International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 09 – Issue 10 || October 2024 || PP. 44-48

The Use of Artificial Intelligence to Personalize the Search for Products in Online Stores

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Abstract: The rapid development of e-commerce and the increase in online sales determine the relevance of research on innovative methods of personalization of product search in online stores. The purpose of this study is to analyze and systematize approaches to the use of artificial intelligence (AI) technologies to optimize search engines in online retail. There are contradictions in the scientific community regarding the effectiveness of various AI methods in the context of e-commerce, as well as the ethical aspects of using personal data for individualization. It is concluded that the integration of neural networks, natural language processing methods, and computer vision into online store search engines can significantly increase the relevance of results and improve user experience. However, the need to develop transparent algorithms, and ensure a balance between personalization and confidentiality is emphasized. The novelty is the formulation of the author's vision of the algorithm for integrating modern deep learning methods within the framework of the use of artificial intelligence to personalize the search for goods in online stores. The article is of interest to experts in the field of e-commerce, developers of AI systems, as well as researchers dealing with the digital economy, and consumer behavior in the online environment.

Keywords: online shopping, artificial intelligence, machine learning, neural networks, online retail, search personalization, search engines, e-commerce

Introduction

In the era of digital commerce, the personalization of user experience has become a decisive factor in the success of online stores. The integration of artificial intelligence (AI) technologies into product search systems introduces numerous additional and new (in a functional sense) options for enhancing the relevance of results and improving customer satisfaction. In light of this, many contemporary publications analyze innovative approaches to applying AI for the optimization of search mechanisms in online retail.

Despite significant progress in the field of e-commerce, existing product search systems in online stores often fail to effectively meet users' individual needs. This leads to a decrease in conversion rates, an increase in the time required to find the desired product, and, consequently, the loss of potential customers. The key issue lies in the mismatch between the complexity and diversity of user queries and the limited capabilities of traditional search algorithms.

Methods and Materials

The study employs methods of comparison, analysis of scientific publications, evaluation of retrospectives (referring to the evolution of search systems in e-commerce), and generalization. The analysis of contemporary scientific literature on the topic allows for the identification of basic research orientations.

Several authors focus on the general trends in the development of e-commerce within the context of the digitalization of the economy. D.V. Zhatikova and I.V. Kutnyuk examine the technological possibilities for e-commerce development in Russia, highlighting the importance of innovative solutions for enhancing the competitiveness of online retailers [3]. E.A. Krutalevich analyzes the directions of Internet commerce development, emphasizing the strategic aspects of implementing new technologies [5]. A.V. Karmyzev explores the potential for meeting population needs through e-commerce, which is indirectly related to the necessity of search system personalization [4]. A. Tiwari, in his research, examines the impact of online shopping on traditional retail, underscoring the revolutionary changes in the e-commerce sector [10].

Another group of studies directly addresses the application of artificial intelligence technologies in the development and functioning of online stores. K.V. Gilchuk and D.M. Bocharov analyze the possibilities of using AI in the creation of online trading platforms [2]. A.A. Oymahmadov and M.A. Bogomolova present a specific example of developing an online electronics store using AI, demonstrating the practical application of theoretical concepts [6]. Sh.V. Asadli focuses on "smart" online sales systems, arguing for the significance of intelligent algorithms in optimizing e-commerce processes [1].

Several researchers concentrate on specific aspects of AI applications in online retail. For instance, A.S. Sharapov explores the use of advanced filtering algorithms in online stores for product selection, directly related

to personalized search [8]. A.E. Slitskaya examines the innovative use of generative artificial intelligence in SEO for e-commerce, revealing new perspectives in the optimization of online store search systems [7].

Of particular interest is the work of Y. Afandi, M. Maskur, N. Fiernaningsih, and A. Fauzi, dedicated to the development of natural language processing applications and semantic analysis in chatbots, improving customer service in online stores. This research demonstrates the potential for integrating linguistic technologies into personalized search systems [9].

Thus, researchers employ variable approaches to studying the problem, ranging from theoretical analysis of e-commerce development trends to practical developments of specific AI solutions for online stores. There is a noticeable trend toward an interdisciplinary approach, synthesizing methods from computer science, linguistics, and marketing.

Results and Discussion

First, it is appropriate to address the characteristics of the evolution of search systems in e-commerce (Table 1). Traditional search methods based on simple keyword matching are being replaced by intelligent algorithms capable of considering multiple factors when generating results. Modern systems analyze user behavioral patterns, purchase history, contextual information, and even the emotional tone of queries to provide the most relevant results.

