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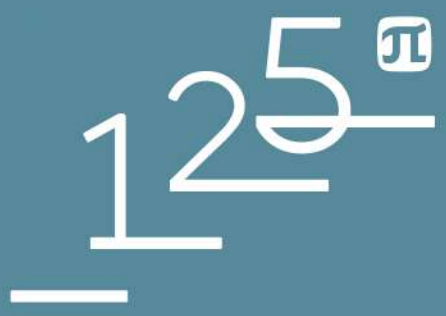

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INTEGRATING GENERATIVE AI FOR TECHNOLOGICAL TREND ANALYSIS AND PATENT RESEARCH AUTOMATION

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Abstract. This study explores the development and application of generative artificial intelligence (AI) for technological trend analysis and patent research automation. The research addresses the inefficiencies in traditional patent research, which is labour-intensive and costly, proposing a solution based on AI technologies such as machine learning, natural language processing (NLP), and vector database systems. The proposed solution incorporates MLOps and RAG frameworks for data collection, analysis, and integration, enabling the automation of patent data processing and keyword extraction through modified TF-IDF algorithms and semantic embeddings. The architecture includes tools for clustering patents by thematic and contextual similarities, significantly reducing the time required for research and enhancing accuracy. Experimental results demonstrate the effectiveness of the developed system, achieving significant improvements in the speed of generating patent studies (30–60 minutes) and the precision of information retrieval. The study highlights the transformative potential of generative AI in streamlining intellectual property analysis and fostering technological innovation.

Keywords: patent research automation, Generative Artificial Intelligence (GAN), Natural Language Processing (NLP), Machine Learning Operationalization (MLOps), Retrieval-Augmented Generation (RAG), TF-IDF Algorithm, Large Language Models (LLMs), vector databases

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ИНТЕГРАЦИЯ ГЕНЕРАТИВНОГО ИИ ДЛЯ АНАЛИЗА ТЕХНОЛОГИЧЕСКИХ ТРЕНДОВ И АВТОМАТИЗАЦИИ ПАТЕНТНЫХ ИССЛЕДОВАНИЙ

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Аннотация. В данной работе исследуются методы интеграции генеративного искусственного интеллекта (ИИ) для анализа технологических трендов и автоматизации патентных исследований. Основное внимание уделено разработке программного продукта, основанного на технологиях машинного обучения, анализа естественного языка (NLP) и векторных баз данных, что позволяет автоматизировать обработку патентных данных и выделение ключевых слов. Предложенная система включает использование MLOps и RAG для автоматизации поиска, анализа и кластеризации данных. Эксперименты продемонстрировали эффективность модифицированного алгоритма TF-IDF для извлечения ключевых слов и применения семантических эмбеддингов для улучшения точности анализа. Разработанная система позволяет уменьшить время генерации патентных исследований до 30–60 минут, значительно повышая производительность и точность. В перспективе рассматривается расширение возможностей системы через интеграцию дополнительных патентных баз и прогнозирование технологических трендов с помощью ИИ.

Ключевые слова: автоматизация патентных исследований, генеративный искусственный интеллект, анализ естественного языка (NLP), MLOps, Системы RAG, алгоритм TF-IDF, большие языковые модели (LLM), векторные базы данных

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Introduction

In the rapidly advancing digital age, companies are actively exploring new approaches to enhance efficiency, improve customer engagement, and strengthen their market positions. Generative artificial intelligence represents a groundbreaking technology that offers unique capabilities for creating, analyzing, and optimizing data in ways that were previously unattainable via traditional methods.

Generative AI impacts businesses in areas such as content detection, creation, authenticity, and regulation. It also has the potential to automate human labour and enhance interactions with both customers and employees. Key technologies in this domain include artificial general intelligence (AGI), AI engineering, autonomous systems, cloud-based AI services, composite AI, computer vision, data-driven AI, edge AI, intelligent applications, model operationalization (ModelOps), operational AI systems (OAISys), prompt engineering, smart robots, and synthetic data (Gupta, 2023).

Research on generative AI is accelerating due to the popularity of technologies like Stable Diffusion, Midjourney, ChatGPT, and large language models.

Critical technologies in this field include AI simulation, AI Trust, Risk, and Security Management (AI TRiSM), causal AI, Data Labelling and Annotation (DL&A), First Principles AI (FPAI), also known as physics-informed AI, foundation models, knowledge graphs, multi-agent systems (MAS), neuro-symbolic AI, and responsible AI. Figure 1 illustrates the placement of AI technologies on a hype cycle chart, reflecting their level of expectations and the estimated time remaining until they reach the plateau of productivity.

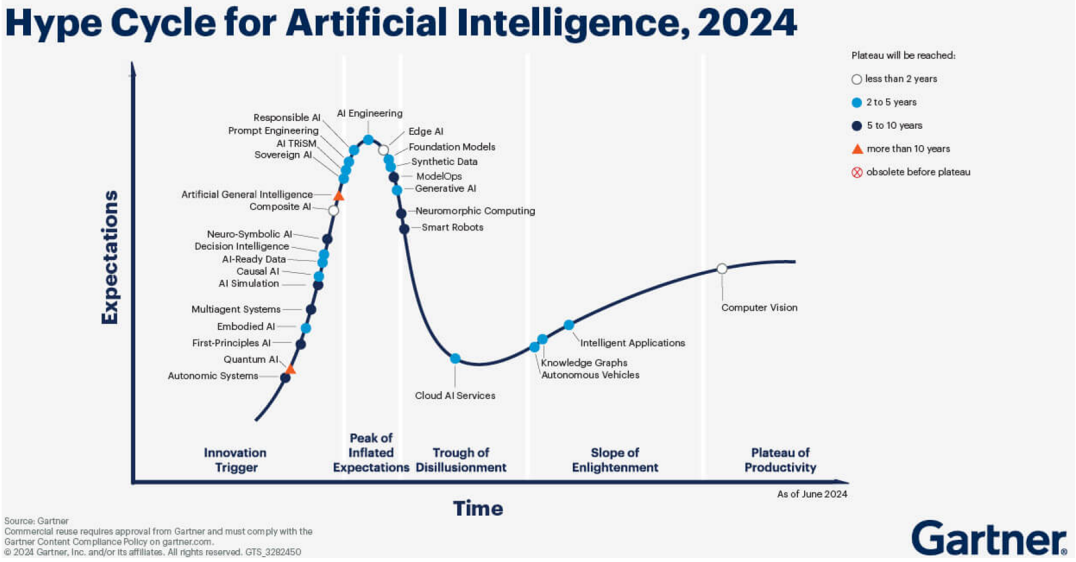


Fig. 1. The "Hype Cycle" for Artificial Intelligence in 2024 according to Gartner (Explore Beyond GenAI on the 2024. Hype Cycle for Artificial Intelligence).

Generative artificial intelligence represents a significant leap in technological advancement, offering immense opportunities across various sectors. It fosters unprecedented creativity and innovation, enabling the exploration of new ideas and solutions. Through automation and optimization, generative AI enhances efficiency, reduces costs, and frees up human resources for strategic tasks. It also delivers personalized experiences, improving customer satisfaction and strengthening relationships. By analyzing vast amounts of data, generative AI provides valuable insights and facilitates informed decision-making (Iyer, 2024; Kutuzova, 2024).

Generative AI holds outstanding potential for transforming businesses. A Gartner study conducted in 2024 revealed that among over 2.500 executives, 38% view it as a means to boost customer experience and loyalty. Additionally, 26% associate it with revenue growth, 17% with cost optimization, and 7% with ensuring business continuity (Bieck, 2024).

The primary areas of application for generative AI include marketing (14%), sales (12%), automated customer support (16%), creative tasks, and employee productivity enhancement. This technology can also significantly accelerate software development by assisting specialists in coding more efficiently. Gartner predicts that by 2027, approximately 30% of manufacturing companies will actively use generative AI to optimize product development processes.

Generative artificial intelligence has revolutionized the healthcare sector, improving diagnosis, treatment, and personalized medicine. A balanced approach to implementing generative AI across various industries, from personalized retail services to healthcare, involves investing in research, fostering collaboration, promoting digital literacy, and prioritizing ethical considerations. Future advancements include enhanced personalization, autonomous decision-making, collaborative intelligence, ethical governance, innovation, sustainability, and continuous learning (Yikilmaz, 2023).

Generative AI models, such as neural networks based on deep learning, can create new content, including images, music, and text. AI algorithms can analyze historical data for predictions and recommendations, enabling businesses to anticipate demand, optimize inventory, and efficiently allocate resources.

Successful implementation of AI in innovative and creative projects depends significantly on several key factors, including the creation of a synergistic environment where AI can maximize creativity and achieve project success, addressing privacy concerns, improving productivity, and resolving issues of bias and discrimination. Figure 2 shows a conceptual model of successful AI implementation.

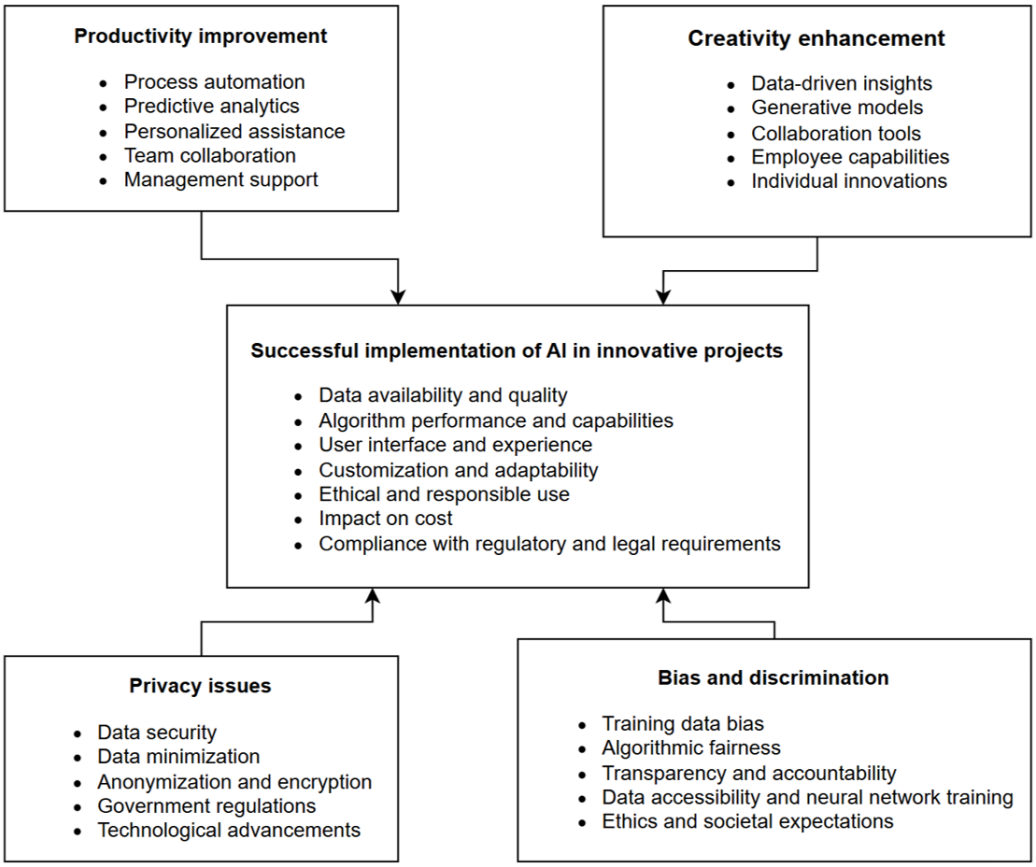
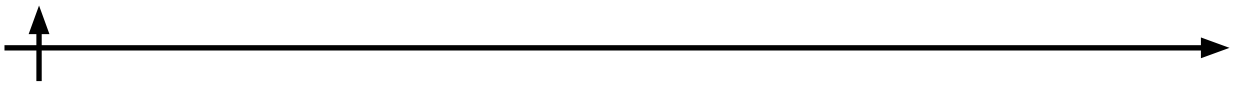


Fig. 2. A conceptual model of successful AI implementation.

The purpose of this study is to explore and develop methods for integrating solutions based on generative artificial intelligence (AI) to analyze technological trends and create tools capable of effectively processing large volumes of data on technological developments and predicting future trends.

In the context of rapid technological development, businesses must continuously monitor and analyze technological trends to remain competitive in the market. Generative AI provides new opportunities for data analysis and the identification of complex patterns, making it a powerful tool for analyzing technological trends. Integrating generative AI solutions for analyzing technological trends can significantly improve the quality and speed of analysis while also offering new insights for business development. With the ability to forecast future technological trends, businesses can make more informed decisions regarding their development strategies and investment in innovation.

Thus, the integration of generative AI solutions for analyzing technological trends is highly



relevant and can bring substantial benefits to companies striving to maintain leadership in their respective industries.

There is a notable problem related to the labour-intensive and time-consuming nature of patent research, which requires significant time and financial resources. Conducting a single patent study typically takes 25–30 working days, amounting to an average of 200 to 240 man-hours. Of this, 10 to 20 working days are spent on finding and organizing patent information. At the time of writing this article, the minimum cost of a patent study conducted by patent agencies is approximately 60.000 rubles. In Russia, over 50.000 patent applications were filed during 2023–2024, while the number of annual patent studies exceeds 250.000. Globally, this number amounts to approximately 3.45 million.

Patent research is the process of searching for and analyzing patent information to obtain various types of data related to patents and intellectual property. Patent research is conducted for a variety of purposes, including determining the novelty of an invention, identifying possible patent rights infringements, assessing the competitive landscape, and supporting innovation processes.

The following types of patent research are distinguished:

1. Novelty Search. This involves verifying whether an invention is new and has not been previously described in patent literature or other sources. This type of research helps to determine whether an invention can be patented.

2. Freedom-to-Operate (FTO) Search. This includes analyzing existing patents to determine whether a product or process would infringe on the patent rights of third parties. This helps companies avoid litigation and licensing issues.

3. Competitive Intelligence. This involves studying the patent activity of competitors to understand their strategies and technological directions. It allows companies to remain competitive in the market.

4. Invalidity Search. This involves searching for information that could invalidate an existing patent, such as prior patents or publications describing the same technology.

5. Patent Landscape Analysis. This is a large-scale analysis of patent information aimed at identifying technological trends, patent clusters, and market opportunities.

The goals of patent research include:

– Identification of novelty: helping to determine whether an invention is new and deserving of patent protection.

– Avoiding infringements: assisting in avoiding violations of other companies' patent rights and potential lawsuits.

– Strategic planning: enabling companies to plan their research and commercial strategies based on the patent activities of competitors.

– Evaluation of patent portfolios: assisting in assessing the value and utility of a company's patent portfolio.

Patent research is often performed using specialized databases and software such as Google Patents, Derwent World Patents Index, Espacenet, XLSCOUT, and DorothyAI. These tools help to automate the process of searching and analyzing patents, making it faster and more accurate.

Current methods for conducting patent research can be divided into two main groups: patent bureaus, where research is conducted manually by professionals, and tools utilizing neural networks, including large language models. The first group includes Garant, Guardium, and Patentus; the second group includes NLPatent, DorothyAI, and XLSCOUT (XLSCOUT About Us).

Materials and Methods

A solution to the described problem could be a software product based on the results of scientific and technical research in the fields of big data analysis, machine learning, natural language processing (NLP), and methods for solving complex data search and analysis tasks using artificial intelligence. At its core, the product leverages natural language analysis methods, including NLP models, text vector classification methods, and web scraping technology to automate the process of acquiring patent data. These tools enable patent departments and intellectual property specialists to automatically generate patent research based on data categorized by the International Patent Classification (IPC) and keywords, using natural language and machine learning methods. The development of this solution assumes the use of the technologies described below.

MLOps is a business model developed by organizations engaged in machine learning. The concept of Machine Learning Model Operationalization Management (MLOps) replaces traditional vertical structures within organizations by promoting the shared use of resources and expertise across departments. MLOps provides a way for data specialists and operational experts to collaborate and communicate effectively to manage the lifecycle of machine learning (ML) production. It is a culture and practice in machine learning engineering that aims to integrate the creation and operation of ML systems (Ops).

The main components or principles of MLOps are presented in Figure 3:

1. Automation—workflow stages can be easily automated without manual intervention.
2. CI/CD—MLOps includes continuous integration/continuous delivery (CI/CD), testing, and monitoring.
3. Version control—the ability to track ML models and datasets using version control systems.
4. Experiment tracking—allows multiple model training experiments to be run in parallel.
5. Testing—testing of various features, data, models, infrastructure, and more.
6. Monitoring—collecting detailed information on the performance of models.

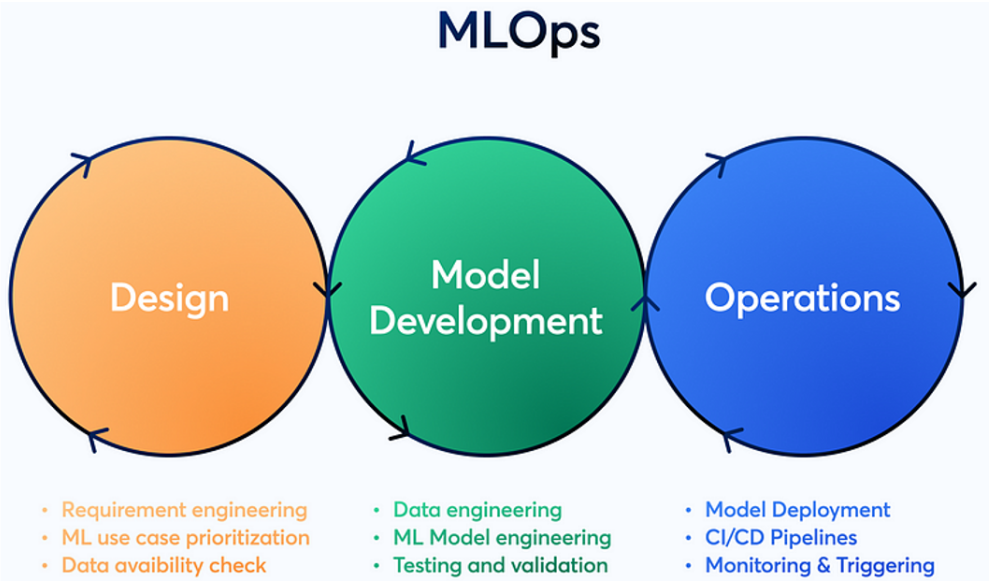


Fig. 3. MLOps principles.

The typical lifecycle or workflow of MLOps includes the following stages: data collection, data analysis, data preparation, model training, model evaluation, model validation, deployment, and monitoring (What is MLOps).

MLOps can be implemented in three different ways. The first level of implementation is a manual process, shown in Figure 4. This approach is common for companies that are just beginning to work with machine learning. A manual ML workflow may be effective if models are rarely modified or retrained.

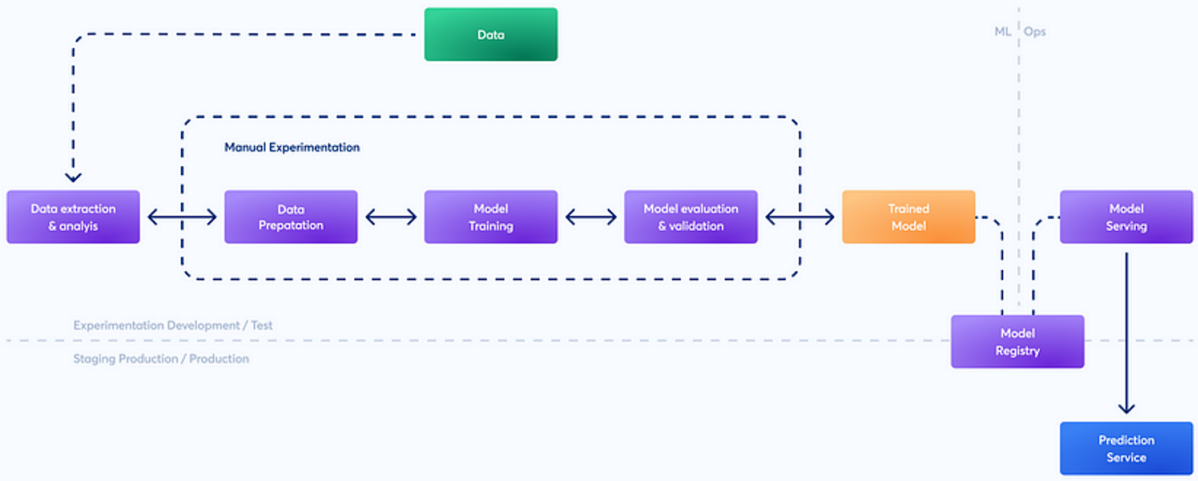


Fig. 4. Steps of the manual MLOps implementation process.

