Data Analysis Application Towards the Effect of Angle of Attack Indicator in General Aviation

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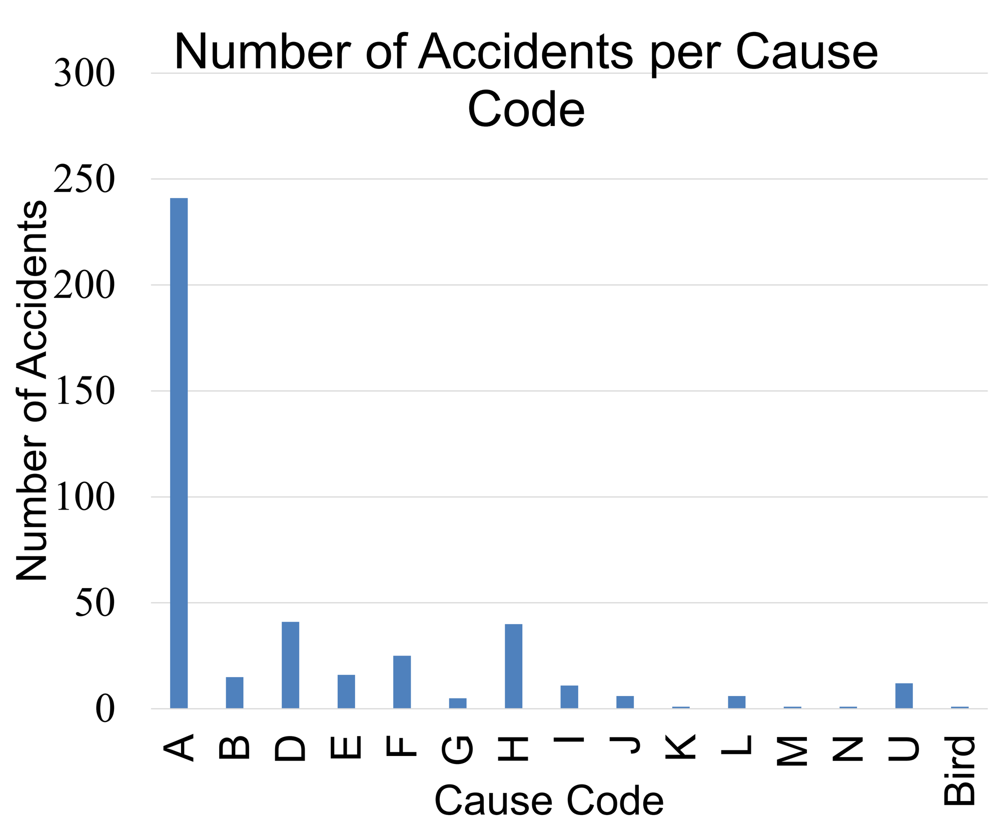
Introduction

In-flight loss of control (I-LOC) is one of the major causes of accidents in general aviation (GA). Based on recent data, "I-LOC accounted for 1,1194 fatalities from 2008 to 2014, close to 54 percent of fatal fixed-wing GA accidents in the United States". Within these I-LOC fatalities, exceeding the critical angle of attack (AOA) in landing or take-off process is one of the major reasons leading to the I-LOC fatalities. In this research, we are testing whether using an angle of attack indicator is effective in assisting with GA pilots making better decisions in order to reduce the I-LOC fatalities.