Table 1 – Evolution of search engines in e-commerce [1, 3, 5, 10]

Period	Key events/technologies	Impact on e-commerce
1990s	Emergence of search engines	Initial attempts to organize data and website directories, simplifying product search.
1998s	Launch of Google: implementation of the PageRank algorithm	Increase in search result relevance and growth in organic traffic for stores.
2000s	Introduction of contextual advertising	Monetization of search, the possibility of targeted ads, and increased competition for top positions.
2010s	Mobile search engines: optimization for mobile devices	Increase in mobile purchases, the emergence of mobile versions of websites and apps for stores.
2015s	Introduction of voice search	Start of content optimization for voice queries, opening new ways of interacting with customers.
2020s	Artificial intelligence, machine learning: personalized search	Improved accuracy of product search, recommendations based on user behavior, and user experience enhancement.

Thus, throughout their evolution, search engines have played a crucial role in the development of e-commerce, helping to improve search relevance, simplify access to goods and services, and open up additional opportunities for user interaction.

Deep learning and neural networks have driven significant shifts in natural language processing, directly impacting the quality of search systems. Recurrent neural networks (RNN) and transformers allow the capture of semantic nuances in user queries, overcoming the limitations of lexical search. For example, the BERT model (Bidirectional Encoder Representations from Transformers) is effectively used to understand the context and intent of customers, even when queries are ambiguous or contain typographical errors [2, 4].

Collaborative filtering methods, enhanced through AI (Fig. 1), enable the identification of hidden connections between various users' preferences. Matrix factorization algorithms, such as SVD (Singular Value Decomposition), help create multidimensional models of user preferences, in which latent factors not explicitly expressed in search queries or product characteristics are taken into account.

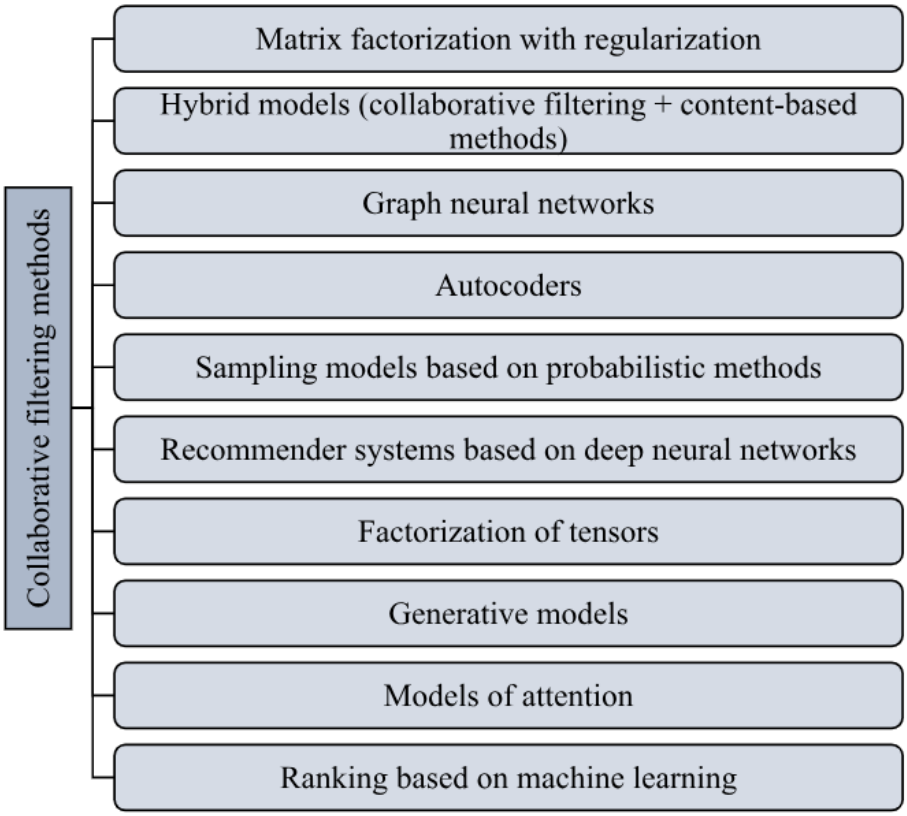

Fig. 1. Systematization of collaborative filtering methods improved by AI [2, 6, 7]

The integration of computer vision into search systems opens up new possibilities for visual product search. Convolutional neural networks (CNN) enable the analysis of images uploaded by users and the identification of visually similar products. The combination of text and visual search creates a more intuitive interface, especially in categories where visual characteristics play a key role (such as clothing, furniture, and interior items).

