

Optimization of Framework for 6G Wireless Networks Using AI- Based Machine Learning Techniques

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World Journal of Advanced Engineering Technology and Sciences, 2026

Publication history-

Abstract

Sixth-generation (6G) wireless communication systems are expected to support extremely high data rates, massive connectivity, and intelligent services. However, the rapid growth of network devices and data traffic will significantly increase energy consumption in future communication networks. Therefore, improving energy efficiency has become a critical challenge for 6G systems. This research proposes an artificial intelligence-based framework for energy optimization in 6G wireless networks. Machine learning techniques are used to analyze network conditions and dynamically allocate resources to minimize power consumption while maintaining high communication performance. A simulation model is developed using MATLAB/Python to evaluate the performance of the proposed AI-based algorithm. Performance metrics such as energy efficiency, throughput, and latency are analysed and compared with conventional resource allocation techniques. Simulation results demonstrate that the proposed AI-based approach significantly reduces energy consumption while maintaining reliable communication. The proposed framework provides a promising solution for sustainable and energy-efficient 6G communication networks.

Keywords: 6G NETWORKS, OPTIMIZATION IN 6G, AI- BASED ALGORITHM

1. Introduction

1.1 Introduction to Wireless Communication

Wireless Communication is a method of transmitting data or information between two or more devices without the use of physical wires or cables. Instead of using cables, it uses radio waves (RF - Radio Frequency) or other types of electromagnetic waves to send signals through the air or free space.

Wired vs Wireless Medium

A wired network is a bounded medium, where data travels along a predefined path such as cables or wires. While reliable, wired networks impose several restrictions in a modern environment where a large number of devices need to connect simultaneously.

Basics of Wireless Communication

Wireless communication works by transmitting signals through free space using Radio Frequency (RF) waves. Here's how it works: One device acts as the Transmitter, sending RF signals through an antenna. Another device serves as the Receiver, capturing the transmitted signals. Both devices must use the same frequency (or channel) for effective communication.

Shared Medium and Half-Duplex Operation

Much like wired devices share a common communication medium, wireless devices share airtime and bandwidth. To avoid signal collisions and interference, Wireless devices operate in half-duplex mode (cannot send and receive data at the same time). Before transmitting, devices follow the IEEE 802.11 standard procedure to check if the channel is free and available.

- Wireless communication in free space relies on the generation of electromagnetic waves:
- The Transmitter sends an alternating current into an antenna, generating moving electric and magnetic fields.

- These fields propagate as travelling waves, with the electric and magnetic fields moving at right angles to one another.
- To sustain the wave propagation, the current must alternate cyclically.
- The Frequency of a wave refers to the number of cycles the wave completes in one second, calculated as:

{Frequency (Hz) = Number of cycles per second}

Frequency Unit Names

Unit	Abbreviation	Meaning
Hertz	Hz	Cycles per second
Kilohertz	kHz	1000 Hz
Megahertz	MHz	1, 000, 000 Hz
Gigahertz	GHz	1, 000, 000, 000 Hz

Advantages of Wireless Communication

- No need for physical cables - offering mobility and convenience.
- Supports connection of multiple devices without the need for numerous ports.
- Easier to deploy in areas where wiring is impractical or expensive.
- Rapid scaling in environments such as offices, cafes, and public spaces.

Challenges of Wireless Communication

- Limited range and dependence on wireless coverage areas.
- Interference due to multiple devices transmitting simultaneously.
- Security concerns must be actively managed to prevent unauthorized access.
- Periodic maintenance is required to keep communication channels reliable.

1.2 EVOLUTION OF MOBILE NETWORKS (1G → 6G)

1) 1G OR FIRST GENERATION TECHNOLOGY (ANALOG)

The first generation wireless mobile communication system is an analog technology developed in 1980s. It was used for voice services and was based on technology called as Advanced Mobile Phone System (AMPS). The AMPS system was frequency modulated and used frequency division multiple access (FDMA) with a channel capacity of 30KHz and frequency band of 824-894MHz. It supports a speed up to 2.4kbps. In 1988, AMPS was allocated with additional 10MHz bandwidth called as Expanded Spectrum, which was first deployed in Chicago, with a service area of 2100 square miles. AMPS was first launched by US in 1982.

