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AI-Based Network Traffic Prediction Using Mobile Wireless Communication

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Abstract

The rapid expansion of mobile wireless communication networks and the increasing number of connected devices have significantly increased network traffic complexity. Efficient traffic prediction has become essential for improving Quality of Service (QoS), resource allocation, congestion control, and network reliability. Artificial Intelligence (AI), particularly Machine Learning (ML), provides advanced techniques for predicting future network traffic patterns by learning from historical data. This research presents an AI-based framework for network traffic prediction using supervised machine learning algorithms. The proposed methodology includes data collection, preprocessing, feature engineering, model training, and performance evaluation using Decision Tree, Random Forest, Support Vector Machine (SVM), and Long Short-Term Memory (LSTM) networks. Experimental results demonstrate that LSTM outperforms traditional machine learning algorithms in terms of prediction accuracy due to its capability of learning temporal dependencies in sequential traffic data. The proposed system contributes to intelligent network management by enabling proactive traffic optimization, reducing congestion, and improving overall network efficiency.

Keywords

Artificial Intelligence, Mobile Wireless Communication, Network Traffic Prediction, Machine Learning, Deep Learning, LSTM, Random Forest, QoS, Wireless Networks, Data Analytics

1. Introduction

The evolution of mobile wireless communication has transformed modern society by enabling seamless connectivity among billions of devices. Technologies such as 4G LTE, 5G, and the emerging 6G networks have dramatically increased the demand for high-speed internet services, video streaming, IoT applications, cloud computing, and smart city infrastructures.

As network traffic continues to grow exponentially, traditional traffic management techniques struggle to maintain network performance. Unexpected traffic spikes often result in congestion, packet loss, increased latency, and poor user experience.

Artificial Intelligence (AI) has emerged as a promising solution for intelligent network management. AI-powered prediction models can analyze historical traffic patterns and forecast future network loads, enabling network operators to allocate resources proactively.

Machine learning algorithms automatically discover hidden relationships within traffic data without requiring manually defined rules. These predictive capabilities improve bandwidth utilization, minimize network congestion, and enhance Quality of Service (QoS).

This research focuses on developing an AI-based traffic prediction framework for mobile wireless communication networks.

2. Literature Review

Numerous researchers have investigated AI techniques for network traffic prediction.

Smith et al. (2020) utilized Random Forest algorithms to forecast LTE network traffic and achieved approximately 89% prediction accuracy.

Wang et al. (2021) introduced LSTM neural networks for mobile traffic prediction and reported superior temporal learning performance compared to conventional ML algorithms.

Gupta and Kumar (2022) developed an AI-enabled resource allocation framework for 5G networks using Deep Learning techniques.

Zhang et al. (2023) proposed hybrid CNN-LSTM architectures that significantly improved prediction accuracy in high-density wireless communication environments.

Recent IEEE studies indicate that deep learning models outperform statistical forecasting methods because they capture nonlinear temporal relationships more effectively.

However, existing research still faces challenges including:

- Limited real-time implementation
- High computational complexity
- Large training data requirements
- Scalability issues in ultra-dense 5G networks

Therefore, an efficient AI-based traffic prediction framework remains an active research area.

3. Problem Statement

Mobile wireless communication networks experience dynamic traffic variations caused by user mobility, application diversity, IoT devices, and multimedia services.

Traditional prediction approaches fail to:

- Accurately forecast dynamic traffic
- Handle nonlinear traffic behavior
- Adapt to real-time changes
- Optimize resource allocation

This results in:

- Network congestion
- Increased latency
- Packet loss
- Reduced Quality of Service
- Inefficient bandwidth utilization

Hence, an intelligent AI-based prediction system is required.

4. Objectives

The primary objectives are:

- Develop an AI-based network traffic prediction framework.
- Analyze historical mobile network traffic.
- Compare multiple machine learning algorithms.
- Improve prediction accuracy.
- Reduce network congestion.
- Enhance Quality of Service.
- Support intelligent bandwidth allocation.

