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ML and AI in Wireless Communication

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ABSTRACT

In wireless communication data is delivered wirelessly with help of advancement in technology. Over the past couple of decades wireless communication has evolved from first generation (1G) to fourth generation (4G). Currently there's fifth generation (5G) in deployment .The next evolution of wireless communication i.e. the sixth generation 6G is already into development and is expected to come into existence by 2030. AI (AI) and Machine Learning (ML) are key parts in future wireless communication technology. Wireless communication plays a significant role in almost all fields like business, entertainment, education, health, safety and most importantly IT sector. Machine learning techniques likes' supervised, un-supervised learning, Reinforcement Learning (RL), Deep Learning (DL) and federate Learning (FL) are crucial in development of these wireless communication. The main goal of Artificial Intelligence/Machine Learning (AI/ML) in wireless technology is to cut back capital expenditures, optimize network performance, and build new revenue streams. Dramatic advancement and research in wireless technology has led to improved performance and low latency. Further, implementation of ML algorithms conjointly permits the wireless network service suppliers to supply high automation levels.

1. INTRODUCTION

Wireless communication was introduced in 19th century and is evolving since then. It involves transmission of data/information between two ends i.e. one device to other device. In modern era wireless communication networks are a hot topic. They are becoming more and more complex due to a large number of service requirements, diverse characteristics of applications in the industry, and devices themselves. Traditional networking approaches and conventional data analysis tools, have limited capacity. These approaches do not support future complex wireless networks with regards complexity of operation and demands of the networks and network providers. The exponentially increasing demand in the number of people using wireless communication technologies requires innovation and research into new technologies. Machine learning (ML) is emerging as one of the most promising technologies that will help engineers conceptualize and implement technologies. Researchers and IT professionals are driving the use of ML into wireless communication technologies, including the need to move away from traditional techniques and to provide cost-efficiently and best quality of service (QoS) to users and manage complexity of future networks. Sixth Generation (6G) is a new wireless technology that many academics and researchers are embarking on. The main potentials of 6G are to extend AI and ML benefits in the wireless networks and to the users. 6G also will provide improvements in technical metrics such as high throughput, supporting new high demand applications, improved usage of radio frequency bands and many more. One of the major ML technologies intended as a key technology for 6G will be DL because of its strong applications in achieving learning from scenarios which are more close to human. Today's technological ambitions represent tomorrow's reality with technologies such as health and wellness applications, prevalent connectivity in smart environments and massive robotics, massive unmanned mobility in three dimensions, augmented reality (AR), and virtual reality (VR), to name only some. Each technology is expected to require more effective and efficient wireless communications than ever. Therefore, 6G wireless networks should offer broadband, near-instant, and reliable property to modify huge knowledge exchange at completely different frequencies by employing a massive kind of technologies. Current wireless networks heavily rely on mathematical models. Such mathematical models often do not reflect the systems accurately. Moreover, there are insufficient mathematical models for some of the building blocks of wireless networks and devices, and the modeling of such blocks therefore becomes challenging. ML will therefore play a vital role in 6G wireless networks, as a result of it's capable of modeling systems that can't be given by a mathematical equation. Moreover, it is expected that it will be possible to use ML tools to replace heuristic to optimize certain localized tasks. Such intelligence will rely on the availability of data streamed from wireless devices in a timely manner, especially in extreme applications such as real-time video monitoring and extended reality (XR). To completely leverage these capabilities, the network ought to support ML-native agents which will be freely placed and affected to the desired network locations

Figure 1. Various Wireless communication Technology.

2. EVOLUTION OF WIRELESS SYSTEM

It's been more than 100 years since the beginning of wireless technology and the progress made in these technology is unimaginable. Mobile wireless communication has undergone many evolution within the past few decades since the introduction of cellular network in early 1970s. Because of immense demand for a lot of connections worldwide, mobile communication support a lot of users telephone became widespread throughout the middle of nineteenth century because of wired transmission and restricted quality, engineers started developing a tool that doesn't needs wired transmission mode. Rapid growth in smartphones is leading to develop much sophisticated wireless technology every passing day for improved performance.

