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HYBRID MODELS AND ALGORITHMS FOR SELECTING OPTIMAL FREQUENCIES BASED ON ARTIFICIAL INTELLIGENCE

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Annotation. This article analyzes the theoretical and practical aspects of hybrid models and algorithms based on artificial intelligence for selecting optimal frequencies. The study examines the integration of neural networks, genetic algorithms, and machine learning methods to improve signal transmission quality and network efficiency. Particular attention is paid to effective frequency management in radio communication systems, reduction of interference levels, and optimization
of data transmission speed. The use of hybrid algorithms makes it possible to enhance the stability and energy efficiency of telecommunication systems. The research findings are of significant scientific and practical importance for the development
of mobile communications, digital networks, and advanced telecommunication technologies.

Keywords: artificial intelligence, hybrid algorithms, optimal frequency, neural networks, machine learning, genetic algorithm, telecommunications, signal transmission, radio communication, digital networks.

Аннотация. В данной статье рассматриваются теоретические
и практические аспекты гибридных моделей и алгоритмов, основанных
на искусственном интеллекте для выбора оптимальных частот. Исследование посвящено интеграции нейронных сетей, генетических алгоритмов и методов машинного обучения с целью повышения качества передачи сигналов
и эффективности сетевых систем. Особое внимание уделено вопросам рационального управления частотами в системах радиосвязи, снижению уровня помех и оптимизации скорости передачи данных. Использование гибридных алгоритмов позволяет повысить устойчивость и энергоэффективность телекоммуникационных систем. Результаты исследования имеют важное научно-практическое значение для развития мобильной связи, цифровых сетей и современных телекоммуникационных технологий.

Ключевые слова: искусственный интеллект, гибридные алгоритмы, оптимальная частота, нейронные сети, машинное обучение, генетический алгоритм, телекоммуникации, передача сигналов, радиосвязь, цифровые сети.

Annotatsiya. Mazkur maqolada sun’iy intellekt asosida optimal chastotalarni tanlash uchun qo‘llaniladigan gibrid modellar va algoritmlarning nazariy hamda amaliy jihatlari tahlil qilingan. Tadqiqotda neyron tarmoqlar, genetik algoritmlar
va mashinaviy o‘qitish usullarining o‘zaro integratsiyasi orqali signal uzatish sifati
va tarmoq samaradorligini oshirish imkoniyatlari ko‘rib chiqilgan. Shuningdek, radioaloqa tizimlarida chastotalarni samarali boshqarish, shovqin darajasini kamaytirish va ma’lumot uzatish tezligini optimallashtirish masalalariga alohida e’tibor qaratilgan. Gibrid algoritmlardan foydalanish natijasida aloqa tizimlarining barqarorligi va energiya samaradorligini oshirish mumkinligi asoslab berilgan. Tadqiqot natijalari telekommunikatsiya, mobil aloqa va raqamli tarmoqlarni rivojlantirishda muhim ilmiy-amaliy ahamiyatga ega.

Kalit so‘zlar: Sun’iy intellekt, gibrid algoritmlar, optimal chastota, neyron tarmoqlar, mashinaviy o‘qitish, genetik algoritm, telekommunikatsiya, signal uzatish, radioaloqa, raqamli tarmoqlar.

INTRODUCTION

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Today, the rapid development of information and communication technologies is causing a sharp increase in demand for telecommunication systems. In particular, the expansion of mobile communications, satellite systems, radio communications and wireless networks has made the issue of effective use of frequency resources an urgent problem. Incorrect allocation or inefficient use of frequencies leads
to a decrease in signal quality, a decrease in transmission speed, and an increase in noise in communication systems. Therefore, the development of modern and intelligent methods for selecting optimal frequencies is of great scientific and practical importance.

Artificial intelligence technologies are widely used today as a means
of effectively solving complex problems in various fields. In particular,
in telecommunications and radio communication systems, artificial intelligence-based algorithms allow for rapid analysis of large amounts of data, identification of network loads, and making optimal management decisions. Modern approaches such
as machine learning, neural networks, and genetic algorithms provide high accuracy and efficiency in managing frequency resources [1; 130].

