

ARTIFICIAL INTELLIGENCE-BASED PERFORMANCE OPTIMIZATION IN 5G AND IEEE 802.11 NETWORKS

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Annotatsiya

This study focuses on improving the performance of 5G and IEEE 802.11 networks using artificial intelligence techniques. Modern wireless networks face challenges such as high traffic, interference, and inefficient resource allocation. To address these issues, machine learning methods are applied to optimize network performance, including better channel selection and resource management. The proposed approach aims to enhance network efficiency, increase data transmission speed, and reduce delays..

Keywords: 5G Networks, IEEE 802.11, Artificial Intelligence, Machine Learning, Network Optimization, Wireless Communication

Аннотация

В данной работе рассматривается повышение эффективности сетей 5G и IEEE 802.11 с использованием технологий искусственного интеллекта. Современные беспроводные сети сталкиваются с такими проблемами, как высокая нагрузка, интерференция и неэффективное распределение ресурсов. Для решения этих задач применяются методы машинного обучения, направленные на оптимизацию выбора каналов и управления ресурсами сети. Предложенный подход позволяет повысить эффективность сети, увеличить скорость передачи данных и снизить задержки..

Ключевые слова: сети 5G, IEEE 802.11, искусственный интеллект, машинное обучение, оптимизация сети, беспроводная связь

INTRODUCTION

In this study, an overview of artificial intelligence techniques is first presented, followed by their practical applications in modern wireless communication systems such as 5G and IEEE 802.11 networks. Artificial intelligence includes a wide range of methods, each with its own characteristics, advantages, and limitations. Among these, machine learning techniques play a key role in analyzing

large volumes of network data and making intelligent decisions. Supervised learning is one of the most widely used approaches in this field. It operates by training models on labeled datasets, allowing the system to learn the relationship between input parameters and expected outputs. This approach is commonly applied to classification and regression problems in wireless networks. For example, classification techniques can be used to identify network conditions or categorize traffic types, while regression methods are useful for predicting numerical values such as signal strength, bandwidth usage, or network performance metrics. In addition to these applications, AI techniques are increasingly used in self-organizing networks (SON), which are designed to automatically manage and optimize network operations.

Table 1.

Characteristics of 5G Service Types

5G Scenario	Key System Performance Requirements	Traffic Features and Challenges
eMBB (Enhanced Mobile Broadband)	Peak data rate: DL 20 Gb/s, UL 10 Gb/s User data rate: DL 100 Mb/s, UL 50 Mb/s Area traffic capacity: 10 Mb/s/m ² Latency: 4 ms	High data rate per user Downlink-dominated traffic Large data transmission
URLLC (Ultra-Reliable Low Latency Communication)	Latency: 1 ms Reliability: 99.999%	Very strict latency and reliability requirements Short packets Real-time communication
mMTC (Massive Machine-Type Communication)	Connection density: up to 1 million devices/km ²	Low data rate per device High connection density Uplink-dominated traffic

There are many techniques in the field of artificial intelligence and each technique has its characteristics, areas of use, advantages, and disadvantages. Of course, although it is not possible to mention all of them in this article, it will be tried to give a general perspective to these techniques

LITERATURE REVIEW

Recent advancements in wireless communication technologies have led to the rapid development of 5G and IEEE 802.11 networks, which are expected to support high data rates, low

latency, and massive connectivity. However, the increasing complexity of these networks has created significant challenges in terms of resource management, interference control, and performance optimization. Traditional optimization methods are often not sufficient to handle such dynamic and complex environments. In recent years, artificial intelligence (AI) has emerged as a promising solution for addressing these challenges. Various studies have demonstrated the effectiveness of machine learning techniques in improving network performance. This method is particularly suitable for dynamic network optimization, where conditions change continuously. In 5G networks, AI-based approaches have been applied to improve key performance metrics such as throughput, latency, and reliability. For instance, self-organizing networks (SON)

supported by machine learning can automatically adjust network parameters, including frequency allocation, transmission power, and bandwidth distribution.