AI algorithms that analyze market trends, competitor behavior, and users' individual price sensitivity allow for the implementation of dynamic pricing systems. This not only optimizes the store's revenue but also personalizes pricing offers, increasing the likelihood of a purchase.

Machine learning is applied to demand forecasting based on retrospective data, seasonality, and external factors. This optimizes inventory and stock management, which, in turn, influences the relevance of search results. Clustering algorithms help identify groups of products frequently purchased together, which are used to form personalized recommendations.

Natural language processing methods are employed to analyze reviews and user-generated content, providing an opportunity to identify hidden product characteristics and consider them when ranking search results. Sentiment analysis helps evaluate the emotional tone of reviews, which can be useful for more accurately assessing a product's relevance to the user's query.

Additionally, the integration of AI into personalization systems raises several ethical concerns, related to data privacy and potential discrimination. Developing transparent algorithms and giving users control over personalization parameters is becoming a key area of research in this field.

A potentially valuable innovation could be the development and implementation of an algorithm that combines several modern deep-learning methods to enhance product search personalization. It is suggested that this algorithm would employ neural network architectures (transformers, recurrent neural networks (RNN), as well as graph neural networks), enabling a deeper analysis of user preferences and product interrelationships.

The unique feature of the proposed algorithm is its ability to simultaneously consider the following aspects (Fig. 2):

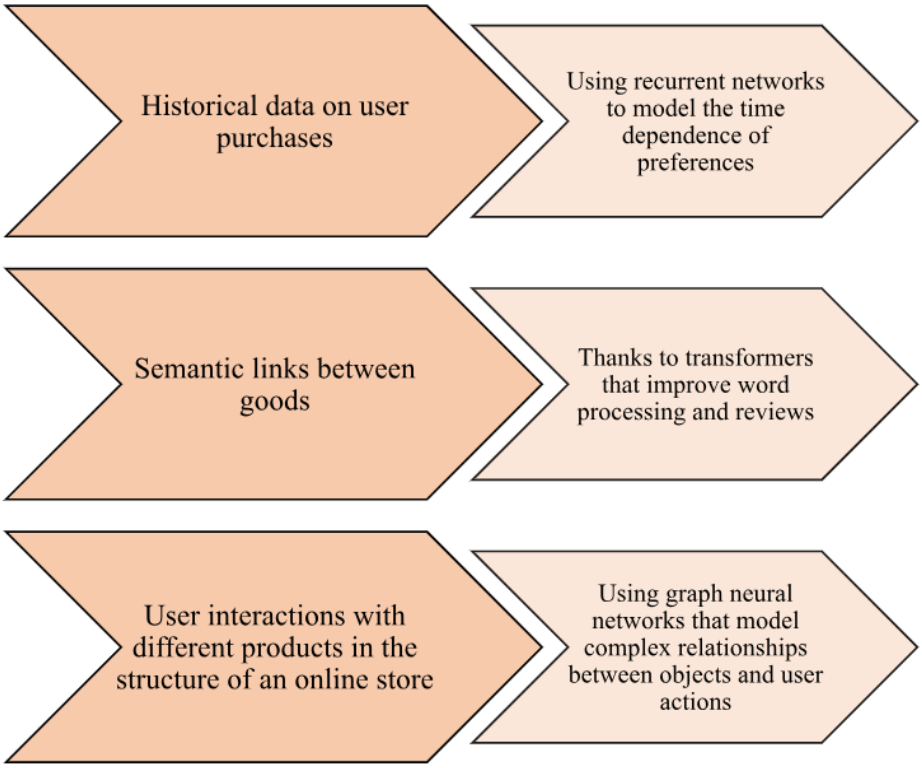

Fig. 2. Features of the algorithm for integrating modern deep learning methods (compiled by the author)

It is important to emphasize that the algorithm should include a self-learning mechanism that automatically adapts search results in real-time based on new user behavior data. This allows the system to respond promptly to changes in customer interests, offering relevant and personalized products in line with shifting preferences.

The integration of modern deep learning methods not only improves search accuracy but also makes it more contextually aware and sensitive to dynamic changes in customer behavior.

Despite the many possibilities, there are several significant limitations when applying artificial intelligence (AI) for product search personalization in online stores, as mentioned in contemporary publications [2, 8, 9].

For instance, search personalization requires large volumes of data (purchase history, user behavior, product interactions). However, this information is often incomplete or unstructured. New or infrequent users may not provide enough data for accurate personalization, which limits AI capabilities.

