25ARAM

Poster 948

Neural Network Prediction of Airport Arrival and Departure Capacity

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Introduction

This poster describes the development of predictive models for Airport Acceptance Rate (AAR) and Airport Departure Rate (ADR) capacity: hourly limits on how many aircraft can arrive or depart an airport, respectively. Incorporated into a real-time decision support system, these forecasts allow airline dispatchers to proactively mitigate potential disruptions.

Data

Predictand: Inferred AAR & ADR

In contrast to previous studies based on historical "called" AAR and ADR capacity from the National Traffic Management Log, we objectively identify cases of near-capacity or degraded capacity operations from historical arrival and departure data from 99 airports in the US, Canada and Mexico for training and evaluation. Degraded capacity cases are those well below the usual level of traffic.

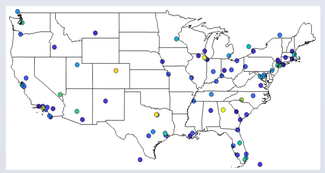

Figure 1: Near-CONUS airports used. Warmer colors denote higher capacity.

Predictors: TWC Forecast on Demand

We utilize a historical archive of FoD point forecasts at airport locations. FoD is TWC's automated, on demand consensus forecast with a Human Over the Loop workflow. Temporal, weather forecast and derived predictors used in the study are shown in the table below.

Ceiling	QPF Snow
Cloud cover	Relative Humidity
cos(DayOfYear)	Scattered CBH
DayOfWeek	Temperature
Dewpoint	UV Index
Dewpoint Depression	Visibility
iconCode	Wind Dir Delta
PrecipProb	Wind Direction
Pressure MSL	Wind Gust
QPF	Wind Speed
QPF Ice	Wx Severity

Approach

We used the MATLAB Deep Learning toolbox to train a neural network model, selecting 3 hidden layers (128, 64 and 32 nodes) based on hyperparameter tuning. The model is exported in ONNX for real-time operational implementation.

We used transfer learning, training first on all airports and then fine tuning for target airports.

The model was trained on forecast lead times of 1, 2 and 3 hours, but applied to all lead times.

Data Analysis

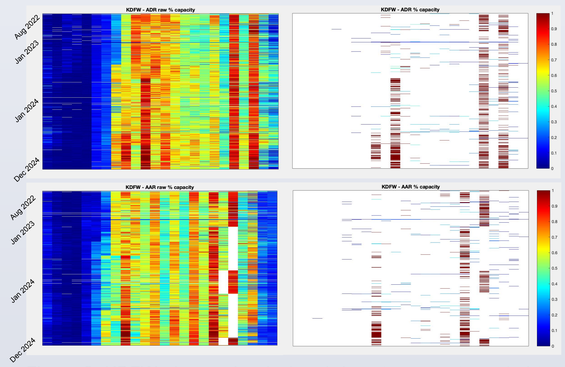

Figure 2: KDFW observed arrival and departure counts scaled to % capacity, shown per day (y-axis) and local hour (x-axis), with legend to the right. (top) ADR and (bottom) AAR; (left) unfiltered and (right) filtered values used for training and evaluation.

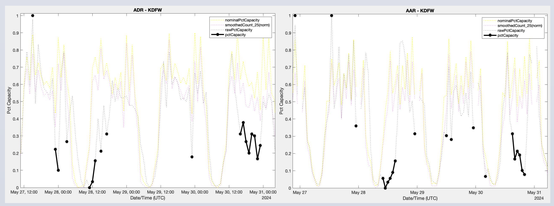

Figure 3: Sample KDFW timeseries for ADR (left) and AAR (right), May 27 - 31, 2024. The dark black dots represent filtered values identified as either full or degraded capacity.

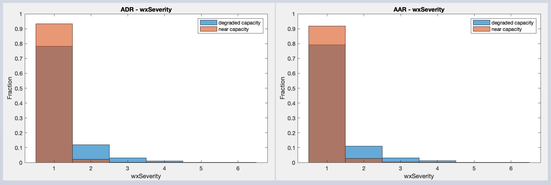

Figure 4: Conditional histograms showing the distribution of filtered % capacity values for degraded (blue) or near capacity (red) as a function of wxSeverity for (left) ADR and (right) ADR.

