

Aviation Safety and Data Mining in Marketing Dimension

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Abstract

The aviation industry is a sector that is developing, changing and growing every day in terms of technological and legal framework. There are generally three factors that enable airlines to hold on to the market. These factors are safety, service quality and price. Airline companies can analyze the customers in the market with a focus on price and quality and develop a business model according to their expectations. For example, business class and economy class passenger expectations are different from each other, so the service and price to be offered to them will be different. However, all customers have one common expectation and that is safety. No matter how high quality the service is or how cheap the price is, no one wants to fly with an airline or plane that is not safe. From an airline company's point of view, an accident or breakdown of one of the company's aircraft can cause irreparable image loss and financial damage. If we look at past examples, we see that there are many airline companies or maintenance organizations that could not recover after an accident and went bankrupt. Safety is an indispensable factor. Therefore, there is a unit in the sector called the safety management system (SMS), which collects data by taking a proactive and reactive approach. The way and purpose of the safety management system is to take a proactive approach to recognize and prevent unsafe situations before they cause accidents or breakdowns, or to take a reactive approach to find the causes of accidents and breakdowns that have occurred as a result of certain factors and to take the necessary measures to prevent the same situations from happening again in the sector. The field of data mining, which is necessary to predict the future behavior of customers in the field of marketing, is an area that marketing also values. In this study, data mining studies to ensure safety in the aviation industry and the security of customer information in marketing will be emphasized, firstly, the concept and importance of data mining will be mentioned.

Keywords

Data Mining, Aviation, Customer, Safety, Marketing

1. Introduction

The airline industry is a sector that creates services with the combination of many fields of activity that are directly affected by developments in the world, crises, oil prices, epidemics, and interstate relations. Risks and dangers are quite high in this complex system. In order for an airline company to operate a flight, it needs work permits from the government, airport ground services (ramp services), passenger services at the terminal, slot and permits from local authorities, permits from the terminal and airport operator to open an office at the airport, etc.

Flight operation is realized by bringing together many activities. Airline service emerges as a result of complex processes such as loading/unloading etc. services provided to the aircraft on the apron, passenger-related services at the terminal, food and beverage services, permits and trainings to be obtained from local and international authorities in the background. These services offered by the airline company are analyzed in three dimensions. Pre-flight services, in-flight services and post-flight services.

While service quality and prices are important competitive tools, flight safety and security are also important. Safety in itself is an important and indispensable part of aviation. Without safety, concepts used for differentiation such as service quality, price, etc. cannot even be mentioned.

There is a unit known as the safety management system that aims to recognize and prevent dangerous events that may occur in aviation before they occur. In our study topic “Aviation safety and data mining”, it is aimed to show to which extent and in which fields of activity data mining is used in the studies carried out to ensure safety in the aviation system. The study consists of three parts.

First, aviation demand, airline transportation and aviation safety as an important component within the system and its importance are mentioned.

In the second part, the concept of data mining, its history, importance, stages of accessing information and areas where it is used are introduced. Briefly, the place, importance and usage areas of data mining in the aviation sector are mentioned. Finally, academic studies in the field of aviation safety and data mining are mentioned, and the rate of use, prevalence and effectiveness in the sector are shown. By examining the studies conducted using data mining in the field of safety, it is aimed to make predictions about the future of data mining in the field of aviation safety.

2. Airline Industry and Safety

Air transportation service is the transportation of cargo (cargo), people, mails

from one place to another from the air by an aircraft. Almost everything is transported by air cargo, which is a sub-type of air transportation; dangerous goods, live animals, valuables, perishable drinks and food, funerals, etc. [1]. All flights from one place to another for whatever purpose; for profit, sportive or personal purposes, etc. fall within the scope of air transportation [2]. Air transportation; all civil aviation activities such as production, technical maintenance, design, repair, ground services, airport, navigation, meteorology, air traffic and communication come together to form the aviation system. The listed civil aviation activities ensure that air transportation is carried out safely, securely, efficiently and effectively [3]. The main objectives of international and national civil aviation organizations (such as IATA, ICAO, EASA, ECAC and DGCA) are to establish internationally accepted rules and regulations in order to create an effective and efficient, safe and secure air transport sector, to improve and maintain it day by day, and to control compliance with these rules and procedures [4].

In the airline industry, there are three factors that ensure market retention. These are:

- Price,
- Service quality,
- Safety.

Safety is the most important factor for both the low cost carrier and the full service airline. Because no one wants to fly with an airplane that is likely to crash, no matter how high quality service it provides or how cheap tickets it offers. If an airplane of an airline company has an accident or breakdown, it can destroy the image it has built by spending millions of dollars until that moment. For these reasons, the most important factor in the aviation system is safety and security. In a system where safety and security are not sufficient, quality cannot be mentioned. Even if an airline company offers a comfortable flight with the latest design airplanes with wide seat spacing and the best catering in terms of food, these services are of no importance if safety and security are not adequately ensured. A comfortable flight or the quality of the catering on board is of no importance after the plane has suffered an accident or breakdown.