FISRT GENERATION (1G)

1G refers to the first-generation of wireless telecommunication technology in mobile telecommunications. The first generation cellular mobile network was first made operational in Japan in 1979 by Nippon Telegraph and Telephone (NTT). Within next five years it covered the whole nation. In 1983 1G technology was introduced in USA then followed by several countries like Finland, United Kingdom and Europe within early to mid-1980s. 1G used analogue signals and it had several disadvantages because of technology limitations. Since 1G was prone to obstacles it was very noisy. Security was another issue in 1G.

SECOND GENERATION (2G)

Second generation (2G) was system introduced as a replacement to analog technology with digital circuit. GSM (Global System for Mobile communication) technology became customary for more development in wireless standards later. This technology was capable of supporting up to 14 to 64kbps (maximum) rate that is decent for SMS and email services. Three primary edges of 2G networks over their predecessors were that phone conversations were digitally encrypted; 2G systems were considerably a lot of economical, letting way larger portable penetration levels; and 2G introduced information services for mobile, beginning with SMS text messages.

THIRD GENERATION (3G)

The next successor of 2G technology is 3G technology. It is the results of ground-breaking analysis and development done out by the International Telecommunication Union (ITU) during early 1980s. 3G specifications and criteria were broken when fifteen years of perseverance and difficult study. Third generation mobile communication started with the introduction of UMTS – Universal Mobile Terrestrial / Telecommunication Systems which has info rate of 384kbps and has been made commercially available for mobile phones. With the introduction of 3G mobile network, smartphones became widespread across the world. Specific applications were developed for smartphones that handles chat, email, video line, games, and social media. 3G basically provides signal to phones to download, send, call, text and surf on internet.

FOURTH GENERATION (4G)

The 4G (fourth generation) of portable mobile communications is the successor of the third generation (3G). It is much faster than 3G and almost everyone is using because even if 5G is in existence it is still not available widely. A 4G system not only provides network but this system has a lot to offer, for instance to laptops with USB, wireless modems, sensible phones, and to different mobile devices. 4G is 5 to 7 times faster than 3G offering speed up to 150 mbps. 4G is also much more secured than previous generation network. LTE wireless technology is employed in fourth generation systems. It's compatibility with previous version so it is easier to upgrade to LTE and LTE advanced networks. Introduction of 4G has not only improved downloading speed but also crystal clear voice calls and low latency.

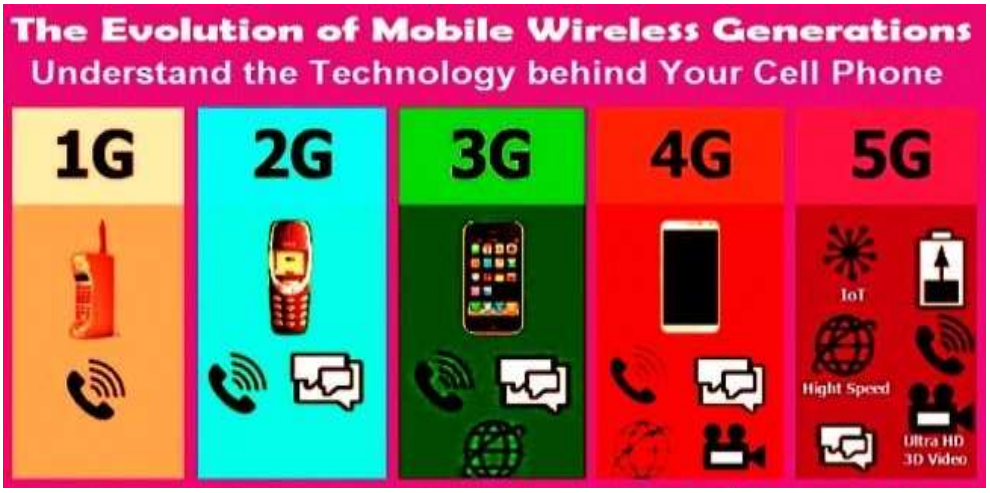

Figure 2. Evolution of Wireless technology

3. ML TECHNIQUES USED

In recent times, machine learning algorithms have gained vital interest within the space of wireless networking and communication. Machine learning driven algorithms and models will alter wireless network analysis and resource management and might be of advantage in handling the increasing volume of communication and computation for evolving networking applications still, the applying of machine learning techniques for heterogeneous wireless networks continues to be beneath dialogue a lot of endeavours are required to link the gap between machine learning and wireless networking analysis.

