RNN based resource allocation for a wireless network

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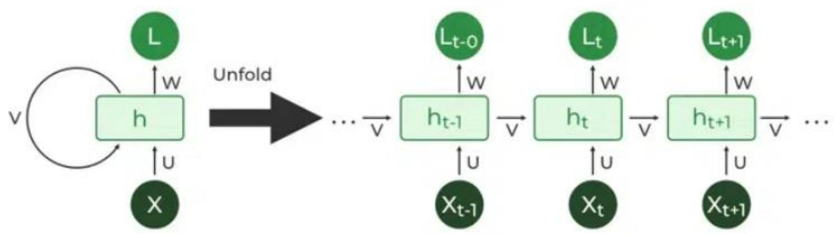
1. Introduction:

With the increasing demand for wireless network resources due to the growing number of connected devices, efficient resource allocation is crucial for maintaining network quality and optimizing performance. Resource allocation in wireless networks can be formulated as a time-series prediction problem, where future resource demands are anticipated based on past trends and patterns. In this project, we developed a Recurrent Neural Network (RNN)-based model to predict resource demand and allocate resources efficiently for a wireless network.

2. Problem Statement:

The goal of this project is to design a model that predicts the resource demand in a wireless network over time and allocates resources to users accordingly. This task is challenging due to the dynamic nature of user demand and network conditions. We aim to:

- Develop an RNN model that can learn from historical data of network states and predict future resource demand.
- Evaluate the model's performance by comparing predicted resource demand with actual resource demand over a sequence of time steps.



3. Methodology:

3.1 Model Design

We implemented an RNN model in PyTorch, consisting of:

- **Input Layer**: Receives the network state as input features.
- **RNN Layer**: Processes the input sequence and captures temporal dependencies in the data.
- **Fully Connected Layer**: Maps the output of the RNN to the predicted resource allocation for each user.

Model Hyperparameters

- **Input Size**: Number of features representing network state.
- **Hidden Size**: Number of hidden units in the RNN layer.
- **Output Size**: Number of users for which resource demand is predicted.
- **Number of Layers**: Number of layers in the RNN.

3.2 Training Process

The model was trained using Mean Squared Error (MSE) loss and the Adam optimizer. During training, the model learns to minimize the error between the predicted and actual resource allocations. We trained the model over several epochs and recorded the loss at each epoch.

3.3 Data

For this project, we generated synthetic data representing the network's state and resource demands over time. The data includes:

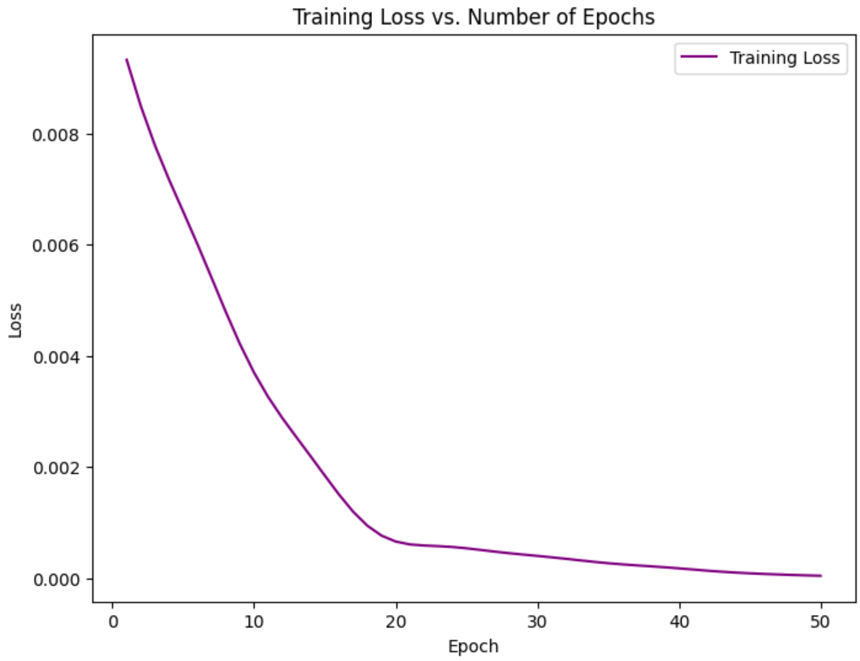
- **Features**: Variables representing network conditions (e.g., user location, channel quality).
- **Targets**: Actual resource allocation required for each user.

