IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 4, June 2025

Impact Factor: 7.67

Optimizing Key Features for Accurate 5G Coverage Prediction

V. Ravi Kumar, D. Sai Kiran[2], K. Mani Shankar[3], G. Shiva Kumar[4], D. Sai Varshith[5]

Professor, Computer Science Engineering[1]

Students, Computer Science Engineering[2-5]

ACE Engineering College, Ghatkesar, India

Abstract: *This system focuses on predicting wireless network generations (2G, 3G, 4G, 5G) in India using a machine learning based approach. It utilizes a mobile network coverage dataset containing features like signal strength, network speed, latency, tower type, weather conditions, and geographical area type. Various machine learning model including Logistic Regression, Random Forest, SVM, and advanced techniques like Stacking and Voting Classifiers were evaluated. A Convolutional Neural Network (CNN) was also used to capture complex patterns in the data. Model performance was assessed using accuracy, precision, recall, and F1-score. The findings help improve coverage prediction, support efficient network planning, and enhance telecom service quality..*

Keywords: Wireless Network Generation, Machine Learning, Latency, Network Speed, Ensemble Learning.

I. INTRODUCTION

Fifth-generation (5G) networks aim to deliver ultra-fast speeds, low latency, and massive connectivity. However, achieving consistent and reliable coverage remains a major challenge due to interference, signal degradation, and deployment complexities [1]. Planning and deploying 5G networks also face issues like high infrastructure costs, spectrum allocation, and urban–rural disparities. Machine learning techniques have been proposed to optimize base station placement and improve coverage accuracy [2].

Deep learning has proven effective in OFDM systems for tasks like channel estimation and signal detection, outperforming traditional approaches and reducing bit error rates [3]. CNN-based models for wireless channel estimation show higher accuracy in mitigating noise and adapting to dynamic signal variations [4]. Neural network-based decoders enhance channel decoding by achieving lower error rates and better adaptability under varying conditions [5].

For indoor environments, genetic algorithms combined with machine learning are used to estimate path loss and optimize base station layout, improving signal quality and reducing interference [6]. Machine learning is also crucial for the future of 5G, offering dynamic solutions for traffic prediction, network optimization, and intelligent resource management [7]. Supervised learning algorithms like SVMs, decision trees, and random forests have shown effectiveness in predicting network coverage areas using real-world data [8].

Online learning models, such as the Machine Learning-Based Online Estimator (MLOE), enable real-time prediction and adaptive network planning by learning from current conditions [9]. Nature-inspired meta-heuristic algorithms, including genetic algorithms and particle swarm optimization, are increasingly used to improve deep learning model performance and convergence in wireless applications [10].

II. LITERATURE SURVEY

A Survey on 5G Coverage Improvement Techniques: Issues and Future Challenges This paper provides an extensive review of various 5G coverage enhancement techniques, identifying key challenges and future directions. The authors discuss issues such as interference, signal degradation, and network deployment complexities. They highlight emerging technologies like massive MIMO, beamforming, and AI-based optimization techniques that improve network performance.[1]

5G Network Coverage Planning and Analysis of the Deployment Challenges This study analyzes the critical challenges associated with planning and deploying 5G networks. The authors focus on issues such as infrastructure costs, urban and rural deployment differences, and spectrum allocation. Machine learning models are proposed for network planning, offering insights into optimizing base station placement and coverage expansion. [2]

Power of Deep Learning for Channel Estimation and Signal Detection in OFDM Systems This paper explores the application of deep learning in Orthogonal Frequency Division Multiplexing (OFDM) systems for channel estimation and signal detection. The authors demonstrate that deep neural networks outperform traditional estimation methods, leading to improved accuracy and robustness. The study provides experimental results showing reduced bit error rates and enhanced performance under varying channel conditions. [3]

Deep Learning-Based Channel Estimation This research focuses on deep learning models for wireless channel estimation, comparing different Authorized licensed use limited to: VIT-Amaravathi campus. Downloaded on November 06,2024 at 09:19:03 UTC from IEEE Xplore. Restrictions apply. neural network architectures. The authors propose a convolutional neural network (CNN)-based approach that significantly improves estimation accuracy compared to conventional techniques. Experimental validation confirms the model's efficiency in mitigating noise and handling dynamic signal variations. [4]

On Deep Learning-Based Channel Decoding This study investigates the use of deep learning in channel decoding for wireless communication. The authors introduce a neural network-based decoder that adapts to different channel conditions, achieving superior decoding performance compared to traditional methods. The study presents empirical results showing significant improvements in decoding efficiency and reduced error rates. [5]

