On the Statistics and Predictability of Go-Arounds

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1. Introduction

2. Data Presentation

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Missed-approach and Go-Arounds

Missed-approach or go-around: the aircraft aborts its landing and is forced, instead, to land on a subsequent approach.

- Go-around $\rightarrow$ Visual Flight Rules
- Missed-approach $\rightarrow$ Instrument Flight Rules

Causes for a missed-approach - Go Around (GA):

- For some reason, the pilot does not think it is safe to land the aircraft
- Visibility requirements at decision height are not met
- Air Traffic Control requests to go-around
Motivation

A GA is initiated when landing safety may be compromised

Impact of GAs:
- Reduction of landing capacity since one landing spot has been “waisted”
- Increased ATC workload to accommodate the aircraft that failed to land
- In dense operations, GAs are at the boundary of acceptable safety levels [1]
- GAs are costly for airlines: fuel burns and potential delays

Go-Around Detection

Sample trajectory with a go-around

(a) Trajectory

Go-around detection: 70 seconds of continuous increase in altitude, following 45 seconds of continuous descent.

(b) Vertical profile

About Go-Arounds
Go-Around Detection

Sample trajectory with a go-around

(a) Trajectory

Vertical profile

(b) Vertical profile

Go-around detection: 70 seconds of continuous increase in altitude, following 45 seconds of continuous descent.

Number of GA

About Go-Arounds
What is NextGen?

- On-going program to modernize the National Airspace System (NAS)

Some objectives:

- Accommodate future demand
- Avoid gridlock in the sky and at our nations airports.

Actors:

- Joint Program Development Office (JPDO), Federal Aviation Administration (FAA), NASA and many others
High-Density Operations

NextGen’s high-density operations:

- Increase throughput at major airports
- Envision Closely Spaced Parallel Approaches with delegated separation procedure

An understanding of the factors and conditions that lead to GAs is necessary to reduce their rate of occurrence and take full advantage of NextGen’s high-density operations.
Observed Factors Leading to GA

Interviews of controllers and traffic managers at SFO, BOS and LGA control towers suggests that:
- Pilot induced GA and weather related GA are infrequent
- GA are often the results of “operational errors”

Most likely factors that lead to GA at SFO
- Presence of another aircraft on the surface
- Unstable approach (too high, too low, too fast, late turn, etc)
- Windshear alerts
- TCAS alert (during parallel landings)
- Not enough time between consecutive landings
- Inadequate sequence
Merging and synchronization of 4 dataset spanning 4 years (2006 to 2009)

- Radar data from OAK. All traffic in a 45 nmi radius, 4.6 sec update rate
- ASPM flight data. For each flight, data on gate-in, gate-out, wheels-on, wheels-off, delays...
- ASPM airport. Weather information, runway configuration, (15 minute update rate)
- Aircraft type and size data base

Analysis focuses on SFO “West configuration”, which is used 80% of the time.

Creation of a state vector of the system with a 1 minute resolution.
System States

135 different states that include:

“Airspace” states

- # of ac, SFO, OAK, SJC inbound, outbound
- Landing rates, takeoff rates
- Average and variation for current and past 5, 10, 15 min
- Aircraft categories for takeoffs and landings
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“Ground” states
- # of ac taxiing in and out,
- Average and variation for current and past 5, 10, 15 min
- Estimated arrival and departure delays (time and number of ac)
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“Ground” states
- # of ac taxiing in and out,
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“Weather” states
- Wind speed, direction
- Visibility, ceiling
Using knowledge extracted from 4 years of data:

- Can we identify precursor factors that lead to go-arounds?
- Can we identify situation/airspace configurations with a higher likelihood of go-arounds?
- Can we predict sufficiently in advance when a go-around will occur?
Classification and Prediction Issues

- GAs are a rare occurrence:
  - 0.7% of fights in IFR conditions
  - 0.42% in VFR conditions
- Frequent from an ATC point of view, but rare from a machine learning point of view
- Data is non separable: No obvious difference between GA and nominal samples
- Some samples that are identical have two different labels

GA are the results of the chain of events, not an isolated event:
- Not seeking to predict only GA
- Come up with an “alert level” corresponding to conditions highly increasing the risk of GA
**Interesting Findings**

\[ \text{variation}(t) = \#ac(t) - \#ac(t - 15) \]

Variation of number of aircraft inbound to SFO and OAK
- The 15 min variation reflects the increase in workload for the air traffic controller
- Different controllers for ac inbound to SFO and OAK, and different routes

Results
- Variation in the number of inbound to SFO ac increases the probability of GA
- An increase in the number of ac inbound to OAK increases the probability of GA at SFO!!
An Alert System for GA using Linear Discriminant Analysis

- **Training (green curve)**
  - 120,000 randomly selected nominal samples
  - 40,000 nominal samples for each year (2006, 2007, 2008)
  - All GA from 2006 to 2008 (1500 GA)

- **Test (blue curve)**
  - All samples from 2009 (250,000+ samples)
  - Includes 500 GA

- **Increased probability (black dashed lines)**
  - 1x line = flipping a coin
  - 9x line = probability of GA is 9x higher during alert level than remaining of the time

**Alert level on test data:**
- Alert level “on” 15% (2h24/day) of the time captures 38% of GA
- Alert level “on” 40% (6h24/day) of the time captures 70% of GA
Conclusion

- Compilation of a large dataset:
  - 135 variables representing the airspace and ground operations as well as weather
  - 1 minute resolution
  - Publicly available: mgariel@mit.edu

- Further analysis of landing sequences presented in the paper

- Found a correlation between increase of inbound traffic to OAK and GAs at SFO

- The methods used were not able to identify GAs from nominal samples in a satisfactory manner (performance was not good enough to turn this research’s results into a useful tool)
Thank you

Questions?