The second level of implementation is ML pipeline automation, shown in Figure 5. This architecture is ideal for deploying new models based on fresh data rather than new machine learning concepts. It automates the ML pipeline, resulting in faster experimentation.

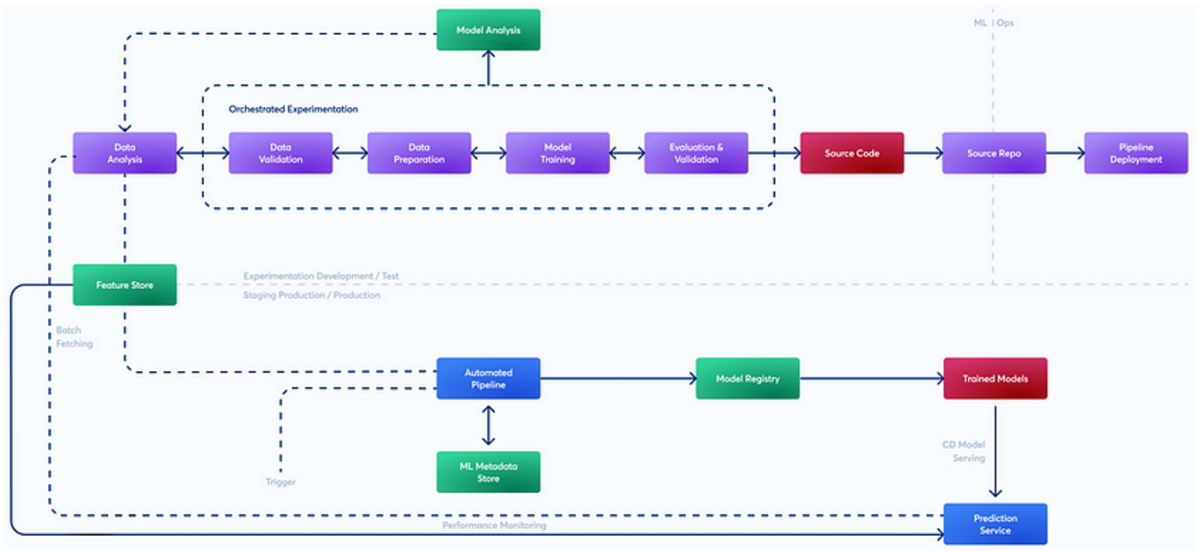


Fig. 5. ML pipeline automation.

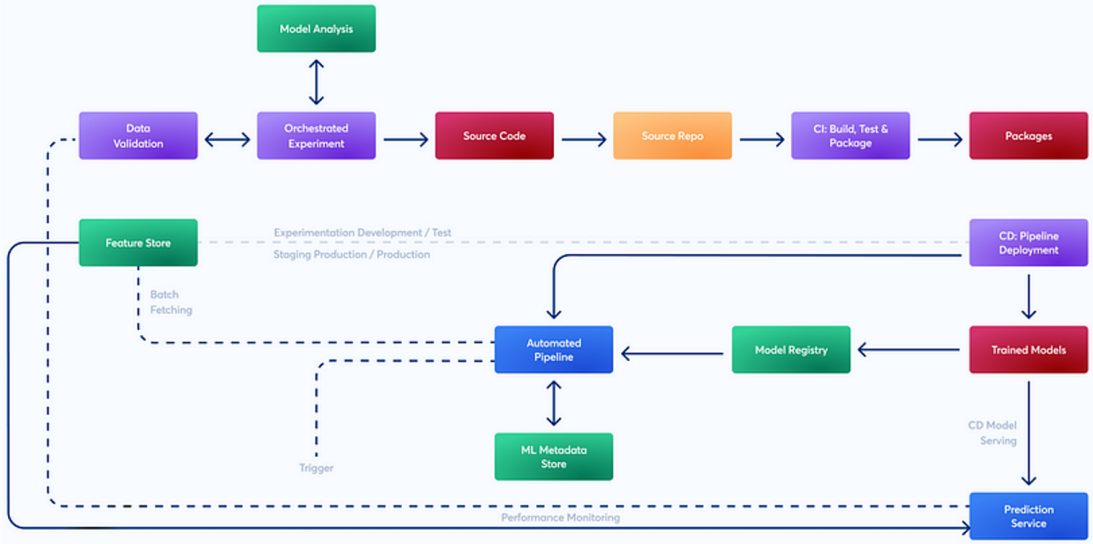


Fig. 6. Automation of the CI/CD pipeline.

MLOps enables companies to significantly reduce the time required for data analysis by creating automated feedback loops capable of identifying patterns in vast datasets without human intervention.

There are several comprehensive and specialized MLOps tools available. Comprehensive solutions for MLOps are fully managed services designed for rapid creation, training, and deployment of machine learning models, such as Amazon SageMaker and Google Cloud MLOps.

While comprehensive solutions are a good option, splitting the MLOps pipeline into multiple microservices allows organizations to build their own MLOps tool stack. These platforms are particularly well-suited for companies just starting out with machine learning: MLFlow, Neptune.ai, Weights & Biases, Cortex, and Polyaxon.

The corporate AI strategy of every organization revolves around ModelOps. ModelOps is a system that enables the integration of multiple AI objects, solutions, and frameworks while maintaining scalability and control. The sequence of ModelOps actions is shown in Figure 7.

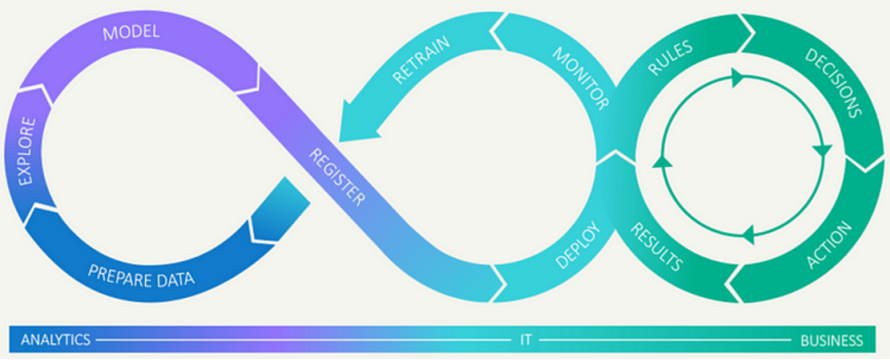
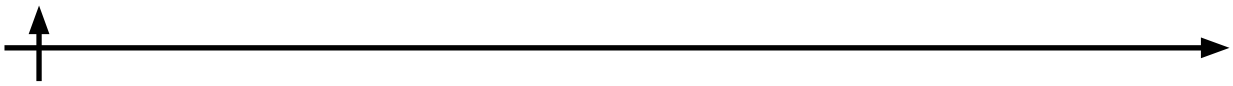


Fig. 7. ModelOps.

To put it simple, ModelOps is an extension of MLOps. In an organization wishing to implement ModelOps, MLOps must first be deployed. ModelOps requires the same skills as MLOps, plus a few additional skills related to IT operations, risk management, and some others (MLOps



vs. DevOps vs. ModelOps).

ModelOps is used by companies to address issues such as:

– Model quantity—to account for differences in business processes, customization, and specialized client groups, each organization needs to manage hundreds of models.

– Complexity—even the most experienced IT teams face overwhelming complexity due to data and innovations in analytics.

– Compliance with regulations—as AI usage increases in markets, adhering to strict and constantly growing models becomes harder.

– Isolated environment—multiple teams are involved in model creation, from deployment to monitoring. Scaling AI can be challenging due to ineffective coordination between teams. ModelOps helps create an environment where models can easily move from the data science team to the IT production team.

The tasks of ModelOps are largely similar to those of MLOps. Typically, ModelOps involves working on CI/CD, development environments, testing, version control for models, and model repositories. ModelOps serves as the link between all other elements of the AI pipeline. The best tools and platforms for ModelOps, focused on models, are ModelOp, Modzy, and Datatron.

MLOps refers to the operationalization and management of AI models in production systems, while ModelOps is considered a superset of MLOps. ModelOps has an advantage over MLOps in that MLOps focuses only on machine learning models, whereas ModelOps aims to operationalize all AI models (ModelOps, MLOps, and Finding Value in Analytics).

MLOps should not be confused with DataOps, a data science domain that primarily focuses on data pipelines, providing valuable insights by connecting disparate data sources and having flexible workflows with data on a scale. DataOps is the practice of moving data operations into an automated, repeatable, scalable environment. It is a software engineering discipline that ensures high-performance data management for analytics.

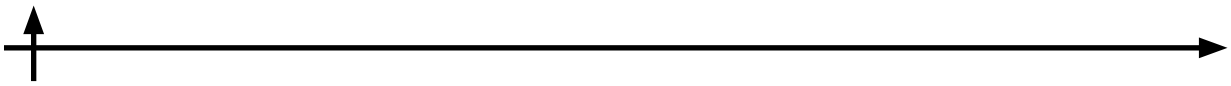
MLOps is not the same as AIOps, as AIOps automates processes in the organization's IT department, not the machine learning team. AIOps—short for Artificial Intelligence Operations—is used for automating processes or detecting patterns that would not be visible to humans. AIOps uses AI to analyze data and then optimize operations based on this data.

RAG is a method for working with large language models where the user asks questions to the program, and additional information from external sources is appended, all of which is then fed into the language model. In other words, supplementary information is added to the context of the language model's request, enabling it to provide a more complete and accurate answer. Retrieval is the process of searching and extracting relevant information. The system responsible for this is called a retriever. Retrieval Augmented Generation (RAG) is a method of generating a response for the user with the additional found information in mind.

It is expensive and inefficient to retrain the model on the customer's knowledge base, such as the patent database, as this would need to be done after each change to the knowledge base. In the RAG system, it is necessary to find the relevant article in the knowledge base and provide the LLM with not only the user's question but also the relevant portion of the knowledge base to form a correct response. (Getting Started with Large Language Models)

It is costly and inefficient to further train a model on the client's knowledge base, in this case, on a patent database, because this would need to be done after every change to the knowledge base. In a RAG system, it is necessary to find the relevant article in the knowledge base and provide not only the user's question but also the relevant part of the knowledge base for generating a correct answer.

The RAG algorithm works as follows. The entire knowledge base is divided into small text fragments called chunks, the size of which can range from several lines to several paragraphs



(approximately from 100 to 1000 words). Chunks are digitized using an embedder and transformed into embeddings, which are vectors. These numbers contain the hidden meaning of each chunk, allowing for semantic search. Then, the vectors are stored in a special database where they can be searched for similarity to a query.

When the user sends a query to the LLM, the query text is encoded into an embedding by the same embedder, and a search is performed in the database to find the most semantically similar vectors. Typically, cosine similarity is calculated between the query vector and chunk vectors, after which the top N most similar vectors are selected (Ahadh, 2021).

At the next stage, the text fragments corresponding to the found vectors are combined with the user's query into a single context and passed to the language model. Thus, the model "thinks" that the user not only asked a question but also provided data for the answer.

An important factor is choosing the optimal number and size of fragments. If too much unnecessary information is provided, or too little, the model will not be able to give the correct answer. The smaller the fragment, the more precise the literal search will be. The larger the fragment, the closer the search is to the semantic one. Different queries require different amounts of fragments. The optimal fragment size must be determined empirically, below which information loses meaning and clutters the context. Fragments should overlap with each other so that input to the model is continuous, not isolated pieces. The beginning and end of a fragment should make sense, ideally matching the start and end of sentences or paragraphs (Thiyagarajan, 2021).

Semantic search via embeddings does not always yield the desired results, especially for specific terms. A combined approach with TF-IDF and ranking algorithms like BM25 is often used (Okada, 2021). To improve accuracy, the user's query can be rephrased several times with the help of an LLM, and fragments can be searched using all variations. Usually, 3–5 variations of the query are made, and the results are then combined. If a lot of information is found in response to a query and it does not fit in the context, it can be simplified using the LLM and passed in a compressed form to be used in generating the answer.

The key element in the algorithm for automatic keyword extraction is the ability to provide users with fast access to the relevant content. Let's look at two common algorithms: TF-IDF (Term Frequency-Inverse Document Frequency)—a statistical measure used to evaluate the importance of a word in the context of a document, which is part of a collection of documents or corpus, literally the inverse frequency of term usage in the document—and TextRank—an algorithm for building a graph model based on the original natural language text (Tixier, 2016).

The TF-IDF algorithm was modified by adding an algorithm to calculate the weight of a patent title based on the characteristics of the patent text. Additionally, an automatic extraction algorithm using Word2Vec was applied to extract semantics.

Experimental results showed that as the number of automatically extracted keywords increased, the accuracy of the TF-IDF, TextRank, and modified TF-IDF algorithms gradually decreased, while the memorization speed increased, thus proving the effectiveness of the modified TF-IDF algorithm for automatic keyword extraction from patent texts.

The TF-IDF algorithm is a time-tested and commonly used algorithm for automatic keyword extraction. This algorithm takes into account that the significance of a word is directly proportional to how often it appears in a document but inversely proportional to how often it appears in the text corpus. The abbreviation TF refers to term frequency. The method of calculating TF is as follows:

$$TF_{i,j} = \frac{N_{i,j}}{\sum_k N_{k,j}} \quad (1)$$

Where $N_{i,j}$, denotes the frequency of occurrence of the word i in the text d_j, and k is the

number of different words in the text.

In other words:

$$TF(t,d) = \frac{Total\ number\ of\ terms\ in\ the\ document\ d}{The\ number\ of\ mentions\ of\ the\ term\ t\ in\ the\ document\ d}$$

The abbreviation IDF refers to the inverse frequency of use of the document.

$$IDF_i = \log \frac{|D|}{|j : t_i \in d_j|} \tag{2}$$

where $|D|$ is the total number of texts in the corpus, and $|j : t_i \in d_j|$ is the number of texts containing the word i in the corpus.

The TF-IDF value is obtained by

$$TF - IDF_{(t,d,D)} = TF(t,d) \times IDF(t,D) \tag{3}$$

If a word has a high TF value and a low IDF value, it is considered to have high criticality. This method is easy to use and widely applied.

The TextRank algorithm is an enhanced version of the PageRank algorithm (Implementation of TextRank Algorithm Methods for Keyword Extraction). The PageRank principle is that if a web page is linked to many other web pages, it indicates that the web page is relatively important, which means its PageRank value is high. Each word or phrase in a text is represented as a node in a text graph, and the relationships between words are described as edges that measure the similarity between words.

PageRank is calculated using the following formula:

$$S(V_i) = (1-d) + d \times \sum_{j \in In(V_i)} \frac{1}{|Out(V_j)|} S(V_j) \tag{4}$$

where $S(V_i)$ is the PR-value of web page V_i, V_j is the web page associated with V_i, i.e. the incoming link, $In(V_j)$ is the set of incoming links, and $Out(V_j)$ is the number of elements in the set of links pointing to external sites for the j web page.

PR-value is one of the most effective ways to measure the return on investment (ROI) in communications, which converts the results of any PR activities, whether it's a press release, social media advertisement, into value added to the business and reputation. PR value is a calculation of the financial benefit from reaching your target audience through paid advertising, making it easy to measure and compare ROI in paid, organic, and owned media (Understanding PR value).

TextRank is a graph-based ranking algorithm. It considers sentences or words in a text as nodes in the graph, with relationships between them as edges, and determines their importance by calculating the weights between nodes. The formula for calculating the TextRank algorithm, based on PageRank, looks as follows:

$$WS(V_i) = (1-d) + d \times \sum_{V_j \in In(V_j)} \frac{W_{ji}}{\sum_{V_k \in Out(V_j)} W_{jk}} WS(V_j) \tag{5}$$

where $WS(V_j)$ is the weight of sentence *i*, the indicator W_{ji} indicates the similarity of sentences, and d is the attenuation coefficient, is usually assumed to be 0.85.

After processing the text with word segmentation and stop word removal, the TF-HF-IDF value is calculated, and individual words are represented as Word2Vec word vectors (Sumayasuhana, 2022). Stop words are words that do not carry semantic meaning in a sentence, such as conjunctions or prepositions. Additionally, special characters must also be excluded from the text. After this, the semantic similarity of the processed words is calculated. Using the hierarchical clustering algorithm, a set of semantic thematic concepts is obtained, i.e., a set of words

with similar semantics. Finally, the overall weight value is calculated:

$$W - score(t_i, d) = score(t_i, d) + \sum_{j=1}^{N} sim(t_i, t_j) \tag{6}$$

$$sim(t_i, t_j) = \cos\theta = \frac{e_i \times e_j}{|e_i| \times |e_j|} \tag{7}$$

where $\sum_{j=1}^{N} sim(t_i, t_j)$ refers to the sum of semantic similarities between the word t_i and other words, $sim(t_i, t_j)$ is a semantic similarity based on Word2vec between words t_i and t_j, e_i is a vector of words t_i, and e_j a vector of words t_j.

An example could be the automatic categorization of articles on news portals by topic using TF-IDF-based clustering. In social networks, this method can be used to group posts and create personalized news feeds. Furthermore, vector representation of texts based on TF-IDF can be applied in machine learning models for document classification. For example, TF-IDF can be used to classify emails for spam filtering or automate customer service by sorting customer queries into appropriate categories (Wang, 2024).

Geometrically, the binary classifier SVM can be represented as a hyperplane in the object space that effectively separates points corresponding to positive and negative instances. During the training process, SVM selects a hyperplane that maximally separates positive and negative examples, creating a gap or margin between them, which represents the distance from the hyperplane to the nearest points of both classes. These nearest points are called support vectors, and they play a key role in defining the hyperplane, while the rest of the training data does not influence the final decision. This property distinguishes SVM from other classification algorithms. One of the main advantages of SVM is its theoretically grounded approach to reducing the risk of overfitting, allowing it to perform well regardless of the feature space's dimensionality. Moreover, SVM does not require parameter tuning, as there is a theoretically grounded "default" choice of parameters that have demonstrated optimal performance in experimental validation.

Figure 8 shows a system model that can perform patent text classification and compare the capabilities of the TF-IDF and TF-RF algorithms (Harmandini, 2024).

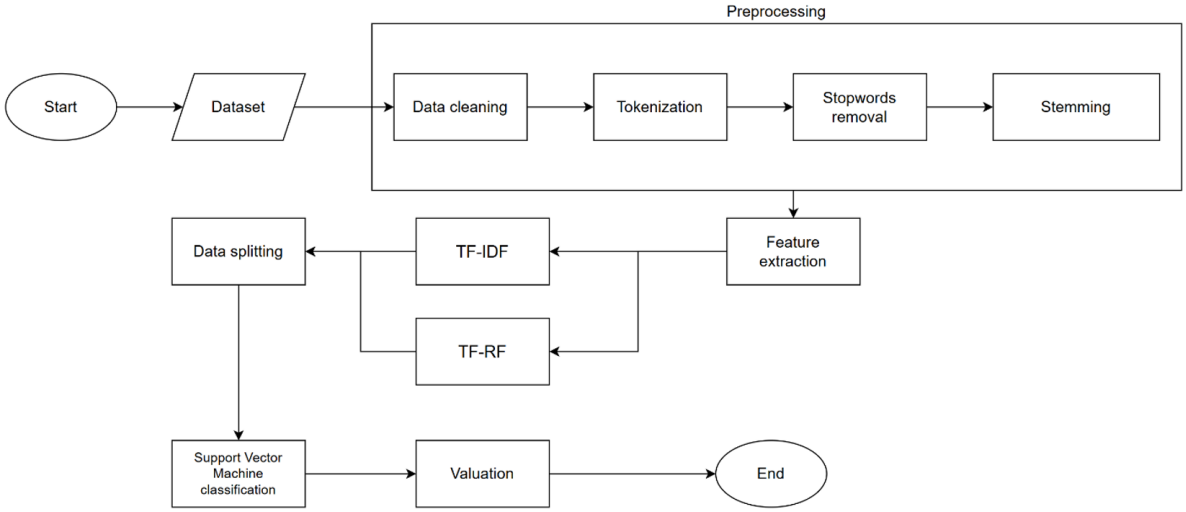
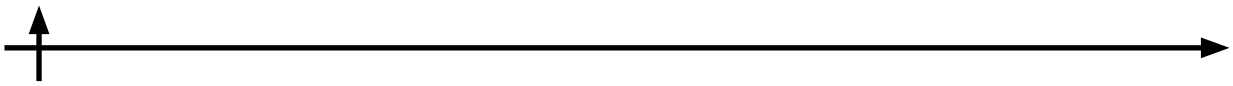


Fig. 8. A system model for performing text classification.