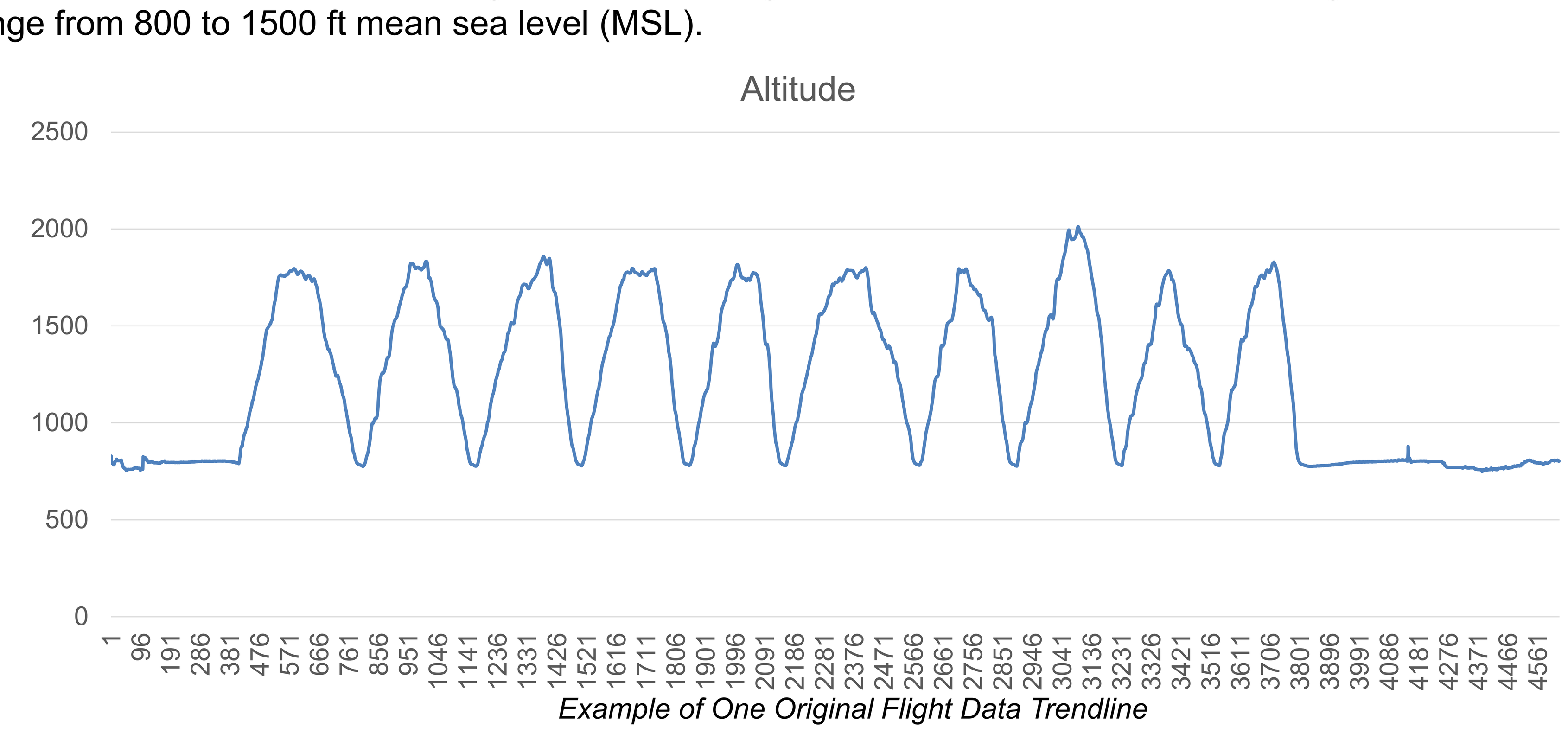
Cause Code	Cause Category
A	Loss of Control
B	Midair collision
D	Controlled flight into terrain (CFIT)
E	Low altitude operations
F	Fuel-relted
G	System/Component Failure (Non-Powerplant)
H	System/Component Failure (Powerplant)
I	Collision with an obstacle(s) during take-off/landing
J	Diverted attention
K	Fire
L	Suicide
M	Cabin Event
N	Abnormal Runway Contact
U	Unknown
Bird	Bird strike

