Application of Visual Analytics to Aviation Safety – Wildlife Strikes – The '5 W Questions'

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Abstract

IST-110 is the North Atlantic Treaty Organization (NATO) Research Task Group on visualization for analysis. The Group works to promote the research and deployment of visual analytics techniques among the NATO member nations and partner nations. The Group promotes collaboration and research in a broad range of NATO application areas. This poster describes an exploration of the Royal Netherlands Air Force (RNLAF) Wildlife Strike Database: it outlines the initial stages of a Visual Analytics approach to understanding, exploring, visualizing and analysing the raw data. The aim of the research is to address the management of wildlife strikes in and around airports by considering the '5 W questions', i.e., '**where**' and '**when**' do '**which** species', in '**what** number', collide with aircraft, and '**why** are wildlife at the airport'?

Keywords: Aviation Safety, NATO, wildlife / bird strikes, visual analytics.

1 Introduction

A wildlife strike incident is defined as a collision between an aircraft and an animal during any / all phases of the flight, including those animals killed by the downwash of aircraft. Birds are mostly involved, bats may be struck during their flight and terrestrial animals can get struck when aircraft are taking-off, landing and taxing. Wildlife strikes are serious hazards for both civil and military aircraft; military aircraft are under significantly increased risk due to their low flight paths, high velocities and single engines.

The first recorded fatality due to wildlife strike was in 1912 when Cal Rodgers collided with a gull which subsequently jammed his control cables. He crashed and drowned at Long Beach, California[1]. The US Department of Defence (DoD) estimated the total civilian and military cost to the US of bird and other wildlife strikes to aircraft in 1990 - 2008 as $600 million p.a.[2&3]. The UK Central Science Laboratory estimated the annual worldwide cost to airlines at $1.2 billion p.a.[4]. Military and civilian costs are due to: downtime, fatalities, damaged parts, repairs, man hours and costs to compensate passengers and reschedule flights. Consequential costs for military such as the detrimental effects on operations and training are also significant. Wildlife strikes continue to be a safety issue: the number of aircraft and worldwide flight movements are increasing, and the populations of many high-hazard wildlife species (e.g. geese) are also growing[7]. This is compounded by improved technology; i.e. faster, quieter and bigger aircraft which yield less warning time for wildlife to avoid collision.

All-in-all, to reduce and manage strikes it is crucial to know and understand the populations, movements and habits of the wildlife; such as when and where they are foraging, roosting and breeding and their flight paths in between. These movement / migration patterns must then be coupled with airport layouts, surroundings, aircraft characteristics, flight schedules and routes. It is the answer to the '5 W questions'; i.e., 'where', 'when', 'which species', 'in what number collide with aircraft' and 'why are wildlife at the airport', that provide the information necessary for managing wildlife strikes[5].

The collection and analysis of data and the derived knowledge allow for the identification of high risk factors and vulnerabilities. Effective aviation risk management strategies related to flight schedules and / or aircraft design may then be developed and implemented to improve aviation safety.

2 Data

Data from the Royal Netherlands Air Force Wildlife Strike Database were used in this study. It is in Excel format and each wildlife strike record contains 79 fields. This study focussed on military operations in the Netherlands; 5,401 incidents were recorded between 1976 and 2012, of which 371 strikes happened outside the Netherlands though to the RNLAF aircraft, for example in Afghanistan, Iraq and over many squadron rotations. The data provides valuable information; however, in some cases multiple fields are unfilled. For example, the species was not recorded in 1,416 cases, i.e. ~26%; and sometimes only qualitative information was provided such as: small, medium or large animal or a flock.

3 Visual Analytics

Visual Analytics is the science of analytical reasoning facilitated by interactive visual interface[6]: it provides an effective means to dynamically and visually interact, explore and analyse big and complex data. It enables the understanding of, for instance, wildlife strike incidents, and can thus facilitate the development of relevant risk mitigation strategies. It is efficient in detecting the expected and more importantly *discovering the unexpected*.

4 Application of Visual Analytics to Wildlife Strikes

At present, aviation safety data are predominantly analysed through intensive manual processing; querying, filtering and reading records. This is sub-optimal and time consuming. Excel spreadsheets or Access databases are commonly used to record wildlife strikes; these contain huge amounts of information with complex inter-dependencies that are almost impossible to detect / identify from the raw data.

