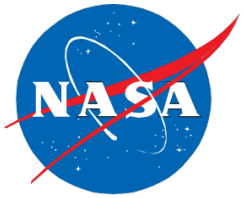

ATD-2 Integrated Arrival/ Departure/Surface (IADS) System

Machine Learning Services

Impeded Taxi In Time Prediction Model (ITIM)

Unimpeded Taxi In Time Prediction Model (UTIM)

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Table of Contents

Model Name

Two Taxi In models are summarized in this document:

- Impeded Taxi In Time Prediction (ITIM)
- Unimpeded Taxi In Time Prediction (UTIM)

Problem Statement

Impeded Taxi In

Accurate taxi time prediction is required for enabling efficient gate-in time prediction as well as any surface congestion based on long taxi in time. The ITIM model predicts the impeded duration of taxi time between the arrival landing, or "on" time, and the “in” time at the arrival stand. This model has been split into two sub-models:

- Impeded Active Movement Area (AMA) Taxi-in time prediction: predicts the impeded duration of time between an arrival’s landing, or “on” time, into the AMA and spot crossing time out of the AMA and into the ramp.
- Impeded Ramp Taxi-in time prediction: predicts the impeded duration of time between an arrival’s spot crossing time into the ramp and “in” time at the arrival stand.

Unimpeded Taxi In

Unimpeded taxi time prediction is required for enabling prediction of gate conflict at landing, as well as prediction of banks based on unimpeded taxi-in time (this may alert controllers that arrivals will need to be impeded). The UTIM model has been split into two sub-models:

- Unimpeded AMA Taxi-in time prediction: predicts the unimpeded duration of time between an arrival’s landing or “on” time into the AMA and spot crossing time out of the AMA and into the ramp
- Unimpeded Ramp Taxi-in time prediction: predicts the unimpeded duration of time between an arrival’s spot crossing time into the ramp and “in” time at the arrival stand.

Technical Approach

Impeded Taxi In

The ML algorithms used in the AMA Taxi-in and Ramp Taxi-in model predictions are Random Forest Regression and GradientBoostingRegressor respectively. Both algorithms are ensemble learning methods. Both sub-models are trained to produce predictions at the time of landing. These models are varying with time; the time-varying inputs are the counts of flights on the surface and whether or not the flight’s gate is occupied (at landing).

Unimpeded Taxi In

The ML algorithms used in the AMA Taxi-in and Ramp Taxi-in models are XGBRegressor and GradientBoostingRegressor respectively. Both algorithms are ensemble learning methods, GradientBoostingRegressor is tuned as a quantile regressor to fit the 20th percentile.

Model Features

Impeded Taxi In

Feature	Description	Sample Value
Arrival runway	Runway ID	17L
Arrival stand	Stand ID	E7
Carrier	Carrier (airline) ID	AAL
Aircraft type	Mapping from specific aircraft to class	WB
Gate occupied at landing	Calculated for each gate as: recent arrival time >= recent departure time	True
arr_runway_AMA_count	Estimated count of arrivals in the AMA	20
dep_AMA_runway_count	Estimated count of departures in the AMA	19
AMA_gate_count	Estimated count of arrivals in the ramp area	15
dep_stand_AMA_count	Estimated count of departures in the ramp area	20
Total flights on surface	Sum of arrival and departure counts in AMA and ramp areas	23

Unimpeded Taxi In

Feature	Description	Sample Value
Arrival runway	Runway ID	17L
Arrival stand	Stand ID	E7
Carrier	Carrier (airline) ID	AAL

Model Inputs & Outputs

See OpenAPI specification in the appendix.

Data Sets

The model train/test dataset for all Taxi In models was extracted from a fused dataset of the TFMS and TBFM feeds. Features were derived from these data sources.