Data Collection

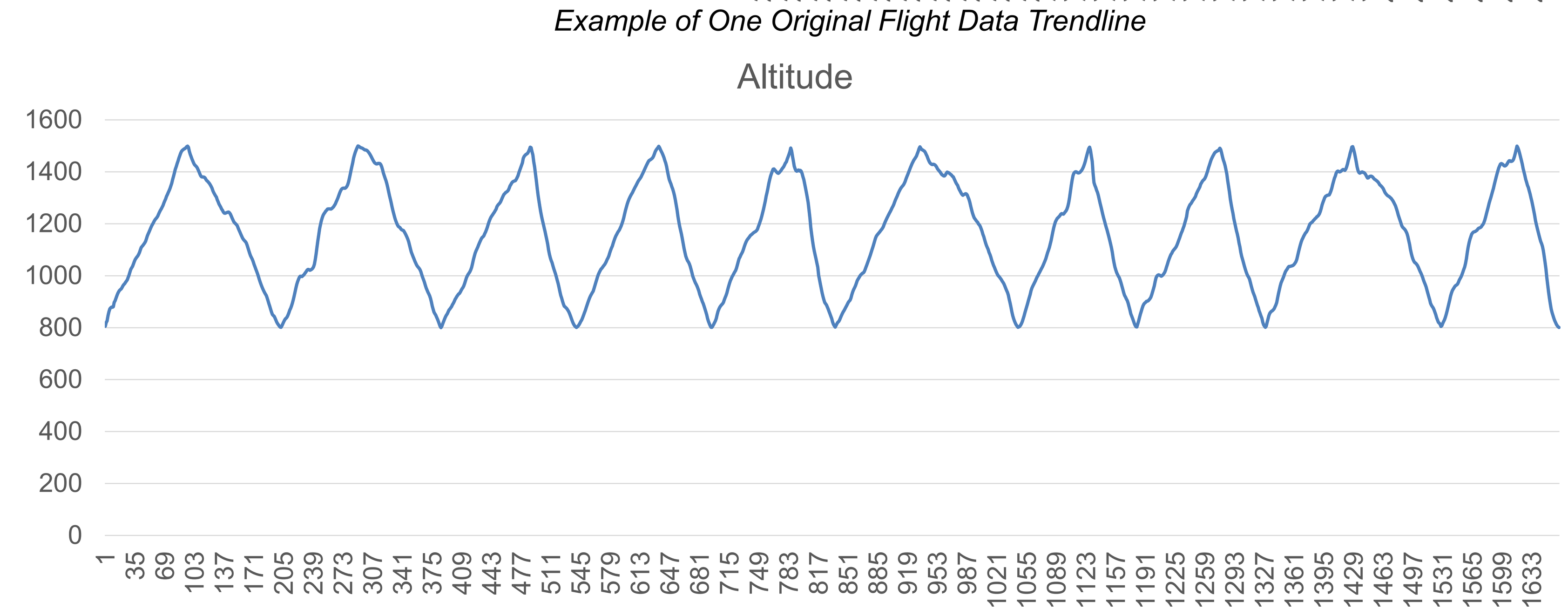
The flight data was collected by a flight instructor flying with several pilots who fly a Cessna 152, where the AOA indicator was installed. The main five variables of interest in this research are bank angle, vertical speed, indicated airspeed, pitch, and runway alignment. These data were collected via Foreflight application for every second of the flight time. The original dataset includes 219,686 rows and 10 columns.

Data Cleaning

The flight data was comprehensive, and it records all the five variables of interest from the very beginning of the flight to the end of the flight. However, only those data that include take-offs and landings were selected for this study. In order to filter the take-off and landing data, we selected the data that falls into a certain altitude interval. The altitude interval indicates that the data belongs to one of the flight statuses, either take-off or landing. The altitude interval had a range from 800 to 1500 ft mean sea level (MSL).



Example of One Original Flight Data Trendline



Example of One Cleaned Flight Data Trendline

Categorization

The filtered data included the intervals for both take-off and landing. However, the interval for each flight status was not classified. **R Studio** was used to determine the flight status for each data point. The method was developed by considering the following:

1. Find the data points where the plane has just changed the flight status base on the index number from the raw data.
2. Assign an index number for each of the data points that have the same flight status.

Results

We run a set of hypothesis testing to investigate whether the AOA indicator would help the pilot to have better control of the plane on both takeoff and landing status. The following variables are considered:

1. Pitch Altitude
2. Bank Angle
3. Altitude
4. Airspeed

Hypothesis testing is as follows:

H_0: $\mu_1 - \mu_2 = 0$

H_1: $\mu_1 - \mu_2 \neq 0$

Where μ_1= mean of the variable without AOA indicator

μ_2= mean of the variable with AOA indicator

The confidence level is 95%

take off	*Pitch AOA*	*Pitch w/o AOA*
Mean	2.8831598	3.401381305
Known Variance	10.2444	8.213
Observations	5330	15316
Hypothesized Mean Di	0	
z	-10.45204	
P(Z<=z) one-tail	0	
z Critical one-tail	1.6448536	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959964	

Hypothesis Testing Result in Pitch Altitude at Take-off

Landing	*Pitch AOA*	*Pitch w/o AOA*
Mean	-4.729510146	-4.590059646
Known Variance	3.781424	3.57951
Observations	4432	14341
Hypothesized Mean Difference	0	
z	-4.199232281	
P(Z<=z) one-tail	1.33911E-05	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	2.67821E-05	
z Critical two-tail	1.959963985	

Hypothesis Testing Result in Pitch Altitude at Landing

For example, in figures above, both the result shows for the parameter of pitch altitude reject the null hypothesis while the p-value is <0.05, which means the AOA indicator did affect the parameter of pitch altitude on both take-off and landing. For the rest of the result, every test parameter was statistically significant except for the takeoff airspeed.

Further Research

The hypothesis testing among all data gave the result that did not include other factors that could possibly be the root cause of variation such as the variability in the pilots' skills. However, we ensured that the wind and other important weather characteristics are consistent throughout the experiments. Here are some expectations for future work:

1. More factors are going to take consideration
2. Use machine learning to evaluate the overall flight performance
3. Improve the data filtering method to detect more pattern

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Acknowledgments

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