Maverick Beta Display

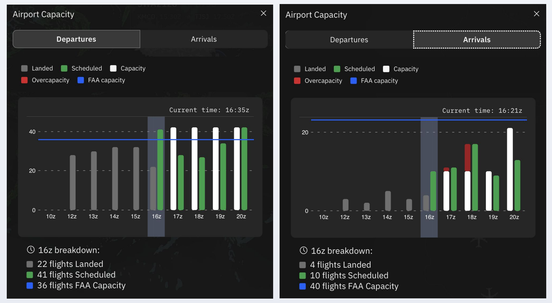

Figure 5: Live beta display for KLGA ADR (left) and KPDX AAR (right), 15 January 2025

Evaluation

We trained on August 2022 – December 2023, then scored it on data from 2024.

RMSE and MAE units are % of airport capacity. Max CSI and AUC are for discriminating degradation of airport capacity below 85%.

Departure Capacity (ADR)

Airport	RMSE	MAE	Max CSI	AUC
KATL	28%	13%	0.24	0.82
KORD	28%	12%	0.20	0.82
KDFW	28%	12%	0.32	0.82
KDEN	30%	12%	0.24	0.80
KCLT	31%	14%	0.34	0.87
KLAX	15%	3%	0.06	0.80
KLAS	29%	12%	0.22	0.76
KJFK	27%	12%	0.20	0.80
KMIA	27%	11%	0.26	0.82

Arrival Capacity (AAR)

Airport	RMSE	MAE	Max CSI	AUC
KATL	31%	13%	0.15	0.68
KORD	34%	16%	0.21	0.71
KDFW	35%	18%	0.46	0.82
KDEN	26%	10%	0.21	0.76
KCLT	35%	17%	0.32	0.62
KLAX	22%	6%	0.04	0.54
KLAS	26%	10%	0.14	0.62
KJFK	27%	10%	0.15	0.80
KMIA	30%	13%	0.25	0.74

Adding En-Route Data

TWC's Terminal Airspace Convection Risk product comprises 7-hour forecasts of arrival and departure gate impacts at 41 global airports.

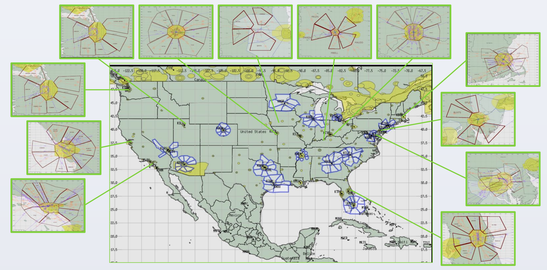

Figure 6: TrACR gates areas used for CONUS airports..

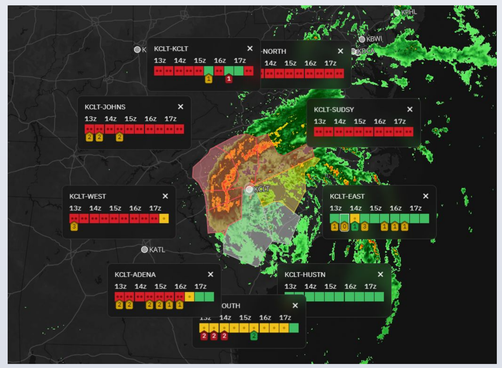

Figure 7: TrACR depiction for KCLT during Hurricane Helene.

Summary

We created neural network forecasts of hourly AAR and ADR based on observed airport arrival and departure counts collected between August 2022 and December 2024. Evaluation on an independent test dataset shows that ADR predictions generally score substantially better than AAR, likely because arriving flights are more sensitive to enroute weather not represented in the point location forecasts used as predictors. Future work will incorporate (1) enroute weather predictors from TWC's TrACR product, (2) runway configuration predictions, and (3) National Airspace System parameters reflecting non-local and non-weather factors.

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