

ABSTRACT

This study proposes a Multi-Output Convolutional Neural Network (CNN) with skip connections to simultaneously predict Bestselling Rank classification (Low/Mid/Best) and continuous Demand regression from 13 clean independent retail input features. The model is implemented in MATLAB R2022b and evaluated on a dataset of 76,000 daily store-product-day observations from five retail stores across four geographic regions (January 2022 to January 2024). To prevent data leakage, TotalPerformance and Weather Condition are excluded from all model inputs. Through systematic five-experiment pixel pattern optimization, the optimal Experiment 5B configuration (pixel = [3,6,9; 4,7,10; 2,13,14], regression loss weight $\lambda = 0.7$) achieves a Bestselling Rank classification accuracy of 99.26% and a Demand Relative RMSE of 11.02% (RMSE = 11.05 unit/day against mean actual demand of 100.28 unit/day) on the held-out test set of 15,200 observations. The key discovery is that the Epidemic variable (Pearson $r = +0.761$ with Demand), absent in Experiments 1–4, is the second-highest demand-correlated feature and its inclusion in Experiment 5B produces the largest single performance improvement. Model outputs are translated into actionable inventory replenishment recommendations using a 90% service level framework.

Keywords: Convolutional Neural Network; Multi-Output Learning; Retail Demand Forecasting; Bestselling Rank Classification; Skip Connection; Pixel Pattern; Inventory Management