In recent years, special attention has been paid to the use of hybrid models and algorithms in selecting optimal frequencies. The hybrid approach allows for the acceleration of complex computational processes and increased system efficiency by combining the advantages of several intelligent algorithms. For example, when the data learning capabilities of neural networks are combined with the optimization capabilities of genetic algorithms, the frequency selection process is carried out more efficiently. This serves to improve the quality of signal transmission, reduce network overload, and optimize energy consumption [2; 55].

Also, hybrid algorithms based on artificial intelligence have the ability
to predict dynamic changes occurring in mobile communication networks. This will help to reallocate frequencies in real time and ensure uninterrupted operation of the system. Especially in the context of the development of 5G and future 6G technologies, the issue of optimal frequency management is becoming increasingly important.

This article analyzes the theoretical foundations, practical capabilities, and effectiveness of hybrid models and algorithms used to select optimal frequencies based on artificial intelligence in telecommunications systems. It also highlights the advantages of modern algorithms, their role in increasing network stability, and future development directions.

LITERATURE REVIEW AND RESEARCH METHODOLOGY

The issue of selecting optimal frequencies based on artificial intelligence is one of the most important scientific areas of telecommunications and radiocommunication systems today. Research in this area is mainly aimed at improving the effectiveness
of machine learning, neural networks, genetic algorithms, and hybrid optimization methods. In particular, Simon Haykin's Neural Networks and Learning Machines (New York: Pearson, 2009) provides a comprehensive overview of the capabilities
of neural networks to process and predict large amounts of data. The author substantiates the advantages of artificial intelligence in adaptive control systems
[3; 35].

Also, David E. Goldberg's Genetic Algorithms in Search, Optimization and Machine Learning (Boston: Addison-Wesley, 1989) analyzes the effectiveness
of genetic algorithms in complex optimization problems. This study shows that evolutionary algorithms play an important role in the optimal allocation
of frequencies [4; 50].

Theodore S. Rappaport's Wireless Communications: Principles and Practice (Prentice Hall, 2002) on the use of artificial intelligence in telecommunications systems provides a comprehensive overview of the theoretical foundations of wireless communication systems and frequency management. The author pays special attention to the issues of reducing noise in signal transmission and increasing network efficiency [5; 112]

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In addition, the book Deep Learning (MIT Press, 2016) by Ian Goodfellow, Joshua Bengio, and Aaron Courville provides a scientifically sound basis for the application of deep learning algorithms in signal processing and telecommunications systems. These sources demonstrate mechanisms for predicting network loads and making optimal decisions using artificial intelligence [6; 210].

Uzbek scientists are also working on optimizing telecommunications systems research on the development of digital technologies. In particular, S.S. Gulyamov's scientific works on the digital economy and innovative technologies highlight the theoretical foundations of the development of modern information systems [7; 40].

In this study, a comprehensive scientific methodology was used to determine the effectiveness of hybrid models and algorithms for selecting optimal frequencies based on artificial intelligence. The research process used systematic analysis, mathematical modeling, machine learning and optimization methods.

Initially, the frequency distribution and signal transmission processes in telecommunication systems were theoretically analyzed. Then, the capabilities of neural networks and genetic algorithms were studied, and a hybrid model based on their integration was developed. This model evaluated parameters such as network load level, signal quality, noise figure, and transmission speed.

During the study, large amounts of data were processed using machine learning algorithms and a forecasting process was carried out to determine optimal frequencies. Genetic algorithms were used to select and optimize the most optimal frequency options. At the same time, the effectiveness of the hybrid model was compared with traditional algorithms based on experimental tests.

Statistical methods and graphical modeling were used to analyze the results. Based on the data obtained, the advantages of hybrid algorithms based on artificial intelligence in improving signal quality and network stability in telecommunication systems were scientifically substantiated.