3.1 DEEP LEARNING

Deep learning may be a set of machine learning that is basically a neural network with 3 or a lot of layers. Deep learning drives several computer science (AI) applications and services that improve automation, performing arts analytical and physical tasks while not human intervention. 6G can innovatively use deep learning (DL) techniques to essentially rethink the communication systems style downside from very cheap to prime layers. though recent proof has shown the ability of decilitre techniques within the communication domain, the exploration and utilization of decilitre techniques in communication systems continues to be in its infancy and may are available a progressive manner.

3.2 SUPERVISED LEARNING

Supervised learning, conjointly referred to as supervised machine learning, may be a subcategory of machine learning and computer science. it's outlined by its use of labelled knowledge sets to coach algorithms that to classify data or predict outcomes accurately. As computer file is fed into the model, it adjusts its weights till the model has been fitted fitly, that happens as a part of the cross validation method. On the premise of continuity of network, FTO is assessed into regression and classification. Some samples of the techniques for FTO are call Trees (DTs), Support Vector Machine (SVM), K-Nearest Neighbours (KNN), Support Vector Regression (SVR) and mathematician method Regression (DPR) algorithms.

3.3 UNSUPERVISED LEARNING

Unsupervised learning, conjointly referred to as unattended machine learning, uses machine learning algorithms to investigate and cluster unlabelled datasets. These algorithms discover hidden patterns or knowledge groupings while not the necessity for human intervention. Its ability to get similarities and variations in info build it the perfect resolution for exploratory knowledge analysis, cross-selling methods, client segmentation, and image recognition. The techniques for unattended cubic centimetre are K-means bunch, gradable bunch algorithms, Principal part Analysis (PCA), and Isometric Mapping (ISOMAP).

3.4 REINFORCEMENT LEARNING

Reinforcement Learning (RL) is one in all the most well liked analysis topics within the field of recent computer science and its quality is merely growing. Reinforcement learning focuses on creating appropriate choices that are generated by mapping the things to actions and evaluating that actions have to be compelled to be thought of for maximising a semi-permanent reward. The techniques for Reinforcement learning are Markov call method (MDP), Q-Learning, policy learning, actor critic (AC) and multi-armed thief (MRB).

