IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Analyzing the Benefits and Challenges of implementing 5G Technology in Communication Networks

[1]Vikas Singhal, Ajay Kumar Sahu, [3]Shivani Dubey, [4]Nitin Srivastava, [5]Kumar Shubham
Department of Information Technology
Greater Noida Institute of Technology (Engineering Institute), Greater Noida, India

Abstract: With its supremacy over earlier generations in terms of speed, potential, and latency along with 5G network technology has completely changed the landscape of communication networks. It is possible that the adoption of 5G technology would greatly improve communication networks, resulting in enhanced connection and the creation of new apps and services. However, this implementation also poses various difficulties, such as the requirement for substantial investment, the possibility of security, and the potential for privacy issues, and the need for extensive infrastructure upgrades. This research paper aims to analyze the benefits and challenges of implementing 5G network technology in communication networks. The research methodology includes a comprehensive review of existing literature and case studies of successful 5G implementations. The paper will examine the potential benefits of 5G technology, such as improved network performance, reduced latency. The issues about privacy and network security that are related to the adoption of 5G We'll also look at how expensive it is to upgrade current infrastructure. Insights into the prospective advantages will be given by this study paper's results. and challenges of implementing 5G network technology in communication networks. This information will be valuable for decision-makers in the field of communication networks, as they consider the feasibility and viability of implementing 5G technology.

IndexTerms - **5G, communication networks, challenges, implementation, speed, latency, network security, infrastructure, energy consumption, cost.**

I. INTRODUCTION

The need for new wireless services has increased as a result of the rapid growth in cell phone usage and cutting-edge applications. The fifth generation of mobile network technology, or 5G, replaces the earlier 1G, 2G, 3G, and 4G generations. In comparison to earlier generations, it offers quicker data transmission rates, lower latency, and greater capacity. By 2020, there will be 20.4 billion machine-to-machine (M2M) correlations between Internet of Things (also known as IoT) devices. By 2025, there is projected to be 75.4–100 billion linked devices, according to Ericsson [2]. By 2025, a total of 2.8 billion people are expected to be fifth-generation (5G) customers, according to Huawei [3].great data rates, enhanced quality of service (QoS), reduced latency, broad geographic coverage, great dependability, and reasonably priced services are all features of 5G.While 4G technology can only deliver maximum speeds of about 100 Mbps, 5G technology can deliver speeds up to 10 Gbps, which is 100 times faster than 4G.The rollout of 5G networks will also make it possible to introduce the Internet of Things (IoT), which will link an expanding number of items to the internet. Various industries, including transportation, healthcare, and manufacturing, will be able to automate more tasks and operate more efficiently as a result. However, there are difficulties in implementing 5G networks, such as the need for significant infrastructure upgrades, including the deployment of new base stations and antennas, as well as the need for additional spectrum allocation. The whole 5G system consists of mMTC (massive Machine Type Communications), eMBB (enhanced Mobile Broadband), and uRLLC (ultra-Reliable Low Latency Communications). Overall, the introduction of 5G network technology promises significant benefits for businesses and consumers, but it also comes with challenges that must be addressed. Biomedical waste management defines waste management as the practices & procedures or the administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment & disposal of waste. Biomedical waste management is a routine procedure of hospital administration as prescribed by law. Hospital waste , hospital acquired infection , transfusion transmitted diseases, rising incidence of hepatitis B, HIV & Other diseases, create potential threat of infection, contamination & serious health hazards to doctors, nurses, ward boys, support staff, sanitation workers, rag pickers & other health care workers. Who are regularly exposed to biomedical waste as an occupation hazard as well as general public in the surrounding area.

II. EVOLUTION OF 5G TECHNOLOGY

The evolution of 5G can be traced back to the early 2010s when researchers and industry experts began exploring ways to increase the capacity and speed of mobile networks beyond what was possible with 4G. The initial International Telecommunication Union (ITU) and Third Generation Partnership Project (3GPP) 5G specifications were published in 2015, marking the start of the official standardization effort for 5G [4].

