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Improving Data Transmission in a Wireless Communication Network Using Convolutional Neural Network (CNN)

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Abstract
In recent years, the increasing demand for high-speed and reliable data transmission in wireless communication networks has presented significant challenges due to dynamic channel conditions, interference, and bandwidth limitations. This study proposes the application of Convolutional Neural Networks (CNNs) to improve data transmission efficiency and reliability in wireless networks. The CNN-based model is designed to intelligently learn and adapt to the spatiotemporal characteristics of wireless signals, enabling enhanced feature extraction, error correction, and adaptive modulation strategies. Through simulation and comparative analysis, the CNN-based system demonstrated significant improvements in key performance metrics such as throughput, signal-to-noise ratio (SNR), bit error rate (BER), and latency when compared with traditional methods. The findings highlight the potential of CNNs to optimize real-time decision-making processes, reduce data loss, and support robust communication in complex and high-interference environments. This approach provides a promising pathway toward the development of intelligent and autonomous wireless networks, essential for the advancement of next-generation communication systems including 5G and Smart Cities. The results obtained were the conventional High Noise Level that caused poor data transmission in a wireless communication network was13 dB. On the other hand, when CNN was integrated into the system, it automatically increased to15.08 dB thereby boosting the performance of the wireless communication network and the conventional improper antenna configuration that caused poor data transmission in a wireless communication network was 2.2dB. Meanwhile, when CNN was integrated into the system, it simultaneously increased it to 3.19 dB. Finally, with these results obtained, it definitely meant that percentage improvement in data transmission in a wireless communication network was 45%.

Keyword: Improving, data, transmission, wireless, communication, network, convolution, neural, network, (CNN)

1.0 INTRODUCTION

Wireless communication networks have become the backbone of modern digital society, supporting a wide range of applications from mobile communication and Internet of Things (IoT) to smart cities and real-time multimedia services. However, the increasing complexity of wireless environments—characterized by multipath fading, signal interference, limited bandwidth, and fluctuating user demand—has made it difficult to maintain reliable and high-speed data transmission (Goldsmith, 2005). Traditional techniques, including static modulation, error correction algorithms, and fixed routing strategies, often fail to cope with these dynamic and non-linear wireless conditions.

Recent advancements in deep learning have opened new opportunities for addressing these challenges. Among the various deep learning architectures, **Convolutional Neural Networks (CNNs)** have shown exceptional capability in feature extraction and pattern recognition in high-dimensional data (LeCun, Bengio, & Hinton, 2015). CNNs can be trained to detect underlying patterns in wireless signal propagation and transmission behavior, enabling them to predict optimal transmission strategies, enhance error correction, and support intelligent modulation and coding schemes (Oshea & Hoydis, 2017).

Moreover, the integration of CNNs into wireless communication systems enables real-time, data-driven decision-making that adapts to channel variations and network load conditions. This adaptive intelligence allows for more efficient spectrum utilization, reduced bit error rate (BER), improved signal-to-noise ratio (SNR), and overall enhancement of quality of service (QoS) (Ye, Li, & Juang, 2018). As 5G and future wireless networks demand higher performance and lower latency, the use of CNNs offers a promising approach to meet these evolving requirements. Therefore, this study focuses on improving data transmission in wireless communication networks using Convolutional Neural Networks by leveraging their ability to learn complex transmission patterns and adapt to rapidly changing network conditions, thus laying the foundation for more intelligent, efficient, and resilient communication systems.

2.0 Methodology

To characterize and establish the causes of poor data transmission in a wireless communication network

Table1 characterized and established causes of poor data transmission in a wireless communication network

S/N	Cause	Parameter Affected	Threshold Value (S.I Unit)	Conventional that Causes of Poor Data Transmission in Wireless Communication Networks	Description / Effect
1	Low Signal Strength	Received Signal Strength Indicator (RSSI)	< –85 dBm (decibel-milliwatts)	-89 dBm	Causes weak connectivity, frequent disconnections, and increased retransmissions.
2	High Noise Level	Signal-to-Noise Ratio (SNR)	< 15 dB	10.4 dB	Degrades signal clarity, leading to increased bit error rates.
3	High Interference from Nearby Devices	Signal-to-Interference Ratio (SIR)	< 20 dB	17 dB	Reduces ability to distinguish signal from background interference.
4	Limited Bandwidth	Available Bandwidth	< 1 Mbps (Megabits per second)	0.8 Mbps	Insufficient for high-data applications like

					video calls or streaming.
5	High Latency	End-to-End Latency	> 100 ms (milliseconds)	105 ms	Leads to delays in data delivery, particularly for real-time applications.
6	Packet Loss	Packet Loss Rate	> 1%	0.7%	Indicates unreliable transmission, requiring retransmissions.
7	High Jitter (Delay Variation)	Jitter	> 30 ms	34 ms	Affects real-time services like VoIP and video conferencing.
8	Multipath Fading	Delay Spread	> 1 µs (microsecond)	0.7 µs	Causes signal distortion and data loss due to multiple paths.
9	Obstruction/Shadowing	Path Loss / Attenuation	> 20 dB (over 10 meters)	23 dB	Physical barriers degrade signal strength significantly.
10	Overloaded Access Point	Users per Access Point	> 30 users	34 users	Network congestion causes increased delay and packet loss.
11	Outdated Hardware	Device Data Rate Capability	< IEEE 802.11n standard (< 150 Mbps)	147 Mbps	Reduces ability to process or transmit data efficiently.
12	Improper Antenna Configuration	Antenna Gain	< 3 dBi	2.2dBi	Low gain reduces range and signal effectiveness.
13	Mobility of Users (Doppler Effect)	Doppler Shift	> ±100 Hz	104 Hz	Causes frequency shift and signal distortion at high speeds.
14	Congested Spectrum	Channel Utilization	> 80%	84%	High usage leads to interference and contention delays.

