requirements or external circumstances allows the team to develop early strategies to eliminate them. This may include creating backup plans or additional tests at different stages of development. The clear structure of the conceptual model also facilitates the process of communication between different teams, ensuring a common understanding of the project's goals and its main tasks. As a

result, the conceptual model becomes not only a document but also a living tool that contributes to the continuous improvement of processes and solutions in the project.

6. Development of a mathematical model of the information system for analyzing and improving website SEO metric

Mathematical modeling is a powerful tool for the study of real systems, which makes it possible to analyze and experiment with systems without directly interfering with real reality. The main idea is to create a model that reproduces the main characteristics and relationships of a real system.

Mathematical modeling allows you to replace a real complex system with a simpler model, which allows you to conduct experiments and analyze its behavior in conditions that may be difficult or even impossible to reproduce in the real world [18].

We will use the approach of the theory of fuzzy sets, which allows us to evaluate and work with the uncertainty characteristic of project management.

1. The fuzzy set A is defined as a set of pairs x, $\mu_A(x)$), where x – the element from the universal set X, a $\mu_A(x)$ – element from the universal membership functions set $[0, 1]$.

2. The universal set X includes all possible states of system elements, such as the effectiveness of SEO indicators, project execution time, cost of resources, etc.

3. Membership functions μ model the degree of membership of each element of the universal set to the corresponding fuzzy set. For example, a function $\mu_{time}(t)$ will describe how much of the given time t is acceptable for completing a certain stage of the project.

4. Fuzzy set operations, such as union, intersection, and addition, are used to model complex relationships between project elements.

The mathematical problem consists of determining the optimal set of project management parameters that ensure the maximum increase in SEO indicators, taking into account time and budget restrictions.

Let $P = \{p_1, p_2, ..., p_n\}$ – vector of project parameters, including variables such as time, cost, resources, etc. The objective function (P) measures the effectiveness of SEO indicators depending on the parameters P. The optimization problem can be formulated as follows:

$$max_p F(P) \qquad (1)$$

with restrictions:

$$g_i(P) \leq b_i, \qquad (2)$$

where $g_i(\text{P})$ – constraint functions for the $i\text{-}th$ resource from the vector b, including time, cost, and other resources.

The use of fuzzy logic makes it possible to make the model flexible and adaptive to changes in conditions of uncertainty and to implement an iterative process of increasing the accuracy of project estimates during project implementation.

In order to develop accurate mathematical formulations, it is necessary to dive into the context of the project and the specifics of the data in more detail. Taking this into account, below we give an example of the mathematical formalization of a model based on the theory of fuzzy sets for managing the project of developing an SEO analytical tool.

Let us have a set of SEO parameters S, where each parameter $s_i \in S$ has a certain weight w_i, which determines its impact on the overall ranking of the website.

For each parameter s_i we introduce a fuzzy variable A_i with the membership function $\mu_A(x)$, where x – s is a possible value of the parameter.

Membership functions: $\mu_{Ai}(x)$ range of values $s_i \rightarrow [0,1]$.
Objective function:

$$F(P) = \sum_{i=1}^{n} w_i \cdot \mu_{Ai}(p_i),\tag{3}$$

where $P = \{p_1, p_2, \ldots, p_n\}$ – vector of specific project parameter values.

Limitation:

We introduce constraints on project resources through fuzzy sets B_j with membership functions $\mu_{Bj}(y)$, where y – s a resource, for example, budget or time.

$$\mu_{Bj}(y_j) \geq \beta_j,\tag{4}$$

where β_j – the fuzzy threshold of satisfaction of the j-th constraint.

Math problem:

$max_p F(P)$ provided that:

$$\forall_j\colon \mu_{Bj}(y_j) \geq \beta_j\tag{5}$$

This approach allows modeling the optimization problem taking into account fuzzy constraints and fuzzy goals. The objective function evaluates the total impact of all parameters on SEO performance using their weights and degrees of belonging to optimal values. Restrictions ensure compliance with the project's resource requirements.

This model can be used to iteratively select optimal project parameters that will be adapted to changing conditions and requirements. For example, you can apply fuzzy logic methods to adapt the work plan based on the real data received on the effectiveness of SEO indicators during the implementation of the project.