The data was split into training and testing sets to evaluate the model’s performance on unseen data.

4. Results:

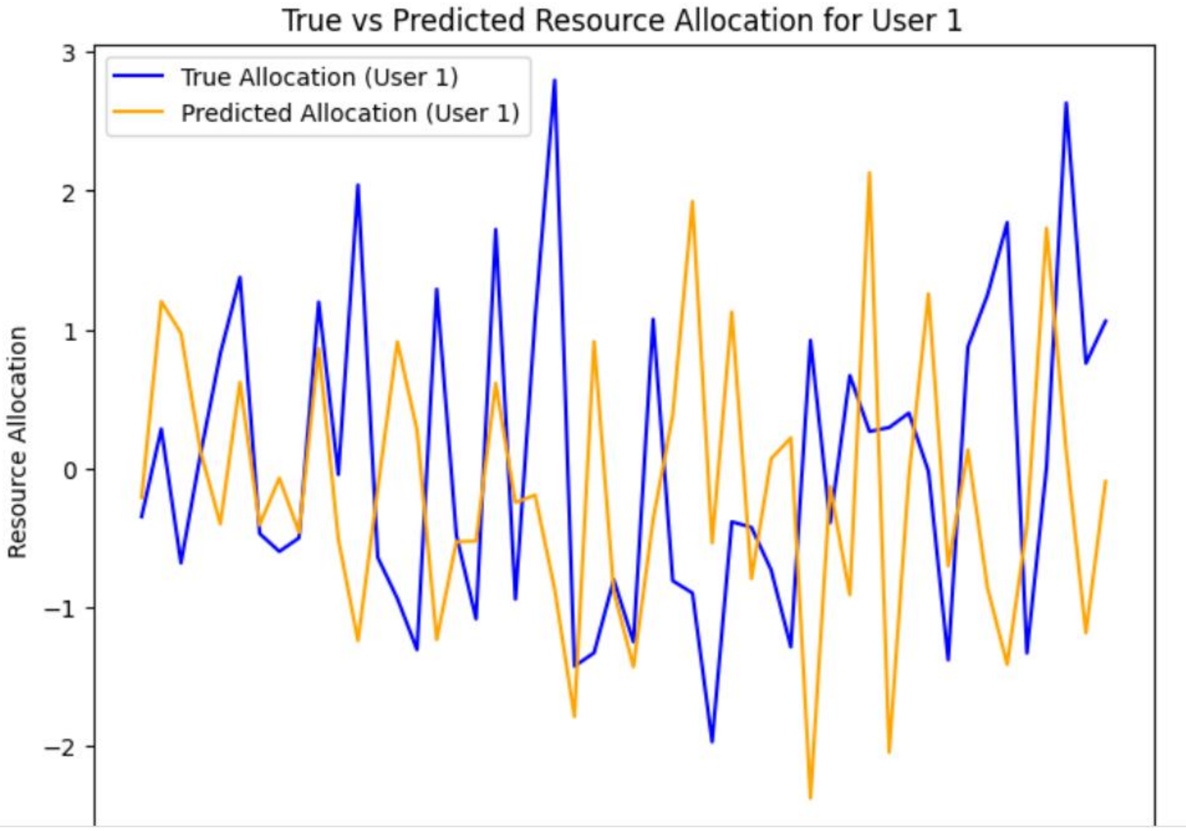
4.1 Training Loss Over Epochs

The model's performance improved over epochs, as shown in the training loss plot. The loss decreased consistently, indicating that the model was learning effectively during training. (For a Total of 50 epochs)