METHODS

This study proposes an artificial intelligence-based approach to optimize the performance of 5G and IEEE 802.11 networks. The methodology is based on applying machine learning techniques to analyze network conditions and improve resource allocation efficiency in dynamic wireless environments. Initially, relevant network parameters such as bandwidth, latency, signal strength, and traffic load are considered as input features. These parameters are essential for evaluating network performance and identifying potential optimization opportunities. The dataset used in this study is generated through simulation-based scenarios that represent real-world wireless communication environments.

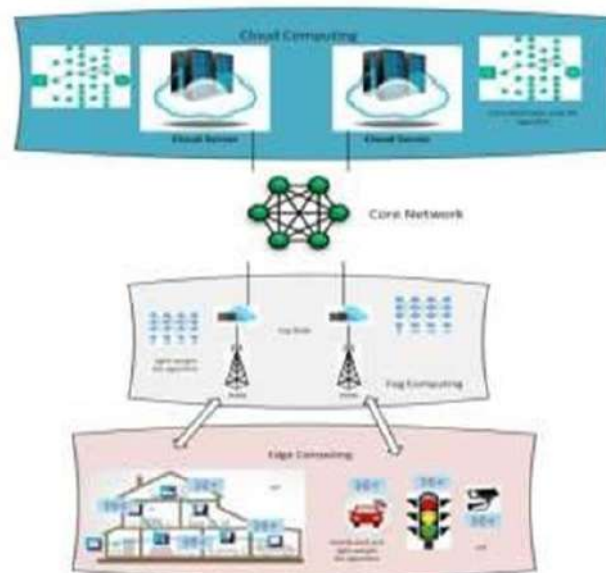


Figure 1 Representation of fog networking

Among the unsupervised learning algorithms, the KMeans clustering algorithm is predicted to be eligible to solve a significant portion of the 5G network problems. Song et al. (2017) stated that the K-Means clustering technique is a principal element to resolve the issue of deciding how the relay devices should be distributed among the base stations (BS). This is a major problem especially for the devices having high mobility such as urban vehicles and using K-Means clustering properly may boost this process. Fog networking is a method to allocate the computing task to smaller devices that are connected to a cloud. Balevi and Gitlin (2018) made a study regarding optimizing the fog networks by using unsupervised machine learning methods. As argued by the authors, their model accomplished to make the network latency diminish by deploying clustering algorithms even though the model was not aware of the number of fog nodes or their location in the space, which is called priori known data.

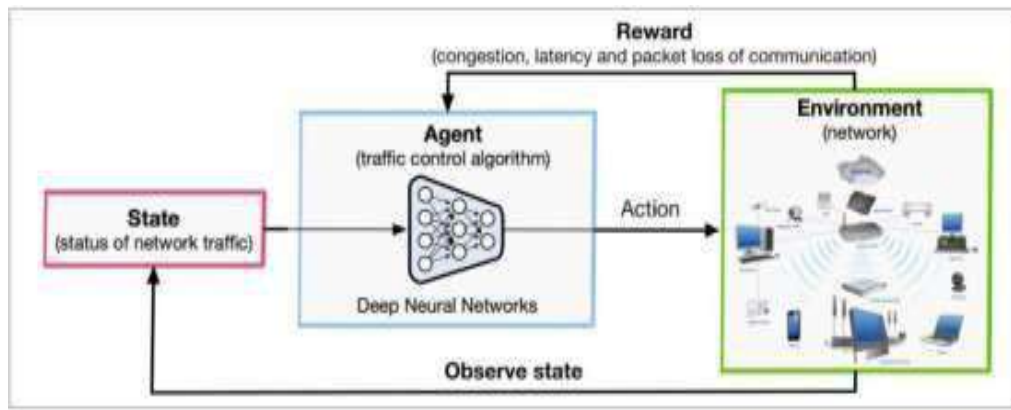


Figure 2 Representation of working process of an agent

To create data sets suitable for the use of artificial intelligence algorithms, several simulation techniques can mimic complex network conditions or scenarios. Nevertheless, simulating a complex environment precisely can be a challenging job in some cases. Fu et al. (2018) indicate that using RL and its advanced versions are more beneficial than other methods to coordinate communication networks since they do not stand in the need of high quality or labeled data.