Indoor Genetic Algorithm-Based 5G Network Planning Using a Machine Learning Model for Path Loss Estimation The paper presents a machine learning-based path loss estimation model for indoor 5G network planning. The authors utilize genetic algorithms to optimize base station placement and minimize signal loss. The study demonstrates the effectiveness of integrating AI techniques in network planning to enhance coverage and reduce interference in complex indoor environments. [6]

2018 ITU Kaleidoscope: Machine Learning for a 5G Future (ITU K) This paper discusses the role of machine learning in shaping the future of 5G networks. It covers various AI-driven solutions for network optimization, resource allocation, and performance enhancement. The authors emphasize the importance of predictive analytics and reinforcement learning in dynamic network management and traffic forecasting. [7]

Mobile Network Coverage Prediction Based on Supervised Machine Learning Algorithms The paper explores the application of supervised learning techniques in mobile network coverage prediction. The authors evaluate algorithms such as decision trees, support vector machines (SVM), and random forests to estimate coverage areas based on real-world network data. Results indicate that ML models can significantly improve coverage prediction accuracy. [8]

Machine Learning-Based Online Coverage Estimator (MLOE): Advancing Mobile Network Planning and Optimization This study introduces a machine learning-based online coverage estimator (MLOE) designed for real-time network coverage prediction and optimization. The authors propose a model that continuously learns from network conditions to enhance coverage estimation and aid in adaptive network planning. [9]

Nature-Inspired Meta-Heuristic Algorithms for Deep Learning: Recent Progress and Novel Perspective The paper presents an in-depth analysis of nature-inspired optimization algorithms used in deep learning applications. The authors review genetic algorithms, particle swarm optimization, and other heuristic approaches that enhance deep learning model performance. The study highlights the potential of these techniques in improving neural network training efficiency and convergence speed.[10]

III. PROPOSED WORK

This study presents a system for predicting 5G coverage efficacy using 27 parameters from various locations. Leveraging techniques like Stacking Classifier, Voting Classifier, and CNN, it identifies key features—Frequency, Signal Strength, Modulation, and Bandwidth. Analyzing 164,160 observations, the system assesses dominant features

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 4, June 2025 Impact Factor: 7.67

and model performance to optimize 5G deployment, aiming to improve predictive accuracy for efficient network planning and management.

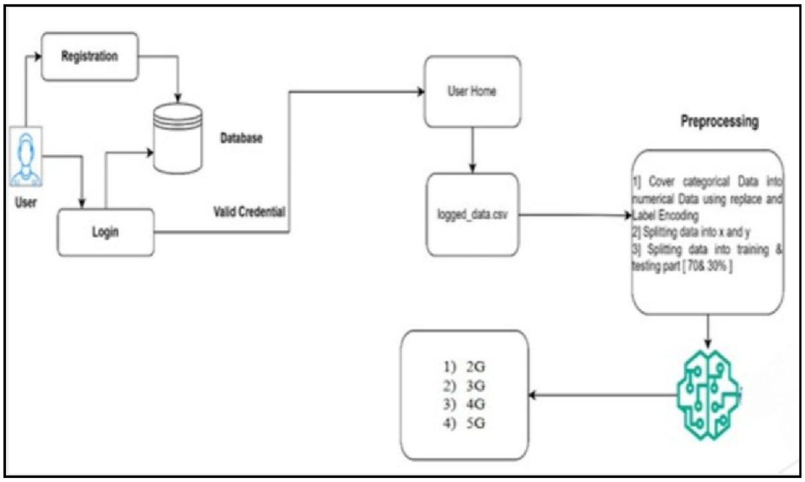

FIG 1. ARCHITECTURE DIAGRAM

The architecture diagram illustrates a comprehensive flow of a machine learning-based system designed to predict wireless network generations (2G, 3G, 4G, or 5G) using various network parameters. The process begins with the user interacting through a web interface, where they can either register as a new user or log in if already registered. Upon successful registration, the user's data is stored in a MySQL database, and valid login credentials allow access to the User Home interface. From this home interface, the user can upload a dataset (logged_data.csv) containing multiple network samples for batch prediction, or proceed with manual entry of network characteristics for real-time prediction.

Once data is submitted, it is directed to the Preprocessing Module, which performs critical preparation steps for machine learning. Firstly, any categorical variables (e.g., location types like rural or urban) are converted to numerical values using Label Encoding. Secondly, the dataset is divided into two parts: features (X) representing the input variables, and labels (y) representing the actual network generation. Thirdly, the dataset is further split into training and testing sets with a 70:30 ratio to allow the model to learn from one portion and be evaluated on another.