A comparison was made of the effect of the number of key words on the performance of the algorithm. The number of selected key words ranged from 1 to 10. For comparison of the algorithms, the following metrics were used: Precision, Recall rate, F-measure, and F1-score.

Precision is a metric that measures how accurately the model classifies positive examples among all predicted positive cases. The formula for calculating precision is a fraction or ratio where the numerator is the number of true positive examples, i.e., those cases where the model correctly predicted a positive outcome, and the denominator is the sum of true positive and false negative examples. FP (False Positive) is the number of false positive examples, where the model predicted a positive result that was actually negative:

$$Precision = \frac{TP}{TP + FP'} \tag{8}$$

Recall rate, or simply recall, is a metric used in machine learning and information retrieval that measures the ability of a model to find all relevant objects or positive examples in the data. In the context of binary classification, it is the proportion of true positive examples that the model correctly classified.

The formula for calculating recall is the ratio of the number of true positive examples to the sum of true positive and false negative results:

$$Recall = \frac{TP}{TP + FN'} \tag{9}$$

where:

TP (True Positives) is the number of examples that were correctly classified by the model.

FN (False Negatives) is the number of examples that the model incorrectly classified as negative.

Recall is important in cases where missing positive examples could have serious consequences. For example, in disease diagnosis, where it is crucial to identify all cases of illness, or in security systems where it is necessary to detect all threats.

F-measure, also sometimes called F1-score, is a metric used to evaluate the performance of machine learning models, primarily in classification tasks. It combines into a single number two important metrics, precision and recall. Thus, the F1-score is the harmonic mean of both metrics.

The formula for calculating F1-score is:

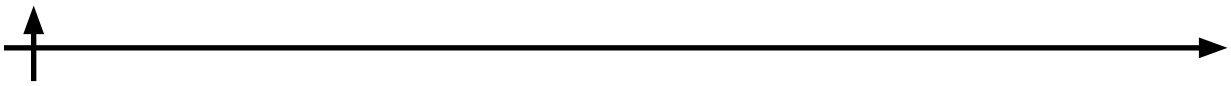
$$F1 = 2 \times \frac{Precision \times Recall}{Precision + Recall} \tag{10}$$

The F1 score provides a weighted representation of how well the model performs when missing positive examples and having false positives matter. This metric is typically used when a balance between precision and recall needs to be maintained. The closer the F1-score is to 1, the better the model performs. If the F1-score is closer to 0, it indicates weak model performance.

Databases can be roughly divided into two groups: specialized vector databases and databases that support vector search. The first group includes Chroma, Vespa, Marqo, Qdrant, LanceDB, Milvus, Pinecone, and Weaviate. The second group includes OpenSearch, ClickHouse, PostgreSQL, Cassandra, Redis, Elasticsearch, Rockset, and SingleStore.

Currently, the project uses PostgreSQL, as it is an open-source product that allows storing vector embeddings alongside the original data. However, with the project's development and further scaling, there may be a transition to Milvus, as this product is well-suited for ensuring high availability and fault tolerance through built-in load balancing mechanisms. The project uses the Langchain framework, which provides faster, cheaper, and more efficient task execution compared to previous agent models (Intro to LLM Agents with Langchain).

There are three agent architectures in LangGraph that demonstrate a plan-and-execute



design style (LangGraph). Building language agents as graphs. These agents promise several improvements over traditional “reflect and act” ReAct agents.

First, they can execute multi-step workflows faster because there is no need to call a larger agent after each action. Each subtask can be executed without an additional LLM call or with a lighter LLM call. Second, they offer cost savings compared to ReAct agents. If LLM calls are used for subtasks, they can usually be sent to smaller models that are domain specific. In this case, the larger model is called on only for planning and replanning steps and generating the final response.

Third, they can provide higher speed and quality of task execution, forcing the planner to explicitly consider all the steps required to complete the entire task. Generating full reasoning steps is a proven prompting method to improve results. Breaking the problem down also allows for more purposeful task execution.

A ReAct agent queries the language model using a recurring cycle of thoughts, actions, and observations. It leverages the benefits of the chain-of-thought approach, opting to choose one action at a time. While this can be effective for simple tasks, it has a couple of main drawbacks:

1. Each tool call requires an LLM call.

2. The LLM plans for only one subtask at a time. This can lead to suboptimal trajectories as it is not forced to “reason” about the entire task.

One way to overcome these two drawbacks is to perform a clear planning stage.

Plan-and-execute is a simple architecture consisting of two components:

1. A planner proposes that the LLM generate a multi-step plan to execute a large task.

2. Executors, which take the user query and a step in the plan and call one or more tools to complete that task.

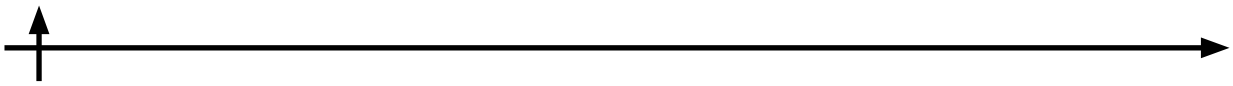
Once the execution is completed, the agent is called again with a request for replanning, allowing it to decide whether to finish with an answer or generate a subsequent plan if the first plan did not yield the desired result (Plan-and-Execute Agents). This agent structure allows us to avoid calling a large LLM for planning each tool call. It is still limited by the sequential tool call and uses the LLM for each task, as it does not support variable assignments.

Results and Discussion

The architecture of the developed product is as follows. In the first stage, automated collection and systematization of data obtained from the patent registry is carried out, for example, from the Rospatent registry. Patents are stored in a PostgreSQL database consisting of 6 tables, each containing about one million rows. Then, the text data is summarized, and the classical TF-IDF method is applied to extract keywords. The vector database stores embeddings obtained using GigaChat. New patent entries from the Rospatent registry are automatically loaded into the database every 24 hours. The current information on patents in text format occupies approximately 3 TB of storage.

The user interaction with the product follows this scenario. The user makes a query on the website regarding a topic of interest. A check is performed to see if there is an existing entry in the database containing a summary of information related to the query. If no corresponding entry exists, it is added at this stage. Patent searches in the database are based on the information in the user's query and the patent title. As a result, a ranked list of the top 5, 10, or 100 results is displayed depending on the search settings, and a brief summary of the entire patent or a specific section can be obtained.

Patents are clustered together based on embeddings obtained through GigaChat. The closer the texts are in meaning, the smaller the cosine distance between them in the vector database. Patents in clusters are grouped by common topics, such as, for example, radio communications



or tablet computers, or by common patent holders. The average cluster size is 100 patents. Cluster names are generated based on patent titles using GigaChat.

The product can be used for analytical work on existing solutions, tech scouting, and intellectual property protection.

In the vector database, data is stored in the form of embeddings. The user makes a query to the database, after which relevant texts are selected from the database. The retrieved texts are sorted and packaged into a prompt. Then, the top 5 or 10 most relevant results are fed into the LLM, along with the prompt, as contexts. The LLM determines the most appropriate context from the provided ones and gives a response to the user's query.

A supporting service based on LLM is used to generate complex prompts. The input to the service consists of a simple prompt and a description of the format in which the answer should be provided. The service generates a complex prompt, which is then sent to the model.

Conclusion

Among the main technical characteristics of the project, the following can be highlighted: the speed of generating patent research, the volume of content, and the accuracy of classification of the data found for analysis. The speed of generating one research study is within the range of 30–60 minutes, which is tens of times faster than manually conducting patent research.

Prospects for further product development are considered, such as the creation of personal user accounts, which will allow for the personalization of the product for companies, and the use of more patent databases, including international ones. There is also the possibility of predicting future technological trends using AI through the clustering of all patents over time and identifying corresponding patterns.

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DIGITAL TOURISM PLATFORMS AS A MEANS TO PROMOTE INDUSTRIAL TOURISM IN RUSSIA: CURRENT STATUS AND IMPROVEMENT SUGGESTIONS

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Abstract. This research considers the main features of digital travel platforms aimed at promoting industrial tourism in Russia. The authors study four currently operating Russian platforms—Travel.RU, PromTourism, the Industrial Tourism section of the Visit Petersburg portal, and "Svoe Za Gorodom" [Your Own Countryside]—in order to assess their functions, strengths, and weaknesses. According to the findings, while these platforms provide helpful functions such as aggregating information and filtering tours, they do lack important features such as direct booking, detailed multimedia content, and user interaction, e.g., reviews and ratings. As a result, the authors conclude that efficient digital platforms for industrial tourism are supposed to incorporate comprehensive information, e-commerce capabilities, personalized user experience, and robust multimedia support to see visible improvements in their overall performance and user engagement.

Keywords: digital tourism platforms, industrial tourism, e-commerce, user experience, booking systems, multimedia content, tourism digitalization

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СОВРЕМЕННОЕ СОСТОЯНИЕ И ПЕРСПЕКТИВЫ РАЗВИТИЯ ЦИФРОВЫХ РЕШЕНИЙ ДЛЯ ОТРАСЛЕВЫХ ТУРИСТСКИХ ЭКОСИСТЕМ РОССИЙСКОЙ ФЕДЕРАЦИИ

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Аннотация. Данное исследование посвящено анализу ключевых особенностей цифровых платформ, ориентированных на развитие промышленного туризма в России. В ходе исследования были рассмотрены четыре действующих онлайн-портала (Travel.ru, PROMTOURISM, раздел «Промышленный туризм» на портале Visit Petersburg, «Свое за городом»), а также выявлены развитые аспекты платформ и их структурно-функциональные ограничения. В результате, авторами был сделан вывод о необходимости комплексного подхода к проектированию цифровых экосистем промышленного туризма, предполагающего интеграцию e-commerce-функций, персонализированных рекомендаций, качественного визуального контента и инструментов взаимодействия с пользователями.

Ключевые слова: цифровые туристические платформы, промышленный туризм, электронная коммерция, пользовательский опыт, системы бронирования, мультимедийный контент, цифровизация туризма

Для цитирования: Клундук Д.Ф., Тихомирова М.Е. Современное состояние и перспективы развития цифровых решений для отраслевых туристских экосистем Российской Федерации // Техноэкономика. 2025. Т. 4, № 2 (13). С. 21–31. DOI: https://doi.org/10.57809/2025.4.2.13.2

Introduction

Internet portals and platforms make an integral part of the current development stage of tourism. They are not only expected to possess an informational component but also integrate with the websites of organizations that shape tourist products via e-commerce, user databases, and personalized customer service. Online travel portals that contain comprehensive information about tourist sites are incredibly convenient and highly in demand. The role of websites remains important as tourists use them to plan trips and select destinations. Since the COVID-19 pandemic, such online resources have been actively created and scaled up in Russia. This format of showing available destinations goes far beyond presenting information. Indeed, it is a powerful marketing tool and an effective way to communicate with tourists. With the development of domestic tourism in Russia and the emergence of its new types, such as industrial, educational, water tourism, etc., the range of excursions, itineraries, and tours is expanding. In this regard, the need for implementation of a single digital information portal for the country, federal district, and region is increasing (Pencarelli, 2020; Mckenna, 2024).

This research aims to identify the necessary functions of digital platforms for industrial tourism. It is necessary to analyze the available domestic experience in the digitalization of industrial tourism and identify its strengths and weaknesses.

Materials and Methods

Currently, there is a wide range of papers that are devoted to the global experience in the development and operation of digital tourism products (Kopyrin, 2023; Bogolyubov, 2023; Mckenna, 2024; Popova, 2023). Significant attention is paid to the need for import substitution in the digitalization of tourism. In 2023, Morozov M. and Morozova N. actively dealt with this issue (Morozov, Morozova, 2023). Industrial tourism is an especially popular research topic in 2024-2025, widely considered both in Russia and worldwide (Tankieva, 2024; Khatami, 2024; Cassia, 2020; An, Lee, 2021; Nikulina, 2017). All the above-mentioned sources were invited in the research.

System, documentary, and logical analyses were also employed in this research.

Results and Discussion

Russia holds several platforms that aggregate useful information on travelling around the country. All of them function quite successfully within the framework of the national project "Tourism and Hospitality Industry." Figure 1 presents the visual designs and names of the selected platforms.

Fig. 1. Russian platforms: digital experience in supporting and developing the tourism industry.

The following platforms were selected for this research:

1. Travel.RU — a national tourist portal that contains information on travelling around the country (RUSSIA Territory of Hospitality);

2. PromTourism — a portal on industrial tourism in Russia and the CIS (Selection of industrial tours);

3. Visit Petersburg: the "Industrial Tourism" section — an official tourist portal of St. Petersburg, supported by the city government; it presents national tourist routes, specifically the industrial ones (Industrial tourism in Saint Petersburg);

4. "Svoe Za Gorodom" [Your Own Countryside]—a platform initiated by the Russian Agricultural Bank to promote agritourism in Russia (Time to look at Russia in a new way).

Assessment of Travel.RU

Travel.RU contains general information on available excursions and tours, as well as popular sites in a particular region or district. In this section the authors will take a closer look at this resource in terms of its functions, digital capabilities, and advantages and disadvantages of the presented content.

The website presents the "North-West" direction but does not fully coincide with the statutory composition of the Northwestern Federal District. All subjects of the Federal District are divided into two directions: "North" and "Northwest." Each of the presented destinations can be filtered by interest in the "More Ideas" section, including the tag "industrial tours." However, when redirected to the "Northwestern Federal District" section, the user finds very limited information. The total number of excursions and tours in the two destinations under

consideration is four, with the information being irrelevant and the list of tourist products incomplete. Since this service does not purely specialize in industrial tourism, there is a limitation in the detailing of routes. Therefore, this source is unlikely to satisfy the requirements of tourists searching for highly specialized destinations, such as the industrial ones. However, it is great for the formation of a tourist's own route or considering more traditional destinations of cultural or educational tourism.

Nevertheless, the functionality of Travel.RU is quite impressive. The website offers the following digital capabilities:

1. Search for routes and tours, including a convenient filter by region, target audience, recreation type, etc.;
2. A calendar of events and a "Popular Destinations" section, which makes it easier for potential tourists to select a destination and get familiar with new ideas and sites;
3. Interactive map of Russia, which allows selecting the region on the map and seeing available routes, attractions, collective accommodation facilities, and catering establishments;
4. High-quality visual design and focus on multimedia content: aesthetically organized site with photos, videos, and interactive tours, no information overload;
5. Multiple website versions: smartphones, tablets, and computers;
6. English version of the website—a great solution for better international engagement.

Figure 2 summarizes the specified benefits and drawbacks of Travel.RU.

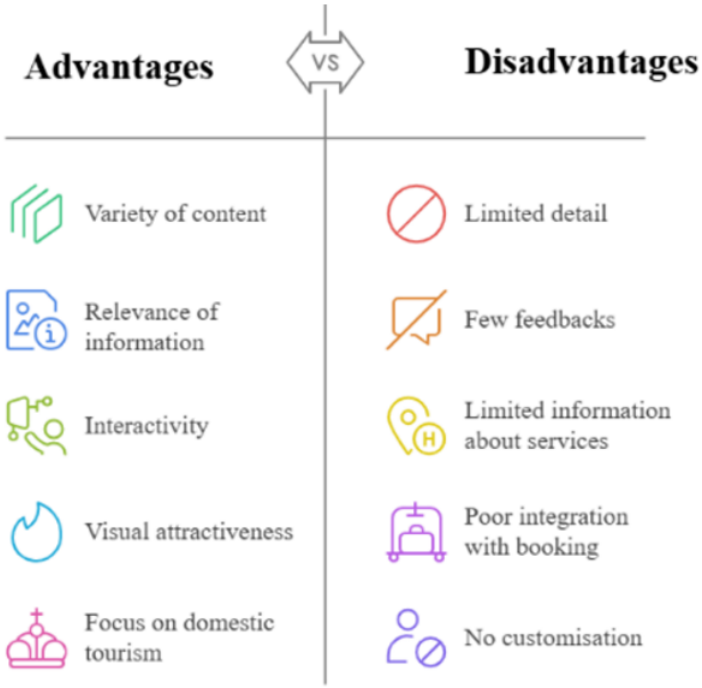

Fig. 2. Advantages and disadvantages of content provided by Travel.RU.

Overall, Travel.RU is a useful and up-to-date travel-planning tool with multiple strengths, such as visual content, high-quality navigation, and convenient filters. However, in order for the platform to increase efficiency, it would be recommended to refine the delivery of tourism data, add elements of user interaction (reviews and ratings), and ensure online booking.

Assessment of PromTourism

The PromTourism platform is a federal digital resource specifically designed for industrial tourism. It serves as a navigation system for those wishing to arrange a visit to operating enter-

prises in Russia and Belarus.

This project is supported by the Agency for Strategic Initiatives for the Implementation of New Projects and the Ministry of Industry and Trade of the Russian Federation, as well as other partners, including the Competence Centre for Tourism and Hospitality. The platform primarily aims at shaping a positive image of industrial enterprises and factories in Russia.

PromTourism holds a wide functionality, with the digital capabilities displayed in five sections. A catalogue of enterprises is presented with a description of excursions, visit requirements, a brief history, a video presentation, and areas of activity.

An advanced search for tours by various parameters is provided in the "Selection of an Industrial Tour" section. The user needs to select relevant information from the six options, including region, industry, audience type, purpose of the visit, and number of participants. In this section, tours are focused on the B2G, B2B, and B2C sectors. With a total of 11 target groups, the "group type" parameter presents an extended list of potential visitors, for example, individual tourists, government agencies, foreign tourists, etc. However, the "number of employees" parameter may not always be accurate to apply to certain target groups presented. It is also important to note that the biggest share of the proposed tours can be visited by groups of 10 individuals.

The "Ready-made Tours" section contains offers of ready tours, which makes it easier for users who do not want to tailor an itinerary of their own. However, such an option is available for only two subjects of the Russian Federation: Moscow and the Chelyabinsk region.

The "Press Centre" section posts updates on the development of industrial tourism in the country as well as news on events and successful cases, thus allowing users to get acquainted with the latest trends in the synergy of industry and tourism.

Another interesting section is called "Promtourism.Practicum"—a consulting centre. It is a large-scale project that extends to friendly countries and regions of the Russian Federation. Its framework provides four training concepts: Industrial Tourism Strategy, Industrial Tourism Practicum, Industrial Tourism Tour Guide, and Industrial Tourism Inspection. All of them are designed for different requests and regions. Their major mission is to adapt an industrial tourist product to the request of a specific enterprise or region. On top of that, Promtourism.Workshop is implemented as a quick and effective way to move from an idea to the first tourist flows.

Figure 3 presented the strengths and weaknesses of the PromTourism website.

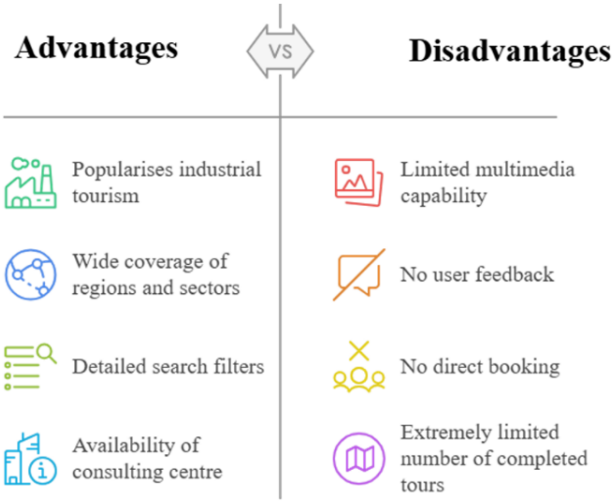

Fig. 3. Advantages and disadvantages of content provided by PromTourism.