Designing specific membership functions for fuzzy logic usually requires detailed data analysis and expert judgment. For example, the membership function for estimating the time of task execution (Time Efficiency). A triangular membership function can be used:

$$\mu_{Time}(t) = \begin{cases} 0 \\ \frac{t-a}{b-a} \\ \frac{c-t}{c-b} \\ 0 \end{cases}\tag{6}$$

if $t < a$

if $a \leq t < b$

if $b \leq t < c$

if $t \geq c$

where a, b, c – parameters determining the ideal *(b)*, acceptable *(a)*, and maximum allowable *(c)* task completion time.

A Gaussian membership function can be used for the membership function of resource cost estimation (Cost Efficiency):

$$\mu_{Cost}(x) = e - \frac{(x-m)^2}{2\sigma^2}\tag{7}$$

where m – is the average cost and σ – is the standard deviation, which is determined based on budget constraints and expert estimates.

The membership function for evaluating the quality of SEO indicators (SEO Quality) can be described as the sigmoidal membership function:

$$\mu_{SEO}(S) = \frac{1}{1+e^{-k(s-s_0)}}\tag{8}$$

where s – actual factor SEO, s_0 – the target value of the factor, a k – the steepness of the curve, which is determined based on the range of desired SEO values.

These membership functions are used to assess how closely the current state of a parameter aligns with the ideal (most desirable) state. Based on these functions, fuzzy logic algorithms can be employed for project management decision-making. For example, the distribution of resources or the work schedule can be adjusted to enhance the overall evaluation of the project.

Therefore, when developing a mathematical model using the fuzzy set theory, specific membership functions were proposed and described to evaluate the main project parameters, such as execution time, resource costs, and the quality of SEO metrics.

The membership functions were chosen based on their ability to capture the specific characteristics of each parameter, as well as their capacity to model the ambiguity and uncertainty that often accompany projects in the field of information technology. By applying triangular, Gaussian, and sigmoid membership functions, various types of distributions and measurement scales were taken into account, allowing for effective handling of the diversity of project variables.

The main advantage of the proposed model is its flexibility and adaptability. The use of fuzzy logic allows for the consideration of changing conditions and uncertainties in the project environment, as well as providing the capability to optimize project decisions in real-time based on the data obtained.

The results of this study can be utilized to build an effective project management system specializing in enhancing the SEO metrics of websites. Further research could focus on integrating the developed mathematical model with contemporary project management tools, as well as improving the methods for assessing the parameters of membership functions based on machine learning and artificial intelligence.

7. Conclusions

The study conducted a comprehensive investigation of project management methods for developing an application aimed at analyzing and improving the SEO metrics of websites. The research covers various aspects, from the theoretical justification for the need for such an application to its practical implementation and evaluation of its effectiveness.

As part of the first task, a conceptual project management model was developed that structures the planning, development, and implementation processes of the application. The model includes key indicators such as:

– site visibility expansion: a planned 30% increase in organic search results in the first 6 months after the application launch.

– average page load time: a reduction of 1.5 seconds, which will allow increasing the site loading speed from 4 to 2.5 seconds, taking into account the requirements for mobile optimization.

– content update frequency: an increase from 1 time per month to 3 times, which will improve the relevance of content, in particular for search engines.

The developed model emphasizes the importance of taking into account market needs, key functionalities, the latest technologies, as well as marketing strategies in the context of SEO, which creates the basis for developing applications that optimize websites to improve their visibility in search engines.

As part of the second task, a mathematical project management model was formulated that formalizes the processes of resource, risk, and time management during the application development. The model includes:

– Resource utilization index: optimal resource utilization, which is 85% for programmers and 70% for designers, taking into account the permissible deviation of ±5%.

– Risk of failure to complete the task within the specified deadline: reduced from the initial 25% to 10% due to improved coordination between teams.

– Project duration: the projected duration is 12 months, taking into account the possibility of reducing the deadline by 10% due to the automation of certain stages.

Mathematical model allows for a quantitative assessment of project implementation effectiveness and the forecasting of potential outcomes, which is a crucial factor in the dynamic environment of IT projects. The necessity for continuous updates to the mathematical model in response to changes in search engine algorithms has been identified, ensuring adaptability to new challenges and enhancing the application's effectiveness.

Thus, the conducted research confirmed the effectiveness of combining conceptual and mathematical models for successful project management in the development of applications aimed at improving website SEO metrics.

The study also revealed the need for further research regarding the integration of the application with other IT systems and platforms, as well as the constant updating of the mathematical model in response to changes in search engine algorithms.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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