2nd INTERNATIONAL CONFERENCE ON
Artificial Intelligence
31 May - 1 June 2026

IICAI
Second International Interdisciplinary Conference on Artificial Intelligence

Hybrid Machine Learning and Deep Learning Approach for Minimum Airfare Prediction

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Abstract

Airfare prediction is a complex challenge driven by dynamic pricing mechanisms, limited real-time visibility, and nonlinear demand–supply interactions. This research focuses on Minimum Fare Prediction, specifically forecasting the lowest price a route will reach over the next three days to help travelers decide whether to purchase immediately or wait. The study proposes a hybrid framework that integrates gradient-boosted tree ensembles, such as XGBoost, with deep temporal architectures including 1D-CNN and LSTM networks. Using a massive proprietary dataset of 49.7 million records from Pateh.com, the models utilize 20 engineered features, including lagged fares and rolling 3-day minima. To measure practical success, a novel Regression Weighted Accuracy (RWA) metric is introduced, rewarding predictions within a 10% tolerance band. Results show the CNN→LSTM hybrid outperforms standard baselines, achieving up to 0.60 RWA on high-traffic routes. The system is currently being A/B tested in a production environment.

Research method

The researchers developed a unified pipeline using 20 engineered features, including lagged fares and rolling 3-day minimum prices.

Models: The framework integrates XGBoost, Histogram Gradient Boosting, 1D-CNN, and LSTM.

Hybrid Architecture: A CNN→LSTM model was designed to extract local patterns (via CNN) and model long-range temporal dependencies (via LSTM) .

Evaluation: Models were tested using a 12-fold time-series cross-validation scheme. Accuracy was measured by RWA, which rewards predictions within a 10% band of the actual minimum fare.

conclusion

The hybrid CNN→LSTM approach proves superior for dynamic pricing tasks by combining local feature extraction with sequence memory. The study confirms that incorporating lagged signals and rolling minima is critical for predictive power. Future enhancements will include integrating competitor prices and macroeconomic indicators to further refine accuracy. This work demonstrates a successful transition from theoretical modeling to a large-scale production environment.

The purpose of the research

The study addresses the common traveler's dilemma: whether to purchase a ticket immediately or wait for a price drop. Existing methods often rely on small datasets or metrics like RMSE that do not reflect the actual user experience of overpaying. The primary purpose is to:

Provide actionable guidance for users on online travel agencies (OTAs).

Bridge the gap in existing literature regarding dataset scale and shallow temporal modeling .

Introduce an evaluation metric, Regression Weighted Accuracy (RWA), that aligns with practical price tolerance.

Practical or simulation results

The models were evaluated on high-traffic routes, such as IFN–DXB.

Performance: The CNN→LSTM hybrid (AI Assistant) achieved the highest performance with an RWA of 0.55, significantly outperforming k-nearest neighbors (0.30) and XGBoost (0.32) .

Scalability: On selected high-traffic routes, the model reached RWA scores of up to 0.60.

Implementation: The system is currently being A/B tested in Pateh’s production environment to provide real-time recommendations.

References

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