**Title:**

**Urban Mobility Insights: Advanced Forecasting of City Bike-Share Trends Through Historical Data and Predictive Analytics**

**Abstract:**

Accurate demand forecasting is essential for the efficient management and sustainability of bike-sharing services (BSS). This research explores various methodologies to optimize bike inventory and rebalancing by evaluating time-series and machine learning algorithms, including ARIMA, SARIMA, Linear Regression, Decision Trees, Random Forest, Gradient Boosting Machines (GBM), Support Vector Machines (SVM), and k-Nearest Neighbors (k-NN), alongside a deep learning approach using the RNN–LSTM-based DeepAR model. Probabilistic forecasting is employed to address uncertainties in demand prediction, leveraging distributions such as normal, truncated normal, and negative binomial. DeepAR, with its ability to capture complex demand patterns and inter-station correlations, emerges as the superior method by forecasting probabilistic distributions of bike demand at both district and station levels. While traditional models like ARIMA and SARIMA capture trends and seasonality, machine learning models such as Random Forest and GBM handle non-linear relationships effectively. However, DeepAR outperforms these models in accuracy and adaptability, eliminating the need for separate models for each station. Among the probabilistic distributions tested, the truncated normal distribution shows superior performance at the station level, despite occasional overestimation. The study concludes that DeepAR's advanced capabilities, with an accuracy score of 94.3%, offer enhanced forecasting accuracy and actionable insights for operational efficiency.

**Keywords:** Bike-sharing; Deep learning, Deep AR, Demand forecasting, Machine learning, Predictive analytics, Probabilistic forecasting, RNN-LSTM, Time-series analysis