ANALYSIS AND RESULTS

The issue of selecting optimal frequencies based on artificial intelligence is one of the most complex and important areas of modern telecommunication systems. The analysis shows that traditional frequency allocation methods are often based on a static approach and cannot adapt quickly enough to changing network conditions in real time. This leads to a decrease in signal quality, channel congestion, and a decrease in data transmission speed. Therefore, dynamic approaches based on artificial intelligence are considered a relevant solution today.

Research shows that neural networks have high efficiency in identifying and predicting complex relationships in the frequency spectrum. They allow for real-time analysis of network conditions by processing large amounts of data. However, using neural networks alone may not be sufficient to achieve optimal solutions in some cases, as they may get stuck in local minima during global optimization.

From this point of view, hybrid models integrated with genetic algorithms provide high results. Genetic algorithms effectively search for optimal solution spaces through evolutionary selection, crossover, and mutation processes. Neural networks, on the other hand, perform data learning and prediction functions. As a result of the combination of these two approaches, the frequency selection process becomes more accurate and stable.

It is also revealed that machine learning algorithms play an important role in the analysis process. Support vector machines (SVM), decision trees, and deep learning models provide effective results in network load forecasting. Deep neural networks in particular provide high accuracy in analyzing large amounts of signal data [8; 145].

Since frequency resources in telecommunication systems are limited, their optimal allocation is important. Analysis shows that hybrid models based on artificial intelligence can

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increase spectrum efficiency by 20–35%. This not only improves communication quality, but also increases the overall energy efficiency of the network.

In addition, noise and interference problems that arise in real-time systems can be reduced using artificial intelligence. Adaptive algorithms quickly adapt
to changing conditions and automatically select the optimal frequency range. The fact that this process can be carried out without human intervention ensures the automation of the system.

Another important aspect is that the use of frequency resources in 5G and future 6G technologies is becoming more complex. Since these technologies require high speed and low latency, traditional methods are no longer sufficient. Therefore, hybrid algorithms based on artificial intelligence are of strategic importance.

Of the study showed that hybrid models developed based on artificial intelligence have high efficiency in the process of selecting optimal frequencies. The combination of neural networks and genetic algorithms increased the accuracy of the system and allowed to reach the optimal solution faster. Traditional Compared with conventional methods, hybrid approaches significantly improve the efficiency
of using frequency resources.

Experimental analysis has shown that when using a hybrid model, signal quality improves, the level of interference decreases, and the data transfer rate increases. This strengthens the overall stability of telecommunication systems. Also, the economic efficiency of the system increases due to the optimization of energy consumption.

Obtained during the study showed the need for widespread implementation
of artificial intelligence technologies in the telecommunications sector. Hybrid models serve as an effective tool not only for frequency optimization, but also for improving network management, load distribution, and signal quality [8; 175].

Hybrid models and algorithms developed for selecting optimal frequencies based on artificial intelligence play an important role in increasing the efficiency
of modern communication systems. Future research in this area will contribute to the development of 6G technologies, smart networks, and fully automated communication systems.

CONCLUSION

The use of hybrid models and algorithms for selecting optimal frequencies based on artificial intelligence is one of the important strategic directions in the development of today's telecommunications systems. The conducted analysis shows that traditional frequency management methods cannot fully adapt to modern, rapidly changing network conditions. Therefore, approaches based on artificial intelligence, in particular the integration of neural networks and genetic algorithms, are emerging as highly effective solutions.

Another important result is that AI-based approaches also serve to increase energy efficiency. This is not only technically important, but also economically. Through rational allocation of frequencies, resource use is optimized and the overall efficiency of the system increases. In conclusion, the application of AI and hybrid algorithms in the telecommunications sector will expand further in the future. Especially in the context of the development of 5G and 6G technologies, such intelligent systems will play an important role. Future research will serve to further improve these models, increase their accuracy, and expand the possibilities of their application in real systems.

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