

Predicting Arrival and Departure Runway Assignments with Machine Learning

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Arrival and departure runway assignments are made by controllers, considering airport configuration, direction of flight, aircraft size, etc.

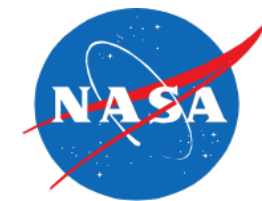
1. *Can we build a data-driven machine learning model to **predict** these runway assignments?*
 2. *Can we develop an approach to train models that uses limited adaptation data, and is readily applicable to multiple airports?*
- Limited amount of recent research related to these questions, but considerable literature on *optimizing* runway assignments
 - Difference is important – we're not trying to change current practice, just model existing controller decision heuristics

Why did we do this research?



- ATD-2 is a NASA project that:
 - Demonstrates Integrated Arrival / Departure / Surface concepts using a data processing and decision support tool
 - Uses an existing tool (STBO) that makes predictions using a rule-based, expert-driven approach
- These ML models developed as part of a project-wide effort to build an ML-powered shadow system to compare against fielded system
 - Airport configuration: ATOMS-16
 - Landing time: ATOMS-15
 - Taxi time: ATOMS-15

What data were used?



- Used Fuser developed for ATD-2: this merges data from various FAA SWIM feeds and other sources, creating convenient, easily-queried source
- **Target:** actual runway used, inferred from surveillance data

• **Features:**

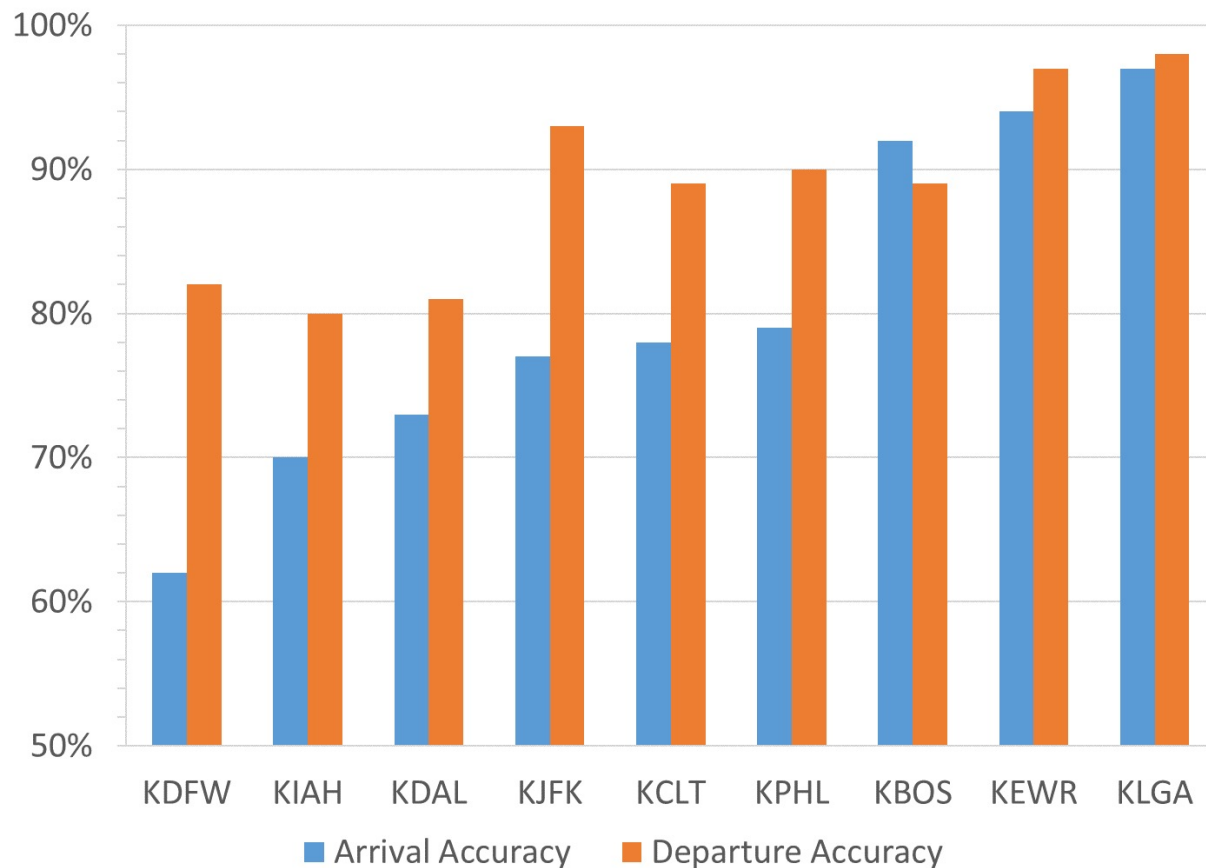
Name	Notes	Sample Value	Imputed?	Encoded?
Aircraft engine class	Limited variation	JET	✓	✓
Wake turbulence category	Proxy for aircraft size	B	✓	✓
Planned fix	As appears in TFMS	DARTZ		✓
Flight plan filed	If not, planned fix is a prediction from TFMS	TRUE	✓	✓
Airport configuration	From D-ATIS	D_17R_18L_A_13 R_17C_17L_18L		✓
Time since configuration change	From D-ATIS	3600 seconds		
Time until operation	Time between observation and estimated landing / takeoff	5400 seconds		
TBFM-assigned runway**	Often non-specific, only reliable at some airports	36R	✓	✓

** arrival runway models only

How well do the models perform?

