International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 5, No. 4, December - February, 2021
Pages 9-15 | Cosmos Impact Factor (Germany): 5.195
Received: 02.12.2020 Published: 28.02.2021

COGNITIVE COMPUTING AND ARTIFICIAL INTELLIGENCE FOR 6G COMMUNICATIONS AND NETWORKS

Dr A. N. NANDAKUMAR[1], FEBY ASHRAF[2], SHABIYA M I[3], CHINCHU JAMES[4]
Professor[1], Assistant Professor[2,3,4]
Department of Computer Science and Engineering, Indira Gandhi Institute of Engineering And Technology, Nellikuzhi P.O, Kothamangalam, Ernakulam (Dist) Pincode 686691

Abstract

Due to the rapid advancement of smart infrastructures and terminals, along with the development of advanced applications like augmented and virtual reality, holographic projection, and remote surgery, it is highly probable that upcoming 5G and 4G networks will be insufficient to meet the increasing demands for data traffic. Similarly, there have been successful efforts to scrutinise 6G systems by both scholars and academics. Recently, artificial intelligence (AI) has been extensively used as an alternative perspective for the design and improvement of 6G systems, offering a significant level of understanding. The paper suggests using AI technology in the design of 6G systems to enable functions such as information discovery, intelligent service provision, mechanical system adjustment, and smart resource management. The proposed network architecture consists of four layers: the smart application layer, the intelligent control layer, the information search and logic layer, and the intelligent sensing layer. The article explores and analyses the applications of AI techniques for 6G organisations. It discusses how to effectively and efficiently optimise network operations using AI methods, such as smart spectrum management, handover management, intelligent mobility, and AI-enabled mobile edge computing. The article also emphasises important areas for future research and potential solutions for 6G networks, including energy management, hardware advancement, algorithm resilience, and computational efficiency.

Keywords: 6G networks, Artificial Intelligence, Remote networks, device-to-device (D2D) technologies, and massive machine-type communications (mMTC).

Introduction

Wireless networks have evolved from the first generation (1G) system to the next fifth generation (5G) frameworks, taking into account factors like as spectrum utilisation, coverage, energy efficiency, dependability, end-to-end latency, and data throughput. 5G systems include three primary utilisation scenarios: ultra-reliable low latency communication (URLLC) that caters to a wide range of services (Letaief et al., 2019). Hence, device-to-device (D2D) technologies, massive multiple-input multiple-output (MIMO), and technologies such as millimeter-wave (mmWave) are used to provide clients with improved services in terms of quality of service (QoS) and quality of experience (QoE), while also boosting network efficiency.

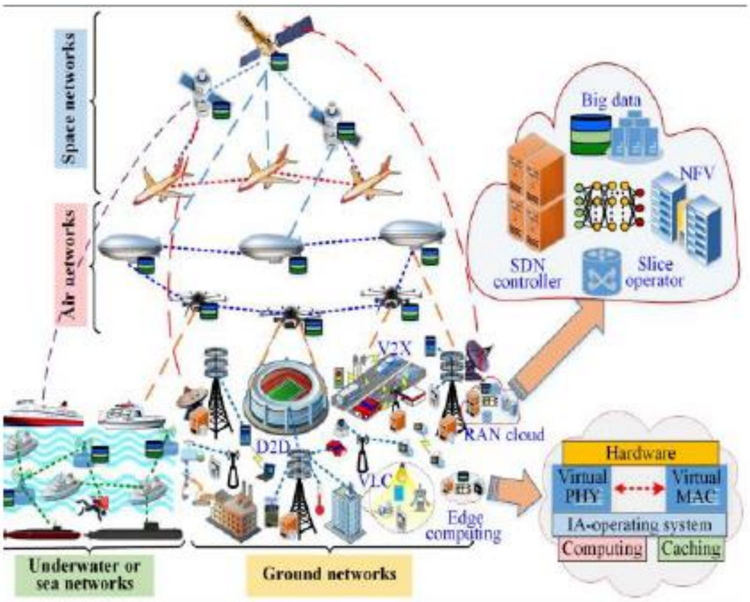
Despite the availability of 5G systems, professionals from various sectors and academia have shifted their attention to the research and development of 6G networks. These networks are expected to support advanced services, such as virtual and augmented reality, remote scientific applications, and holographic imaging. Additionally, 6G networks aim to accommodate a larger number of smart devices and offer limitless connectivity. (Manogaran et al., 2020). For instance, we explored the roadmap to developing 6G networks, including the essential requirements, enabling architecture, and approaches.