The processed data is then fed into the Machine Learning Engine, represented by a neural network icon in the diagram. This engine may consist of one or multiple models, including Random Forest, Stacking Classifier, Voting Classifier, or Convolutional Neural Networks (CNN). These models are pre-trained using the training data and are capable of identifying complex patterns among input features such as signal strength, frequency, latency, tower density, user density, and others. Once the input is evaluated, the model produces a predicted output, identifying the most likely generation of the wireless network for the given conditions.

The output is categorized into one of the four classes: 2G, 3G, 4G, or 5G, and this result is displayed back to the user through the interface. This architecture not only supports user management and secure access but also provides the ability to perform both individual and batch predictions with high accuracy. By integrating database management, preprocessing logic, and advanced machine learning, the system delivers a robust, scalable, and user-friendly solution for intelligent 5G network generation prediction.

IV. RESULTS

The bar graph provides a detailed comparison between the existing system and the proposed system for predicting wireless network generations, using four essential evaluation metrics: Accuracy, Precision, Recall, and F1-score. Each of these metrics reflects a different aspect of the system's classification performance. The existing system, shown in light blue, consistently performs lower across all metrics, achieving around 70–72% in accuracy and precision, and slightly less in recall and F1-score (about 68–70%). This suggests that the existing models likely suffer from generalization issues, possibly due to simpler algorithms, insufficient feature extraction, or limited training strategies.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, June 2025
Impact Factor: 7.67

In contrast, the proposed system, represented by green bars, demonstrates a substantial performance enhancement. It achieves over 90% in accuracy, precision, and F1-score, and about 92% in recall. These values indicate that the proposed system is not only more accurate overall but also more consistent in correctly identifying all classes of wireless generations (2G, 3G, 4G, and 5G), with fewer false positives and false negatives. The higher recall reflects the model's capability to capture even the harder-to-predict cases, and the elevated F1-score confirms a strong balance between precision and recall.

This significant performance gain is attributed to the use of advanced techniques in the proposed system, such as ensemble models (like Stacking and Voting classifiers) and deep learning approaches (like CNNs), which are capable of capturing complex patterns in high-dimensional network data. Moreover, effective preprocessing, feature engineering, and model tuning contribute to the overall efficiency of the system. In summary, the graph clearly validates that the proposed system offers a more reliable, scalable, and intelligent solution for 5G network generation prediction, making it suitable for practical use in telecom network planning and optimization.

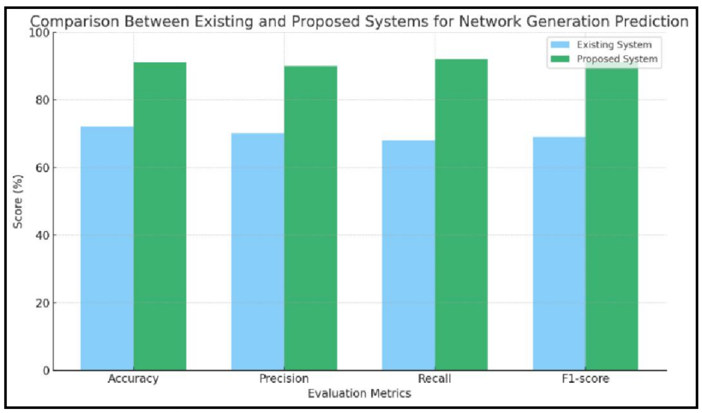

Fig 2. Comparison between Existing system and proposed system

The following are the output screens of the Network generation prediction system:

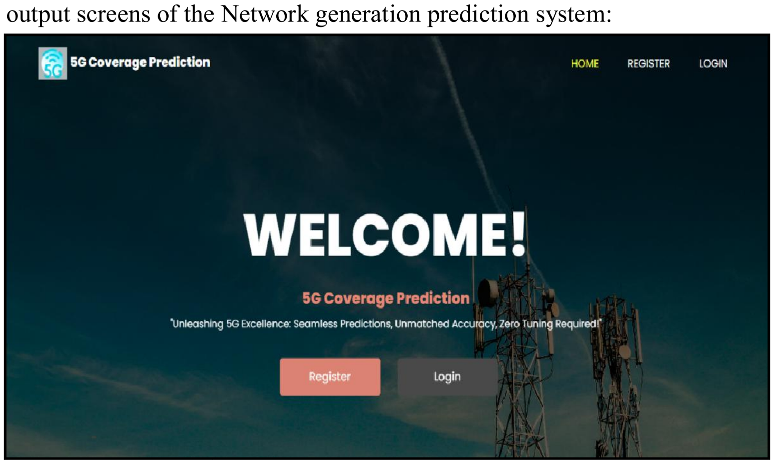

Fig 3 Home page of the user interface

DOI: 10.48175/IJARSCT-27644

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, June 2025
Impact Factor: 7.67