Since industrial tourism has been a priority for the state for the past few years, the information provided by PromTourism is relevant and specialized in the cooperation of industry and tourism. It seeks to cover all 73 industry-specific regions of the Russian Federation and partnerships with Belarusian enterprises. Such a large sample of industrial sectors allows users to choose their tour by interest and geographical preference.

Nevertheless, some significant shortcomings are also present, including insufficient visual content, no online booking, an incomplete "Ready-made tours" section, and no user reviews, which could boost trust and awareness of potential visitors.

In general, PromTourism provides extensive searching opportunities, especially for the B2B and B2G segments at both Russian and international levels. What would boost the efficiency of the platform is definitely booking excursions, combined with an existing business filter as a means to attract more users.

Assessment of the "Industrial tourism" section of the Visit Petersburg website

The Visit Petersburg website itself is an official tourist portal of St. Petersburg that aims at emphasizing the status of the city as one of the key areas in the tourism industry. The website functions as sort of a guide to St. Petersburg, helping different categories of tourists to plan a high-quality, comfortable trip.

The website presents 4 components of "Industrial Tourism": industrial enterprises of St. Petersburg, excursions, trips to plants and factories, and tips for tourists. Every section provides a wide list of enterprises in various industries; however, not all of them are described in a sufficient way and are lacking videos and photos. Nevertheless, an integrated approach has been taken to solve the problems of tourists during the preparation and during visits to industrial enterprises. One of the steps to do so was a memo, developed in order to give access to the set of tips for industrial tourists in St. Petersburg.

Figure 4 summarizes the major upsides and downsides of the content delivery of the platform under consideration.

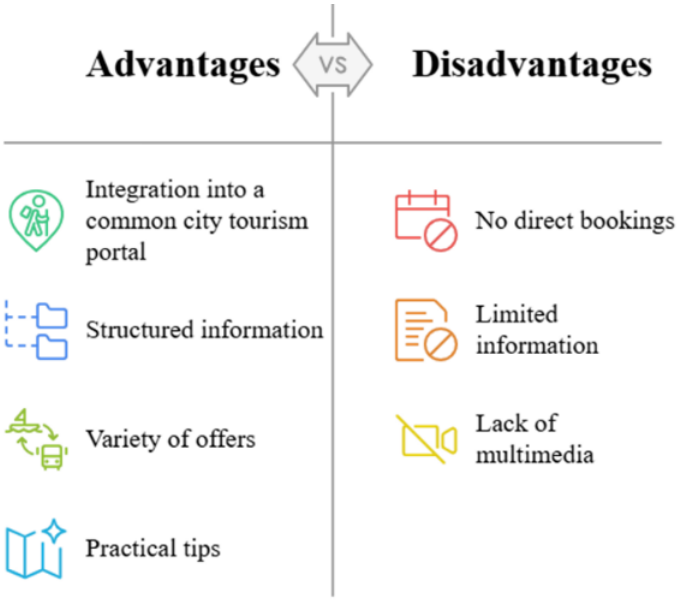

Fig. 4. Advantages and disadvantages of content provided by the "Industrial Tourism" section of the Visit Petersburg website.

The very fact of coverage of industrial tourism serves as a driver for its popularization. According to the platform, the reason why you should visit the city is to take a tour to the industrial enterprises of the northern capital.

"Industrial Tourism" delivers all information on excursions to enterprises, tours, and trips in a clearly structured way. The site offers a comprehensive classification of businesses by industry, which makes it way easier for users to navigate and search.

When it comes to the imperfections, the following range is identified: absence of an online booking option, no redirection to the websites of plants and factories, insufficient detail, and lack of visual content, which prevents the user from building whole-scale expectations for the future visit.

A high-quality boost in the efficiency of this platform and improvement of user experience depend on the integration of online booking and expansion of multimedia content.

Assessment of "Svoe Za Gorodom" [Your Own Countryside]

Despite the fact that the "Svoe Za Gorodom" website does not specifically focus on industrial tourism, it was still selected for this research as one of the most successfully implemented projects in Russia. This domestic digital project for tourism support should in no way be neglected.

"Svoe Za Gorodom" promotes ecotourism and rural tourism in Russia, offering users tours and excursions in the countryside. The following extensive functions and digital capabilities are available:

1. A poster with events of interest outside the city in a particular month—a selection of the most popular events around Russia, with the opportunity to sort all activities by location, time, and topic.

2. Catalogue of tours and excursions—a wide range of tourist products, including multi-day trips, gastronomic tours, agro-tours, and eco-tours. It is possible to filter these tours by regions, categories, and days.

3. Farm Information—data on various farms available for a visit, with itinerary descriptions, workshops, and tastings, as well as their prices.

4. Direct online booking—users have the opportunity to book tours and excursions on the site, which simplifies the process of planning trips and reduces the time spent on searching for primary sources of information on tourist products.

5. Gift certificates—an extremely convenient and original feature that allows attracting more new users.

For better clarity, Figures 5 and 6 below show the entire collection of identified advantages and disadvantages in the content delivery by "Svoe Za Gorodom."

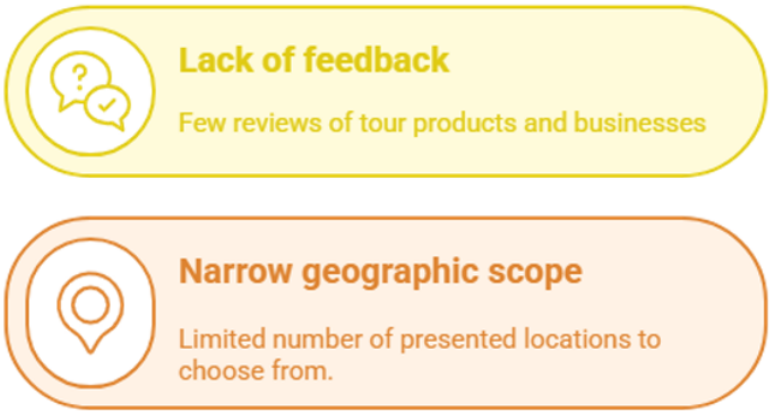

Fig. 5. Disadvantages of content provided by "Svoe Za Gorodom".

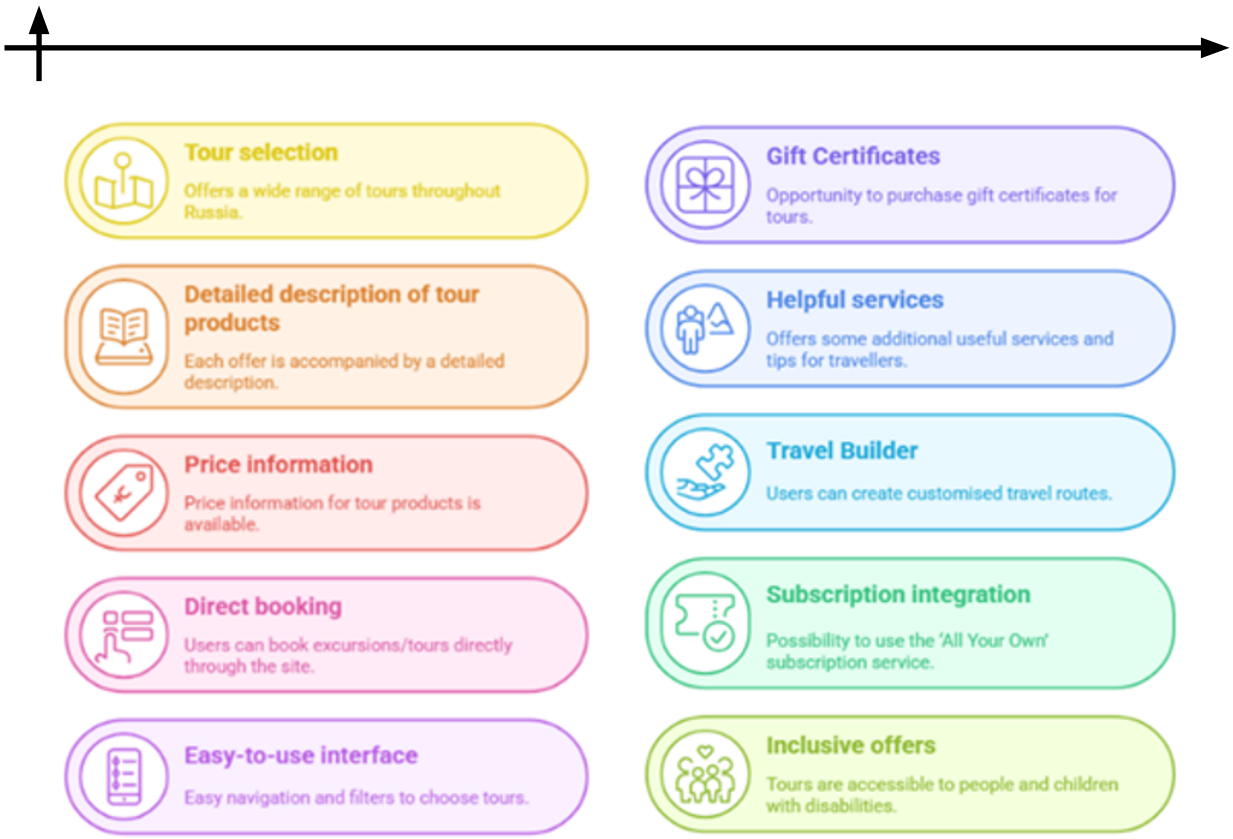

Fig. 6. Advantages of content provided by "Svoe Za Gorodom".

Overall, "Svoe Za Gorodom" is a comprehensive digital platform that combines many necessary functions for users to meet all their needs with the help of a wide range of available tours, detailed descriptions of tourist products, price lists, direct booking, interactive interfaces, gift certificates, additional services, and offers for challenged people.

Of course, some areas for improvement are visible enough. For instance, it would be a win-win for the platform to expand the geography and encourage customer reviews.

Conclusion

Domestic digital platforms show significant progress in supporting tourism but still require a range of improvements to boost convenience, interactivity, and completeness of information (Ilyina, Mikhailova, 2013; Ilyina, 2016). Successful practices, such as direct booking in "Svoe Za Gorodom," can serve as a benchmark for other projects. What is more, further digitalization should focus on a more detailed practical implementation of the main mission—the popularization of specific types of tourism (Voronova, Vasiliev, 2024). Thus, it is necessary for the platforms to meet the needs of users and not only facilitate the search for ideas but also ensure their practical implementation (e.g., direct booking) (Tikhomirova, Voronova, 2025).

As a result of the overview provided in this research, the authors specified the set of functions and services that are absolutely inherent for the tourism platforms to progress (Figure 7):

1. Detailed and comprehensive information on the destination that will enable the users to find out the basic information about the site, its features, description, photos, and videos.

2. Promotion of destination products and services. Websites, as a global showcase for tourism promotion, should boost the attractiveness of a destination via high-quality visual content, etc.

3. Support and improvement of advertising offers.

4. Destination branding. The online service should be able to reflect the image that needs to be created for a particular destination and support the chosen approach to branding. Thus,

what should be implemented is a complex approach that would demonstrate the visual quality and interactivity of the site and provide a convincing presentation of the image.

5. Ability to build personalized relationships with tourists and travel representatives. People should be able to register on the website and receive more detailed information if they need it, as well as provide more details about their travel interests. Databases of individuals (B2C segment) and representatives of the tourism business (B2B segment) can be created by registering on sites and then used to maintain constant contacts.

6. Involvement of users in discussions.

7. Visitor databases and conducting research (online surveys, databases of registered people). This can be a very inexpensive and productive method of data collection because it takes place online, and the respondents are not only tourists but also professionals and specialists in tourism.

8. Long-term partnerships with destinations—a comprehensive tourism information portal can be an excellent tool for partnerships with tourism stakeholders and other organizations.

9. E-commerce opportunities—the functionality of the website should allow visitors to book excursions and tours of their choice.

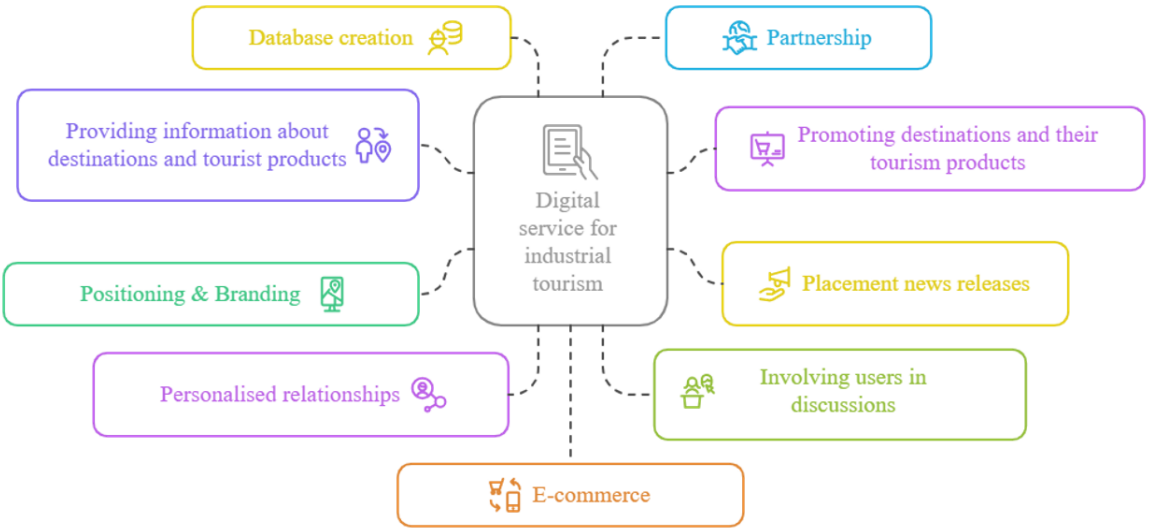

Fig. 7. Main functions of a digital service for industrial tourism.

Despite the visible success of the existing digital tourism platforms in Russia, some imperfections can be identified, including limited interactivity, lack of direct booking, and insufficient multimedia. To optimize these platforms in the future, it is necessary to implement e-commerce features, increase user engagement through reviews and personalized accounts, expand multimedia, and promote an integrated user-centred approach.

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A MODEL FOR SATISFACTION IMPROVEMENT IN PARTICIPANTS OF THE EDUCATIONAL PROCESS VIA THE INTRODUCTION OF LEAN TOOLS IN THE ADMINISTRATION OF UNIVERSITIES

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Abstract. This paper considers a model to boost satisfaction in all educational stakeholders at higher education institutions via the introduction of lean manufacturing techniques into administrative departments. The authors emphasize the importance of using lean methodology due to increasing competition in the education market and the need for resource optimization. The authors propose a model that illustrates the relationship between resources, processes, lean manufacturing tools, and the level of satisfaction among students, faculty, and staff. The research method involves analyzing current processes, identifying areas for improvement, and implementing techniques such as 5S, value stream mapping, Kanban, and standardization. According to the results, the implementation of lean techniques can reduce time and cost, decrease bureaucratic burden, and enhance service quality. In turn, it would have a positive impact on the satisfaction of all participants in the educational process. The practical significance of this research lies in the potential to apply the proposed model in order to enhance the university performance and ensure sustainable development or higher education.

Keywords: lean manufacturing, higher education institution, dean's office, participant satisfaction, process optimization, standardization, operational efficiency, management model

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МОДЕЛЬ ПОВЫШЕНИЯ УДОВЛЕТВОРЕННОСТИ УЧАСТНИКОВ ОБРАЗОВАТЕЛЬНОГО ПРОЦЕССА ЧЕРЕЗ ВНЕДРЕНИЕ ИНСТРУМЕНТОВ БЕРЕЖЛИВОГО ПРОИЗВОДСТВА В АДМИНИСТРАТИВНЫХ ПОДРАЗДЕЛЕНИЯХ ВУЗОВ

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Аннотация. Статья посвящена разработке модели повышения удовлетворенности участников образовательного процесса в высших учебных заведениях через внедрение инструментов бережливого производства в административных подразделениях. Авторы рассматривают актуальность применения Lean-методологии в условиях растущей конкуренции на рынке образовательных услуг и необходимости оптимизации ресурсов. В работе предложена модель, которая демонстрирует взаимосвязь между ресурсами, процессами, инструментами бережливого производства и уровнем удовлетворенности студентов, преподавателей и сотрудников. Методология исследования включает анализ существующих процессов, выявление потерь и их устранение с помощью таких инструментов, как 5S, картирование потока создания ценности, канбан и стандартизация. Результаты показывают, что внедрение инструментов бережливого производства способствует сокращению временных и ресурсных затрат, снижению бюрократической нагрузки и повышению качества услуг, что, в свою очередь, положительно влияет на удовлетворенность всех участников образовательного процесса. Практическая значимость исследования заключается в возможности применения предложенной модели для повышения эффективности деятельности вузов и их устойчивого развития.

Ключевые слова: бережливое производство, высшее учебное заведение, деканат, удовлетворенность участников, оптимизация процессов, стандартизация, операционная эффективность, модель управления

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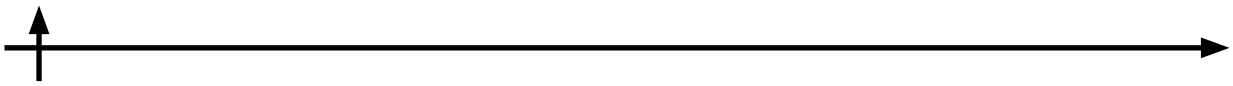
Introduction

Higher education institutions play a crucial role in socio-economic development by acting as a catalyst and contributing to the formation of intellectual capital. They are essential for transferring knowledge and skills to future professionals, as well as for generating new knowledge, innovation, and technology. The quality of higher education has a direct impact on a country's competitiveness and its ability to face modern challenges, ensuring its long-term sustainable development.

In the context of improving the efficiency of higher education institutions, the concept of lean manufacturing has become increasingly relevant. This approach, which is based on the principles of flexibility, resource optimization, customer focus, and loss minimization, offers powerful tools for enhancing educational processes and improving service quality (Loginova, 2021).



With increasing competition in the education market, implementing lean manufacturing principles has become not only desirable but essential for the successful operation of universities (Myslyakova, 2020; Romanov, 2021). Optimizing processes, rationally utilizing resources, and enhancing the quality of educational programs enable universities to strengthen their market position, attract talented students and faculty, and contribute significantly to economic and societal development (Pulin, 2020; Lyamin, 2023; Bykova, 2020).

The adaptation of Lean-principles in higher education involves transforming them to fit the specific needs of educational activities. Customer orientation in this context means focusing on the needs of students and other stakeholders. Resource optimization implies using financial, material, time, and intellectual assets rationally. The introduction of lean technologies into educational processes improves the quality of services, reduces costs, and enhances interaction with the outside world. This, in turn, helps increase the competitiveness and long-term sustainability of higher education institutions (Sharafullina, Chelombitko, Golubenko, 2020; Turieva, Brenman, 2024).

The relevance of integrating lean manufacturing into the strategic and operational activities of higher education institutions is determined by several interrelated factors. In today's rapidly evolving educational environment, where competition in the education market is growing, universities are faced with the challenge of increasing resource efficiency, optimizing business processes, and ensuring high-quality education. Lean manufacturing, which focuses on minimizing all kinds of losses and continuous improvement, provides a set of tools to help achieve these goals (Avdeeva, 2019; Akmayeva, 2019).

The significance of implementing this approach stems from the need to adapt to changing student and labour market demands, enhance the transparency and accountability of the university, and pursue sustainable development in the long run. Therefore, introducing lean manufacturing principles represents a strategically significant step towards enhancing the competitiveness and efficiency of modern universities.

One of the key principles of lean manufacturing is a focus on the customer. In the case of educational institutions, this means focusing on the needs and expectations of various stakeholders, including students, teachers, administrators, and potential employers. Implementing this approach requires an in-depth understanding of the current needs of each stakeholder group, as well as systematic efforts to optimize and improve internal processes.

This includes the use of lean manufacturing techniques such as MUDA and process standardization, as well as continuous improvement (Kaizen). These tools help to improve the quality of education and meet the expectations of every party involved in the academic process.

Materials and Methods

The study used an integrated approach to increase the satisfaction of participants in the educational process by introducing lean manufacturing tools to the administrative departments of the university.

At the first stage, the authors analyzed the current processes of the dean's office to identify losses that did not add value for students, faculty, and staff. Monitoring, document analysis, and interviews with key stakeholders were used for this purpose.