One important point we need to know here is that safety and security are different concepts. In the aviation sector, they do not cover the same things. Aviation security is a concept that covers the activities and resources required to prevent all kinds of terrorist attacks and sabotage against the civil aviation activities that constitute the aviation system such as production, design, repair, technical maintenance, airport, navigation, ground services, communication, air traffic and meteorology, in other words, against aircraft, people and air transportation infrastructure within the scope of aviation activities.

3. Data Mining

It can also be stated that aviation safety is an element that affects aviation safety and is one of the efforts carried out to ensure safety.

Aviation safety, on the other hand, is a concept that covers minimizing the risk that may be experienced in all aviation activities, but it needs a much broader explanation. Aviation safety can be defined as all unintentionally dangerous situations arising from mistakes, violations and non-compliance with safety rules by employees (maintainers, pilots, managers, ramp attendants, operations officers, tower control officers, cabin officers, etc.) who are part of the aviation system. For example, an airplane crashing due to an overlooked situation in maintenance (maintenance error), an accident caused by the pilot's wrong decision or carelessness, an accident or breakdown as a result of the ground crew's failure to comply with the balance rules while loading the aircraft, etc. fall within the scope of safety.

Aviation safety is at the heart of all decisions taken by international and national aviation organizations and the rules, regulations and laws they set. Everything is primarily for the sake of creating a safer system. There is a true saying that "Aviation laws are written in law". The development of the sector has been achieved through innovations in rules and laws, aircraft design and all infrastructure and systems that make up the sector as a result of the lessons learned from accidents and crashes [5].

Knowing what is being done to ensure aviation safety, what is the safety management system that emerged in order to ensure safety, and how it works will facilitate the understanding of the study.

The purpose of the Safety Management System (SMS) is to ensure that all safety risks that may affect aviation safety in all operational units and all processes, in other words, all safety risks that may arise, can be reduced to reasonable levels.

IMS works by focusing on processes rather than results, and instead of a reactive approach that learns lessons from accidents, incidents and incidents, it works with a proactive approach that recognizes hazardous situations, errors and violations in the system in advance, offers solutions to these situations in a timely manner, and at the same time implements these suggestions, aiming to remove the danger before it occurs. Hazardous situations in the system are identified through methods such as effective safety reporting from personnel, routine audits and controls, regulatory compliance checks, audits by international and national aviation organizations and performance measurement. By continuously measuring safety performance, it tries to prevent accidents and incidents before they occur. These are also data collection methods. The aviation sector aims to increase safety by collecting data through all these methods.

Data mining is the process of finding anomalies, patterns and correlations in large data sets in order to predict outcomes. By using different techniques, this information can be used to increase revenues, reduce costs, improve customer relationships, reduce the amount of risk, and more. A common definition of data mining is "the discovery of unexpected, interesting or valuable things in large data sets" [6]. Data mining is the semi-automated discovery of patterns, associations, changes, anomalies, rules, and statistically significant structures and events

in data. In short, data mining seeks to extract knowledge from data. Data mining differs from traditional statistics in several ways; formal statistical inference is an assumption, which means forming and confirming a hypothesis against the data. Data mining, on the contrary, is an exploration, which means that patterns and hypotheses are automatically extracted from data. In other words, data mining is about data, while statistics is about people [7].

The process of extracting information to predict future directions by discovering hidden connections has a long history. The concept of “data mining”, sometimes referred to as “knowledge discovery in databases”, was not defined until 1990.

The term data mining essentially consists of three integrated pieces of scientific knowledge:

- Statistics (numerical expression of data relationships),
- Machine learning (algorithm that learns from data to make predictions),
- Artificial intelligence (human-like intelligence expressed by machines and/or software) [8].

Data mining technology is old but new, as it continues to evolve to keep pace with the unlimited potential of big data and cost-effective computing power.

Over the past decade, advances in processing speed and power have enabled us to move beyond tedious, time-consuming manual applications to easy, fast and automated data analysis. The more complex the aggregation of various data sets, the greater the potential for relevant predictions.