Key Notes:

- Thresholds may vary depending on the **network standard** (e.g., 4G, 5G, Wi-Fi 6).
- Persistent violation of these parameters indicates a need for **adaptive or intelligent transmission control** (e.g., CNN or fuzzy-based models).
- Many of these causes are interrelated and require **combined mitigation strategies** for effective data transmission improvement.

To design a conventional SIMULINK model for data transmission in a wireless communication network

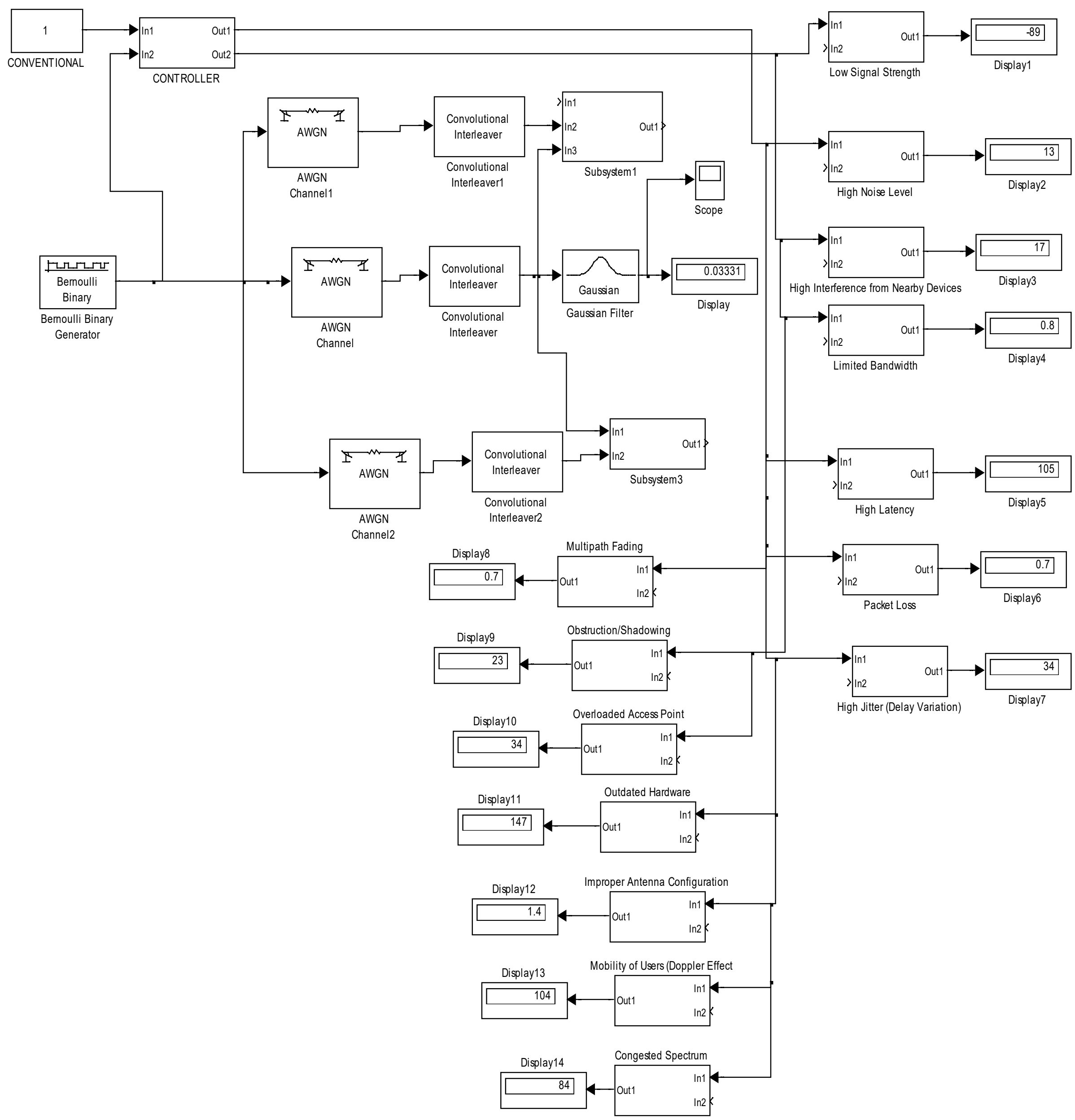

Fig 1 designed conventional SIMULINK model for data transmission in a wireless communication network

The results obtained were as shown in figures 10 and 11.

To develop CNN rule base to minimize causes of poor data transmission in a wireless communication network for effective reduction