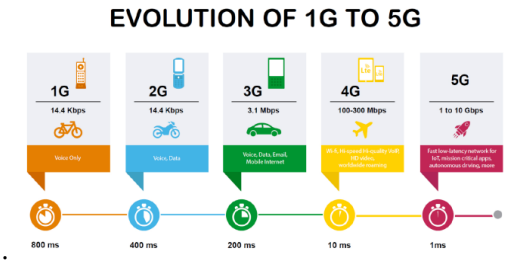

Figure 1. Evolution of 5G technology

The first phase of 5G development focused on enhancing the performance use of large MIMO (multiple-input, multiple-output) and beam forming technology to improve the radio access network (RAN), which improved the spectral efficiency and coverage of mobile networks. This led to the release of the first set of 5G standards in 2018, known as 5G NR (New Radio) Release 15, which enabled the deployment of 5G networks in sub-6 GHz frequency bands [5]. The second phase of 5G development, which was finished in 2019, concentrated on extending the capabilities of 5G beyond mobile broadband to allow new use cases such massive machine-type communications (mMTC), ultra-reliable low-latency communications (URLLC), and improved mobile broadband (eMBB).As a result, 5G NR Release 16 was made available, bringing new features like network slicing, which enables operators to build multiple virtual networks on top of a single physical network, and integrated access and backhaul (IAB), which enables more effective deployment of 5G networks in locations with sparse fiber infrastructure [6,7].The ongoing third phase of 5G development is expected to further enhance the capabilities of 5G to support new use cases such as Industry 4.0, autonomous vehicles, and smart cities. This includes the development of 5G NR Release 17, which is expected to be finalized in 2022 and will introduce new features such as multi-link connectivity, which allows devices to simultaneously connect to multiple 5G cells for improved reliability and coverage, and advanced positioning, which enables more accurate positioning of devices using 5G networks.

III. HOW 5G IS DIFFERENT

- **Speed:** The potential for download rates of up to 20 gigabits per second (Gbps) is what makes 5G networks so much quicker than 4G. Over 100 times faster than 4G.
- **Latency:** The period of time it takes for data to move between a device and a network is called latency, and 5G networks have much reduced latency. With 5G networks, latency might be cut to only one millisecond, which would be around 50 times quicker than 4G.
- **Capacity:** 5G networks have been designed to handle a much greater volume of data than 4G. This means that they can support more devices simultaneously without becoming congested or slowing down.
- **Coverage:** 5G networks are designed to provide better coverage than 4G, particularly in areas that were previously hard to reach with wireless technology.
- **Spectrum:** 5G uses a wider range of spectrum than 4G, including high-frequency bands that were previously unused for wireless communications. This allows 5G to support more devices and provide faster speeds [8,9].

Figure 2. Remote operation with IoT device

Table 1. Requirements of 5G

Specifications of 5G Technology
Entire coverage i.e, (100%)
Up to 10 Gbps data rate—10 to 100 times faster than 4G and 4.5 G networks, which have a latency of one millisecond and 1000 bandwidth per unit area, respectively.
When compared to 4G LTE, there can be up to 100 times as many connected devices per square foot.
network energy consumption is reduced by 90%
Up to 10 years of battery life are possible for the low-power IoT gadget.

IV. APPLICATIONS OF 5G TECHNOLOGY

Internet of Things (IoT): With its high bandwidth and low latency, 5G is capable of accommodating a vast number of IoT devices. enabling smart homes, cities, and factories. It will also allow for more efficient and faster machine-to-machine communication [10].

