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A Tree-based Machine Learning Model for Go-around Detection and Prediction

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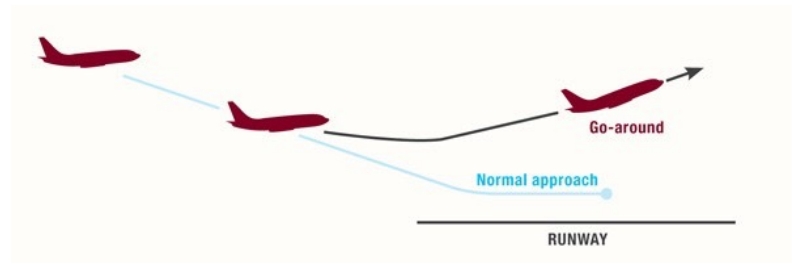


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Introduction: Go-around

- Go-around is a manoeuvre to abandon the approach to landing under unsafe conditions.
- Go-around may be due to several conditions such as unstable approach, unexpected appearance of hazards on the runway, wind shear, low clouds, problem of visibility, etc.



Research motivation

- Go-around is a safety critical manoeuvre:
 1. Last-minute instructions given by ATCs overload pilots; and
 2. Go-around manoeuvre increases the cognitive workload on controllers.

- Go-around manoeuvre challenges:
 1. The timely cooperation between the pilot and ATC is hard to establish; and
 2. Digitalization of airport control towers may bring more challenges in safely conducting go-around manoeuvres.

Research Objectives

- Objectives: Investigate new metrics that help in improving safety of air-side airport operations.
 - ➔ Couple the tower/remote control environment with alert systems that increase ATC situation awareness for more optimal, efficient, and safer operations.
 - ➔ A **data-driven approach** to assist ATC in **predicting and detecting** a go-around.
- Research Question: How a go-around can be **predicted** at an **early stage** in order to help both **ATC** and **pilot** to be **prepared**, to **cooperate**, and to ensure a **safe** and **efficient** go-around manoeuvre ?

Research Gaps

Specificity of the solution:

- All the previous works have proposed a specific solution for a single runway.

Prediction accuracy:

- Most of the go-around prediction models proposed in the literature possess a very low accuracy.

Data imbalance:

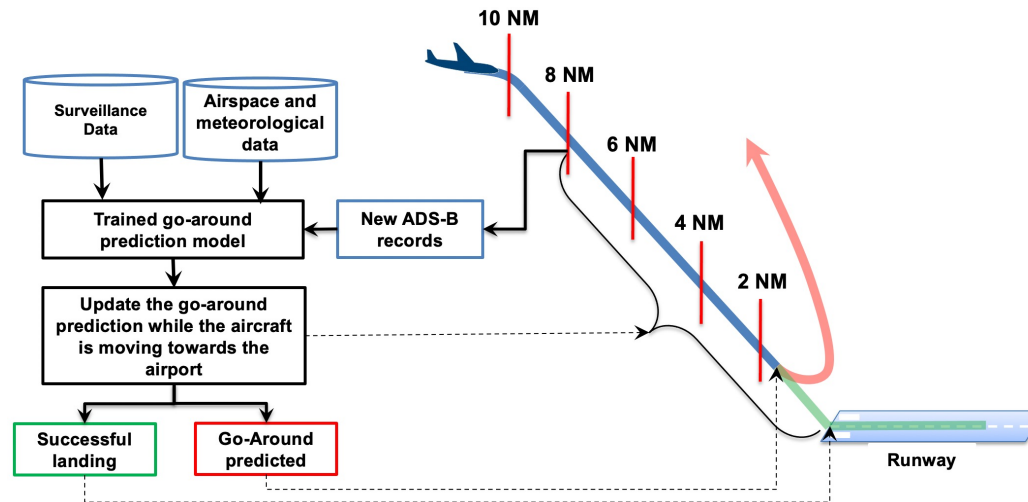
- Go-around is a rare-event.

Go-around trajectory labelling:

- Previous works use the altitude increase in the flight profile as the only criterion to identify a go-around.

Proposed Approach

- A machine learning prediction model for go-around events when an aircraft is in its final approach phase.

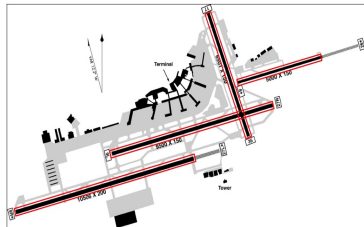


A data-driven prediction model of Go-Around event for an aircraft in its final approach phase.

Proposed Methodology

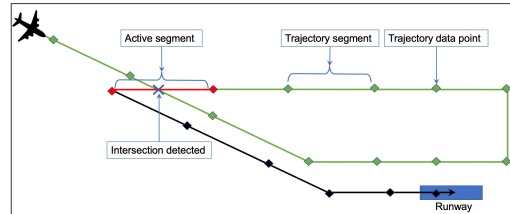
1- Data collection

- ADS-B flight data: Open-Sky Network.
- Ten months of flights to/from KPHL.
- METAR data.

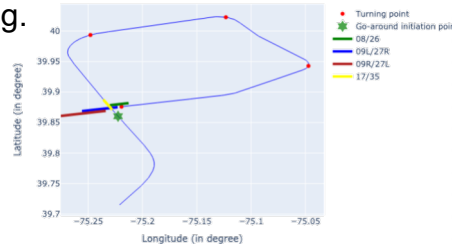


2- Go-around label identification

1. Altitude increase by more than 300 ft.
2. Flight 2D trajectory intersects with itself.



3. Change in the aircraft heading when the altitude increase is initiated, and at the final landing.



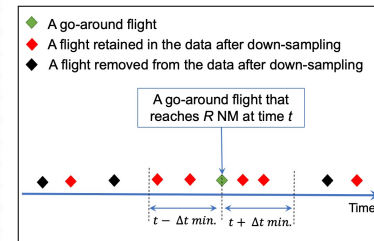
4. Compute the number of turning points.

