Artificial Intelligence to Expedite Data Analysis on Runway Incursions and Excursions

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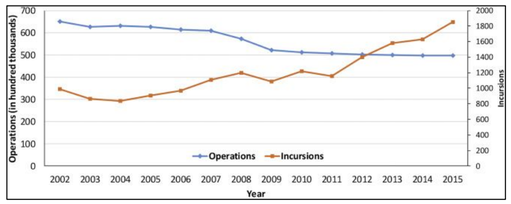
Introduction

Research Focus:

Our project aims to improve safety of the National Airspace System (NAS). Through this, we hope to additionally improve operational efficiency by cutting down potentially harmful events.

Near Collision at JFK Airport Between Delta, American Planes Under Investigation

Delta aircraft aborted takeoff and came within 1,000 feet of American Airlines plane on runway Friday night, FAA says



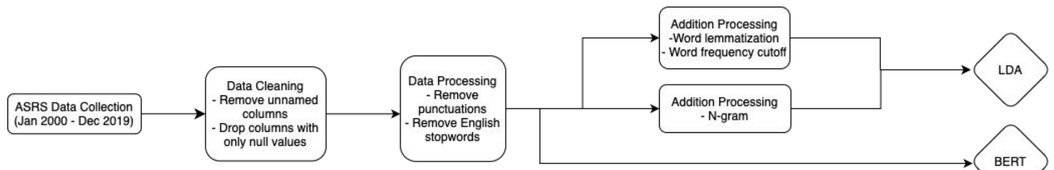
Statistical modelling of runway incursion occurences in the United States

Motivation:

In recent months especially, the news has been flooded with close call situations. The near collision at JFK with Delta is just one example of a plight that is becoming increasingly more common. With the potential of AI increasing exponentially over recent years, we want to utilize its power to stop dangers for the FAA at their source

Despite aircraft safety being a continual focus and success of the FAA, we see the rate of other, less pressing events such as incursions on a steady climb in the past few years. If left unchecked, this will be the next issue for the FAA to face. By acting proactively to address incursions, excursions, and unstable approaches, we can end the problem now.

Methodology

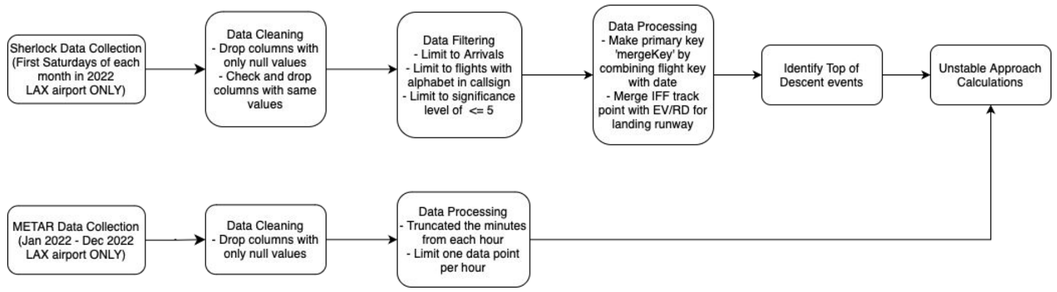


Incident Report Clustering - LDA:

- Used a systematic grid search to determine the optimal number of topics, between 2 and 10, for the datasets
- Incorporated multi-word phrases (“n-grams”) which is supported in the NLTK software library
- Experimented with different numbers of word n-grams, ranging from bigrams to 5-grams

Incident Report Clustering - BERTopic:

- Experimented with multiple combinations of model parameters to optimize topic coherence and distinctiveness
- Fine-tuning parameters in n-grams, UMAP model, vectorizer model, sentence transformer, and the embedding model



Top of Descent Events Identification:

- Top of Descent Events: Determined by where rate of climb was -250 feet per second, and the
- Landing event: Calculated where ‘alt’ was less than or equal to 128 feet, the elevation of LAX airport

Unstable Approach:

- Calculated the ground distance, bearing, and glidescope of all our flights
- Compared the bearing and glidescope of the aircraft trajectory at the waypoints to the optimal
- Convert ground distance unit from nautical miles to feet and bearing degrees unit from magnetic north to true north
- Categorized as unstable approach when bearing is 0.5° off from optimal and glidescope is 0.14° off from the optimal

Key Findings

Incident Report Clustering - LDA:

Model	Incursion Incidents	Excursion Incidents	Combined Incidents
Bigram	31,608.93	22,831.72	770.65
Trigram	18,628.52	15,081.76	92.99
4-gram	37,707.14	3,383.02	18.12
5-gram	**5,716.40**	**554.26**	**3.73**

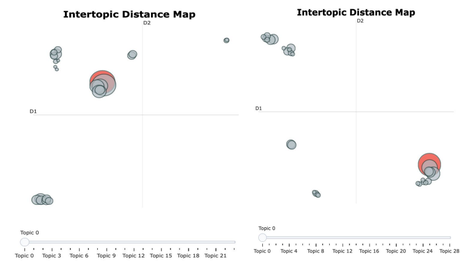
Summary of perplexities of different ngram LDA models.

We used various n-grams to analyze the text data related to runway incursion and excursion incidents. By comparing the models' perplexity scores and the interpretability of the derived topics, the lower perplexity scores and meaningful topic keywords indicate that the 5-gram model has captured underlying themes and patterns more effectively than the other models, providing valuable insights into the factors contributing to these incidents

Incident Report Clustering - BERTopic:

With BERT, we identified coherent and distinct topics related to runway incursions using the BERTopic model. The optimized model configuration yielded five primary clusters of topics, which provide valuable insights into the factors contributing to runway incursions and excursions

BERT Intertopic distance map for incursion (left) and excursion (right)

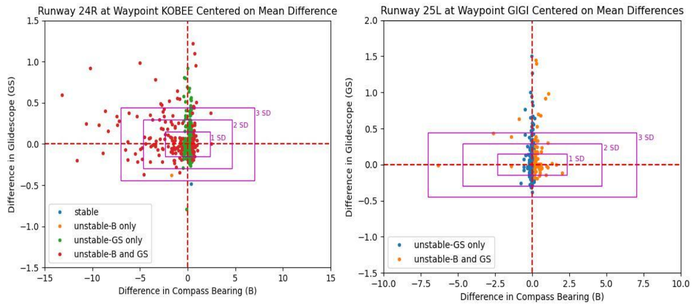


Unstable Approach:

	Based on Bearing	Based on Glidescope	Both
Number of Stable Occurrences	3,150	4	1
Number of Unstable Occurrences	267	3,413	3,416

Summary of number of stable and unstable occurrences with current standards.

We propose a new standard of determining an optimal glidescope that is based on actual statistics of the flight, including vertical speed, ground speed, and altitude of aircrafts at runway threshold based on aircraft type. If all these variables are stable and the glidescope difference is outside of the accepted 0.14 degrees, then the flight is likely on a stable approach to the runway



Deviations of bearing and glidescope centered on mean of the differences for runway 24R (left) and 25L(right) at waypoint KOBEE.

There is an overwhelming number of occurrences that have a glidescope degree fall out of accepted 0.14 degree variation at LAX airport. At LAX airport, the weather is often clear for the pilots to manually fly the airplane. This is a good practice for the pilots as it keeps them proficient. We believe that the standard provided is too rigid for manual piloting

Conclusion

1. This is our initial work in using AI to analyze FAA data to understand the safety issues involved in runway incursions, excursions, and unstable approaches
2. Data being collected by the FAA can reveal useful patterns and elad to important recommendations to increase safety and improve flight operations
3. There are useful techniques from AI that can be used effectively to understand incident reports
4. We also presented recommendations for improving the collection of the data to improve future analyses

Next Steps

1. Try different clustering, topic modeling methods and large language model algorithms to obtain new insights about the safety aspects involved in the incidents
2. Automated extraction of structured events and event classification based on the characteristics of incidents
3. Explore different language modeling approaches, data-pre-processing methods, and machine learning parameters
4. Set up larger-scale experiments