2) **2G OR SECOND GENERATION TECHNOLOGY (DIGITAL)**

The second generation wireless mobile communication system is a digital technology introduced in late 1980s. It uses digital signals for voice transmission and has a speed of 64kbps. The bandwidth of 2G is 30-200KHz. 2G provides services such as short message services (SMS), picture messages and multimedia message services (MMS). It uses digital modulation schemes such as Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). TDMA allows division of signals into time slots. CDMA provides each user with a special code to communicate over a multiplex physical channel. TDMA technologies like GSM, PDC, iDEN, IS-136 and CDMA technology like IS-95 are used. GSM (Global System for Mobile Communication) is the most widely used 2G mobile standard. 2G was commercially launched on GSM standard in Finland, in 1991. GSM technology was the first one to support international roaming. This enabled the mobile subscribers to use their mobile phone connections in different countries of the world with better quality and capacity.

3) **2.5 G TECHNOLOGY**

The GSM technology was continuously improved to provide better services which led to development of advanced systems called as 2.5 Generation (2.5G) systems. 2.5G lies between 2G and 3G technologies. In addition with circuit switched domain of 2G system, 2.5G implements a packet switched domain, and provides a data rate of 144kbps. 2G used technologies such as General Packet Radio Service (GPRS) and EDGE (Enhanced Data rates in GSM Environment). GPRS provides packet switching protocols, short setup time for ISP connections and the possibility to charge the subscriber according to the amount of data sent rather than connection time. GPRS supports flexible data transmission rates and provides continuous connection with the network. GPRS is the significant step towards 3G.

4) **3G OR THIRD GENERATION TECHNOLOGY-**

The third generation wireless mobile communication system was introduced in 2000. The goal of 3G systems was to offer increased data rates from 144kbps to 384kbps in wide coverage areas and 2Mbps in local coverage areas. 3G offers advanced services to the users as compared to 1G and 2G. Along with voice communication it includes data services, access to TV/videos, Web browsing, e-mail, video conferencing, paging, fax and navigational maps. It has a bandwidth of 15-20MHz used for high speed internet, video chatting, etc. A 3G mobile system was defined by an organization called 3rd Generation Partnership Project (3GPP) which fulfils the IMT-2000 standards. It was called as UMTS (Universal Mobile Telecommunication System) in Europe, which is TSI driven. IMT2000 is the ITU-T name for the third generation system, while CDMA2000 is the name of American 3G variant. Also the IMT2000 has accepted a new 3G standard from China, i.e. TD-SCDMA. WCDMA is the air-interface technology for UMTS. The first commercial 3G network was launched by NTT Docomo in Japan, in 2001.

5) **4G OR FOURTH GENERATION TECHNOLOGY-**

The fourth Generation mobile system was introduced in the late 2000s and was all IP based network system. The main goal of 4G technology is to provide high speed, high quality, high capacity, security and low cost services for voice and data services, multimedia and internet over IP. The reason for the transition to all IP is to have a common platform to all the technologies developed so far. It has the capability 100Mbps and 1Gbps. To use 4G mobile network, multimode user terminals should be able to select the target wireless system. To provide wireless services anytime and anywhere, terminal mobility is a key factor in 4G. Terminal mobility implies automatic roaming between different wireless networks. The 4G technology integrates different existing and future wireless technologies (e.g. OFDM, MC-CDMA, LAS-CDMA and Network-LMDS) to provide freedom of movement and uninterrupted roaming from one technology to another. LTE (Long Term Evolution) and WiMAX (Wireless Interoperability for Microwave Access) are considered as 4G technologies. The first successful field trial for 4G was conducted in Japan, in 2005.

6) **5G OR FIFTH GENERATION TECHNOLOGY.**

The fifth generation mobile and wireless communication network is the real wireless world which would be supported by LAS-CDMA, OFDM, MC-CDMA, UWB, Network-LMDS, IPv6.5G can be called as the perfect real wireless world or World Wide Wireless Web(WWWW) as it has no limitations. The basic protocol for running on both 4G and 5G is IPv6.5G aims to provide unlimited access to information and the ability to share data anywhere, anytime by anyone for the benefit of the world. 5G technologies covers all the advanced features which makes 5G mobile technology most powerful and will be in huge demand in future. The 5G mobile is all-IP based for mobile and wireless network interoperability. The standardization activities for 5G have already started this year which may lead to commercial availability around 2020.

5G network, the Physical and Data Link layer defines the 5G wireless technology indicating it as an Open Wireless Architecture(OWA). The 5G technology also maintain virtual multi-wireless network. To perform this the Network layer is sub-divided into two layers; upper network layer for mobile terminal and lower network layer for interface. Here all the routing will be based on IP addresses which would be different in each IP network worldwide. In 5G technology the higher bit rate loss is overcome by using Open Transport Protocol(OTP). The OTP is supported by Transport and Session layer. The application layer is for quality of service management over various types of networks.