In contrast to previous generation systems, 6G systems would need to adapt themselves by acquiring

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 5, No. 4, December - February, 2021
Pages 9-15 | Cosmos Impact Factor (Germany): 5.195
Received: 02.12.2020 Published: 28.02.2021

knowledge to meet the strict requirements and demands of the intelligent data society of 2030. These requirements include: wide frequency bands, a traffic capacity of up to 1 Gbs/m2, up to 107 devices/km2, extensive connectivity, very high mobility, high energy efficiency, extremely high reliability, less than 1 ms end-to-end delay, a peak data rate of at least 1 Tb/s, and a user-experienced data rate of 1 Gb/s. Additionally, 6G systems should provide ultra-high data rates and ultra-low latency (Orange et al., 2020).

Figure 1: Architecture of 6G Network



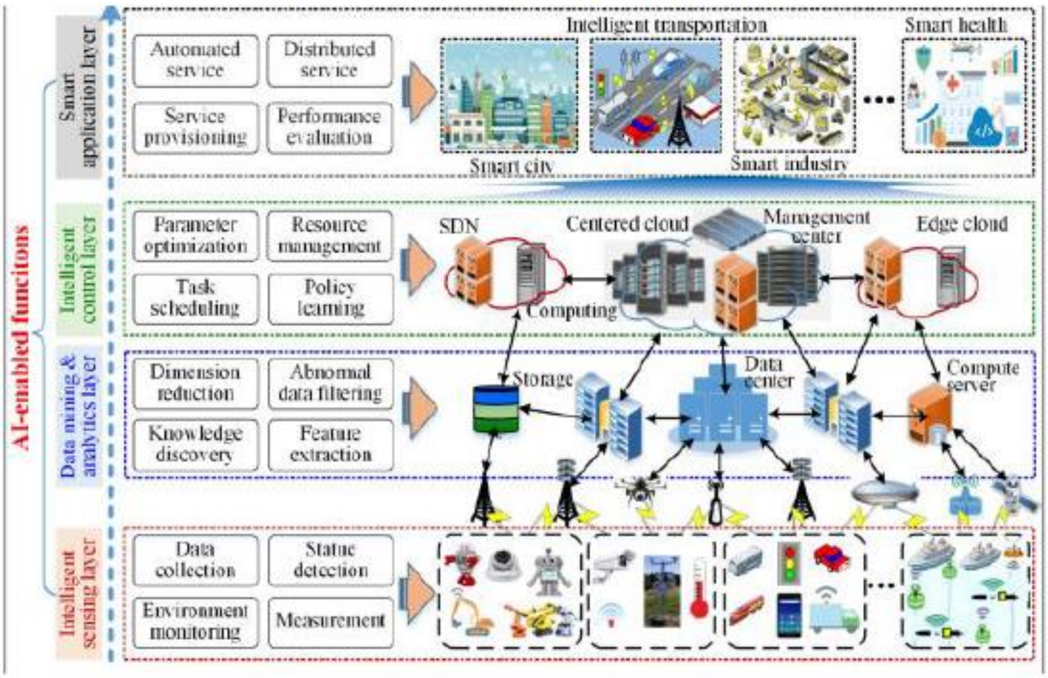
Based on prior system development plans, the first 6G networks will mostly rely on advanced 5G systems such as NFV and SDN frameworks. However, as compared to 5G networks, 6G networks need meeting the aforementioned stringent requirements, such as very high data speeds, extremely low latency, extremely high reliability, and uninterrupted connectivity (Pouttu 2018). 6G systems exhibit significant scale, complexity, and variety, as well as dynamic characteristics. These difficulties need networks that possess the qualities of being highly flexible, adjustable, and intelligent (Basar et al., 2019). Artificial intelligence (AI), equipped with robust learning capabilities, powerful reasoning abilities, and intelligent recognition capabilities, enables the architecture of 6G networks to understand and adapt to support various services without the need for human contact.