What is more, the authors assessed efficiency based on a comparison of indicators before and after introduction of lean tools, such as query processing time, error rate, participant satisfaction, and departmental efficiency. Descriptive statistics and comparative analysis were invited to process statistical data. This approach ensures the repeatability of the research and the ability to adapt the proposed model to other universities, considering their unique organizational characteristics.

Results and Discussion

To optimize the operation of university departments, the integration of lean manufacturing tools is essential. As part of implementing lean manufacturing tools in university departments, it is crucial to identify and eliminate potential losses that may arise at various stages of the process. These losses primarily include the following:

– Preparation of unnecessary or overly voluminous reports, providing information that exceeds the requested amount, or duplicating data in different documents—all these are examples of overproduction;

– Lengthy approval and decision-making processes, slow IT system operations, and delays in delivery and/or response to calls;

– Errors in the preparation of documents, such as spelling, punctuation, and content, as well as mistakes in entering data;

– Various comments during re-approvals and information requests for clarifications and reformulations;

– Missing records or lost documents.

Another set of common issues is presented below:

– Irrational planning of work areas and inconvenient file locations;

– Departure of an employee for a meeting that could have been organized remotely;

– Sequential coordination instead of parallel coordination;

– Transferring documents or information manually to the next stage;

– Restoring and saving files;

– Transporting files or folders with documents;

– Storage of prepared information and analytical materials that are no longer relevant, accumulation of unresolved tasks and issues, as well as excess office supplies—unnecessary reserves;

– Excessive information in documents (emails), unnecessary information on presentation slides, and unnecessary approvals—excessive processing.

Eliminating the identified losses at all stages of the cycle is a key factor in improving its operational efficiency. Meanwhile, the analysis and assessment of activities should be conducted systematically in order to continually improve and create a sustainable organization.

Researchers and scientists are focusing on the potential of lean tools to optimize various university processes, including educational, research, and administrative activities.

Vladyka M.V., Gorbunova E.I., and Polevoy I.N., in their work, emphasize the need for a modern integrated lean manufacturing concept adapted to the specific needs of educational institutions. They also note the significance of adopting a synergistic approach to managing lean production technologies through the use of complementary and reinforcing tools and techniques that form an integrated lean educational system (Vladyka, 2019).

On the other hand, Khuziev G.M. and Sagitova N.S. emphasize the importance of employing a process-based approach when implementing lean production tools. They argue that in order to achieve effectiveness, it is essential to develop an adaptable model that prioritizes meeting the needs and expectations of all stakeholders (Khuziev, 2019).

In her research, Surovitskaya G.V. emphasizes the importance of lean manufacturing tools in the context of increased uncertainty and a rapidly changing external environment. These tools are crucial for ensuring the sustainable development of organizations. The author states that the maximum efficiency is achieved through the integrated use of these tools, considering their interrelationships and synergies (Surovitskaya, 2023).

The research data indicate a significant positive correlation between the use of lean technologies in universities and the satisfaction of participants in educational and administrative processes. The implementation of the 5S approach ensures the ergonomic working conditions for

the faculty and a convenient learning environment for students, stimulating their engagement and internal motivation.

In addition, mapping the value stream helps minimize the time spent on administrative tasks, reducing psycho-emotional stress and increasing employee satisfaction. This, in turn, contributes to a more efficient educational process.

Thus, it can be concluded that the use of lean tools in higher education is an effective way to optimize the management of educational, scientific, and administrative processes. Researchers emphasize the need to tailor lean approaches to the specific needs of universities, such as developing integrated models based on a process-oriented approach and combining various methods.

As mentioned above, the growing demand for management efficiency and the rational use of resources dictates the need for an increasing interest in the lean manufacturing methodology (Chelombitko, 2020; Hadasevich, 2022; Shustrov, 2023). The directorate (dean's office), as the key administrative unit responsible for coordinating educational, scientific, and economic processes at the institute (faculty) level, represents an important platform for the implementation of lean techniques (Silkina, 2023; Yanchevskaya, 2024; Lyamin, 2024). Therefore, the study of the practical application of these techniques in the operations of the directorate carries an outstanding significance.

Table 1. Application of lean tools in the operation of Dean's Office

Lean tools	Application example
5S	The introduction of a document management system that follows the 5S principles will reduce the time it takes to find necessary documents and lower the risk of losing valuable information.
Mapping	An analysis of the transfer process may identify redundant stages or duplicated functions, which can reduce the time needed to process a student's request.
Kanban	Using Kanban boards to manage exam retake and consultation requests can prevent overlaps and delays.
Standardization	Standard operating procedures (SOPs) for processing sabbatical requests will help reduce lead times and errors.

Students are key participants in various processes at the university, not only related to educational activities but also in other areas, such as administrative ones. Student satisfaction directly affects the reputation of the institution.

The implementation of lean principles and techniques, such as value stream mapping, standardization of procedures, and the Kanban system, can help reduce processing times, minimize errors, and improve service quality. This includes optimizing processes related to academic certificate issuance and course transfer.

These changes have a positive impact on the corporate image of the institution and enhance student loyalty. As for the personnel aspect, it is worth noting that the staff of the Dean's office performs a significant amount of operational work on a daily basis. They are responsible for document management, accounting document preparation, and coordination between teaching staff and students.

The introduction of lean tools, such as the 5S system, helps to structure work procedures and optimize time for information retrieval. It also reduces stress factors associated with multitasking by standardizing operational procedures. For instance, the ergonomization of the professional environment through the 5S (sorting, maintaining order) system significantly reduces the risk of losing documentation and optimizes access to information assets.

This transformation leads to an increase in operational efficiency and a higher level of professional self-fulfillment among the staff. The introduction of lean production tools has contributed to the development of a culture of continuous improvement in the dean's office.

For example, the Kaikaku system for proposal submission has provided an accumulation of ideas for optimizing the dean's office activities from key stakeholders, demonstrating a synergistic effect that not only increases operational efficiency but also strengthens team spirit and engagement among participants.

This integration of lean tools into the operations of the Dean's Office at the university represents a scientifically sound approach to improving administrative and managerial processes. The implementation of this approach has several benefits:

1. It reduces the duration of task cycles;
2. It reduces errors in document management;
3. It increases the loyalty of the academic community, including students, staff, and faculty.

In today's competitive higher education landscape, universities face increasing pressure to deliver quality educational services. To meet these challenges, it is essential for universities to optimize their operations and improve efficiency.

Administrative, educational, and research processes within universities often suffer from bureaucracy and inefficient resource allocation, leading to decreased satisfaction among key stakeholders such as employees, teachers, and students. To address these issues, universities must adopt modern management approaches to enhance their efficiency and create a more positive working and learning environment.

A model has been developed to analyze the impact of Lean manufacturing tools on participant satisfaction. This model examines the relationship between the implementation of Lean techniques, process optimization, and enhanced satisfaction for all stakeholders involved.

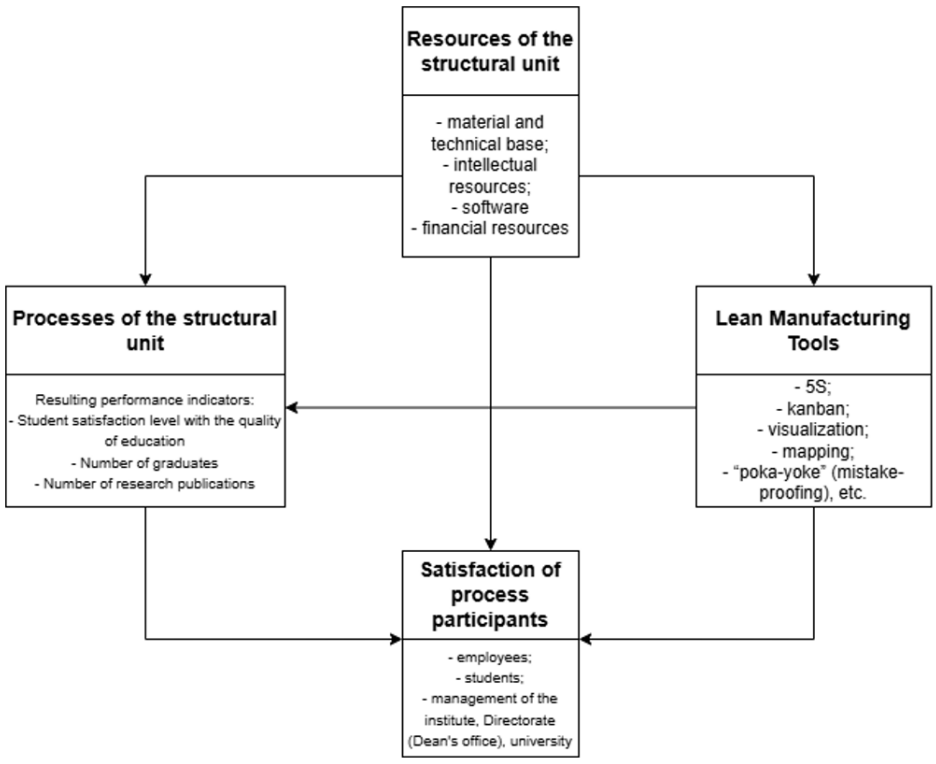
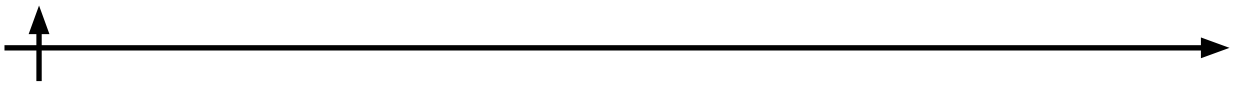


Fig. 1. Model of the lean-tools impact (designed by the authors).



The proposed model illustrates the relationship between the implementation of lean techniques and the level of satisfaction among participants in university activities. It also shows the correlation between the resources, procedures, and tools used in lean manufacturing and the satisfaction level of participants.

The model is based on the idea that optimizing processes through lean tools leads to improved efficiency, reduced costs, and enhanced service quality. This, in turn, positively impacts the satisfaction of university staff, faculty members, students, and other stakeholders.

This model can be seen as a system where resources are inputs, processes are converters, lean production techniques are catalysts for increased efficiency, and participant satisfaction is the result of activities reflecting the effectiveness of the whole system.

Resources form the foundation for the operation of any university department. These include:

- Material and technical resources (classrooms, laboratories, equipment);
- Human resources (teachers' qualifications, staff's scientific potential);
- Information technology (educational management systems, online learning platforms);
- Financial resources.

The availability of these resources—including financial, logistical, human, and informational—has a significant impact on the selection and use of lean manufacturing tools. The development of a set of techniques that ensure maximum efficiency is determined by the specific needs of the organization and its limitations in terms of resources.

Resource potential is a crucial factor in determining the efficiency and quality of operations in structural units. Adequate resource availability is a necessary condition for the sustainable operation and development of processes. Insufficient or inappropriate use of resources can lead to decreased productivity and poor performance. The modern material and technical infrastructure is linked to student satisfaction with the educational experience, while intellectual capital influences the publication activity of graduates and their competitiveness in the job market. Resources also influence the selection of lean manufacturing methods, as their implementation requires specific infrastructure and skills.

It is important to note that optimizing processes through the use of lean techniques can lead to improved performance, which in turn enhances the satisfaction of those involved in the process. Lean manufacturing techniques aim to eliminate waste, increase efficiency, and enhance the quality of work. These techniques have a dual impact: they improve the performance of the organization and the satisfaction of its members.

The interrelation between resources, processes, lean production tools, and participant satisfaction forms a complex system of interdependencies that determines the effectiveness of higher education institutions.

The proposed model demonstrates the complex impact of lean production resources, processes, and tools on the satisfaction of participants in university business processes. It emphasizes the importance of an integrated approach to implementing lean production principles in organizational activities. Effective resource management and the use of lean manufacturing tools are key factors in optimizing processes and increasing satisfaction among all stakeholders.

The implementation of this model can increase the efficiency of university structural divisions and create a favourable environment for all participants in the educational process. However, further research is needed to develop methods for quantifying the impact of each element of the model on the final results of university activities.

Conclusion

Overall, the developed model, which incorporates resource management, process optimiza-

tion, and the use of lean techniques, has a significant impact on enhancing the satisfaction of participants in the university's educational programs. The results indicate that the systematic implementation of the lean methodology not only contributes to enhancing the operational efficiency of the university's departments but also creates a supportive environment, significantly improving both productivity and the quality of educational services.

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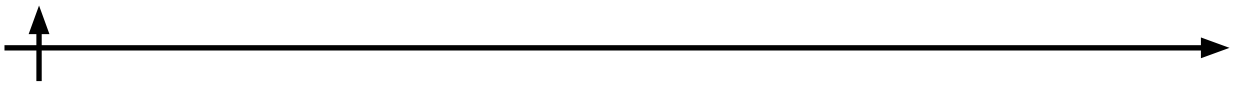

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INDUSTRY-SPECIFIC APPLICATION OF METHODS FOR REQUIREMENTS MANAGEMENT IN TOURISM AND HOSPITALITY

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Abstract. This paper aims to identify the most effective methods for requirements management in tourism and hospitality, which is a highly relevant issue within the growing complexity of managing hotel and tourism enterprises. In the course of the research, the authors define the major bottlenecks and limitations of current approaches and articulate a set of improvement suggestions for requirements management in hotels at different levels with due consideration of existing GOSTs.

Keywords: digitalization, enterprise architecture, requirements management, tourism, hospitality

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ОТРАСЛЕВЫЕ ОСОБЕННОСТИ ПРИМЕНЕНИЯ МЕТОДОВ УПРАВЛЕНИЯ ТРЕБОВАНИЯМИ В ТУРИЗМЕ И ГОСТЕПРИИМСТВЕ

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Аннотация. Данное исследование направлено на выявление наиболее эффективных методов управления требованиями в сфере туризма и гостеприимства в условиях повышения уровня сложности управления предприятиями гостинично-туристской области. В ходе исследования были определены ключевые проблемы и ограничения существующих подходов, а также разработаны рекомендации по улучшению системы управления требованиями в гостиницах различного уровня с учетом актуальных государственных стандартов.

Ключевые слова: цифровизация, архитектура предприятия, управление требованиями, туризм, гостеприимство

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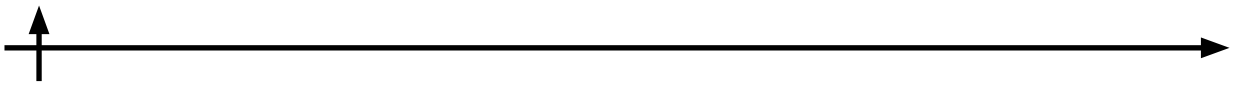
Introduction

The digital transformation of tourism has led to significant changes in how hospitality businesses operate. Today, these businesses make complex economic systems whose effectiveness depends on the balance of various elements (Voronova, 2024; Karamyshev, 2019). To create an efficient enterprise structure, it is essential to manage requirements during the implementation of a digital transformation strategy (Maydanova, 2023; Konovalova, 2018; Morgan, 2021). As more digital communication platforms emerge within tourism market, customers expect greater convenience, speed, and accuracy when receiving external and internal services. In order to meet the increasing demands of consumers, employees, suppliers, and partners in the hotel and tourism industry, a more effective requirements management system is needed. Due to the ever-changing and diverse nature of these demands, it has become essential to implement modern management methods.

Requirements management involves collecting, analyzing, documenting, monitoring changes, and assessing how well they meet guest expectations. This research aims to examine the current methods of requirements management used in the hotel industry and identify their specific application.

Materials and Methods

This study is based on international standards from the ISO 9000 series and the national standard GOST R 59194. The authors also invited the findings of research conducted by both



international and Russian scholars in digital transformation of the service sector, enterprise architecture, and requirements management.

Results and Discussion

In accordance with the ISO 9000 series of international standards, a requirement is defined as a perceived or mandatory need or expectation. Requirements management is governed at the state level, and its concept is described in the national standard of the Russian Federation.

According to GOST R 59194-2020, requirements management is defined as the set of activities for the creation, analysis, structuring, documenting, approval, and monitoring product requirements. It also includes the coordination and control of changes to requirements if necessary.

By definition, requirements management is the process of developing and managing product requirements. In the context of the tourism and hotel industry, requirements management refers to the creation and fulfillment of requirements for tourist services.

The main prerequisites for implementing requirements management in this industry include:

1. Increased competition. With a growing number of potential customers due to population mobility, hotels need to compete more to attract and satisfy tourists.

2. Changing customer behavior. Modern customers demand an individual approach and rapid adaptation to their needs. They also expect constant communication and monitoring service delivery online.

3. Increasing amount of data. The integration of information systems ensures the collection of a large amount of customer data, which allows for the creation of personalized offers and the enhancement of marketing campaign (Ilyina, 2013).

Several groups may have demands for hospitality services. Firstly, it is worth noting that guests of hospitality businesses can and do express requirements for the quality, range, and speed of services. Department managers, investors, and government officials may also have requirements for hotel services (Huang, 2022). Therefore, prior to addressing the issue of requirement management, it is essential to identify the parties involved in order to effectively implement service management tools (Evgrafov, 2017).

When analyzing the methods of requirements management from the perspective of the state and their application within national borders, it is possible to argue that management will rely on a set of documents. However, at the international level, it is necessary to take into account other regulations. Thus, requirements management can be viewed from two perspectives: global and national requirements.

Requirements management in the hospitality industry at the global level is carried out by the UNWTO through agreed-upon global standards. In 1979, the first set of quality standards (BS-5750) was introduced, and over time, they have been revised and are now known as ISO 9000.

The ISO series of quality standards aims to help businesses implement and maintain an effective quality management system. ISO 9000 is the first and most important standard in this series. Subsequently, other global standards have emerged: ISO 9001, 9002, 9003, and 9004. Each of them contains a list of specific requirements for the hospitality industry that govern the operations of hospitality businesses and the industry as a whole.

The two main standards that affect the hospitality industry are ISO 9000 and ISO 9001:

– ISO 9000 is an introduction to quality management systems; it provides a dictionary of terms related to quality systems;

– ISO 9001, "Quality Management Systems - Requirements", establishes requirements for quality management systems and defines a model for a process-based approach to quality management.

ISO 9001 focuses on the quality of meeting the needs of customers, with the main goal of exceeding their expectations. The close alignment with current and future customer needs ensures the organization's future success. Involving employees and achieving goals set for the company is an important principle of quality management (Kobyak, 2014). Every member of staff has a set of duties and responsibilities that must be met according to company standards. The more skilled the company's employees, the greater the organization's ability to add value.

Another important principle of creating a management system within an organization in accordance with ISO 9001 is the process approach. Necessary and expected outcomes are achieved only when all activities are presented and managed as an integrated whole. The quality management system comprises interconnected processes that contribute to the formation of the outcome and allow the organization to optimize its current resources and procedures, including identifying and addressing problematic areas within the company (Voronova, 2019). Successful organizations always prioritize continuous improvement that is aimed at maintaining the existing level of performance, as well as enhancing it in the future. This enables the organization to avoid stagnation and move forward, transforming into a more modern entity by altering working conditions and creating fresh opportunities.

Another important principle is relationship management. For the necessary success of the organization, a supplier relationship management system is required. Many of the services offered by the organization are directly linked to the quality of services and products provided by suppliers. When the organization manages relationships with different partners, it enables mutually beneficial conditions to be achieved, which directly relates to the success of the organization.

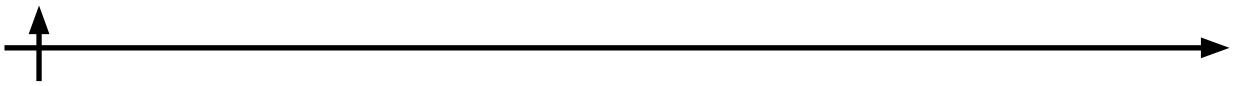
GOST R 50690-2000, "Tourist Services. General Requirements" is a significant regulation that stems from multiple international standards. This document stipulates the basic requirements for tourism products and services in the hospitality industry.

The need for quality standards arises from a multitude of requirements and changes. These requirements, when gathered together, can have significant importance and are used in various contexts, such as resolving controversial issues. The systematization of these requirements is essential, as otherwise, there will be an increase in the number of requirements, which may begin to conflict with each other, negatively affecting the hotel industry. The overall requirements allow for the improvement of the quality of tourist services in the hotel industry and the protection of hotel guests.