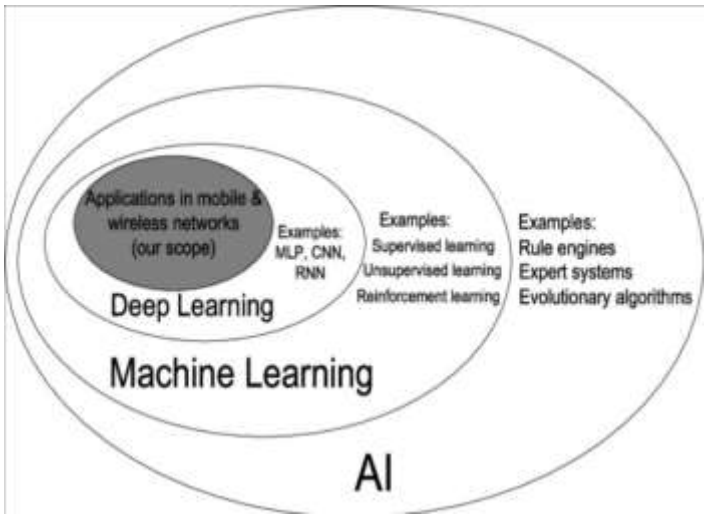

Figure 3. ML techniques used

4. METHODOLOGY

Fifth generation (5G) and sixth generation (6G) mobile networks use higher range wireless spectrum for transmission of data. These technologies are far faster than 3G and 4G. 5G has speed of peak 20 Gbps while that of 4G is 1 Gbps. 5G also has low latency which results in increased performance in business applications as well as other fields too. There are many complexities in developing 5G and 6G and these complexities is reduced with the help of AI and ML. This could be achieved by applying ML and software-defined networking (SDN) solutions. Although the compact mobile phones have evolved to smartphones over the years the core algorithms that run them has not evolved since the 1990s. Replacing traditional algorithms with Machine learning algorithms will dramatically reduce power consumption and give improved performance. At the applying level, ML uses powerful functions in terms of exploitation the placement of users to produce sensitive info, playacting face recognition, etc. that have provided revolutionary changes for meeting the rising demands of low latency and quicker process. Application layer act because the interface between the user and good applications wherever the most aim of the applying layer is that the effective management of resources, automation of tasks, and improvement of security and safety through present and continuous observation to realize the on top of performance metrics application is directly put in on smartphones that use constitutional deep learning algorithms or exploitation actuators that management the living surroundings of residents. Machine learning (ML) models square measure machine systems that square measure wont to learn the discriminative options a few system that can't be portrayed by a mathematical model. These models square measure usually utilized in tasks like regression, classification, Associate in nursing interactions between Associate in Nursing intelligent agent and a surroundings. Once a model is trained on the given information, then this model will effectively takes the choice on unknown information and additionally performs the tasks supported arithmetic calculations. The role of ML-based 6G techniques is to reshape the imagined plan into physical world for breakdown the difficult problems with energy, quality of service (QoS), and quality of expertise (QoE). Within the mean-time apace increasing market of the IoT devices to deliver transmission content has caught the eye of assorted fields like, industrial, and care. 5G is up to 20 times faster than 4G and it offers more than just fast internet speed.

5. FUTURE

Even though 5G is still in the process of roll out as it is not available everywhere, its successor sixth generation (6G) is already in the hype of development. Like its predecessors, 6G networks area unit expected to be quicker and handle colossal amount of information measure with lower latencies. 6G networks area unit expected to produce additional numerous capabilities than their predecessors and area unit over possible to support applications on the far side current mobile applications, like virtual and increased reality (VR/AR), AI and therefore the web of Things (IoT). it is also speculated that mobile network operators can adopt versatile, decentralized models for 6G, with native spectrum licensing, spectrum sharing, and infrastructure sharing. All are going to be handled by intelligent automatic management underpinned by mobile edge computing, short-packet communication and block chain technologies. New wireless communication standards area unit developed concerning each 10 years, and 6G is predicted to come back into play 2030. because it stands, nothing is ready in stone with reference to 6G, and even its designation can be replaced by one thing else. With the rollout of 5G, customers can still use additional mobile devices and consume web information at ever-increasing rates. on the far side amplifying applications for higher property and performance, tomorrow's 6G network style ought to use AI and machine learning (to improve help and efficiencies), support bigger property outcomes, increase security, and expand and improve property with remote areas of the planet. The 6G network should be additional economical than 5G and consume less power. Energy potency achieved through digitization is vital for an additional property mobile business due to the anticipated growth in information generation. The 6G network will power the applications required to create this happen. The network should be over simply secure. It should even be reliable. Whereas privacy is a very important element of security, consistent, reliable, and rapid, end-to-end information delivery.

6. CONCLUSION

Tough 6G is still in talks and non-existent, it has reached to the conclusion that future technologies will heavily depend of 6G. The deployment of 5G is slowed down because of not meeting necessary infrastructure requirements. On contrary 6G will not face any such hurdles as it will be built on infrastructure that has been already there for 5G. Hence network operators must put efforts in implementing advanced ML techniques for efficient operation, control and optimization. There is a strong need to build a solution for meeting the current challenges such as latency, power allocation, privacy, security, inter-operate ability of models, etc. at application level and infrastructure level to enhance the smart applications. It is clear that ML will play an important role in implementing 6G. Followed by 6G future vision we have elaborated how ML at application level and infrastructure level can be more productive to meet the future 6G challenges for current ML and future 6G. Next-generation wireless networks ought to offer ultra-reliable, low-latency communication. Wireless network applications like period traffic information, device readings from driverless cars, or diversion streaming recommendations generate extreme volumes of knowledge that has got to be collected and processed in period. These communication needs and core intelligence will solely be achieved through the mixing of machine learning techniques in wireless infrastructure and end-user devices.

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