TRAFFIC CONGESTION MODEL

Impact of Batch Normalization:

Batch Normalization improved all gradient descent methods by stabilizing training, reducing internal covariate shift, and enabling faster convergence. Mini-batch benefits from improved accuracy and generalization, while batch GD gains stability and higher learning rates. For SGD, BN significantly smooths updates, reducing variance and improving accuracy despite its noisy nature.

Role of Auto encoders:

Autoencoders played a key role in reducing 25 features to 12 while preserving essential information. In training, they effectively minimized loss, improving data efficiency. This dimensionality reduction helped in capturing important patterns, making the dataset more suitable for tasks like classification and clustering, ultimately enhancing model performance and insights.

Summary Report on Gradient Descent Methods

1. Mini-Batch Gradient Descent

- **Accuracy:** 0.8685
- **Precision:** 0.8798
- **Recall:** 0.8669
- **F1 Score:** 0.8692
- **Observation:** Mini-batch gradient descent achieves a high accuracy and the best precision among the three methods. It balances computational efficiency with convergence stability by updating the model using small batches of data.

2. Batch Gradient Descent

- **Accuracy:** 0.8685
- **Precision:** 0.8708
- **Recall:** 0.8700
- **F1 Score:** 0.8690

- **Observation:** Batch gradient descent shows similar accuracy to mini-batch but has slightly lower precision. It is more stable but computationally expensive due to using the entire dataset in each update.

3. Stochastic Gradient Descent

- **Accuracy:** 0.8204
- **Precision:** 0.8462
- **Recall:** 0.8176
- **F1 Score:** 0.8191
- **Observation:** Stochastic gradient descent has the lowest accuracy and F1 score, indicating less stable convergence. However, it is computationally faster and more suitable for large datasets, despite its higher variance in updates.