Data mining is the discovery of valuable and interesting information hidden in large data sets. It is both an art and a technology. Data mining techniques are widely used in business and science. The data industry and the demand for data analysts is growing rapidly in our world. Companies can achieve incredible success in different markets thanks to the information they obtain [9]. Nowadays, data mining is also frequently used to make the use of public resources more efficient. Data mining can provide effective solutions in many research areas such as medicine, biology, education and computer science. Data mining can help where traditional methods such as statistics are difficult. Countries with a high level of development are aware of the potential and power of data mining. Therefore, investments in data science are constantly increasing. In addition to all these, information circulation in the global world is rapidly expanding [10]. Only unstructured data constitutes 90 percent of the digital universe. All these experiences reveal the increasing importance of data mining every day.

The general steps of data mining are as follows [11]:

Identification of required data

- Data preparation and pre-processing
- Selecting the model
- Training the selected model
- Model validation and implementation.

Data Mining in the Airline Industry

Data mining is used in almost every sector such as communication, education,

retail manufacturing, insurance, banking, transportation. Data mining in the aviation sector will be examined in detail.

Data mining is used in the aviation sector as it is used in many sectors. As a result of the researches, it was found that there are studies conducted in many fields in the aviation sector by utilizing data mining.

Areas where data mining is used in aviation are as follows [12]:

- **Air traffic, airline operations and airport studies**
 - Applications related to air traffic control and management
 - Assessing and understanding passenger demands and needs, passenger feedback and customer satisfaction analysis research
 - Check-in and baggage handling
 - Flight plan and fleet determination
 - Analyzing/forecasting/predicting the causes and duration of delays
 - Identifying and setting up a Network/Hub point, airport capacity analysis
 - Airport related applications
- **Efforts in the field of safety and security**
 - Analysis of accident/incident data, safety/risk management
 - Applications related to human factors
 - Flight and airport security
- **Studies in aircraft systems and maintenance**
 - Analysis of information obtained from flights and identification of deviations
 - Maintenance-related analysis such as fault detection and segregation, part life
 - Efficiency analysis of aircraft energy (power) groups, applications such as noise/fuel/emission
- **Studies in the field of Unmanned Aerial Vehicles (UAV)**
 - Control
 - Analysis of flight data
 - Multi-mission planning and analysis strategy planning

Data mining is used by UAV with 12%, security and security forces with 24%, airlines and airport operations with 30%, and aircraft systems and maintenance with 34%. As it is understood from these studies, data mining has been utilized in all fields of activity that make up the aviation system and will continue to be utilized at an increasing rate [12].

The Use of Data Mining in Ensuring Aviation Safety

The information that data mining is utilized in almost every field of activity that constitutes the aviation system has been obtained as a result of the examination of the studies. When we examine the studies conducted in the field of aviation safety, which is our main field of study, we reach the following results.

Research in the field of Safety/Security has focused on the analysis of incidents/incidents/accidents and the realization of forecasts/predictions related to them. In addition, even issues related to risk management based on forecasts and predictions have been studied within this framework. In addition, we can say that contents such as airport security, terrorist threat/analysis are among the studies in this field [12]. It has been mentioned that safety and security are not

the same thing, but security is one of the studies carried out in order for a safe aviation system to exist. In short, it is one of the sub-elements of safety.

Olli Sjöblom, [13] in his 2014 study “Data mining in promoting aviation safety management”, used the narratives of 1240 flight safety reports of deviation events in Finnish from 1994-1996 provided by the Finnish Civil Aviation Authority (FCAA) as data for his research. Air traffic is a field of activity that is not free of hazards but full of incidents and deviations that need to be investigated to find potential accident trends. Air traffic is estimated to grow by 5% - 6% over the next two decades, and global air travel is likely to double in the next 10 - 15 years [13]-[15]. As a result, the number of accidents will increase if nothing is done to improve traffic. The European Commission [16] stated that new, effective and efficient efforts are needed to improve safety in the airline industry. Recent aviation studies show that data mining can be used to detect these dangerous trends [13]. In short, Sjöblom reviewed studies that tried to identify dangerous situations that may arise in parallel with the development of air traffic by using data analysis method.

Zohreh Nazeri conducted a study titled “Aviation Safety Data Mining Application Workbench at American Airlines” in 2003. In the study, the application of MITER Corporation’s Aviation Safety Data Mining Workbench to American Airlines Aviation Safety Action Program (ASAP) data was explained. In other words, the data for this study were American Airlines air safety reports submitted by pilots under the Aviation Safety Action Program (ASAP). In recent years, the Federal Aviation Administration (FAA) in the US and the air transportation industry have been seeking new advanced methods to address safety issues and identify potential safety hazards. The objective of his project was to demonstrate the usefulness of data and text mining tools in analyzing aviation safety data and to assess the ability of these tools to improve the analysis of domestic airline safety. This work was conducted in support of the efforts of the Global Aviation Information Network’s (GAIN) Analytical Methods and Tools Working Group B.