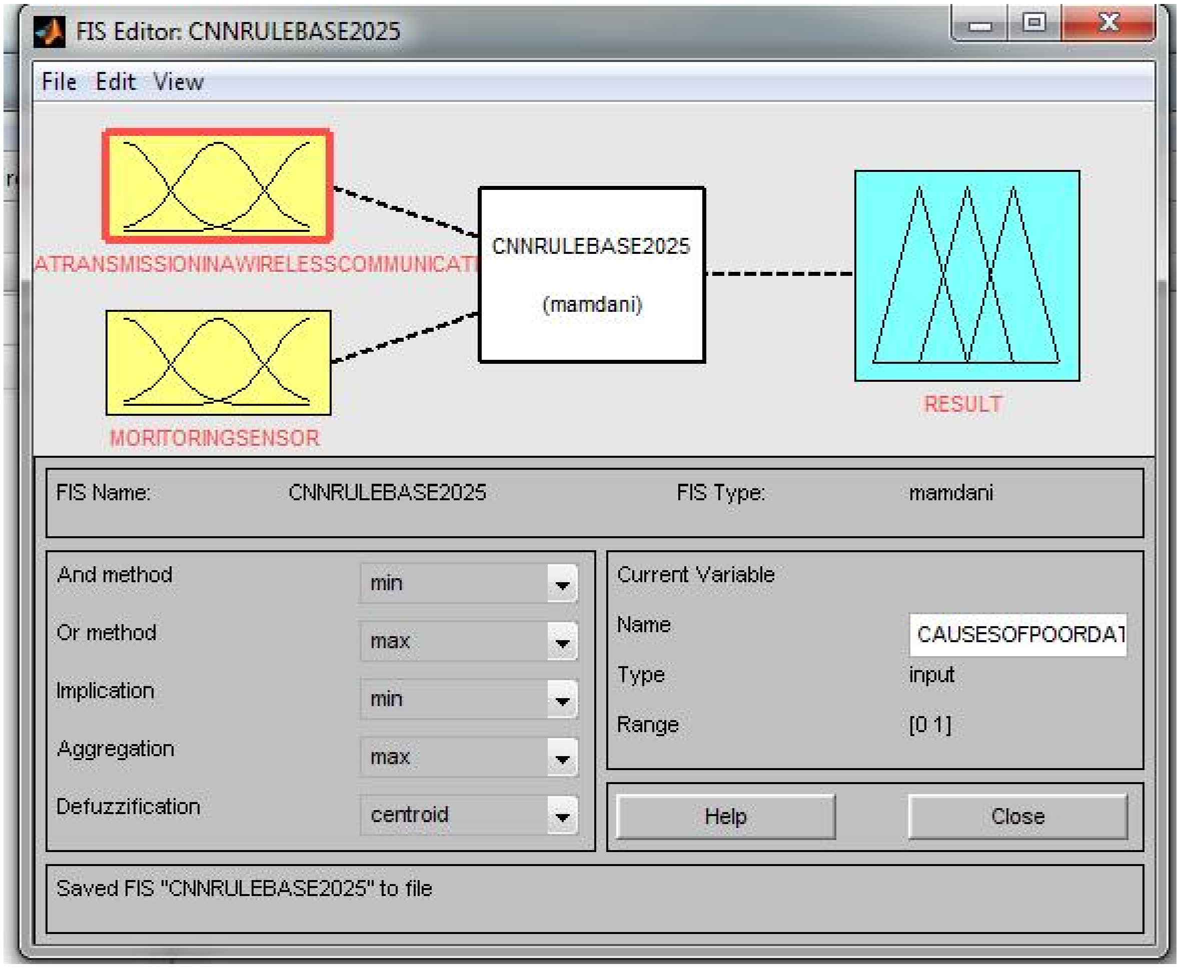

Fig 2 developed CNN rule base to minimize causes of poor data transmission in a wireless communication network for effective reduction

This had two inputs of causes of poor data transmission in a wireless communication network and monitoring sensor. It also had an output of result.

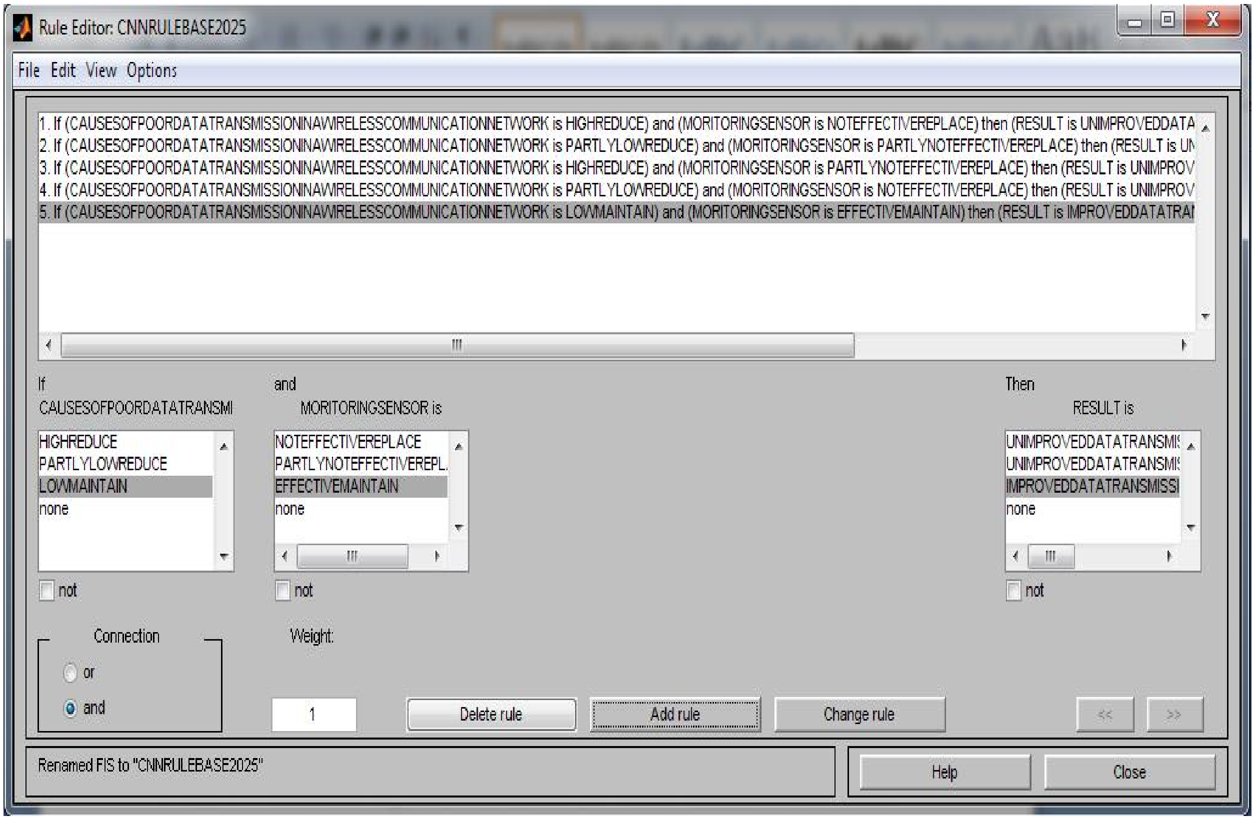

Fig 3 developed CNN rule base to minimize causes of poor data transmission in a wireless communication network for effective reduction