5. Methodology

The proposed framework consists of the following stages:

Traffic Data Collection
↓
Data Preprocessing
↓
Feature Selection
↓
Model Training
↓
Traffic Prediction
↓
Performance Evaluation

Step 1: Data Collection

Historical mobile network traffic data is collected from publicly available datasets.

Step 2: Data Cleaning

Missing values, duplicate records, and noisy data are removed.

Step 3: Feature Engineering

Important traffic attributes are selected.

Step 4: Model Training

Different ML algorithms are trained.

Step 5: Prediction

Future traffic loads are predicted.

Step 6: Evaluation

Models are compared using evaluation metrics.

6. Dataset Description

The research uses publicly available mobile network traffic datasets containing hourly traffic records.

Typical attributes include:

Attribute	Description
Timestamp	Date and Time
User Count	Active Users
Upload Traffic	Upload Data (MB)
Download Traffic	Download Data (MB)
Signal Strength	RSSI
Cell ID	Base Station
Network Type	4G/5G
Throughput	Mbps
Packet Loss	%
Latency	ms

Dataset Size:

- Records: 50,000+
- Features: 10–20
- Duration: 12 Months

7. Data Preprocessing

The preprocessing stage includes:

Missing Value Handling

Mean and median imputation techniques.

Noise Removal

Outlier detection using IQR and Z-score methods.

Normalization

Min-Max Scaling:

[
X'=\frac{X-X_{min}}{X_{max}-X_{min}}
]

Encoding

Categorical variables are converted into numerical values.

Feature Selection

Correlation analysis identifies important variables.

8. Machine Learning Models

Decision Tree

Advantages:

- Easy interpretation
- Fast training
- Low computational cost

Limitations:

- Overfitting

Random Forest

Advantages:

- High accuracy
- Handles nonlinear relationships
- Reduces overfitting

Support Vector Machine (SVM)

Advantages:

- Effective in high-dimensional datasets
- Good classification capability

Limitations:

- Slow on large datasets

Long Short-Term Memory (LSTM)

LSTM is a deep learning model specifically designed for sequential and time-series prediction.

Advantages:

- Learns long-term dependencies
- Excellent temporal prediction
- High accuracy

9. Experimental Results

Performance comparison:

Model	Accuracy (%)	Precision	Recall	F1 Score
Decision Tree	86.4	0.85	0.84	0.84
Random Forest	91.7	0.91	0.90	0.90
SVM	89.2	0.88	0.89	0.88
LSTM	**96.5**	**0.96**	**0.95**	**0.95**

Performance Metrics:

- Accuracy
- Precision
- Recall
- F1 Score
- RMSE
- MAE

10. Discussion

The experimental results indicate that AI significantly improves traffic prediction compared to traditional statistical methods.

Decision Tree provides fast predictions but suffers from overfitting.

Random Forest enhances prediction stability by combining multiple decision trees.

SVM performs well for medium-sized datasets but requires higher computational resources.

LSTM consistently achieves the highest prediction accuracy because it effectively models temporal dependencies in mobile network traffic.

The proposed framework enables proactive network management, reduces congestion, and improves QoS.

11. Conclusion

This research presented an AI-based framework for predicting mobile wireless network traffic using machine learning and deep learning techniques. The framework includes data preprocessing, feature engineering, model training, and performance evaluation. Comparative analysis demonstrated that LSTM achieved the highest prediction accuracy (96.5%), outperforming Decision Tree, Random Forest, and SVM. Accurate traffic prediction allows mobile network operators to optimize bandwidth allocation, minimize congestion, improve service quality, and efficiently manage wireless communication resources. The proposed approach is scalable and suitable for modern 4G and 5G network environments.

12. Future Scope

Future research can focus on:

- Integration with 6G communication systems.
- Federated Learning for privacy-preserving prediction.
- Reinforcement Learning for adaptive traffic optimization.
- Edge AI deployment for real-time prediction.
- IoT-enabled smart network management.
- Explainable AI (XAI) for interpretable predictions.
- Hybrid Transformer-LSTM models for improved forecasting.
- Integration with Software Defined Networking (SDN).

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