Figure 3. Features of 5G Technology

- **Autonomous vehicles:** 5G's swiftness and responsiveness will be critical for self-driving cars to communicate in real-time with each other and their surrounding infrastructure. This will help to improve road safety while also reducing traffic congestion.
- **Virtual and Augmented Reality (VR/AR):** The high bandwidth of 5G will enable faster and smoother streaming of VR and AR content, allowing for more realistic and immersive experiences.
- **Telemedicine:** The low latency and high bandwidth characteristics of 5G will allow doctors to remotely diagnose and treat patients in real time. This will be especially valuable in emergency circumstances or in locations where medical resources are scarce.
- **Smart cities:** Because of 5G's low latency and high bandwidth, applications for intelligent traffic management and smart energy systems in cities, and enhanced public safety will be possible.
- **Gaming:** The low latency and high bandwidth of 5G will enable quicker and more reliable online gaming, resulting in a more fluid and responsive gaming experience.
- **Remote work:** Because of 5G's fast speed and low latency, The increased accessibility and connectivity provided by 5G technology will enable a greater number of individuals to work remotely. allowing them to collaborate and interact with colleagues and clients in real-time.
- **Education:** The high bandwidth of 5G will allow for quicker and more reliable streaming of educational information, allowing for more engaging and immersive learning experiences.
- Entertainment: 5G's high speed and low latency will enable quicker and smoother streaming of video and audio material, providing for a more seamless entertainment experience.

- **Figure 4.** Applications of 5G

- **Improved governance:** A better foundation for e-governance and smart city architecture may be developed by governments using 5G. We may look to the authorities in an emergency to deliver better public service, faster processing, and real-time information. We may describe it as a government that is proactive and "connected" that provides excellent public service.
- Many industries will gain from the introduction of fifth-generation mobile networks. The technology may be imaginatively applied in a wide range of situations. Hospitals will be equipped with 5G-capable equipment for remote patient monitoring and intelligent ambulances with real-time connections.
- We may also anticipate straightforward financial transactions thanks to digital wallets and programmes that connect wearables, smartphones, smart gadgets, automobiles, and a variety of other technologies.

Businesses may fully benefit from these technological breakthroughs by combining 5G, edge computing, IoT, AI, and extended reality (XR)[11].

V. COMPONENTS OF 5G TECHNOLOGY

a) **Data transmission:** The procedure begins when a machine delivers data to the 5G network, such as a smart phone or PC. Electromagnetic waves that move through the air are used to transfer the data.

b) **Antennas:** An antenna network attached to towers, buildings, and other structures makes up the 5G network. The devices' data signals are gathered by the antennas, which then send them to the core network.

c) **Core network:** The core network, which processes the data signals gathered from the antennas, is the main part of the 5G network. The communication between the devices and the internet is controlled by a network of servers, routers, and switches.

d) **Radio access network:** A crucial component of the 5G network, the radio access network (RAN), controls communication between the devices and the antennas. To enhance the signal quality and strength, it makes use of cutting-edge techniques such massive multiple-input multiple-output (MIMO) and beam forming.

e) **Low-band and high-band frequencies:** Low-band and high-band frequencies are combined in 5G networks to provide higher throughput and lower latency. While high-band frequencies provide faster speeds but have a constrained range, low-band frequencies can traverse large distances and enter buildings.

f) **Multi-connectivity:** Multi-connectivity, which enables simultaneous connections between devices and numerous antennas, is another crucial aspect of 5G networks. Devices are able to get a stronger and more dependable signal as a result, particularly in regions with severe network congestion.

g) **Edge computing:** Edge computing, which enables data processing and storage to be done locally rather than in the cloud, is also supported by 5G networks. By doing this, latency is decreased and the network's overall performance is enhanced.

h) **IoT and other applications:** Applications like the Internet of Things (IoT), virtual reality, and augmented reality can all be supported by 5G networks. These applications call for fast, low-latency communications, which 5G networks are well-suited to deliver [14,15].

VI. CHALLENGES FACED DURING INSTALLING 5G TECHNOLOGIES

- **Infrastructure:** Infrastructure investments will be necessary to implement 5G. Installing new base stations and other equipment falls under this category. This can be particularly challenging in remote locations with underdeveloped infrastructure.
- **Spectrum:** 5G requires access to a large amount of high-frequency spectrum for high-speed and low-latency connectivity. However, allocating this spectrum is a complex and time-consuming process.
- Security: 5G networks are more complex than previous generations, which makes them more vulnerable to cyber-attacks. Ensuring the security of 5G networks will be a critical challenge for service providers and regulators.
- **Compatibility:** Many existing devices are not compatible with 5G technology, which means that consumers and businesses may need to purchase new equipment to take advantage of the benefits of 5G.