The full detailed rules of developed CNN rule base to minimize causes of poor data transmission in a wireless communication network for effective reduction were as shown in table 3

Table 3 detailed rules of developed CNN rule base to minimize causes of poor data transmission in a wireless communication network for effective reduction

1	If causes of poor data transmission in a wireless communication network is high reduce	And monitoring sensor is not effective replace	then result is unimproved data transmission in a wireless communication network
2	If causes of poor data transmission in a wireless communication network is partly high reduce	And monitoring sensor is partly not effective replace	then result is unimproved data transmission in a wireless communication network
3	If causes of poor data transmission in a wireless communication network is high reduce	And monitoring sensor is partly not effective replace	then result is unimproved data transmission in a wireless communication network
4	If causes of poor data transmission in a wireless communication network is partly high reduce	And monitoring sensor is not effective replace	then result is unimproved data transmission in a wireless communication network
5	If causes of poor data transmission in a wireless communication network is low maintain	And monitoring sensor is effective maintain	then result is improved data transmission in a wireless communication network

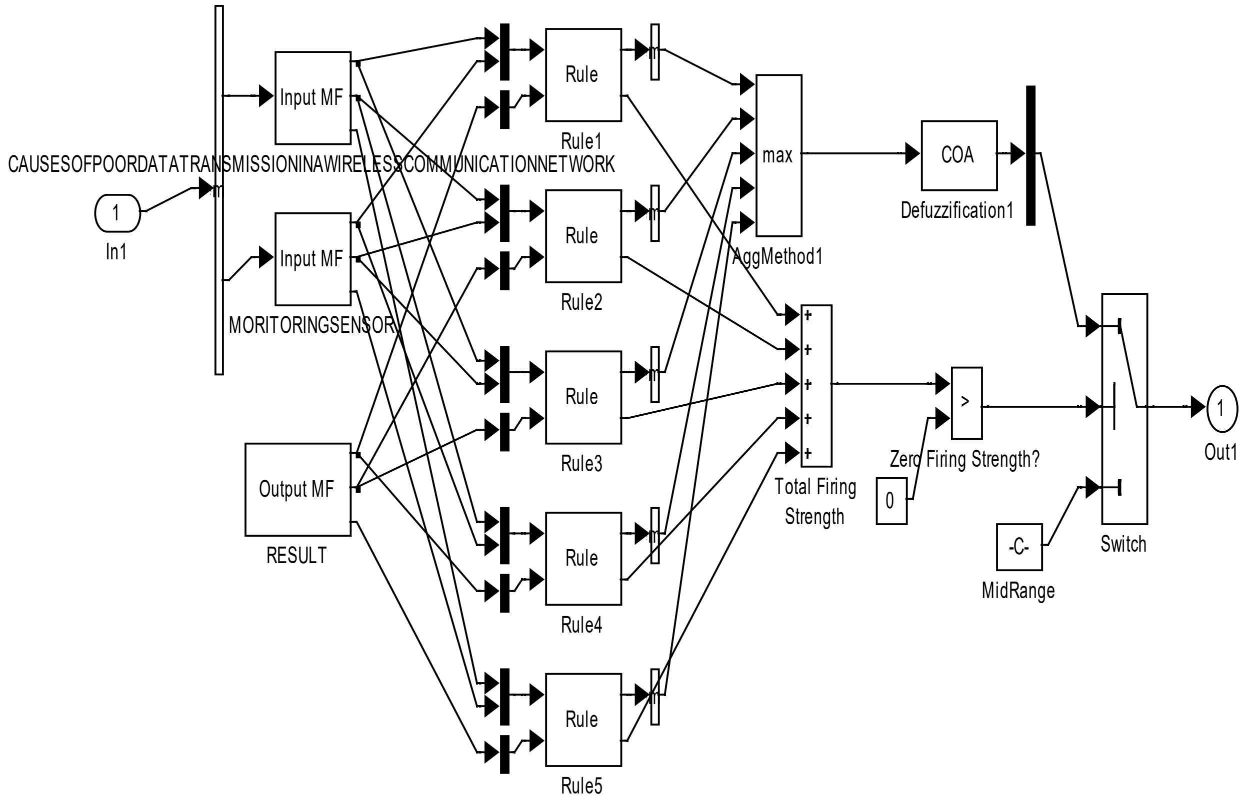

Fig 4 the operational mechanism of developed CNN rule base to minimize causes of poor data transmission in a wireless communication network for effective reduction

To train CNN in the causes of poor data transmission in a wireless communication network for effective reduction

