

Using a Machine Learning Approach to Develop a Macroscopic Passenger Flow Model for Departure Passengers at an Airport Terminal

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Abstract

Effective passenger flow management is a cornerstone of airport terminal operations, directly impacting service quality, resource allocation, and traveller satisfaction. As global air traffic demand continues to grow, airport systems must contend with increasingly complex, dynamic, and high-volume environments. Traditional modelling methods—such as queuing theory, regression models, and discrete event simulation (DES)—have provided valuable frameworks for analysing terminal processes. However, these methods often struggle to deliver scalable, flexible, and real-time solutions required for modern operational decision-making. In particular, simulation-based approaches, while robust, are computationally intensive and often impractical for day-to-day operational use. This study introduces a hybrid methodology that integrates discrete event simulation with machine learning to develop a macroscopic passenger flow model focused on departure processes. The aim is to provide a predictive, data-driven framework capable of capturing the temporal and behavioural complexity of passenger movement through an airport terminal. The research begins with an extensive literature review to identify the key determinants of congestion and flow disruptions. These include temporal arrival patterns, check-in modalities (e.g., counter, kiosk, online), counter allocation strategies, processing times, and passenger characteristics such as group size and baggage quantity. A comprehensive DES model was developed using Simio software, simulating the full departure journey—from curb side check-in to security clearance at the boarding gate. Grounded in empirical data collected from Bandaranaike International Airport, Sri Lanka, this simulation replicates realistic system behaviour and serves as a high-fidelity synthetic data generator. This approach overcomes a common limitation in aviation analytics: the lack of consistent, large-scale real-world datasets. The synthetic data generated through DES was used to train and evaluate machine learning algorithms, with a focus on forecasting short-term fluctuations in passenger flow and terminal congestion. Among the models tested with a sample data set, Long Short-Term Memory (LSTM) networks outperformed both Support Vector Regression (SVR) and Random Forest (RF) in terms of predictive accuracy, generalization capability, and robustness against overfitting. The LSTM model achieved the lowest mean squared error and root mean squared error, demonstrating strong potential for operational deployment. The proposed DES-ML framework offers a scalable, interpretable, and efficient solution for airport stakeholders. It enables near real-time delay prediction and flow estimation, supporting more agile resource planning and enhancing passenger service levels. Moreover, the modular nature of the framework allows for adaptation to varying airport configurations and operational policies. In conclusion, this research demonstrates the value of integrating simulation and machine learning to develop a macroscopic, predictive passenger flow model that bridges the gap between high-fidelity analysis and real-world applicability. The hybrid model not only

advances academic understanding of terminal dynamics but also provides a practical decision-support tool for improving operational performance in airport environments.

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