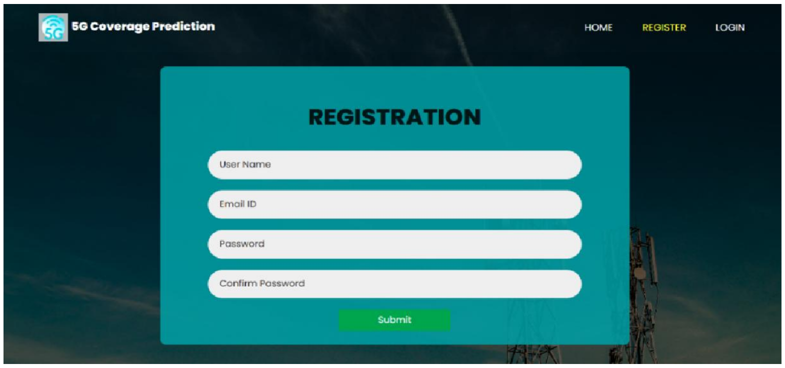

Fig 4 Registration Page

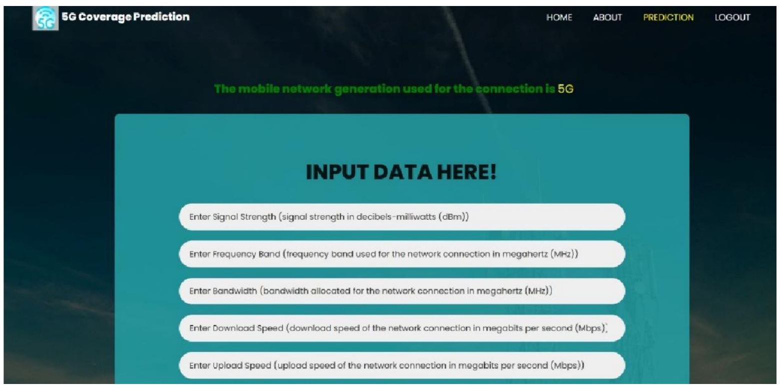

Fig 5 Output Page (1)

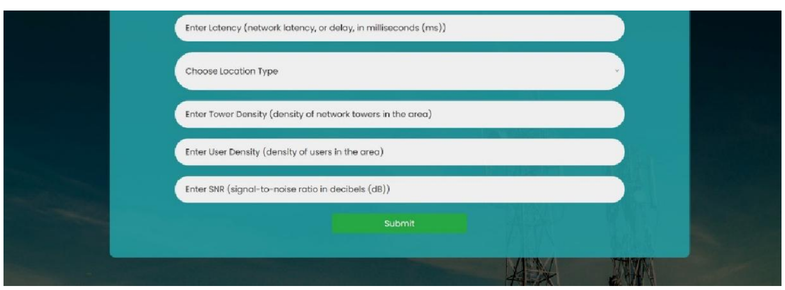

Fig 6 Output Page (2)

V. CONCLUSION

This system presents a machine learning-based approach to accurately predict wireless network generations (2G, 3G, 4G, or 5G) using a dataset containing key network coverage parameters. By leveraging advanced machine learning and deep learning techniques, including Logistic Regression, Random Forest, Support Vector Machines (SVM), Stacking Classifier, Voting Classifier, and Convolutional Neural Networks (CNN), the system effectively analyzes complex dependencies among factors such as signal strength, network speed, latency, and environmental conditions. The comparative evaluation of these models using accuracy, precision, recall, and F1-score provides valuable insights into their predictive capabilities. The implementation of this system benefits telecom operators, network engineers, and policymakers by offering a data-driven approach to optimize network deployment and improve coverage predictions. Users can interact with the system to input real-time network parameters, select machine learning models, and obtain network generation predictions, making the application practical for real-world use. By enhancing the accuracy of network classification, this research contributes to improved connectivity, efficient resource allocation, and better network management strategies. Future work can focus on integrating real-time data streams, refining deep learning models, and expanding the system's applicability to global datasets for broader scalability and impact.