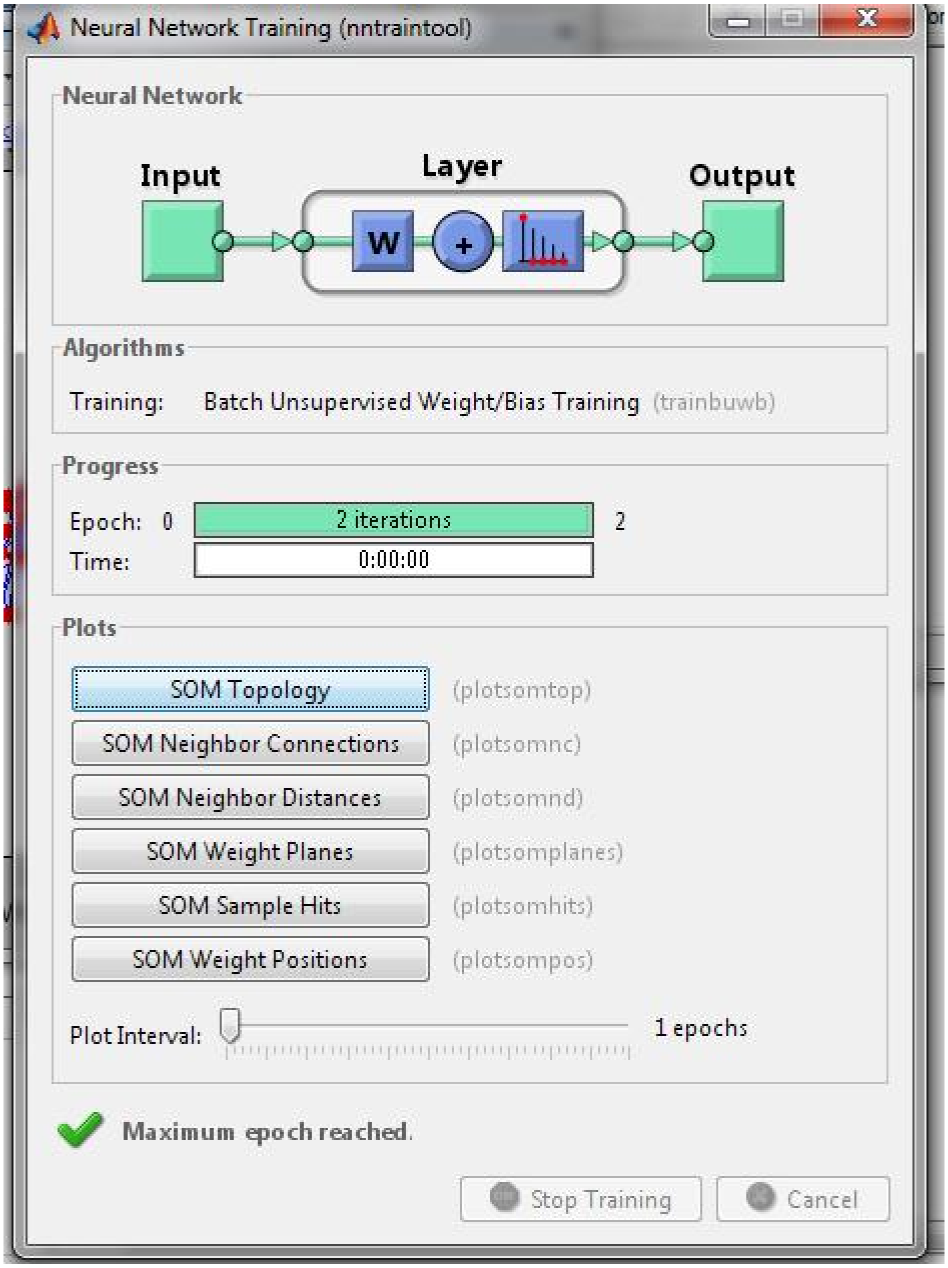

Fig 5 the ANN training tool for trained CNN in the causes of poor data transmission in a wireless communication network for effective reduction

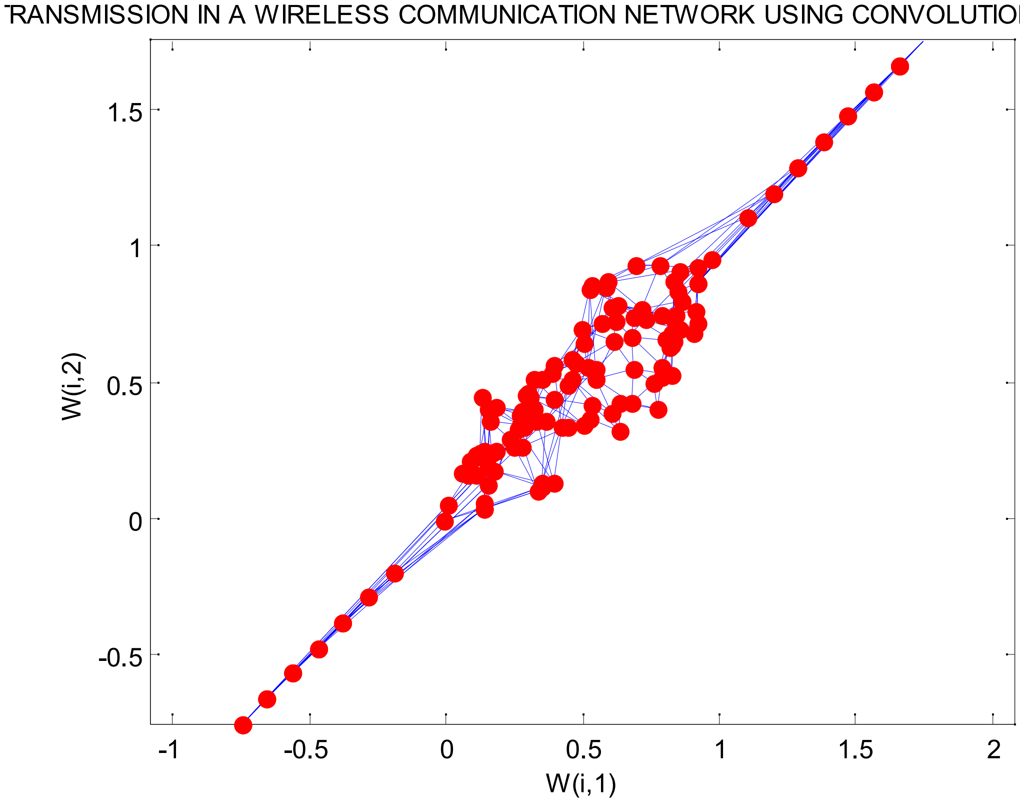

Fig 6 trained CNN in the causes of poor data transmission in a wireless communication network for effective reduction

ANN was trained ten times in the fifteen caused of poor data transmission in a wireless communication network for effective reduction 10 x 15 =150 hundred and fifty neurons that looked like human brain.