Block Diagram and Flow Chart Illustrating the Proposed Methodology

The expansion of 6G systems will include a vast extent, exhibit several facets, be dynamic, highly complex, and diverse. In addition, 6G systems need a reliable network infrastructure and the ability to meet various quality of service requirements for different devices. They also need to process a substantial amount of data generated from real-world environments (Sheth et al., 2020). Artificial intelligence techniques with strong evaluation capability, learning capability, optimisation capability, and intelligent recognition capability can be applied to 6G networks to intelligently perform performance improvement, data discovery, sophisticated learning, structure organisation, and complex decision-making (Chowdhury et al., 2020). The study introduces an AI-based approach for 6G systems, consisting of four distinct layers: smart application layer, intelligent control layer, analytics layer, and information search and intelligent sensing layer.

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 5, No. 4, December - February, 2021
Pages 9-15 | Cosmos Impact Factor (Germany): 5.195
Received: 02.12.2020 Published: 28.02.2021

Figure 2: Methodology for 6G Networks



The approach for 6G Networks encompasses several AI techniques, such as meta-heuristics, game theory, optimisation theory, deep learning, and other forms of machine learning, including unsupervised, supervised, and reinforcement learning. Out of these approaches, deep learning and machine learning are the most often utilised AI methodology in wireless systems (Viswanathan and Mogensen 2020).
The objective of self-directed learning is to identify hidden patterns and extract important insights from unlabeled data, and it is divided into clustering and dimensionality reduction. Grouping aims to categorise a collection of tests into different groups based on their similarities. This process primarily involves the use of K-means clustering and hierarchical clustering algorithms (Giordani and Zorzi 2020). Decreasing the measurement transforms a higher-dimensional information space into a lower-dimensional domain without sacrificing essential data. Isometric mapping (ISOMAP) and Principal component analysis (PCA) are two primary techniques used for reducing dimensions.
In 6G networks, the primary tasks are detecting and recognising information. These networks have the ability to intelligently gather a significant amount of data from the physical environment using various devices such as mobile phones, drones, cars, sensors, and cameras (Yang et al., 2019). AI-enabled systems may obtain dynamic, reliable, and flexible information by connecting with the physical environment. This includes using radiofrequency identification, monitoring weather conditions, detecting ranges, identifying intrusions, and recognising obstacles.

Algorithms

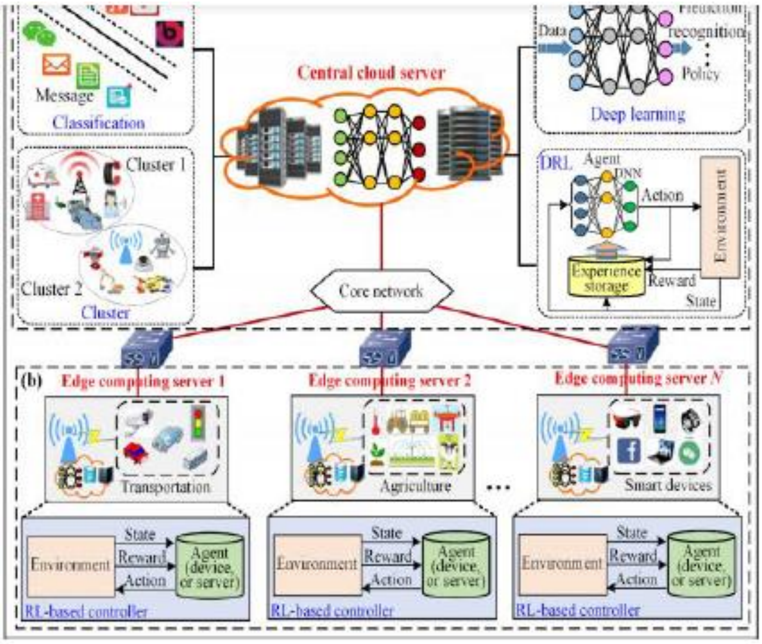
According to Zhang et al. (2019), the 5G systems have significantly enhanced the VR/AR experience for 5G users by providing high data transmission capacity and minimal idleness. However, there are still significant challenges in the implementation of obstructive virtual reality (VR) on 5G networks, which need to be addressed in the next 6G networks. Cloud VR/AR services may provide immersive experiences to customers, however latency is a significant problem, and the resulting unpredictability leads to further concerns (Chowdhury and Jang et al 2019). Transmitting VR/AR via cloud services enhances accessibility and efficiency, but due to the limitations of 5G transfer rates, high-resolution images need to be compressed. Therefore, the real-time transmission of large quantities of lossless

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 5, No. 4, December - February, 2021
Pages 9-15 | Cosmos Impact Factor (Germany): 5.195
Received: 02.12.2020 Published: 28.02.2021

images or videos will have to wait until the advent of 6G networks.