RESULTS

The composite formation of 5G technologies can be handled with the help of AI. With technologies such as multiple-input multiple- output (MIMO), RF spectrum, or spectrum-management helping the development of 5G technologies, it has become vital to distribute resources intelligently and manage systems correctly in this complex structure. the predictions made with ANN for the network densities of slices have been quite successful. In addition, according to the authors' claim, the behaviors of users who move physically following certain patterns can be determined and

their next dispositions can be predicted and the necessary resources can be shared based on this information.

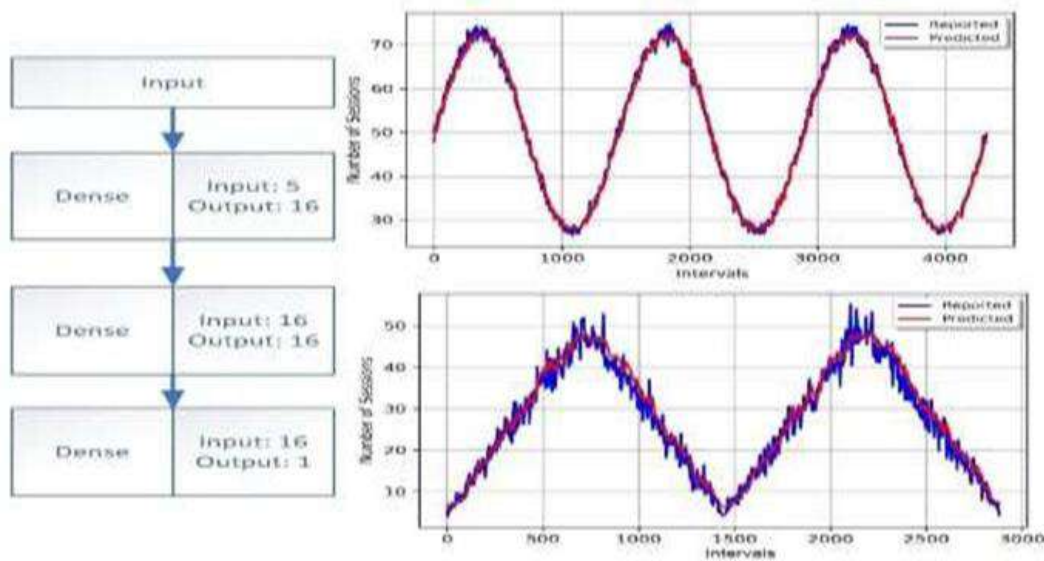


Figure 3 The predictions made by neural networks and the actual values about network density

The method based on performing Artificial Intelligence operations on more than one device at the same time is called AI at the edge or on-device AI. In contrast, Yao et al. (2019) think that the current capacities of mobile devices are not yet at a sufficient level for situations that require high processing power such as AI training, and therefore, the application of the "AI at the edge" method on mobile devices does not seem possible for now..Central systems, or AI over the bridge, on the other hand, provide a much more comfortable environment in terms of technical competence According to Wang et al. (2018), new technologies such as graphic processing units (GPU) and neural network processing unit (NPU) offer important opportunities for neural network applications. AI over the bridge systems have the potential to satisfy the severe processing, power, and memory needs of 5G networks. Thus, the units of 5G systems that require different treatment.

CONCLUSION

In summary; basic artificial intelligence techniques, successful AI studies that can seriously support 5G technologies, and discussions in this field are explained. It does not seem possible at the moment to reach high standards such as low latency and high speed required by 5G systems with traditional approaches..

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