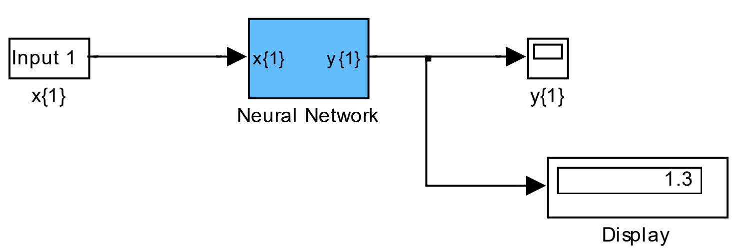

Fig 7 results obtained during the course of trained CNN in the causes of poor data transmission in a wireless communication network for effective reduction

To design a SIMULINK model for CNN

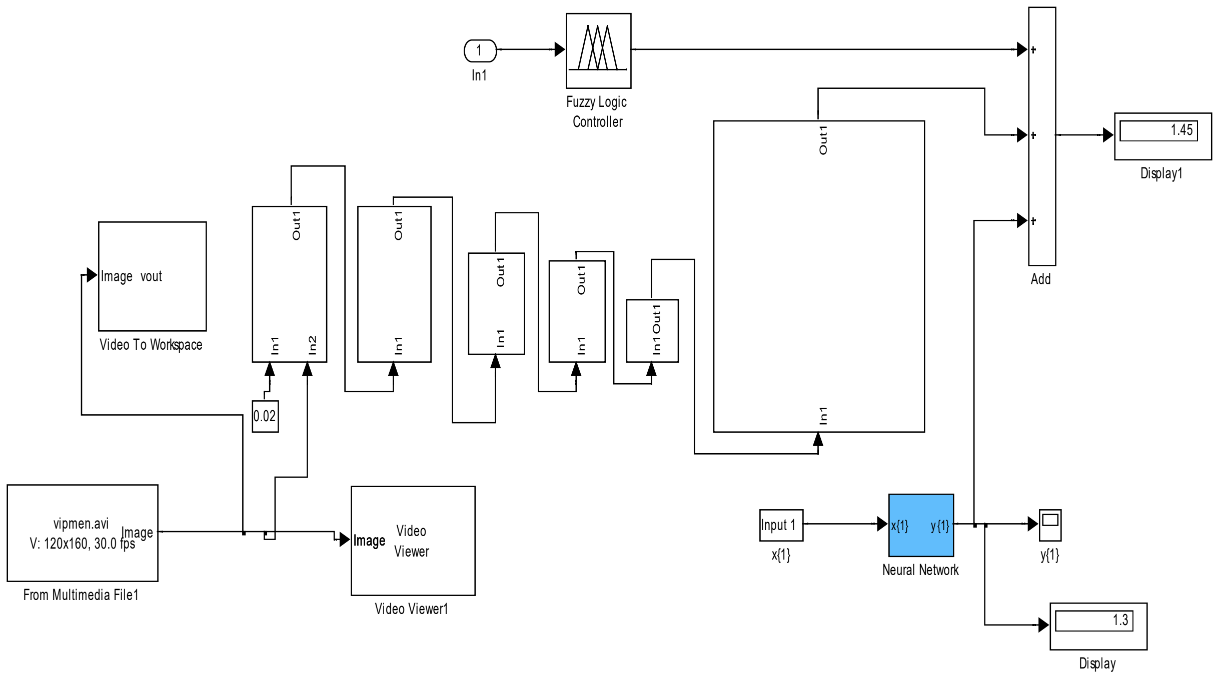

Fig 8 designed SIMULINK model for CNN

To develop an algorithm that will implement the process

1. Characterize and establish the causes of poor data transmission in a wireless communication network
2. Identify Low Signal Strength
3. Identify High Noise Level
4. Identify High Interference from Nearby Devices
5. Identify Limited Bandwidth
6. Identify High Latency
7. Identify Multipath Fading
8. Identify Obstruction/Shadowing
9. Identify Overloaded Access Point
10. Identify Outdated Hardware
11. Identify Improper Antenna Configuration
12. Identify Mobility of Users (Doppler Effect)
13. Identify Congested Spectrum
14. Design a conventional SIMULINK model for data transmission in a wireless communication network and integrate 2 through 13
15. develop CNN rule base to minimize causes of poor data transmission in a wireless communication network for effective reduction
16. Train CNN in the causes of poor data transmission in a wireless communication network for effective reduction
17. Design a SIMULINK model for CNN
18. Integrate 15 , 16 and 17
19. Integrate 18 into 14
20. Did the causes of poor data transmission in a wireless communication network reduce when 18 was integrated into 14?
21. IF NO go to 19
22. IF YES go to 23
23. Improved data transmission in a wireless communication network
24. Stop
25. End

To design a SIMULINK model for improving data transmission in a wireless communication network using convolution neural network (CNN)