FEATURES

- 5G provides large broadcasting of data in Gigabit.
- 5G terminals have software-defined radios.
- 5G uses different modulation techniques and error-control techniques.
- 5G provides hundreds of channels without streaming.
- 5G technology offer transporter class gateway with unparalleled consistency.
- 5G technology supports virtual private network.
- 5G offers bidirectional bandwidth and less traffic
- 5G provides 25Mbps connectivity speed with data bandwidth higher than 1Gb.
- Remote diagnostics is a great feature of 5G.
- The uploading and downloading speed of 5G is very high.

1.3 Overview of 6G Technology

The sixth generation mobile and wireless communication network can integrate the satellite communication networks and 5G to provide global coverage. The satellite communication network may consist of telecommunication satellite networks, earth imaging satellite networks and navigation satellite networks. The goal of 6G is to integrate these kinds of satellite networks to provide network position identifier, multimedia and internet connectivity, and weather information services to the mobile users. The four countries which have these satellite systems are: The Global Position System(GPS) by USA, the Galileo by Europe, the COMPASS by China and the GLONASS by Russia. If 6G integrates with 5G with these satellite networks, it would have four different standards. So handoff and roaming will be a big issue in 6G. The radio over fiber system is already in existence, but with the advent of 6G technology, mankind will be more close to any extraterrestrial civilization in the universe.

FEATURES

- Ultra fast Internet access.
- Data rates will be up to 10-11 Gbps.
- Smart Homes, Cities and Villages.
- May be used in the production of Energy from galactic world.
- Home automation, Space technology, Defence applications will be modified with 6G networks.
- Satellite to Satellite Communication
- Natural Calamities will be controlled with 6G networks.
- Sea to Space Communication.
- Mind to Mind Communication may be possible.

Energy Consumption Challenges in Wireless Networks

Energy consumption in wireless networks, particularly Wireless Sensor Networks (WSNs) and IoT, is constrained by limited, non-rechargeable battery power, requiring, efficient data transmission, processing, and idle-mode management. Key challenges include high communication power demands, maintaining network longevity, and handling large-scale, random deployment of nodes.

Core Energy Challenges

- **Limited Power Supply:** Sensor nodes often operate on batteries in remote or hazardous areas where replacement is impractical, making efficiency vital for network lifespan.
- **Communication Overhead:** Transmitting and receiving data over wireless channels consumes significant energy, often more than data processing.
- **Idle Listening and Overhearing:** Nodes consume energy even when not transmitting, such as when listening to an idle channel or receiving irrelevant packets.
- **Packet Collisions and Retransmission:** In dense networks, packet collisions require retransmissions, which waste energy.
- **Environmental Factors:** In harsh environments, nodes may require more power to transmit signals through obstacles, or high temperatures can affect battery performance.
- **Security Processing:** Implementing encryption, such as cryptography headers, adds processing overhead that drains battery life.

Network-Level Challenges

- **Scalability and Coverage:** Maintaining full network coverage with thousands of nodes while ensuring long-term operation is difficult.
- **Unreliable Wireless Channels:** Signal fading and interference require higher transmission power, reducing node battery life.
- **Network Maintenance:** Since nodes are often deployed randomly and left unattended, protocols must be efficient and self-organizing.

Research focuses on low-power communication protocols (like ZigBee), energy-aware routing algorithms, node duty-cycling (sleeping modes), and data aggregation to reduce the amount of data transmitted.

1.4 Importance of Energy Efficiency in 6G

Energy efficiency and power optimization are crucial focal points in the development of 6G wireless communication systems, aimed at fostering sustainability and environmentally conscious practices. As the demand for data transmission escalates and the number of connected devices proliferates, it becomes imperative to curtail energy consumption while upholding superior network performance. This section delves into a comprehensive exploration of strategies and technologies that can be employed to achieve exemplary energy efficiency and power optimization within the realm of 6G. The pursuit of energy efficiency encompasses a broad spectrum of considerations, encompassing advanced power management techniques, dynamic energy harvesting, and energy-aware network design and protocols. By implementing sophisticated power management techniques, such as intelligent power allocation, adaptive power control, and energy-saving algorithms, network components and devices can efficiently harness power resources, thereby mitigating unnecessary energy dissipation.

1.5 Role of Artificial Intelligence in Network Optimization

Artificial intelligence (AI) optimizes networks by automating traffic management, predicting failures, and enabling self-healing, which boosts performance, reduces downtime, and lowers operational costs. By using machine learning

to analyze real-time data, AI dynamically allocates resources, improves service quality (QoS), and ensures efficient, secure, and resilient operations.

