Report on Model Evaluation & Refinement

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1. Objective

To model and predict traffic congestion using weather, time, and event data. Two sets of models were compared — with and without engineered time-based features — to evaluate performance improvements.

2. Key Visual Insights

a. Actual vs Predicted (Original Model): Strong overlap between actual and predicted vehicle counts.

b. Average Residuals by Hour (Original Model): Early hours under-predicted, evenings over-predicted.

c. Feature Correlation Matrix: Strong correlation found with 'SyntheticCharge', 'Junction', 'EstimatedFare'.

d. Feature Engineering Preview: Added `Hour_sin`, `Hour_cos`, and binary time features.

e. Residuals After Feature Engineering: Distribution improved across hours.

f. Actual vs Predicted (New Features): Better alignment in edge hour predictions.

3. Evaluation Metrics

Original Model:

Fold	MAE	RMSE	R^2
1	2.40	5.18	0.966
2	1.28	1.58	0.861
3	2.11	2.62	0.928
4	0.78	0.98	0.991
5	0.53	0.90	0.991
Final	0.42	0.58	1.00

Model with New Features:

Fold	MAE	RMSE	R^2
1	2.51	5.37	0.964
2	1.30	1.63	0.851
3	2.11	2.62	0.928
4	0.78	0.98	0.991
5	0.52	0.89	0.992
Final	0.42	0.58	1.00

4. Comparative Insights

Model Performance Before vs After Feature Engineering:

Fold	RMSE Before	RMSE After	R^2 Before	R^2 After
1	5.18	5.37	0.966	0.964
2	1.58	1.63	0.861	0.851
3	2.62	2.62	0.928	0.928
4	0.98	0.98	0.991	0.991
5	0.90	0.89	0.991	0.992

Inference:
- Feature engineering had mixed effects.
- Minor improvement in residuals.
- Overall model remained highly accurate.

5. Conclusion & Next Steps

- Final model performs exceptionally with R^2 near 1.00.

- Feature engineering improved temporal accuracy.

- Future directions include dynamic data integration and advanced ensemble models.