The immersive VR/AR experience will be enhanced with 6G systems. A variety of sensors will be used to collect tactile data and provide feedback to users. Therefore, in 6G systems, the XR is likely to combine traditional Ultra-Reliable Low Latency Communications (URLLC) with enhanced Mobile Broadband (eMBB), which may be referred to as Mobile Broad Bandwidth and Low Latency (MBBLL) (Dang et al., 2020). The security concerns associated with eMBB and URLLC in multisensory XR applications include malicious behaviour, access control, and internal communication.

Flow Chart



The focal cloud worker has a strong computational capacity, allowing for the use of complicated and comprehensive AI algorithms or computations to provide various learning capabilities, as seen in the above image. For instance, the administration employs various and powerful MEC systems. In this case, AI-based characterisation may be effectively used to optimise traffic flow selection for distinct service features (Zhang et al., 2020). In addition, the affiliation of MEC servers may be obtained by an AI-based group rather than individual selection, which will be more effective in reducing the number of participants.

The primary cloud worker may receive a large amount of data from edge computing servers, which must be processed to automatically extract characteristics and discover information. In this scenario, one may acquire deep learning to train algorithmic models for achieving management identification, traffic and behaviour prediction, and security detection (Giordani et al., 2020). Furthermore, in complex and dynamic MEC systems, it is easy to provide a coherent description of the coordination between resource management decisions and their influence on the current circumstances. Deep reinforcement learning (DRL) may be used to explore optimal asset management strategies inside complex perceptual environments characterised by high-dimensional spaces. Encounter replay is used in DRL to leverage historical data for improved learning efficiency and accuracy, enabling the MEC to provide superior performance for competitor devices.

IRJGES

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 5, No. 4, December - February, 2021
Pages 9-15 | Cosmos Impact Factor (Germany): 5.195
Received: 02.12.2020 Published: 28.02.2021

Results

Table 1 A critical analyses of different techniques proposed for B5G/6G systems

From: The shift to 6G communications: vision and requirements

Technology enabler	Pros	Cons	Use cases	Research initiatives
Quantum Communication (QC) and QML [72, 75]	Faster High-performance processing Power	Costly Complex	Drug industry Radar industry Mathematics	D-Wave Systems Inc. IBM Corporation Intel Corporation Cambridge Quantum Computing Limited
Blockchain [61, 77, 78, 80]	Distributed Stability Integrity Immutability Traceability	Inefficient High storage Privacy concerns Decentralize	Supply-chain Voting Healthcare Security Digital identity	IBM Alibaba Group (China) Fujitsu (Japan) Mastercard ING Groep (Dutch banking firm)
Reconfigurable Intelligent Surfaces (RIS)s [55, 56]	Low complexity Power efficient Low cost	Difficulty in phase configuration	Comm. and Defense industry	- World-wide

The advanced wireless communication system will consist of large self-repairing and self-arranging robots. These AI robots need significant computational power. The need for energy will increase as the number of intelligent robots grows. Traditional GPUs do not meet the energy efficiency requirements of modern wireless network communication systems. In such a scenario, a company design that is both energy-efficient and flexible, as well as intelligent, will be necessary. The firm has moved its focus to the Internet of Things (IoTs), Internet of Battlefield Things (IoBTs), and Electric Vehicles (EVs). The sensors are distributed ubiquitously. There is a sensor located at the entrance, as well as in the forced-air system, in-vehicle, on the TV, in the fridge, and in workplaces. Each of these sensors requires energy-efficient communication.
The increase in the number of interconnected devices led to a growth in the capacity of channels and an increase in demand for data retrieval. A highly advanced sensor system generates an enormous amount of data, exceeding several terabytes (TB) on a daily basis. This information production requires a high-capacity link for efficiently handling the load. In previous eras ranging from 1G to 5G, remote conventions were designed for specific systems. As mMTC and IoTs advance, there is a need for efficient and affordable devices to be designed. The Internet of Things (IoT) facilitates the progress of vehicular communication, specifically in the context of autonomous driving referred to as V2X (vehicle-to-infrastructure). The car must establish connections with other vehicles, pedestrians, and several sensors installed inside the vehicle. Collectively, this communication should be very reliable and have a reasonably low latency and enhanced security. The modern robotization paradigm involves the use of several sensors to collect and generate a substantial amount of data. The base area traffic capacity for 6G is about 1000 megabits per second per metre.