Key Roles of AI in Network Optimization:

- **Predictive Maintenance & Fault Detection:** AI algorithms identify patterns and predict network congestion or failures before they impact users, enabling proactive maintenance.
- **Intelligent Traffic Management:** AI analyzes traffic patterns in real-time, automatically adjusting routing to prevent congestion, improve speed, and ensure high-quality service, especially during peak demand.
- **Self-Healing Networks:** AI-driven systems can automatically detect, diagnose, and repair network issues, reducing reliance on manual intervention and minimizing downtime.
- **Dynamic Resource Allocation:** AI dynamically manages and allocates resources like bandwidth, power, and storage, ensuring optimal performance for applications like 5G and 6G.
- **Network Automation & Configuration:** AI automates configuration, such as antenna tuning or parameter optimization, resulting in more efficient network operations.

Benefits:

- **Reduced Operational Costs:** Automation and efficient resource allocation reduce the need for manual, costly interventions.
- **Enhanced User Experience:** Proactive issue resolution and optimized traffic flow ensure higher reliability and better service.
- **Improved Security:** AI can detect unusual patterns that indicate potential security threats.

1.6 Research Objectives-

The primary objective of this research is to develop an Artificial Intelligence (AI)-based framework for optimizing energy consumption in future 6G wireless communication networks while maintaining high network performance and reliability.

The specific objectives of this study are as follows:

1. To analyze the energy consumption challenges in 6G wireless communication networks.
This includes studying the impact of dense network deployment, massive connectivity, and advanced communication technologies on power usage.
2. To investigate the role of Artificial Intelligence and Machine Learning techniques in improving energy efficiency in wireless networks.
Various AI algorithms such as machine learning and reinforcement learning will be studied for intelligent network optimization.
3. To design an AI-based energy optimization model for 6G networks.
The proposed model will dynamically allocate network resources and adjust transmission parameters to reduce energy consumption.
4. To implement the proposed AI-based model using simulation tools.
The system will be simulated using tools such as MATLAB or Python to evaluate the performance of the proposed approach.
5. To evaluate the performance of the proposed system using different performance metrics.
Metrics such as energy efficiency, latency, throughput, and network utilization will be analyzed.

6. To compare the performance of the AI-based energy optimization method with traditional network management techniques.

This comparison will demonstrate the effectiveness of AI in reducing energy consumption and improving network performance.

KIEN N GUYEN [7] in June 29, 2018- The next-generation wireless networks are evolving into very complex systems because of the very diversified service requirements, heterogeneity in applications, devices, and networks. The network operators need to make the best use of the available resources, for example, power, spectrum, as well as infrastructures. Traditional networking approaches, i.e., reactive, centrally-managed, one-size fits-all approaches, and conventional data analysis tools that have limited capability (space and time) are not competent anymore and cannot satisfy and serve that future complex networks regarding operation and optimization cost effectively. A novel paradigm of proactive, self-aware, self-adaptive, and predictive networking is much needed. The network operators have access to large amounts of data, especially from the network and the subscribers. Systematic exploitation of the big data dramatically helps in making the system smart, intelligent, and facilitates efficient as well as cost-effective operation and optimization. We envision data-driven next-generation wireless networks, where the network operators employ advanced data analytics, machine learning (ML), and artificial intelligence. We discuss the data sources and strong drivers for the adoption of the data analytics, and the role of ML, artificial intelligence in making the system intelligent regarding being self-aware, self-adaptive, proactive and prescriptive. A set of network design and optimization schemes are presented concerning data analytics. This paper concludes with a discussion of challenges and the benefits of adopting big data analytics, ML, and artificial intelligence in the next generation communication systems.

PROSPER CHEMOUIL [9] IN 6 JUNE 2019-

Research in large-scale networking systems has been shaped and will continue to be guided by specific characteristics of applications and the underlying platforms and infrastructures. On the one hand, applications are growing at an accelerated pace, which is fundamentally unpredictable in both breadth and depth. On the other hand, the underlying networking has been the focus of a huge transformation enabled by new models resulting from virtualization and cloud computing. This has led to a number of novel architectures supported by emerging technologies such as Software-Defined Networking (SDN), Network Function Virtualization (NFV), and more recently, edge cloud and fog networking, or network slicing [1], [2]. This evolution towards enhanced design opportunities along with increasing complexity in networking and its applications has fueled the need for improved network automation in agile infrastructures. At the same time, their complexity has dramatically increased. The networking dynamics have had the effect of making it even more important and challenging to design scalable network measurement and analysis techniques and associated tools. Critical applications such as resource allocation, network monitoring, security enforcement, or dynamic network management require real-time mechanisms for online analysis as well as efficient techniques for offline deep analysis of massive historical data.