It is also important to remember the requirements for the classification of hotels. In the hospitality industry, hotels are classified into different types and each must comply with the regulations set by the Decree of the Government of the Russian Federation No. 1860 from November 18, 2020. These requirements are set by the government and apply to all hospitality businesses.

When a hospitality company opens, its type and classification must be determined. In the Russian Federation, the assignment of a class to a hospitality business is voluntary. First, the hotel management ensures the readiness for the class award and selects the organization that will conduct the inspection. Next, after reviewing the application, a commission arrives and assesses the business. Based on the results of this assessment, the company receives a star rating or a type of business designation.

In addition to the basic regulations that govern the operation of hospitality businesses at the global and national levels, there are also internal regulations set by businesses and consumers. These regulations include the level of service, the quality of customer care, and the qualifications of staff. This combination of regulations allows businesses to monitor their performance. The stakeholders in this context are consumers and hospitality companies. Consumer concerns are about the quality of hotel services, while hospitality companies are concerned about how



to deliver them with minimal investment and maximum returns. To manage these concerns, methods such as service standards, quality standards for hotel services, and qualifications for employee positions are employed. These methods of requirements management allow hotel managers to provide services according to the needs of both consumers and the company itself, including its internal elements such as personnel, services, and equipment. Let us take a closer look at each method of requirement management.

Hospitality companies provide services to tourists, and their implementation requires a greater emphasis on human interaction than on equipment. The staff of the company provides services to guests from their arrival at the hotel till their departure. During this process, the customer has specific service requirements, which depend on the classification of the hotel and the services it offers. Therefore, service standards are developed to organize interactions that take into account the needs of the hospitality company.

Each company develops its own set of standards, as it is impossible to unify all factors that may influence the service process. This occurs due to the fact that each enterprise has its own classification, service duration, and customers with unique features.

Service standards are a set of mandatory rules for customer service that are designed to ensure the established level of quality for all operations. The development of these standards is a way to manage the customer service needs of a business and is a complex process that involves four basic principles, which must be followed:

1. The service standards must not conflict with the requirements of state standards in the Russian Federation or technical requirements.

2. The standards must be quantifiable with respect to the standardized object.

3. There must be a documented rationale for the standards, which is essential for their implementation, as well as competent allocation of resources, personnel, and links between them.

4. It is essential to take into account the classification and category of the hotel when drawing up the standards.

When developing standards for hospitality enterprises, it is important to consider that several departments typically operate within these businesses. Therefore, the most effective way to manage service requirements is by creating standards for each department and establishing single standards that apply to all departments.

For example, general service standards could include general rules for staff behavior that apply to all employees. Service standards for the reservations department, on the other hand, might include specific requirements for how guests should be treated during the booking process, how to handle telephone conversations with guests, and how to build communication with them.

Conclusion

When forming complex organizational structures and functional models, it is essential to maintain a high level of cross-functional collaboration within a single information space. This requires taking into account the interests of all stakeholders when developing the necessary IT services that support business operations (Voronova, 2019; Vasiliev, 2025).

Requirements management involves monitoring their implementation. Tools such as internal quality audits, control over the service delivery process, consumer surveys via questionnaires or online polls, the use of "secret guest" verification, and other methods are employed to assess quality management. These tools enable researchers to analyze compliance with requirements. In the event of non-compliance with service or quality standards, managers have the ability to address the issue.

Another method of requirements management in the hospitality industry is the development

of job descriptions and qualifications for employees. People who work in hotels provide services and, therefore, need to have certain skills and knowledge related to hospitality. Since there are a lot of different positions in a hotel, it is important to create job descriptions for each. These descriptions should be consistent with the labor and civil laws of the Russian Federation.

Creating job descriptions ensures a reasonable and efficient division and organization of work, as well as the correct selection and placement of employees. It also helps to clearly define the responsibilities of each employee and establish areas of responsibility. In addition, it helps to establish rules and standards of behavior in the workplace.

Thus, staff qualification requirements are used to select employees who meet the needs of a particular position in a hospitality company. This ensures that the services provided by the company are delivered by qualified professionals, minimizing the risk of poor quality.

The process of managing staff qualification requirements is divided into several stages. At the recruitment stage, for example, the tool used is the requirements for the position. The hiring process includes a job description and employment contract, which serve as a management method for ensuring that the employee meets the requirements.

The use of requirements management techniques allows organizing the work of a hospitality company while taking into account the needs of customers, employees, and the company itself. These techniques help to avoid misunderstandings between staff, clients, and the business, define clear boundaries for action, and improve operations as a whole.

It is important to regularly update and improve all requirements. This is typically done by the organization itself or by hiring a contractor who specializes in improving or optimizing existing requirements.

Overall, the primary methods of requirements management in the hospitality industry include standardization, operating regulations, internal standards and rules.

Requirements management is carried out at the global level through international standards and country-specific standards, as well as at the macro level within the hospitality industry itself. Requirements are necessary for the successful implementation of business activities and the regulation of relationships between stakeholders.

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OPERATING ALGORITHM OF THE STRATEGIC CENTRE FOR DIGITAL TECHNOLOGIES IN THE FISHING INDUSTRY

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Abstract. This article considers the technological development in the fishing industry and the use of digital technology in this sector. The study examines the main challenges of digitalization in the economy of the fishing industry, and presents conclusions and recommendations for the implementation of digital technologies. The use of a digital platform, as a system for interaction between independent participants in the economy through an algorithm, in a unified information environment, reduces transaction costs by using digital information processing techniques and optimizing the division of labour. The unique aspect of this digital platform is the feedback from participants, which ensures sustainable development and minimizes risks in a turbulent economic climate. This process ensures the smooth operation of the program and prevents errors. As a result of the research, the authors propose a functional model of a situational centre that reflects the structure and functions of the system, as well as the information flows and material objects that connect these functions.

Keywords: fishing industry, situation centre, information society, process control

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ЦИФРОВЫЕ ТЕХНОЛОГИИ В РЫБНОЙ ПРОМЫШЛЕННОСТИ: АЛГОРИТМ РАБОТЫ СТРАТЕГИЧЕСКОГО ЦЕНТРА

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Аннотация. Данная статья посвящена анализу технологического развития рыбной отрасли. В ходе исследования были рассмотрены основные проблемы цифровизации экономики в отрасли рыбного хозяйства, а также представлены выводы и предложения применения цифровых технологий в рассматриваемой отрасли. Применение цифровой платформы, как системы взаимодействия посредством алгоритма независимых участников отрасли экономики в единой информационной среде, снижает транзакционные издержки за счет использования цифровых технологий обработки информации и оптимизации системы разделения труда. Уникальность цифровой платформы заключается в обратной связи с участниками процесса, в обеспечение устойчивого развития при минимизации рисков развития в турбулентной экономике. Данный процесс не допускает разлаженной работы программы и в дальнейшем предотвращает возникновение ошибок. В результате исследования авторами предложена функциональная модель ситуационного центра, отражающая структуру и функции системы, а также потоки информации и материальные объекты, связывающие эти функции.

Ключевые слова: рыбная отрасль, ситуационный центр, информационное общество, процессное управление

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Introduction

In the context of digital development in the economy, one of the most significant issues is the analysis of fishing and marine industry and the implementation of strategic reforms. This is a relevant issue because the marine industry is a major sector of the economy with access to the world's oceans, and the fishing industry, in particular, plays a critical role in food security.

In addition, it is essential to address the challenge of optimizing processes related to fish extraction, transportation, processing, and distribution to end users. At present, automated, information-based, and digital production processes in Russia fall short of modern standards.

In the fishing industry, there has been little attention paid to the development of digital platforms. However, the advancement of technological and digital technologies has created new demands for advanced training and expertise among specialists involved in production processes at enterprises (Sergeev, 2019). This has led to the generation of innovative engineering solutions and made the innovation process more sustainable.

Today, the concept of a digital economy is a promising research area. Scientists explore digitalization processes in education, sales, medicine, fishing, and agriculture. While most of their

works have a theoretical focus, they do not fully address practical economic challenges and the consequences of digital transformation at a national, regional, or sectoral level.

Materials and Methods

According to "Digital Economy: Pros and Cons of the Network Intelligence Era" by Tapscott D., the term "digital economy" was first coined at the end of the 20th century. The Rosstat experts consider that several factors influence the development of the digital economy:

– The human factor, including the level of education, training, and information literacy of the population;

– Innovative potential;

– Information and communication technologies;

– Economic factors, such as the economic conditions and purchasing power;

– The information industry;

– Information security.

Using modern digital technologies to collect and process information can lead to effective economic growth and improve production and management processes in organizations, as well as their structure and assets.

The process of digitalization plays an important role in all aspects of society, and the government is particularly interested in this. This is the exact reason why Russia has introduced a number of regulations that aim to effectively integrate digital technologies into social and industrial life. One of these is the "Strategy for the Development of the Information Society in the Russian Federation 2017-2030" and the state program "Digital Economy of Russia".

According to the "Strategy for the Development of the Information Society of the Russian Federation for 2017-2030", "digital economy" is defined as "economic activities where digital data makes the key factor of production." Processing and analyzing large amounts of data can significantly improve the efficiency of various types of production, technologies, equipment, storage, sales, and delivery compared to traditional forms of management.

In 1995, American computer scientist Nicholas Negroponte defined digitalization as the process of transitioning from the movement of atoms to the movement of bits.

Some examples of digitalization in the public sector include:

– Digital platforms for interdepartmental communication to facilitate on-time and reliable information transfer;

– Cost reduction and efficiency improvements in government structures;

– Development of digital platforms for the interaction between the state and population;

– Personal digital data (e-IDs have become a platform for voting, banking, access to government services, etc.);

– Digital money (digital currency, electronic payments).

Currently, digital platforms have taken over the whole world and have wide practical applications due to the expanded production of mobile phones, high-speed Internet, digital technologies, in particular artificial intelligence, cloud computing, database processing, etc.

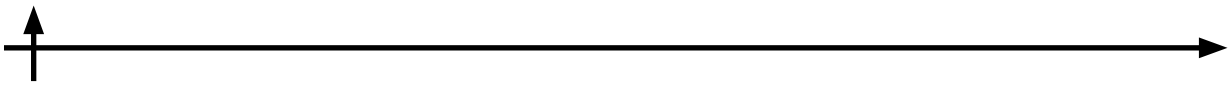
Digital platforms are complex systems that:

– have a hybrid structure that includes a technological design, an ecosystem, and a platform-based business model;

– use an application as the main software;

– experience direct network externalities, where the value of the platform increases as more users join, and indirect externalities, where users of other groups increase the value of their platform;

– provide openness and accessibility to software tools, inputs, and outputs;



– focus on creating value through direct relationships and transactions among stakeholders.

The use of innovative digitalization models contributes to the development of the Russian economy by introducing new forms, methods, techniques, and areas for realizing the economic potential of a business entity in dynamic environments.

Digital innovation is defined as an innovation based on modern information technology, that enables the creation of a computational management process via data collection, processing, analysis, and timely decision-making with regard to various factors. This process allows for the implementation of new methods for organizing and managing businesses, optimizing and reducing costs, and increasing the efficiency of audits.

The process of digital transformation in the fishing industry has not been well considered, as it is based on the use of natural resources and requires large-scale investments. The main challenges of this industry lie in complex socio-economic, environmental, and economic areas with a complicated structure and unpredictable consequences, making it difficult to apply principles, methods, approaches, and models from the digital economy.

Despite this, the fishing industry plays an important role in the country's economy, yet it cannot keep up with technological advancements. The history of technological development in the industry dates back to the 1950s and 1970s, when powerful fleets and processing facilities were developed. Improvements in fishing vessels and the use of synthetic materials have allowed for increased and improved catches in challenging areas. In the 21st century, technologies such as satellite tracking, aviation, and unmanned ships have been introduced.

The use of digital technologies can help control seafood supplies, combat illegal activities effectively, identify new opportunities for fishermen, switch to the digital processing of paper documents on board ships, and ensure efficient and targeted fishing (Davlikanova, 2019; Kudryavtseva, 2021; Mnatsakanyan, 2019; Volkogon, 2019). It can also ensure safety through electronic journals, apply satellite monitoring, and implement international electronic reporting systems.

Reporting is one of the most important tasks of the fishing industry. It involves maintaining ship, technological, and commercial logs, as well as submitting financial and accounting documents. To ensure quick and effective monitoring, this information is sent to regulatory authorities in the form of daily ship reports (SSDs).

The EPJ (Electronic Processing Journal) is a technology that introduces a trade journal using information technology. Its advantages include keeping the fishing log in electronic form, eliminating paper document management, and speeding up data processing.

The interrelation between information from the fishing log and SSD occurs through a GPS receiver that automates the entry of ship coordinates into both the log and the SSD, eliminating data entry errors. The display of the vessel's route in electronic form from the start to the end of the fishing trip helps with the automatic determination of coordinates, monitoring, and data quality control.

The challenges in changing the management system of the fishing industry to meet the demands of a digital economy are linked to the interdependence of activities within the sector, as well as external factors such as environmental, social, and political influences. Due to the specific nature of the fishing industry, which involves long-term operations on large vessels, high costs, and complex technologies, the process of managing the industry is hindered by uncertainty about operating conditions.

To mitigate the associated risks, it is essential to use forecasting techniques for the fishing sector and related industries. Managing the innovative development of the fishing industry necessitates making strategic decisions based on information and communication between different elements of the sector.

Currently, there is a lack of scientific research in the field of innovative development of the digital economy in the fishing industry, which is a significant factor in the successful implementation of digital technology models and methods in practice (Saidova, 2024). The successful implementation of an innovative model can contribute to the development of the fishing industry's economy.

To analyze the industry's innovative activity, statistics and reporting use data on the volume, structure, and dynamics of innovations. The key to innovative development lies in the interdependence between the public and private sectors through digitalization.

The Strategy for the Development of Maritime Activities in the Russian Federation until 2030 considers the problem of developing the country's national maritime activities and the issues related to the development and preservation of the resources of the World Ocean. These problems hinder the development of fishing and fish farming in Russia. To solve these problems and increase the limited maritime potential, the strategy proposes to modernize the fleet and develop the infrastructure of seaports.

Great emphasis is placed on the issue of information support, education, and training of personnel using new technologies (Costa, 2022). However, it should be noted that digitalizing industry processes with outdated technologies will not be effective. Instead, it must be continuously updated with improved technological systems, from catch methods to controlling processing and delivery to the end user. This is not taken into account in the Strategy for the Development of the Fisheries Complex of the Russian Federation until 2030.

Results and Discussion

The conducted research shows that, considering the specific characteristics of fish products in terms of quality, freshness, safety, and nutritional value, as well as current trends in technologies, the following activities are necessary for the future growth of the fishing industry:

1. Implementation of technological modernization in the fishing industry through the introduction of digital platforms that enable effective communication between all stakeholders in the industry;

2. Reduction of waste via product reuse and processing;

3. Control over the entire production process, from capture, processing, transportation, distribution, storage, and delivery to the final consumer, using electronic systems connected to GPS for real-time tracking and information processing (Big Data) (Lee, 2021);

4. Smart and selective fishing methods, such as laser trawling, to increase the reproduction of sustainable fish stocks and reduce the negative impact on the marine environment;

5. Integration of new technologies into existing or new equipment;

6. Automated transportation of fish from trawlers to holds and then from ships to shore using unmanned drones (with the help of a single regional control centre), reducing transactions and costs (Borovkov, 2018; Volkogon, 2019; Merkulov, 2019; Kostrikova, 2019; Maitakov, 2018; Byaletskaya, 2020.).

For the fishing industry, creating a situation centre is a complex task. To solve this problem, it is necessary to create a unified digital platform based on common methods for designing databases, interfaces for participants, and mechanisms for information transmission (Grigoreva, 2025; Jang, 2025).

The use of digital technologies is essential for increasing the efficiency of fisheries. However, it also involves high energy consumption (Millar, 2007). The fishing industry can be a pilot project for the transition to digital platforms.

A digital platform in the fishing industry is a system that allows independent participants to interact through an algorithm in a single information space. It reduces transaction costs by

using digital information processing technologies and optimizes the division of labour. The uniqueness of the platform allows for feedback and ensures sustainable development with minimal risks to economic growth.

For the successful implementation of the platform, it is important to ensure that the software product is not disrupted, as this could lead to errors. Users have the opportunity to benefit from a user-friendly interface and access to a database and reports. In order to analyze the quality of management, it is essential to follow all the rules and algorithms in order to ensure efficient and reliable results (Figure 1).

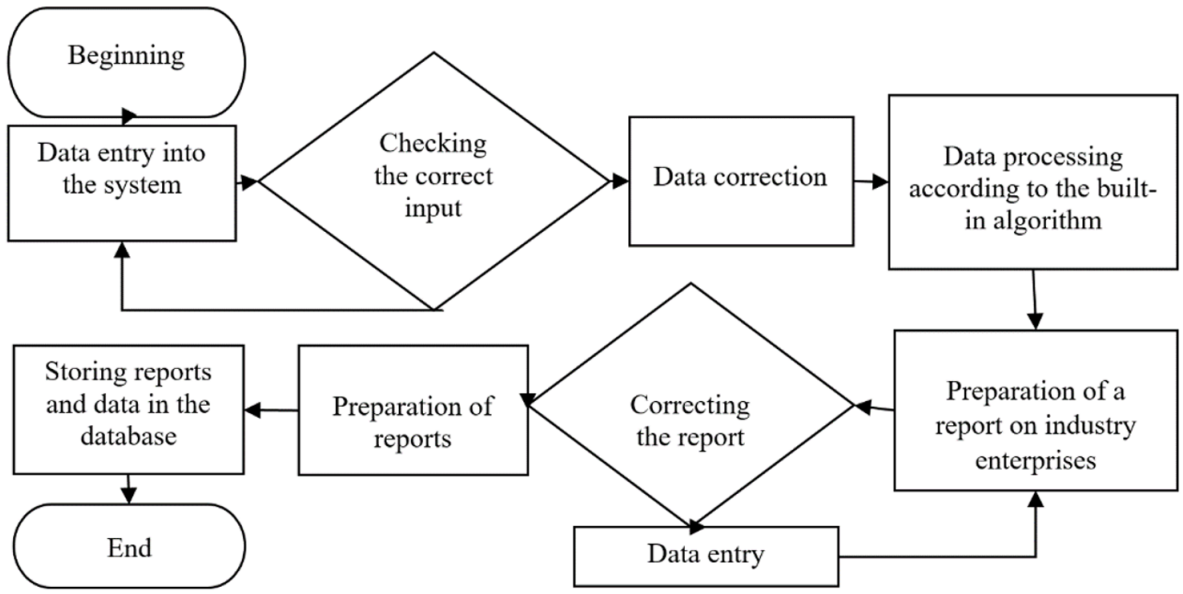


Fig. 1. Data entry and processing algorithm.

The data protection process is divided into several subprocesses at all levels:

1. Control and verification of data entered into the system.
2. Database storage and protection, as well as report generation.

A functional model of the situational centre has been proposed. This model reflects the structure, functions, information flows, and material objects of the system. It also shows how these elements are connected.

The situational centre's functions allow it to perform a basic data processing algorithm that consists of the following steps:

1. Input of data into the system;
2. Calculation of performance indicators based on criteria;
3. Aggregation of indicators to evaluate work quality;
4. Generation of a graph of alternative scenarios for the situation centre;
5. Search for optimal management decisions for the operation of the centre.

The “data representation” function provides the following features: adding, storing, editing, and deleting data.

The “forming estimates of indicators” function implements the process of determining the weights for indicators in order to estimate them.

The “getting an aggregated indicator” function creates a single indicator for the quality of work in the fishing industry by combining the estimates of various criteria.

Building a graph of alternatives implements the analysis of BDD (best-deteriorated-data) and BDR (best-discriminant-ratio) data, creating a graph based on the indicator values and

weights of edges.

Search for Optimal Management Solutions uses the complete selection mechanism on the graph of alternatives, generating a list of management decisions with optimized characteristics.

The computer system of the situational centre includes the following structural and functional components:

– A component for the formation of requirements to determine the main assessment areas;

– A component for building a hierarchical structure based on the types of activities of fishing industry enterprises;

– An information representation component for processing;

– An aggregation component for estimating indicators;

– A management decision-making component based on assessments.

Figure 2 shows the interrelationship between the components of the situational centre.