- For the successful deployment of 5G networks, CSPs must have a well-defined strategy for implementing network slicing and other necessary arrangements. The deployment approach they choose, based on their spectrum network purchase, will determine the success of the deployment process and the ability to target specific 5G use cases. However, there are several challenges in implementing 5G networks, including the utilization of mm-Wave frequencies and the need for a large number of small cell towers. This requires a new deployment approach while also ensuring compliance with regulations.
- Furthermore, to ensure successful implementation, mobile devices at the user end must be upgraded to support 5G bands. Although the initial stages of 5G implementation support the sub-6 GHz range, a significant number of 4G devices will need to be replaced with 5G-enabled devices to realize the full potential of 5G networks [10,11].

Table 2. Cost comparison between different sector

Cost component	Urban area	Suburban area	Rural area
Infrastructure	$15 billion	$8 billion	$5 billion
Spectrum licenses	$6 billion	$3 billion	$1 billion
Equipment	$4 billion	$2 billion	$1 billion
Training and development	$1 billion	$500 billion	$250 billion
Total	$26 billion	$13.5 billion	$7.25 billion

security and privacy issues with the implementation of 5G networks Security and privacy concerns remain despite the fact that 5G will be at the forefront of delivering advancements to the commercial sector. When developing security protocols, it is important to take into account privacy issues like identity, personal information, and geo-location tracking. A single cell tower could send and receive signals on the 4G network, which also had a wider coverage area.

Figure 5. Challenges for 5G Security

From time to time, there will be obstacles in the adoption of 5G. The good news is that CSPs can roll out 5G rather easily and users may take advantage of the offerings without any problems with careful planning and timely countermeasures.

VII. POLICIES RELATED TO 5G TECHNOLOGY

The deployment and use of 5G technology are subject to various policy and regulatory frameworks that govern its implementation. These frameworks address a range of issues, including international standards, spectrum allocation, and privacy and security regulations.

a) **International standards:** The third Generation Partnership project (3GPP) and the International Telecommunication Union (ITU) are two examples of the organizations that create the global standards that apply to 5G technology. The interoperability, effectiveness, and security of 5G technology are all guaranteed by these standards. Usually, while awarding licenses for the implementation of 5G, the government demands adherence to these requirements.

b) **Spectrum allocation:** 5G technology requires access to certain radio frequency spectrum bands to operate. Governments are responsible for allocating these bands to service providers through spectrum auctions or other mechanisms. Spectrum allocation policies need to balance the demand for spectrum with the need to avoid interference with other uses of the radio spectrum, such as satellite communications and government services.

c) **Privacy and security regulations:** The deployment of 5G technology raises concerns about privacy and security. Governments have developed regulations to address these concerns, such as data protection laws and cybersecurity regulations. Service providers are required to implement measures to protect user data and ensure the security of their networks.

d) **Infrastructure deployment policies:** The deployment of 5G infrastructure, including small cells and other components, requires access to public rights of way and other infrastructure. Governments may need to develop policies to streamline the permitting and approval process for 5G infrastructure deployment, while also ensuring that the infrastructure is deployed in a manner that is safe and minimizes disruption to communities.

e) **Competition and antitrust regulations:** The deployment of 5G technology may impact competition in telecommunications markets. Governments may need to develop regulations that address concerns related to market concentration and anticompetitive behavior.

f) Overall, the policy and regulatory issues related to 5G technology are complex and multifaceted. Governments need to balance the need to promote the deployment of 5G technology with the need to protect privacy, ensure security, and promote competition in telecommunications markets [15,16].