In 2018, Sinem Kahvecioğlu, in her study titled “Data Mining and Its Applications in Aviation: A Brief Overview of the Present and Future” in 2018, Sinem Kahvecioğlu talked about data mining and its importance, and aimed to reveal its prevalence in the aviation sector by examining and introducing the studies conducted using this method in the aviation sector.

Taşçi, 2020, “Reduction of Flight Data Using the Rough Set Method” in this research, possible failure situations were evaluated by evaluating the variables that can provide information about the condition of the engine and the variable groups that affect them together in the studies that predict instant engine failure (there are studies in which engine maintenance is performed by evaluating the data recorded during flight in airplanes, as well as studies in which maintenance methods that predict engine failure are determined by instantaneous evaluation of data during flight). Exhaust gas temperature (EGT) is one of the variables used in decision-making in studies conducted to monitor the condition of the

engine. In this study, the rough set method, which is accepted as a pre-process in data mining methods, was used on aircraft data to reduce some features in the data. Datasets consisting of various attributes were obtained with the study. After the classification of the obtained datasets according to certain criteria, failure prediction was made.

Kaya, 2020 “Rough set based aircraft failure reliability prediction model in the aviation industry and its application in Turkey”, a supervised learning algorithm, the rough set based LEM2 algorithm, was used in the aircraft failure reliability model for prediction and classification purposes. In order to obtain reliable results from the information set in the information sets containing the failures of the aircraft parts examined in the model, it was subjected to preprocessing and data cleaning stages. In the attribute selection process, firstly, the factors that are important for obtaining effective results in the prediction of reliable data are introduced to the literature in detail, and then the LEM2 algorithm is applied to these factors. In the classification process, classification algorithms were applied to the dataset to predict aircraft failure reliability and based on these predictions, prediction performance was achieved. She prepares a study using data mining to in-depth analyze and use local mass data about agricultural product quality safety tests in China [17].

In addition to these, Sharma and Sabitha 2016 [18], Asgary *et al.* 2015 [19], Lukacova 2014 [20], Zhu and Ni 2013 [21], Christopher *et al.* 2016 [22], Liu and Cui 2017 [17], Duvviri *et al.* 2017 [23] have conducted studies on accident/incident data analysis and safety/risk management. Again, since we consider aviation safety as a sub-element of safety, we can accept study on airport and flight safety within this framework. The value of civil aviation’s big data puts it in danger of a privacy and security issue. Governance of civil aviation big data plays an important role in managing and protecting data by connecting the department, process, people and other elements of the organization with the entire lifecycle [24].

In the process of processing the data by bringing them together in a computer environment, the information of the customers using the airline can be collected in a detailed area [25]. The segmentation of these data is considered necessary in order to be effective in marketing [26], analysis and control processes [27]. In order to be effective in marketing compared to competitors, customers’ information should be processed within a system in order to be analyzed in depth [28]. data mining, which provides integrated information to the enterprise in the field of marketing [29], has an important place in aviation.

4. Conclusions

Data mining, the discovery of valuable and interesting information hidden in large data sets, is both a technology and an art. Data mining techniques are widely used in business and science. This situation is rapidly increasing the demand for data industry and data analysts in our world. Companies can achieve incredible success in different markets thanks to the information they obtain. In

order to transform the data obtained through various research methods into meaningful information, it is necessary to use various data mining techniques.

Companies can use this useful information filtered through data mining techniques for marketing, measuring customer satisfaction and expectations, making various predictions and recognizing unwanted situations that are likely to occur.

Almost every sector benefits from this science today and this situation seems to continue to increase.

The aviation industry has also benefited from data mining in many fields of activity. For example, airline operations, air traffic and airport studies, safety and security, aircraft systems and maintenance/repair have benefited from various data mining methods to obtain important information and useful studies have been carried out.

Especially in the examination of the studies on aviation safety, which is the main subject of our study, it has been concluded that data mining methods have not yet been used intensively in the sector, in other words, they are not used at the desired value. Measures are taken to increase aviation safety and security with the valuable data obtained as a result of research in the field of safety and security. The safety management system, which aims to keep aviation safety at a reasonable level, can prevent accidents, crashes and serious incidents before they occur with the valuable information it will obtain by using data analysis methods as well as various data acquisition methods (safety reporting, routine audits, control of compliance with rules and procedures, etc.). Companies that want to become advantageous against their competitors in the aviation sector will be able to understand their customers and become stronger in the market thanks to their in-depth studies on data mining in order to analyze customer information accurately.

As a result of the academic studies analyzed, it was concluded that data mining techniques are used in the aviation sector and aviation safety, but academic studies on this subject are few and limited. Since there are not enough academic studies on data mining in certain areas of the aviation industry and in the field of safety, it can be said that it is a virgin field.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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