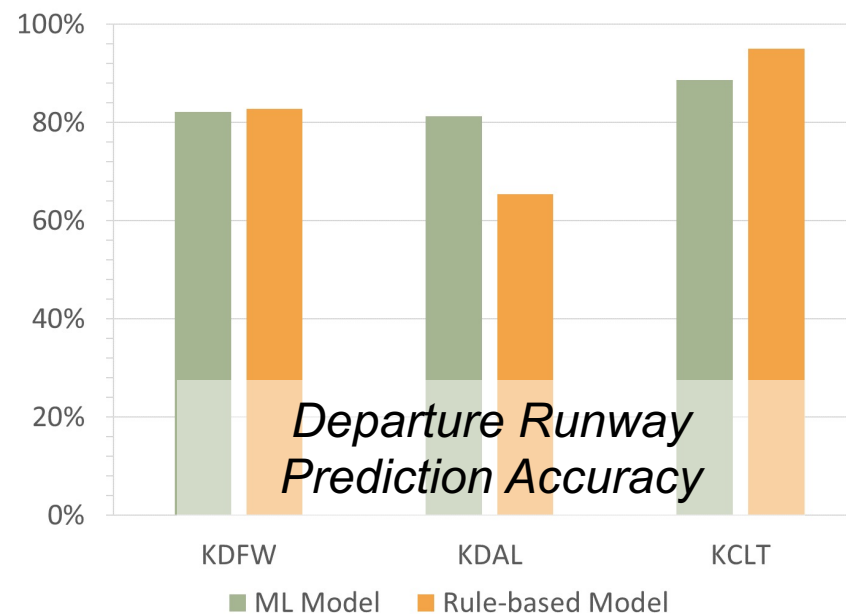
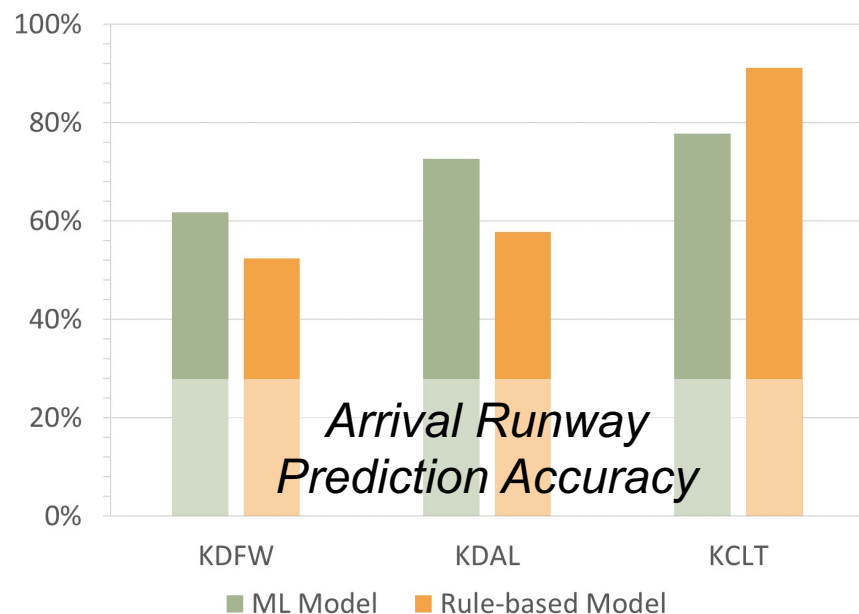


- Overall, models perform quite well



- Models trained using data from April – December 2020
 - These results are from models trained using XGBoost algorithm; other algorithms performed worse
 - These results reflect predictions for test dataset, which includes a variety of lookahead times
- *These issues / tradeoffs and more explored in detail in the paper!*

Important to compare to existing rule-based, expert-driven model:



- Existing rule-based model shows some better, some worse performance
- For project purposes, the performance of these ML models sufficient for operational need
- Importantly, these ML models can be retrained, or developed for other airports very easily – not so with the rule-based, expert-driven approach

Runway assignment prediction problem can be successfully addressed by ML

- Departure runway models show higher accuracy, suggesting this is more predictable, or some missing features may influence arrival assignments
- XGBoost algorithm produces great models
- Combination of open source tools including Fuser, scikit-learn, Kedro, and MLflow allowed research team to quickly train models for other airports
- Separate models trained on 2019 and 2020 had similar performance

 *As traffic recovers in 2021 and beyond, which model is most relevant for our live data? When is model retraining necessary?*