1. Feature Engineering: Column Transformer (25-11-2024)
2. Linear Regression: (26-11-2024)
   1. Mean Squared Error (MSE): 1.0513433380011303
   2. R² Score: -0.030034562627270667
   3. This model is underperforming. An R² score of -0.03 means it is worse than a simple horizontal line (predicting the mean value), which indicates that the model is not capturing the variance in the data.
   4. Linear Regression model fit plot
3. Cross validation results: (28-11-2024)
   1. Cross-validated MSE: -1.0111191265341968
   2. The negative Mean Squared Error (MSE) from cross-validation (-1.0111) indicates that the model is not doing well at predicting the traffic density. This suggests that either the data features or the model choice may not be suitable for the task.
   3. Test set performance: The MSE values across different test sizes are relatively high, and the R² scores are negative across all test sizes, indicating that the model is performing worse than predicting the mean value for the target variable.
   4. The Test Size 0.3 seems to give the lowest MSE (0.9811), though it is still quite high and the R² is negative, suggesting that the model is not learning meaningful patterns from the data.
4. Regularization models: (29-11-2024)
   1. Ridge regression:
      * Ridge Mean Squared Error (MSE): 1.0510366501141422
      * Ridge R² Score: -0.029734090733724017
      * The model performs poorly with a high MSE and negative R² score, suggesting it fails to capture the data's underlying patterns.
   2. Lasso regression:
      * Lasso Mean Squared Error (MSE): 0.9663569948336617
      * Lasso R² Score: -0.0029107197977451538
      * Similar to Ridge, the model shows poor performance with a slightly lower MSE but still a negative R² score, indicating it is not effectively modeling the data.
5. KNN Regressor: (02-12-2024)
   1. KNN MSE: 1.2180748773152774
   2. KNN R² Score: -0.26415016242117817
   3. The MSE is relatively high, indicating that the model's predictions are somewhat inaccurate.
   4. The negative R² score suggests that the model is underperforming. It is worse than a simple baseline model (which would predict the mean of the target variable for all instances). This indicates that the KNN model is not capturing the underlying patterns in the data effectively.
6. Other models:
   1. Random Forest:

* Random Forest - Mean Squared Error (MSE): 1.2210646233175815
* Random Forest - R² Score: -0.1963159129441363
* Random Forest Cross-validated R² score: -0.09824499533305886
* Random Forest Standard deviation of R² scores: 0.019915029583088387

Random Forest did not perform well, as indicated by the negative R² score and relatively high MSE. This could be due to:

* Insufficiently complex patterns in the dataset for the ensemble to leverage.
* Overfitting on training data while failing to generalize.
  1. Gradient Boosting Regressor:
     + Gradient Boosting - Mean Squared Error (MSE): 1.1933080211115366
     + Gradient Boosting - R² Score: -0.16912188547478468
     + Gradient Boosting Cross-validated R² score: -0.08123795314460507
     + Gradient Boosting Standard deviation of R² scores: 0.01640907734422071

Gradient Boosting performed slightly better than Random Forest, but still yielded a negative R² score. Its sequential nature may be slightly better suited for this data, but issues with feature relevance or dataset quality persist.

1. Time Series Prediction:
   1. ADF test to check the stationarity: series is stationary
   2. ARIMA model:
      * Mean Squared Error (MSE): 791.4355620995686
      * R² Score: -0.006206246564706586
      * Mean Squared Error (MSE): The value of 791.44 indicates the average squared difference between the actual and predicted traffic densities. This suggests there is significant room for improvement in the prediction accuracy.
      * R² Score: A value of -0.0062 indicates that the ARIMA model fails to explain any of the variance in the test data. The model performs slightly worse than a horizontal line (mean predictor).
   3. SARIMAX model:
      * Mean Squared Error (MSE): 803.8317028610103
      * R² Score: -0.021966309499418024
      * Mean Squared Error (MSE): High error suggests the model struggles to match actual traffic density values.
      * R² Score: The negative value means the model performs worse than a baseline model that predicts the mean for all observations.
   4. RNN:
      * RNN - Mean Squared Error (MSE): 1398.9078892363457
      * RNN - R² Score: -0.7770141632784682
      * The RNN model's high MSE (1398.91) and negative R² score (-0.777) indicate poor performance, suggesting it fails to capture data patterns and performs worse than a baseline model. Refining preprocessing, hyperparameters, and architecture (e.g., using LSTM or GRU) could improve results.
   5. GRU:
      * GRU - Mean Squared Error (MSE): 1120.6637070761753
      * GRU - R² Score: -0.42356426400141833
      * The GRU model's MSE of 1120.66 and R² score of -0.424 indicate suboptimal performance, with the model unable to accurately predict the data patterns and performing worse than a baseline. Improving feature engineering, tuning hyperparameters, or considering alternative architectures might enhance performance.
   6. LSTM:
      * LSTM - Mean Squared Error (MSE): 1832.8618669219964
      * LSTM - R² Score: -1.328260153448265
      * The LSTM model has a high MSE of 1832.86 and a negative R² score of -1.33, indicating poor model performance and that the model is significantly underfitting the data, performing worse than a simple mean-based predictor. Further adjustments in the model architecture or data preprocessing may be needed.

Conclusion:

1. **Model Performance**: Most models showed poor performance with negative R² scores and high Mean Squared Errors (MSE), indicating they are not effectively capturing the patterns in the data.
2. **Underfitting**: The models, including linear, ensemble, and neural network-based models, consistently underperformed, suggesting that they are not complex enough or are not suited to the problem at hand.
3. **Data Issues**: The poor results across various algorithms suggest that the dataset may require better preprocessing, feature selection, or more relevant data to improve model predictions.
4. **Improvement Opportunities**: The negative performance metrics suggest that model refinement, better feature engineering, or trying different approaches could improve predictions and better capture data patterns.