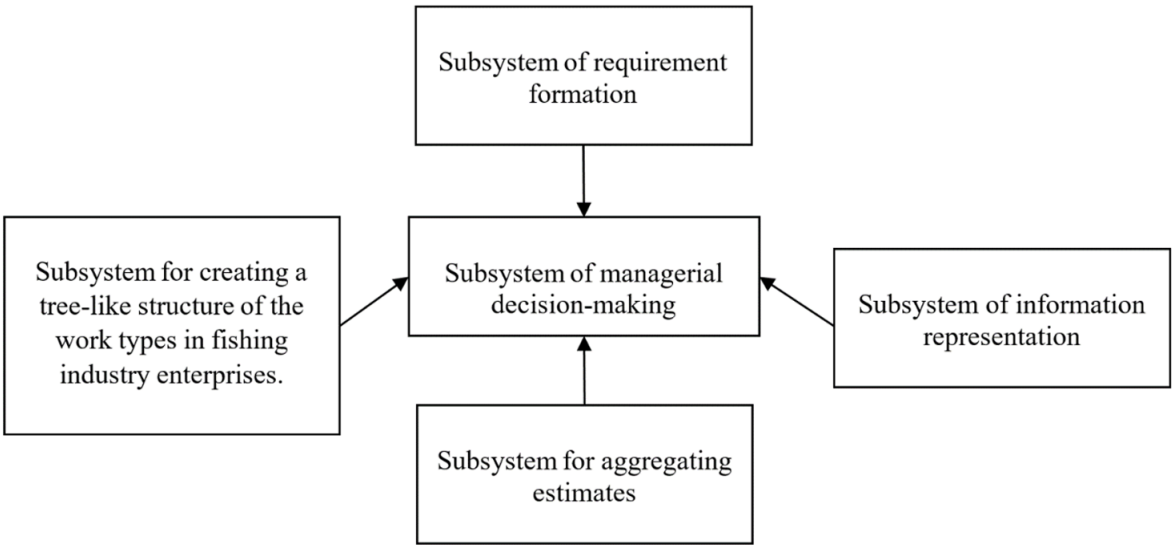


Fig. 2. Interrelation between subsystems of the situational centre.

The use of digital platforms accelerates the automation of the fishing industry, raw material processing, and efficient product distribution.

Conclusion

As a result of this research, the authors:

– explored the digital economy and factors that influence its potential;

– defined the aspects of the Strategy for the Information Society Development in Russia for 2017-2030 and the State Program “Digital Economy”;

– presented the concept of digitalization and its types in the public sector;

– provided a definition, description, and advantages of digital platforms;

– analyzed the technological development of the fishing industry;

– highlighted the main challenges in the rapidly growing sector of the digital economy.

– proposed development solutions for the fishing industry;

– generated a functional model of a situational centre, reflecting the structure and functions of the system, information flows, and material objects connected to these functions.

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PMS-SYSTEMS IN THE HOSPITALITY INDUSTRY: SPECIFICS OF IMPLEMENTATION

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Abstract. This article aims to assess the specifics and key properties of PMS-systems in order to evaluate the prospects for their adoption in the hospitality industry. In the course of the research, the authors have reviewed the theoretical foundation of cloud-based PMS and studied the market for IT solutions available in the Russian Federation. They have also analyzed and classified the automated control systems of the hotel market and concluded that the implementation of cloud-based PMS systems and process automation can optimize hotel management and improve service quality. Based on these findings, it will be possible to design a project for the PMS-systems implementation with due consideration of the unique operational needs of hospitality industry.

Keywords: process automation, hotel business, cloud PMS, implementation project, multi properties, process unification, management company

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ОСОБЕННОСТИ ВНЕДРЕНИЯ PMS-СИСТЕМ НА ПРЕДПРИЯТИЯХ ИНДУСТРИИ ГОСТЕПРИИМСТВА

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Аннотация. Данная статья посвящена анализу особенностей и ключевых характеристик функционала PMS-систем с целью оценки перспектив их внедрения на предприятия индустрии гостеприимства. В ходе исследования авторами были рассмотрены теоретические основы облачных PMS решений, изучен рынок IT решений, актуальных на территории Российской Федерации на текущий момент, а также проанализированы и классифицированы доступные на рынке гостиничной индустрии предложения по автоматизированным системам управления. В результате, было установлено, что внедрение облачных PMS систем, а также автоматизация процессов могут способствовать оптимизации управления гостиничным предприятием и улучшить качество предоставляемых услуг. На основании полученных результатов в будущем возможно проектирование процесса внедрения PMS системы с учетом всех особенностей операционного управления предприятиями сферы гостеприимства.

Ключевые слова: автоматизация процессов, гостиничный бизнес, облачные PMS, проект внедрения, мульти проперти, унификация процессов, управляющая компания

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Introduction

In today's rapidly evolving domestic hotel industry, the success of hospitality businesses is largely dependent on the level of automation. The competitive edge of hotels is not only determined by management's ability to create effective personnel models and maintain guest loyalty but also by the state of the physical and technical infrastructure, the capabilities of IT solutions deployed within the organization, and how well these solutions integrate with operational processes.

The COVID-19 pandemic and economic sanctions against the Russian Federation have led to a significant transformation of the tourism sector in our country. Following the crisis, the industry has lost billions of rubles and thousands of jobs. However, at the same time, there has been a surge in domestic automation projects and digital startups that offer new opportunities for hoteliers in Russia (Balshina, 2022; Vasiliev et al., 2025).

The introduction of cloud-based property management systems (PMS), integrations, and automation of processes can help a hotel enterprise optimize its management, improve the quality of services offered, and ensure a more enjoyable stay for guests.

Materials and Methods

To effectively assess the performance of IT solutions and justify the need for a cloud-based

property management system (PMS) in the hospitality industry, the researchers conducted expert assessments, opinion polls, and reviewed domestic and international scientific papers on efficient hotel process automation.

Results and Discussion

A cloud platform is a complex of interconnected services that provide the user with the opportunity to quickly and reliably rent computing resources in the required volume. The user gets access to these facilities via the Internet. This method of using computing resources is called "cloud computing."

Cloud computing acts as a replacement and complement to traditional data centres with the customer's local IT infrastructure. You do not need to purchase, connect, and maintain physical equipment yourself. All these tasks are taken over by the cloud provider, which is responsible for maintaining the operability and optimal performance of the necessary hardware and software. The client gets the opportunity to temporarily use computing resources in the required volumes.

The advantages of cloud technologies over physical hardware include the following:

1. Speeding up the scaling process;
2. High level of security;
3. Accelerating the market entry of new digital products;
4. Reducing the time and number of procurement stages;
5. Financial flexibility and cost optimization.

Currently, there are three types of clouds: public, private, and hybrid. Table 1 shows the advantages of each type.

Table 1. Advantages of different cloud systems (designed by the author)

Public Cloud	Private Cloud	Hybrid Cloud
Instant access to updates: The provider constantly implements new technologies and improvements.	Flexibility and customization are key features of a private cloud. It can be tailored to meet any business's specific needs, including unique security, networking, and application configurations.	High fault tolerance — if some of the capacities fail, workflows can be moved to the cloud.
No infrastructure costs. All equipment is provided and maintained by the provider.	High level of security. The entire infrastructure is used by only one company, which eliminates the risks associated with shared access.	Flexibility — sensitive data can be stored in a private cloud, and applications that do not require special security measures can be operated in a public environment.
Flexibility and scalability. The amount of resources can be increased or decreased as needed.	Compliance with regulatory requirements. A private cloud makes it easy to implement solutions that meet the requirements of data protection laws for government agencies or CII facilities.	Scalability — additional resources can be added or disabled at any time.
High fault tolerance. The infrastructure is designed so that there is always a reserve of resources, which ensures the smooth operation of services even if individual components fail.	High performance. The physical hardware is not shared with other users, which ensures a guaranteed level of performance.	Cost—effectiveness is the reduction of capital expenditures on new servers and their upgrades, paying only for the resources actually consumed.

Each type of cloud service has its own unique advantages, and choosing the right solution should depend more on understanding the specific needs of the customer. It also depends on the scale of the project and the amount of data that needs to be stored on the server (Gurieva, 2017).

In Russia, multi-cloud technologies are just beginning to gain popularity, and many companies are still opting for hybrid or public cloud solutions. According to iKS-Consulting, the volume of the cloud market in Russia in 2018 was 68.4 billion rubles ($1.1 billion), and the forecast for 2022 is more than 155 billion rubles with an annual growth rate of 23%.

After the adoption of the 152-FZ law on personal data, Russian companies began to switch to virtual services more actively. According to a PwC study, 66% of companies are currently using cloud technologies, either at an advanced or intermediate level.

For most companies, cloud technologies are not a new concept—29% have been using them for more than 5 years and another 28% for 3-5 years. At the same time, many companies use a hybrid (30%) or private cloud (29%) approach.

The main obstacles to implementing clouds into business processes include:

– The risk of data leakage and loss;
– Fear of losing control of processes;
– Concerns about potential problems with cloud providers;
– Lack of information about cloud systems;
– Internal resistance to change;
– Compliance with regulations and requirements.

To correctly formulate the requirements for a cloud service, it is important to have a general understanding of its structure. The cloud can be roughly divided into several infrastructure levels.

1. Data Processing Centre (DPC)

It is based on a data processing centre, or data centre—a specialized building that houses server and network equipment. It is on the basis of this equipment that services are provided: servers, data storage systems, routers, switches, cables, and more.

2. Virtualization layer

The next level is virtualization. It is a technology that allows you to create virtual computing environments on physical hardware (virtual resources, software-defined networks, and overlay). Virtualization makes it possible to share physical hardware resources between multiple virtual machines that operate independently of each other, even if they use the same server.

3. The software that manages server virtualization is called a hypervisor. Different cloud providers use different hypervisors to organize their virtual resources.

When ordering cloud services, you are not actually purchasing a data centre, physical hardware, or a hypervisor. Instead, you are purchasing the services that are located above these infrastructure levels (Pandya, 2023). These services are the ones that you get a temporary right to use, which is what a cloud service actually is.

There are several cloud service delivery models available, including IaaS, PaaS, and SaaS. Depending on the model you choose, the responsibility for data security and safety will change (Figure 1).

The IaaS (Infrastructure as a Service) model assumes that the provider is responsible for the physical security and fault tolerance of the cloud platform, as well as for network protection and event logging of all infrastructure components (Stratan, 2017). Clients are responsible for backing up virtual machines and ensuring the security of virtual networks and guest operating systems. They also control user access.

When using PaaS (Platform as a Service) or SaaS (Software as a Service), clients trans-

fer more functions to providers, including security and fault tolerance for virtual machines (Shrivastav, 2021). However, clients retain responsibility for managing user access and configuring products and services.

The choice of service model has a direct impact on the allocation of security responsibilities. Physical security of data centres and equipment is always the responsibility of the cloud provider. Typically, the infrastructure and management aspects are taken over by the provider, while application software and additional services are under the control of the customer. However, the client always maintains control over access to data (Moisescu, 2024; Oskam, 2022).

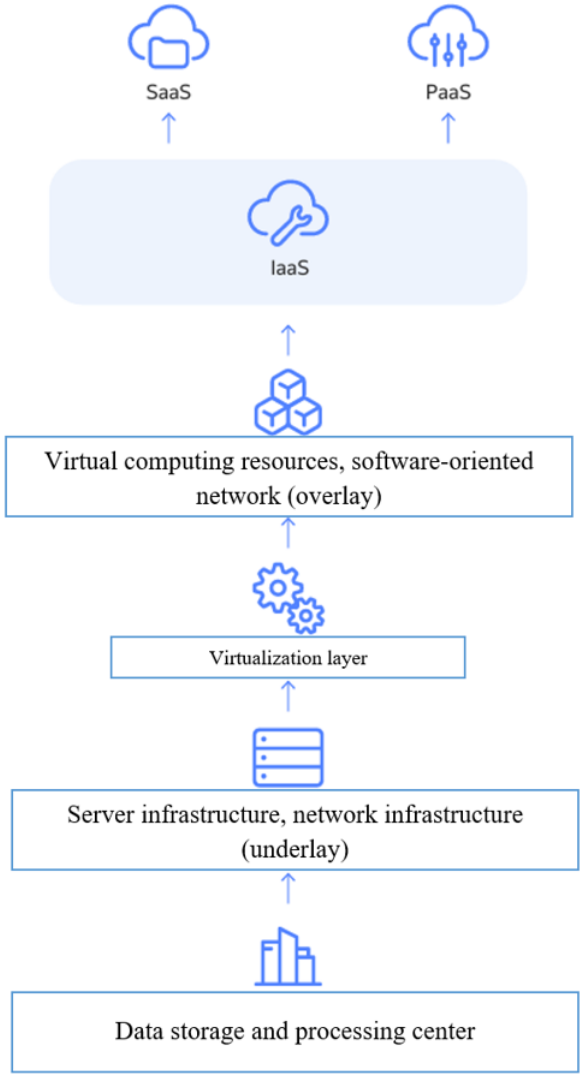

Fig. 1. Delivery models of cloud service: IaaS, PaaS, SaaS.

According to CorpSoft24, the cloud market in Russia is growing primarily due to the IaaS (Infrastructure as a Service) model. Companies are migrating their on-premise infrastructure to the cloud, as the cost of hardware and delivery times have increased, and the import substitution factor remains significant. By September 2023, cloud business growth in Russia was 35% compared to the previous year.

PMS (Property Management System) is software used in the hotel and tourism industry to automate various aspects of hotel management (Zakic, 2022). It helps with booking management, customer service, room accounting, availability, rate tracking, payment processing, and

billing (Sheresheva, 2016).

PSM is the main solution for hotels, allowing them to automate many tasks. Some of the main benefits of PMS include the ability to manage room reservations, assign tasks to employees, generate financial reports, and track statistics (Shinkov, 2021).

The main functions of a PMS (property management system) include:

– Booking management: Automation of the booking process, including online booking through the hotel's website and integration with various booking platforms;

– Room management: Monitoring room availability, conditions, cleaning, and maintenance;

– Customer service: Managing customer information, preferences, and history and providing feedback;

– Financial accounting: Automation of billing, payment processing, and financial management;

– Reporting and analytics: Providing reports and analytical data to optimize operations and make informed decisions.

PMS for a hotel can be cloud-based or local. The cloud-based option is more popular in the hotel industry, as it does not require licenses. The software does not need to be installed on each computer. When buying software from a provider, the hotel manager receives a username and password to access the service (Thusi, 2022). The program can be used at the hotel on a desktop computer, laptop, tablet, or smartphone. An internet connection is usually required, although some mobile apps offer an offline version.

Hotel management systems have a modular structure. Users can add additional features such as accounting, sales analysis, room reservations, and more. This approach is more efficient than buying separate software for each task.

PMS is often integrated with other systems, such as customer relationship management (CRM), human resources (HR), and accounting systems, to ensure efficient and effective facility management. This integration helps to improve overall service quality and increase customer satisfaction, making a business more competitive in the market.

To boost sales, most hotels integrate all possible booking channels. However, managing OTAs manually can be time-consuming and prone to errors.

The main modules of the PMS (Property Management System) include:

1. Booking module: This allows users to quickly customize the search form for rooms on the hotel website using CSS styles that fit seamlessly into the overall design. Visitors can book a room directly through the hotel website without the need for intermediaries;

2. Calendar: This is a clear and intuitive interface element. The days of the week are represented by columns, with numbers divided into categories along the lines. At the intersections, the number of available rooms is displayed. To enhance readability, the calendar is coloured in different shades. When the user hovers the cursor over a booking, information about the guest and payment details appears;

3. Income management tools: To manage income within the PMS, a reporting module connects with various tools, including Manager's report—statistics on key hotel metrics.

The following modules work together to provide a comprehensive and efficient system for managing a hotel's operations:

– Pick-up—reflects the changes in working with numbers and revenue during the specified period and tracks the growth rate of bookings;

– Nutrition reports—provides nutrition reports and guest information, as well as their chosen rate;

– Room upload reporting—monitors the number of downloads by room category and the

total for the selected period;

– Sales of additional services reporting—tracks the number of services sold and the amount booked/credited by date;

– Revenue reporting for rooms—reflects the amount of bookings for each room or category;

– Cash flow—clearly shows receipts and expenses for the items for the specified period.

4. Business Service Module: The hotel management system's maintenance module allows you to create tasks, assign them to employees, and notify them via the smartphone application. Thanks to fast data exchange, you can monitor staff work every minute, automatically generate cleaning schedules, and check cleaning status. These measures increase customer loyalty and service levels.

5. Email List and Feedback Module: The PMS (property management system) for hotels has an IP telephony function. You can monitor customer calls, record them, and generate reports on quality and quantity. The service automatically sends newsletters to users according to their preferences, analyzes reviews from various sites, and provides timely feedback.

Conclusion

In order to choose the right PMS (Property Management System) for a hotel, it is important to consider several factors:

1. Identify your top priorities: Determine which aspects of your business are most important, such as booking, restaurant management, or reporting. Choose a PMS that meets the specific needs of your hotel.

2. Assess scaling potential: Analyze whether your company has the potential for growth. Will the PMS be able to support an increased number of bookings and new features?

3. Look for future growth: Consider the developer's plans for the system. Will they continue to develop and improve it? Will it be able to adapt to changing business needs?

By taking these factors into account, you can make an informed decision about which PMS will best suit your hotel's needs and support its growth.

– Request information about the possibility of integration with other software. It is important to consider the potential for combining the PM system with other services, such as CRM, channel managers, fiscal terminals, and electronic locks. For certain types of businesses, this is crucial.

– Cost of tariff plans: Analyze the prices of various suppliers and assess their compatibility with your company's budget. Also, consider how well your budget is structured.

– Data protection: Verify whether PMS offers reliable information protection and ensures confidentiality of customer data. This is a critical requirement in the hospitality industry.

– Technical support: Gather information about its quality by reviewing reviews or consulting with colleagues who use the PMS.

The results of this study can be applied in the development of roadmaps, the implementation of algorithms, and the creation of instructions for the transition or implementation of cloud-based property management systems at hotels.

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INVESTIGATION OF PLATINUM PRICE SEASONALITY USING HIGH-ORDER AUTOREGRESSION

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Abstract. This research investigates platinum price seasonality using high-order autoregressive modeling. The research object is daily platinum price dynamics (LME data, 2015−2024), focusing on long-term dependencies and cyclical patterns. The method employs stepwise decomposition of a 270-day lag autoregression AR(270) into computationally efficient 15-day lag sub-models, enabling significance testing of all coefficients while minimizing resource demands. Results identify the one-day lag as the dominant predictor, with marginal effects at 6−15-day lags and MAPE (1.15%) confirm model robustness. Conclusions indicate no statistically significant weekly cycles due to the overwhelming influence of short-term lags, though the method's applicability in low-resource environments (e.g., Microsoft Excel) facilitates accessible high-order autoregression.

Keywords: platinum price forecasting, high-order autoregression, seasonal cycles, stepwise decomposition, computational efficiency, lagged coefficients, time series analysis

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ИССЛЕДОВАНИЕ СЕЗОННОСТИ ЦЕНЫ ПЛАТИНЫ С ПОМОЩЬЮ АВТОРЕГРЕССИИ БОЛЬШОГО ПОРЯДКА

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Аннотация. В данном исследовании изучается сезонность цен на платину с использованием авторегрессионного моделирования высокого порядка. Объектом исследования является ежедневная динамика цен на платину (данные LME за 2015-2024 гг.) с акцентом на долгосрочные зависимости и циклические закономерности. Метод использует пошаговую декомпозицию авторегрессии AR(270) с запаздыванием в 270 дней на эффективные в вычислительном отношении подмодели с запаздыванием в 15 дней, что позволяет проверять значимость всех коэффициентов при минимизации затрат ресурсов. Результаты показывают, что задержка на один день является доминирующим предиктором, с незначительными эффектами при задержке на 6-15 дней, а MAPE (1,15%) подтверждает надежность модели. Выводы указывают на отсутствие статистически значимых недельных циклов из-за подавляющего влияния краткосрочных задержек, хотя применимость метода в средах с низким уровнем ресурсов (например, Microsoft Excel) облегчает доступ к авторегрессии высокого порядка.