Conclusions

This study proposes the use of AI methodologies to enable knowledge engineering for 6G systems. The ultimate objective is to support various services, improve network performance, and provide reliable availability. The study has also presented AI-driven solutions for addressing many aspects of 6G systems provisioning, such as AI-enhanced mobile edge processing, intelligent spectrum

International Research Journal in Global Engineering and Sciences. (IRJGES)
ISSN : 2456-172X | Vol. 5, No. 4, December - February, 2021
Pages 9-15 | Cosmos Impact Factor (Germany): 5.195
Received: 02.12.2020 Published: 28.02.2021

management, handover management, smart mobility, and AI-driven mobile edge computing. The report concludes by emphasising many potential avenues for investigation and potential solutions for 6G networks.

References

[1]. G Basar E, Di Renzo M, De Rosny J, Debbah M, Alouini MS, and Zhang R (2019) Wireless communications through reconfigurable intelligent surfaces. IEEE Access 7:116753–116773

[2]. Chowdhury MZ, Shahjalal M, Ahmed S, and Jang YM (2020) 6G wireless communication systems: applications, requirements, technologies, challenges, and research directions. IEEE Open J Commun Soc 1:957–975.

[3]. Chowdhury MZ, Shahjalal M, Hasan M, and Jang YM et al (2019). The role of optical wireless communication technologies in 5G/6G and iot solutions: prospects, directions, and challenges. Appl Sci 9(20):4367.

[4]. Dang S, Amin O, Shihada B, and Alouini MS (2020). What should 6G be? Nat Electronics 3(1):20–29.

[5]. Giordani M, Polese M, Mezzavilla M, Rangan S, and Zorzi M (2020). Toward 6G networks: use cases and technologies. IEEE Commun Magazine 58(3):55–61.

[6]. Giordani M and Zorzi M (2020) Satellite communication at millimeter waves: a key enabler of the 6G era. In: 2020 International Conference on Computing, Networking and Communications (ICNC). pp. 383–388. IEEE, New York.

[7]. Letaief KB, Chen W, Shi Y, Zhang J, and Zhang YJA (2019) the roadmap to 6G: AI-empowered wireless networks. IEEE Commun Magazine 57(8):84–90.

[8]. Monogram G, Rawal BS, Saravanan V, Kumar PM, Martínez OS, Crespo RG, Montenegro-Marin CE, and Krishnamoorthy S (2020) Blockchain based integrated security measure for reliable service delegation in 6G communication environment. Comp Commun 161:248–256.

[9]. Orange JSB, Armada AG, Evans B, Galis A, and Karl H (2020) White paper for research beyond 5G (final edit). Networld (NW) pp. 1–43.

[10]. Pouttu A (2018) 6 Genesis-taking the first steps towards 6G. In: Proc. IEEE Conf. Standards Communications and Networking.

[11]. Sheth K, Patel K, Shah H, Tanwar S, Gupta R, and Kumar N (2020) A taxonomy of AI techniques for 6G communication networks. Comput Commun 161:279–303.

[12]. Viswanathan H and Mogensen PE (2020) Communications in the 6G era. IEEE Access 8:57063–57074.

[13]. Yang P, XiaoY, Xiao M, and Li S (2019) 6G wireless communications: vision and potential techniques. IEEE Network 33(4):70–75.

[14]. Zhang Z, Xiao Y, Ma Z, Xiao M, Ding Z, Lei X, Karagiannidis GK, and Fan P (2019) 6G wireless networks: vision, requirements, architecture, and key technologies. IEEE Vehicular Technol Magazine 14(3):28–41.

[15]. Mathew A. Artificial intelligence and cognitive computing for 6G communications & networks. International Journal of Computer Science and Mobile Computing. 2021;10(3):26-31.

[16]. Ji B, Wang Y, Song K, Li C, Wen H, Menon VG, Mumtaz S. A survey of computational intelligence for 6G: Key technologies, applications and trends. IEEE Transactions on Industrial Informatics. 2021 Jan 18;17(10):7145-54.

[17]. Letaief KB, Shi Y, Lu J, Lu J. Edge artificial intelligence for 6G: Vision, enabling technologies, and applications. IEEE Journal on Selected Areas in Communications. 2021 Nov 8;40(1):5-36.