3- Feature engineering

1. Flight information.
2. Flight parameters.
3. Flight landing performance metrics.
4. Airport performance metrics.
5. meteorological data.

4- Machine learning model

- Prediction model: eXtreme Gradient Boosting (XGBoost) classifier.
- A novel method of down- sampling.



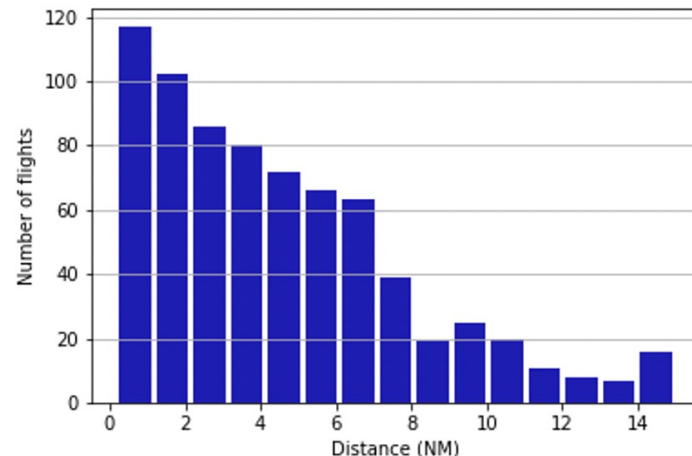
Computational Results

Go-around trajectory labeling

- ❖ **731 go-arounds** are identified, including **93** flight change their runway following a go-around.
- ❖ Only go-arounds initiated within 10 NM from the runway threshold are considered → **662 go-around**.
- ❖ The number of go-around accounts for **0.5%** of the total number of arrivals → Highly imbalanced dataset.

Machine learning model

- ❖ Data partition: 80 % training data and 20% test data.
- ❖ Three-fold cross-validation to determine the optimal parameters for each prediction model.



Distance between the go-around initiation point and the runway threshold, in NM.

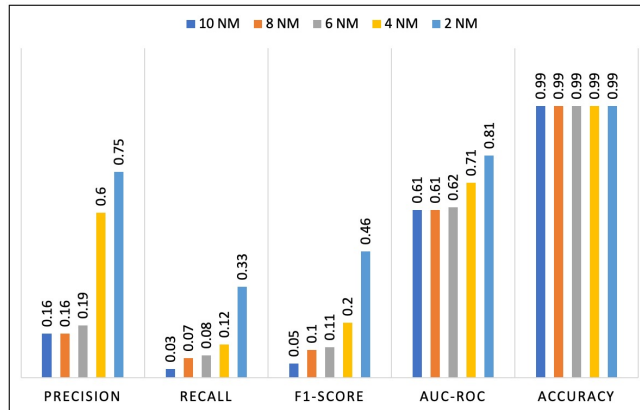
Radius	Full data-set		Down-sampled data-set	
	Nb. arrivals	Nb. go-around	Nb. arrivals	Nb. go-around
10 NM	132,118	662	5663	662
8 NM	132,073	617	5516	617
6 NM	131,965	509	5344	509
4 NM	131,825	369	4825	369
2 NM	131,662	206	3427	206

Data Demography

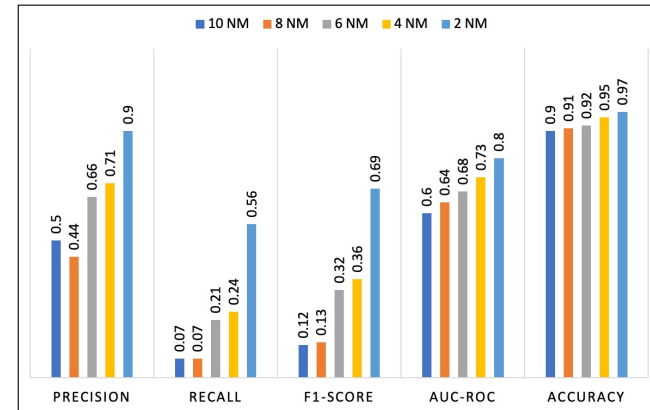
Computational Results

Prediction results

- The algorithm performance increases as the aircraft approaches the landing,
- The best results are recorded at 2 NM, and
- The system places higher priority to predicting a correct go-around (high precision) than to detecting a go-around (high recall).



With the full dataset, **33 %** of the go-arounds are detected with a **75 % correct alert rate**.



With the down-sampling technique, **half of the go-around** are detected, with **90 %** of the system go-around alerts are actual go-arounds.

Conclusions

Efficiency

- Detect half of flight go-arounds.

Accuracy

- 90 % of correct go-around system alerts.

Adaptability

- Applicable for the complete runway system.

Amendment

- Updated prediction in different radii.

Future works

Things to improve

- The decision to go-around may be due to several factors that are hard to be measured and/or collected, such as the pilot experience, personality, or his/her level of fatigue, etc;
- The visibility data provided in METAR is not accurate and does not provide the actual visibility level at the considered decision height; and
- The model lacks the airport surface movement data.

Future works

- Predict the safety level of an approach profile:
 - Reduce the impact of the pilot subjectivity on the prediction; and
 - Alleviate the data imbalance problem.

**THANK YOU FOR YOUR
ATTENTION**