CHOWDHURY [2] in 20 July 2020 - The demand for wireless connectivity has grown exponentially over the last few decades. Fifth-generation (5G) communications, with far more features than fourth-generation communications, will soon be deployed worldwide. A new paradigm of wireless communication, the sixth-generation (6G) system, with the full support of artificial intelligence, is expected to be implemented between 2027 and 2030. Beyond 5G, some fundamental issues that need to be addressed are higher system capacity, higher data rate, lower latency, higher security, and improved quality of service (QoS) compared to the 5G system. This paper presents the vision of future 6G wireless communication and its network architecture. This article describes emerging technologies such as artificial intelligence, terahertz communications, wireless optical technology, free-space optical network, blockchain, three-dimensional networking, quantum communications, unmanned aerial vehicles, cell-free communications, integration of wireless information and energy transfer, integrated sensing and communication, integrated access-backhaul networks, dynamic network slicing, holographic beamforming, backscatter communication, intelligent reflecting surface, proactive caching, and big data analytics that can assist the 6G architecture development in guaranteeing the QoS. Besides, expected applications with 6G communication requirements and possible technologies are presented. We also describe potential challenges and research directions for achieving this goal.

LATIF U. KHAN[3] in August 20,2020-Internet of everything(IoE)-based smart services are expected to gain immense popularity in the future, which raises the need for next-generation wireless networks. Although fifth-generation (5G) networks can support various IoE services, they might not be able to completely fulfil the requirements of novel applications. Sixth-generation (6G) wireless systems are envisioned to overcome 5G network limitations. In this article, we explore recent advances made toward enabling 6G systems. We devise a taxonomy based on key enabling technologies, use cases, emerging machine learning schemes, communication technologies, networking technologies, and computing technologies. Furthermore, we identify and discuss open research challenges, such as artificial-intelligence-based adaptive transceivers, intelligent wireless energy harvesting, decentralized and secure business models,intelligent cell-less architecture,and distributed security models. We propose practical guidelines including deep Q-learning and federated learning-based transceivers, blockchain-based secure business models, homomorphic encryption, and distributed-ledger based authentication schemes to cope with these challenges. Finally, we outline and recommend several future directions.

HELIN YANG [4] IN DECEMBER 2020- With the rapid development of smart terminals and infrastructures, as well as diversified applications (e.g., virtual and augmented reality, remote surgery and holographic projection) with colorful requirements, current networks (e.g., 4G and upcoming 5G networks) may not be able to completely meet quickly rising traffic demands. Accordingly, efforts from both industry and academia have already been put to the research on 6G networks. Recently, artificial intelligence (AI) has been utilized as a new paradigm for the design and optimization of 6G networks with a high level of intelligence. Therefore, this article proposes an AI-enabled intelligent architecture for 6G networks to realize knowledge discovery, smart resource management, automatic network adjustment and intelligent service provisioning, where the architecture is divided into four layers: intelligent sensing layer, data mining and analytics layer, intelligent control layer and smart application layer. We then review and discuss the applications of AI techniques for 6G networks and elaborate how to employ the AI techniques to efficiently and effectively optimize the network performance, including AI-empowered mobile edge computing, intelligent mobility and handover management, and smart spectrum management. Moreover, we highlight important future research directions and potential solutions for AI-enabled intelligent 6G networks, including computation efficiency, algorithms robustness, hardware development and energy management.

ABDUL RAHMAN ALKANDARI [1] in 2022 -The meaning of wireless communication is the way of transferring information between two points or more than that, which are not connected by a physical conductor. Most of wireless technologies are using radio waves and distances for radio waves can be very short (a few meters) like Bluetooth or so far away (millions of kilometres) for deep-space communications. Wireless communication went through multiple generations. Recently, 5G network is the latest generation of wireless communication networks that enable a huge transfer amount of data through its channels. 6G network is intended to provide faster wireless network than 5G soon so both can serve Internet of Things (IoT) applications.