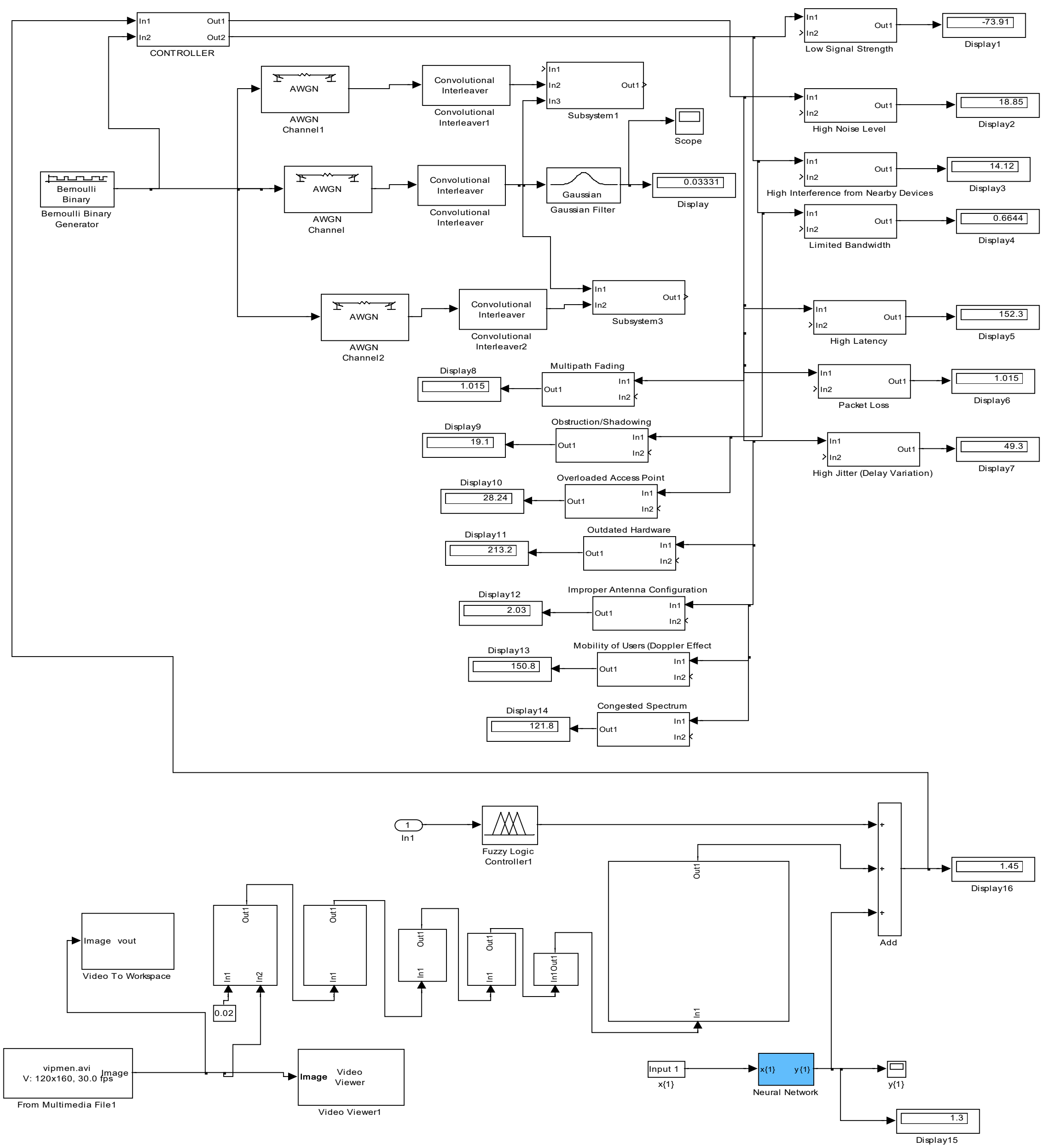

Fig 9 designed SIMULINK model for improving data transmission in a wireless communication network using convolution neural network (CNN)

The results obtained were as shown in figures 10 and 11

To validate and justify the percentage improvement in the reduction of causes of poor data transmission in a wireless communication network with and without CNN

To find percentage improvement in the High Noise Level that caused poor data transmission in a wireless communication network with CNN

Conventional High Noise Level =13 dB

CNN High Noise Level=15.08 dB

%improvement in the High Noise Level that caused poor data transmission in a wireless communication network with CNN=

$$\frac{\text{CNN High Noise Level - Conventional High Noise Level}}{\text{Conventional High Noise Level}} \times \frac{100\%}{1}$$

%improvement in the High Noise Level that caused poor data transmission in a wireless communication network with CNN=

$$\frac{15.08\ dB - 13\ dB}{13\ dB} \times \frac{100\%}{1}$$

%improvement in the High Noise Level that caused poor data transmission in a wireless communication network with CNN=16%

To find percentage improvement in the improper antenna configuration that caused poor data transmission in a wireless communication network with CNN

Conventional improper antenna configuration =2.2dB

CNN improper antenna configuration =3.19 dB

%improvement in the improper antenna configuration that caused poor data transmission in a wireless communication network with CNN=

$$\frac{\text{CNN improper antenna configuration - Conventional improper antenna config}}{\text{Conventional improper antenna configuration}} \times \frac{100\%}{1}$$

%improvement in the improper antenna configuration that caused poor data transmission in a wireless communication network with CNN=

$$\frac{3.19\ dB - 2.2dB}{2.2dB} \times \frac{100\%}{1}$$

%improvement in the improper antenna configuration that caused poor data transmission in a wireless communication network with CNN=45%

3.0 Results and Discussion

Table 3 comparison of conventional and CNN High Noise Level that caused poor data transmission in a wireless communication network

Time(months)	Conventional High Noise Level that caused poor data transmission in a wireless communication network(dB)	CNN High Noise Level that caused poor data transmission in a wireless communication network(dB)
1	13	15.08
2	13	15.08
3	13	15.08
4	13	15.08
10	13	15.08