VIII. FUTURE PROSPECTS FOR 5G TECHNOLOGY

5G technology has already brought a range of new use cases and applications, and there is still potential for further development and innovation. Some of the potential future developments for 5G technology include:

a) **Emergence of new use cases and applications:** When compared to earlier generations of wireless technology, 5G has the potential to support a variety of new use cases and applications. These might include programmed for industries like manufacturing, transportation, and healthcare, as well as novel entertainment and media technologies. For example, 5G could enable real-time remote surgeries or the development of autonomous vehicles that rely on high-speed connectivity to make real-time decisions [18,19].

b) **Evolution of network architecture**: As 5G networks continue to evolve, they are likely to become more virtualized and software-driven. This will enable network operators to more easily manage and control network resources, and to dynamically allocate resources based on demand. Utilizing network slicing, which enables the development of numerous virtual networks on a single physical network, is becoming more popular. This technology could become more widespread in the future.

c) **Development of new business models:** 5G technology could enable new business models, such as the sale of network slices to third-party service providers. By using data analytics and monetizing the data produced by connected devices, it may potentially make it possible to develop new revenue sources.

d) **Enhanced Mobile Broadband:** Compared to earlier generations, 5G will offer much faster internet rates, more bandwidth, and reduced latency. This will make it possible for mobile devices to seamlessly broadcast 4K/8K films, VR, AR, and immersive gaming experiences.

e) **Connectivity for the Internet of Things (IoT):** 5G will lay the groundwork for tying billions of IoT devices together, allowing the development of smart homes, smart cities, industrial automation, and other IoT applications. Real-time monitoring, control, and communication between linked devices will be possible because to its low latency and high device density support [20].

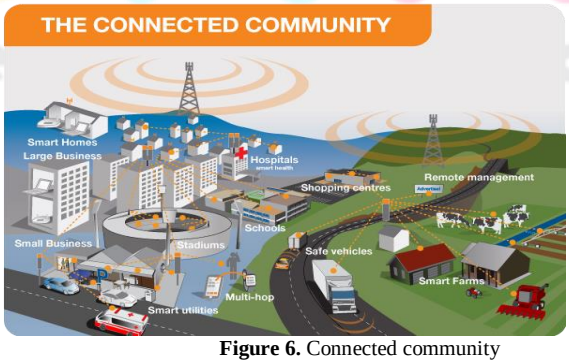

Figure 6. Connected community

IX. ANALYSIS OF 5G TECHNOLOGY WITH OTHER WIRELESS TECHNOLOGIES

- **Technical Capabilities:** With regard to data transfer rates, latency, and capacity, 5G technology is intended to provide these improvements over 4G. These capabilities are accomplished through the employment of cutting-edge technology including beam forming, massive MIMO (multiple input multiple output), and millimeter wave (mmWave).

- **4G technology:** 4G provides high-speed data transfer rates, but not as fast as 5G. It supports up to 1 Gbps download speed, which is lower than the maximum speed of 5G [21, 22].
- **Wi-Fi technology:** Wi-Fi technology provides fast wireless data transfer rates, typically ranging from 10-50 Mbps for 802.11n and up to 1 Gbps for 802.11ac. It is primarily used for indoor applications and has a shorter range than cellular technologies.
- **Bluetooth technology:** Bluetooth is commonly used for short-range communication between devices, such as wireless headphones, speakers, and other IoT devices.
- **Market Adoption:** Many nations are currently deploying their 5G networks, so the technology for 5G is still in the early stages of adoption. However, the adoption rate is expected to increase rapidly in the coming years [23,24].