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Wildlife strikes pose significant threats to aviation; it is therefore crucial to identify the characteristics of, and patterns in, the incidents with respect to: wildlife species, airport situation, aircraft type, nature of the damage, seasonal / daily trends, etc. Strikes that happen during the en-route phase are outside airports' environs, thus have no relevant airport information. *Figure 1* shows the 2,093 strikes with known associated airport information during 1976 – 2012 (Tableau 8.1 was used in this study). The strikes occurred at the eleven Netherlands military airbases (some are no longer in operation) and involved Jets, Jet-engine carriers, turboprops, helicopters and other small (<6,000kg) aircraft as well as 189 wildlife species. In the geospatial display (*Figure 1 top*), each pie chart represents the number of wildlife strikes at a particular location at the relevant airport, the colours represent the wildlife species and the size represents the number of strikes. It can be observed that the nature of the locations and the wildlife species in the strikes vary as do the number of wildlife involved (where/what/which). The bar chart (*bottom left*) is a multi-dimensional representation which, like other elements in the dashboard, can be zoomed into and examined in detail by passing the cursor over the relevant area. Multi-dimensional data can be accessed including month, year, time of day and phase of flight; additional data can be added and granularity changed as required. The bar height corresponds to the number of strikes; its colour represents the phase of flight and it is labelled with the airport, wildlife species and number. This provides information on the temporal patterns of the strikes as well as the phase of flight and the movement patterns of the wildlife, i.e. when/where/which/what. The tree map (*bottom right*) shows the wildlife species, aircraft types, altitudes, airports, number of wildlife species; as well as the resulting damage cost The size of the rectangle corresponds to the number of wildlife strikes; its colour represents the aircraft types, i.e. where/which/what. Dashboards such as this provide an effective and intuitive interactive means of exploring – and thus understanding – the data, such as the temporal trends and patterns of aircraft, wildlife species, locations, phase of flights, strikes, i.e. **where, when, which and what**.

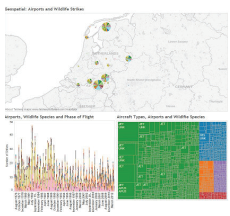

Figure1: Netherlands Military wildlife Strikes

Through the interactive exploration, querying and filtering of the data using the dashboard it was discovered that a significant number of strikes caused little damage. Leeuwarden Airbase however, suffered the two highest damage costs of ~€6.7M and €5M. The former was caused by a collision between an F-16B and White-fronted goose (*Anser Albifrons)* at 600feet in 1989; the engine was struck and damaged, the number of birds involved was not known. While the latter was caused by the collision between 2 Roe deer (*Capreolus Capreolus*) and an F-16A during take-off on the runway in 2001; the landing gear was severely damaged.

Figure 2 (Bar chart at the top) shows that Swifts (*Apus Apus*) caused the most number of strikes (542 strikes), of which 160 happened locally to eight different airports: the others were all en-route so do not have relevant airport information. 498 strikes happened during May, June and July (with highest altitude at 4,000feet) among these 404 collisions involved Jets. Bottom left shows that July had the most number of wildlife strikes (821 strikes) and bottom right shows that Eindhoven Airbase (591 strikes) had the most number of strikes, and there has been a noticeable increase in recent years. Most of this may be related to the number of increasing aircraft movements for which we have not been correcting the data.

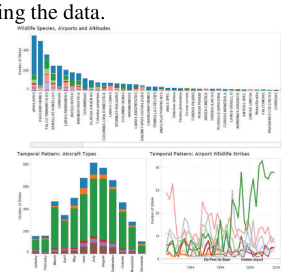

Figure 2: Wildlife Strike Patterns and Trends

Some strikes were caused by more than one wildlife species, e.g. in 1996, when a group of Lapwings and Starlings collided with a C-130 during landing at Eindhoven Air Base, resulting in 34 casualties.

5 CONCLUSIONS

This poster illustrates the use and effectiveness of Visual Analytics in analysing, exploring and understanding data of the RNLAF wildlife strike database. It shows that Visual Analytics provides an intuitive, interactive, flexible and easy to use approach. The approach provides a clear view of the data characteristics, thus providing guidance for the direction of further analysis.

Future work should include: temporal / geospatial characteristics analysis as well as consideration of the types of aircraft and the number of aircraft movements involved. Correlations between the kinetic energy of collisions, wildlife species, phase of flight, part of aircraft and the extent of damage should also be investigated.

This initial exploration / overview of wildlife strikes in the RNLAF database shows promise in understanding and answering the first four of the 5 W questions, i.e., 'where', 'when', 'which species' and 'what number'[5]. Future work should investigate the 'why are wildlife at the airport' and the en-route sites. A clear recommendation to the aviation industry arises even from this initial work: the need to *improve the reporting and recording* of wildlife strike incidents. In order to improve aviation safety, risk factors and vulnerabilities must be identified. At present, much salient information is frequently omitted from incident reports. Visualising the data analysis in this manner quickly highlights the issue of 'unknowns' in this – and indeed any – database.

6 REFERENCES

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