REFERENCES

[1] "Predicting 5G Network Coverage with CNN and Ensemble Learning Techniques", Authors: P. Nagamani, V.Joshnavi, P. Sai Lokesh, K. Subramanyam Sivaram, D. Smaily, 2025. https://www.taylorfrancis.com/chapters/edit/10.1201/9781003641537-90/predicting-5g-network-coverage-cnn-ensemble-learning-techniques-nagamani-joshnavi-sai-lokesh-subramanyam-sivaram-smaily

[2] "ANALYSIS AND OPTIMIZATION OF URBAN-SUBURBAN 5G COVERAGE PREDICTIONS" Authors: Hakeem Babalola Akande, Fatima Olamide Abass, October 2024. https://fjs.fudutsinma.edu.ng/index.php/fjs/article/view/2761

[3] "Comparative Analysis of Machine Learning Algorithms for 5G Coverage Prediction: Identification of Dominant Feature Parameters and Prediction Accuracy". Authors: Hajiyar Yulina, Iskandar, Hendravan, February 2024. https://ieeexplore.ieee.org/abstract/document/10418223

[4] "A Survey on 5G Coverage Improvement Techniques: Issues and Future Challenges". Authors: C. Sudhamani, M. Roslee, J. J. Tiang, and A. U. Rehman. Published in Sensors, February 2023 https://www.mdpi.com/1424-8220/23/4/2356

[5] "Mobile Network Coverage Prediction Based on Supervised Machine Learning Algorithms" Authors: Mohd Fazuwan Ahmad Fauzi, Rosdiadee Nodrin, 2022. https://ieeexplore.ieee.org/abstract/document/9779262

[6] "5G Network Coverage Planning and Analysis of the Deployment Challenges". Authors: M. M. Ahamed and S. Faruque. Published in Sensors, October 2021 https://www.mdpi.com/1424-8220/21/19/6608

[7] "Analysis and Optimization of 5G Coverage Predictions Using a Beamforming Antenna Model and Real Drive Test Measurements" Authors: Marco Sousa, Andre Alves, Pedro Vieira, Maria Paula Queluz, Antonio Rodrigues, July 2021. https://ieeexplore.ieee.org/abstract/document/9486925

[8] "Power of Deep Learning for Channel Estimation and Signal Detection in OFDM Systems". Authors: H. Ye, G. Y. Li, and B.-H. Juang. Published in IEEE Wireless Communications Letters, February 2018. https://ieeexplore.ieee.org/document/8048821

[9] "Deep Learning-Based Channel Estimation". Authors: M. Soltani, V. Pourahmadi, A. Mirzaei, and H. Sheikhzadeh. Published in IEEE Communications Letters, April 2019 https://ieeexplore.ieee.org/document/8653391

[10] "On Deep Learning-Based Channel Decoding". Authors: T. Gruber, S. Cammerer, J. Hoydis, and S. T. Brink. Presented at the 51st Annual Conference on Information Sciences and Systems (CISS), 2017 https://ieeexplore.ieee.org/document/7926071

[11] "Indoor Genetic Algorithm-Based 5G Network Planning Using a Machine Learning Model for Path Loss Estimation". Authors: Y. H. Santana, R. M. Alonso, G. G. Nieto, L. Martens, W. Joseph, and D. Plets. Published in Applied Sciences, April 2022. https://www.mdpi.com/2076-3417/12/8/3923

[12] "2018 ITU Kaleidoscope: Machine Learning for a 5G Future (ITU K)". Published in 2018. https://ieeexplore.ieee.org/document/8730071

[13] "Mobile Network Coverage Prediction Based on Supervised Machine Learning Algorithms". Authors: M. F. A. Fauzi, R. Nordin, N. F. Abdullah, and H. A. H. Alobaidy. Published in IEEE Access, 2022. https://ieeexplore.ieee.org/document/9763310

[14] "Machine Learning-Based Online Coverage Estimator (MLOE): Advancing Mobile Network Planning and Optimization". Authors: M. F. A. Fauzi, R. Nordin, N. F. Abdullah, H. A. H. Alobaidy, and M. Behjati. Published in IEEE Access, 2023. https://ieeexplore.ieee.org/document/10011620

[15] "Nature Inspired Meta-Heuristic Algorithms for Deep Learning: Recent Progress and Novel Perspective" Authors: H. Chiroma, A. Y. Gital, N. Rana, S. M. Abdulhamid, A. N. Muhammad, A. Y. Umar, and A. Abubakar, 2020.https://link.springer.com/chapter/10.1007/978-3-030-17795-9_5