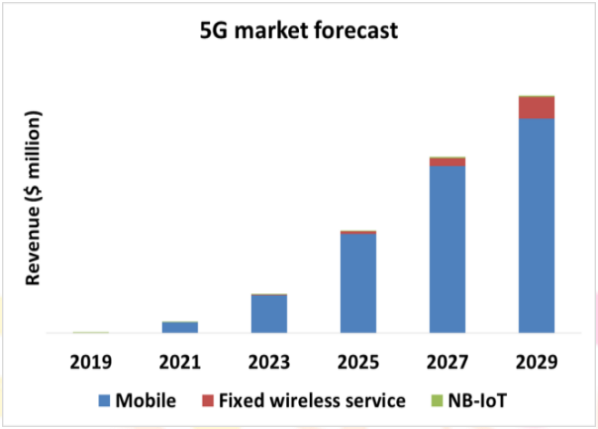

Figure 7. 5G market adoption till 2029

Table 3. Comparing various generation up to 5G

Generation	Data Rate (Mbps)	Frequency Band (GHz)	Latency (ms)	No. of Connected Devices
1G	0.01	0.15	2000	1
2G	0.3-0.6	0.9-1.9	300-400	10
3G	2-14	0.2-2.1	100-500	100
4G	100-300	0.7-6	30-50	1000
5G	100-1000+	24-86	<10	1 million

X. CONCLUSION

Finally, the adoption of 5G network technology in communication networks has the potential to have a significant positive impact, including faster data transfer rates, reduced latency, and increased network capacity. This may result in better user experiences and open the door to the creation of new services and apps. However, there are a number of obstacles to the adoption of 5G, including the need for sizable infrastructure investments, potential security issues, and the potential to widen the digital divide. Overall, while 5G technology shows great promise for the future of communication networks, careful consideration and planning are required to ensure a successful implementation that maximizes its benefits while minimizing its challenges.

REFERENCES

1. Tony-Mayeko, Alliance. (2022). Study on 5G Technology and Logical Review. 9. 1-10.
2. Gupta, Akhil & Jha, Rakesh. (2015). A Survey of 5G Network: Architecture and Emerging Technologies. Access, IEEE. 1206-1232.10.1109/ACCESS.2015.2461602.
3. Ahmad, Ijaz, et al. "5G security:Analysis of threats and solutions." 2017 IEEE Conference on Standards for Communications and Networking (CSCN). IEEE, 2017.
4. Rost, P. Berberana, I., Maeder, A., Paul, H. Suryaprakash, V. Valenti, M. Wübben, D.Dekorsy, A. and Fettweis, G. 2015. Benefits and challenges of virtualization in 5G radio access networks. IEEE Communications Magazine, 53(12), pp.75-82.