The data used for training/testing was split such that 20% of the data was used for the testing sample. If the testing sample start time is identified, then all samples from flights that landed on those dates became test samples. Otherwise, test samples are randomly selected. The data collected for different airports spans the following time ranges:

Airport	Start date	End date
KCLT	2020-08-01	2020-12-31
KJFK	2020-05-01	2021-01-01
KDFW	2020-08-01	2020-12-31

Model Results / Evaluation

Impeded Taxi In

Active Movement Area

Airport	Mean Absolute Percent Error: Training Dataset	Mean Absolute Percent Error: Test Dataset
KCLT	25	27.6
KJFK	15.1	17.0
KDAL	Dummy Model	
KDFW	14.8	16.4

Ramp

Airport	Mean Absolute Percent Error: Training Dataset	Mean Absolute Percent Error: Test Dataset
KCLT	42.8	49.8
KJFK	59.7	71.1
KDFW	79.5	81.3

Unimpeded Taxi In

Active Movement Area

Airport	Mean Absolute Percent Error: Training Dataset	Mean Absolute Percent Error: Test Dataset
KCLT	13.2	15.9
KJFK	11.4	13.9
KDFW	10.9	11.8

Ramp

Airport	Tilted Loss: Training Dataset	Tilted Loss: Test Dataset	Fraction Less than Actual: Train Dataset	Fraction Less than Actual: Test Dataset
KCLT	30.9	31.8	0.80	0.78
KJFK	19.7	16.0	0.78	0.84
KDFW	17.6	18.6	0.79	0.79

Open Source Repository

https://github.com/nasa/ML-airport-taxi-in

Appendix: OpenAPI Specification

Explore

Taxi In OVC Client

1.0.0-dev19 OAS3

Taxi In OVC Client

Servers

http://localhost:9099/ - Taxi In OVC Client

Computed URL: `http://localhost:9099/`

Server variables

port 9099

default

POST /unimpeded/ramp/taxi-in

POST /unimpeded/ama/taxi-in

POST /impeded/ramp/taxi-in

POST /impeded/ama/taxi-in

Schemas

ImpededTaxiInRequest

```
{
    airport*        string
                    example: KDFW

                    airport name

    flights*
                        [...]
}
```

ImpededTaxiInRequestFlight {

```
aircraftType           string
                       example: CRJ7
                       nullable: true

                       carrier name

arrivalCountsInAma     integer($int32)
                       example: 16
                       nullable: true

                       arrival counts in ama

arrivalCountsInRamp    integer($int32)
                       example: 1
                       nullable: true

                       arrival counts in ramp

arrivalRunway          string
                       example: 17C
                       nullable: true

                       arrival runway actual

arrivalStand           string
                       example: C17
                       nullable: true

                       arrival stand actual

carrier                string
                       example: AAL
                       nullable: true

                       carrier name

departureCountsInAma   integer($int32)
                       example: 11
                       nullable: true

                       departure counts in ama

departureCountsInRamp  integer($int32)
                       example: 18
                       nullable: true

                       departure counts in ramp

gateOccupiedAtLanding  boolean
                       default: false
                       example: false

                       gate occupied at landing

gufi                   string
                       example: ABC123.CLT.MEX
                       nullable: true

                       gufi

totalFlightsOnSurface  integer($int32)
                       example: 1
                       nullable: true

                       total flights on surface
```

}

TaxiInResponse {

airport* string
example: KDFW

airport name

flights* [...]

}

TaxiInResponseFlight {

error* string
example: ABC123.CLT.MEX

error description

gufi* string
example: ABC123.CLT.MEX

gufi

pred* number($float)
example: 304.0

taxi in prediction value

}

UnimpededTaxiInRequest {

airport* string
example: KDFW

airport name

flights* [...]

}

UnimpededTaxiInRequestFlight {

arrivalRunway	string *example: 17C* *nullable: true* arrival runway actual
arrivalStand	string *example: C17* *nullable: true* arrival stand actual
carrier	string *example: AAL* *nullable: true* carrier name
gufi	string *example: ABC123.CLT.MEX* *nullable: true* gufi

}