DAOUD BURGHAL [8] in 27 October 2023- Accurate Channel State Information (CSI) is critical for maximizing the throughput of massive Multi-Input Multi-Output (mMIMO) systems. Due to the environment dynamics and user mobility, CSI aging is a major challenge to achieving the large throughput of mMIMO promised by theory. CSI prediction can be used to overcome this without increasing the signaling overhead. Motivated by the anticipated native support for Artificial Intelligence(AI)in the fifth generation and beyond cellular standards, we propose deep learning CSI prediction solutions based on 3-Dimensional (3D) Complex Convolutional Neural Networks (CCNN). These solutions provide improved capabilities for capturing temporal and spatial correlations, enhancing CSI prediction performance. In particular, they utilize the angle delay decomposition of previously observed CSI to predict the future one. In one architecture, the network, dubbed CSI Prediction Network,uses small kernel swith circular padding to efficiently capture the correlation between propagation paths in the angle domain. This architecture can be further improved by the use of an attention-like model to vary the weights and enhance prediction performance adaptively. We also propose methods to enhance robustness to noise and time and frequency offsets. We tested these solutions using 3GPP-compatible simulations and field measurements in a *commercial* network. Our solutions demonstrate stable performance and significantly outperform several benchmarks, especially at low and medium speeds. They strike a balance between performance and architecture complexity, indicating suitability for actual implementation.

MERVE OZKAN-OKAY [5] in 18 January 2024- Given the continually rising frequency of cyberattacks, the adoption of artificial intelligence methods, particularly Machine Learning (ML), Deep Learning (DL), and Reinforcement Learning (RL), has become essential in the realm of cybersecurity. These techniques have proven to be effective in detecting and mitigating cyberattacks, which can cause significant harm to individuals, organizations, and even countries. Machine learning algorithms use statistical methods to identify patterns and anomalies in large datasets, enabling security analysts to detect previously unknown threats. Deep learning, a subfield of ML, has shown great potential in improving the accuracy and efficiency of cybersecurity systems, particularly in image and speech recognition. On the other hand, RL is again a subfield of machine learning that trains algorithms to learn through trial and error, making it particularly effective in dynamic environments. We also evaluated the usage of ChatGPT-like AI tools in cyber-related problem domains on both sides, positive and negative. This article provides an overview of how ML, DL, and RL are applied in cybersecurity, including their usage in malware detection, intrusion detection, vulnerability assessment, and other areas. The paper also specifies several research questions to provide a more comprehensive framework to investigate the efficiency of AI and ML models in the cybersecurity domain. The state-of-the-art studies using ML, DL, and RL models are evaluated in each section based on the main idea, techniques, and important findings. It also discusses these techniques' challenges and limitations, including data quality, interpretability, and adversarial attacks. Overall, the use of ML, DL, and RL in cybersecurity holds great promise for improving the effectiveness of security systems and enhancing our ability to protect against cyberattacks. Therefore, it is essential to continue developing and refining these techniques to address the ever-evolving nature of cyber threats.

SABARIRAJAN PARAMASIVAM [10] IN 2024- This work introduces a design and simulation of an autonomous mobile robot with a self-learning control system by incorporating reinforcement learning for real-time optimization of adaptability in its performance. The use of Raspberry Pi with an attached camera module allows the robot to perform object detection for identification and executing automatic pick-and-place actions. Ultrasonic sensors can support navigation as well as obstacle detection, while the gripper mechanism will aid fine material handling. As such, the system is capable of application in loading and unloading as well as transport. With the RL framework, the robot can optimize its real-time activities with a reward-penalty system to perfect its operational behavior for efficient task execution. The L293D motor driver is used to control the robot's movement accurately, giving stability and precision in handling. Various material handling scenarios are tested by simulation to validate the performance of the control system and to check whether the robot can autonomously execute its tasks. This phase of simulation is aimed at proving that the proposed system will be effective in material handling as it lays the groundwork for hardware implementation with eventual real-world use in industrial settings.

YUSUF USMAN [6] in 1 October 2025- The transition from 5G to 6G networks demands groundbreaking advances in intelligence, adaptability, and security to support emerging applications such as real-time telemedicine, immersive extended reality (XR), and autonomous systems. This article provides a comprehensive analysis of how artificial intelligence (AI), machine learning (ML), and large language models (LLM) are revolutionizing next-generation telecommunications. We present a structured roadmap for integrating these technologies into 6G infrastructure, emphasizing their transformative roles in intelligent network management, dynamic resource allocation, and proactive threat mitigation. By addressing key challenges such as ultralow latency, heterogeneous data handling, and ethical governance, this study bridges theoretical innovations with practical applications. Notable contributions include novel frameworks for AI-enhanced security, self healing networks, and privacy-preserving techniques like federated learning. Furthermore, we explore critical ethical considerations, including bias mitigation and transparency in AI decision-making, while highlighting emerging research directions such as adaptive learning systems and hybrid AI architectures. This work underscores the synergistic potential of AI and 6G, equipping researchers and industry stakeholders with actionable insights to develop resilient, user-centric networks that will shape the future of global connectivity.