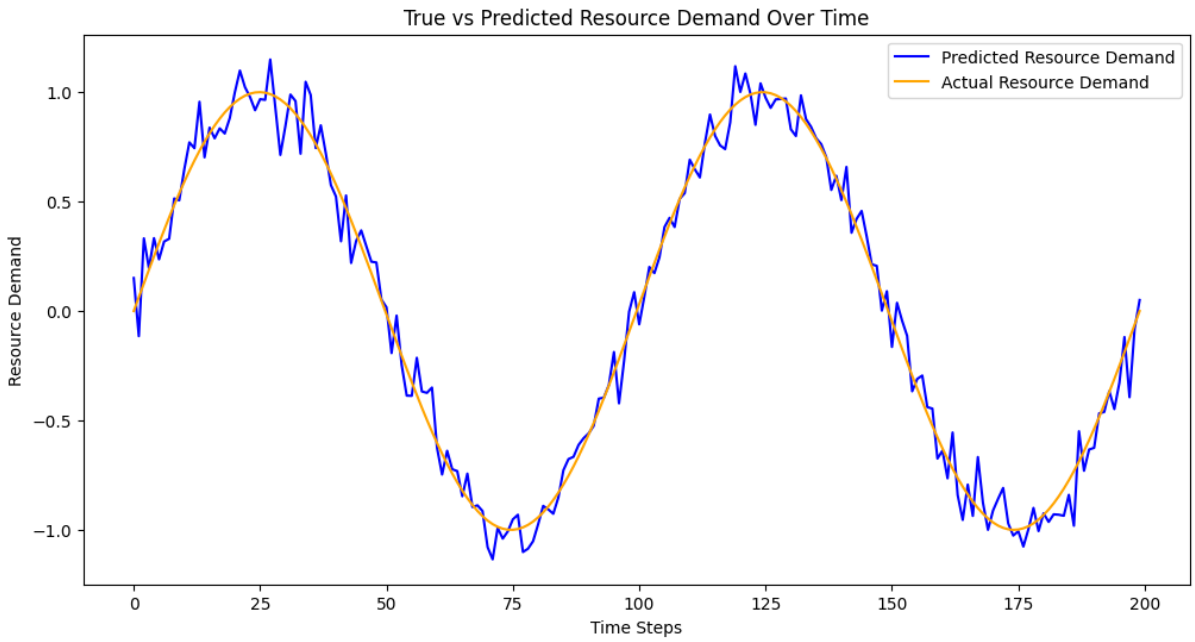


4.2 True vs Predicted Resource Demand

To evaluate the model's performance on the test data, we compared the predicted resource demand with the actual demand over time. Figure shows that the predicted demand closely follows the trend of the actual demand, indicating that the RNN model was able to capture the underlying patterns effectively.



True vs Predicted Resource Allocation for User 1
True Allocation (User 1)
Predicted Allocation (User 1)
Resource Allocation
3
2
1
0
−1
−2



True vs Predicted Resource Demand Over Time
Predicted Resource Demand
Actual Resource Demand
Resource Demand
1.0
0.5
0.0
−0.5
−1.0
0
25
50
75
100
125
150
175
200
Time Steps

5. Conclusion:

In this project, we successfully implemented an RNN-based model for resource allocation in a wireless network. The model was able to learn from past network conditions and predict future resource demands effectively. The results suggest that RNNs can be valuable tools for dynamic resource allocation in wireless networks. Future work may involve expanding the model to include additional network conditions and testing it on real-world data.

6. References:

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[3] **Kumar, V., & Kumar, A. (2020).** "Deep learning-based resource allocation in smart grid." IEEE Transactions on Smart Grid.

[4] **Zhao, Z., & Xu, W. (2020).** "RNN-based intelligent resource allocation for IoT applications." Journal of Network and Computer Applications.