5. Hui, H. Ding, Y. Shi, Q. Li, F. Song, Y. & Yan, J. (2020). 5G network-based Internet of Things for demand response in smart grid: A survey on application potential. Applied Energy, 257, 113972.
6. Vitturi, S. Zunino, C. and Sauter, T. 2019. Industrial communication systems and their future challenges: Next-generation Ethernet, IIoT, and 5G. Proceedings of the IEEE, 107(6), pp.944-961.
7. Ejaz, W. & Ibnkahla, M.(2017, November 20). Multiband Spectrum Sensing and Resource Allocation for IoT in Cognitive 5G Networks. IEEE Internet of Things Journal, 5(1),150–163.https://doi.org/10.1109/JIOT.2017.2775959
8. Akpakwu, Godfrey & Silva, Bruno & Hancke, Gerhard & Abu-Mahfouz, Adnan. (2017). A Survey on 5G Networks for the Internet of Things: Communication Technologies and Challenges. IEEE Access. 5. 3619 - 3647. 10.1109/ACCESS.2017.2779844.
9. Salaheddine, F. Han, T. Zhang, N. Security in 5G and beyond recent advances and future challenges. Security and Privacy. 2023; 6(1):e271. doi:10.1002/spy2.271
10. Khuntia, Mitrabinda & Singh, Debabrata & Sahoo, Sipra. (2021). Impact of Internet of Things (IoT) on 5G. 10.1007/978-981-15-6202-0_14.
11. Imam-Fulani, Yusuf Olayinka, et al. "5G Frequency Standardization, Technologies, Channel Models, and Network Deployment: Advances, Challenges, and Future Directions." Sustainability 15.6 (2023): 5173.
12. Imam-Fulani, Yusuf Olayinka, Nasir Faruk, Olugbenga A. Sowande, Abubakar Abdulkarim, Emmanuel Alozie, Aliyu D. Usman, Kayode S. Adewole et al. "5G Frequency Standardization, Technologies, Channel Models, and Network Deployment: Advances, Challenges, and Future Directions." Sustainability 15, no. 6 (2023): 5173.
13. Pujari, Vinayak & Patil, Rajendra & Tambe, Mr & Prof, Asst. (2021). Research Paper on Future of 5G Wireless System. 2021.
14. Lin, H., Zeadally, S., Chen, Z., Labiod, H. and Wang, L., 2020. A survey on computation offloading modeling for edge computing. *Journal of Network and Computer Applications*, *169*, p.102781.
15. Zhu, Zhengfa, Jun Peng, Xin Gu, Heng Li, Kaiyang Liu, Zhuofu Zhou, and Weirong Liu. "Fair resource allocation for system throughput maximization in mobile edge computing." *IEEE Access* 6 (2018): 5332-5340.
16. Cero, Enida, Jasmina Baraković Husić, and Sabina Baraković. "IoT's tiny steps towards 5G: Telco's perspective." *Symmetry* 9.10 (2017): 213.
17. Wei, Ziling, et al. "Dynamic edge computation offloading for Internet of Things with energy harvesting: A learning method." *IEEE Internet of Things Journal* 6.3 (2018): 4436-4447.
18. Wollschlaeger, Martin, Thilo Sauter, and Juergen Jasperneite. "The future of industrial communication: Automation networks in the era of the internet of things and industry 4.0." *IEEE industrial electronics magazine* 11.1 (2017): 17-27.
19. Xu, J., Chen, L. and Ren, S., 2017. Online learning for offloading and autoscaling in energy harvesting mobile edge computing. *IEEE Transactions on Cognitive Communications and Networking*, *3*(3), pp.361-373.
20. Ajay Kumar Sahu, Pankaj Kumar Gupta, Amit Kumar Singh, Kushal Singh, Ujjwal Kumar (2023), "A Convolutional Neural Network Approach for Detecting the Distracted Drivers", International Journal of Scientific Research in Computer Science and Engineering, Vol.11, Issue.1, pp.1-6, E-ISSN: 2320-7639 (Online), DOI: https://doi.org/10.26438/ijsrcse/ v11i1.16.
21. Anand Kumar Dohare, Pankaj Kumar Gupta, Uma Tomer, Gaurav Singh, Ajay Kumar Sahu (2023), "Effectiveness Of Machine Learning In Survey Optimization", Journal of Data Acquisition and Processing, Vol. 38, Issue 1, pp. 2749-2756, ISSN: 1004-9037, https://sjcjycl.cn/ DOI: 10.5281/zenodo.7765727.
22. Dr. Shivani Dubey, Dr. Ajay Kumar Sahu, "Implementation of Virtual Voice Assistant in collaboration of Emotion Detector", International Journal of Innovative Research in Technology (IJIRT), ISSN: 2349-6002, Volume 9 Issue 8, pp. 51-57, January 2023.
23. Singh, T., Sahu, A. K., Dubey, S., Sharma, M. P., Verma, S., & Kumar, C. (2022), "Treatment of thyroid disease through Machine Learning Predictive Model", International Journal of Health Sciences, 6(S8), 3176–3188. https://doi.org/10.53730/ijhs.v6nS8.12813, http://scienceschoolar.us/ journal/index.php/ijhs.
24. K. Suresh Kumar, Vinay Kumar Nassa, Dipesh Uike, Ashima kalra, Ajay Kumar Sahu, Vijay Anant Athavale, V. Saravanan (2022), "A Comparative Analysis of Blockchain in Enhancing the Drug Traceability in Edible Foods Using Multiple Regression Analysis", Journal of Food Quality, vol. 2022, 6 pages. https://doi.org/10.1155/2022/1689913. Hindawi, ISSN: 1687-5265, Impact Factor. 3.200, https://www.hindawi.com/journals/cin/.

.