Proposed AI-based frameworks for 6G energy optimization use intelligent, cross-layer, and distributed AI (DRL, FL) to enable green, autonomous networks. These architectures integrate AI at physical, MAC, and network

layers—using NWDAF and Digital Twins—to dynamically manage resources, beamforming, and routing, significantly boosting energy efficiency while maintaining low-latency, high-throughput performance.

The machine learning algorithm used for intelligent resource allocation

Machine Learning-Based Resource Allocation Algorithms (MLRA) have emerged as a viable solution to the challenges posed by the next generation (6G) of network infrastructure. Compared to traditional algorithms, MLRA are more adaptive and provide a better utilization of available resources. The algorithms are able to determine the optimal parameters for resource allocation based on observed network behaviour. As 6G networks become increasingly used, MLRA will be crucial in ensuring that resources are efficiently and effectively allocated. The algorithms can identify when unutilized resources are available and quickly reallocate them to more successful users or applications. 6G networks are expected to provide gigabit speeds and up to 1000x bandwidth increase. This requires intelligent resource allocation algorithms which can quickly and accurately respond to changing user behaviour and demand. MLRA will be critical in enabling this shift and allowing users to benefit from the features and performance of 6G networks.

REINFORCEMENT LEARNING (RL)

RL learns to execute operations through iterative trials and error computations. This learning method consists of several elements such as environment, agent, state, action and reward spaces. An agent is assigned in an environment space which learns to perform actions on the basis of the state the agent experiences. A reward value is provided to the agent for its choice of action. The agent uses its own experience to train itself and choose the corresponding action/policy to maximize the reward.

DEEP LEARNING (DL)

DL analyzes the given data sets to determine the characteristics and interpret the relation between these data. It is similar to artificial neural networks, however the difference lies in the number of hidden layers in the neural network. The implementation of DL is enabled by the breakthrough development of the learning algorithms and hardware capabilities. The enhancement of learning algorithms such as supervised learning and reinforcement learning can be achieved by adopting DL mechanism. This allows the use of DL in various applications such as network access, routing optimization, device localization, antenna orientation, channel estimation, resource allocation and security threat detection.

DEEP REINFORCEMENT LEARNING (DRL)

DRL mechanism is somewhat similar to the RL mechanism. However, with the increased complexity in the problem study, the number of states and the probable actions will increase or will not be available to extract. The Q-value table, which records the reward value for actions executed at a particular state, will thus be difficult to construct. The DL mechanism is then implemented for mapping the state and the corresponding action to deal with the difficulty of storing the reward value for the high problem complexity. Even when the reward value is partially available or not available, DRL helps to generalize this reward value.

The proposed system uses Deep Reinforcement Learning (DRL) for intelligent resource allocation.

Model Components

State (S):

- Channel conditions
- Traffic load
- Network energy consumption
- User demand

Action (A):

- Power allocation

- Bandwidth allocation
- Base station activation/deactivation

Reward (R):

The reward function maximizes energy efficiency:

$$Reward = \frac{Throughput}{Energy\ Consumption}$$

The learning agent selects actions that maximize the reward.

7. Algorithm Implementation Steps**Step 1: Initialize Network Environment**

- Create base stations
- Generate users
- Initialize network parameters

Step 2: Collect Network Data

- Monitor traffic load
- Measure channel conditions
- Track energy consumption

Step 3: Train Machine Learning Model

- Use training dataset
- Update model parameters

Step 4: Predict Optimal Resource Allocation

The trained model determines:

- Power levels
- Bandwidth distribution
- User scheduling

Step 5: Apply Optimization

The network controller adjusts parameters dynamically.

Step 6: Evaluate Network Performance

Measure performance metrics.

8. Performance Evaluation Metrics

The proposed model is evaluated using the following metrics:

1. Energy Efficiency

$$EE = \frac{Total\ Data\ Rate}{Total\ Energy\ Consumption}$$

Higher values indicate better energy performance.

2. Network Throughput

Total data successfully transmitted in the network.

$$Throughput = \frac{Total\ Data}{Transmission\ Time}$$

3. Latency

Time delay in packet delivery.

4. Packet Loss Rate

Percentage of packets that fail to reach their destination.

5. Spectral Efficiency

Efficient utilization of available spectrum.