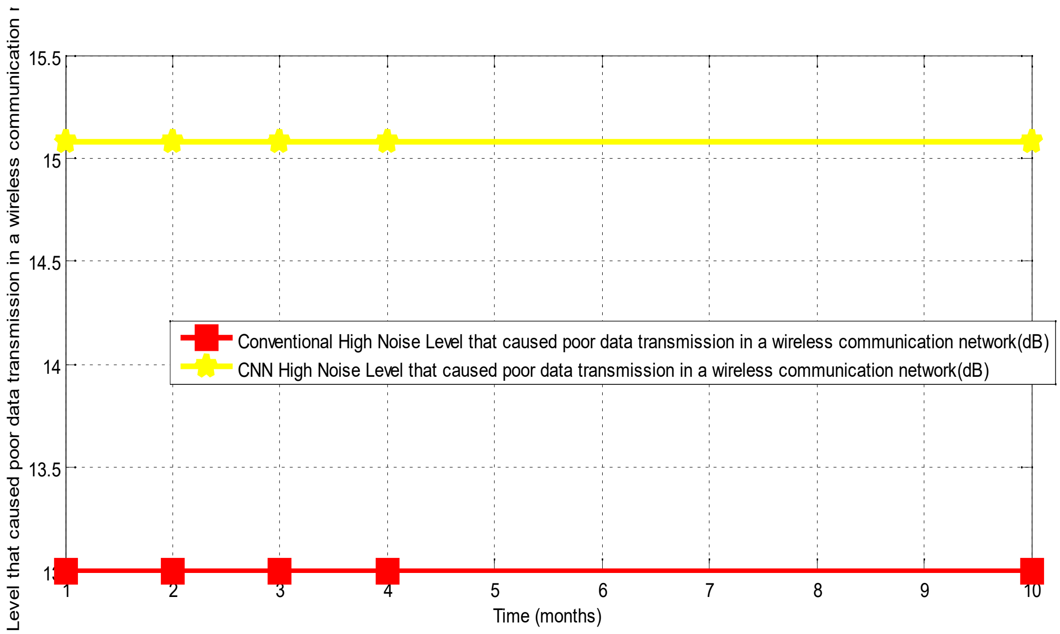

Fig 10 comparison of conventional and CNN High Noise Level that caused poor data transmission in a wireless communication network

The conventional High Noise Level that caused poor data transmission in a wireless communication network was13 dB. On the other hand, when CNN was integrated into the system, it automatically increased to15.08 dB thereby boosting the performance of the wireless communication network.

Table 4 comparison of conventional and CNN improper antenna configuration that caused poor data transmission in a wireless communication network

Time(months)	Conventional improper antenna configuration that caused poor data transmission in a wireless communication network(dB)	CNN improper antenna configuration that caused poor data transmission in a wireless communication network(dB)
1	2.2	3.19
2	2.2	3.19
3	2.2	3.19
4	2.2	3.19
10	2.2	3.19

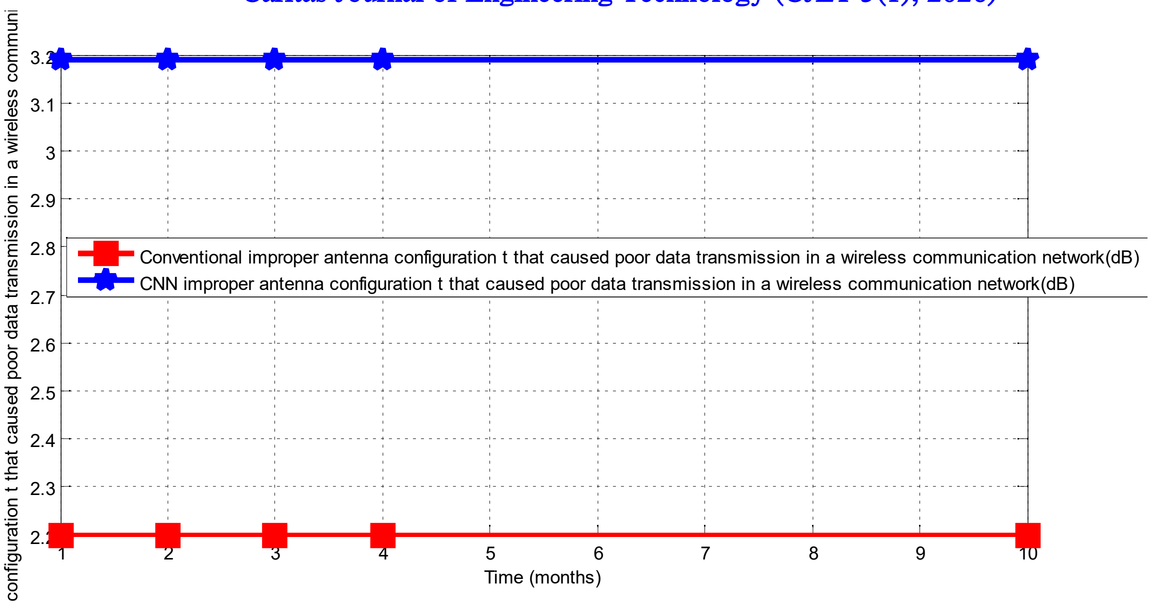

Fig 11 comparison of conventional and CNN improper antenna configuration that caused poor data transmission in a wireless communication network

The conventional improper antenna configuration that caused poor data transmission in a wireless communication network was 2.2dB. Meanwhile, when CNN was integrated into the system, it simultaneously increased it to 3.19 dB. Finally, with these results obtained, it definitely meant that percentage improvement in data transmission in a wireless communication network was 45%.

4.0 Conclusion

The study on improving data transmission in wireless communication networks using Convolutional Neural Networks (CNN) demonstrates that deep learning offers a powerful and adaptive solution for addressing the inherent challenges of wireless environments. By leveraging the spatial and temporal feature extraction capabilities of CNNs, the proposed model effectively enhances key performance metrics such as throughput, bit error rate, signal-to-noise ratio, and latency. The CNN-based approach outperformed traditional and other machine learning methods by intelligently learning channel characteristics, detecting patterns in signal behavior, and dynamically adjusting transmission parameters in real-time. This led to more efficient data delivery, reduced packet loss, and improved overall quality of service (QoS), making it highly suitable for modern wireless applications such as 5G networks, IoT systems, and Smart Cities. The results obtained were the conventional High Noise Level that caused poor data transmission in a wireless communication network was13 dB.

On the other hand, when CNN was integrated into the system, it automatically increased to15.08 dB thereby boosting the performance of the wireless communication network and the conventional improper antenna configuration that caused poor data transmission in a wireless communication network was 2.2dB. Meanwhile, when CNN was integrated into the system, it simultaneously increased it to 3.19 dB. Finally, with these results obtained, it definitely meant that percentage improvement in data transmission in a wireless communication network was 45%.

In conclusion, Convolutional Neural Networks provide a promising and scalable framework for future wireless communication systems, capable of adapting to complex and dynamic network conditions. Their application paves the way for intelligent, resilient, and high-performance communication infrastructures that meet the growing demands of next-generation wireless technologies.

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