For new users or products, AI algorithms lack sufficient information to generate relevant recommendations. This complicates search personalization for individuals without a history of interactions or for newly added products.

Data collection and processing raise privacy concerns. There are strict legal regulations that limit access to personal information and establish rules for data processing, complicating the development of AI models.

Modern deep learning methods (such as transformers, graph neural networks, etc.) require significant computational power for training and operation. This increases infrastructure costs and slows down request processing, especially under high load in large online stores.

Many complex models (particularly deep neural networks) are often viewed as "black boxes," making it difficult to explain why the system recommends certain products. The lack of explainability can reduce trust from users and system administrators.

Although AI can work with text data and product descriptions, personalization based on images, video, and audio is still limited. This narrows the possibilities for offering personalized recommendations in online stores where visual or multimedia aspects of products are important.

The accuracy of personalization directly depends on the quality of product metadata (descriptions, tags, categories). If product information is incomplete or inaccurate, the AI system often generates irrelevant results.

Periodic changes in user preferences (for example, seasonal sales or holidays) can disrupt models trained on outdated data, requiring frequent updates and adaptations of algorithms to new conditions.

Conclusions

The application of artificial intelligence for product search personalization in online stores represents a multifaceted and rapidly evolving field. The integration of advanced technologies such as machine learning, natural language processing, and computer vision enables the creation of highly efficient search systems that can significantly improve user experience and substantially increase conversion rates.

However, the limitations discussed in this article highlight the need for the development of more flexible and effective approaches to search personalization, as well as the importance of balancing technological solutions with ethical and legal considerations.

It appears that future research in this area will bring significant changes to the ways customers interact with online stores, opening new opportunities and tools for the development of e-commerce.

References

[1]. Asadli Sh.V. "Smart" online sales systems / Sh.V. Asadli // Science and innovations of the XXI century. Collection of articles based on the materials of the IX All-Russian Conference of Young Scientists. Surgut: 2023. – pp. 43-51.

[2]. Gilchuk K.V. Application of artificial intelligence technologies in the development of online stores / K.V. Gilchuk, D.M. Bocharov // Informatics, control systems, mathematical and computer modeling (IUSMKM-2020). Collection of materials of the XI International Scientific and Technical Conference. - D.: 2020. – pp. 349-352.

[3]. Zhatikova D.V. Technological possibilities of e-commerce development in Russia / D.V. Zhatikova, I.V. Kutnyuk // Self-government. – 2023. – № 1 (134). – Pp. 401-405.

[4]. Karmyzov A.V. The potential of meeting the needs of the population through online commerce / A.V. Karmyzov // Socio-economic development of organizations and regions in the context of digitalization of the economy. Materials of the reports of the International Scientific and Practical Conference. – Vitebsk: 2020. – pp. 162-166.

[5]. Krutalevich E.A. Directions of development of online commerce in the digital economy / E.A. Krutalevich // Development of the service sector: strategies, innovations, competencies. Materials of the All-Russian scientific and practical conference. – Nizhny Novgorod: 2019. – pp. 131-136.

[6]. Oymakhmadov A.A. Development of an online store of electronic equipment using artificial intelligence technologies / A.A. Oymakhmadov, M.A. Bogomolova // Current problems of computer science, radio engineering and communications. Materials of the XXXI Russian Scientific and Technical Conference. – Samara: 2024. – pp. 328-329.

[7]. Slitskaya A.E. The use of generative artificial intelligence in SEO for e-commerce / A.E. Slitskaya // Innovation and investment. - 2023. – No. 11. – pp. 326-329.

[8]. Sharapov A.S. The use of advanced filtering algorithms in online stores for the selection of goods / A.S. Sharapov // XXVI Tupolev readings (school of young scientists). Materials of the International Scientific Conference. – Kazan: 2023. – pp. 2737-2742.

[9]. Afandi Y. Semantic and natural language processing development applications for chatbots to enhance online store customer service / Y. Afandi, M. Maskur, N. Fiernaningsih, A. Fauzi // International journal on advanced technology, engineering, and information system (Ijateis). – 2023. – Vol. 2. – No. 4. – URL: https://ojs.transpublika.com/index.php/IJATEIS/article/view/986 (date of application: 09/23/2024).

[10]. Tiwari A. E-commerce revolution: exploring the impact of online shopping on traditional retail / A. Tiwari // International Journal for Research in Applied Science and Engineering Technology. – 2023. – Vol. 11. – No. 11. – Pp. 2221-2226.