9. Simulation Workflow

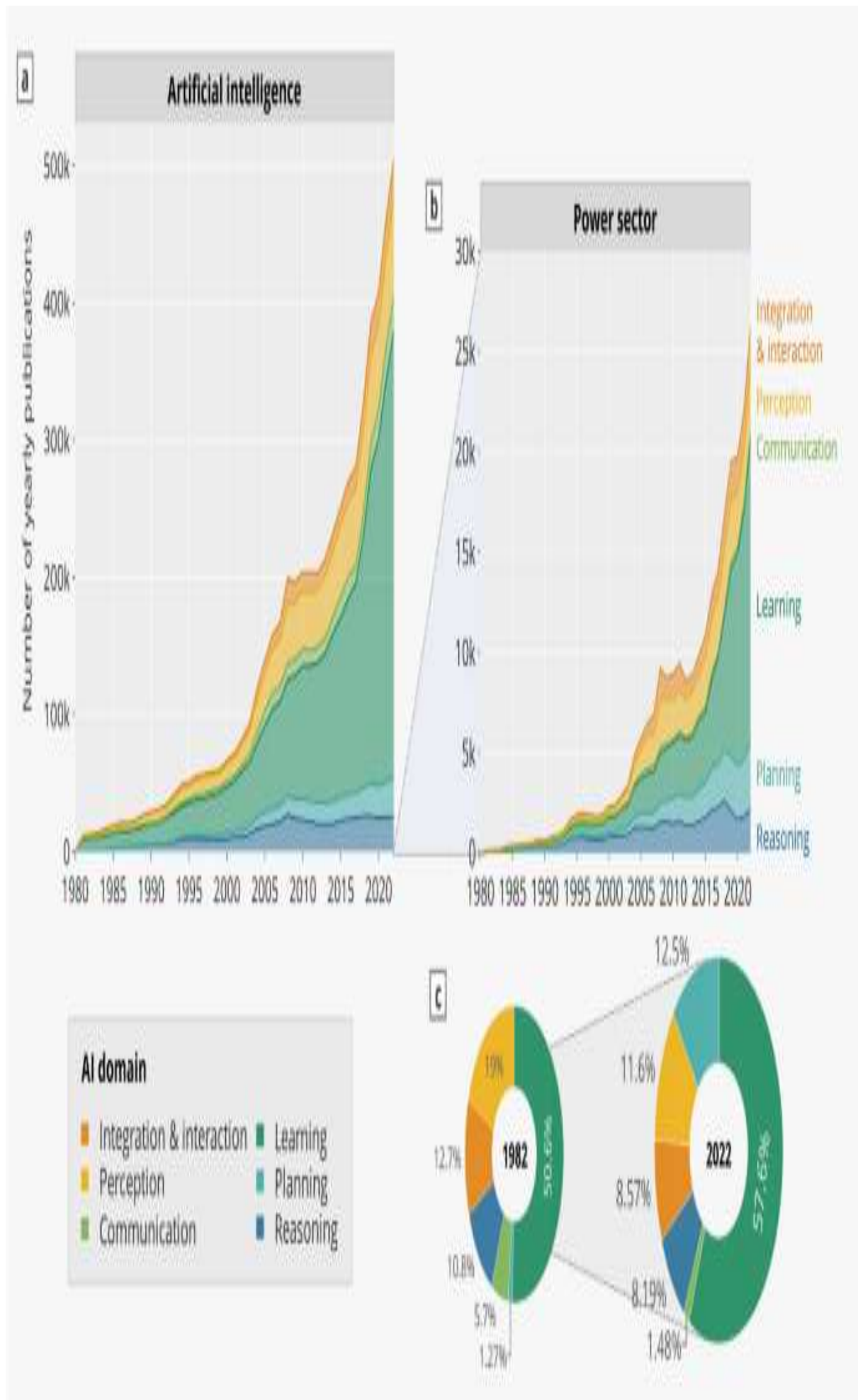
The complete simulation workflow is:

1. Initialize network environment.
2. Generate network traffic data.
3. Train machine learning model.
4. Predict optimal resource allocation.
5. Apply energy optimization strategies.
6. Run network simulation.
7. Measure performance metrics.
8. Compare results with conventional methods.

10. Expected Simulation Results

The proposed AI-based model should achieve:

- 20–40% reduction in energy consumption
- Improved spectrum utilization
- Lower communication latency
- Higher network throughput.
- **Energy Efficiency Analysis**



- Energy efficiency measures how effectively the network transmits data relative to the energy consumed.

Observations

- The proposed AI model dynamically adjusts transmission power and resource allocation.
- Energy consumption decreases when base stations operate in sleep mode during low traffic periods.
- Intelligent scheduling reduces unnecessary transmissions.

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