Ключевые слова: прогнозирование цен на платину, авторегрессия высокого порядка, сезонные циклы, пошаговая декомпозиция, вычислительная эффективность, коэффициенты с запаздыванием, анализ временных рядов

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Introduction

Forecasting the price dynamics of semi-precious and precious metals is a critical task, as these prices significantly impact various economic sectors and industries. Platinum, for instance, is widely used in automotive manufacturing, medicine, and electronics. Platinum prices are influenced by macroeconomic factors, industry-specific trends, and seasonal fluctuations. At the same time, modern research highlights the complex interaction of macroeconomic news and structural demand changes in the formation of seasonal patterns of precious metals, including platinum (Elder, 2012; Mirkin, 2014).

Investigating price seasonality and identifying long-term cycles is of particular interest. Understanding periodic components in precious metal price dynamics can improve long-term forecasting accuracy (Mirkin, 2012).

Classical works like (Box, 1976) laid the foundation for autoregressive (AR) models, now widely applied to precious metal price forecasting (Troutman, 1979; Morimune, 1995). However, identifying long-term trends and cyclical patterns requires more complex models.

High-order vector autoregression models AR(p), where p is the lag order, can capture linear dependencies across extended time intervals. These models face challenges including high com-

putational complexity and numerous coefficients (Svetunkov, 2022; Bogomolov, 1996). Alternative approaches, such as Bayesian estimation methods (Chib, 1994), are also aimed at solving problems of high dimensionality and multicollinearity in models with large lags, although they require other computing resources. Diverse methods that could improve autoregression models are observed today, for example, complex-valued modelling (Stein, 2002; Phillips, 1987). This study employs a stepwise decomposition method for high-dimensional AR models proposed in (Svetunkov, 2012).

Materials and Methods

Platinum price data was sourced from the London Metal Exchange (LME) open database. The data is represented as timeseries with one day steps of platinum mean price values in stock market. The daily time series covers 23 November 2015 to 29 November 2024, with September–November 2024 reserved for validation.

The AR(270) model allows to present the general view:

$$y_{270} = a_0 + a_1 y_{269} + a_2 y_{268} + ... + a_{270} y_1 \quad (1)$$

where $a_0, a_1, ..., a_{270}$ are coefficients of autoregressive model and $y_1, ..., y_{270}$ the price with the appropriate time shift.

In order to get model (1) it is necessary to construct 18 models with 15-days lag which reduces the computational complexity. These models could be given in the following form:

$$\begin{aligned} \widehat{y_{15}} &= b1_0 + b1_1 y_{14} + ... + b1_{15} y_1 \\ \widehat{y_{30}} &= b2_0 + b2_1 y_{29} + ... + b2_{15} y_{15} \\ \widehat{y_{45}} &= b3_0 + b3_1 y_{44} + ... + b3_{15} y_{31} \\ &\cdots \\ \widehat{y_{270}} &= b18_0 + b18_1 y_{269} + ... + b18_{15} y_{255} \end{aligned} \quad (2)$$

where bk coefficients correspond to the k model equations.

For computational convenience and to investigate the regression with a 135-day lag, the model derivation was divided in two stages. In the first stage, coefficients for the AR(135) and AR(135–270) models were obtained, where the former accounts for the influence of elements with lags ranging from 1 to 135 days, while the latter covers lags from 135 to 270 days.

Each of the models above (AR(135) and AR(135-270)) consist of 9 models from (2). Therefore, they could be written in the form:

$$\begin{aligned} y''_{135} &= \alpha_0 + \alpha_1 \widehat{y_{15}} + \alpha_2 \widehat{y_{30}} + ... + \alpha_9 \widehat{y_{135}} \\ y''_{270} &= \alpha_{10} + \alpha_{11} \widehat{y_{150}} + \alpha_{12} \widehat{y_{165}} + ... + \alpha_{18} \widehat{y_{270}} \end{aligned} \quad (3)$$

where $\alpha_0, ..., \alpha_{18}$ coefficients of models (2) linear combination.

In the second stage, the equation (4) as a linear combination of models (3) could be constructed:

$$\begin{aligned} y_{270} &= \beta_0 + \beta_1 y''_{135} + \beta_2 y''_{270} \\ y_{270} &= \beta_0 + \beta_1 (\alpha_0 + \alpha_1 \widehat{y_{15}} + \alpha_2 \widehat{y_{30}} + ... + \alpha_9 \widehat{y_{135}}) + \\ &+ \beta_2 (\alpha_{10} + \alpha_{11} \widehat{y_{150}} + \alpha_{12} \widehat{y_{165}} + ... + \alpha_{18} \widehat{y_{270}}) \end{aligned} \quad (4)$$

where $\beta_0, \beta_1, \beta_2$, coefficients which allow to compose AR(270) model from AR(135) and AR(135-270) models.

Subsequently, it is only necessary to substitute the equations of models (2) into (3) and (4). By grouping coefficients, we can then derive the target coefficients of model (1). These coefficients may be expressed in the form:

$$a_0 = \beta_0 + \beta_1\alpha_0 + \beta_1\alpha_1 bl1_0 + ... + \beta_2\alpha_{18} bl8_0$$
$$a_1 = \beta_2\alpha_{18} bl8_1 \quad (5)$$
$$...$$
$$a_{270} = \beta_1\alpha_1 bl1_{15}$$

Thus, we can construct an AR(270) regression model that accounts for platinum price dynamics with a 270-day depth, enabling identification of long-term dependencies and cycles.

Subsequently, statistically significant coefficients should be identified to build a refined model exclusively incorporating these coefficients, which yields optimal predictive accuracy.

The steps above can be implemented in Microsoft Excel using the Data Analysis tool package. After constructing the first set of models, the AR(135) model according to equation (3) can be developed, producing the comparative plot of actual data versus model predictions shown in Figure 1.

Fig. 1. The plot of AR(135) regression.

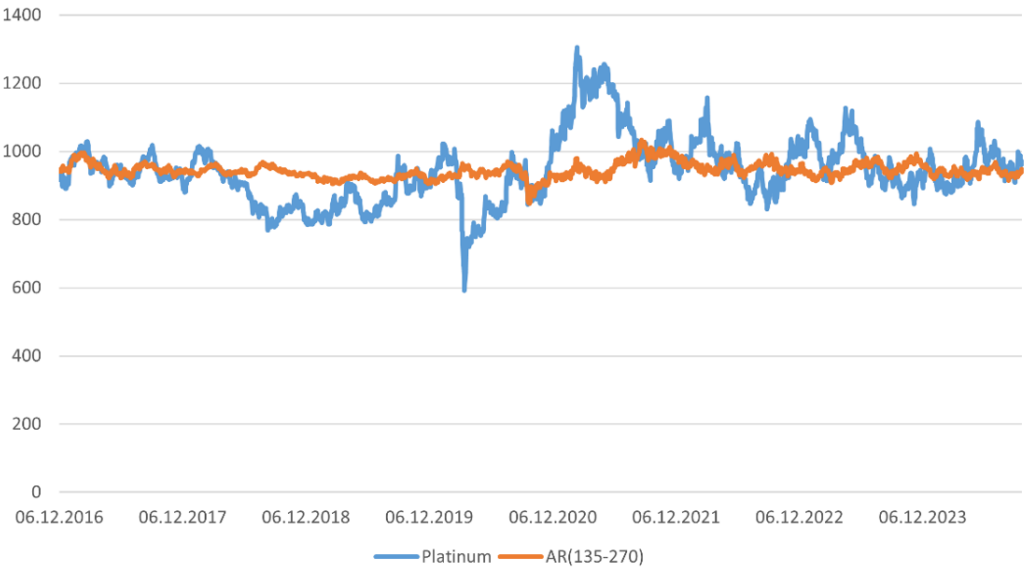


Fig. 2. The plot of AR(135-270) regression.

The graph demonstrates substantial agreement between actual data and model predictions. Subsequently, analogous procedures should be performed for the remaining nine models (2), then combined as specified in equation (3). This yields the AR(135−270) regression covering lags from 135 to 270 days (Figure 2).

Subsequently, using equations (4) and (5), we can construct the comprehensive AR(270) autoregression model, which combines the two preceding models. The comparative plot of the full model against actual data is shown in Figure 3.

Fig. 3. The plot of AR(270) regression.

Moreover, the contribution of different coefficients to the overall model must be evaluated. The coefficients exhibiting the greatest impact are $a_1, a_6, a_7, a_8, a_{10}, a_{11}, a_{13}, a_{15}$. Their values are presented in Table 1.

Table 1. The most valuable coefficients

a_1	0.9936
a_6	-0.0651
a_7	0.0593
a_8	-0.0261
a_{10}	0.0502
a_{11}	-0.0346
a_{13}	0.0456
a_{15}	-0.0351

The values demonstrate that coefficient a_1 contributes significantly more than other coefficients, though the listed coefficients still exhibit marginal influence on the model.

In addition, an autoregression model incorporating only these significant coefficients was constructed and based on the corresponding elements above (Figure 4).

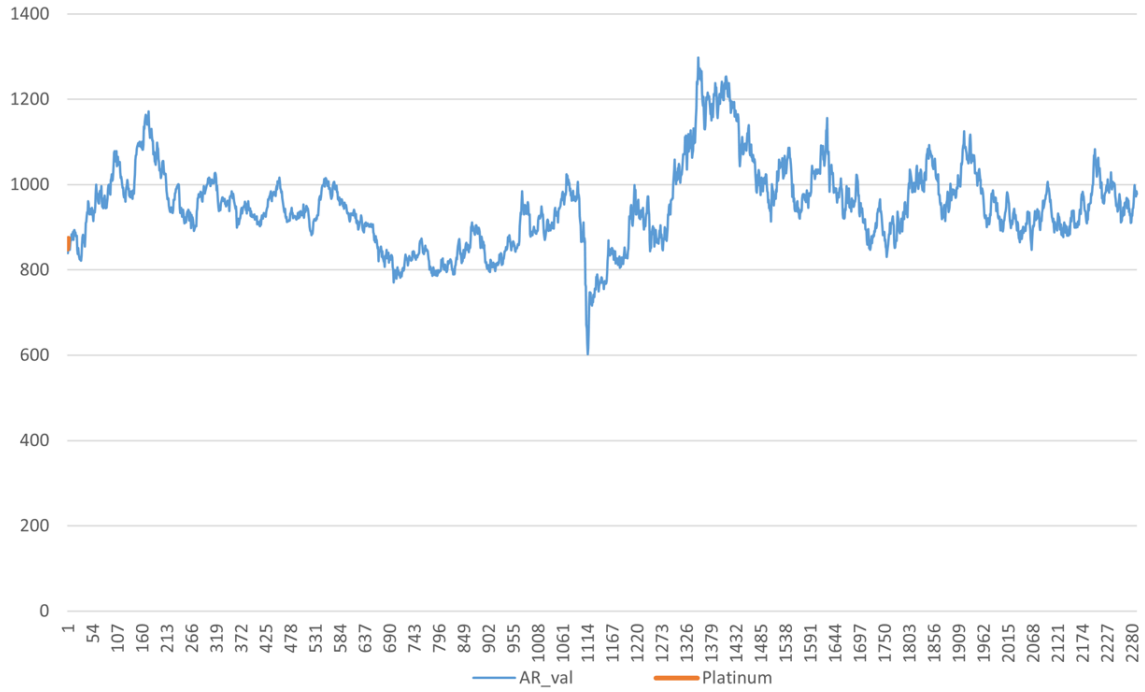


Fig. 4. The plot of AR with inly valuable elements.

The given plot demonstrates that the autoregression model with valuable elements also allows to get high quality description of platinum prices.

Results and Discussion

After several models were constructed their quality with AIC criterium and sum of squared deviations were rated. The results of this rating are provided in Table 2.

Table 2. Values of AIC and sum of squared deviations for constructed models

Model	Sum of squared deviations	AIC
AR(15)	501046.43	5.40
AR(30)	6463860.00	7.97
AR(45)	10553145.40	8.46
AR(60)	13663363.90	8.73
AR(75)	15389746.90	8.85
AR(90)	16672730.03	8.94
AR(105)	17929456.29	9.02
AR(120)	18498608.69	9.06
AR(135)	19189262.52	9.10
AR(150)	19630640.97	9.13
AR(165)	19896583.86	9.15

Model	Sum of squared deviations	AIC
AR(180)	19931981.53	9.16
AR(195)	19251665.32	9.13
AR(210)	19013775.30	9.13
AR(225)	18924874.53	9.13
AR(240)	18914368.36	9.14
AR(255)	18927227.47	9.15
AR(270)	18917953.72	9.15
AR(1-135)	473310.95	5.41
AR(150-270)	17927793.70	9.14
AR(1-270)	451061.00	5.40
AR_val	501420.61	5.40

The visualization of Table 2 is represented in Figures 5 and 6.

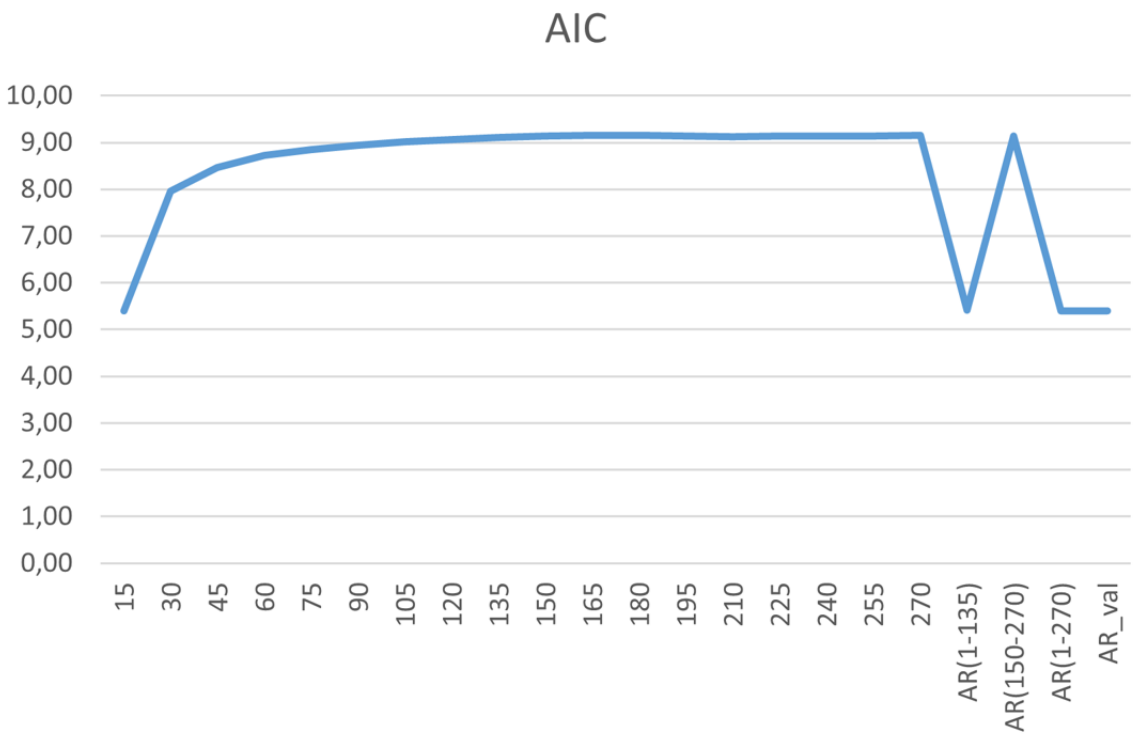


Fig. 5. The plot of AIC values for models.

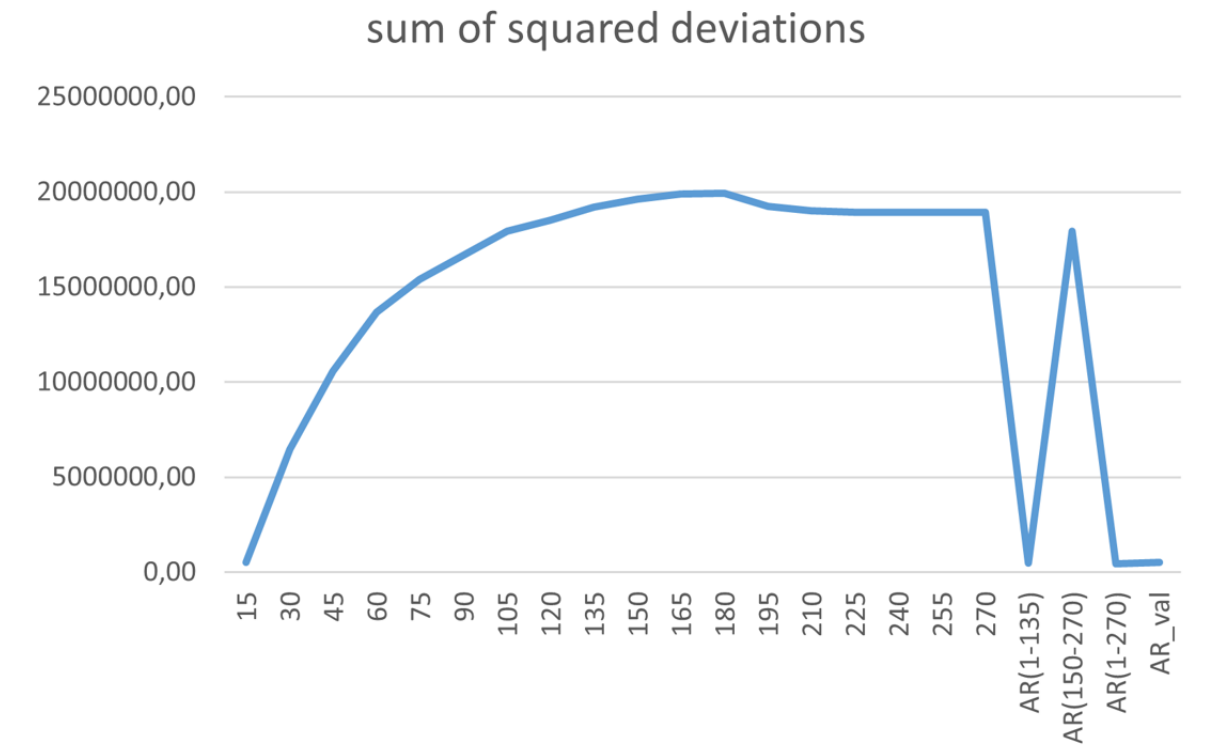


Fig. 6. The plot of sum of squared deviations for models.

Based on the data provided, it can be seen that all models with valuable coefficients from Table 1 have the best values. You can also calculate the average percentage error of MAPE using a model with significant coefficients, which will be 1.15%. This value indicates the high quality of the resulting model.

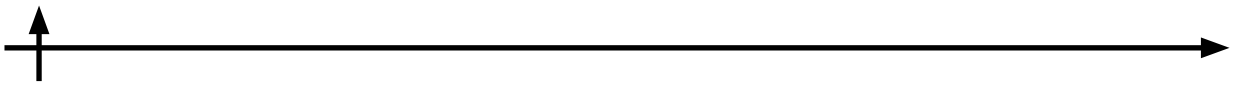
The overwhelming significance of the one-day lag aligns with findings in ML-based studies, where short-term technical indicators often dominate predictions for precious metals (Cohen, 2022). This suggests that platinum prices are primarily driven by immediate market reactions rather than latent seasonal cycles.

Conclusion

The method employed in this study enables the construction of a high-order autoregression with a 270-day lag. This allows for the assessment of the impact of the platinum price from over six months prior on its current price. Furthermore, this method facilitates the evaluation of the significance of all coefficients.

Additionally, the method is not computationally intensive. This is because it involves computing a low-order regression at each stage, making it feasible for implementation even using tools like Microsoft Excel.

Following the evaluation of the constructed models, it was concluded that the platinum price is most significantly influenced by its value on the preceding trading day. This result is consistent with the well-known high sensitivity of precious metals markets to the latest available information and short-term changes in supply and demand (Batten, 2008), which may overshadow weaker seasonal signals. A minor influence was also observed from data with lags ranging from 6 to 15 days, corresponding to a cycle of 1-3 trading weeks. However, since the influence of these elements is an order of magnitude lower than that of the coefficient, it is not possible to draw a definitive conclusion regarding the presence of weekly cycles in platinum price dynamics. It



is important to note that the conclusion that there are no statistically significant weekly cycles should be interpreted with caution within the framework of the chosen linear AR specification. As emphasized in the literature (Hansen, 2005), complex nonlinear dependencies or structural shifts can be masked in linear models, and alternative specification methods (for example, models with time-varying parameters or threshold models) could potentially reveal other patterns.

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